FINAL

MODELING PROTOCOL IN SUPPORT OF A FIVE PERCENT PLAN FOR PM-10 FOR THE MARICOPA COUNTY NONATTAINMENT AREA

Maricopa Association of Governments

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Nomenclature

AERMET	AERMOD Meteorological Processor
AERMOD	AMS/EPA MODel
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
AMS	American Meteorological Society
AZMET	Arizona Meteorological Network
BACM	Best Available Control Measures
CAA	Clean Air Act
CAMx	Comprehensive Air Quality Model with Extensions
CART	Classification And Regression Tool
CO	Carbon Monoxide
DRI	Desert Research Institute
EC	Elemental Carbon
EGAS	Emission Growth Analysis System
EPA	Environmental Protection Agency
EPS3	Emissions Preprocessor System
FDDA	Four Dimensional Data Assimilation
FORTRAN	FORmula TRANslation
FSL	Forecast Systems Laboratory
IDA	Inventory Data Analyzer
ISCST3	Industrial Source Complex Short Term
LTO	Landings and Take-Offs
MAG	Maricopa Association of Governments
MAGE	Mean Absolute Gross Error
MB	Mean Bias
MCAQD	Maricopa County Air Quality Department
MFB	Mean Fractional Bias
MM5	Mesoscale Meteorological Model
MNB	Mean Normalized Bias
MOBILE6	EPA-approved Onroad Mobile Source Emissions Model
NAAQS	National Ambient Air Quality Standards
NCAR	National Center for Atmospheric Research
NCDC	National Climate Data Center
NEI	National Emission Inventory
NH3	Ammonia
NOx	Oxides of Nitrogen
NWS	National Weather Service
OC	Organic Carbon
OSW	Office of Surface Water
PM-10	Particulate Matter less than or equal to10 microns
PSU	Pennsylvania State University
RVP	Reid Vapor Pressure
SAMSON	Solar and Meteorological Surface Observation Network
SCRAM	Support Centre for Regulatory Air Quality Models

SLAMS	State and Local Air Monitoring Stations
SO2	Sulfur Dioxide
TEOM	Tapered Element Oscillating Microbalance
TSD	Technical Support Document
VHT	Vehicle Hours of Travel
VMT	Vehicle Miles of Travel
VOC	Volatile Organic Compounds

1. Overview of Modeling Study

1.1 Background

Under the 1990 Clean Air Act Amendments the Maricopa County nonattainment area was initially classified as Moderate for PM-10 particulate pollution. Because attainment of the particulate standard was not achieved by December 31, 1994, the nonattainment area was reclassified to Serious on June 10, 1996. The new attainment date for Serious nonattainment areas was December 31, 2001.

As the designated Regional Air Quality Planning Agency, the Maricopa Association of Governments (MAG) prepared the "Revised MAG 1999 Serious Area Particulate Plan For PM-10 for the Maricopa County Nonattainment Area." EPA subsequently approved the MAG Plan to meet the particulate matter standards in the Phoenix area (67 FR 48718, published July 25, 2002). As part of the approval, EPA granted the request for an extension of the attainment date to December 31, 2006.

Due to numerous exceedances in November 2005 through March 2006, several monitors in the Maricopa County nonattainment area will not meet the 24-hour PM-10 standard by 2006[1]. Under the Serious Area PM-10 Plan, local cities and towns, Maricopa County, and Arizona Department of Environmental Quality are implementing 77 control measures for the primary sources of airborne particulates. The primary sources of particulate pollution in the nonattainment area are fugitive dust from construction sites, agricultural fields, unpaved parking lots and roads, disturbed vacant lots, and paved roads.

For areas that fail to attain the PM-10 standard by the applicable attainment date, CAA section 189(d) requires that a Five Percent Plan for PM-10 be submitted to EPA within one year of the attainment date. Because the Maricopa nonattainment area will not meet the PM-10 standards by December 31, 2006, MAG must submit a new PM-10 attainment plan by December 31, 2007. The Five Percent Plan must show reductions in PM-10 emissions of five percent per year until attainment is achieved at all monitors.

1.2 Conceptual Model

MAG has conducted an analysis of 24-hour PM-10 data during the period March 2005 through March 2006 in order to develop a conceptual model for the Five Percent Plan for PM-10. Major features of the conceptual model for the Maricopa County nonttainment area are described in this section. A more detailed discussion of the conceptual model is provided in Attachment VI.

PM-10 in the arid Southwest largely consists of coarse particles (i.e. aerodynamic diameter greater than 2.5 microns but less than or equal to 10 microns) which are typically crustal in nature and derive mainly from windblown dust, resuspended road

[1] EPA revoked the annual PM-10 standard on September 21, 2006. Therefore, this document addresses modeling for the 24-hour PM-10 standard only.

dust (from paved and unpaved roads), unpaved parking lots, disturbed vacant land, mining operations, construction, and agricultural activities (e.g., tilling and harvesting, travel on unpaved farm roads). Other components of particulate matter (PM), such as sulfates, nitrates, and organic and elemental carbons (OC and EC), are typically found in the fine fraction of PM (i.e., aerodynamic diameter less than or equal to 2.5 microns), but can also contribute to coarse PM. Previous analyses of PM-2.5 data in the Phoenix area have shown that mobile source exhaust, burning, and industrial sources are important constituents of PM-2.5. EPA designated Maricopa County as an attainment area for PM-2.5 in September 2005. The co-located PM-10 and PM-2.5 monitors at the Durango Complex site indicate that PM-2.5 readings on days with high PM-10 concentrations range from 6 to 15 percent of the PM-10 on high wind days and 14 to 22 percent, on low wind days. Therefore, the PM-10 problem in the Maricopa County nonattainment area is largely attributable to coarse particles, comprised primarily of geologic material.

The first step in understanding PM-10 in the Maricopa County nonattainment area is to identify the important crustal constituents of PM-10. High PM-10 concentrations generally occur in September through March, on days with stagnant or near-stagnant conditions. Due to the lack of wind, the local contribution of PM-10 near the sites that exceed the PM-10 standard is very important. The contribution of specific local sources can be best understood by identifying the potential sources of PM-10 near monitoring sites, assembling meteorological, emissions, and monitoring data, and applying air quality models to evaluate the relationship between PM-10 emissions and concentrations.

To meet the requirements of CAA section 189(d), MAG will prepare a Plan that shows a five percent reduction in emissions per year until attainment of the 24-hour PM-10 standard is achieved at all monitors. Due to the numerous exceedances experienced in 2006, the earliest attainment year that can be achieved is now 2009. The Five Percent Plan will demonstrate through modeling that the 24-hour PM-10 standard will be met at all monitors by December 31, 2009. This will require implementation of additional PM-10 control measures. Legally binding commitments to implement these control measures will be included in the Five Percent Plan submitted to EPA.

As the designated Regional Air Quality Planning Agency, MAG conducts modeling of PM-10 emissions and concentrations and prepares air quality attainment and maintenance plans. This protocol will detail the procedures that will be followed in conducting all aspects of air quality modeling for the Five Percent Plan for PM-10.

1.3 Management Structure and Committees

MAG has responsibilities for regional involvement in a number of planning issues and has established an extensive mechanism for ensuring coordinated policy direction from elected officials, coordinated management and technical input, advice from the appropriate agency staff, as well as direct citizen input. Figure 1-1 illustrates the MAG Policy Structure and Figure 1-2 presents the MAG Committee Structure. All policy committees and formal technical committees follow the Arizona open meeting law, which requires, among other requirements, the posting of meeting notices and agendas at least 24 hours prior to any meeting.

The MAG Regional Council is the governing body of MAG. It is comprised of elected officials from each member agency, two ex-officio members representing the Arizona State Transportation Board, and a representative from the Citizens Transportation Oversight Committee. This composition of elected officials is a reflection of citizen input at the local government level. The MAG Regional Council agenda includes a call to the audience, providing the opportunity for public comments at each monthly meeting.

MAG holds at least one formal public meeting prior to the adoption of any new or update to the nonattainment area plan. Formal public meetings are advertised locally at least 30 days prior to the meeting date and documentation is available for public review during this 30-day period. Draft documents are distributed to appropriate federal, state, and local agencies for review and comment during this period. Comments received are analyzed with a staff response for consideration by the MAG Air Quality Technical Advisory Committee and MAG Regional Council before taking approval action. Documentation of the comments and responses are incorporated into the plan document.

Due to the technical complexity of many MAG programs, committees consisting of professional experts are often needed to assist in program development. The Air Quality Technical Advisory Committee is composed of representatives from eight MAG member agencies, citizens, environmental interests, health interests, the automobile industry, the fuel industry, utilities, public transit, the trucking industry, the rock products industry, construction firms, the housing industry, architecture, agriculture, industry, business, parties to the Air Quality Memorandum of Agreement, and various State and Federal agencies. The role of the Technical Advisory Committee is to review and comment on technical information generated during the planning process and make recommendations to the MAG Management Committee.

1.4 Participating Organizations

The Air Quality Planning Team will provide technical oversight for this project. This team includes staff representatives from the Maricopa Association of Governments (MAG), the Arizona Department of Environmental Quality (ADEQ), the Arizona Department of Transportation (ADOT), and the Maricopa County Air Quality Department (MCAQD). The activities of this working group are directed by a Memorandum of Agreement among the agencies involved (see Attachment III). Representatives of other agencies, including EPA and the U.S. Department of Transportation, will be consulted on technical matters, as needed. The Air Quality Planning Team will meet as necessary during the PM-10 modeling effort. Periodic reports on the status and progress of various phases of the modeling work will be presented at these meetings, and technical issues will be discussed and resolved.

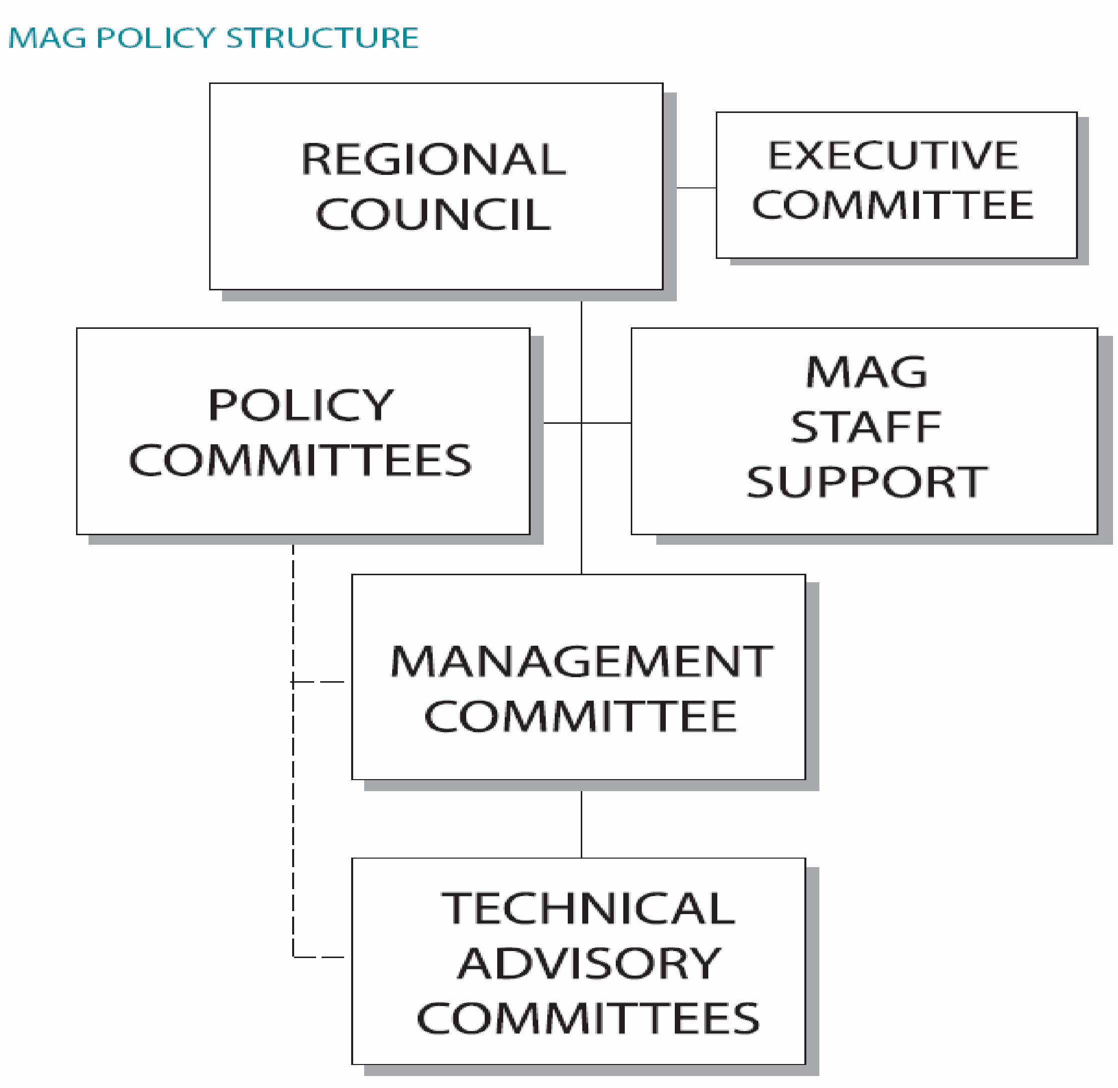

Figure 1-1 MAG Policy Structure

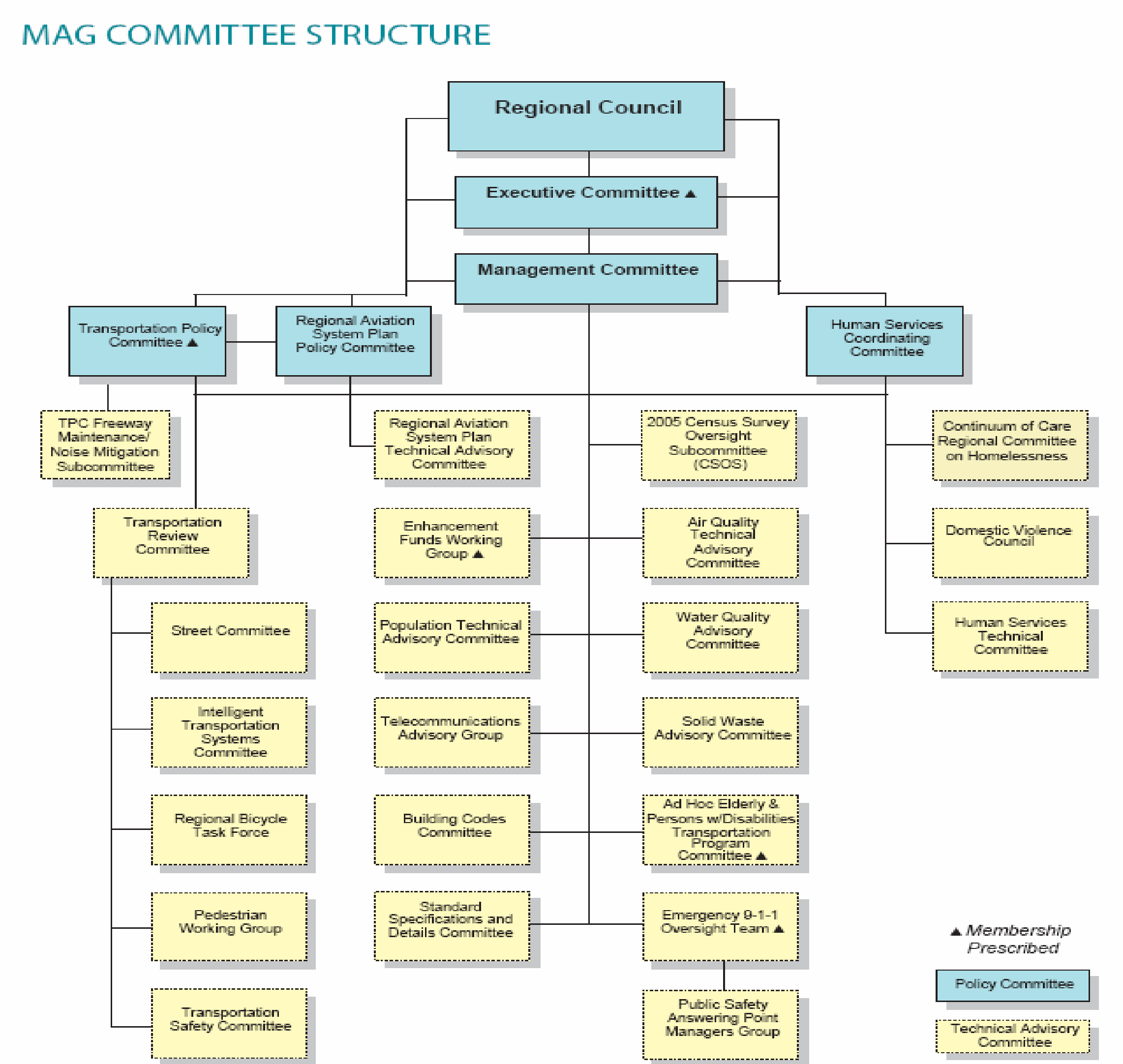

Figure 1-2 MAG Committee Structure

1.5 Schedule

The following modeling tasks will be conducted for the Five Percent Plan for PM-10. The schedule is illustrated in Figure 1-3.

1. **September 2006:** Prepare the protocol describing the purpose, background, and procedures to be followed in modeling for the Five Percent Plan for PM-10.
2. **September 2006:** Assist the Maricopa County Air Quality Department (MCAQD) in preparing the 2005 periodic emissions inventory for PM-10.
3. **October 2006:** Prepare point and area source emissions for 2006 based on the 2005 periodic emissions inventory.
4. **October 2006:** Apply MOBILE6.2 and M6Link to prepare onroad mobile source emissions (for paved and unpaved roads) and the EPA NONROAD model and the MAG Aviation Processor to prepare nonroad mobile source emissions for 2006.
5. **October 2006:** Process area, point, onroad, and nonroad emissions using M6Link to obtain gridded, temporally allocated emissions for design days.
6. **October 2006:** Gather appropriate meteorological data and process with AERMET for input to AERMOD.
7. **December 2006:** Conduct AERMOD performance evaluation for the base case design days.
8. **December 2006:** Prepare 2007 through 2009 base case emissions inventories using appropriate growth factors and existing control measures.
9. **February 2007:** Conduct base case simulations for the attainment year with the AERMOD and proportional rollback models.
10. **July 2007:** Conduct control measure evaluations and model attainment with committed control measures.
11. **September 2007:** Document technical issues and data in the Technical Support Document for the Five Percent Plan for PM-10.

	2006										2007								
PM-10 Modeling Task List	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
1. Finalize modeling protocol							★												
2. Assist in preparing 2005 periodic emissions inventory							★												
3. Prepare 2006 point and area source emissions								★											
4. Prepare 2006 onroad and nonroad mobile source emissions								★											
5. Process emissions for design days								★											
6. Prepare meteorological data for AERMOD								★											
7. Conduct AERMOD performance evaluations										★									
8. Prepare 2007-2009 base case emissions inventories										★									
9. Conduct base case simulations for attainment year												★							
10. Evaluate control measures and model attainment																	★		
11. Finalize Technical Support Document																			★

Figure 1-3 Modeling Schedule for the Five Percent Plan for PM-10

2. Air Quality Models

This chapter discusses the selection of the air quality models to be applied in demonstrating attainment of the PM-10 standard for the Five Percent Plan. Domain selection, design day selection, and ambient air quality monitoring data are also discussed.

2.1 Selection of Air Quality Models

The U.S. Environmental Protection Agency (EPA) suggests a number of alternative models for PM-10 application. In general, the suitability of the model is based on the following factors:

- The meteorological and topographic complexities of the area
- The level of detail and accuracy needed for the analysis
- The technical competence of those undertaking such simulation modeling.
- The resources available
- The detail and accuracy of the database, e.g., emissions inventory, meteorological data, and monitoring data

EPA PM-10 State Implementation Plan (SIP) development guidelines encourage application of dispersion modeling when it is determined to be the most suitable approach. Attachment IV provides EPA guidelines on air quality modeling.

Air quality model selection and application are mainly dependent upon data requirements, the availability of emissions, meteorology, and air quality data, and the validity of the representation of PM-10 concentrations[1]. There are three fundamental modeling approaches: receptor chemical mass balance, receptor speciated rollback, and grid-based dispersion modeling with day specific data. MAG is proposing that two different modeling approaches be applied in the Five Percent Plan, a grid-based dispersion model and receptor speciated rollback.

The grid-based dispersion model is proposed for application to the area analyzed as part of the Salt River Area PM-10 Study conducted by the Arizona Department of Environmental Quality (ADEQ)[2]. A dispersion model is appropriate because the meteorology and terrain in the Salt River Area are complex and there is a large and diverse set of sources contributing to elevated PM-10 concentrations. In addition, MAG is currently conducting a PM-10 Source Attribution and Deposition Study that includes saturation monitoring in the Salt River Study area. The objective of the MAG Study is to better define the sources contributing to the high monitored PM-10 values in the area, especially during stagnant weather conditions. This will improve inputs to the dispersion model and enable identification of cost-effective measures to reduce PM-10 concentrations.

MAG is recommending that receptor speciated rollback be applied for one design day and monitoring site located outside the Salt River Study Area. In this case a more simplistic rollback approach is appropriate, because there was only one exceedance and there are a limited number of sources surrounding the monitor. The design day to be modeled with rollback had high wind (01/24/06) conditions. The next two sections discuss in more detail the rationale for selection of the AERMOD and rollback models.

2.1.1 AERMOD

Due to the wide variety of sources contributing to high PM-10 concentrations in the Salt River Study Area[2], receptor speciated rollback does not provide enough information upon which to base an attainment demonstration, since many source types cannot be distinguished. The Chemical Mass Balance (CMB) model cannot discriminate between soil-entrained dust from construction activities versus soil-entrained dust from vehicles or wind erosion. Based on a review of EPA guidelines, it appears that the grid-based dispersion model, AERMOD, is the most suitable for evaluating PM-10 exceedances in the Salt River Study Area.

AERMOD (AMS/EPA Regulatory Model) is a steady-state Gaussian plume dispersion model that assesses pollutant concentrations from a variety of sources. Sources and receptors located in complex terrain can be simulated considering the transport and dispersion from multiple point, area and/or volume sources based on characterization of the boundary layer. Mobile sources are considered as multiple area or volume sources joined together[5].

EPA adopted AERMOD as a regulatory model on December 9, 2005, as a replacement for ISCST3. Compared with ISCST3, AERMOD contains improved algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed is less than 1 m/s[1][8]. This is a desirable feature, since one of the design days, December 12, 2005, is characterized by stagnant conditions.

AERMOD has a proven track record in modeling various pollutants, including PM-10. Previous research by Desert Research Institute has shown that the AERMOD predecessor, ISCST3, performed well in assessing the local PM-10 source attribution in the Clark County, Nevada[4].

AERMOD contains improved algorithms for dealing with low wind speed (near calm) conditions. No other model has been found to perform better for modeling area source fugitive dust. This is important because fugitive dust is a major contributor to high PM-10 levels in the Salt River Study Area and throughout the remaining nonattainment area[3].

MAG has also selected AERMOD based on its past usage[2], public familiarity, and the resources available[1]. The general characteristics that make AERMOD suitable for application in the Salt River Study Area include:

- It is capable of handling a wide range of regulatory applications in all types of terrain
- If fugitive dust emissions are properly specified, gravitational settling and dry deposition are handled well

- Low-level emission sources, such as area sources, can be modified to produce a more realistic urban dispersion
- The minimum layer depth can be changed to calculate the effective parameters for all dispersion settings

Despite its advantages for PM-10 modeling, AERMOD:

- Does not explicitly address the urban transport of PM-10
- Has no algorithm to handle secondary PM-10 formation
- Requires source-receptor locations to be well defined
- Can be data-intensive (e.g., microinventories, meteorology)

These limitations should not inhibit the successful application of AERMOD for the Salt River Study Area. The quantification of long distance and intra-urban transport will be addressed in defining the boundary conditions for AERMOD modeling. Saturation monitoring to be performed for the MAG PM-10 Source Attribution and Deposition Study will assist in quantifying the urban transport levels of PM-10 for the Salt River Study Area during stagnant conditions. PM-10 monitoring in pristine areas of the state (e.g., Organ Pipe National Monument) will provide the basis to quantify the rural background contribution. These efforts should ameliorate the urban transport deficiency associated with application of AERMOD. ADEQ has already conducted analyses of the urban transport and background levels contributing to high PM-10 levels in the Salt River Study Area in 2002. (See ADEQ comments in ATTACHMENT VII).

AERMOD's inability to handle formation of secondary PM-10 is not a drawback for this area, since high PM-10 levels are attributable to fugitive dust. Attention will be paid to defining the source receptor relationships as accurately as possible. The MAG PM-10 Source Attribution and Deposition Study, being conducted June 2006 through May 2007, will be particularly helpful in this regard. The Study consultants will assemble emissions and meteorology data for the Salt River Area on the design days to be modeled with AERMOD. All assumptions and justifications will be described in the Technical Support Document.

AERMOD requires two types of inputs, emissions and meteorological data. The emissions are input as gridded data (area, mobile and non-road) and point source data. Each source can be treated explicitly in AERMOD by providing information such as the type of source, pollutant emission rate, and source dimension. Day specific emissions data will be prepared for input to AERMOD.

2.1.2 Rollback

Although AERMOD is an appropriate choice for modeling PM-10 in the Salt River Study Area, where the meteorology is complex and the emission sources are numerous, the proportional rollback model is a more appropriate approach for areas that have a small number of exceedances and more easily-defined sources.

On January 24, 2006, winds traveling over vacant disturbed land surrounding the Higley monitor caused an exceedance of the PM-10 standard. MAG is recommending that the proportional rollback model be used to demonstrate attainment of the PM-10 standard at the Higley monitor on January 24, 2006. Since only one exceedance occurred during the period March 2005 through March 2006 and the sources can be more easily identified, rollback is a more appropriate model for modeling the Higley site.

The proportional rollback model assumes that there is a linear relationship between PM-10 emissions and concentrations. The rollback model was used successfully to demonstrate attainment in the EPA-approved Serious Area PM-10 Plan for Clark County, Nevada[6].

Although it is not one of the EPA preferred models for PM-10 attainment demonstrations, the proportional rollback model is an appropriate technique if the significant sources responsible for the high PM-10 concentrations and background PM-10 concentrations can be accurately specified. According to Clark County, the rollback model used in their Serious Area PM-10 Plan has the following characteristics[6]:

Advantages

- Appropriate for representing fugitive dust
- No meteorological data is required
- Considers all PM-10 sources within the microscale area surrounding the monitor

Disadvantages

- Sources outside the microscale area are excluded
- Control factors are not considered outside the microscale area
- Secondary particulates are not addressed.

Since the exceedances of the 24-hour standard on the design day at the Higley monitor is due to fugitive dust, not secondary particulates, rollback is an appropriate technique. The fact that rollback does not address sources outside the modeling domain can be rectified by careful specification of background concentrations. If the PM-10 concentrations at the edges of the HIgley modeling domain cannot be deduced from other sources, additional saturation monitoring may be performed. This will ensure that the background levels are adequately characterized for the purposes of rollback modeling. The fact that control factors are not considered outside the microscale area is not a critical drawback, since control measures would be implemented on a region-wide basis.

The inputs to the rollback model include a day specific emissions inventory for the modeling domain and air quality monitoring data. The modeling domain for rollback will initially be defined as a 2 km x 2 km area surrounding the Higley monitor. This domain size will be expanded if it is determined that significant sources of PM-10 are located outside this domain. Examination of aerial and satellite imagery and meteorological data will be performed to identify the significant sources contributing to the exceedance at the Higley monitor. The development of modeling emissions inventories are described in the next section.

2.2 Emissions Inventories

In the Maricopa County nonattainment area, PM-10 is largely produced by re-entrained paved and unpaved road dust, vacant disturbed areas, agricultural and construction activities, and wind blown dust[3]. For the Five Percent Plan, inventories quantifying the emissions from these sources need to be developed for two different, but important, purposes. Design day specific inventories are needed to model attainment at individual monitors with AERMOD and rollback. In addition, annual average daily emissions for the years 2007, 2008, and 2009 emissions inventories are needed to show that committed control measures will achieve a five percent per year reduction in emissions between 2007 and 2009. The modeling and annual average daily emissions inventories are discussed below.

2.2.1 Modeling Inventories

To model the impact of localized emission sources on ambient concentrations of PM-10, many state agencies and research organizations have used a day specific micro-inventory approach[2,7]. For the Five Percent Plan, design day emission inventories will be developed for the Salt River Study Area and the modeling domain surrounding the Higley monitor. The boundaries for these modeling domains are discussed in a following section.

In general, the major sources of PM-10 emissions in the Maricopa County nonattainment area include vehicular traffic, vacant lots, unpaved shoulders, and agricultural, construction, and industrial activities. AERMOD-ready gridded hourly emissions will be developed for all known sources of PM-10 in the Salt River Study Area for December 11-13, 2005. Daily emissions will be estimated for the known sources of PM-10 in the modeling domain surrounding the Higley monitor on January 24, 2006.

The base case modeling inventories will utilize data from the Maricopa County 2005 periodic emissions inventory for PM-10, the ADEQ Salt River Area PM-10 Study, and the MAG PM-10 Source Attribution and Deposition Study. The latest population estimates, land use data, and road networks will also be used.

EPA's MOBILE6.2 model will be applied to derive PM-10 emissions factors for exhaust, brake wear, and tire wear emissions. EPA's AP-42 will be applied to calculate the PM-10 emission factors for unpaved roads. Local data being collected as part of the MAG Silt Loading Study by the University of California, Riverside, College of Engineering, Center for Environmental Research and Technology (CE-CERT) will be utilized to develop paved road emission factors. The justification for use of these factors, rather than AP-42, will be included in the Technical Support Document for the Five Percent Plan. These locally-derived factors will be applied to vehicle travel estimates produced by the MAG transportation models to estimate paved road emissions.

To develop base case emissions for input to the rollback model, emissions inventories specific to the sources and design day for the modeling domain surrounding the Higley monitor will be developed. To the extent possible, the emissions for the Higley modeling domain will represent PM-10 generation activities that occurred on January 24, 2006.

For AERMOD, hourly emissions profiles will be built for the PM-10 sources in the Salt River Study Area. After the hourly emissions profiles are built, the files will be input to the M6Link program developed by MAG. M6Link is a MAG program written in FORTRAN that converts land use and traffic data to hourly emission rates and scalars for the grid cells that will surround each of the monitoring sites. The output of M6Link, PM-10 emissions ($g/s/m^2$) for each cell, will be merged with a file of PM-10 emissions from industrial point sources to produce the file that will be input to AERMOD to estimate ambient PM-10 levels.

Maps showing the spatial surrogates used to apportion emissions into the modeling grids and emission density plots of significant source categories will be included in the Technical Support Document. The percent contribution from each modeled source category will also be provided for the peak modeling concentrations.

To demonstrate attainment, the base case emissions inventories for the design days will be adjusted to reflect emissions expected to occur in 2009. The general methodology for creating the 2009 base case emissions will follow EPA guidance on the preparation of emission projections[10]. These adjustments will entail the use of growth factors, ongoing control programs, and retirement rates for obsolete sources of emissions. The growth factors used to create the 2009 base case inventories will represent the latest socioeconomic projections approved by MAG.

Additional control measures will be evaluated using the 2009 base case emissions and AERMOD or rollback models. The 2009 emissions inventories with committed control measures will be used to demonstrate attainment of the PM-10 standard at the Durango Complex, Higley, and West 43rd Avenue monitors.

2.2.2 Five Percent Inventories

In addition to modeling attainment at the monitors that exceed the 24-hour PM-10 standard, the Five Percent Plan must show a five percent reduction in emissions per year until the PM-10 standard is achieved. According to Section 189(d) of the Clean Air Act, the emissions inventory to be used in meeting this requirement must represent the year that the plan is due to EPA. Since MAG will submit the Five Percent Plan to EPA by December 31, 2007, a 2007 PM-10 emissions inventory for an annual average day will be developed.

In order to show a five percent reduction from 2007 to 2008, and 2008 to 2009, emissions inventories must also be developed for 2008 and 2009. The 2007, 2008 and 2009 base case emissions will be “grown” from the 2005 periodic emissions inventory for PM-10 prepared by the Maricopa County Air Quality Department. All sources of PM-10 emissions will be included in these inventories. The 2007, 2008 and 2009 annual average daily emissions inventories will represent the entire PM-10 nonattainment area.

The general methodology for creating the 2007, 2008 and 2009 base case emissions inventories will follow EPA guidance on the preparation of emissions projections[10]. These adjustments will entail the use of growth factors, ongoing control programs, and retirement rates for obsolete sources of emissions. The growth factors used to create these inventories will reflect the latest socioeconomic projections approved by MAG.

Emissions reduction credit for new and strengthened PM-10 control measures will be applied to reduce 2007 base case PM-10 emissions by at least five percent per year until the attainment year of 2009. This means that 2009 emissions with new and strengthened control measures must equal 90 percent or less of total 2007 emissions.

The onroad mobile source component of the 2009 emissions with committed control measures will provide the basis for a new PM-10 conformity budget. The PM-10 sources contributing to this budget will include exhaust, tire wear, and brake wear emissions, as well as fugitive emissions from paved roads, unpaved roads, and road construction.

2.3 Meteorological Data

AERMET is a general purpose preprocessor for organizing available meteorological data into a format suitable for use by the AERMOD air quality dispersion model. AERMOD requires meteorological data in order to model pollutant concentrations and deposition. Table 2-1 provides the necessary meteorological parameters for PM-10 concentration and deposition evaluation[8].

Meteorological data for the design days of December 11-13, 2005 for the Salt River Study Area will be based on the wind, temperature and surface pressure measurements collected at monitoring sites in the area. Surface data can be obtained from the National Climate Data Center (NCDC), SCRAM web site, SAMSON surface data AriZona METeorological network (AZMET), and monitor specific meteorology data. The upper air station data for meteorological modeling will be derived from the FSL (Forecast Systems Laboratory) stations shown in Table 2-2. Upper air sounding data will be obtained from the Tucson Airport taken at 5 a.m. and 5 p.m. on each of the design days. Any missing data will be supplemented using either NCDC or SCRAM meteorological data. Site and day specific meteorological data are provided in Attachment I.

Table 2-1 Required Meteorological Information

	Meteorological Data		
Surface Hourly Data	**Units**	**Concentration**	**Dry Deposition**
Wind Speed	Knots	X	X
Wind Direction	tens of degrees	X	X
Ambient air temperature	F	X	X
Opaque Cloud Cover	tenths	X	X
Station pressure	millibars		X
Daily Upper Air Data		X	X
Morning Mixing Height	m	X	X
Afternoon Mixing Height	m	X	X

Table 2-2 Meteorological Monitoring Stations

NWS (33 sites)								
Site	**Abbr.**	**Lat**	**Lon**	**UTM (Zone 12)**		**Elev. (m)**	***Address***	**County**
				Northing (m)	**Easting (m)**			
Casa Grande Municipal Airport	KCGZ	32.95000	-113.76389	3646004.74	428339.63	446	510 E. FLORENCE BLVD, Casa Grande	Pinal
Chandler Municipal Airport	KCHD	33.26917	-113.93306	3681421.13	424459.38	379	2380 S. STINSON WAY, Chandler	Maricopa
Davis-Monthan Air Force Base	KDMA	32.16667	-111.44806	3558916.01	511000.13	824	DAVIS-MONTHAN AFB, Tucson	Pima
Douglas Bisbee International Airport	KDUG	31.46917	-112.42222	3482443.65	632656.74	1266	1415 MELODY LANE, BLDG C, Douglas Bisbee	Cochise
Phoenix Deer Valley Municipal Airport	KDVT	33.69028	-110.72083	3728325.15	401239.94	450	702 W DEER VALLEY DR, Phoenix	Maricopa
Tucson NEXRAD	KEMX	31.88300	-110.00556	3527531.19	536222.38	1586	Tucson	Pima
Mesa/Falcon Field	KFFZ	33.46667	-109.37917	3703264.45	431857.54	424	4800 FALCON DR, Mesa	Maricopa
Flagstaff	KFGZ	36.21700	-111.67222	4008326.71	426567.23	2192	Flagstaff	Coconino
Libby AAF Fort Huachuca	KFHU	31.60000	-111.81700	3496292.91	563243.03	1438	401 GIULIO CESARE AVE, Sierra Vista	Cochise
Flagstaff Pulliam Airport	KFLG	35.14028	-112.15472	3888806.53	438763.21	2137	6200 S. PULLIAM DR, 204, Flagstaff	Coconino
Flagstaff NEXRAD	KFSX	34.56700	-114.55944	3825044.89	481654.04	2260	Flagstaff	Coconino
Gila Bend U.S. Army Airfield	KGBN	32.43333	-112.68333	3589715.73	341743.08	262	Gila Bend	Maricopa
Grand Canyon National Park Airport	KGCN	35.94611	-110.61700	3978587.39	395854.86	2014	Grand Canyon	Coconino
Glendale Municipal Airport	KGEU	33.52722	-112.38333	3710488.09	379721.07	325	6801 N. GLEN HARBOR BLVD 201, Glendale	Maricopa
Goodyear Municipal	KGYR	33.41667	-110.84583	3698335.76	371380.94	295	1658 SO LITCHFIELD RD, Goodyear	Maricopa
Laughlin/Bullhead International Airport	KIFP	35.15750	-110.33333	3893236.68	722300.40	212	2550 LAUGHLIN VIEW DR, Bullhead City	Mohave
Kingman Airport	KIGM	35.25778	-109.60361	3905575.22	233156.32	1050	7000 FLIGHTLINE DR, Kingman	Mohave
Winslow Municipal Airport	KINW	35.02806	-110.95528	3876190.43	525466.06	1505	21 WILLIAMSON AVE, Winslow	Navajo
Mesa Williams Gateway Airport	KIWA	33.31660	-109.63556	3686574.65	439496.98	421	6001 SOSSAMAN RD, Mesa	Maricopa
Williams AFB/Chandler	KIWA	33.31667	-111.76667	3686574.65	439496.98	421	6001 SOSSAMAN RD, Mesa	Maricopa
Luke Air Force Base/Phoenix	KLUF	33.53333	-111.81111	3711271.17	371553.24	332	LUKE AFB, Glendale	Maricopa
Yuma Marine Corps Air Station	KNYL	32.62361	-109.06667	3612935.22	240675.79	64	Yuma	Yuma
Nogales International Airport	KOLS	31.42083	-111.73333	3476252.27	514652.98	1198	Nogales	Santa Cruz
Page Municipal Airport	KPGA	36.92056	-112.06556	4086153.63	460091.83	1314	697 VISTA AVENUE, Page	Coconino
Phoenix Sky Harbor International Airport	KPHX	33.43417	-111.65000	3699914.60	402291.25	345	3400 SKY HARBOR BLVD, Phoenix	Maricopa
Prescott Love Field	KPRC	34.64917	-111.65000	3835058.29	369663.82	1537	6546 CRYSTAL LANE, Prescott	Yavapai
Wind Rock Airport	KRQE	35.65000	-112.29528	3946850.91	675023.86	2055	Window Rock	Apache
Safford Municipal Airport	KSAD	32.85722	-111.91056	3636283.38	627670.20	968	4550 E AVIATION WAY, Safford	Graham
Scottsdale Airport	KSDL	33.62278	-114.60000	3720703.49	415540.50	460	15000 N AIRPORT DR, Scottsdale	Maricopa
St. Johns Industrial Airpark	KSJN	34.51833	-111.20000	3820822.44	648772.04	1747	St. Johns	Apache
Show Low Regional Airport	KSOW	34.26528	-110.88333	3792017.67	591549.62	1955	3150 AIRPORT LOOP, Show Low	Navajo

Tucson International Airport	KTUS	32.13139	-112.05111	3555000.31	504218.01	805	Tucson	Pima
Yuma International Airport	KYUM	32.65000	-112.38333	3615031.47	725106.73	65	2191 E 32ND ST, Yuma	Yuma

AZMET (23 sites)

Site	Abbr.	Lat	Lon	UTM (Zone 12)		Elev. (m)	***Address***	County
				Northing (m)	Easting (m)			
Aguila	AGUI	33.946667	-113.188889	3758401	297716	655	0.6 Miles NW of Aguila City Limits	Maricopa
Bonita	BONI	32.463611	-109.929444	3592330	600610	1346	18 Miles N on Rex Allen Dr from Willcox at I-10	Graham
Buckeye	BCK1	33.400000	-112.683333	3696899	343454	304	3.5 km S of Exit 109 from I-10	Maricopa
Coolidge	COOL	32.980000	-111.604722	3649232	443496	422	0.8 km SW of the Curry Rd & Bechtel	Pinal
Eloy	ELOY	32.773889	-111.556944	3626358	447840	461	0.8 km E of 11 Miles Corner Rd on Arica Rd	Pinal
Harquahala	HARQ	33.483333	-113.116667	3706876	303337	350	1.8 km N of the Intersection of Courthouse Rd & 491st Ave	Maricopa
Laveen	LAVE	33.376389	-112.150000	3693605	393027	315	3921 W Baseline Rd	Maricopa
Litchfield	LITC	33.467222	-112.398056	3703959	370087	309	1 Mile N of McDowell Rd on Cotton Ln	Maricopa
Marana	MARA	32.461111	-111.233333	3591572	478071	601	1 Mile W of I-10 on Trico-Marana Rd	Pima
Maricopa	MARI	33.068611	-111.971667	3659313	409299	361	NW corner of field #5 S of Irrigation Lab Building	Pinal
Mohave	MOHA	34.967222	-114.605833	3872026	718581	146	14.2 Miles S of Bullhead City on AZ Route 95	Mohave
Paloma	PALO	32.926667	-112.895556	3644751	322765	219	9 Miles W of Gila Bend on I-8 to Paloma Exit	Maricopa
Parker	PARK	33.882778	-114.447778	3752091	736045	94	8 Miles S of Poston & 0.4 Miles E on Nez Rd	La Paz
Phx. Encanto	ENCA	33.479167	-112.096389	3704947	398135	335	SE of Thomas Rd & 19th Ave (Encanto Golf Course)	Maricopa
Phx. Greenway	PGRN	33.621389	-112.108333	3720728	397193	401	SE of Greenway & 23rd Ave (Cave Creek Golf Course)	Maricopa
Queen Creek	QUEE	33.258333	-111.641667	3680110	440233	430	0.1 km E of Queen Creek Rd & Ellsworth Rd	Maricopa
Roll	ROLL	32.744444	-113.961111	3626837	222539	91	County 4th St & Ave 39 E	Yuma
Safford	SAFF	32.813333	-109.678333	3631367	623729	901	0.8 km SE of Lone Star Rd & Mountain Rd	Graham
Tucson	TUCS	32.280278	-110.945833	3571504	505101	713	1 km NW of Campbell Ave & Roger Rd	Pima
Waddell	WADD	33.618056	-112.459722	3720763	364592	407	2 Miles W of Cotton Ln & 0.4 Miles S of Greenway Rd	Maricopa
Yuma Mesa	YMES	32.611944	-114.633889	3610740	722021	58	0.32 km W of Ave A on 15th St	Yuma
Yuma North Gila	YUMA	32.735278	-114.529444	3624641	731506	44	2.1 km W on 7th Ave from Gila Center	Yuma
Yuma Valley	YVAL	32.712500	-114.705000	3621744	715106	32	5 Miles W of Yuma on 8th St	Yuma

FSL (4 sites)

Site	Abbr.	Lat	Lon	UTM (Zone 12)		Elev. (m)	Address	County
				Northing (m)	Easting (m)			
Flagstaff/Bellemt	FGZ	35.23	-111.82	3898858	425383	2179	123 miles North from Central Phoenix	Coconino
Tucson	TUS	32.12	-110.93	3553739	506603	788	113 miles South from Central Phoenix	Pima
Yuma/US Army	YUM	32.87	-114.33	3640036	749823	131	138 miles West from Central Phoenix	Yuma
Yuma/US Army	1Y7	32.87	-114.40	3639872	743271	98	142 miles West from Central Phoenix	Yuma

Attachment V provides the weather map information for all four design days. Additional meteorology data will be collected in the Salt River Study Area by the MAG PM-10 Source Attribution and Deposition Study during November and December of 2006.

Surface pressure along with surface roughness length, non-time albedo, bowen ratio, anthropogenic heat flux and fraction of net radiation absorbed at the ground are the main meteorological parameters used for the dry deposition calculation in AERMOD[7]. Surface roughness length is a measure of the height of obstacles to the wind flow. A surface roughness length representative of either measurement site or facility site can be used. Noon-time albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. AERMET has standard tables representing different land use types and various seasons. Bowen ratio is a measure of the amount of moisture at the surface. Like the albedo, the bowen ratio has three different tables depending on the land use type, different seasons and various (dry, average and wet) conditions. Anthropogenic heat flux (W/m^2) is the surface heating caused by human activity, including automobiles and heating systems. EPA recommends that a value of 0.0 W/m^2 and 20 W/m^2 be used for rural and large urban areas, respectively. The flux of heat into the ground during the daytime is parameterized as a fraction of net radiation. EPA recommends values of 0.15 for rural and 0.27 for urban areas.

The choice of meteorological data to be used to model the Salt River Area will take into consideration the availability and accuracy of meteorological data for December 11-13, 2005; meteorology at the monitors with the highest PM-10 concentrations during this period (i.e., West 43rd Avenue and Durango Complex); and the wind speeds and directions that best simulate the transport of emissions during the modeled event. The PM-10 Source Attribution Study will also provide insights as to the appropriate meteorology to be used as inputs to AERMOD.

2.4 Modeling Domains

The AERMOD modeling domain (Salt River Study Area) is shown in Figure 2-1. This area was initially defined in the ADEQ Salt River Area PM-10 Study[2]. The highest PM-10 readings are typically recorded at the monitors in this area. There are four PM-10 monitors in the Salt River Study Area: Bethune Elementary, Durango Complex, South Phoenix, and West 43rd Avenue. MAG proposes to apply AERMOD to the Salt River Study Area for the period December 11-13, 2005 (stagnant conditions). The Durango Complex, Greenwood, West 43rd Avenue, and West Phoenix monitors exceeded the PM-10 standard on December 12. In addition, the Durango and West 43rd sites exceeded on December 13. The Greenwood monitor is located two blocks north, and the West Phoenix monitor, two miles north, of the Salt River Study Area. On December 12, the Durango and West 43rd monitors had higher readings (i.e., 206 and 233, respectively) than Greenwood and West Phoenix (i.e., 172 and 155, respectively).

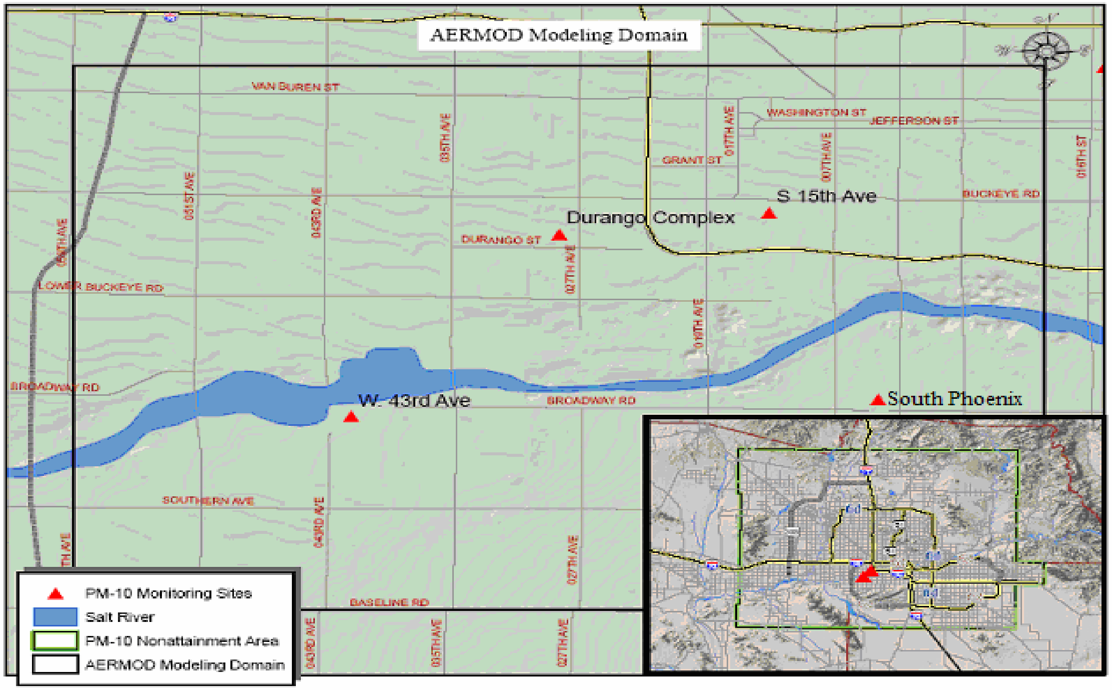

Figure 2-1 Salt River Study Area

Due to the diversity and number of PM-10 sources in the Salt River Area, this area is considered to be a worst-case representation of sources throughout the nonattainment area. This area has the highest density of PM-10 emissions in the nonattainment area. In addition, all major sources of PM-10 emissions, except unpaved roads, are represented in the area. These sources include: light and heavy dust-generating industries, active agricultural land, active construction sites, vacant lots, and unpaved parking areas. The area also includes four monitors, two of which typically record the highest PM-10 concentrations in the nonattainment area.

Preliminary analyses of monitoring data from the Durango and West Phoenix sites during January and February 2006 indicate that the ratio of PM-2.5 to PM-10 at these two continuous monitors remains relatively constant over the day. This suggests that the high readings at these two monitors are attributable to similar sources. The MAG PM-10 Source Attribution and Deposition Study will confirm this finding through saturation monitoring during November and December 2006. The Technical Support Document will describe the source mix around the Greenwood and West Phoenix monitors and will demonstrate that regionally implemented control measures will eliminate the small number of exceedances at these two monitors north of the Salt River Area. The TSD will provide convincing evidence that attainment of the PM-10 standard within the Salt River Area will also result in attainment at the Greenwood and West Phoenix monitors.

While ADEQ used 400 m grids to model the Salt River Study Area, MAG will consider using a smaller size if the MAG PM-10 Source Attribution and Deposition Study recommends this adjustment. The Study will update the PM-10 emissions inventory for the area and perform additional meteorological and particulate matter monitoring during the fall of 2006. A recommendation to reduce the grid size for AERMOD modeling could result from the emissions inventory update and saturation monitoring.

For rollback modeling, a domain of 2 km by 2 km surrounding the Higley monitor is proposed. There is significant acreage of vacant disturbed land adjacent to the Higley monitor that is likely to be the primary source of PM-10 emissions that caused the single exceedance at this monitor.

Prior studies performed by ADEQ and Clark County, Nevada, will be examined to determine the distance of influence for PM-10 sources. In addition, field work being performed by the MAG PM-10 Source Attribution and Deposition Study in the fall of 2006 will provide additional insights into PM-10 deposition rates in the nonattainment area. The size of the modeling domain for the Higley monitor may be increased if these studies and/or aerial and satellite imagery and meteorological data indicate that there are significant contributing sources outside of the 2 km x 2 km modeling area.

The rollback modeling domain for Higley is illustrated in Figure 2-2. Attachment II discusses the domain selection process.

2.5 Design Day Selection

A detailed description of the design day selection process is provided in Attachment I. The primary criteria applied in selecting the design days for PM-10 modeling were:

- Days with high 24-hour PM-10 concentrations that are close to the design value for each monitor
- Availability of the air quality, emission and meteorological data for the selected days and episode

The Durango Complex and West 43rd Avenue monitors are located about two miles apart, to the north and south, respectively, of the Salt River. These two monitors consistently record the highest PM-10 concentrations in the nonattainment area. The Durango and West 43rd monitors exceeded the 24-hour PM-10 standard on 20 and 22 days, respectively, between March 2005 and March 2006. Sixteen of the exceedances at Durango and West 43rd occurred on the same day. Most of the exceedances occurred during the fall and winter of 2005-2006 under low wind and severe inversion conditions.

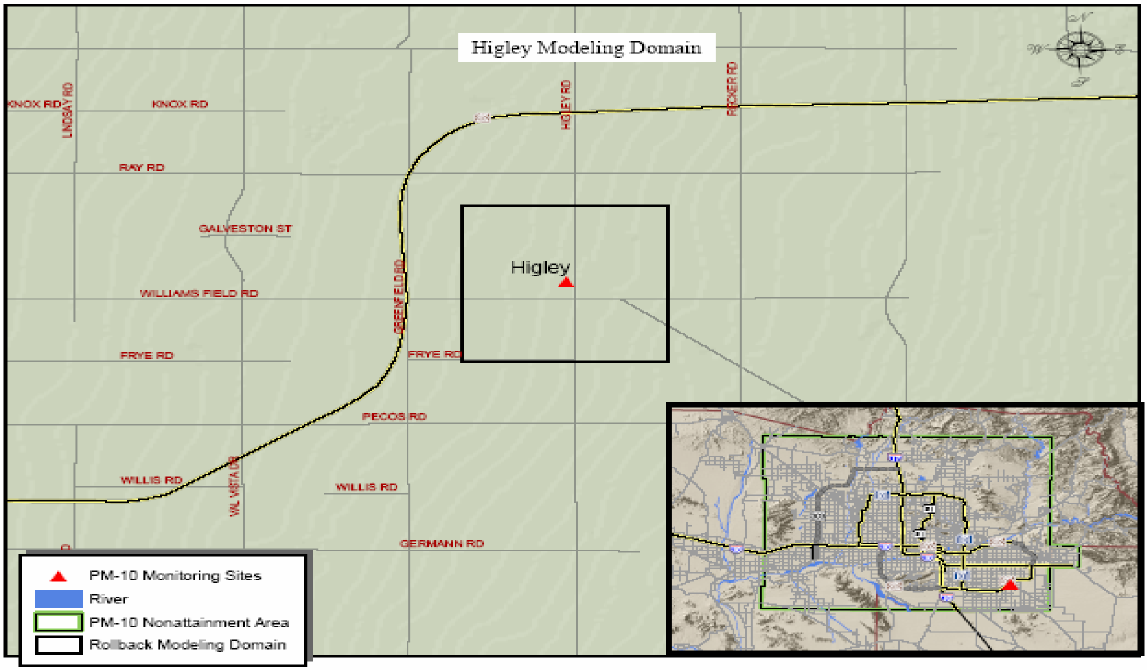

Figure 2-2 Rollback Modeling Domain for Higley

December 11-13, 2005 have been selected as the dates to be modeled with AERMOD to represent these stagnant conditions. On December 12, the West 43rd Avenue monitor recorded a 24-hour PM-10 concentration of 233 ug/m^3, while Durango Complex was 207 ug/m^3. On December 13, the West 43rd Avenue monitor 24-hour reading at West 43rd Avenue was 167 ug/m^3; Durango was 166 ug/m^3. December 11 will be modeled as a spin-up day.

On March 10, 2006, the West 43rd Avenue monitor recorded the highest PM-10 concentration at this monitor of 260 μ/m^3. The exceedance was caused by the prevalence of high winds for many hours; the average wind speed for the day was 9 mph. Durango (240 μ/m^3) and Greenwood (166 μ/m^3) also experienced exceedances on this day. However, ADEQ has advised MAG that the PM-10 readings on this day have been flagged as a natural event due to high winds. Therefore, this day will not be modeled for the Five Percent Plan.

Other monitors that exceeded the PM-10 standard between March 2005 and March 2006 were Buckeye and Higley. Although the Buckeye monitor had five exceedance days during this period, the monitor is located outside of the western boundary of the PM-10 nonattainment area and therefore, will not be modeled for the Five Percent Plan.

During the period March 2005 through March 2006, the Higley monitor exceeded the 24-hour PM-10 standard only once, on January 24, 2006. Windy conditions on this day caused disturbed vacant lands in the vicinity of the monitor to emit PM-10. To ensure that this monitor does not violate the PM-10 standard in the future, it is proposed that the area surrounding the Higley monitor be modeled with rollback on January 24, 2006.

In summary, the proposed design days and models for the Five Percent Plan are:

- December 11-13, 2005 (low wind) - AERMOD
- January 24, 2006 (high wind) - Rollback

December 11-13, 2005 are low wind days with significant inversion conditions. December 12 had the highest 24-hour PM-10 average of 233 μ/m^3 at West 43rd Avenue and 207 μ/m^3 at Durango Complex. The Greenwood and West Phoenix monitors also recorded exceedances on this day of 173 and 155 μ/m^3, respectively.

On January 24, 2006, only the Higley monitor experienced an exceedance with a 24-hour concentration of 170 μ/m^3. Meteorological analysis indicates persistence of a few hours of high winds on this day.

2.6 Ambient Monitoring Data

Air quality monitoring networks operate in urban and rural areas throughout Arizona. ADEQ and MCAQD continually monitor and assess air quality in the metropolitan centers and in the remote areas of the state. There are total of 20 PM-10 monitoring stations; 15 are maintained by MCAQD and 5, by ADEQ. Table 2-3 lists and Figure 2-3 illustrates the locations of the PM-10 monitoring sites in Maricopa County. Maricopa County uses a combination of one-in-six day filter based monitors and continuous TEOMs, whereas ADEQ uses DICHOT sampling techniques. The Chandler, Central Phoenix, Glendale, South Phoenix, South Scottsdale, and West Phoenix stations are part of the National Air Monitoring Stations (NAMS) network and the remainder are part of the State and Local Air Monitoring Stations (SLAMS) network.

Air quality monitoring data provides multiple inputs to air quality models. First, the data indicate where there are exceedances of the standard. Second, the data provide background concentrations that are used in modeling future attainment. Third, the data allow the assessment of modeling performance in simulating base year PM-10 concentrations.

This protocol considers the monitoring data from March 2005 through March 2006, because this represents the period when exceedances occurred that will prevent the area from attaining the 24-hour PM-10 standard by December 31, 2006. Analysis of data from this period indicates that 30 exceedance days occurred in the nonattainment area. Twenty-four of these exceedance days occurred at the West 43rd Avenue and/or Durango Complex monitors.

Saturation monitoring to be performed as part of the MAG PM-10 Source Attribution and Deposition Study during the fall of 2006 will assist in quantifying the contribution of the urban transport component to PM-10 concentrations in the Salt River Study Area. Monitoring data from pristine locations such as Organ Pipe National Monument will be utilized to identify the rural background component of the PM-10 transported into the area.

The monitoring data indicate that the PM-10 in the nonattainment area is primarily coarse material emitted by primary sources. Co-located PM-10 and PM-2.5 monitors at Durango Complex indicate that PM-2.5 concentrations are typically 14 to 22 percent of the monitored PM-10 concentrations on low wind days that exceeded the 24-hour standard. On high wind exceedance days, the PM-2.5 concentrations ranged from 6 to 15 percent of the 24-hour PM-10 concentrations. The highest 24-hour average PM-2.5 concentration in 2006 of 38.5 $\mu g/m^3$ was observed at Durango Complex on a low wind day, February 9, 2006. This value is slightly higher that the new 24-hour PM-2.5 standard of 35 $\mu g/m^3$, but does not constitute a violation of the standard.[2] This monitoring data confirms that the high PM-10 concentrations in the nonattainment area are caused primarily by fugitive dust emissions from primary, not secondary, sources. Attachment I provides a more detailed analysis of ambient monitoring data for PM-10.

Table 2-3 PM-10 Monitoring Sites in Maricopa County

Site Name	Operator	Location
Buckeye*	MCAQD	Hwy 85 & MC 85
Chandler	MCAQD	1475 E. Pecos Road
Central Phoenix*	MCAQD	1845 E. Roosevelt Street
Durango Complex*	MCAQD	2702 AC Esterbrook
Dysart	MCAQD	Dysart Road & Bell Road
Glendale	MCAQD	6000 W. Olive Avenue
Greenwood	MCAQD	27th Avenue/I-10
Higley*	MCAQD	15500 S. Higley Road
Mesa	MCAQD	Broadway & Brooks
North Phoenix	MCAQD	601 E. Butler Road
South Phoenix	MCAQD	4732 S. Central Avenue
South Scottsdale	MCAQD	2857 N. Miller Road
West Chandler	MCAQD	163 S. Price Road
West 43rd Ave*	MCAQD	3940 W. Broadway Road
West Phoenix*	MCAQD	3847 W. Earll Drive
Bethune Elementary	ADEQ	1310 S. 15th Avenue
Goodyear /Estrella	ADEQ	15099 W. Casey Abbott Drive
JLG Super Site	ADEQ	4530 N. 17th Avenue
Palo Verde	ADEQ	36248 W. Elliot Road
Tempe	ADEQ	3340 S. Rural Road

*Continuous TEOM monitors in Maricopa County

[2] A violation of the standard occurs when the three year average of the 98th percentile value is greater than 35 μ/m^3.

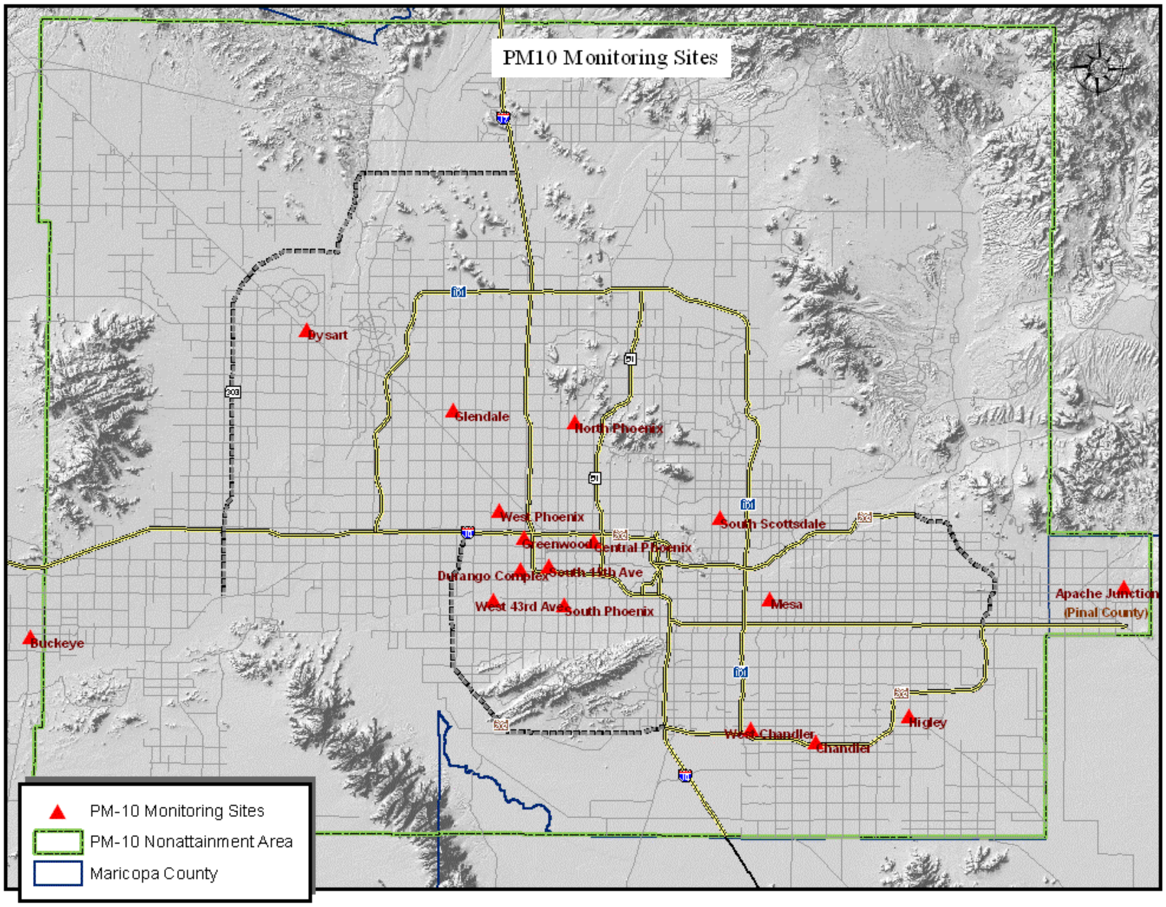

Figure 2-3 PM-10 Monitoring Sites In or Near the Maricopa County PM-10 Nonattainment Area

2.7 Design Value Determination

The design value is based on the highest short-term concentration over a multi-year period. Table 2-4 provides the design values for PM-10 monitors in Maricopa County, where the design value represents the highest PM-10 concentration over the period 2003 through 2005, excluding natural events. Monitors missing from the table did not have three years of valid data.

Design values will be recalculated for 2004-2006 when verified 2006 monitoring data are available. Refer to http://www.maricopa.gov/aq/status/REVIEW05.pdf for the latest information on PM-10 monitoring conducted by Maricopa County.

Table 2-4 Design Values for Maricopa County PM-10 Monitors (in $\mu g/m^3$)

Site Name	Design Value	2003	2004	2005
Chandler	240	240	150	130
West Chandler	206	206.1	70	94
Glendale	150.5	150.5	69.1	84.4
Higley	224.9	224.9	~492.6	142
Mesa	176.4	176.4	49	85.5
Durango Complex	206.9	195.2	~208.7	206.9
South Phoenix	164.3	164.3	132.3	147.3
West 43rd Ave	233.1	156.7	~251	233.1
West Phoenix	157.5	157.5	100.1	155
Central Phoenix	124.9	113.9	55.5	124.9
North Phoenix	155	155	46.3	80.8
Greenwood	172.7	166.1	100.1	172.7
South Scottsdale	172.4	172.4	77	120.7

~ Indicates Natural or Exceptional Events

It is interesting to note, with the exception of the Durango Complex, West 43rd Avenue, and Greenwood monitors, the design values are based on the highest 24-hour concentration recorded in 2003. This suggests that the general trend in PM-10 emissions may be decreasing except at the monitoring sites in the Salt River Area.

3. AERMOD Performance Evaluation

EPA has instituted formal evaluation criteria for Gaussian dispersion models such as AERMOD[1,11]. The guidelines for air quality models suggest a three-step evaluation procedure. First, the procedure should show how the modeling is used. Second, it should guide the use of statistical performance measures, including measures of difference such as bias, variance and gross variability of the difference, and correlation measures such as time, space, and time and space combined. Third, more information should be provided for justifying the site-specific use of alternate models. In addition, sensitivity analysis is encouraged since these analyses provide information on the effect of inaccuracies in the databases and the uncertainties in model estimates.

Model performance data will be provided for all of the AERMOD-modeled monitors for all design days. The rule of thumb in the modeling community is that any AERMOD prediction within a factor of two of the measurements is acceptable. Simulated and observed 24-hour average PM-10 concentrations at each monitoring station for the two design days will be plotted with wind speed and direction.

Scatter plots of predicted versus observed PM-10 concentrations will be provided in order to determine the accuracy of model estimation. The scatter of the points, diverging in many cases far from the 1:1 line, indicates that the model is not simulating the measurements accurately. Each point represents a paired model prediction (model concentration plus background) and measurement, averaged for one hour. Regression statistics will be performed to determine the regression coefficient, slope and intercept. Hourly time series plots will be developed for each design day for each site, comparing predicted (background and model concentration) with observed concentrations. This is a viable measure since the available monitoring data is continuous. This will be very useful in determining how accurate the model is predicting by hour. Another way to present these data is to plot the measurements from their highest to lowest value as a single line, and to plot the paired model prediction as a separate line.

4. Attainment Demonstration

4.1 Identification of Attainment Year

Because of numerous exceedances of the standard in 2006, the earliest date that attainment can be achieved at PM-10 monitors in the Maricopa County nonattainment area is December 31, 2009. The primary purpose of air quality modeling with AERMOD and rollback is to show that attainment of the 24-hour PM-10 standard will be achieved by this date in the modeling domains. Attainment will be modeled based on emission reductions attributable to commitments contained in the Five Percent Plan. These commitments may represent new control measures or a strengthening of existing measures in the Serious Area PM-10 Plan[9].

4.2 Identification of Control Measures

The committed measures already implemented in the Serious Area PM-10 Plan[9] will be assumed in the 2009 base case modeling inventory. These committed measures will also be in the 2007, 2008, and 2009 base case emissions inventories to be used in meeting the five percent per year requirement. Additional measures that are needed to model attainment and achieve five percent per year reductions in emissions will be submitted to the MAG Air Quality Technical Advisory Committee for consideration as part of the Suggested List of Measures. Following Regional Council approval of the Suggested List of Measures, the local jurisdictions and the Legislature will be requested to consider the implementation of the measures under their respective authorities. Each jurisdiction determines which measures are feasible for implementation by that jurisdiction. These measures then become committed measures in the Five Percent Plan.

Emissions reductions attributable to the commitments received from implementing entities will be estimated based on the latest available information from EPA and other sources (e.g., the WRAP Fugitive Dust Handbook). These reductions will be incorporated into the 2009 modeling for the selected design days. Based upon model output, it will be determined if the control measures demonstrate attainment of the 24-hour PM-10 standard. The committed measures will also be applied to the 2008 and 2009 base case emissions inventories for the PM-10 nonattainment area to show five percent per year reductions, relative to 2007 base case emissions. If additional control measures are needed to satisfy the modeling or five percent per year requirement, the process described above will be repeated.

4.3 Modeling Attainment Test

To demonstrate attainment of the 24-hour PM-10 standard in 2009, the concentrations estimated by AERMOD and rollback should not exceed 154 ug/m^3 at any monitor in the modeling domain on the selected design days. If the application of the AERMOD model for the 2005 base case results in modeled values that differ significantly from monitored concentrations, AERMOD results will be applied in a relative manner. That is, the percent change from model is applied to monitored value net of background, and then background is added back in. The background concentrations would be subtracted from the monitored value before the change is applied and would be added back in after the change is applied. The result would be compared with the 24-hour standard on the design days to determine if attainment is achieved. This is a variant of the rollback model, in which emissions and concentrations are assumed to be proportional. A similar approach was applied in the ADEQ Salt River Area Study, where modeled results using AERMOD were significantly below the monitored values.

4.4 Modeling Reliability and Uncertainties

AERMOD and rollback are considered to be appropriate tools for projecting the future air quality impact of changes in emissions. However, future year modeling results should not be considered absolute guarantees of future air quality. Uncertainties in the models used and their inputs, along with meteorological variability, may result in actual future air quality that differs from predicted air quality. Higher concentrations than those modeled may occur for any of the following reasons:

Meteorological variability - In selecting design days, the goal is to select periods that represent worst-case conditions. If episodes with more severe stagnation occur in the future, emission controls designed to reach attainment for a historical episode may not be adequate.

Emissions variability - Emission estimates are based on average source usage, taking into account seasonal, diurnal, and day-of-week factors. Nonroad and onroad mobile emissions estimates take into account day-specific temperatures as well. However, emissions on a given day may be greater than average due to greater than average usage, lower temperatures, or other factors. Uncertainty in growth projections - If growth projections underestimate true growth rates, future year emissions may be greater than projected emissions. Uncertainty in control measure effectiveness - If actual emission reductions from a given control measure are smaller than the estimated emission reductions, future concentration will be greater than modeled concentrations.

Model performance - If the model under-predicted concentrations at a particular site, or has failed to capture a particular aspect of the meteorology, then a level of emission reduction that appeared to be adequate during modeling may not actually be adequate. By similar reasoning, future measured concentrations may be lower than modeled concentrations because of these variabilities and uncertainties. In addition, future measured concentrations will still be limited to monitoring site locations. As a result, although modeled future design values below 155 μ/m^3 are adequate to demonstrate attainment, modeling results are better thought of as points on a probability distribution. If the modeled peak is very close to 155 μ/m^3, however, the probability that attainment will result may be well below 100 percent given the probabilistic nature of meteorology and modeling.

References

[1] Revisions to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, U.S. Environmental Protection Agency, Federal Register, Vol. 70, No. 216, p. 68218, November 9, 2005. (Attachment IV)

[2] Revised PM-10 State Implementation Plan for the Salt River Area, Technical Support Document, Air Quality Division, Arizona Department of Environmental Quality, June 2005.

[3] 2002 Periodic Emissions Inventory for PM-10 for the Maricopa County, Arizona, Nonattainment Area, Maricopa County Air Quality Department, June 2004 (Revised March 2006).

[4] Field Testing and Evaluation of Dust Deposition and Removal Mechanisms: Final Report, DRI, Las Vegas, Nevada, January 2003.

[5] User's Guide for AMS/EPS Regulatory Model – AERMOD EPA-454/B-03-001, September 2004.

[6] PM-10 State Implementation Plan for Clark County, June 2001.

[7] Air Dispersion Modeling Workshop, Course Notes, Lakes Environmental, February 2006.

[8] User's Guide for AERMET, EPA-454/B-03-002, November 2004.

[9] Revised MAG 1999 Serious Area Particulate Plan for PM-10 for the Maricopa County Nonattainment Area, Maricopa Association of Governments, February 2000.

[10] Procedures for Preparing Emissions Projections, EPA-450/4-91-019, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, July 1991.

[11] Modeling Fugitive Dust Impacts from Surface Coal Mining Operations – Phase II, Model Evaluation Protocol, U.S. EPA, October 1994.

[12] One-hour Ozone Redesignation Request and Maintenance Plan for the Maricopa County Nonattainment Area, Appendix III-ii, Volume 2, Maricopa Association of Governments, March 2004.

ATTACHMENT I

DESIGN DAY SELECTION

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1. Episode Selection Methodology

The following steps were implemented in selecting the 24-hour average PM-10 design days for the AERMOD and rollback models.

- Analyze the distribution of 24-hour PM-10 annually, seasonally, daily and hourly
- Tabulate all days from March 2005 – March 2006 for all PM-10 monitors in the nonattainment area having 24-hour PM-10 concentration of 155 μ/m^3 or higher
- Identify the days and monitoring stations with the highest and second highest 24-hour PM-10 concentrations
- Quantify the total number of exceedance days for each monitoring station
- Analyze the sensitivity of PM-10 concentrations to different meteorological parameters – wind speed, pressure and inversion
    - Classify the exceedance days as low and high wind days
- Identify the major PM-10 emissions sources contributing to the above exceedance days

A 36-hour backward trajectory analysis was also performed to confirm that the major PM-10 sources are of predominantly local origin.

1.1 Results of 24-hour PM-10 Analysis

PM-10 data from March 2005 to March 2006 has been analyzed. The analysis is described in the following sections. All the above-mentioned steps were followed to determine the appropriate design days for air quality modeling.

There are 20 PM-10 monitoring stations located in Maricopa County. Of these, fifteen are maintained by MCAQD and five, by ADEQ. Currently, there are seven continuous monitoring stations located in the PM-10 nonattainment area. These are Buckeye, Central Phoenix, Durango, Greenwood, Higley, West 43rd Avenue, and West Phoenix. All of these monitors have continuous data for the analysis period March 2005 through March 2006, except the West Phoenix and Greenwood stations, where continuous monitoring began on September 1, 2005 and January 1, 2006, respectively. A detailed analysis of data from these seven monitoring stations has been conducted and the results are presented below. These are the only monitoring sites where exceedances occurred between January 1, 2004 and March 31, 2006.

1.1.1 Temporal Patterns

1.1.1.1 Annual Distribution of PM-10

Figure 1 shows the annual distribution of 24-hour PM-10 exceedances from 2000 to 2006. The year 2006 includes data for the months of January, February and

March only. The year 2005 had the highest number of exceedances, followed by 2006 (through March).

1.1.1.2 Seasonal Distribution of PM-10

Figure 2 shows the seasonal distribution of the 24-hour PM-10 exceedances for the period March 2005 through March 2006. The exceedance days occurred predominantly during the fall and winter months of November through February, with the highest number occurring in December.

1.1.1.3 Daily Distribution of PM-10

Figure 3 shows the daily distribution of the PM-10 exceedances during the period March 2005 through March 2006. The exceedances occurred most frequently on Thursday (9 days). None of the exceedances occurred on a weekend.

1.1.1.4 Diurnal Pattern

Figure 4 shows the hourly distribution of PM-10 concentrations on days that exceeded the 24-hour standard from March 2005 through March 2006. The figure shows the diurnal pattern of PM-10 concentrations, with the peak occurring from 6 to 10 a.m. with a second peak occurring from 6 to 10 p.m. The increased PM-10 seems to be correlated with high morning and evening vehicle traffic, assisted by low wind speeds and a temperature inversion.

1.1.1.5 Highest PM-10 Values

Table 1 gives the highest and second highest 24-hour PM-10 values for the selected period, along with latitude and longitude information, and the total number of exceedances for each monitor. The highest 24-hour PM-10 concentration during the period March 2005 through March 2006 occurred at the Buckeye station on February 14, 2006. This reading of 272.9 ug/m^3 was caused by local agricultural activity. The second highest concentration of 260.0 ug/m^3 was observed at the West 43rd Avenue monitor on March 10, 2006, a day with elevated wind speeds. The second highest concentration at the West 43rd Avenue monitor of 233.1 ug/m^3 occurred on December 12, 2005 during stagnant conditions. The largest number of exceedances during this period was observed at West 43rd (22 days) and Durango Complex (20 days).

Table 2 presents a tabulation of the number of total exceedance days greater than or equal to155 ug/m3 at each monitoring site for the year 2000 through March of 2006. It is important to note that the exceedances prior to 2005 were recorded at monitors that were sampled once every six days. Therefore, each of these exceedances actually represents an expected daily exceedance rate that is six times the value shown. This means that the total exceedance days including expected exceedances are much higher than shown in Table 2. All monitors that exceeded the standard in 2005 were converted to a daily sampling schedule in 2005.

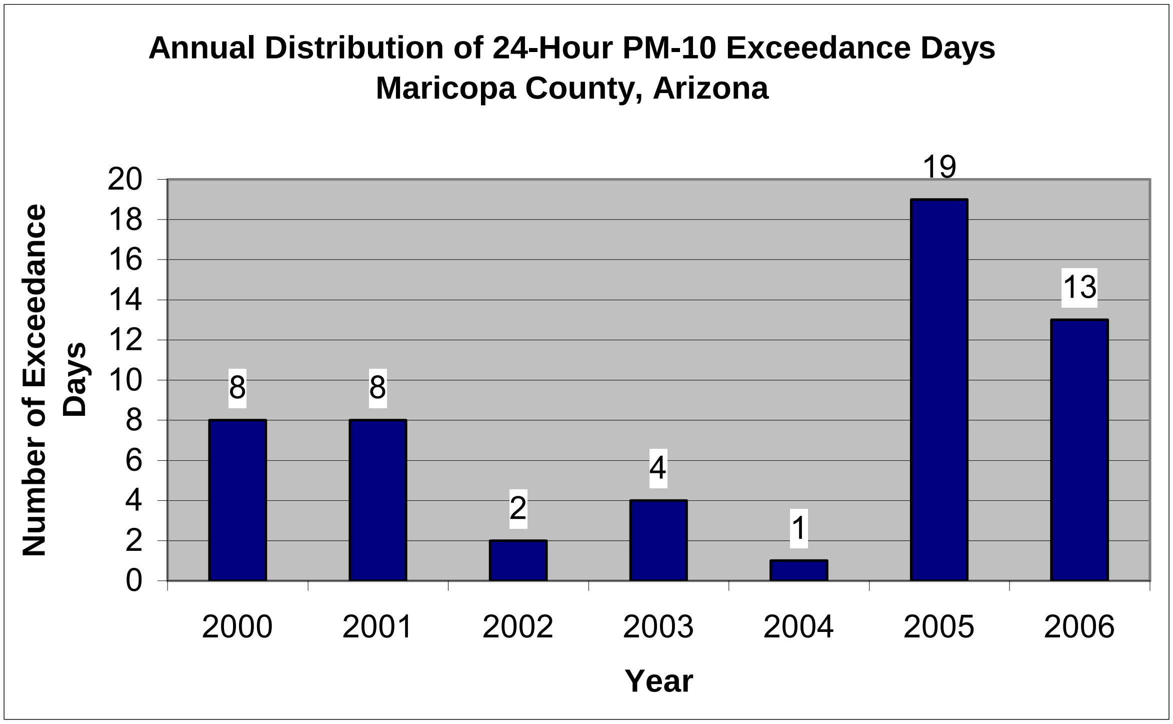

Figure 1. Annual Distribution of 24-hour PM-10 Exceedance Days (≥155 $\mu g/m^3$)

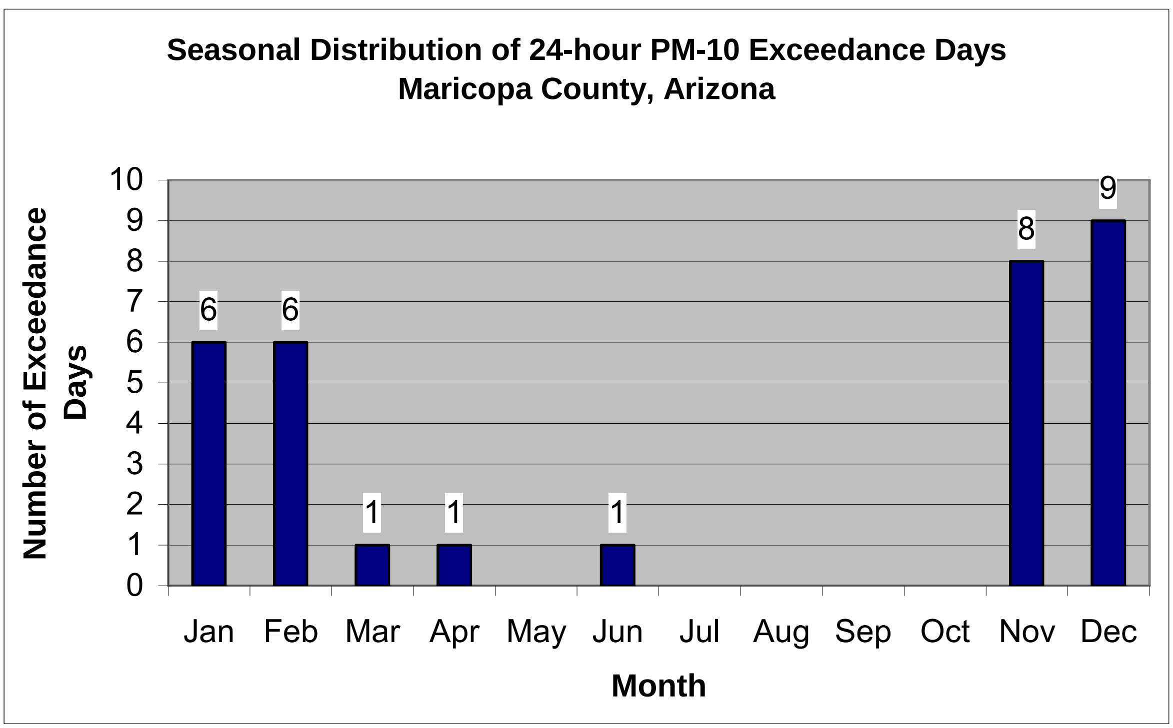

Figure 2. Seasonal Distribution of 24-hour PM-10 Exceedance Days (≥155 $\mu g/m^3$) from March 2005 – March 2006

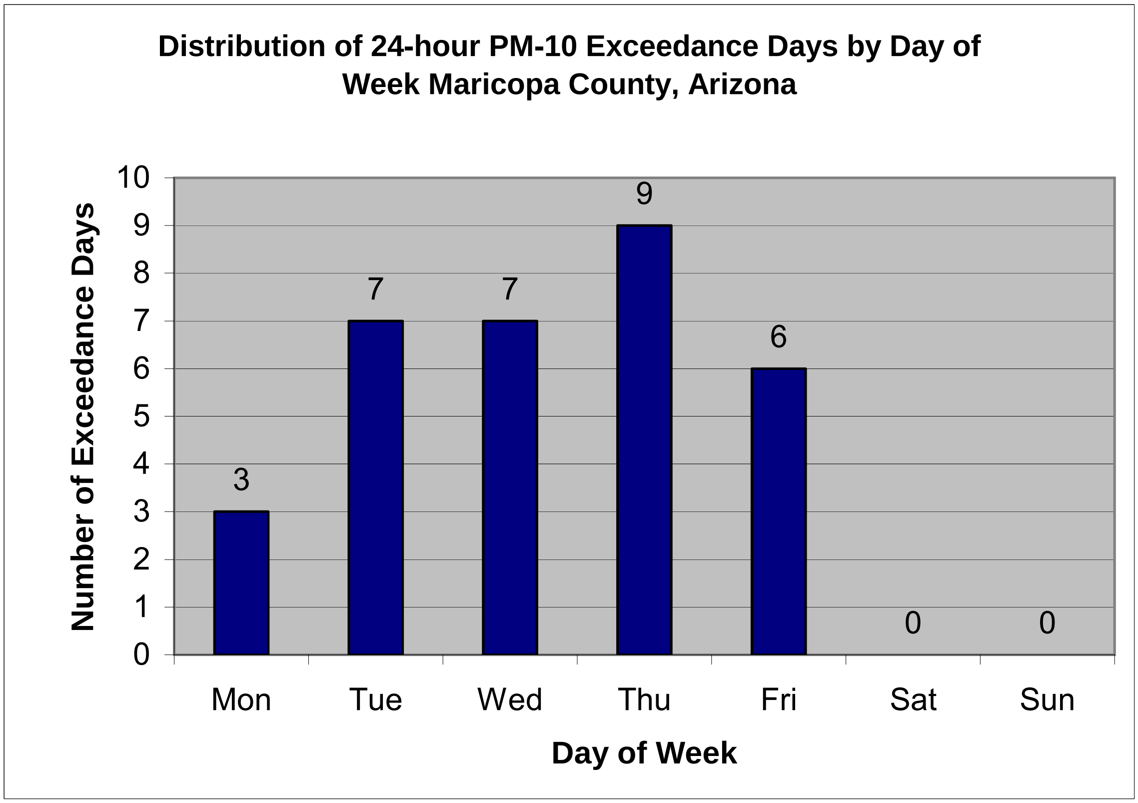

Figure 3. Daily Distribution of 24-hour PM-10 Exceedances (≥155 $\mu g/m^3$) from March 2005 – March 2006

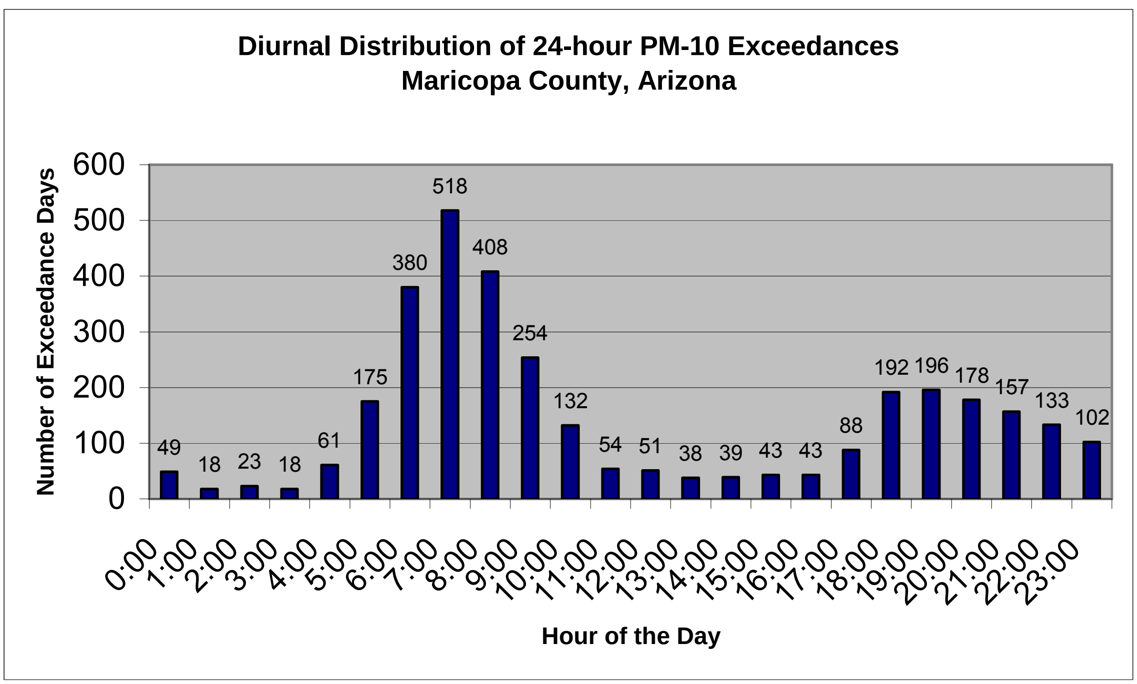

Figure 4. Diurnal Distribution of 24-hour PM-10 Exceedances (≥155 $\mu g/m^3$) from March 2005 – March 2006

Table 1. Highest and Second Highest PM-10 Values, March 2005 – March 2006

Site	Lat	Long	1st Highest $\mu g/m^3$	2nd Highest $\mu g/m^3$	Number of Exceedances
			272.9	191.9	
Buckeye	33.3698	-112.62014	(02/14/2006)	(02/17/2006)	5
			116.6	104.3	
Central Phoenix	33.45793	-112.04601	(12/12/2005)	(12/13/2005)	0
			240.0	206.9	
Durango Complex	33.42631	-112.11762	(03/10/2006)	(12/12/2005)	20
			173.0	166.0	
Greenwood	33.46076	-112.11746	(12/12/2005)	(03/10/2006)	2
			170.5	150.6	
Higley	33.31067	-111.72199	(1/24/2006)	(02/9/2006)	1
			260.0	233.1	
West 43rd	33.40627	-112.14394	(03/10/2006)	(12/12/2005)	22
			155.0	125.8	
West Phoenix	33.4837	-112.14207	(12/12/2005)	(12/21/2005)	1

Table 2. Number of Days ≥ 155 μg/m^3 by Monitoring Site, 2000 – March 2006

24-hour average greater than or equal to 155 □g/m^3								
City Location	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006***	**Total Days**
#Buckeye	-	-	-	-		2	3	5
Chandler	1	0	0	1	0	0	0	2
W. Chandler	0	0	0	2	0	0	0	2
#Dysart	-	-	-	0	0	0	0	0
Glendale	0	0	0	0	0	0	0	0
Goodyear/Estrella	0	0	0	0	0	0	0	0
Higley	1	1	0	1	1	0	1	5
#Maryvale	1	0	0	0	0	Shutdown	-	1
Mesa	0	0	0	1	0	0	0	1
Palo Verde	0	0	0	1	0	0	0	1
Durango Complex	2	1	2	1	0	13	7	**26**
South Phoenix	1	0	0	1	0	0	0	2
W. 43rd Ave.		Not operating	1	2	0	13	9	**25**
West Phoenix	0	0	0	1	0	1	0	2
#Salt River	6	6	2	Shutdown	-	-	-	14
Central Phoenix	0	0	0	0	0	0	0	0
North Phoenix	0	0	0	1	0	0	0	1
JLG Site	0	0	0	1	0	0	0	1
Greenwood	2	0	0	1	0	1	1	5
South Scottsdale	0	0	0	1	0	0	0	1
Tempe	0	0	0	0	1	0	0	1
#Surprise	0	0	0	Shutdown	-	-	-	0
Bethune Elementary	-	-	-	-	0	0		0

*Notes: 2006 data is through March 2006 only and has not been validated by MCAQD. Some of the days in 2006 may be flagged as natural events.

Maryvale (Closed 04/01/2004), Salt River (Closed in 2002), Surprise (Closed 7/15/03), Bethune Elementary School (Opened 10/19/2004), Buckeye (Opened 8/01/2004), and Dysart (Opened 7/16/03)

1.1.2 Meteorological Dependence of High PM-10 Concentrations

Meteorological data were used to assess the potential of air pollution to accumulate in certain locations. Several weather factors are involved in high PM-10 concentrations; these are existence of an inversion, wind speed, wind direction, temperature, and precipitation.

1.1.2.1 Inversion Layers

Inversion is a meteorological phenomenon where air temperature increases with distance above the earth's surface. Inversion occurs in a stable atmosphere in which upper warm air traps a layer of cooler air near the ground. The vertical movement of the air is hindered, resulting in higher pollutant concentrations. The strength, duration, and altitude of the inversion determine the amount of vertical mixing that can occur. The vertical mixing area is also referred to as mixing height or mixing depth. Inversion is very common during the winter months and two types of inversions can occur, radiation or subsidence.

In a radiation inversion, also called a nocturnal inversion, the increase in temperature with height is caused by radiational cooling of the earth's surface. Radiation cooling is the process by which the earth's surface and adjacent air are cooled by the release of infrared radiation from the ground. During a radiation inversion, little or no dispersion of air occurs near the surface. The dissipation of the inversion occurs by the re-heating of the surface by solar radiation.

A subsidence inversion is a temperature inversion that develops aloft as a result of air gradually sinking over a wide area and being warmed by adiabatic compression. This is usually associated with subtropical high-pressure areas.

Delta temperature is commonly used to measure the occurrence of a temperature inversion layer. Delta temperature is a measurement of the change in temperature between two points. Measurement instruments are located on a tower with thermometers at heights of two and six meters. The delta temperature (DELT) represents the difference between the temperatures measured at the higher and lower instruments. A negative reading means normal conditions, with warmer air at 2M and cooler air at 6M. The greater the negative DELT, the more that the air will mix and move (since warm air rises), thus reducing air pollution concentrations near the ground. When DELT is positive, there is a warm air blanket resting on top of the cool air mass below. This is characteristic of a temperature inversion that traps air pollutants close to the ground.

Tables 7, 8, and 9 provide the hourly DELT values at monitoring stations in the Maricopa County nonattainment area. Only the Higley, North Phoenix, Tempe, West 43rd Avenue, and West Phoenix monitors measure DELT. Since Durango is located within two miles of West 43rd Avenue, DELT values are assumed to be the same for both monitors. Figures 5 to 11 show the variation in PM-10 concentrations with DELT.

1.1.2.2 Wind Speed and Direction

Wind speed and direction play an important role in determining the dispersion and transport of pollutants. High wind speeds in the mixing zone cause high vertical mixing and horizontal transport of the pollutants. In the Maricopa County nonattainment area, the summer months are usually associated with high winds (average hourly wind speeds greater than 15 mph) due to cold dry fronts over Arizona. In contrast, the winter months are usually associated with light, variable winds, less than10 mph. At night, winter winds generally originate from the south-southeasterly end of the air basin and flow in a north-northwesterly direction. Low wind speeds combined with inversion conditions common during the winter months can result in high PM-10 concentrations. Appendix A1-A provides wind rose information for the selected design and episode days. Figures 5 to 11 show the relationship between PM-10 concentrations and inversion conditions.

1.1.2.3 Temperature

The Maricopa County nonattainment area is characterized by hot dry summers and mild winters. The average temperatures at Sky Harbor Airport, based on National Weather Service data for 1971-2000, are 57°F in the winter (December–February) and 91°F in the summer (June-August). With the exception of the months of March and August, the monthly temperatures during the period March 2005 through March 2006 were higher than normal. During the months when the most exceedances of the 24-hour PM-10 standard occurred (November 2005 through March 2006), the monthly temperatures ranged from 1.5 to 3.6 degrees warmer than average.

1.1.2.4 Precipitation

Sky Harbor Airport, which is located in the PM-10 nonattainment area, receives an average of 8.3 inches of rain per year. The months of April, May, and June typically receive little or no precipitation. Other months average between three-quarters and one inch of rain. In 2005, the nonattainment area experienced the longest drought in 70 years, beginning October 18, 2005, and lasting 143 days. Lack of precipitation renders particles more likely to become airborne when disturbed by human activity.

1.1.3 Design Day Selection Approach

The selection of the design days followed the steps identified in Section 1.1. All days with concentrations greater than or equal to 155 μ/m^3 during the period March 2005 through March 2006 were taken into consideration and each of these days was assigned to one of the following regimes. Appendix A1-B provides the monitoring data for all of the PM-10 exceedance days.

1.1.3.1 Regime 1

Regime 1 represents low wind days. There are 44 monitored exceedances in this regime. Table 3 ranks the PM-10 exceedances that occurred on low wind days according to the highest to lowest observed PM-10 concentration. All of the days in this regime occurred during the months of November 2005 through February 2006. Meteorologically, these days had mean wind speeds of about 3 mph and some had delta temperatures with high positive values, indicating the presence of a significant inversion. Relative humidity was observed to be higher than normal on these days, indicating elevated PM-10 potential.

The exceedance at the Buckeye monitor of 273 μ/m^3 on February 14, 2006 is the highest monitored value in this regime. However, since the Buckeye monitor is located outside of the PM-10 nonattainment area and the Five Percent Plan addresses the nonattainment area only, this site has been excluded as a candidate for modeling. On December 12, 2005, the West 43rd Avenue monitor experienced its highest PM-10 concentration of 233 μ/m^3, followed by a Durango Complex value with 207 μ/m^3 on the same day. The Greenwood and West Phoenix monitors also had PM-10 concentrations that exceeded the 24-hour standard on this day. The West 43rd Avenue and Durango monitors also exceeded the standard on the following day, December 13. December 12 and 13 have been selected as design days representative of this regime; the monitoring locations and dates to be modeled with AERMOD are shaded in Table 3.

1.1.3.2 Regime 2

Regime 2 is representative of high wind days. A high wind day is defined as having average wind speeds greater than 15 mph for at least two consecutive hours. Table 4 ranks the PM-10 exceedances that occurred on high wind days according to the highest to lowest observed PM-10 concentration. There are six monitored exceedances in this regime. West 43rd had the highest concentration of 260 μ/m^3 on March 10, 2006, followed by Durango, with a concentration of 240 μ/m^3 on the same day. Greenwood also exceeded the standard (166 μ/m^3) on March 10, 2006. ADEQ has determined that the exceedances on March 10 were due to a regional weather event and has asked EPA to flag the data as a natural event. As a result, this date is not considered to be an appropriate candidate for modeling in the Five Percent Plan. In addition to the low wind day cited above, the Buckeye monitor also exceeded the standard on one high wind day, November 18, 2005. As indicated above, the Buckeye monitor is outside the nonattainment area and is also excluded from consideration for modeling. The remaining high wind exceedance days are at the West 43rd Avenue monitor on February 15, 2006 and the Higley monitor on January 24, 2006. Since the West 43rd Avenue monitor is already being addressed in Regime 1, the exceedance at the Higley monitor has been selected to represent the design day for Regime 2. The day to be modeled with rollback, January 24, 2006, is shaded in Table 4.

Table 3. Ranking of the High PM-10 days (≥155 μ/m³) for Low Wind Days

	Regime 1		
Rank	**Station Name**	**Date**	**24-hour PM-10(/m³)**
1	Buckeye	2/14/06	273
2	**West 43rd**	**12/12/05**	**233**
3	**Durango Complex**	**12/12/05**	**207**
4	West 43rd	2/9/06	205
5	West 43rd	2/9/06	205
6	West 43rd	12/21/05	201
7	Durango Complex	12/21/05	200
8	West 43rd	12/2/05	195
9	Buckeye	2/17/06	192
10	West 43rd	1/10/06	191
11	Durango Complex	11/22/05	190
12	West 43rd	1/19/06	184
13	West 43rd	2/8/06	184
14	Durango Complex	1/19/06	184
15	Durango Complex	12/14/05	181
16	Durango Complex	12/22/05	179
17	West 43rd	12/14/05	177
18	West 43rd	11/23/05	176
19	West 43rd	11/2/05	174
20	West 43rd	11/22/05	173
21	**Greenwood**	**12/12/05**	**173**
22	Durango Complex	1/12/06	170
23	West 43rd	1/12/06	170
24	Durango Complex	1/11/06	169
25	West 43rd	12/22/05	168
26	**West 43rd**	**12/13/05**	**167**
27	West 43rd	11/1/05	166
28	West 43rd	11/10/05	166
29	**Durango Complex**	**12/13/05**	**166**
30	West 43rd	1/11/06	166
31	Durango Complex	12/2/05	165
32	Durango Complex	11/23/05	165
33	Durango Complex	11/3/05	164
34	West 43rd	11/3/05	161
35	Buckeye	2/13/06	160
36	Durango Complex	12/1/05	159
37	Durango Complex	12/23/05	158
38	Durango Complex	2/15/06	158
39	West 43rd	1/13/06	157
40	West 43rd	12/23/05	157
41	Durango Complex	12/15/05	156
42	Durango Complex	11/17/05	156
43	Durango Complex	1/10/06	156
44	**West Phoenix**	**12/12/05**	**155**

Table 4. Ranking of the High PM-10 days ($\geq$155 μ/m^3) for High Wind Days

	Regime 2		
Rank	Station Name	Date	24-hour PM-10 (ug/m3)
1	West 43rd	3/10/06	260
2	Durango	3/10/06	240
3	West 43rd	2/15/06	202
4	Buckeye	11/18/05	170
5	Greenwood	3/10/06	166
6	**Higley**	**1/24/2006**	**160**

1.1.4 Recommendations

The two regimes above were considered in the selection of design days for modeling in the Five Percent Plan. Based on the selection methodology, it is proposed that December 11-13, 2005 (low wind) and January 24, 2006 (high wind), be selected as design days. AERMOD will be applied to model the December episode and rollback, January 24, 2006 for the Higley monitor. A wind rose analysis for the monitoring stations that exceeded the 24-hour PM-10 standard on the design days selected for modeling are provided in Appendix A1-A.

1.1.4.1 Characteristics of Selected Design Days

Design days have been selected from the period March 2005 – March 2006 for AERMOD and rollback modeling. The characteristics of two of these days are outlined below. The inversion strength and wind factor are the key parameters in predicting elevated PM-10 concentrations and these can be quantified using the radiosonde and wind rose data shown in Table 5.

The data in Table 5 was extracted from the Department of Atmospheric Science, University of Wyoming, weather database for seven candidate episode periods (http://weather.uwyo.edu/upperair/sounding.html). The radiosonde data is for Tucson and is the closest source available. The Tucson radiosonde provides data on the vertical structure of the atmosphere. The balloons are launched in Tucson twice daily, in the early morning (00Z = 5 a.m. local time) and the evening (12Z = 5 p.m. local time). The highest values are identified in Table 5 in bold text.

12/12/05 (Regime 1)

(1) West 43rd Avenue and Durango Complex both had the highest 24-hour PM-10 averages of 233.1 μ/m^3 and 206.9 μ/m^3, respectively. The Greenwood monitor also exceeded the standard at 155.0 μ/m^3. Other monitoring stations recorded values close to the standard: Higley – 142.7 μ/m^3 and West Phoenix - 141.7 μ/m^3.
(2) Analysis of the variation in hourly PM-10 concentrations with respect to wind speed and delta temperature has shown that high PM-10 concentrations are associated with low wind speed and high delta temperatures (e.g., significant inversions).
(3) Observation of peak PM-10 concentrations around 8 a.m. in the morning and 6 p.m. in the evening suggests the dominance of local PM-10 sources, especially from onroad sources.
(4) Figures 5 and 6 show the influence of meteorological parameters on the hourly PM-10 concentrations at the West 43rd and Durango monitors, respectively, on December 12, 2005.

01/24/06 (Regime 2)

(1) Only Higley had an exceedance on this day.
(2) The average wind speed in the vicinity of the monitor was 7.5 mph, with several hours of higher winds (greater than 15 mph)
(3) Figure 7 shows the influence of meteorological parameters on the hourly PM-10 concentrations at the Higley monitor on January 24, 2006.

Table 5. Meteorological Parameters Obtained from Soundings Data at Tucson for Design Days

		Inversion Depth		Relative Humidity		Wind		Temp	
Date	Avg Depth	12Z Depth	00Z Depth	12Z	00Z	12Z	00Z	12Z	00Z
	m	m	m	%	%	knots	knots	°C	°C
12-Dec-05	259.2	272.4	246	21	14	3	3	12.2	19.4
24-Jan-06	274	273	274	26	11	8	15	12.8	20.6
Interpretation		Low Depth implies elevated PM-10 Potential		High RH implies elevated PM-10 potential		Low winds implies elevated PM-10		Low Temp. implies elevated PM-10	

Table 6. Dependence of PM-10 Concentrations on Meteorological Parameters: Data Obtained from ADEQ

Date	Day	PM-10 AQI	Dispersion	Mixing Ht ft	Inversion Ht	Inversion C	TWS (deg & kts)
1-Nov-05	Tue	106	Very good	6200	1250	2.6	11013
2-Nov-05	Wed	104	Good	6300	2041	5.4	16308
3-Nov-05	Thu	105	Marginal	2554	1552	6.9	22008
10-Nov-05	Thu	106	Marginal	2600	2641	5.8	11407
18-Nov-05	Fri	108	Good	6300	m	m	4010
22-Nov-05	Tue	118	Marginal	3400	1690	6.3	Variable 4
23-Nov-05	Wed	111	Poor	1982	1841	5.7	Variable 2
1-Dec-05	Thu	102	Marginal	3500	3999	6.4	12605
2-Dec-05	Fri	121	Marginal	3200	2126	5.2	12806
12-Dec-05	**Mon**	**140**	**Poor**	**2200**	**1174**	**3.1**	**Variable 3**
13-Dec-05	Tue	107	Fair	4500	1520	5.4	28105
14-Dec-05	Wed	114	Low fair	4900	1339	5.5	1105
15-Dec-05	Thu	101	Low good	4900	1719	3.2	7909
21-Dec-05	Wed	123	Marginal	2600	869	9.1	8906
22-Dec-05	Thu	113	Low fair	2300	1168	8.6	11310
23-Dec-05	Fri	102	Marginal	3400	2100	6.6	25404
10-Jan-06	Tue	118	Marginal	3200	1880	4	6304
11-Jan-06	Wed	108	Marginal	2800	2828	6.8	7307
12-Jan-06	Thu	108	Marginal	3900	1949	7.9	23103
13-Jan-06	Fri	102	Good*	5200	1679	9	6110
19-Jan-06	Thu	115	Good	4500	1597	4.1	24012
24-Jan-06	**Tue**	**109**	**High good**	**4000**	**0**	**0**	**9416**
8-Feb-06	Wed	115	Very good	4100	1509	6.9	6920
9-Feb-06	Thu	125	Marginal	1500	1592	4.5	6511
13-Feb-06	Mon	103	Marginal	4200	1880	3.5	24604
14-Feb-06	Tue	159	Good	4200	1712	6.1	15213
15-Feb-06	Wed	124	Good	5800	1499	5.5	22711
17-Feb-06	Fri	119	Fair	4000	0	0	20806

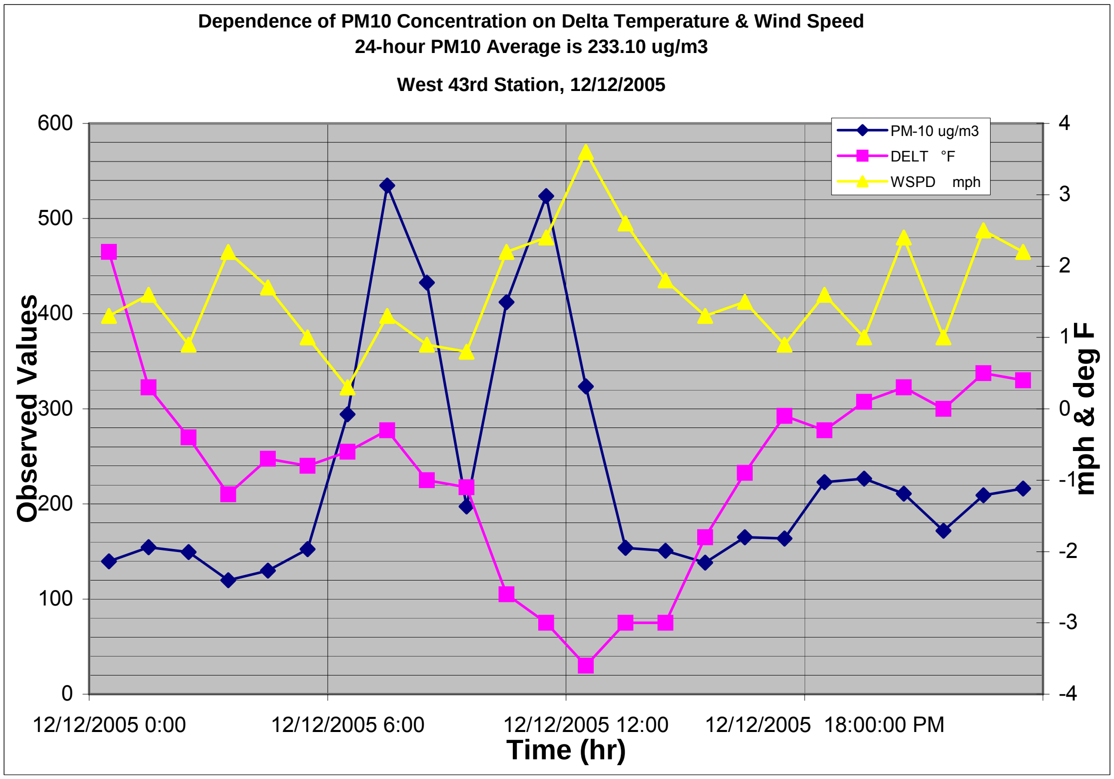

Figure 5. Hourly Observed PM-10 Concentration ($\mu g/m^3$) with Delta Temperature (°F) & Wind Speed (mph) for West 43rd Station on 12/12/2005[1]

[1]Delta Temperature Data was not measured.

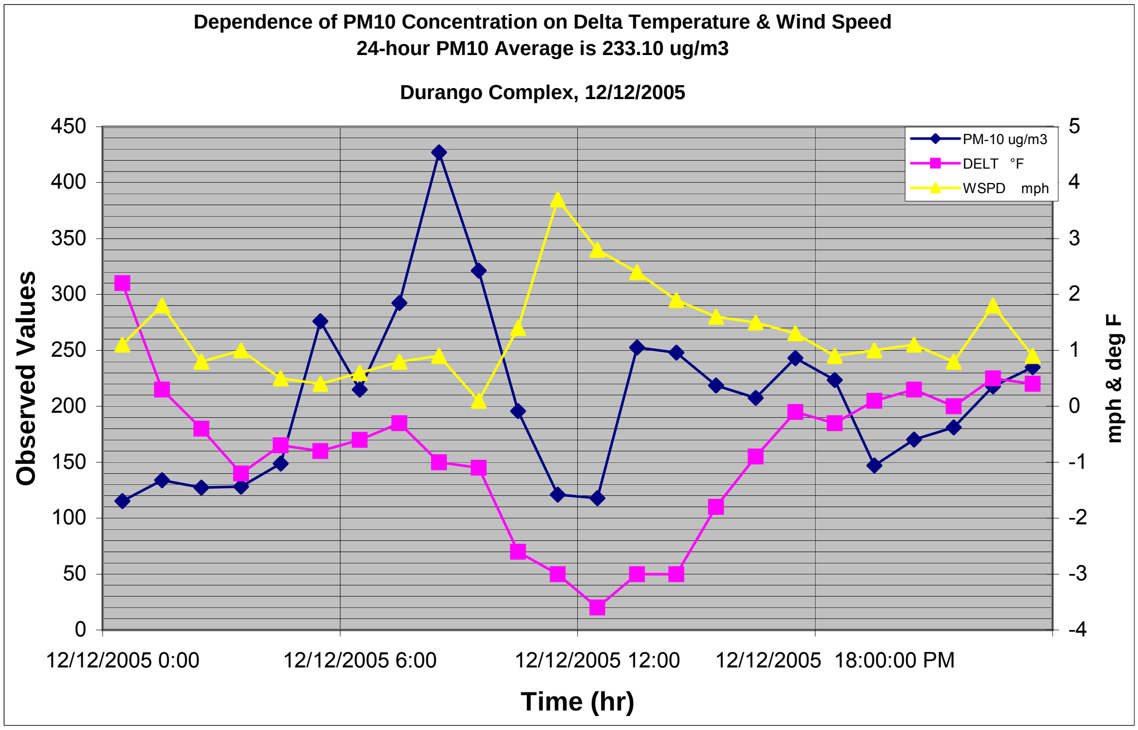

Figure 6. Hourly Observed PM-10 Concentration (μg/m^3) with Delta Temperature (°F) & Wind Speed (mph) for Durango Complex Station on 12/12/2005

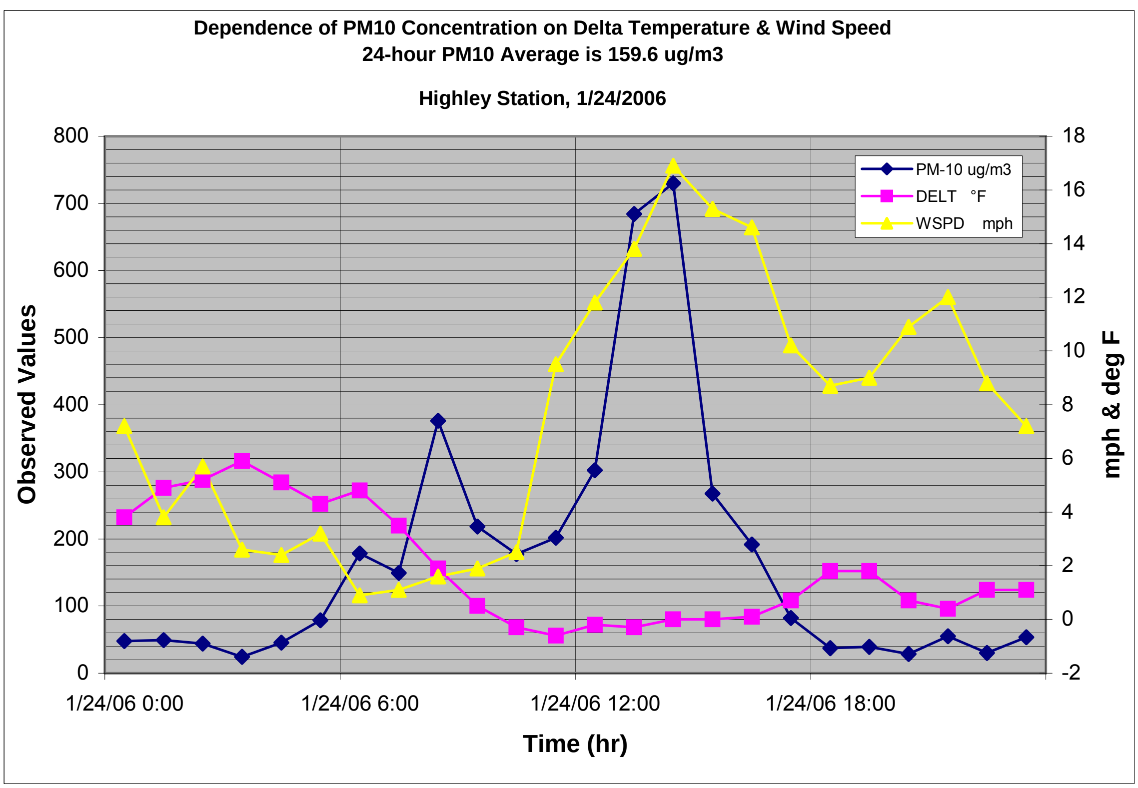

Figure 7. Hourly Observed PM-10 Concentration (μg/m^3) with Delta Temperature (°F) & Wind Speed (mph) for Higley Station on 01/24/2006

APPENDIX A1-A – Wind Roses

There are 20 PM-10 monitoring stations in Maricopa County. The West 43rd Avenue, Durango Complex, Higley, Greenwood, and Buckeye monitors had exceedances of the 24-hour PM-10 standard during the study period – March 2005 to March 2006. The West 43rd and Durango monitors are located near the Salt River Basin. All of the monitoring sites that exceeded the standard are equipped with continuous TEOM monitors and instruments that measure meteorology. The Maricopa County Air Quality Department has provided MAG with the monitoring observations for the study period. There are a total of 32 days on which one or more monitors exceeded the 24-hour PM-10 standard during the study period. All of the exceedance days occurred in November 2005-March 2006, except two, on April 4, 2005 at the West 43rd Avenue and on June 21, 2005 at Buckeye. A detailed discussion of exceedance days is provided in Attachment 1.

The Salt River Basin in Maricopa County lies at the southwestern edge of rapidly rising terrain. To the west and southwest of the valley, desert elevations, punctuated by mountain ranges, predominate all the way to the Colorado River at Yuma. The mesoscale circulation is driven by valley-to-mountain flows in the daytime (winds from the west) and by mountain-to-valley downslope flow at night (winds from the east and northeast). On a metropolitan scale, these winds would be expected to be influenced by the Salt River channel flow and by nocturnal drainage off the slopes of the South Mountains and, perhaps, from downslope flow from the Estrella Mountains.

Wind roses are plotted for all of the design and episode days for the West 43rd Avenue, Durango Complex, Higley, and Buckeye monitors. These wind roses are based on a standard 16 divisions in meters per second. The length and color of the extending cones represent the percentage and magnitude of the wind speed, respectively. The wind orientation considered is ‘blowing from’.

Figures AI1 to AI20 provide a series of wind roses for specific days and monitoring sites. Figures AI1 and AI2 show the monthly analysis of wind speed and direction for the West 43rd Avenue monitor from November 05 to February 06. Observation reveals the dominance of westerly winds for all of the months. All days in the winter season are low wind days, except a few in the month of February. These low winds are a consequence of high-pressure patterns that suppress the passage of high-wind synoptic fronts.

Figures AI3 to AI6 provide the wind roses by time of day for the selected exceedance days at the West 43rd Avenue monitor. From examination of the figures it is evident that nighttime downslope flow is from the east and daytime upslope is from the west. Also, the presence of drainage flows from South Mountain is apparent during the hours of 1800 to 2300.

Figures AI7 and AI8 show the monthly analysis of wind speed and direction for Durango Complex from November 2005 through February 2006. Figures AI9 to AI12 provide the wind roses by time of day for the selected exceedance days at the Durango Complex monitor.

Figures AI13 and AI14 show the monthly analysis of wind speed and direction for the Buckeye monitor from November 2005 through February 2006. Figures AI15 and AI16 provide the wind roses by time of day for the selected exceedance day, February 14, 2006, at the Buckeye monitor.

Figures AI17 and AI18 show the monthly analysis of wind speed and direction for the Higley monitor from November 2005 through February 2006. Figure AI19 and AI20 provide the wind roses by time of day for the selected exceedance day, January 24, 2006, at the Higley monitor.

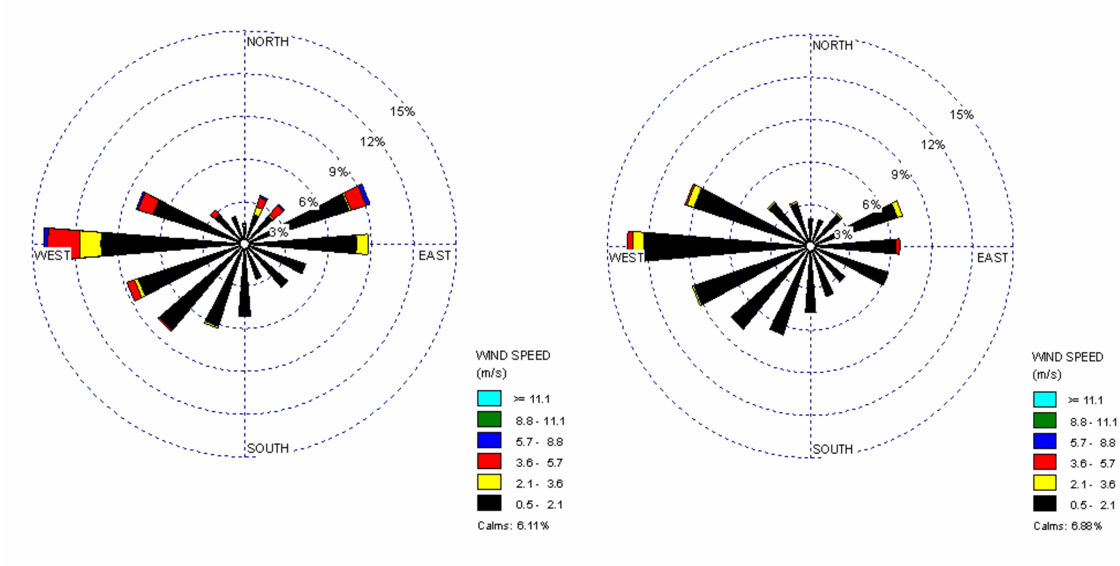

Figure AI1. West 43rd Wind rose: November, 05 (left) and December, 05 (right)

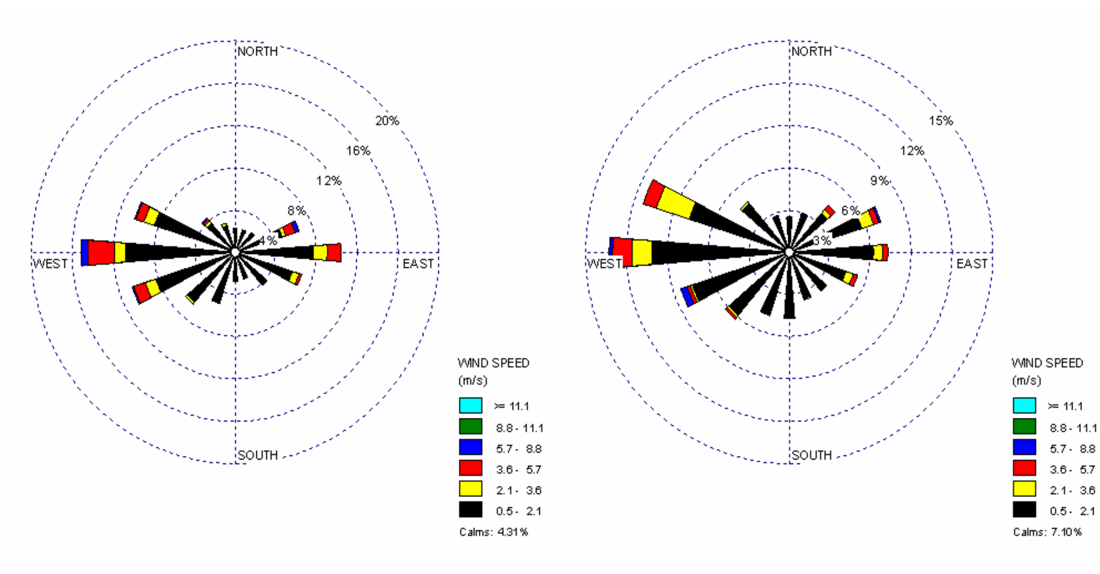

Figure AI2. West 43rd Wind rose: January, 06 (left) and February, 06 (right)

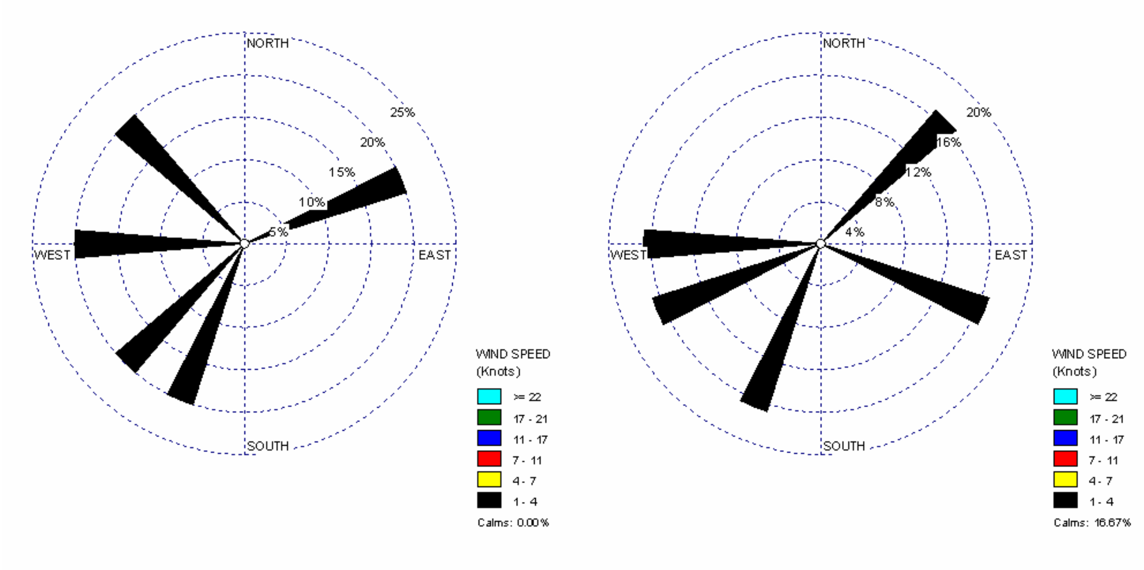

Figure AI3. West 43rd Wind Rose for 12th December, 2005: Hour 00-04 (Left) and Hour 05-10 (Right)

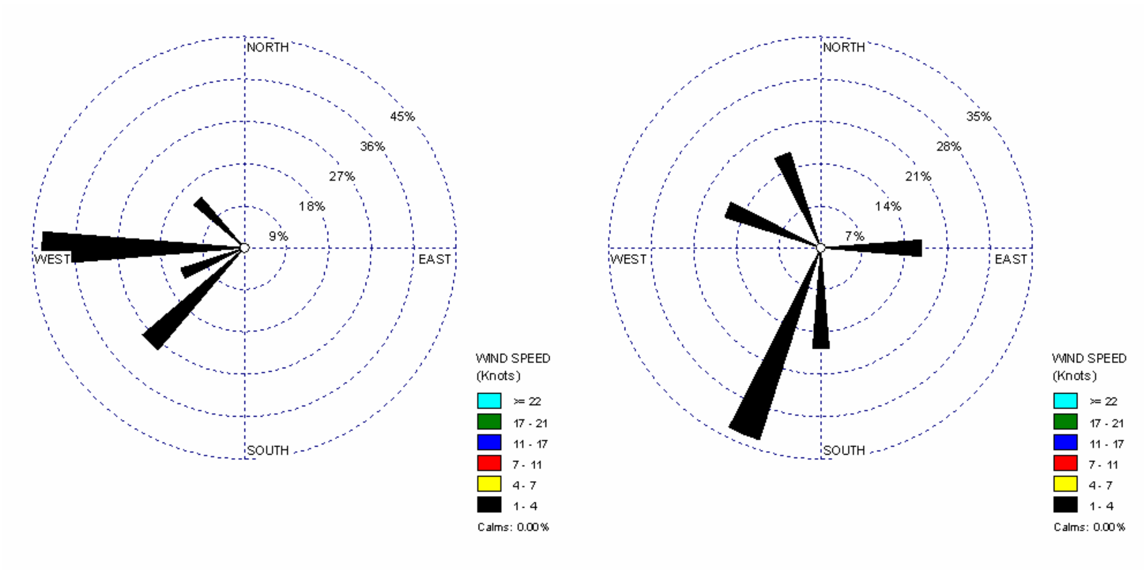

Figure AI4. West 43rd Wind Rose for 12th December, 2005: Hour 11-17 (Left) and Hour 18-23 (Right)

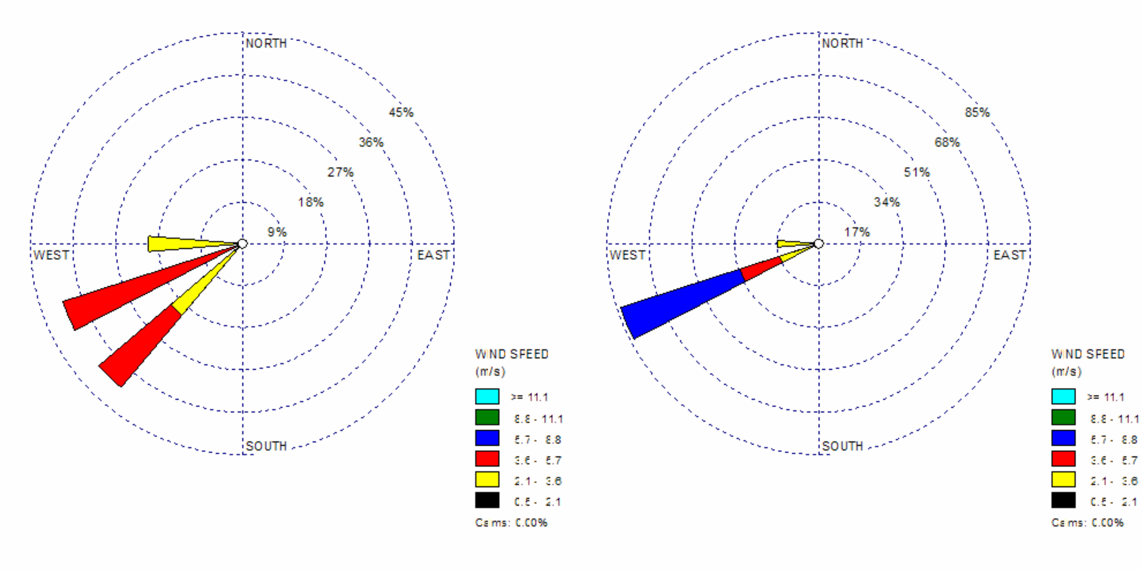

Figure AI5. West 43rd Wind Rose for 10th March 2006: Hour 00-04 (Left) and Hour 05-10 (Right)

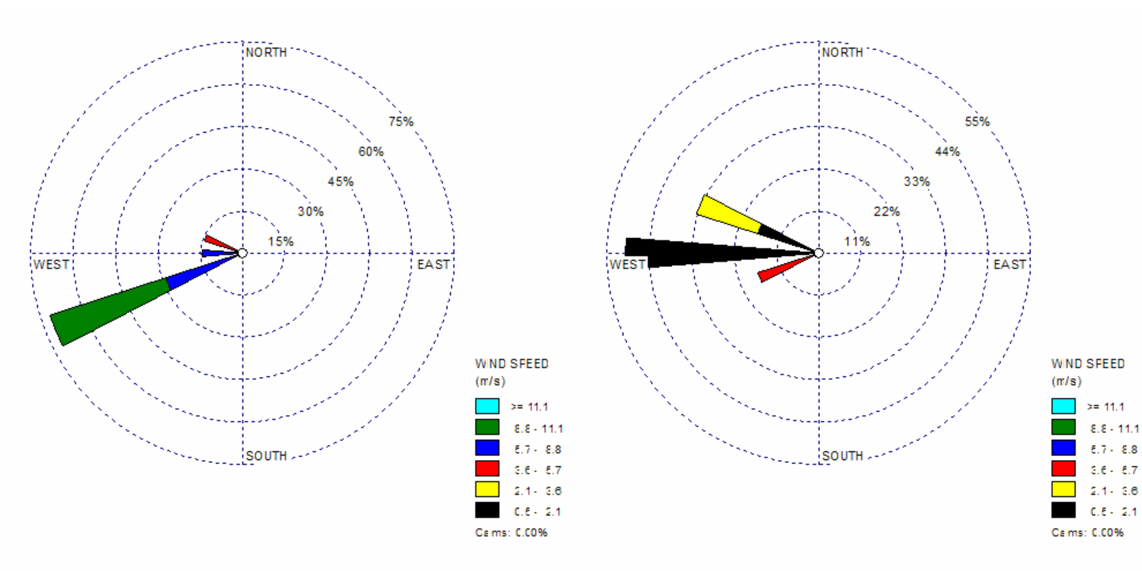

Figure AI6. West 43rd Wind Rose for 10th March 2006: Hour 11-17 (Left) and Hour 18-23 (Right)

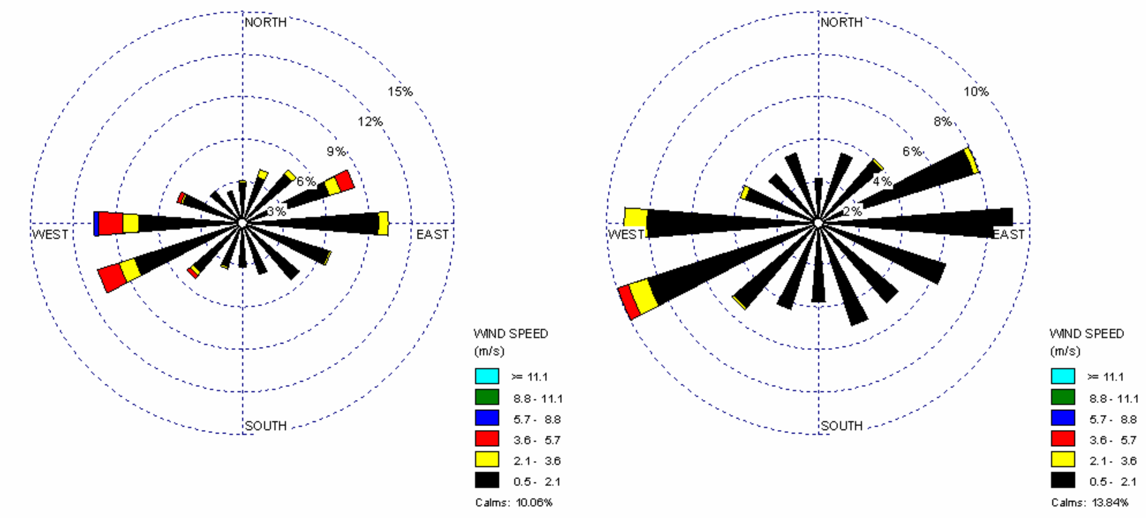

Figure AI7 Durango Complex Wind rose: November, 05 (left) and December, 05 (right)

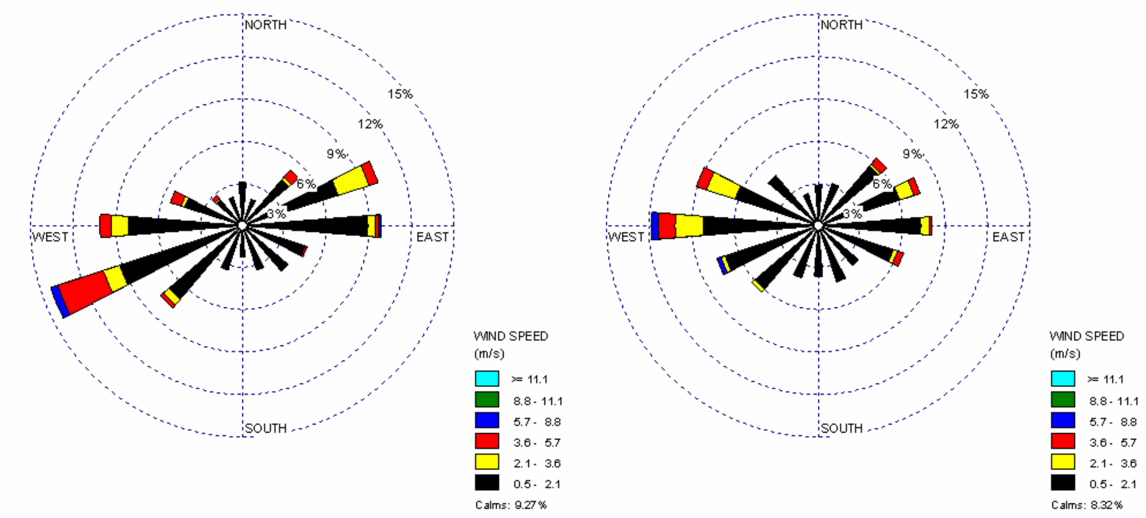

Figure AI8 Durango Complex Wind rose: January, 06 (left) and February, 06 (right)

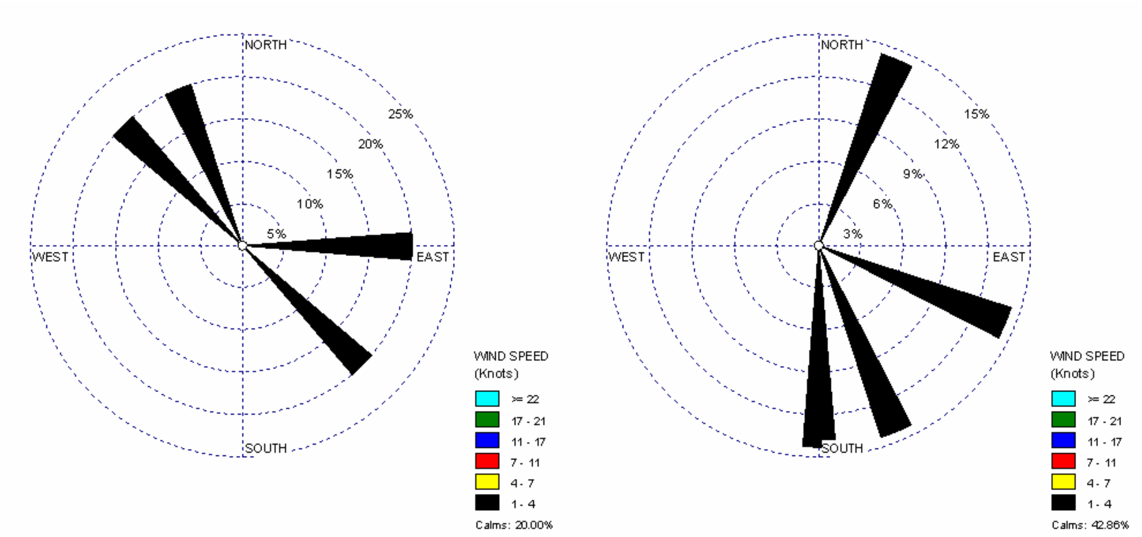

Figure AI9 Durango Complex Wind Rose for 12th December, 2005: Hour 00-04 (Left) and Hour 05-10 (Right)

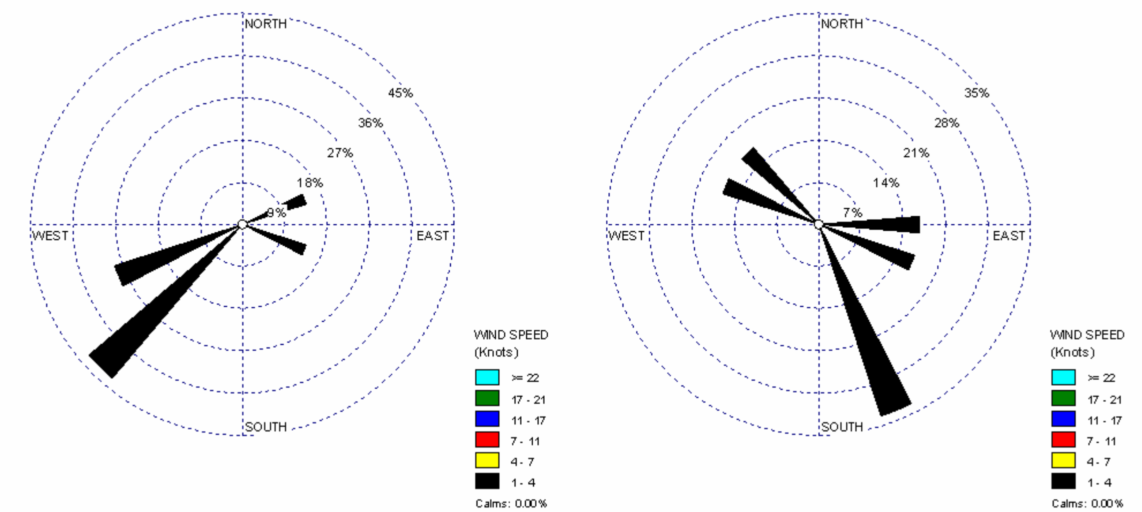

Figure AI10. Durango Complex Wind Rose for 12th December, 2005: Hour 11-17 (Left) and Hour 18-23 (Right)

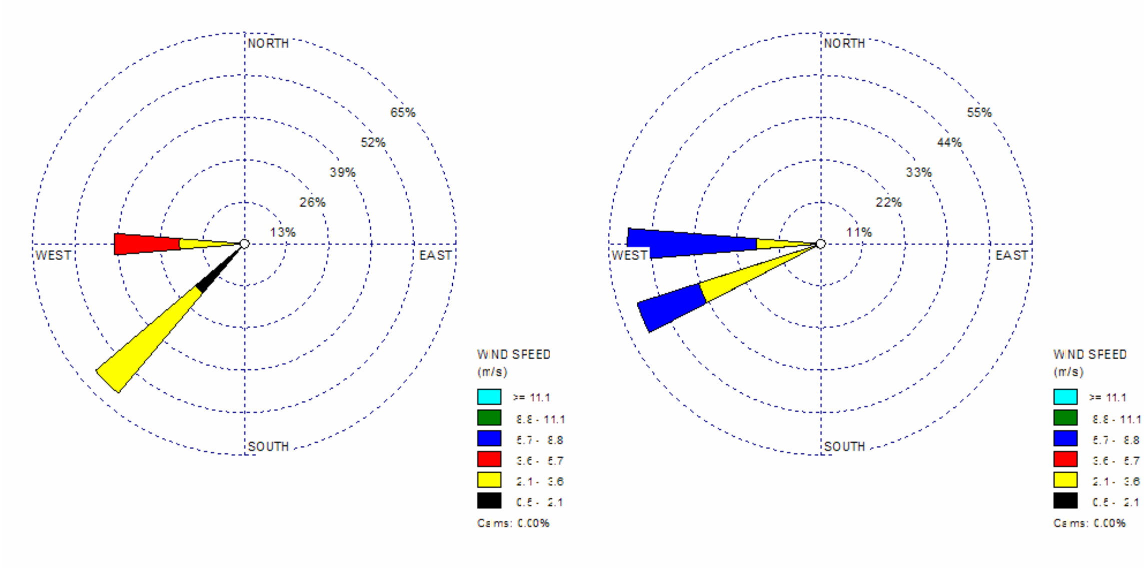

Figure AI11. Durango Complex Wind Rose for 10th March, 2006: Hour 00-04 (Left) and Hour 05-10 (Right)

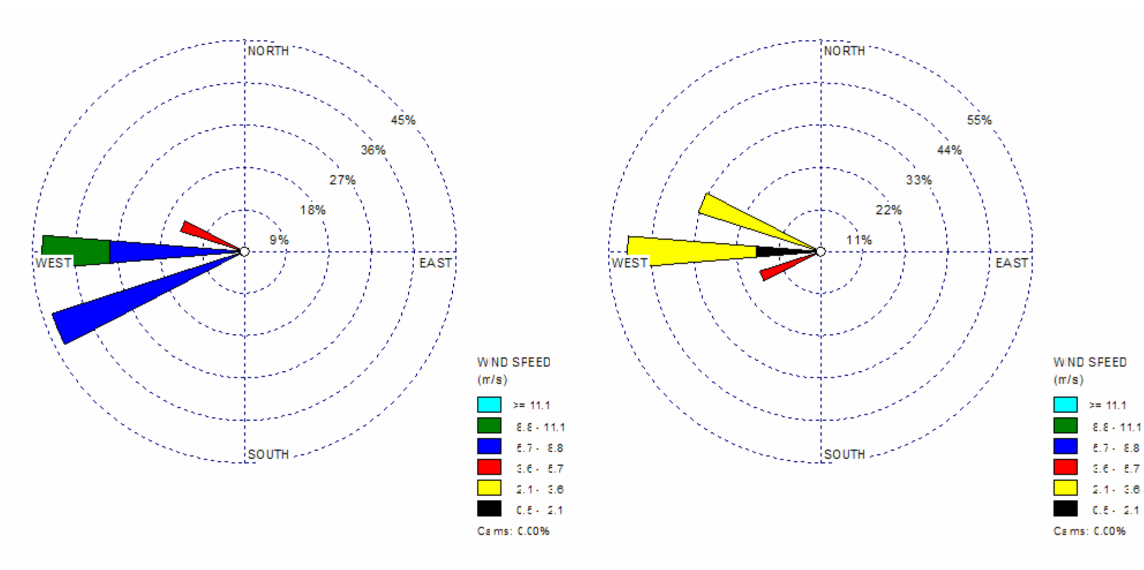

Figure AI12. Durango Complex Wind Rose for 10th March, 2006: Hour 11-17 (Left) and Hour 18-23 (Right)

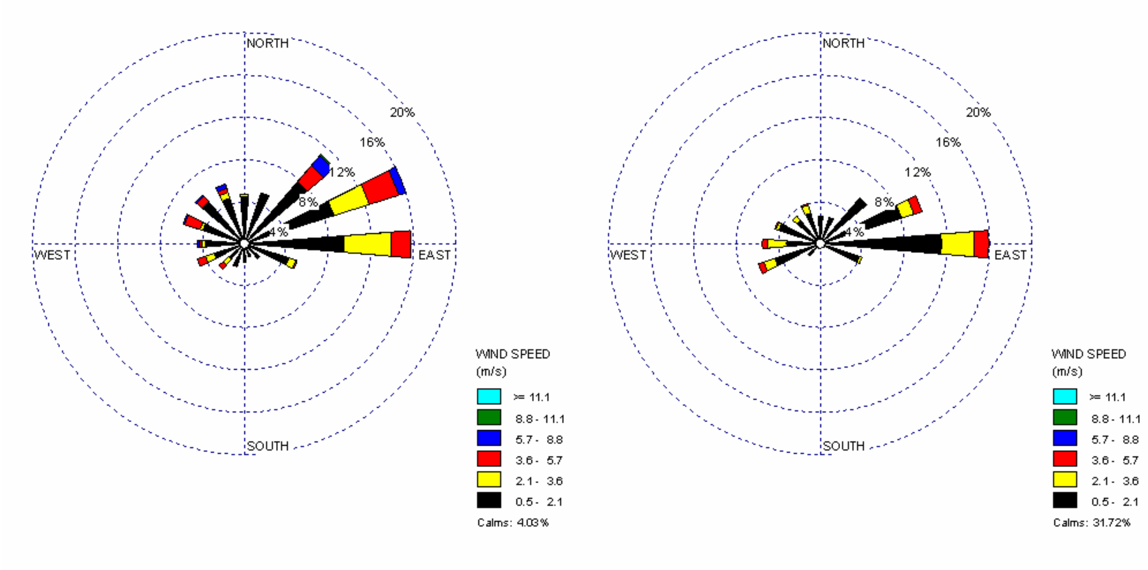

Figure AI13. Buckeye Wind rose: November, 05 (left) and December, 05 (right)

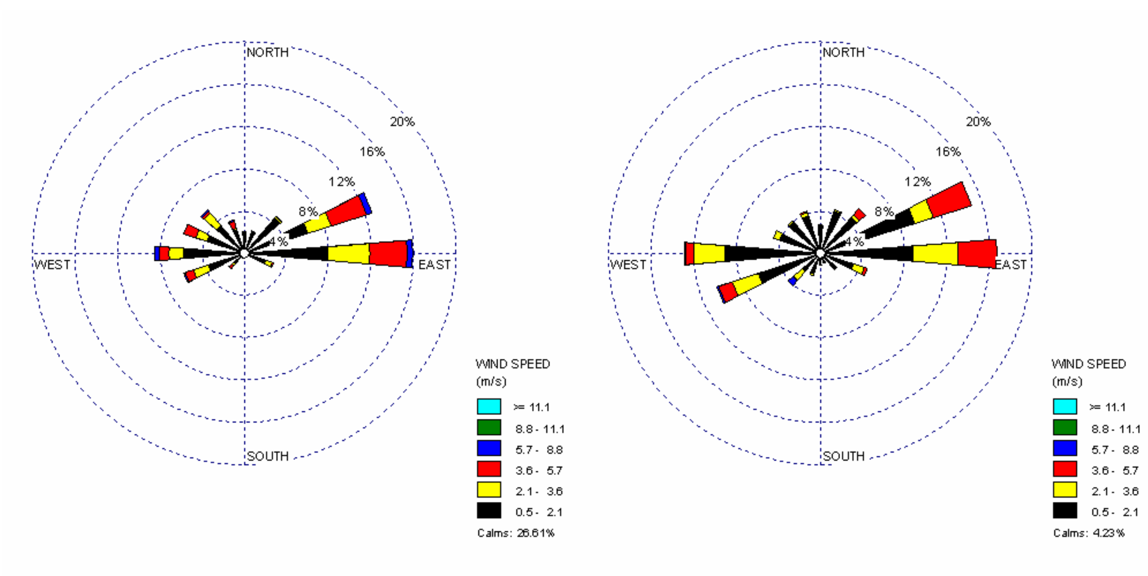

Figure AI14. Buckeye Wind rose: January, 06 (left) and February, 06 (right)

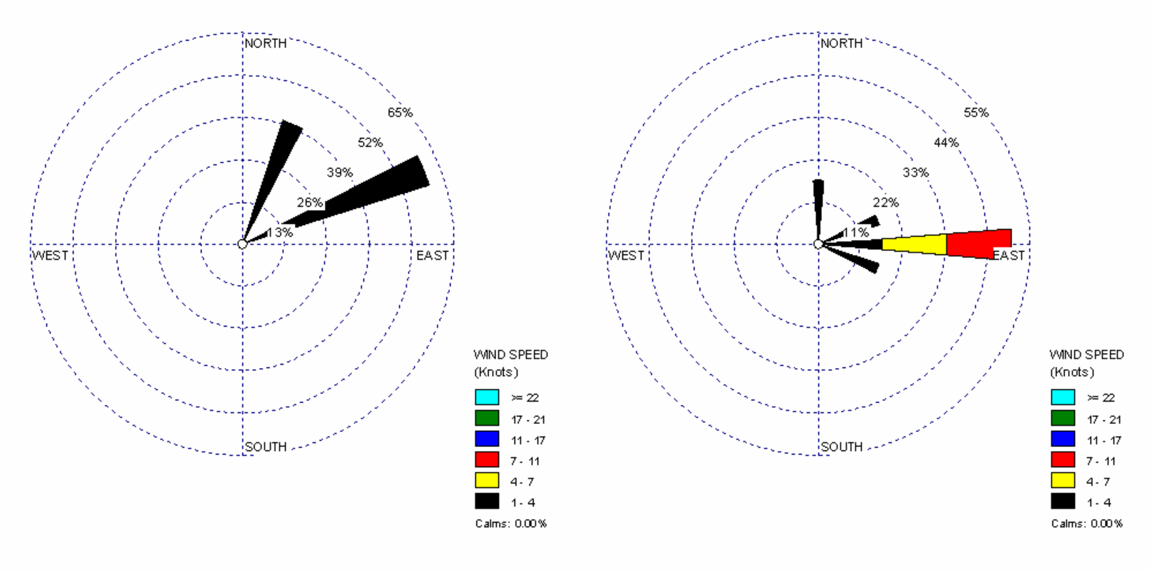

Figure AI15. Buckeye Wind Rose for 14th February 2006: Hour 00-04 (Left) and Hour 05-10 (Right)

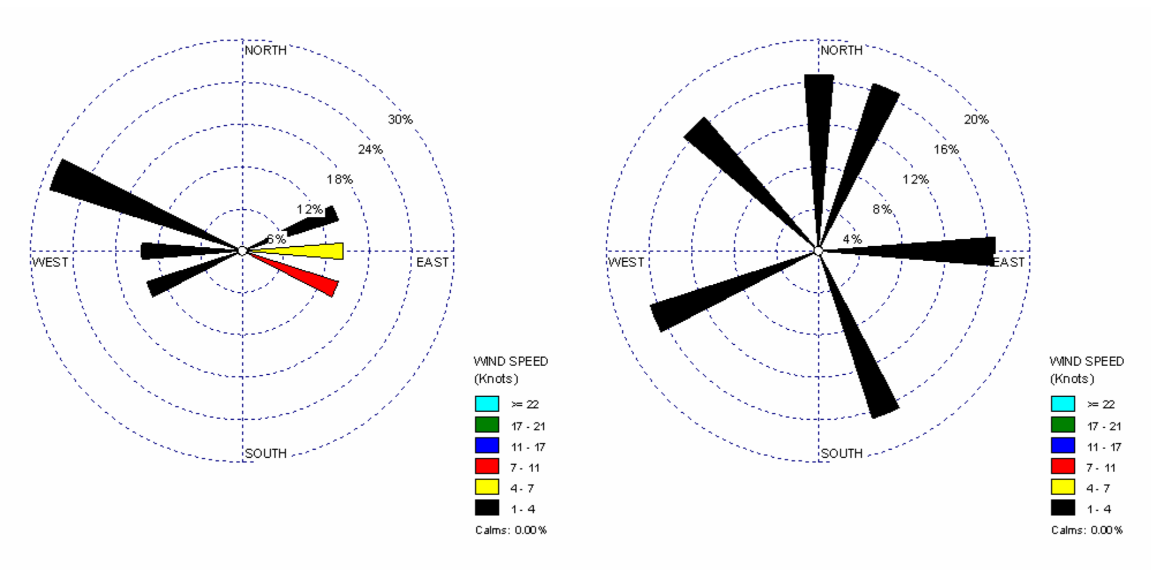

Figure AI16. Buckeye Wind Rose for 14th February, 2006: Hour 11-17 (Left) and Hour 18-23 (Right)

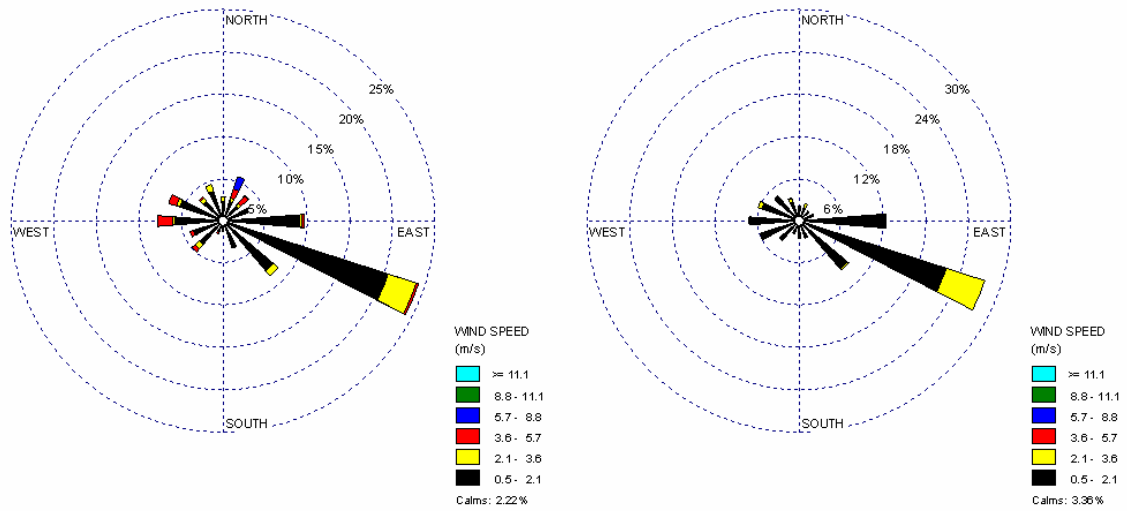

Figure AI17. Higley Wind Rose for November 05 (Left) and December 05 (Right)

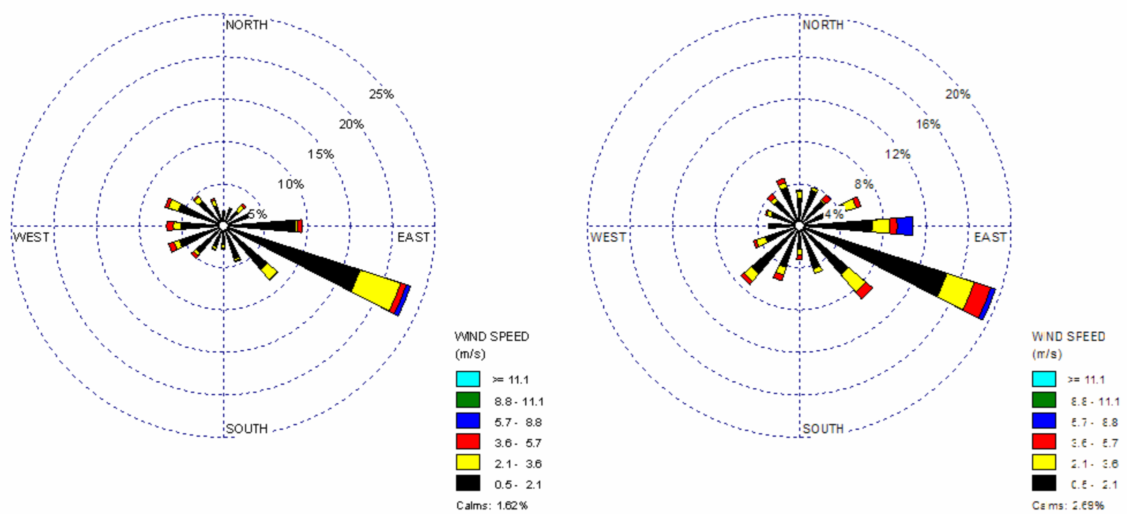

Figure AI18. Higley Wind Rose for January 06 (Left) and February 06 (Right)

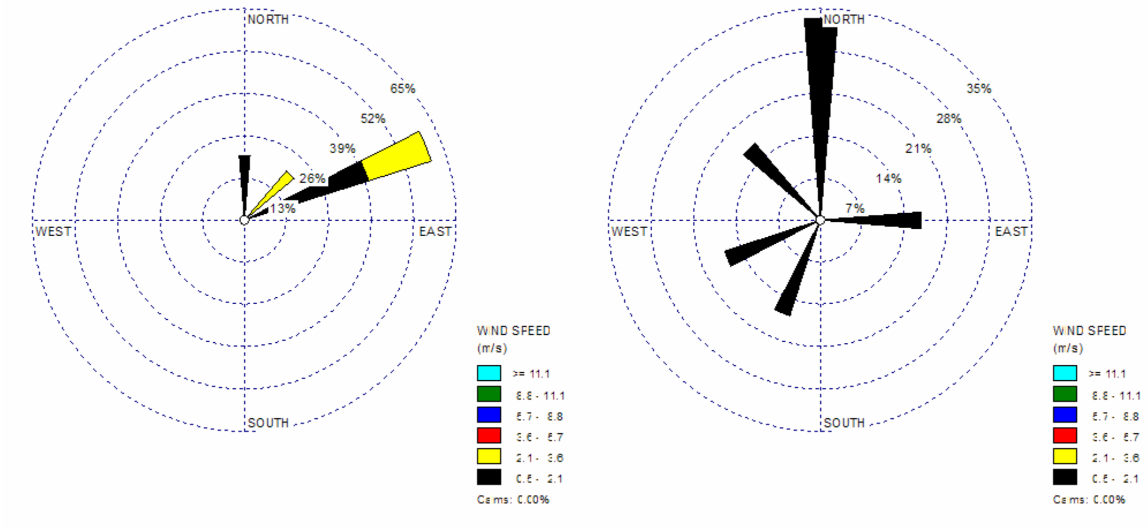

Figure AI19. Higley Wind Rose for 24th January 2006: Hour 00-04 (Left) and Hour 05-10 (Right)

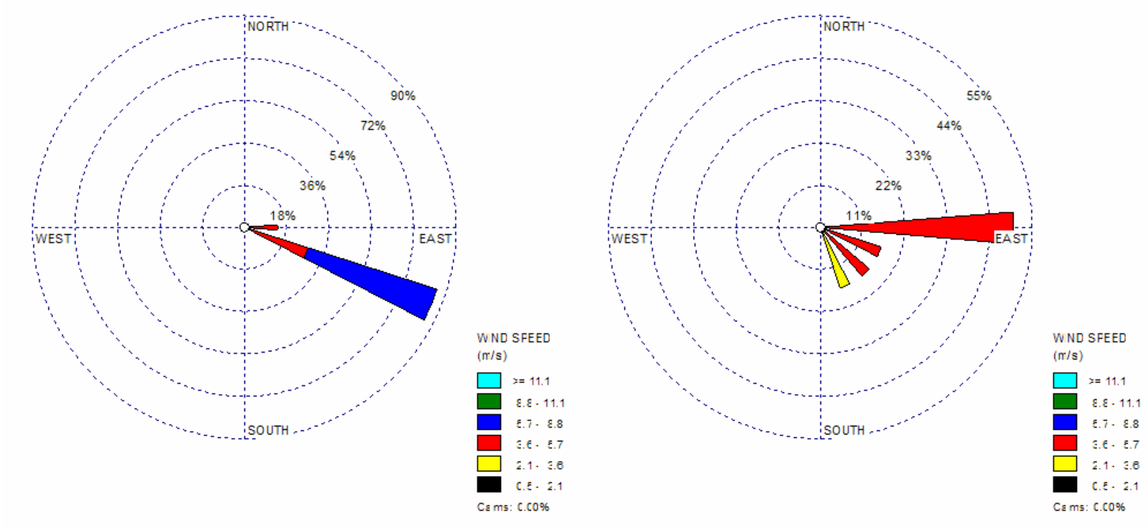

Figure AI20. Higley Wind Rose for 24th January 2006: Hour 11-17 (Left) and Hour 18-23 (Right)

APPENDIX A1-B – PM-10 Exceedance Days

Table BI1. Continuous PM-10 Monitoring Data for All Exceedance Days at West 43rd Avenue Site

Date	Hour	WSPD mph	WDIR	PRESS	DELT °F	PM-10 ug/m3	TEMP °F	WSMAX mph	24-Hour PM10 Avg (ug/m3)
4/4/2005	0	1.3	36	28.76	2.5	40.9	60.7	7.7	**172.7**
	1	1.1	41	28.76	2.6	41.7	59	9.5	
	2	0.5	104	28.77	2.6	48.7	56.1	8.4	
	3	3.2	83	28.77	2.1	61.9	55.9	6.5	
	4	1.6	76	28.78	1.2	93.1	55.9	5.3	
	5	1.4	116	28.77	0.5	174.4	55.1	6.7	
	6	1.7	243	28.78	-0.7	219	53.6	7.6	
	7	1.7	300	28.8	-1.9	220.8	57.4	4.4	
	8	0.6	220	28.8	-2.6	266	63.9	5	
	9	3.3	296	28.8	-4.5	151.7	70	9.2	
	10	3.9	262	28.79	-4.1	67.8	73.2	18.9	
	11	12.2	241	28.79	-4.6	129.5	76.5	21.5	
	12	12.8	252	28.76	-4.5	229.3	78	28.6	
	13	17.1	248	28.76	-3.8	652.5	78.2	37.3	
	14	19	249	28.75	-3.4	560.4	77.4	36.8	
	15	18.8	264	28.74	-2.8	563.6	77	34.9	
	16	16.7	279	28.75	-2.3	168.4	75.5	31.5	
	17	17.5	292	28.77	-1.7	131.4	73.1	31.8	
	18	13.4	293	28.79	-0.9	76.8	69.8	29.3	
	19	10.8	310	28.83	-0.3	58.1	65.5	20.8	
	20	10.4	322	28.86	0	44.6	63.1	22	
	21	3.6	277	28.89	0	44.5	61	10.9	
	22	4.4	248	28.91	-0.1	55.1	58.6	11.5	
	23	6.9	259	28.92	-0.2	45	58.3	12.4	
11/1/2005	0	1.6	233	29.05	1.2	97.3	56.3	3.7	**166.4**
	1	0.3	168	29.05	2.7	111	54.6	3.9	
	2	1.8	88	29.04	2.6	88.9	54.3	4.4	
	3	1.6	266	29.02	2.2	115.4	54	5.4	
	4	0.9	316	29.02	3.4	144.6	54.3	5.5	
	5	0.6	18	29.02	2.7	266.3	53	2.8	
	6	2.1	278	29.04	1.2	296.3	54.3	7.1	
	7	0.7	78	29.06	0.6	432.7	56.9	4.2	
	8	0.7	71	29.07	-1.1	463.8	65.5	3.3	
	9	3.5	88	29.07	-0.9	266.6	73.1	7.9	
	10	7.8	74	29.06	-1.2	86.1	79.7	14.9	
	11	6.3	80	29.03	-1.3	65.1	82	14.4	
	12	5.7	89	28.99	-1.4	43.1	83.8	13.6	
	13	5.1	90	28.96	-1.4	40.3	85.3	16.1	
	14	3.3	77	28.94	-1.2	37.2	86.1	12.1	
	15	3.7	109	28.92	-1	29.7	86.7	10.6	
	16	1.2	85	28.91	-0.3	42.3	85.8	5.6	
	17	1.3	357	28.9	1.7	115.3	81.5	3.8	
	18	2.1	214	28.91	1.4	364.3	74.6	4.8	

	19	2.5	200	28.91	1.5	237.4	69.9	3.9	
	20	0.6	171	28.91	1.7	188.5	66.5	4.1	
	21	1.9	151	28.92	2.3	147.3	64.1	4.5	
	22	1.8	85	28.92	1.5	143.3	62.8	3.6	
	23	1.9	103	28.92	2.2	170.8	61.8	3.5	
11/2/2005	0	0.6	231	28.92	2.1	93.6	59.9	3.6	**173.9**
	1	3.1	284	28.92	-0.1	100.5	59.4	5.8	
	2	1.3	303	28.91	0.9	79.2	57.2	4.2	
	3	1.4	237	28.91	0.8	114.6	55.4	4.5	
	4	1.3	309	28.91	0.6	124.5	53.7	3.5	
	5	1.6	239	28.92	-0.2	214.7	53.7	3.7	
	6	0.1	236	28.93	0.5	202.7	52.5	3.1	
	7	1.4	255	28.94	-0.1	309.4	56.9	4.4	
	8	1.3	216	28.97	-1.3	522.5	62.4	4.2	
	9	0.5	81	28.98	-1.5	245.5	70.1	4.4	
	10	0.8	39	28.98	-1.6	-999	76	4.6	
	11	4.1	65	28.96	-2	-999	80	12.2	
	12	2.8	141	28.92	-1.6	89.2	81.9	8.5	
	13	0.7	190	28.89	-1.8	94	84	6.7	
	14	3.1	301	28.88	-3.2	88.9	86.7	8.3	
	15	2.3	327	28.87	-1.8	77.8	85.7	7.7	
	16	2.4	299	28.86	-1.2	71.2	85.2	6.1	
	17	4.1	290	28.86	0	89.4	80.4	7.3	
	18	1.6	258	28.86	1.5	240.3	74	5.4	
	19	2.9	182	28.87	1.2	286.4	69.9	4.9	
	20	2.3	199	28.88	0.7	234.1	67.7	4	
	21	0.5	351	28.88	2.8	212.5	64.2	3.4	
	22	1.6	150	28.89	1.9	231.4	62.6	6.2	
	23	1.1	212	28.9	0.3	104.2	62.4	7.5	
11/10/2005	0	2.8	91	28.91	1.4	50.1	64.7	5.2	**166.2**
	1	0.9	193	28.91	1.7	38.2	65.5	4.9	
	2	3.2	230	28.91	0	72.8	63.2	6.1	
	3	0.1	247	28.9	0.7	61	59.7	2.7	
	4	1.9	78	28.9	0.8	89.3	58.9	5.3	
	5	0.6	347	28.9	0.3	145.6	59.7	2.8	
	6	2.1	260	28.92	-0.5	247.7	58.6	6.4	
	7	1.5	187	28.94	-0.5	251.2	59.3	6	
	8	1.7	277	28.95	-1.7	253.5	62.6	5.6	
	9	0.8	55	28.96	-0.9	264.3	64.1	5.9	
	10	2.4	111	28.95	-0.8	170.1	67	6.3	
	11	1.9	215	28.94	-1.5	178.5	70.1	7.8	
	12	2.2	294	28.91	-1.8	154.4	72.8	7.7	
	13	1.1	333	28.88	-1.2	115.6	74.4	7.4	
	14	3.6	283	28.86	-1.6	178.5	74.5	8.1	
	15	3.1	261	28.84	-1.7	198.3	75.2	7	
	16	1.8	229	28.83	-0.8	204.7	74.3	5.1	
	17	1.8	235	28.82	-0.3	218.6	71	4.6	
	18	1.5	196	28.82	0.3	265.3	66.6	3.4	
	19	2	129	28.82	1.3	232.1	63.7	4.5	
	20	2	219	28.82	0.8	194.2	62.7	4.6	
	21	2	239	28.83	0.5	194.2	60.1	4.4	
	22	2.7	278	28.83	0.3	130.8	58.6	6.3	
	23	4.9	283	28.83	-0.1	79.5	59.4	10.9	
	0	1.6	138	28.99	3.1	93.6	47.6	4.8	

	1	0.9	177	28.99	1.8	94	47.3	3.4	
	2	2	202	29	1.2	83.1	45	5.7	
	3	0.9	271	29	1.4	87.1	44.6	4.3	
	4	1.7	327	29	1	148.7	45.2	3.8	
	5	0.7	102	29	1.9	159.2	43.1	3.5	
	6	0.4	217	29.01	1.4	323.1	43.8	4.1	
	7	1.9	233	29.02	0	476.7	45.5	4.3	
	8	1.5	250	29.04	-2	297.1	51.2	5	
	9	1.5	293	29.04	-2.6	190.9	58.8	5.6	
11/22/2005	10	1.9	343	29.04	-2.6	184.4	65.4	5	**173.4**
	11	1.7	74	29.01	-1.2	105.5	70.2	5.2	
	12	1.8	102	28.98	-0.9	73	72.7	5.3	
	13	1.4	160	28.95	-1.3	69	75.4	7.6	
	14	1.7	231	28.94	-1.9	54.1	77.3	6	
	15	1.5	271	28.94	-1.1	62.9	77.1	5.4	
	16	2.6	234	28.93	-0.2	174.3	74.8	4.5	
	17	2	215	28.93	0.8	310.8	69.5	3.6	
	18	1	167	28.94	2	270.1	63.2	3.2	
	19	1.6	65	28.95	2.4	254.5	60.7	2.8	
	20	2.1	73	28.95	3.9	159	58.5	3.6	
	21	1.8	127	28.96	2.5	162.3	57	3.9	
	22	0.7	262	28.96	1.3	181.5	55.5	3.9	
	23	1.4	240	28.96	1.6	147.6	53.1	4.6	
	0	0.7	164	28.95	2.2	126.1	51	2.7	
	1	2.1	144	28.95	2.1	114.7	49.9	4.6	
	2	0.8	218	28.95	1.3	135.8	48.6	3.8	
	3	1.8	39	28.94	2.8	130	48.4	4.8	
	4	4.8	72	28.93	1.6	66.7	50.4	7.8	
	5	1.2	248	28.94	0.3	173.3	49.3	6.3	
	6	2.5	283	28.95	-0.5	208.3	48.5	5	
	7	2.2	297	28.96	0.1	212.3	51.6	8.6	
	8	1	263	28.97	-0.7	355.1	54.8	4.2	
	9	0.7	255	28.97	-0.9	438.4	58.9	5.7	
11/23/2005	10	2	119	28.96	-0.4	278.1	63.6	5.7	**175.5**
	11	2.8	255	28.95	-1.5	170.7	66.4	7.5	
	12	3.6	267	28.92	-1.9	91.9	67.9	7.3	
	13	1.6	291	28.89	-1.3	81.3	68.3	4.5	
	14	1.4	357	28.87	-1.1	86.1	69.6	4.4	
	15	4.4	52	28.85	-0.3	155.7	71	7.6	
	16	1.5	98	28.84	0	193.6	71	6.9	
	17	2.2	274	28.86	0.5	233.2	67.3	5	
	18	2.6	320	28.86	0.6	195.8	63.1	5.9	
	19	0.8	215	28.87	0.1	234.3	61.5	8.2	
	20	3.7	276	28.89	0.2	154.5	61.2	8.2	
	21	1.7	111	28.88	0.6	137.5	60	8.1	
	22	2.8	170	28.88	0.5	102.2	59.4	7.6	
	23	2.3	55	28.87	1.5	137.2	58.7	4.8	
	0	2.1	305	28.93	0.7	133.4	49.4	4.3	
	1	2.1	301	28.92	1.3	131.3	48.4	4.7	
	2	1.3	267	28.92	0.4	134.2	46.4	4.1	
	3	2.1	236	28.93	0.3	122.7	45.1	4	
	4	1.4	256	28.92	0	130.5	44	4.1	
	5	1.7	328	28.91	0.5	151.7	43.3	3.7	
	6	1.3	264	28.92	0.4	270.4	43.5	4.9	

	7	2.5	269	28.93	-0.2	337.6	44.8	7.9	
	8	1.2	282	28.94	-1.5	262	48	4.9	
	9	0.3	145	28.95	-1.2	295.6	53.5	4.8	
12/2/2005	10	1.8	143	28.95	-0.8	215.1	57.6	7.3	**195.2**
	11	1.8	243	28.93	-2.1	150.5	62.1	6.5	
	12	0.2	213	28.9	-0.9	128.5	64	5.4	
	13	2	45	28.87	-0.7	120.3	66.3	5.7	
	14	1.5	4	28.86	-0.9	114.1	68.4	5.2	
	15	2.1	351	28.84	-0.8	106.2	68.9	5.1	
	16	1.6	354	28.84	0	104	67.7	4.3	
	17	0.7	241	28.83	0.8	212.8	63.6	3.5	
	18	1.3	225	28.83	0.4	345.1	59.6	3.7	
	19	1.8	151	28.83	0.8	326.3	57.2	4.8	
	20	1.5	275	28.83	0.2	272.1	56.3	4.8	
	21	1.1	181	28.83	0.6	251.5	54.7	5.3	
	22	2.4	175	28.81	0.8	206.5	53.6	6.5	
	23	1.3	252	28.81	0	163.5	53.6	6.2	
	0	1.3	68	28.96	2.2	139.8	45.7	4	
	1	1.6	308	28.95	0.3	154.4	46.2	4.9	
	2	0.9	229	28.94	-0.4	149.5	44.6	5.7	
	3	2.2	194	28.94	-1.2	119.8	45.1	5	
	4	1.7	277	28.94	-0.7	130	44.4	7.2	
	5	1	247	28.96	-0.8	152.4	43.7	5.3	
	6	0.3	167	28.97	-0.6	294.4	44.4	4	
	7	1.3	102	28.98	-0.3	534.7	46	4.8	
	8	0.9	212	28.98	-1	432.8	48	4.6	
	9	0.8	48	29	-1.1	197.4	51.5	3	
12/12/2005	10	2.2	272	29.01	-2.6	412.2	55.2	4.9	**233.1**
	11	2.4	234	28.98	-3	523.7	57.7	6.7	
	12	3.6	246	28.95	-3.6	323.7	61.1	8	
	13	2.6	274	28.94	-3	153.8	61.8	6.1	
	14	1.8	279	28.93	-3	150.9	62.8	4.8	
	15	1.3	230	28.92	-1.8	138.4	62.2	4.3	
	16	1.5	265	28.93	-0.9	165	61.2	4.4	
	17	0.9	311	28.92	-0.1	163.5	57.7	3.5	
	18	1.6	181	28.93	-0.3	223	55.6	6.5	
	19	1	336	28.94	0.1	226.7	54.4	4	
	20	2.4	100	28.94	0.3	210.9	53.2	6	
	21	1	200	28.95	0	171.7	52.4	4.4	
	22	2.5	292	28.95	0.5	209.2	49.7	5.1	
	23	2.2	213	28.95	0.4	216.3	46.8	5.4	
	0	1.9	147	28.94	1.8	122.1	44.8	5.8	
	1	1.8	270	28.94	0.8	142.8	43.7	5.2	
	2	2.2	225	28.95	0.7	160	40.9	4	
	3	2.2	218	28.95	0.6	138.7	39.4	4	
	4	0.7	202	28.95	0.9	160.1	38	2.5	
	5	1.8	214	28.95	0.6	254.8	37.3	3.7	
	6	1.4	222	28.95	0.2	351	36.4	3.1	
	7	1.3	229	28.97	0.2	329.4	36.9	3.8	
	8	1.5	178	28.99	-1.7	253.2	41.4	5.2	
	9	1.6	165	29	-3.1	165.5	47.6	4.8	
12/13/2005	10	1.8	211	29	-4.9	109.7	55	6.2	**167.7**
	11	2.3	267	28.99	-7.1	106.1	62	5.8	
	12	2.2	243	28.95	-5.8	89.7	64.3	7.3	

	13	-999	-999	28.92	-999	75.5	-999	-999	
	14	-999	-999	28.91	-999	70.3	-999	-999	
	15	2.6	281	28.91	-1.9	70.5	63.9	5.9	
	16	1.9	245	28.91	-0.5	113.9	62.1	4	
	17	1.7	152	28.91	0.9	168.2	56.9	3.8	
	18	1	126	28.92	2.1	203.4	52.6	3.3	
	19	2	122	28.93	1.4	222.7	48.8	5.4	
	20	3.2	89	28.94	1.7	172.1	47	5	
	21	3.1	50	28.94	2.3	180.7	46.7	5	
	22	1.4	253	28.95	1.1	171.4	44.8	4.4	
	23	1.1	105	28.96	2.8	193.4	42.8	3.6	
	0	2.4	212	28.96	0.5	169.2	40.7	4.8	
	1	1.7	294	28.96	0.7	127	38.8	4.3	
	2	0.6	166	28.97	1.6	106.2	37.2	3.9	
	3	0.6	208	28.97	1.3	124.5	36.3	3.8	
	4	0.6	171	28.97	1.6	126.5	35.2	2.8	
	5	0.3	130	28.97	1.4	235.5	34.9	2.8	
	6	1.5	266	28.99	0.6	297.2	34.6	4	
	7	2	302	29.02	0.3	329.2	35.3	5.4	
	8	2	261	29.04	-2.3	383	42.1	5.2	
	9	1.4	266	29.07	-4.9	288.3	48.2	4.8	
12/14/2005	10	2.2	100	29.07	-3.9	162.7	52.9	5.7	**177.1**
	11	1.7	141	29.04	-4.6	111	58.3	6.2	
	12	2.1	205	29	-5.5	-999	63.3	7	
	13	2.4	238	28.96	-5.7	-999	66.2	7.7	
	14	2.3	259	28.95	-4.6	86.4	67.2	7	
	15	3.7	273	28.94	-2.5	76.1	66.2	8.8	
	16	3.9	266	28.94	-0.5	66	63.7	7.8	
	17	1.5	216	28.94	1.2	131.1	58.4	3.4	
	18	0.9	154	28.94	2.2	247.4	53.3	5.5	
	19	2.6	109	28.95	1.6	161.7	49.8	4.8	
	20	1.1	75	28.96	1.5	166.4	48.8	6.3	
	21	1.3	263	28.97	1.7	166.5	46.3	7.7	
	22	2	206	28.98	1	179.9	44.4	5.1	
	23	0.6	241	28.98	1.6	155	42.5	5	
	0	0.9	294	29.09	1.8	183.9	45.5	4.8	
	1	2.1	227	29.09	0.5	155.9	43.8	4.4	
	2	1.5	148	29.1	1.7	108.6	41.9	5.5	
	3	0.1	234	29.09	1.3	100.9	42.4	4.8	
	4	0.5	95	29.08	1.5	115	40.9	5.6	
	5	2	72	29.08	1.7	145.1	42.5	4.7	
	6	1.6	286	29.09	0.6	237.1	41.5	5.5	
	7	2	223	29.11	0	259	40.8	4.7	
	8	0.1	42	29.13	-0.8	240.3	45.5	4.8	
	9	0.7	102	29.14	-0.8	245.8	52.3	4.3	
12/21/2005	10	0.6	331	29.14	-1.8	263.9	59.2	4.9	**200.6**
	11	1.3	294	29.11	-2.5	276.1	65.6	4.2	
	12	1.5	45	29.07	-1.2	152.6	68.7	5.6	
	13	2.4	62	29.03	-0.9	132.8	72.6	9.2	
	14	3.3	50	29.02	-0.4	59.2	73.9	6.2	
	15	4.7	360	29.01	-0.6	128.1	73.7	7.8	
	16	2	340	29.01	0.1	166.6	72.2	3.8	
	17	0.5	297	29.01	2	252.7	66.7	3.7	
	18	0.5	143	29.01	3.5	298.7	59.8	3.4	

	19	0.9	106	29.02	2.6	341.2	55.8	4.1	
	20	2	94	29.03	2.8	336.1	54	7.1	
	21	2.1	140	29.02	3.2	213.8	52.2	4.8	
	22	1.5	76	29.02	2.9	184.1	51	3.9	
	23	1.7	344	29.02	2.1	217.3	50	5.4	
12/22/2005	0	1.8	228	29.02	1.2	201.8	47.8	8	**168.4**
	1	0.2	242	29.01	1.9	156	45.3	3.1	
	2	3.1	151	29.01	2.1	133.1	43.9	7	
	3	2.1	15	29	1.8	118.1	44.2	5.5	
	4	1.8	289	29	1.8	195.7	43.4	5.4	
	5	1	223	28.99	1.1	228.3	41.8	5.4	
	6	0.9	190	29	0.2	246.5	41	3.1	
	7	2	289	29.01	0	266.1	43.9	6.6	
	8	3.6	271	29.04	-0.8	194.8	46.9	7.2	
	9	1.3	210	29.05	-1.3	193.4	51.3	7.2	
	10	0.6	228	29.05	-1.1	244.8	57.3	5.2	
	11	1.8	118	29.02	-0.7	258	63.9	5.7	
	12	0.5	283	28.99	-1.4	160.7	69.2	4.9	
	13	1.7	108	28.95	-0.7	81.3	71.5	7.7	
	14	1.7	294	28.94	-1.7	77.6	74.2	6.2	
	15	1.1	290	28.93	-0.8	64.2	73.9	4.6	
	16	1.8	303	28.93	0.2	69.1	72.8	3.6	
	17	2.4	295	28.94	1.4	91.9	68	4.9	
	18	1.8	245	28.95	2.2	169.2	61.7	5.1	
	19	2.1	174	28.96	2	225.3	57.3	3.4	
	20	1.8	143	28.96	2.2	204.2	54.2	3.5	
	21	0.4	148	28.96	2.5	140.8	53.2	4.1	
	22	0.7	215	28.97	2	150.3	50.9	5.1	
	23	1.5	268	28.99	1.1	169.7	50.5	4.3	
12/23/2005	0	2.7	142	28.99	1.7	130.2	48.8	7.9	**156.7**
	1	0.6	78	28.96	0.7	91.4	49.7	9.6	
	2	2.5	321	29	0	99.1	49.7	9.9	
	3	3.9	120	28.99	0.7	84.6	48.1	7.3	
	4	2.9	289	28.99	0.1	96.9	47.2	6	
	5	1	223	29.01	0.6	124.6	45.3	6.3	
	6	1.2	277	28.99	0.5	143.6	44	4.6	
	7	1.7	307	29.02	0.8	242.5	45.1	4.1	
	8	1	126	29.03	0	340.6	48.2	5	
	9	2	287	29.06	-1.9	405.1	54.1	5.3	
	10	1.1	266	29.05	-2.1	190.5	59.5	4.9	
	11	1.6	249	29.02	-2.5	145.8	65.2	6.2	
	12	1.5	249	28.98	-1.7	113.8	68.7	6.9	
	13	2.9	295	28.96	-2.8	78.2	72.1	8.2	
	14	5	300	28.96	-2.6	63.2	74.1	10.2	
	15	3.7	300	28.95	-1.7	47.9	74.3	10	
	16	3	301	28.96	-0.7	54.1	73.2	6.7	
	17	1.9	252	28.97	1	121.1	67.4	3.6	
	18	2.9	86	28.98	2.3	175.8	61.4	5.1	
	19	3.6	90	29	2.8	298.1	58.5	5.4	
	20	2.4	82	29.01	2.3	251.1	55.8	4.5	
	21	0.5	106	29.02	2.3	186.9	53.6	3.8	
	22	1.1	248	29.03	1.5	157.2	52.6	6.7	
	23	1.5	272	29.03	0.8	118.4	49.6	5.3	
	0	2	183	29.11	2.7	67.6	41	5.2	

	1	1.4	176	29.11	3.4	62.7	40.9	5.2	
	2	0.3	202	29.11	3.1	58.2	39.6	4	
	3	1	355	29.1	3.8	95.1	38.9	3.4	
	4	0.7	55	29.09	3.7	173.1	37.7	3.1	
	5	1	44	29.08	3	227.5	37.6	2.9	
	6	0.8	302	29.09	2.5	512	37.6	3	
	7	1.2	274	29.1	2.1	688.7	38.7	2.8	
	8	0.4	332	29.11	0.6	637.2	43.9	2.2	
	9	1.5	308	29.12	-2.1	538	53.3	3.2	
1/10/2006	10	2.7	54	29.12	-0.9	162.9	59.1	6.4	**190.5**
	11	5.4	69	29.09	-0.8	89.3	64.3	13.2	
	12	8.2	91	29.05	-1	64.4	67.3	14.6	
	13	5.8	96	29.02	-0.8	29.5	68.7	12.2	
	14	4.1	106	28.99	-0.7	35.9	70.2	10.9	
	15	3	117	28.98	-0.5	35.6	70.8	9.2	
	16	1.9	65	28.97	0	33.5	70.3	5.4	
	17	2.1	216	28.96	0.7	181.4	66.8	5.9	
	18	2.5	227	28.96	1.4	160.9	59.1	5.5	
	19	1	291	28.96	3.2	131.7	54.6	4	
	20	2.2	124	28.97	3.8	188.2	50.8	3.7	
	21	1.5	178	28.98	2.6	138.1	48	4.2	
	22	1.2	267	28.98	2.2	142.4	46.6	7.5	
	23	1.8	211	28.98	1.1	117.8	43.5	5.2	
	0	3.2	124	28.97	2.5	148.5	41.4	6.2	
	1	1.1	245	28.96	1.5	105.6	41	5.8	
	2	2.6	208	28.97	1.4	122.5	39.1	4.4	
	3	2.1	221	28.96	0.9	89.1	38.1	5.2	
	4	1.2	324	28.96	1.6	108.8	37.2	7.9	
	5	0.9	330	28.96	1.9	218.2	36.9	3.9	
	6	1.2	223	28.96	1.2	364	35.4	4.2	
	7	0.8	252	28.97	0.7	366	35.2	3.2	
	8	2.4	294	28.98	-0.7	398.5	39.5	5	
	9	1.1	266	28.99	-1.8	356.5	47.3	4.4	
1/11/2006	10	2.7	84	28.99	-0.9	176.2	55.2	8	**165.7**
	11	1.9	171	28.96	-1.2	156.7	59.4	8.7	
	12	2	145	28.92	-1.1	77	62.4	7.1	
	13	3.8	113	28.88	-0.8	52	66.1	10	
	14	1.8	270	28.86	-1.9	46.2	69.5	8.2	
	15	3.3	284	28.86	-2	51.3	70.1	8.4	
	16	1.2	270	28.85	-0.2	33.7	68.3	4.1	
	17	3.8	280	28.85	0.9	109.1	63.9	6.8	
	18	2.9	284	28.86	1.8	98.6	58.6	5.6	
	19	1.6	163	28.86	3.4	128.1	54	4.3	
	20	2.6	106	28.85	2.7	198.9	50	6.9	
	21	0.4	56	28.85	2.3	170.1	48.1	5.2	
	22	2	13	28.86	2.2	203.1	46.1	4.5	
	23	1.5	83	28.87	2.7	199	44.1	3.9	
	0	2.2	199	28.88	1.4	171.8	41.6	7.2	
	1	1	224	28.87	1.1	140.1	39.3	4.5	
	2	2.9	36	28.89	2.7	160	39.5	5.3	
	3	0.4	80	28.88	1.9	149.7	39	3.5	
	4	1.1	243	28.88	1.2	203.3	36.4	3.5	
	5	3	293	28.89	0	159	36.1	6.9	
	6	2.3	242	28.91	0.1	221.3	35	6.3	

	7	2.2	336	28.93	1.7	215.3	35.5	5.3	
	8	1.4	192	28.96	0.1	363	38.9	3.7	
	9	1.2	253	28.98	-1.5	394.1	45.8	4.2	
1/12/2006	10	1.7	78	28.99	-0.9	221.9	51.5	6.7	**169.8**
	11	2.8	113	28.98	-0.7	171.7	56.7	8.3	
	12	1.8	132	28.95	-1	116.1	61.6	7.5	
	13	1.3	217	28.92	-2	92	65.6	6.7	
	14	2.6	241	28.91	-2.4	90.5	68	7.2	
	15	3.2	252	28.9	-2.2	60.9	69.2	7.6	
	16	3.1	296	28.9	-0.8	75.1	67.9	5.9	
	17	2.7	302	28.91	0.7	111.8	64.1	5.3	
	18	3.4	319	28.93	1.8	158.3	58.5	5.2	
	19	0.2	257	28.94	3	139.4	55.2	3	
	20	2	110	28.95	3.9	201	51.4	5.9	
	21	2.2	112	28.96	2.8	171.7	48.9	4.6	
	22	1.4	258	28.98	2.8	163.4	47.4	4.7	
	23	2.1	132	28.99	2.7	124.3	44.7	6.2	
	0	2.7	90	29.01	1.8	109	45.2	6	
	1	2.2	289	29.01	1.9	123	43.1	4.4	
	2	2	207	29.03	0.6	111.3	39.9	4.4	
	3	0.6	272	29.03	1.3	112.1	39.1	2.9	
	4	1.4	355	29.04	2.5	179.6	39	5.4	
	5	1	195	29.05	1.2	267.1	37.8	4.2	
	6	1.7	255	29.05	0.8	343.9	37.4	6.1	
	7	1.3	196	29.05	1	299.9	37.6	5.5	
	8	0.9	359	29.06	-0.1	249.5	44.5	2.8	
	9	1.1	146	29.06	-0.9	-999	52.1	5.5	
1/13/2006	10	2.6	235	29.06	-2.5	269.6	58.4	6.1	**157.3**
	11	1.3	344	29.04	-2.2	95.4	64	5.5	
	12	4.7	73	29	-1	103.6	66.6	10.9	
	13	6.4	82	28.95	-1	76.6	70.7	13.7	
	14	1.8	65	28.92	-0.8	45.4	72.7	7.3	
	15	0.3	269	28.92	-1	50.3	74.8	6.1	
	16	2	6	28.9	0.1	51.8	73.3	4.9	
	17	0.6	276	28.89	0.9	110.3	69.9	4.2	
	18	2	254	28.9	2.2	196.2	62.2	5.2	
	19	1	161	28.89	3.6	197.8	57.7	4.1	
	20	2.5	182	28.9	2	192.1	55.1	4.9	
	21	1	196	28.89	2.2	148.5	52.3	4.7	
	22	2	71	28.88	2.1	140.7	52.3	4.7	
	23	0.3	15	28.88	2.9	143.2	51.1	4.1	
	0	1.7	100	28.86	0.7	132.8	45.8	4.5	
	1	0.9	347	28.86	1.1	154.4	43.4	3.9	
	2	1.5	208	28.85	0.1	154.9	43.2	5.3	
	3	0.6	238	28.84	0.1	147.9	41.9	4.4	
	4	1.8	166	28.83	0.3	191.7	41.6	5.9	
	5	1.3	154	28.81	0.1	109.6	41.6	6.1	
	6	0.3	232	28.81	0.1	292.7	41.8	4.2	
	7	4.5	285	28.82	0.3	281.6	41.9	7.2	
	8	2.8	200	28.84	-0.3	284	45.3	7.5	
	9	4.7	234	28.85	-2.2	178.8	55.4	11.6	
	10	12.7	265	28.86	-1.8	348.1	58.8	26.6	
1/19/2006	11	16.6	269	28.85	-1.6	808.1	59.9	29.2	**184.00**
	12	15.4	264	28.85	-2.2	349.8	61.6	27.8	

	13	15.5	268	28.85	-2.3	355.9	62.5	27.2	
	14	13.2	278	28.85	-2	129.5	63	24.8	
	15	13.3	299	28.87	-1.5	186.4	61.6	27.1	
	16	13.4	318	28.89	-0.8	77.1	59.2	23.4	
	17	9.1	298	28.9	-0.2	8.7	56.9	16.4	
	18	4.3	268	28.92	-0.2	24.5	52.9	11.6	
	19	4.4	291	28.94	-0.1	24.1	51.9	10.9	
	20	3.4	280	28.96	0.2	28.8	49.5	7	
	21	3.7	264	28.98	0.6	34.3	46.5	6.2	
	22	1.8	196	28.99	2	35.7	43.8	4.4	
	23	1.1	300	29	3.3	76.8	42	5	
2/8/2006	0	1.4	25	28.99	4.4	222	51	5.7	**184.0**
	1	0.2	166	28.99	6.6	212	48.6	1.9	
	2	0.7	28	28.98	3.9	227.4	47.2	2.6	
	3	0.6	347	28.98	5.3	247	45.2	2.6	
	4	0.7	5	28.97	4.9	223.2	44.6	2.7	
	5	1.7	325	28.97	6.2	188.3	44.4	4.6	
	6	3	33	28.97	4	246.8	46.2	4.7	
	7	0.9	83	28.98	3.3	454.3	46.1	4.3	
	8	0.8	308	28.99	-0.3	686.3	51.6	3.7	
	9	1.4	256	28.99	-2.4	348.4	60.8	4.3	
	10	5	79	28.99	-1.4	154.4	69.8	17.1	
	11	11	90	28.97	-1.2	84.6	75.3	19.4	
	12	11.3	85	28.94	-1.3	54.9	78	21.6	
	13	7.4	91	28.9	-1.3	41.2	80	18.7	
	14	6.9	86	28.86	-1.2	28.4	81.3	15	
	15	6	96	28.85	-0.9	27.4	82.1	14	
	16	5.7	74	28.83	-0.5	22.8	82.3	12.3	
	17	2.5	98	28.82	0.9	69.1	79.5	5.6	
	18	0.9	85	28.82	2.9	124.9	72.4	2.4	
	19	2.3	128	28.83	3.6	220.2	66.7	3.4	
	20	0.9	95	28.84	4.4	169.4	61.8	3.5	
	21	0.9	109	28.85	6.8	121.9	59.9	3.7	
	22	0.9	2	28.86	5.6	136.6	58	7.2	
	23	1.5	59	28.86	6	104.4	58	4.4	
2/9/2006	0	2.4	42	28.86	5.6	146.5	55.5	4.9	**204.6**
	1	1.5	100	28.85	6.2	108.7	53.9	6.2	
	2	0.6	124	28.85	3.3	60.5	54.2	6.6	
	3	1.2	356	28.84	3.1	136.8	52.1	4.5	
	4	2	47	28.83	4.7	158.8	51.4	4.2	
	5	2.2	291	28.83	1.8	280	51.2	5.6	
	6	1.8	324	28.83	2	367.5	51.6	4.3	
	7	1.3	237	28.84	2.5	551	53.5	3.8	
	8	0.1	73	28.85	0.8	473.7	55.2	5.3	
	9	3.1	283	28.87	-0.7	485.1	58.7	7.4	
	10	1	2	28.87	-0.6	507.1	61.6	4.9	
	11	1.2	23	28.87	-1	263.1	68.7	5.6	
	12	2.7	275	28.86	-2.4	169.5	72.3	5.8	
	13	1.1	122	28.84	-0.9	125.9	73.3	5	
	14	3.6	116	28.83	-0.8	86.9	75.2	11.1	
	15	7.2	163	28.83	-1	84.4	76.1	17.4	
	16	10.6	121	28.85	-0.6	236.8	72.3	21.4	
	17	4.1	154	28.84	-0.3	47.7	70.8	9.5	
	18	2.3	232	28.85	-0.2	122.6	67.3	7.7	

	19	1.4	260	28.86	0.6	81.7	63.5	7.1	
	20	1.5	223	28.87	1.8	94.9	60.5	6.8	
	21	1	346	28.88	2.6	90.2	58.2	4.7	
	22	1.8	5	28.89	2.1	130.8	56	5	
	23	2.8	141	28.9	3.4	101.1	53.1	4.8	
2/15/2006	0	4	59	28.74	2.3	100.5	51.4	6.2	**202.2**
	1	3	59	28.75	1.2	86	50.3	6.2	
	2	0.4	165	28.76	1.6	93.1	46.7	5.3	
	3	0.5	163	28.76	1.9	115.8	42.6	5	
	4	1.3	79	28.77	2	132.9	41.8	4.5	
	5	2.2	157	28.78	2.1	159.4	41.6	7.1	
	6	1.8	135	28.77	1.5	230.6	41.2	7.1	
	7	0.6	184	28.77	0.7	314	44.1	4.6	
	8	3.2	287	28.78	-2	440.6	50.9	8.7	
	9	4.6	276	28.79	-2.8	299.3	58.1	9.7	
	10	5.2	286	28.81	-3.3	133.5	64.2	9.9	
	11	3.2	293	28.8	-3.9	51.5	68.4	9.5	
	12	2	287	28.77	-3.1	46.6	69.6	8.7	
	13	3.5	302	28.73	-3.6	66.5	72.5	12	
	14	9.6	243	28.69	-3.6	225.8	75.9	20.7	
	15	15.5	239	28.66	-2.1	829.4	76.5	30.9	
	16	14.6	246	28.64	-1.8	591	75.6	28.8	
	17	15.1	255	28.64	-0.6	274.3	72.2	28	
	18	14.4	257	28.66	-0.4	346.2	67.1	27.6	
	19	12.7	277	28.69	-999	97.5	63.2	25.1	
	20	5.7	275	28.71	-999	48	60.8	16.2	
	21	3.1	242	28.73	-0.4	57	58.6	10.1	
	22	8.8	226	28.74	-0.4	57.8	58.5	16.6	
	23	8.3	224	28.77	-0.4	56	57.8	15.7	
3/10/2006	0	8.3	235	28.55	-0.2	28.7	55.4	15.7	**260.8**
	1	5.9	233	28.54	-0.1	30.6	54.4	13.4	
	2	10.9	238	28.55	-0.1	61.7	53.8	21.3	
	3	11.2	252	28.54	-0.2	57.4	52.7	22.4	
	4	6.2	260	28.54	-0.4	36.8	51.9	13.9	
	5	5.8	278	28.55	-0.8	45.5	51.8	16.1	
	6	6.5	248	28.57	-0.1	90.4	51.8	16	
	7	8.9	257	28.59	-0.3	89.3	53	18.8	
	8	13.8	254	28.62	-1.4	257.5	55.5	25.7	
	9	16.9	254	28.65	-2.2	654.7	56.8	27.6	
	10	15.3	255	28.66	-2.9	426.2	59.6	28.5	
	11	16.3	245	28.65	-3.2	602.9	62.4	31.5	
	12	18.7	254	28.64	-3.3	814.5	64.1	34.6	
	13	20.2	250	28.63	-999	815.1	64.2	37.8	
	14	21	251	28.62	-999	952.7	63.7	37.1	
	15	20.7	256	28.63	-999	729.5	62.6	39.6	
	16	17.9	274	28.62	-2	157.9	60.8	30.9	
	17	12.9	286	28.62	-1.2	38.7	58.4	22.4	
	18	6.7	283	28.61	-0.7	28.2	55	16.9	
	19	4.8	292	28.62	-1	45.9	53.1	8.6	
	20	4.1	265	28.63	-0.8	50	52.1	8.8	
	21	2.7	277	28.65	-0.7	56	50.7	7.5	
	22	4.8	278	28.66	-0.9	46	50.1	7.5	
	23	12.8	241	28.67	-0.7	144.1	50	29.6	

Table BI2. Continuous PM-10 Monitoring Data for All Exceedance Days at the Durango Complex Site

Date	Hour	WSPD mph	WDIR	PRESS	DELT °F	PM-10 ug/m3	TEMP °F	WSMAX mph	24-Hour PM10 Avg (ug/m3)
11/3/2005	0	0.5	158	28.75	-0.3	170.5	66.4	3.8	**163.8**
	1	1.1	189	28.74	0.1	104.9	64.3	3.8	
	2	0.8	57	28.73	1.2	87.5	64.9	3.8	
	3	2	56	28.72	0.3	81.1	66.2	6.5	
	4	2.2	67	28.72	-0.5	55.7	66.1	6.3	
	5	1.1	276	28.73	-1	111.8	65.2	7.1	
	6	1.9	231	28.75	-0.7	183.7	62.2	7.6	
	7	0.7	127	28.76	-0.2	222.7	62.6	2.3	
	8	0.4	226	28.77	-1	356	65.8	3.4	
	9	2.2	302	28.78	-1.5	310.9	69.5	5.9	
	10	2.3	304	28.8	-1.5	171.6	71.8	9.7	
	11	2.1	146	28.79	-1	251.7	74	6.5	
	12	0.6	114	28.77	-1.1	209.8	78.4	4.4	
	13	3.4	102	28.73	-1.2	127.8	80.8	8.4	
	14	1.7	14	28.72	-1.5	102.3	81.3	7.7	
	15	1.4	25	28.71	-1.1	79.6	84.5	5.6	
	16	2.5	39	28.69	-0.5	54.9	83.9	6.4	
	17	0.7	57	28.69	0.4	71.4	76.9	3.9	
	18	1.7	277	28.7	1.8	170.6	72.1	4	
	19	1	207	28.71	1.3	210.3	68.8	4.4	
	20	1.4	108	28.7	1.9	126.2	66.9	4.3	
	21	1.2	60	28.71	2	297.2	65.8	3.4	
	22	0.9	349	28.71	1.2	178.4	64.1	3.8	
	23	0.9	212	28.71	2	194.3	61.5	5.9	
11/17/2005	0	0.6	213	28.85	1.3	133.8	55.4	6	**156.2**
	1	0.9	253	28.85	1.1	155.9	53.5	3.6	
	2	0.6	173	28.85	2.3	129.1	51.3	2.5	
	3	0.1	273	28.84	2.7	108.8	50.8	2.9	
	4	0.7	286	28.83	1.4	133.4	50.3	2.9	
	5	0.8	218	28.84	1.4	196.9	49.6	3.3	
	6	1	311	28.85	1	303.9	48.8	3.2	
	7	0.7	264	28.87	0.2	442.2	54	2.5	
	8	0.4	250	28.89	-1.3	370.7	64.7	2.6	
	9	0.2	220	28.89	-1.2	238.5	73.5	3.4	
	10	0.9	46	28.89	-1.3	134.7	76.6	6.1	
	11	2.1	78	28.88	-1.1	67.9	77.4	7.9	
	12	0.5	74	28.84	-1.6	38.1	81.4	5.1	
	13	1.4	260	28.81	-1.9	41.9	81.7	6.4	
	14	1.4	273	28.79	-2	37	82.1	6	
	15	2.9	290	28.77	-1.7	33.2	82.1	7.5	

	16	3.2	268	28.77	-0.9	48.2	80.9	6.7	
	17	3	223	28.77	0.3	123.8	73.4	6.2	
	18	0.9	238	28.78	1.3	108.3	67.4	4.6	
	19	2.1	280	28.8	2	171.8	64.8	4.3	
	20	1.4	83	28.81	3	164.1	62.3	3.3	
	21	1.6	93	28.83	2.9	187.6	60	4.3	
	22	1.2	100	28.85	2.5	190.5	59.1	5.4	
	23	0.1	282	28.87	1.8	188.8	56.7	4.8	
11/22/2005	0	0.5	354	28.84	3.1	185.3	53.3	3.3	**189.6**
	1	0.6	2	28.84	1.8	158	51.5	3	
	2	0.7	195	28.85	1.2	148	50.1	3.1	
	3	0.4	263	28.85	1.4	90.7	49.2	2.3	
	4	1.9	335	28.84	1	127.1	49.5	4.8	
	5	0.7	299	28.85	1.9	148.1	47.9	2.8	
	6	1.1	312	28.86	1.4	257.1	47.1	3	
	7	0.3	220	28.87	0	334.7	52	3.5	
	8	-999	-999	28.89	-2	358.1	59.8	-999	
	9	-999	-999	28.89	-2.6	316.9	70	-999	
	10	-999	-999	28.89	-2.6	238.9	74.1	-999	
	11	-999	-999	28.86	-1.2	163	77.4	-999	
	12	-999	-999	28.83	-0.9	112	80	-999	
	13	-999	-999	28.8	-1.3	117.9	81.5	-999	
	14	-999	-999	28.79	-1.9	39.5	82.2	-999	
	15	-999	-999	28.78	-1.1	65.5	80.5	-999	
	16	-999	-999	28.78	-0.2	120.2	76	-999	
	17	-999	-999	28.78	0.8	132.1	70.3	-999	
	18	-999	-999	28.78	2	153.3	67	-999	
	19	-999	-999	28.79	2.4	247	63.7	-999	
	20	-999	-999	28.79	3.9	242.4	62	-999	
	21	-999	-999	28.8	2.5	268.3	61.4	-999	
	22	-999	-999	28.8	1.3	257	59.4	-999	
	23	-999	-999	28.8	1.6	269.8	57.9	-999	
11/23/2005	0	-999	-999	28.8	2.2	223.9	55.9	-999	**165.1**
	1	-999	-999	28.79	2.1	203.4	54.5	-999	
	2	-999	-999	28.79	1.3	113	53.2	-999	
	3	-999	-999	28.79	2.8	91.7	53.5	-999	
	4	-999	-999	28.78	1.6	52.8	55	-999	
	5	-999	-999	28.79	0.3	104	55.7	-999	
	6	-999	-999	28.8	-0.5	190.1	55.6	-999	
	7	-999	-999	28.81	0.1	284.2	56.2	-999	
	8	1.6	339	28.82	-0.7	265.8	58.8	5.2	
	9	0.2	123	28.82	-0.9	197.6	63.6	5.1	
	10	2.6	93	28.81	-0.4	221.7	67.8	6.4	
	11	1	247	28.79	-1.5	103.1	70.7	5	
	12	3.8	262	28.77	-1.9	186.6	70.7	7.8	
	13	1.6	258	28.74	-1.3	129.9	71.1	4.7	
	14	0.9	280	28.71	-1.1	126.4	74.3	4.2	
	15	2.2	19	28.69	-0.3	162.8	74.3	6.4	

	16	1.4	28	28.69	0	134.6	72.9	6.8	
	17	1.8	245	28.7	0.5	186.4	69.7	4.6	
	18	2.4	304	28.71	0.6	252.3	68.5	6.5	
	19	0.7	209	28.71	0.1	221.8	66.7	8.6	
	20	3	257	28.73	0.2	189.4	65.8	7.5	
	21	0.7	3	28.73	0.6	129.1	65	6.7	
	22	2	158	28.73	0.5	102.2	63.8	8.3	
	23	1.2	7	28.72	1.5	88.9	63.4	3.7	
12/1/2005	0	1.8	97	28.82	0.4	85.1	50.9	6.2	**158.9**
	1	1	263	28.83	0.5	126.7	47.6	4.2	
	2	0.3	20	28.84	1.2	162.9	47	2.3	
	3	1.6	25	28.83	1.9	85.2	46.8	4.7	
	4	2.2	30	28.83	1.4	77.2	47.5	5.9	
	5	0.8	15	28.84	-0.4	113.1	46.1	3.9	
	6	1.1	147	28.84	0.2	232.2	42.7	6.1	
	7	2.1	277	28.86	-0.5	382.4	45.1	4.9	
	8	1.5	165	28.87	-1.1	323.2	53	4.1	
	9	2.2	95	28.88	-1	263.9	58.6	7.4	
	10	1.2	62	28.89	-1.2	136.2	67.6	4.6	
	11	3.8	95	28.86	-0.9	85.8	70.1	8.3	
	12	2.2	74	28.81	-1	58.7	72.6	8	
	13	1.9	88	28.78	-1.2	51.4	75.1	7.5	
	14	1.2	302	28.76	-1.5	46.6	76.2	4.8	
	15	1	238	28.75	-0.6	51	75.3	3.9	
	16	1.6	250	28.74	-0.4	83.1	71.8	4.7	
	17	1.9	271	28.74	0.5	111.3	67.4	4.9	
	18	1.6	145	28.74	1.1	249.7	62.4	3.6	
	19	0.4	284	28.75	1.2	172.7	60	3.1	
	20	0.1	166	28.76	2	230.9	58.4	2.3	
	21	0.6	102	28.77	2.5	267.1	56.1	4.8	
	22	0.4	46	28.77	2.5	237.1	55.4	3.6	
	23	2.5	106	28.78	1.2	179.7	55.2	5.7	
12/2/2005	0	1.9	79	28.77	0.7	65.7	55.3	6.8	**165.1**
	1	0.3	328	28.77	1.3	74.6	53.5	3.9	
	2	1.7	341	28.77	0.4	81.3	52.4	4.6	
	3	0.9	51	28.77	0.3	107.3	51.5	4.8	
	4	2.4	114	28.76	0	143.2	49.6	6.7	
	5	0.2	197	28.76	0.5	201.2	47.6	2	
	6	0.7	31	28.76	0.4	207.4	48.9	5.6	
	7	1.3	232	28.77	-0.2	286.6	48.4	5	
	8	1.6	260	28.78	-1.5	251	55.1	5.2	
	9	1.6	89	28.79	-1.2	246.4	61.4	7.5	
	10	2.2	147	28.79	-0.8	182.4	65.2	7.4	
	11	1.4	192	28.77	-2.1	137.9	68.7	6.7	
	12	0.9	94	28.75	-0.9	106.5	70.6	4.4	
	13	0.8	52	28.71	-0.7	102.4	72.3	5.8	
	14	0.8	336	28.7	-0.9	90.2	72	4.3	
	15	1.8	325	28.69	-0.8	86.6	71.3	4.5	

	16	1.2	341	28.68	0	76.5	69.4	4.5	
	17	0.6	333	28.68	0.8	146	66.7	2.2	
	18	0.8	219	28.67	0.4	179.5	63.6	2.5	
	19	0.8	126	28.67	0.8	265.9	61.9	4.3	
	20	0.5	255	28.67	0.2	267.4	60.7	3.1	
	21	0.5	259	28.67	0.6	265.6	59.4	5.7	
	22	2.5	147	28.66	0.8	226.7	57.6	5.1	
	23	0.7	341	28.66	0	162.9	58.4	3.5	
	0	1.1	100	28.8	2.2	115.3	50.1	3.3	
	1	1.8	327	28.79	0.3	133.9	50.2	4	
	2	0.8	313	28.78	-0.4	127.3	49.2	4.2	
	3	1	136	28.78	-1.2	128.1	49.5	4.8	
	4	0.5	244	28.78	-0.7	148.8	48.1	3.7	
	5	0.4	210	28.79	-0.8	275.9	48.3	3.4	
	6	0.6	171	28.81	-0.6	214.9	48.1	3.1	
	7	0.8	103	28.82	-0.3	292.5	48.7	3.2	
	8	0.9	151	28.83	-1	427.2	50.9	2.6	
	9	0.1	252	28.84	-1.1	321.4	55.7	2.1	
12/12/2005	10	1.4	29	28.85	-2.6	195.9	58.7	4.5	**206.9**
	11	3.7	60	28.82	-3	120.9	62.4	8.6	
	12	2.8	103	28.79	-3.6	117.9	63.7	7.9	
	13	2.4	239	28.79	-3	252.4	63	6.6	
	14	1.9	236	28.77	-3	247.8	64.5	6.4	
	15	1.6	219	28.77	-1.8	218.8	63.6	3.7	
	16	1.5	231	28.77	-0.9	207.5	62.4	5.1	
	17	1.3	244	28.77	-0.1	243.1	60.7	4.4	
	18	0.9	151	28.77	-0.3	223.6	59.4	7.2	
	19	1	315	28.79	0.1	147	58.5	3.8	
	20	1.1	84	28.79	0.3	170.3	57	5.7	
	21	0.8	110	28.8	0	181.1	56.8	3.3	
	22	1.8	291	28.79	0.5	217.9	53.8	4.7	
	23	0.9	161	28.79	0.4	235.1	50.5	4.4	
	0	2.1	122	28.78	1.8	142	48.1	5.1	
	1	0.6	309	28.78	0.8	144.4	46.1	3.3	
	2	0.4	206	28.79	0.7	199.2	44	2.1	
	3	0.4	175	28.79	0.6	185.1	42.5	2.3	
	4	0.4	172	28.79	0.9	196	41.6	2.3	
	5	1.2	161	28.79	0.6	253.7	40.9	3.4	
	6	0.9	181	28.79	0.2	204.7	40	2.8	
	7	1	187	28.81	0.2	267.8	39.5	3.1	
	8	1.1	143	28.83	-1.7	320.1	48.1	3.8	
	9	1.9	149	28.84	-3.1	231	53.3	6.5	
12/13/2005	10	2	162	28.85	-4.9	97.4	59.3	6.7	**166.1**
	11	1.7	250	28.83	-7.1	92	65.2	6	
	12	2.4	232	28.8	-5.8	103.8	65.4	6.4	
	13	2.3	271	28.77	-999	70	66	6.9	
	14	2.8	235	28.75	-999	71.3	67.4	8.1	
	15	2.6	238	28.75	-1.9	82.7	64.9	5.8	

	16	2.4	223	28.75	-0.5	148.2	63.6	5.6	
	17	1	166	28.75	0.9	123.9	58	2.6	
	18	0.7	216	28.76	2.1	196.8	55.6	3.1	
	19	1.4	94	28.77	1.4	186.4	53	4.4	
	20	2.1	71	28.78	1.7	189.4	51.9	4.9	
	21	1.3	16	28.78	2.3	143.9	50.6	3.1	
	22	1.2	324	28.79	1.1	169.3	48.1	3.2	
	23	0.9	122	28.8	2.8	166.7	46.4	3.6	
	0	1.5	157	28.8	0.5	156.4	44.4	3.6	
	1	1.5	275	28.8	0.7	135.9	42.3	3.2	
	2	0.5	355	28.81	1.6	127.6	41.8	3.1	
	3	0.1	103	28.82	1.3	151.6	40.4	2.8	
	4	0.8	77	28.81	1.6	191.7	39.4	3.7	
	5	0.2	335	28.81	1.4	264.7	39.2	3.2	
	6	0.2	90	28.83	0.6	226.7	39.1	4.6	
	7	0.6	268	28.86	0.3	393.6	39.4	4.4	
	8	0.7	217	28.88	-2.3	385.5	48.5	3.4	
	9	1.7	180	28.91	-4.9	344.5	54.1	5.1	
12/14/2005	10	1.8	104	28.92	-3.9	242.1	59.2	5.9	**181.3**
	11	1.8	143	28.88	-4.6	95.4	63.3	6.6	
	12	1.7	160	28.85	-5.5	63.6	65.4	6.4	
	13	1.7	206	28.81	-5.7	60.3	67.1	6.6	
	14	2.3	255	28.79	-4.6	76.9	69	7.3	
	15	3.9	252	28.79	-2.5	76.8	68.3	9	
	16	3	239	28.78	-0.5	104.6	65.1	8.3	
	17	0.8	201	28.78	1.2	135.8	59	2.9	
	18	0.3	269	28.78	2.2	177.4	56.3	4.9	
	19	1.9	86	28.8	1.6	323.8	54.8	4.7	
	20	0.7	61	28.8	1.5	205.3	52.8	4	
	21	1.5	107	28.81	1.7	193.6	51.4	7.8	
	22	1.1	127	28.82	1	95.7	49.6	5.2	
	23	0.4	206	28.82	1.6	120.6	46.6	5	
	0	1.7	336	28.81	2.1	122.4	45.6	6.4	
	1	0.5	141	28.79	1.3	102.8	44.1	3.3	
	2	0.2	345	28.78	1.8	106.5	43	3.5	
	3	0.8	205	28.78	1.1	120.7	42.1	3.8	
	4	0.5	344	28.76	1.2	172.9	43	2.6	
	5	1	226	28.76	0.3	224.3	44.1	5.9	
	6	0.9	8	28.76	0.8	258.2	44.1	3.6	
	7	0.8	17	28.75	0.8	375.7	43.2	2.8	
	8	0.8	156	28.75	-0.3	402	51.3	3.3	
	9	1	272	28.74	-1.8	329.5	54.8	6.2	
12/15/2005	10	5.1	275	28.75	-4.4	-999	58.3	9.6	**156.4**
	11	3	289	28.71	-5.6	-999	61.3	8.2	
	12	1.3	268	28.68	-4.5	70.5	63.9	5.4	
	13	2.4	237	28.64	-2.8	96.1	62.9	7.9	
	14	6.3	235	28.62	-2.2	164.9	60.9	11.6	
	15	6.6	247	28.61	-1.6	162.7	59	12.8	

	16	4.7	245	28.6	-0.8	138.5	57.6	9.9	
	17	4.5	262	28.6	-0.2	112.4	55.8	8.6	
	18	3.1	253	28.59	0.2	148.2	53.9	6.7	
	19	6.4	253	28.6	0.3	71.9	53.8	11.8	
	20	6	258	28.59	0.5	55.6	53.2	10	
	21	1.4	250	28.6	1.6	58	48.9	7.6	
	22	0.2	187	28.61	3.2	95.6	45.4	4.3	
	23	1.9	290	28.61	1.7	51.5	46.3	7.4	
12/21/2005	0	0.9	259	28.93	1.8	130.3	50.3	4.5	**200.4**
	1	0.7	224	28.93	0.5	145.2	48.3	5.4	
	2	1.3	149	28.94	1.7	138	46.4	5.5	
	3	0.5	16	28.93	1.3	112.1	46.3	3.6	
	4	0.4	227	28.92	1.5	164.7	45.8	3.7	
	5	1	43	28.92	1.7	157.1	46.7	4.4	
	6	1.4	328	28.93	0.6	259	46.7	5.6	
	7	1.6	219	28.95	0	264.7	44.9	5.9	
	8	0.3	182	28.97	-0.8	303	53.3	3	
	9	1	120	28.98	-0.8	331.6	61.3	4	
	10	0.7	271	28.98	-1.8	315.6	68.2	2.6	
	11	0.9	198	28.96	-2.5	202.7	73	3.4	
	12	0.4	151	28.91	-1.2	143.8	76.3	4.2	
	13	1	84	28.88	-0.9	146.3	78.4	5.5	
	14	1.5	67	28.86	-0.4	74.6	77.2	6.1	
	15	3.2	327	28.86	-0.6	114.7	75.8	6.2	
	16	2.2	320	28.85	0.1	144.4	75.3	4.6	
	17	0.2	331	28.85	2	147.6	68.7	2.6	
	18	0.3	206	28.85	3.5	192.9	62.8	2.4	
	19	1	359	28.86	2.6	253.3	60.5	5.2	
	20	0.7	37	28.87	2.8	306	58	4.2	
	21	2	116	28.87	3.2	259	57	3.9	
	22	0.8	40	28.87	2.9	295.2	54.8	2.6	
	23	1.4	330	28.87	2.1	207.7	52.9	4.7	
12/22/2005	0	0.7	208	28.86	1.2	176.6	51.6	8.1	**179.1**
	1	0.4	271	28.85	1.9	171.4	49.8	3.9	
	2	2.7	101	28.85	2.1	159.8	48.7	5.5	
	3	1.5	342	28.84	1.8	151.2	48.8	5.1	
	4	0.9	318	28.84	1.8	119.8	47.4	4.6	
	5	0.3	60	28.83	1.1	173.3	46.6	4.3	
	6	0.9	196	28.84	0.2	277.3	45.9	3.9	
	7	1.5	289	28.85	0	369	48	5.4	
	8	1.2	230	28.88	-0.8	335.3	51.3	5.4	
	9	1.1	164	28.89	-1.3	357.7	58.7	7.4	
	10	0.2	177	28.9	-1.1	298.9	66.3	4.7	
	11	2.6	95	28.87	-0.7	200.6	73.1	9.2	
	12	2.6	89	28.84	-1.4	27.2	76.2	6.9	
	13	2.8	76	28.8	-0.7	29.9	78.2	8.6	
	14	0.3	52	28.78	-1.7	46.2	79.9	5.3	
	15	1.1	238	28.77	-0.8	53.4	78.7	3.9	

	16	2.3	271	28.77	0.2	113.4	76.9	5.1	
	17	1.6	276	28.78	1.4	105.6	69.3	3	
	18	0.9	240	28.79	2.2	168.3	64.3	2.7	
	19	1.2	151	28.8	2	184.7	61.5	3	
	20	1.8	121	28.8	2.2	137.7	59.9	3	
	21	0.7	121	28.81	2.5	215.2	58.5	3.4	
	22	0.4	87	28.81	2	216.1	56.3	3.3	
	23	1.6	254	28.83	1.1	209.8	55.5	3.8	
12/23/2005	0	1.6	128	28.83	1.7	164.2	52.7	5.3	**157.6**
	1	3.1	59	28.8	0.7	97.2	55.5	9.1	
	2	2.7	295	28.84	0	161.3	55.1	12.3	
	3	3.4	103	28.83	0.7	128.1	52.8	6.4	
	4	1.2	310	28.83	0.1	126.9	51.1	3.9	
	5	0.6	194	28.85	0.6	181.8	49.5	5.5	
	6	0.5	337	28.83	0.5	210.4	48.6	4.5	
	7	1.2	289	28.86	0.8	263.4	48.9	4	
	8	0.9	128	28.87	0	404.8	52.5	3.4	
	9	1.6	250	28.9	-1.9	306	60.6	4.5	
	10	2.2	100	28.9	-2.1	172	67.4	5.8	
	11	2.1	134	28.86	-2.5	134.5	71.9	6	
	12	1.1	144	28.83	-1.7	56.4	75.1	7	
	13	3.3	240	28.8	-2.8	67	75.6	8.5	
	14	4.4	271	28.8	-2.6	58.1	76.3	10	
	15	3.2	257	28.8	-1.7	56.1	77.5	9.8	
	16	2.1	270	28.81	-0.7	54.4	76.1	4.8	
	17	2.3	240	28.81	1	86.3	68.8	4.5	
	18	1.3	55	28.83	2.3	196.9	65.1	4.2	
	19	1.5	50	28.85	2.8	215.6	63.2	3.8	
	20	1.9	84	28.85	2.3	167	60.2	4.3	
	21	1.7	16	28.86	2.3	183.5	58.8	4.9	
	22	0.8	204	28.87	1.5	126.3	56	5.2	
	23	0.9	276	28.88	0.8	163.6	53.5	3.4	
1/10/2006	0	0.9	197	28.95	2.7	94.7	44.6	3.9	**155.6**
	1	1	172	28.95	3.4	80	44.3	4	
	2	0.4	208	28.95	3.1	71.1	43.4	2.9	
	3	1	311	28.94	3.8	89.1	41.6	3.1	
	4	0.6	340	28.93	3.7	298.2	40.9	2.8	
	5	1.1	331	28.92	3	287.9	40.3	3.1	
	6	1	296	28.93	2.5	334	40.3	2.7	
	7	0.8	271	28.94	2.1	370.9	40.9	2.5	
	8	0.3	325	28.96	0.6	403.6	52.3	2.4	
	9	0.2	319	28.97	-2.1	220.3	64.7	3.9	
	10	0.8	63	28.97	-0.9	132	69.9	5.8	
	11	4.7	66	28.93	-0.8	71	71.8	14.6	
	12	6.8	79	28.89	-1	49.4	72.6	14.5	
	13	4.8	71	28.86	-0.8	26.1	74.3	10.7	
	14	4.5	93	28.83	-0.7	24.6	75.4	13.5	
	15	1.8	72	28.82	-0.5	30.4	76.5	10.7	

	16	1.2	44	28.81	0	29.3	75.2	5.5	
	17	1	215	28.8	0.7	48.8	67.2	4	
	18	2.4	229	28.8	1.4	110.5	61.5	5.3	
	19	0.9	327	28.8	3.2	153.5	56.2	2.1	
	20	0.6	67	28.81	3.8	189.9	53.6	2.3	
	21	1.7	137	28.81	2.6	211.7	52.3	2.7	
	22	0.9	253	28.82	2.2	186.6	49.1	5.2	
	23	0.9	178	28.82	1.1	220	47.7	6.3	
	0	2.4	115	28.81	2.5	122.7	46.7	5	
	1	0.5	107	28.8	1.5	90.4	46.1	5.3	
	2	0.8	200	28.81	1.4	157.9	43.3	3.7	
	3	1.7	232	28.8	0.9	132.1	41.6	4.2	
	4	1.2	318	28.8	1.6	141.2	40.7	3.8	
	5	1.7	314	28.8	1.9	212.9	40.7	4.7	
	6	0.7	289	28.8	1.2	264.5	39.6	2.9	
	7	0.7	221	28.81	0.7	418.2	38.6	2.6	
	8	1.5	294	28.82	-0.7	421.5	45	4	
	9	1.3	143	28.83	-1.8	431.8	56.6	4.8	
1/11/2006	10	3.2	61	28.83	-0.9	188	64.3	9.4	**169.3**
	11	1.3	124	28.81	-1.2	84.2	69.2	5.7	
	12	1.3	148	28.77	-1.1	71.4	70.3	6.7	
	13	3.6	96	28.72	-0.8	50.8	71.9	8.7	
	14	0.3	177	28.7	-1.9	44.2	74	7.2	
	15	2.9	252	28.7	-2	65.9	73.6	7.6	
	16	1.9	248	28.69	-0.2	66.4	72.5	5.2	
	17	3.9	260	28.69	0.9	106.8	66.8	6.7	
	18	3.4	263	28.7	1.8	155	61.3	6.1	
	19	1.9	153	28.7	3.4	153.3	56.1	4	
	20	1.8	84	28.69	2.7	136.2	54.8	5.2	
	21	0.8	351	28.69	2.3	180.6	51.3	3.2	
	22	1.5	357	28.69	2.2	165.1	50.7	4.5	
	23	1	9	28.71	2.7	201.4	48.4	3.9	
	0	1.4	130	28.71	1.4	146.2	46.2	4.5	
	1	1.1	158	28.71	1.1	140.4	43.9	4.6	
	2	1.6	1	28.73	2.7	142.5	44	4.7	
	3	0.4	93	28.72	1.9	152.2	41.9	1.8	
	4	1.1	53	28.71	1.2	145	41.9	4.2	
	5	1.4	355	28.73	0	155.3	42.5	5.3	
	6	1.4	145	28.75	0.1	275.3	40.8	3.4	
	7	2	289	28.77	1.7	264.1	39.2	4.8	
	8	1.7	335	28.8	0.1	272.8	45	5.5	
	9	1.2	193	28.82	-1.5	293.4	55	3.9	
1/12/2006	10	0.9	117	28.83	-0.9	190.7	63	3.6	**170.1**
	11	2.1	108	28.82	-0.7	-999	66.1	5.8	
	12	2.6	95	28.79	-1	-999	69	8.6	
	13	1.6	143	28.76	-2	90.4	71.4	6.1	
	14	2.7	227	28.75	-2.4	73.2	72.6	7.1	
	15	3.5	235	28.74	-2.2	63.1	72.1	7.4	

	16	2.5	269	28.74	-0.8	59.4	71.7	5.8	
	17	2.5	284	28.75	0.7	90.2	67	5.2	
	18	1.9	294	28.77	1.8	141.5	61.1	5.6	
	19	0.5	312	28.78	3	189.1	57.2	3.1	
	20	1.3	108	28.79	3.9	162	55.3	3.8	
	21	1.7	85	28.8	2.8	210.3	53.2	3.8	
	22	1	243	28.82	2.8	202.7	51.4	3.8	
	23	1.4	83	28.83	2.7	282.5	49.7	7.1	
1/19/2006	0	2.8	84	28.7	0.7	90.9	51.8	5.4	**183.9**
	1	2.2	82	28.69	1.1	84.9	50.3	6.6	
	2	1.3	97	28.68	0.1	89	49.7	4.9	
	3	0.7	155	28.67	0.1	136.4	47.2	3.5	
	4	2.6	121	28.66	0.3	129.5	47.5	5.9	
	5	2.6	103	28.65	0.1	115.7	47.7	6	
	6	1.1	78	28.65	0.1	109.7	47.8	3.2	
	7	2.6	269	28.66	0.3	342.4	45.8	6.7	
	8	1.8	204	28.67	-0.3	330.9	51.4	6.3	
	9	3.5	237	28.69	-2.2	160.8	60.7	10	
	10	10.1	240	28.7	-1.8	332.5	61.9	23.3	
	11	16.1	246	28.69	-1.6	832.9	62.1	34	
	12	16.2	245	28.68	-2.2	605.2	63.3	32.2	
	13	15.9	245	28.68	-2.3	459.2	63.9	30.9	
	14	12.9	265	28.68	-2	87.4	64.6	27.2	
	15	11.4	285	28.7	-1.5	156.2	63.3	26.4	
	16	10.6	296	28.72	-0.8	71.8	60.9	23.1	
	17	8.5	283	28.74	-0.2	14.2	59.2	19.3	
	18	5.4	267	28.76	-0.2	28.9	57.2	13.1	
	19	3.6	265	28.78	-0.1	33.2	55.3	11.4	
	20	1.9	257	28.8	0.2	32.5	53.4	8.6	
	21	3.8	244	28.82	0.6	46.7	50.6	8.3	
	22	1.1	186	28.83	2	56.2	46.8	4.2	
	23	1.3	264	28.84	3.3	65.7	44.7	3.3	
2/15/2006	0	3.4	43	28.57	2.3	94.7	55.8	8.1	**157.5**
	1	3.6	52	28.58	1.2	71.3	54.3	8.4	
	2	0.9	65	28.59	1.6	68	51.8	4.9	
	3	1.3	117	28.58	1.9	104	48.5	4.4	
	4	1.3	31	28.59	2	97.2	47.8	5.8	
	5	1.3	101	28.6	2.1	182.1	46.7	8.4	
	6	2.3	86	28.6	1.5	164.3	47.2	7.4	
	7	3	67	28.6	0.7	130.8	53.3	7.9	
	8	3.2	74	28.61	-2	125.4	64	7.8	
	9	1.5	226	28.62	-2.8	243	70.4	6.5	
	10	4	259	28.64	-3.3	147	71.3	9.9	
	11	3.4	270	28.63	-3.9	44.1	72.9	9.7	
	12	-999	-999	28.6	-3.1	46.3	74.1	-999	
	13	-999	-999	28.57	-3.6	56.2	75.9	-999	
	14	-999	-999	28.52	-3.6	169.4	77.4	-999	
	15	14.1	239	28.49	-2.1	630.4	78.7	27.9	

	16	15.5	247	28.47	-1.8	490.2	78.4	27.4	
	17	15.1	260	28.47	-0.6	323.3	75.2	28.8	
	18	13.3	263	28.48	-0.4	221.8	70.8	25.6	
	19	14	272	28.51	-999	161.2	67.4	26.8	
	20	7.3	271	28.54	-999	64.9	64.8	16.3	
	21	5	254	28.56	-0.4	57.3	62.3	10.5	
	22	6.4	230	28.57	-0.4	47.5	61.2	12.9	
	23	6.6	230	28.6	-0.4	41.5	60.9	14.2	
3/10/2006	0	6.2	233	28.37	-0.2	27.2	58.8	13.1	**240.7**
	1	4.5	221	28.37	-0.1	25.9	57.5	10	
	2	6.4	227	28.37	-0.1	29.9	56.8	14.9	
	3	9.4	260	28.36	-0.2	40.8	56.1	17.4	
	4	5.8	266	28.36	-0.4	41.9	55.1	14.1	
	5	7	278	28.37	-0.8	50.9	55.4	16.9	
	6	5.8	240	28.4	-0.1	60.7	53.9	14.6	
	7	7.1	257	28.42	-0.3	70.9	55.3	20.1	
	8	13.3	258	28.45	-1.4	214.2	58.6	23.5	
	9	15.1	259	28.47	-2.2	466.6	59.9	27.6	
	10	15.2	270	28.48	-2.9	522.7	61.6	32.1	
	11	15.5	251	28.48	-3.2	396.1	64.1	28.1	
	12	17	258	28.47	-3.3	651.6	65.4	36	
	13	18.8	254	28.46	-999	906.1	65.4	34.5	
	14	20.2	260	28.45	-999	948.8	65	36.1	
	15	19.4	267	28.45	-999	739.3	64.9	40.7	
	16	17.1	279	28.45	-2	203.5	62.6	31.2	
	17	11.8	291	28.44	-1.2	42.2	60.2	22.6	
	18	7.4	291	28.44	-0.7	36.6	57.4	15.7	
	19	5.4	293	28.44	-1	41.3	56.8	9.4	
	20	5.2	272	28.45	-0.8	46.9	56	10.7	
	21	4.3	267	28.47	-0.7	56	54.1	11.3	
	22	5.3	280	28.48	-0.9	49.3	53.8	9.3	
	23	11.4	247	28.5	-0.7	108.7	53.6	25.6	

Table BI3. Continuous PM-10 Monitoring Data for All Exceedance Days at Buckeye Site

Date	Hour	WSPD mph	WDIR	PRESS	PM-10 μg/m^3	TEMP °F	Relative Humidity	WSMAX mph	24-Hour PM-10 Avg (μg/m^3)
	0	2.1	296	28.84	41.4	92.1	22.5	16.4	
	1	3.5	186	28.85	36.4	89.2	25.6	10	
	2	2.3	280	28.84	54.2	87.2	28.5	5.5	
	3	2.6	276	28.86	54.2	85.1	31.8	6.3	
	4	3.4	335	28.87	61.5	81.6	35.7	6.2	
	5	3.7	12	28.89	88.8	81.3	37.2	6.6	
	6	3	32	28.9	186.4	82.9	38.3	8.3	

6/21/2005	7	0.7	182	28.92	195.8	86.7	37.8	3.5	**158**
	8	1	118	28.93	256.3	86.9	44.1	6.1	
	9	3.2	86	28.93	153.5	93.7	28.3	8.9	
	10	4.2	78	28.94	127.6	99.6	20.3	10.6	
	11	3.4	76	28.92	101.1	103.5	17.2	9.1	
	12	1.7	154	28.9	61.1	106.1	15.2	6.9	
	13	3.1	276	28.87	91.8	109.8	14.2	9.6	
	14	5.9	290	28.85	114	111.7	13.7	10.6	
	15	6.4	289	28.82	72.4	112.4	14.1	12.7	
	16	4.7	297	28.8	46.7	112.4	13.4	10.3	
	17	8.7	211	28.8	654.4	107.8	14.5	50.1	
	18	12.3	275	28.8	448.2	103.9	16.5	36.7	
	19	4.6	311	28.8	148.6	100.3	19.5	12	
	20	0.9	139	28.82	80.6	99.3	21	5.7	
	21	6.6	66	28.85	82.5	98.5	21.3	29.2	
	22	6.1	130	28.92	546.7	99.4	20.8	26.3	
	23	4.8	36	28.9	87.6	98.1	21.3	17.3	
11/18/2005	0	1.3	29	29.17	61.5	50.7	49	8.4	**169.6**
	1	3.9	45	29.18	53.3	59.7	32	17.1	
	2	13.8	52	29.18	302	67.9	19.2	29.2	
	3	16.5	54	29.18	338.6	67.1	18.6	32.9	
	4	14.8	55	29.19	163.3	65.8	19.2	31.6	
	5	8.6	56	29.23	29.1	62.9	22	19	
	6	13	48	29.24	73.7	63.2	21.8	25.7	
	7	16.4	40	29.25	291	64.6	20.6	33.9	
	8	15.6	45	29.26	533.8	67	18.7	34	
	9	20.4	52	29.26	693.3	69.2	17.3	40.7	
	10	19.7	54	29.27	385.2	71.4	16.4	40.6	
	11	18.4	51	29.25	168.3	73.6	15.4	38.3	
	12	14.4	40	29.23	75.1	75.4	15.6	31.6	
	13	11.1	37	29.21	37.6	77	14.9	24.7	
	14	9.2	34	29.18	23.3	78.4	13.9	23.5	
	15	7.6	42	29.17	32.9	78.6	13.7	17.9	
	16	5.1	56	29.15	38.9	77	15.3	13.1	
	17	1.2	42	29.14	186.7	70.9	18.8	4.2	
	18	1.9	302	29.14	228.7	63.7	23.8	5.5	
	19	4.2	313	29.15	91.1	61.4	24.3	8.5	
	20	0.6	108	29.15	67.6	56.2	32.4	7.5	
	21	0.5	350	29.15	81.4	51.4	43.1	3.7	
	22	1.5	208	29.16	73.1	49.9	45.1	6.8	
	23	1.1	311	29.16	42.1	47.2	50.8	6.8	
	0	0.3	65	29.21	50.6	46.6	29.7	3.9	
	1	1.7	344	29.2	46.5	45.6	29.6	5.5	
	2	1.9	93	29.19	62.5	44.2	33.8	6.1	
	3	2	294	29.18	61.3	40.6	43	5	
	4	3	329	29.17	42.5	40.1	39.1	5.8	
	5	1.1	326	29.16	71.1	38.8	39.4	4.9	

2/13/2006	6	2.4	317	29.17	98.7	37.5	56.7	7.6	**159.7**
	7	1.4	7	29.19	292	39.2	38.1	8.3	
	8	1.7	260	29.2	381.9	44.6	38	6.2	
	9	0.7	241	29.21	188.9	52.3	27.8	3.6	
	10	4.6	74	29.22	107.9	64.4	17.8	14.1	
	11	5.3	102	29.2	84.2	67.8	15.2	12.9	
	12	1.2	91	29.18	51.6	70.9	13.3	5.8	
	13	2.9	265	29.14	48.9	75.1	12.4	9.9	
	14	3.1	299	29.1	50.5	76.3	11.6	10.8	
	15	3.1	274	29.07	54.5	77.2	10.3	7.5	
	16	3.5	277	29.05	54.1	77.2	10.8	8.2	
	17	3.3	255	29.05	68.1	74.9	13.4	6	
	18	2.3	243	29.04	81.9	70.2	15.9	3.8	
	19	1.3	313	29.05	412.5	63.2	17.7	5.6	
	20	4.6	351	29.05	438.4	58.1	19.3	10.7	
	21	1.1	153	29.06	274.2	54.6	30.5	6.3	
	22	3.4	96	29.06	324.4	57.1	25.4	9.4	
	23	1.6	27	29.04	485.7	50.1	31.7	4.9	
2/14/2006	0	4.7	33	29.03	613.6	49.2	29.7	9	**272.9**
	1	2.4	73	29.03	665.7	47.9	37.4	6.7	
	2	2.4	65	29.01	555.3	46.1	40	6.2	
	3	2	63	28.99	333.1	46.2	36	6.1	
	4	3.3	18	28.98	646.1	44	42.1	7.8	
	5	2	353	28.98	257	41.9	35.7	6.9	
	6	2.7	107	28.97	145.8	43.8	40.2	6.8	
	7	0.6	62	28.98	359.1	42.4	49.5	6.7	
	8	4.9	84	28.99	336.2	50.1	34.7	10.8	
	9	6.5	83	28.98	142	55.5	29.4	13.6	
	10	8.7	87	28.98	135.4	62.8	20.3	17.2	
	11	8	103	28.97	120	65.6	19.5	13	
	12	6	96	28.94	109.5	68.2	19	14.1	
	13	3.3	74	28.89	58.9	72.5	14.5	8.8	
	14	1	290	28.87	78.5	75.5	12.2	7.4	
	15	3.9	301	28.85	123.3	76.6	11.6	7.9	
	16	3.9	284	28.84	105.8	76.6	13.4	9.1	
	17	4.7	244	28.82	68	73.3	18.5	10.7	
	18	3.1	288	28.82	74.3	68.8	18	9.1	
	19	5.6	213	28.83	82	66.2	19	11.1	
	20	4.2	237	28.84	36.1	62.3	23.3	8.9	
	21	0.8	15	28.85	672.3	59	22.8	5.2	
	22	3.5	34	28.85	254.5	56.4	23.5	10.1	
	23	4.1	27	28.86	577.8	53.1	25.6	6.9	
	0	1.6	340	29.02	275.5	51.2	30.2	5.3	
	1	4.4	337	29.02	589.2	50.5	26.3	7.8	
	2	0.7	220	29.01	210	49.7	35	6.6	
	3	0.5	277	29	222.4	49.1	36.4	4.7	
	4	1.3	70	29	212.9	49.4	36.8	3.6	

2/17/2006	5	0.7	136	29	106.3	48.9	42.6	3.9	191.9
	6	0.6	292	29.01	140.5	48.8	40.2	2.6	
	7	0.7	116	29.02	291.5	49.5	35.3	3.4	
	8	1	73	29.03	224.4	50.9	34.9	3.4	
	9	1.2	35	29.04	170	54.2	29.7	4.1	
	10	1.1	326	29.04	179.9	56.8	27.4	3.4	
	11	2.3	242	29.04	197.5	58.5	31.8	4.9	
	12	4	267	29.04	45.7	60.6	24.3	7.9	
	13	6.5	281	29.02	82.4	61.7	18.7	10.3	
	14	6.4	276	29	48.8	62	15.8	10.1	
	15	5.3	276	29	130.7	61	19.2	8.6	
	16	3	281	28.99	155.6	60.4	19.7	6	
	17	2.1	273	28.99	117.6	59.6	19.5	4.2	
	18	2.2	307	28.98	84	58.8	19.3	5.8	
	19	1	41	28.99	299.2	55.3	23	4.8	
	20	0.8	130	29.01	347	51.7	29.5	3.1	
	21	1.9	310	29.03	124.8	46.8	30.6	4.2	
	22	3.1	350	29.04	91.9	43.4	30.1	6.2	
	23	0.5	120	29.05	258	42.6	34.6	3.2	

Table BI4. Continuous PM-10 Monitoring Data for All Exceedance Days at Higley Site

Date	Hour	WSPD mph	WDIR	PRESS	DELT °F	PM-10 μg/m³	TEMP °F	WSMAX mph	24-Hour PM-10 Avg (μg/m³)
1/24/2006	0	7.2	54	28.53	3.8	47.8	54.6	12.3	**159.6**
	1	3.8	78	28.51	4.9	49	52.2	7.3	
	2	5.7	70	28.54	5.2	43.8	52.8	13	
	3	2.6	61	28.52	5.9	24.1	50.1	6.4	
	4	2.4	349	28.51	5.1	45.3	47	4.9	
	5	3.2	6	28.51	4.3	78.9	47.2	5.9	
	6	0.9	1	28.52	4.8	178.3	47.1	5.5	
	7	1.1	207	28.53	3.5	149.4	47.9	7.1	
	8	1.6	97	28.54	1.9	376.1	49.6	6.1	
	9	1.9	255	28.57	0.5	218.3	54.9	5.3	
	10	2.5	304	28.57	-0.3	177.4	60.9	7.3	
	11	9.5	99	28.55	-0.6	201.6	69.9	23	
	12	11.8	108	28.51	-0.2	302.4	73.5	23.7	
	13	13.8	122	28.49	-0.3	684.3	74.4	28.1	
	14	16.9	116	28.46	0	729.9	74.3	27.8	
	15	15.3	103	28.45	0	267.4	75.2	27.3	
	16	14.6	109	28.45	0.1	191.8	75.1	25.8	
	17	10.2	104	28.45	0.7	82.2	71.2	20.5	
	18	8.7	91	28.45	1.8	37	65.5	11.9	

	19	9	91	28.45	1.8	39.1	63.8	14.4	
	20	10.9	99	28.45	0.7	28.7	66.3	19	
	21	12	105	28.45	0.4	54.7	67.4	22.5	
	22	8.8	127	28.45	1.1	30	65	19.9	
	23	7.2	168	28.48	1.1	53.3	63.7	14.8	

Note: 999 Refer to Data Not Available

ATTACHMENT II

MODEL DOMAIN SELECTION

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Nomenclature

ADEQ	Arizona Department of Environmental Quality
AERMOD	AMS/EPA MODel
ASU	Arizona State University
CMAQ	Community Multiscale Air Quality Model
EDAS	Enhanced Data Acquisition System
HYSPLIT	Hybrid Single-Particle Langrangian Integrated Trajectory
ISC	Industrial Source Complex
MCAQD	Maricopa County Air Quality Division
MSL	Mean Sea Level
MSL	Mean Sea Level
NOAA	National Oceanic & Atmospheric Administration
PM-10	Particulate Matter 10 microns in diameter or smaller
SLAMS	State and Local Air Monitoring Sites
TEOM	Tapered Element Oscillating Microbalance
UAM	Urban Airshed Model
UTC	Universal Transverse Mercator

1. Model Domain Selection

The following steps were considered in selecting the domains for AERMOD and rollback modeling:

- PM-10 nonattainment area boundaries
- Location of meteorological and air quality monitoring sites
- Distribution of major emissions sources
- Deposition and concentration of pollutants
- Previous PM-10 studies

Selection of the modeling domain takes into consideration all of these factors, as explained below.

1.1 PM-10 Nonattainment Area Boundaries

A 3,000 square mile area of Maricopa and Pinal Counties is a Serious nonattainment area for PM-10. The nonattainment area is located in a valley at an elevation of 1,105 feet above mean sea level (MSL) and is completely surrounded by mountains. The Salt River/South Mountains are located on the southern border of the study area and rise to an elevation of 2,507 feet above MSL. To the northwest, the Phoenix Mountains rise to an elevation of 2,310 feet above MSL. The Estrella Mountains are located to the southwest of the study area and have an elevation of 3,320 feet above MSL. On the western boundary, the White Tank Mountains rise to an elevation of 4,026 feet above MSL. On the eastern boundary, the Superstition Mountains rise to an elevation of 4,620 feet above MSL[7].

1.2 Location of Meteorological and Air Quality Monitoring Sites

Air quality monitoring networks operate in urban and rural areas throughout Arizona. ADEQ and MCAQD continually monitor and assess air quality in the metropolitan centers, as well as in more remote areas of the state. There are 20 PM-10 monitoring stations in the Maricopa County PM-10 nonattainment area. MAG has analyzed the air quality data from these monitors for March 2005 to March 2006. During this period, the Buckeye, Durango Complex, Greenwood, Higley, and West 43rd Avenue monitors exceeded the 24-hour PM-10 standard. Most of the exceedances occurred at Durango Complex and West 43rd Avenue which are located in the Salt River Study Area. Figure 1-1 shows the location of the PM-10 monitoring sites in or near the nonattainment area[2].

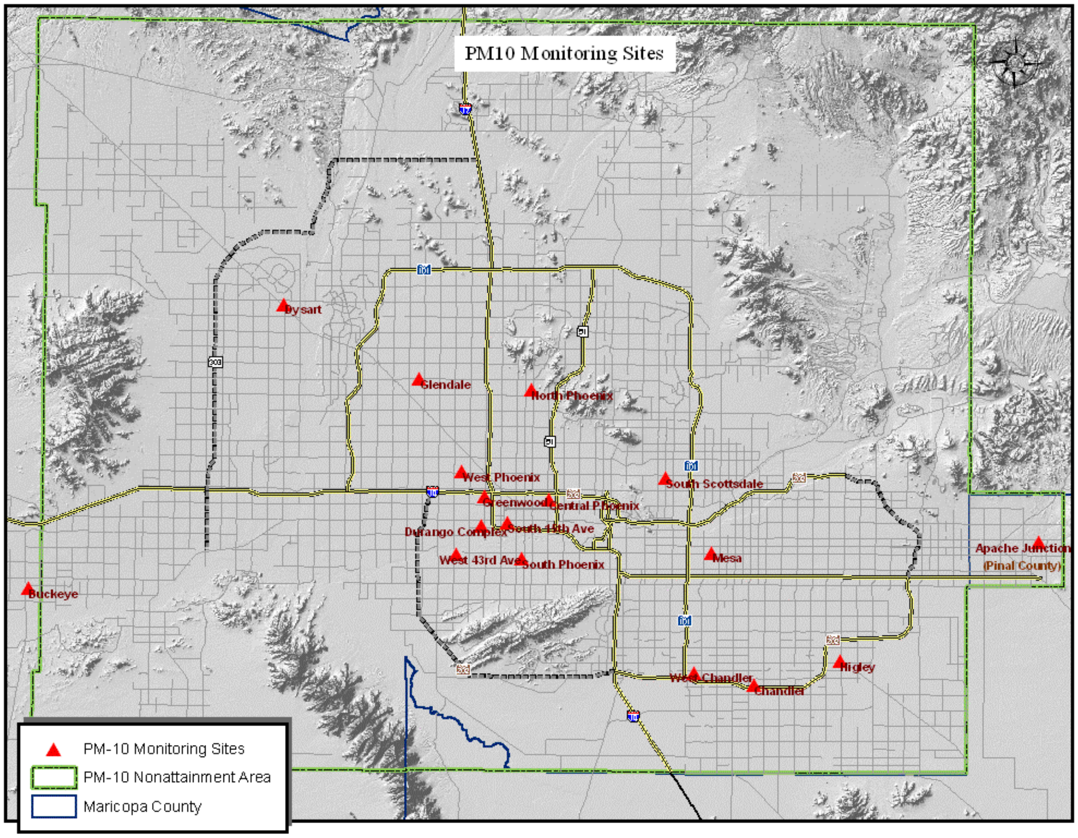

Figure 1-1 PM-10 Monitoring Sites In or Near the Maricopa County PM-10 Nonattainment Area as of 12/31/2005

1.2.1 Durango Complex

This monitor began operation on January 6, 1999. Continuous co-located PM-10 and PM-2.5 monitors currently operate at this site. Instruments that measure wind speed/direction and atmospheric pressure are also located at Durango[3].

Figures 1-2, 1-3, and 1-4 show the satellite imagery around the Durango Complex monitor at elevations of 6,462 feet, 34,493 feet, and 18.2 miles, respectively. All of the satellite photos were taken in December 2005. Figure 1-5 shows the 36-hour backward trajectory analysis at the Durango Complex monitor on December 12, 2005 conducted at heights of 10m, 100m and 800m. The backward trajectory analysis was done using the NOAA HYSPLIT model. The start time for the analysis was 07:00 a.m. UTC on December 12, 2005. EDAS 40km meteorological data was used.

Figure 1-2 Satellite Imagery around Durango Complex (Red Dot) at 6,462 ft

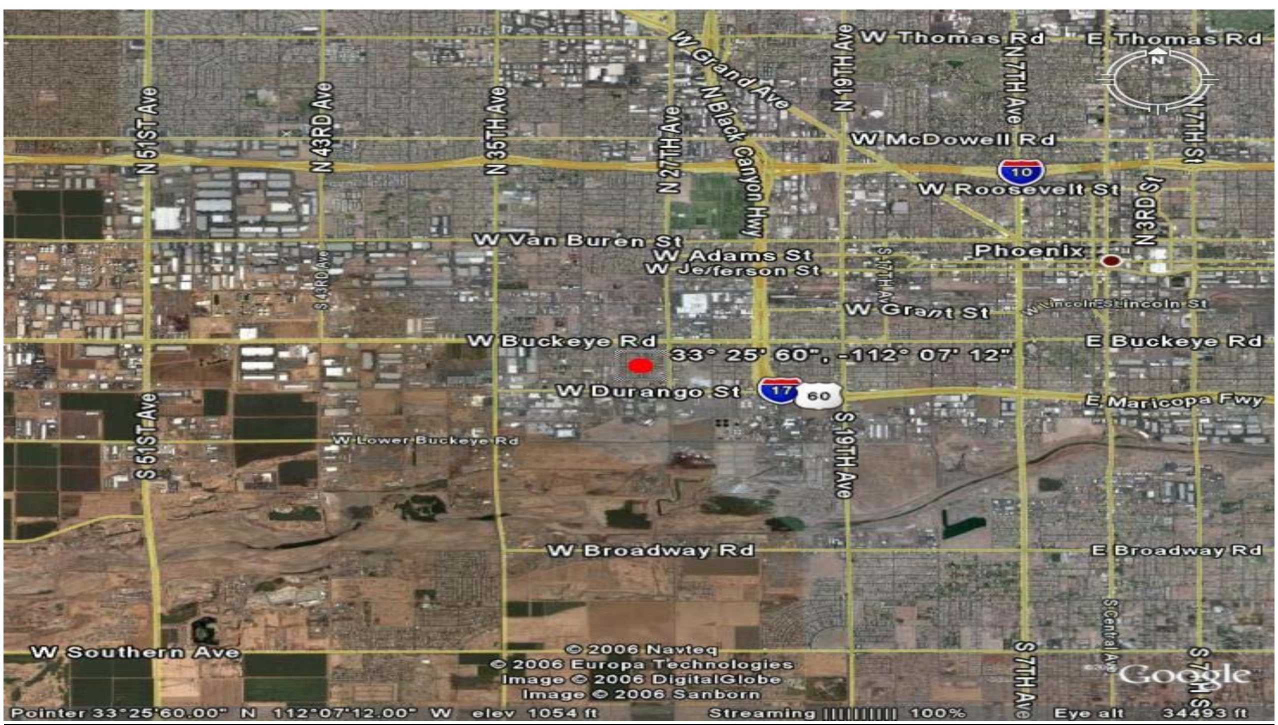

Figure 1-3 Satellite Imagery around Durango Complex (Red Dot) at 34,493 ft

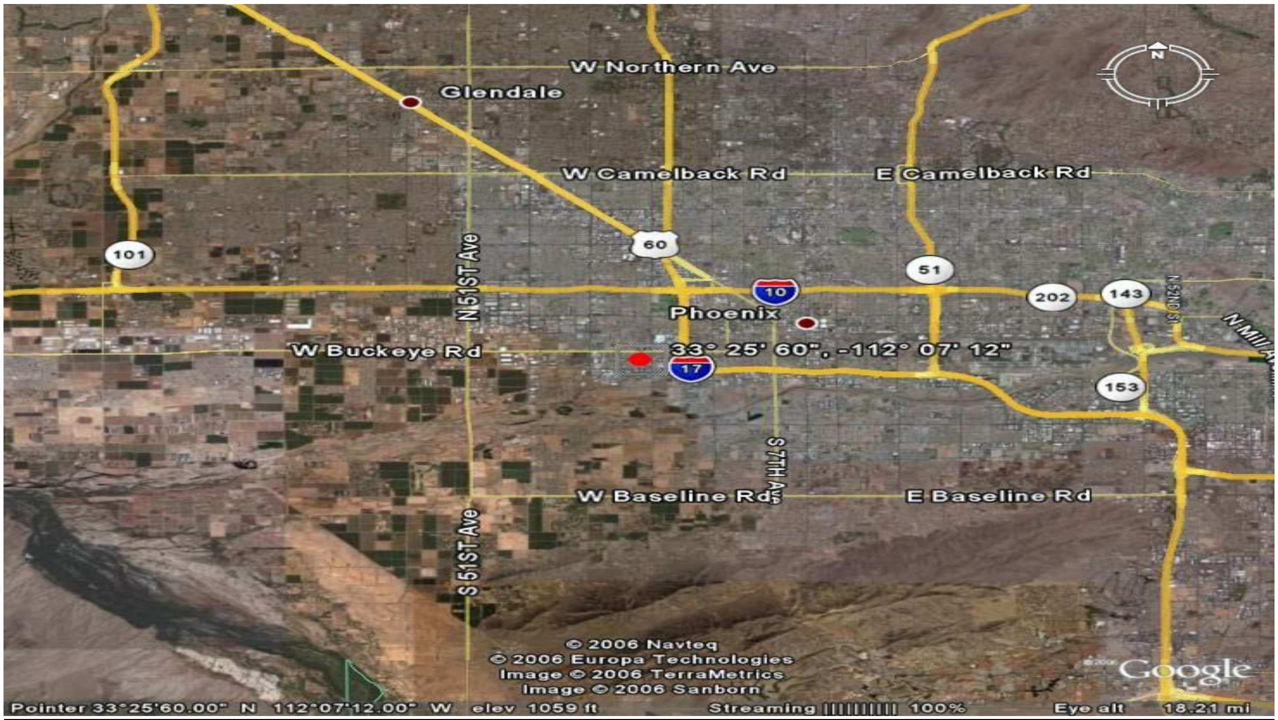

Figure 1-4 Satellite Imagery around Durango Complex (Red Dot) at 18.2 miles

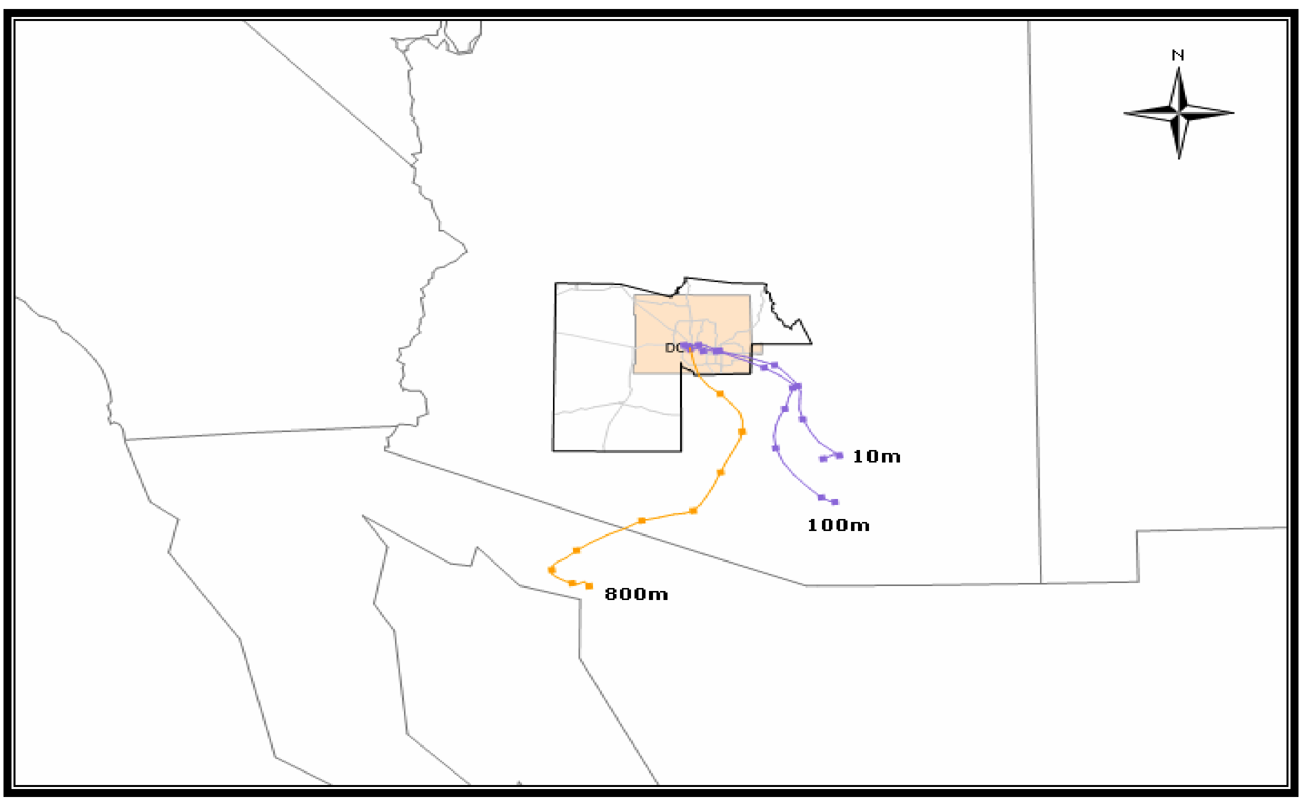

Figure 1-5 Backward Trajectories for December 12, 2005 – Durango Complex

1.2.2 West 43rd Avenue

This monitoring site is surrounded by a combination of heavy industry and residential homes. The site has one continuous TEOM PM-10 monitor and a temperature inversion instrument. The main purpose of the monitor is to measure maximum concentrations of PM-10 and determine the impact on ambient pollution levels of significant sources or source categories[3]. The sources around the site include sand and gravel operations, auto and metal recycling, landfills, paved and unpaved haul roads, and cement casting. Figures 1-6, 1-7 and 1-8 show the satellite imagery around the West 43rd Avenue monitor captured at elevations of 10,298 feet, 20,176 feet and 10.1 miles, respectively. All of the satellite photos were taken in December 2005.

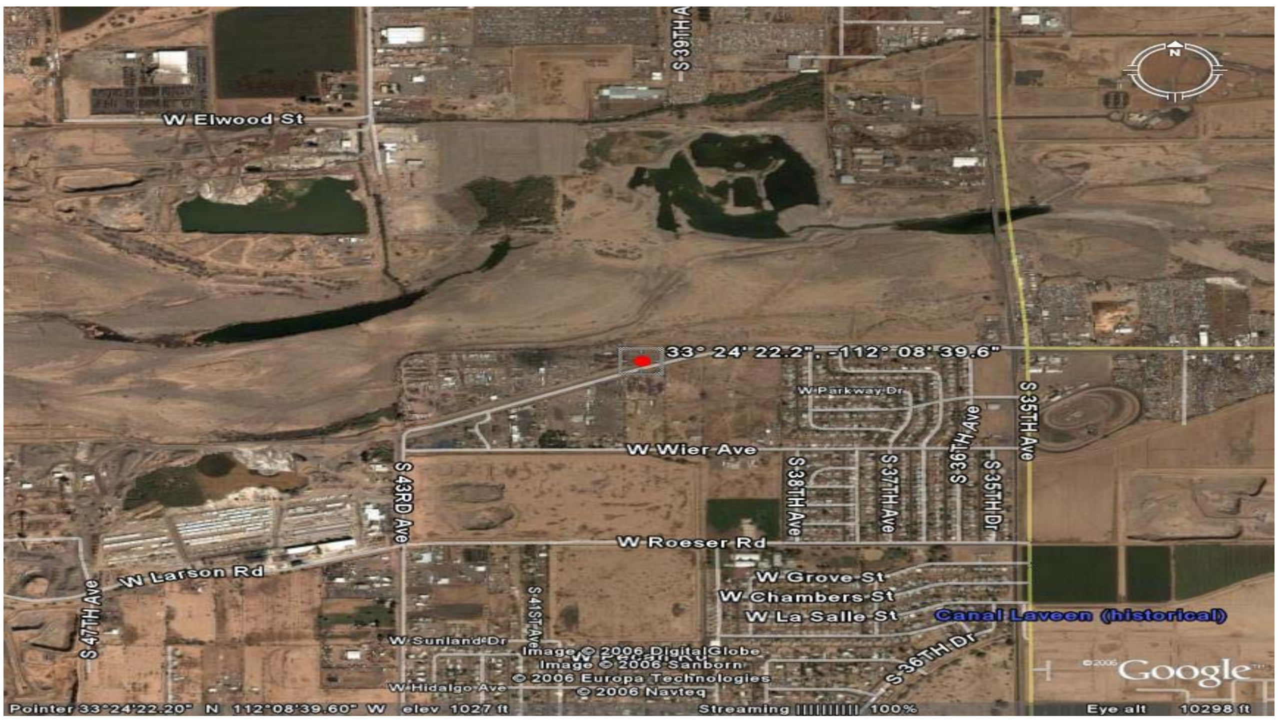

Figure 1-6 Satellite Imagery around West 43rd (Red Dot) at 10,298 ft

Figure 1-7 Satellite Imagery around West 43rd (Red Dot) at 20,176 ft

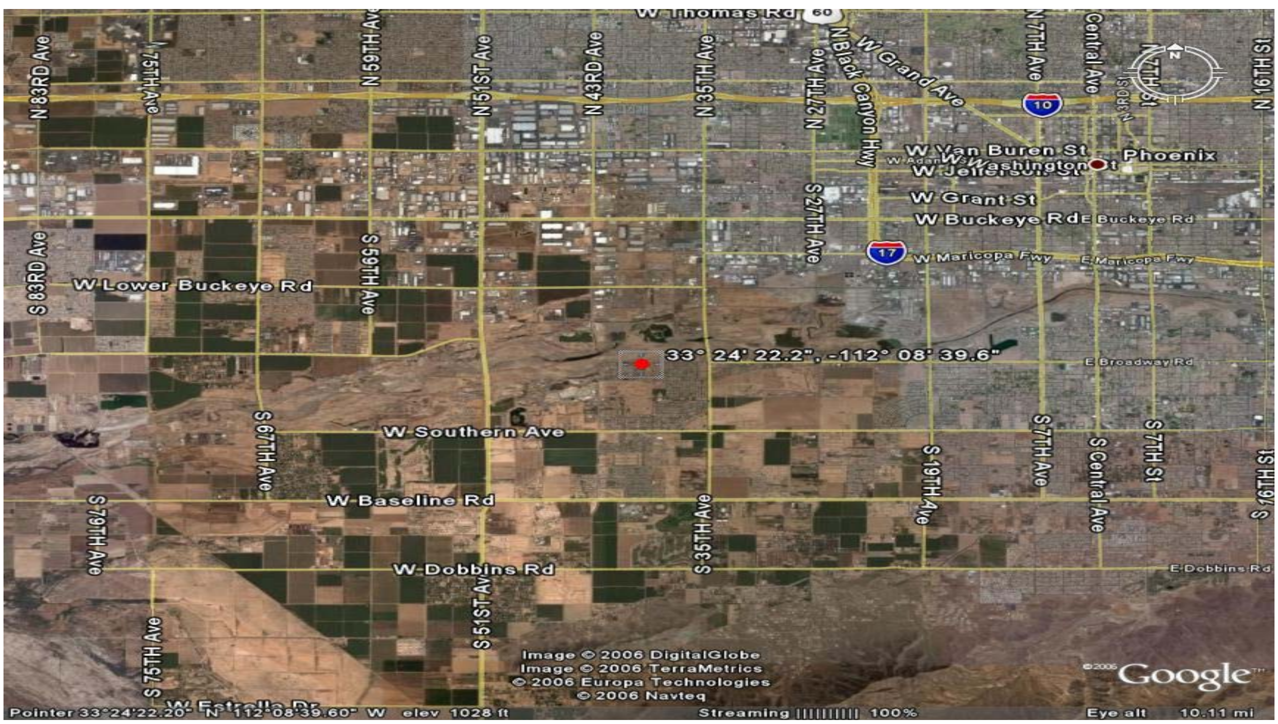

Figure 1-8 Satellite Imagery around West 43rd (Red Dot) at 10.1 miles

1.2.3 Higley

In 1994, ADEQ set up this site to monitor background particulate concentrations near the urban limits of Maricopa County. Since then, urban expansion has enveloped the site, so the monitor no longer serves its original intended purpose. MCAQD installed a (1-in-6 day) PM-10 (SLAMS) in the second quarter of 2000. On October 1, 2004, the 1-in-6 day PM-10 monitor was replaced with an hourly continuous PM-10 monitor[3]. Figures 1-9, 1-10 and 1-11 show the satellite imagery around the Higley monitor at elevations of 6,152 feet, 12,013 feet, and 26,569 feet, respectively. All of the satellite photos were taken in December 2005. Figure 1-12 shows the 36-hour backward trajectory analysis at the Higley monitor on January 24, 2006 taken at heights of 10m, 100m and 800m. The backward trajectory analysis was done using the NOAA HYSPLIT model. The start time for the analysis was 07:00 a.m. UTC on January 24, 2006. EDAS 40km meteorological data was used.

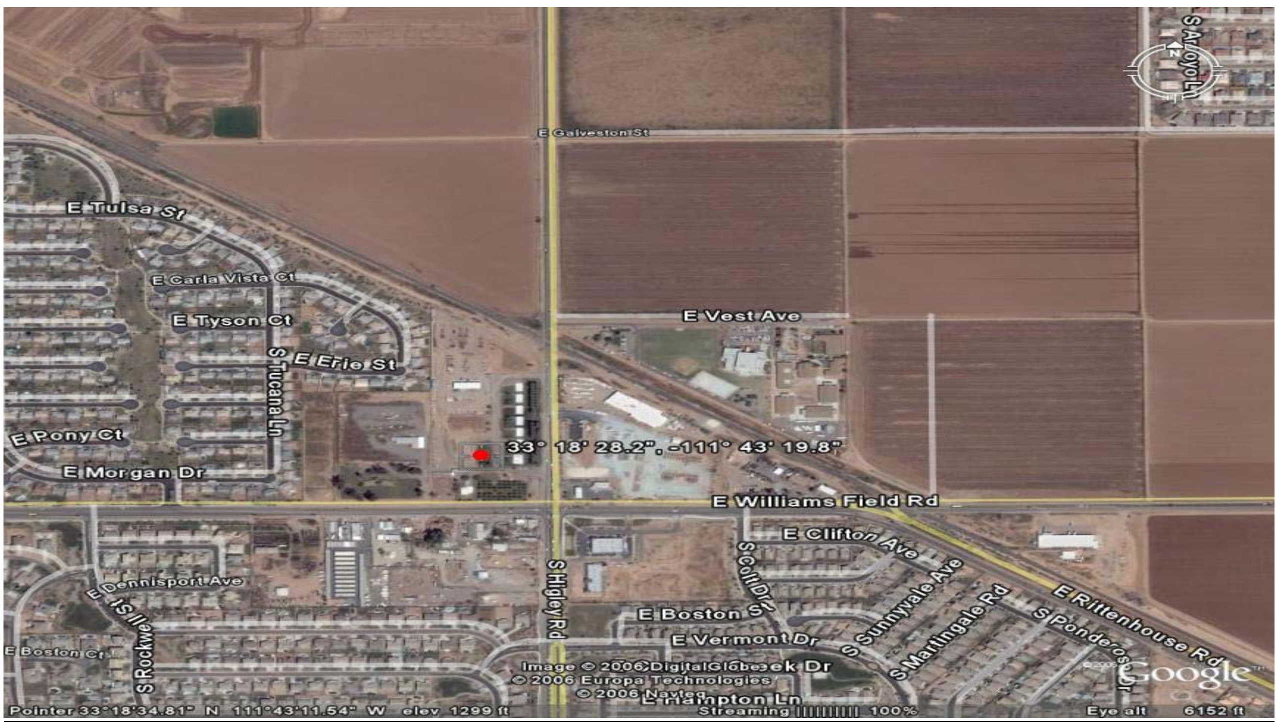

Figure 1-9 Satellite Imagery around Higley (Red Dot) at 6,152 ft

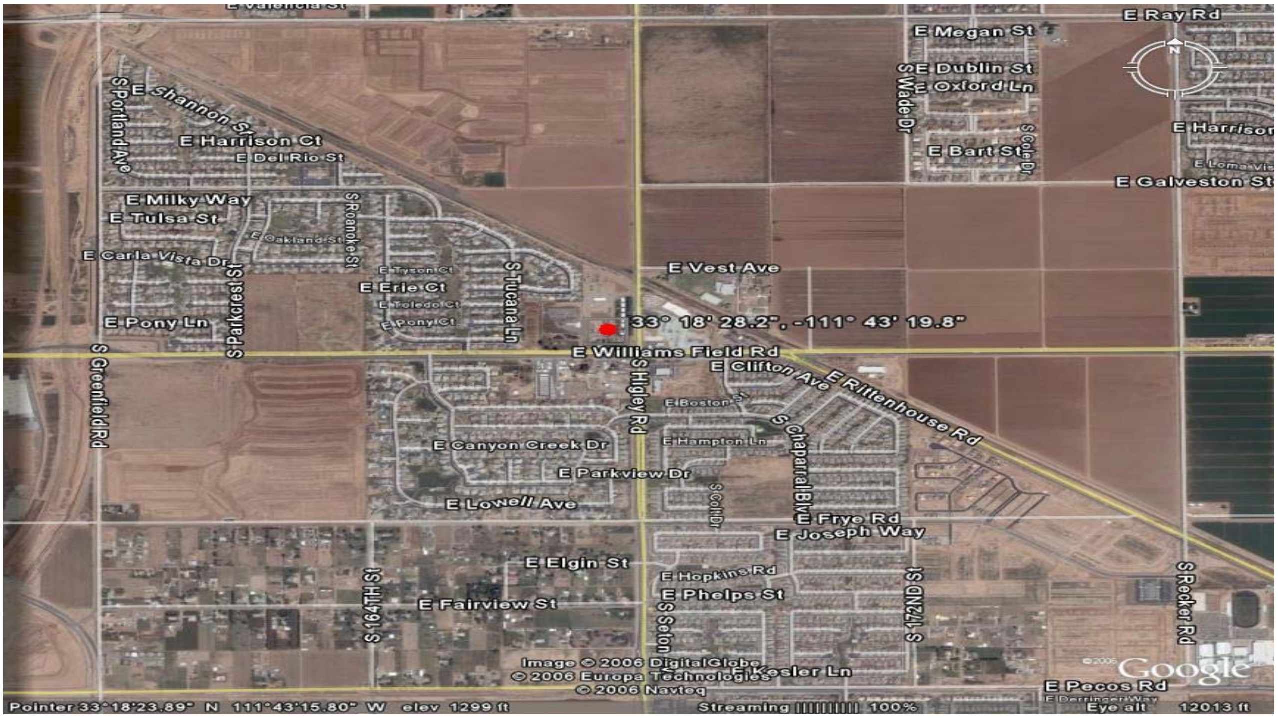

Figure 1-10 Satellite Imagery around Higley (Red Dot) at 12,013 ft

Figure 1-11 Satellite Imagery around Higley (Red Dot) at 26,959 miles

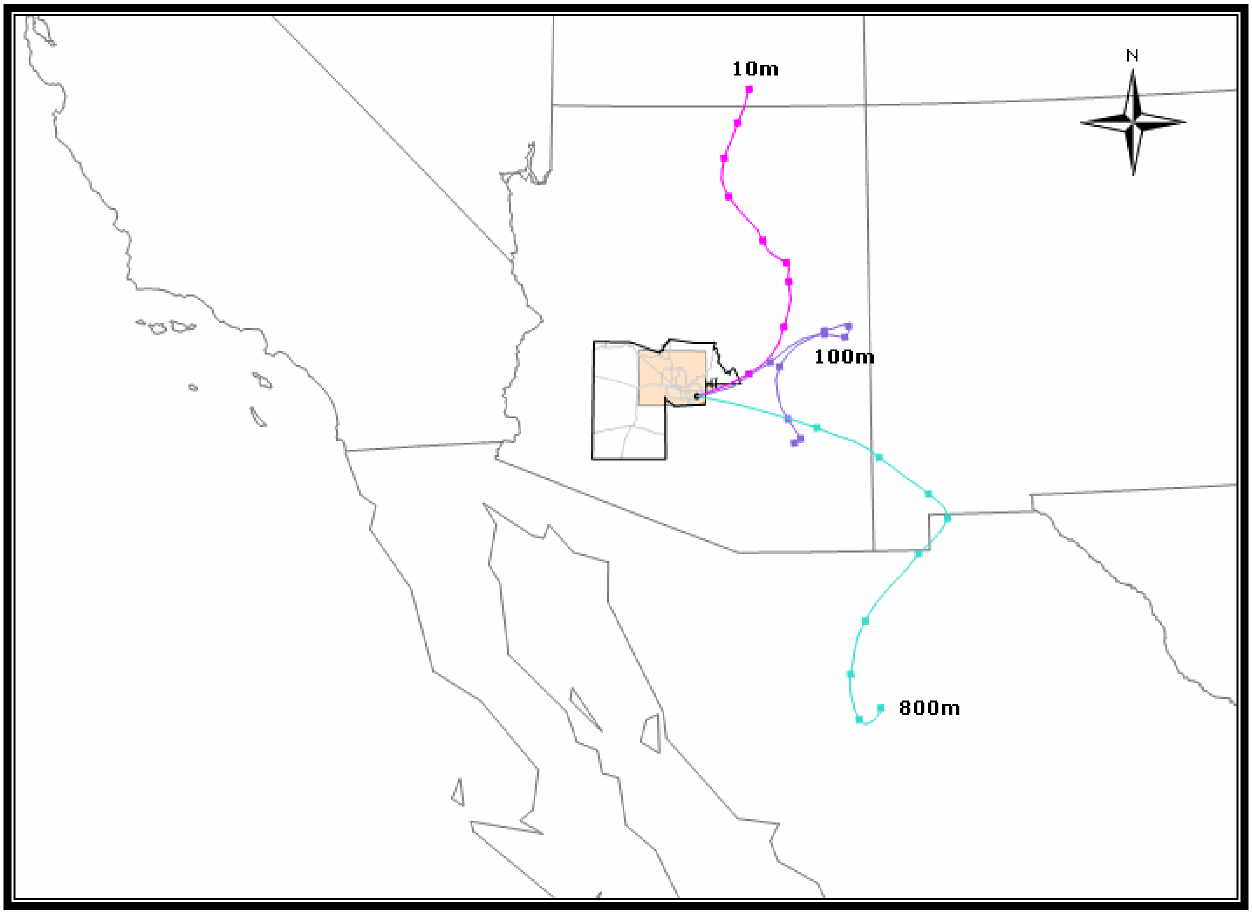

Figure 1-12 Backward trajectory for January 24, 2006 – Higley

1.3 Distribution of Major Emissions Sources

The major PM-10 emissions sources in the Maricopa County nonattainment area are:

- Agricultural land
- Alluvial channels
- Construction areas
- Miscellaneous disturbed areas
- Paved roads
- Unpaved roads
- Unpaved shoulders
- Unpaved parking lots
- Surface mining
- Vacant lots

Figure 1-13 shows 2002 annual average daily PM-10 emissions, based on the latest MCAQD periodic emissions inventory[9]. The distribution of emissions sources surrounding each monitor varies widely. In the ADEQ Salt River Area PM-10 Study, the emissions sources for a 37 square mile area were inventoried for the year 2002. As mentioned previously, the Bethune Elementary, Durango Complex, South Phoenix, and West 43rd Avenue monitors are located in the Salt River Study Area. 2002 PM-10 emissions sources for low and high wind days from the Salt River Study Area are shown in Figures 1-14 and 1-15[1]. Figure 1-16 shows the comparable land use patterns in the Salt River Area in 2002.

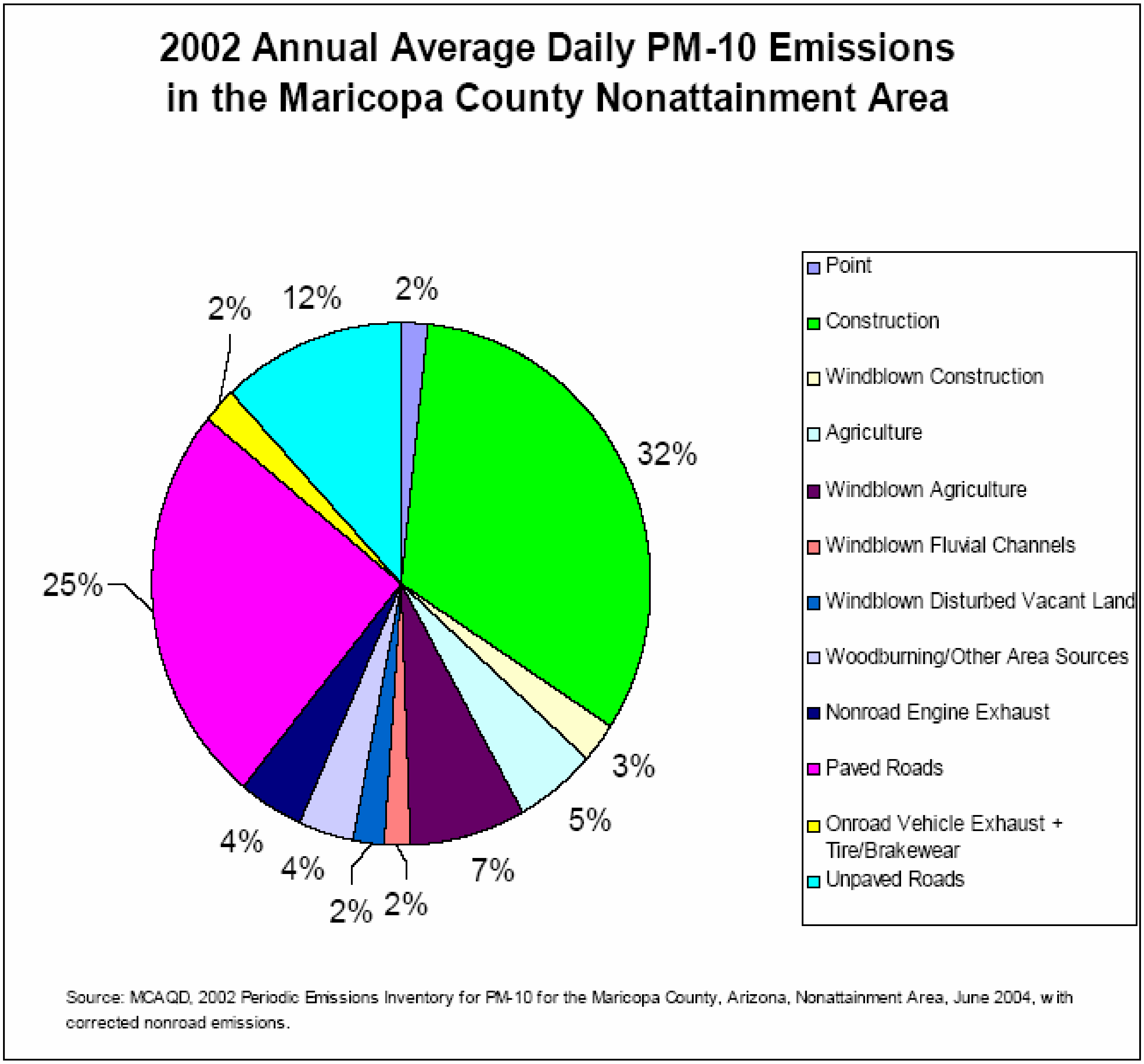

Figure 1-13 2002 Annual Average Daily PM-10 Emissions

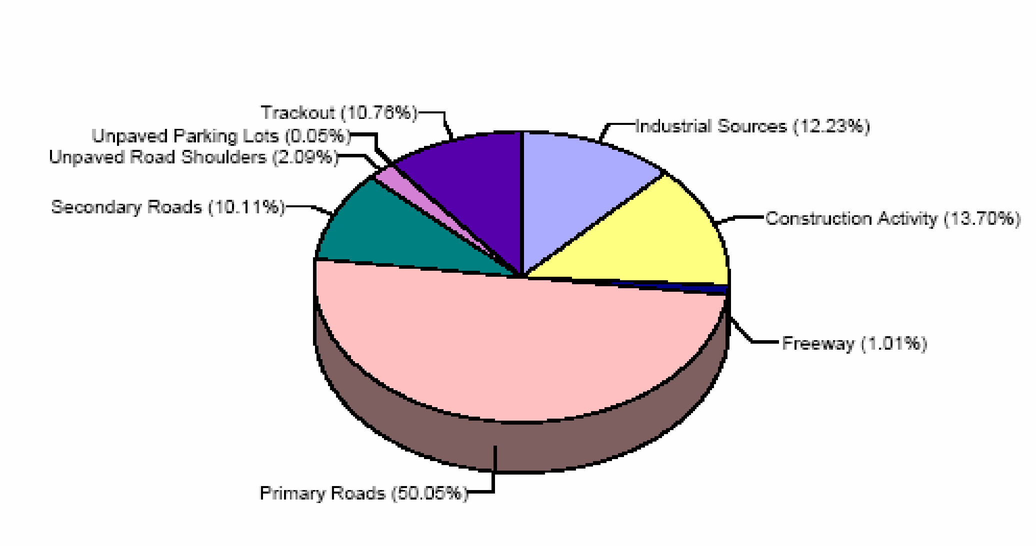

Figure 1-14 Salt River Area PM-10 Emissions on December 16, 2002 (Low Wind Day)[1]

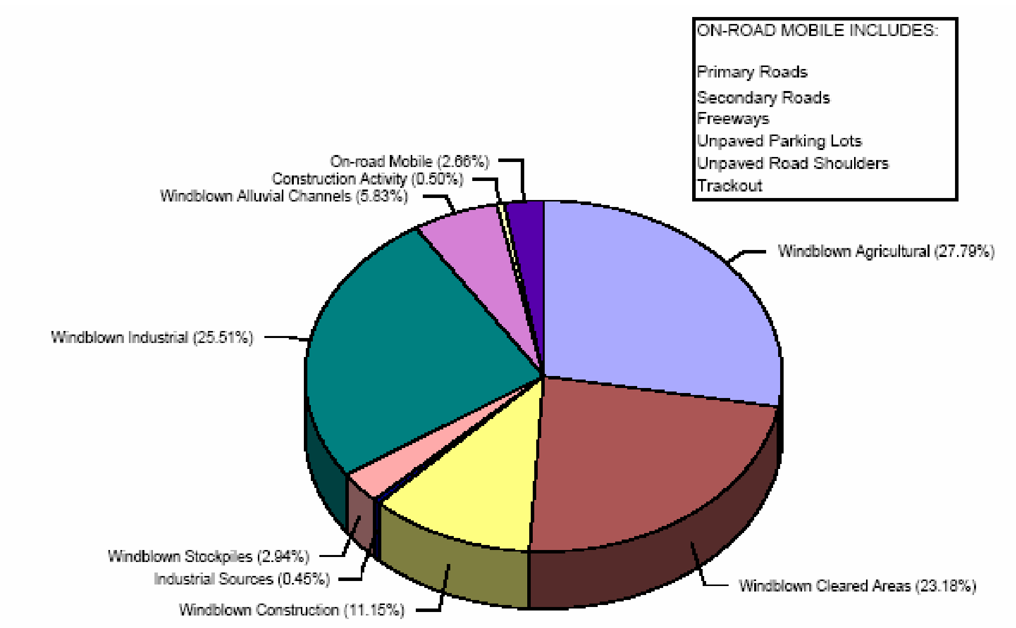

Figure 1-15 Salt River Area PM-10 Emissions on April 15, 2002 (High Wind Day)[1]

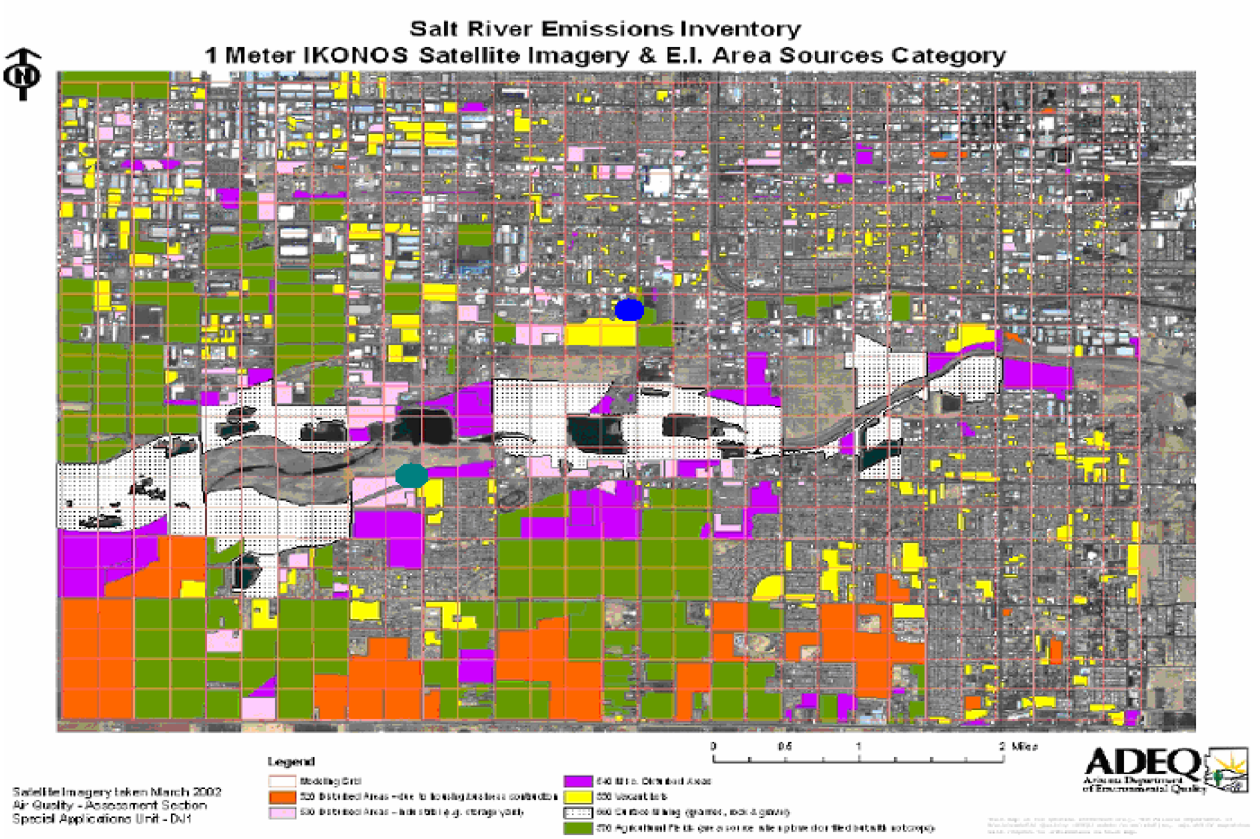

Figure 1-16 2002 Land Use Data for the Salt River Study Area[1]

1.4 Deposition and Concentration of Pollutants

Dry deposition is frequently characterized as being analogous to resistance in an electrical circuit. The flux to the ground is assumed to be equal to the concentration measured at a given height multiplied by the mass transfer coefficient, which is also dependent on height. The mass transfer coefficient is called the deposition velocity[8]. Aerosol deposition velocity calculated by grid models and observation is shown in Figure 1-17[6]. The HYSPLIT model developed by NOAA provides predictions of concentrations and deposition (both wet and dry) of both gaseous and particulate pollutants[4]. To understand the dry deposition and concentration of particulate pollutants over a specified point on design days, HYSPLIT4 was run. The results are presented in Figures 1-18 to 1-21.

The concentration of particulates was calculated considering the various HYSPLIT modeling options. Particle diameter was assumed to be greater than or equal to 1um and density equal to 1 g/cc. The 24-hour layer average concentration was calculated based on the mixing height on these respective days with the top height of the pollutant source set at 25 meters.

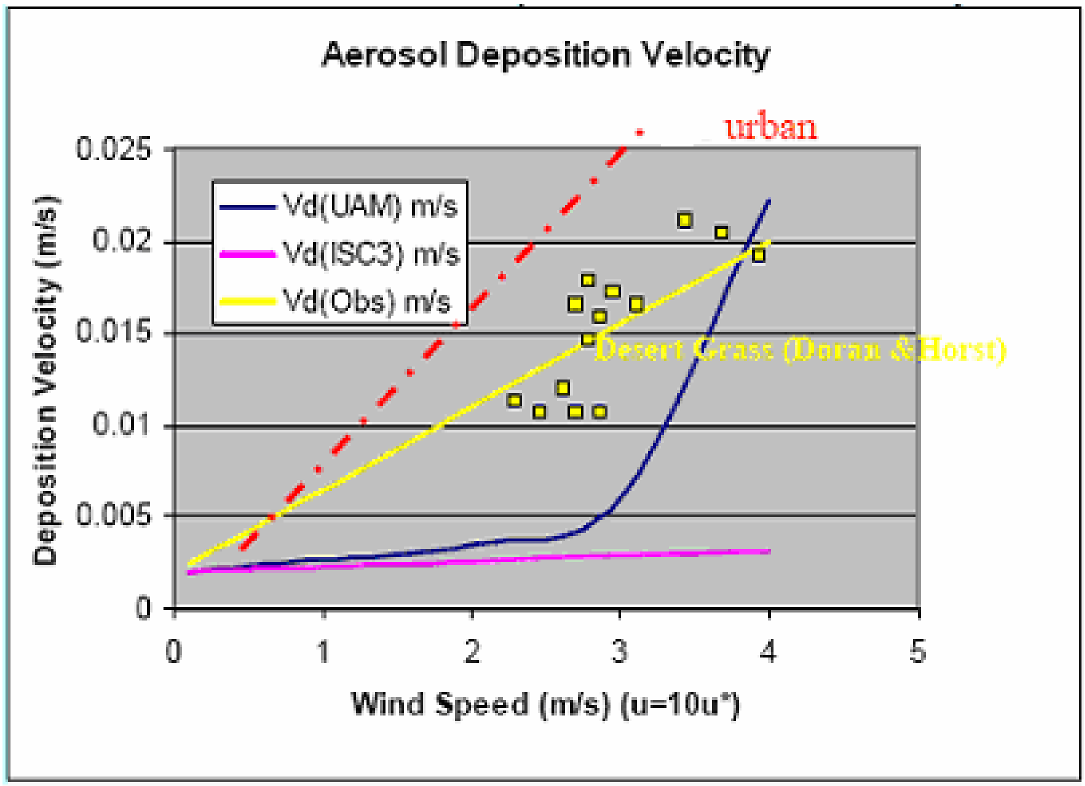

Figure 1-17 Aerosol Deposition Velocity by Grid Models and Observation[6]

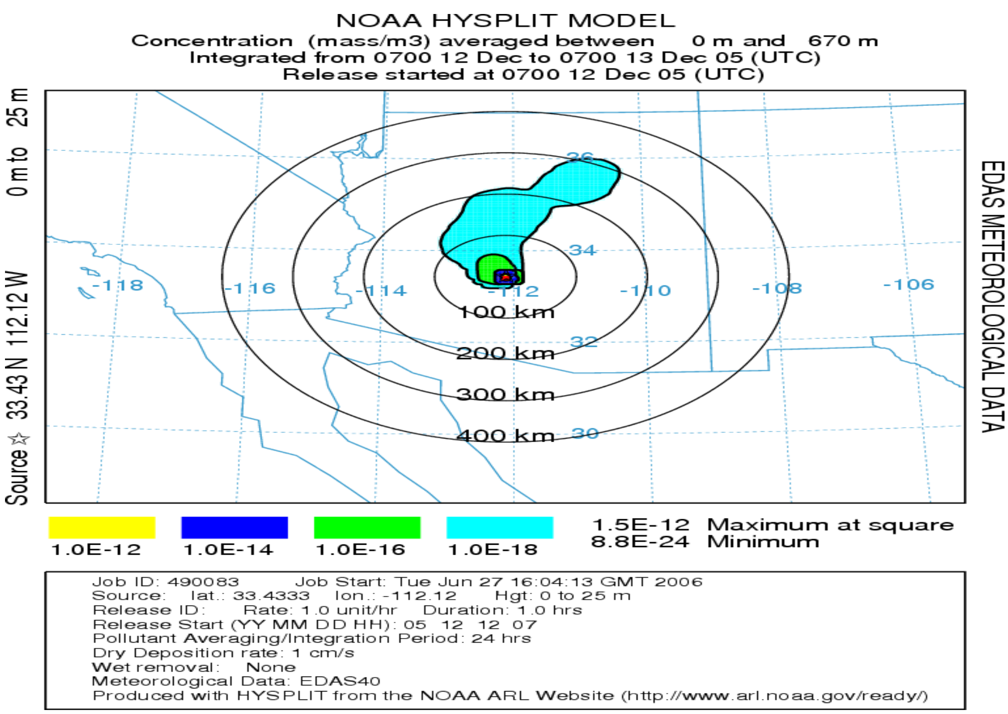

Figure 1-18 Pollutant Concentrations Obtained from HYSPLIT Gaussian Plume Model for December 12, 2005

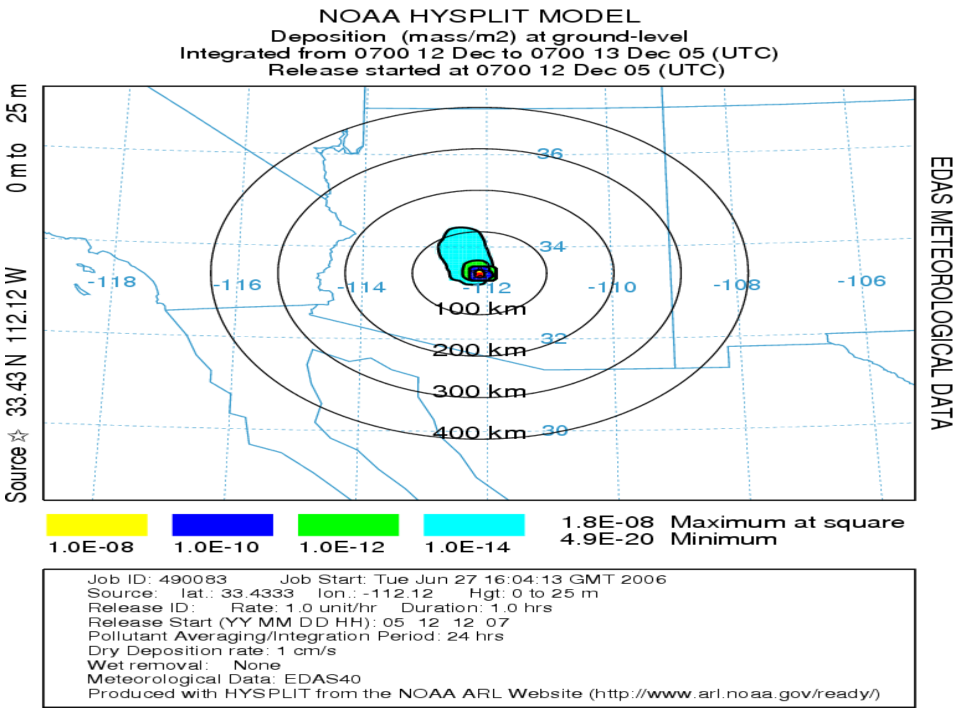

Figure 1-19 Dry Deposition Obtained from HYSPLIT Gaussian Plume Model for December 12, 2005

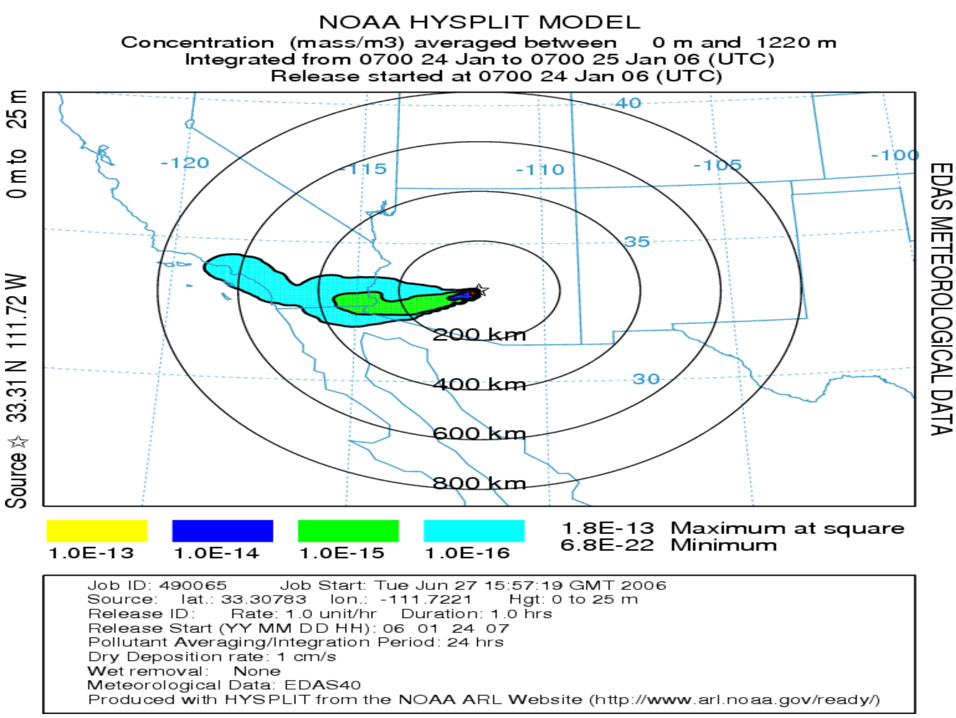

Figure 1-20 Pollutant Concentrations Obtained from HYSPLIT Gaussian Plume Model for January 24, 2006

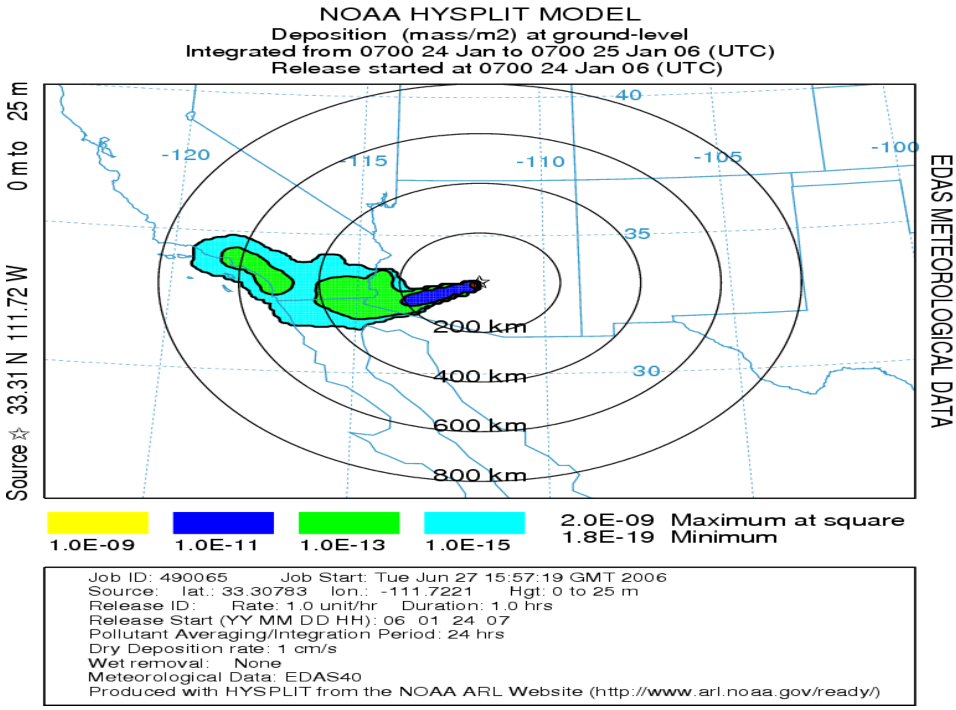

Figure 1-21 Dry Deposition Obtained from HYSPLIT Gaussian Plume Model for January 24, 2006

Dry deposition calculations are performed in the lowest model layer based upon the relationship that the deposition flux equals the velocity times the ground-level air concentration. This calculation is available for gases and particles. The dry deposition velocity can be set directly for each pollutant by entering a non-zero value in the first field. The dry deposition rate considered is 1 cm/s[4].

1.4.1 December 12, 2005

On December 12, 2005, a stagnant day, the HYSPLIT data in Figure 1-5 indicates that there were light southwesterly winds. Figures 1-18 and 1-19 confirm that the pollutant concentrations and dry deposition on this low wind day were predominantly of local origin. Wind speeds on this day averaged 1.6 mph and the highest hourly wind speed of 3.6 mph occurred between 11 p.m. and 12 midnight at the West 43rd Avenue site. Similar wind speed data were observed at the Durango Complex, Greenwood and West Phoenix stations.

1.4.2 January 24, 2006

Figure 1-12 shows the 36-hour backward trajectory on January 24, 2006. On this high wind day, the winds aloft (800m) originated in the southeast, with lower level winds from the east and northeast. The analysis of monitoring data on January 24, 2006 at Higley reveals that the PM-10 exceedances were caused by high easterly winds. Wind speeds on this day averaged 7.6 mph. The highest hourly wind speed of 16.9 mph occurred between 1 and 2 p.m., with the second high between 2 and 3 p.m. at 16.1 mph. Since there were two hours with wind speeds exceeding 15 mph, this day qualifies as high wind. Figures 1-20 and 1-21 show that the areas of highest pollutant concentrations and deposition on this high wind day were much larger than the Maricopa County PM-10 nonattainment area and the impacted areas extended westward all the way to Southern California.

1.5 Previous PM-10 Studies

Two previous PM-10 studies results were considered in evaluating the air quality modeling domains:

- PM-10 SIP for the Salt River Area, ADEQ[1]
- PM-10 modeling using CMAQ, ASU[5]

1.5.1 PM-10 SIP for the Salt River Study Area

In this ADEQ Plan, the elevated PM-10 concentrations in the Salt River Study Area were simulated using the Industrial Source Complex Short Term (Version-3) (ISCST-3). Contributions to overall PM-10 in the domain were predicted using separate, day specific source category emissions files. The modeling domain consisted of an array of 400 x 400 meter grids, 30 in the east-west (EW) direction and 21 in the north-south (NS) direction, for a total of 630 grids. The dimensions of the array were 7.5 miles (12 kilometers) EW and 5.2 miles (8.4 km) NS. The study domain includes four monitors, the major industrial activities in the area, an expansive area of active agricultural land, and active residential construction sites.

1.5.2 PM-10 Modeling using CMAQ, ASU

High (episodic) particulate matter (PM) events over the sister cities of Douglas (AZ) and Agua Prieta (Sonora), located on the US-Mexico border, were simulated by Arizona State University using the 3D Eulerian air quality model, MODELS3/CMAQ. Best available input information was used for the simulations. In spite of the inherent uncertainties in the emissions inventories, chemistry and meteorology, the CMAQ model evaluations showed acceptable results. The CMAQ modeling domain was nested down from a coarse 36 km grid resolution directly to the fine-grid domain of 0.5 km grid resolution. Sensitivity studies on the role of boundary conditions indicate insignificant regional contributions, as well as trivial contributions of secondary particles to the occurrence of high PM events in the study area. High PM episodes in the study area, therefore, are local events that largely depend on local meteorological conditions. The major PM emission sources were identified as vehicle activities on unpaved/paved roads and wind-blown dust. The study concluded that there is a need for modifications to

MODELS3/CMAQ to allow more interaction between meteorology and emissions, which is currently absent in dealing with particulate matter.

1.6 Modeling Domains

All of the above factors were considered in determining the size of the modeling domains to be used with AERMOD and rollback. Based on these factors, MAG is proposing that a much larger modeling domain be defined for the Durango and West 43rd monitors than for the monitor outside the Salt River Study Area that exceeded the standard (i.e., Higley).

1.6.1 AERMOD Modeling Domain – Salt River Study Area

The Durango Complex and West 43rd Avenue monitors are located within 2 miles of each other (as the crow flies) and share many common emissions sources. It is recommended that modeling for the Five Percent Plan build upon the 2002 emissions inventory work done by ADEQ in the Salt River Area PM-10 Study[1]. In the ADEQ Study, the modeling domain consisted of an array of 400x400 meter grids, 30 east-west and 21 north-south, for a total of 630 grids. A smaller grid size may be considered if emissions inventory updates and monitoring in the Salt River Study Area during the fall of 2006 indicates that this would improve the accuracy of the AERMOD model. The dimensions of the grid array are 7.5 miles by 5.2 miles, an area of approximately 37 square miles. The domain includes the two monitors that recorded the highest PM-10 concentrations on December 12, 2005, as well as the Bethune Elementary and South Phoenix monitors. It is proposed that this domain be used to model PM-10 concentrations with AERMOD on December 11-13, 2005.

1.6.2 Rollback Modeling Domain - Higley

The Higley monitor is located at the southeast corner of the PM-10 nonattainment area. As indicated in Figures 1-14 through 1-16, the predominant sources of PM-10 to the north and east of the Higley monitor are vacant lands under development or used for agricultural purposes. The analysis of monitoring data on January 24, 2006 at Higley reveals that the PM-10 exceedances were caused by high easterly winds. Wind speeds on this day averaged 7.6 mph. The highest hourly wind speed of 16.9 mph occurred between 1 and 2 p.m. The average between 2 and 3 p.m. was 16.1 mph. Since there were two hours with wind speeds exceeding 15 mph, this day qualifies as a high wind day.

Due to the limited number and type of emissions sources contributing to elevated PM-10 concentrations at the Higley monitor, it is proposed that the rollback model be applied with a domain size of 2 km x 2 km. Prior studies performed by ADEQ and Clark County, Nevada, will be examined to determine the distance of influence for PM-10 sources. In addition, field work being performed by the MAG PM-10 Source Attribution and Deposition Study in the fall of 2006 will provide additional insights into PM-10 deposition rates in the nonattainment area. The size of the modeling domain for the Higley monitor may be increased if these studies and/or aerial and satellite imagery and meteorological data indicate that there are significant contributing sources outside of the 2 km x 2 km modeling area.

REFERENCES

[1] Revised PM-10 State Implementation Plan for the Salt River Area, Technical Support Document, ADEQ, June 2005

[2] 2005 Air Monitoring Network Review, Maricopa County Air Quality Department, May 2006

[3] HYSPLIT User's Guide, version 4.8, June 2006

[4] Modeling of episodic particular matter events using a 3-D air quality model with fine grid: Applications to a pair of cities in the U.S./Mexico border , Yu-Jin Choi*, Peter Hyde[+], and H. J. S. Fernando*, *Environmental Fluid Dynamics Program, Department of Mechanical and Aerospace Engineering, Arizona State University, Tempe, AZ 85285, [+]Arizona Department of Environmental Quality, Phoenix, AZ 85102, USA, Submitted to Atmospheric Environment, November 15, 2005

[5] Particulate Transport between the Utah and Salt Lake Valleys, John Watson and Dan Freeman, Desert Research Institute, September 2001. (http://www.pnl.gov/VTMX/WatsonFreeman2001.html)

[6] Road Dust is Overestimated in Air Quality Grid Models, Yayi Dang, Rick Hardy, Mike McGown, Idaho DEQ, October 2004.

[7] Revised MAG 1999 Serious Area Particulate Plan for PM-10 for the Maricopa County Nonattainment Area, Maricopa Association of Governments, February 2000

[8] Field Testing and Evaluation of Dust Deposition and Removal Mechanisms: Final Report, Desert Research Institute, January 2003

[9] 2002 Periodic Emission Inventory for PM-10 for the Maricopa County, Arizona, Nonattainment Area, Maricopa County Air Quality Department, June 2004

ATTACHMENT III

INTERAGENCY MEMORANDUM OF AGREEMENT

MEMORANDUM OF AGREEMENT

AMONG

THE ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

AND

THE ARIZONA DEPARTMENT OF TRANSPORTATION

AND

MARICOPA COUNTY, BY AND THROUGH THE MARICOPA COUNTY ENVIRONMENTAL QUALITY AND COMMUNITY SERVICES AGENCY

AND

THE MARICOPA ASSOCIATION OF GOVERNMENTS

PURPOSE

The purpose of this Memorandum of Agreement is to provide the framework and guidelines to promote coordinated decision making in planning, development, and implementation, and enforcement of those actions necessary to attain and maintain the National Ambient Air Quality Standards in Maricopa County, hereafter referred to as the Nonattainment Area Plan, or NAP. This Memorandum is required pursuant to A.R.S. 49-406 D. and E. The Memorandum also provides the framework and guidelines for preparing plans designed to address other air pollution problems of regional concern.

SCOPE

This Memorandum is designed to address the control of the following pollutants: Carbon Monoxide, Ozone, Particulates, and Other Air Pollution Problems of Regional Concern.

The geographical area of concern is Maricopa County or the area specifically designated by the Administrator of the U.S. Environmental Protection Agency as not having attained the National Ambient Air Quality Standards for one or more of the pollutants named above.

RESPONSIBILITIES AND AUTHORITIES

The Arizona Department of Environmental Quality (ADEQ) has the primary authority in the State of Arizona for air pollution control and abatement. ADEQ is charged with preparation, development and maintenance of the State Implementation Plan (A.R.S. § 49-404); designation of areas of the state with respect to compliance with the National Ambient Air Quality Standards (A.R.S. § 49-405); and assuring that nonattainment area plans are implemented (A.R.S. § 49-406 J.). ADEQ has original jurisdiction and control over portable, mobile, and specific types of stationary air pollution sources (see A.R.S. § 49-402 A.). In addition, ADEQ is responsible for development of stationary source permitting procedures and standards (see A.R.S. § 49-480 B.). ADEQ is also responsible for providing technical assistance to political subdivisions of the State for implementing air pollution control programs (A.R.S. § 49-424 A.8.), conducting research on the amounts of hazardous air pollutants in ambient air and their impacts on human health (A.R.S. § 49-426.06); management and implementation of programs under the Air Quality Fee Fund (A.R.S. § 49-551), implementation of the Vehicle Emissions Inspections Program (A.R.S. § 49-521 through 550), and conducting research on vehicular emissions and clean burning fuels (A.R.S. § 49-553). The Department may delegate authority to a county for implementing air pollution control statutes (A.R.S. § 49-424 B.)

The Arizona Department of Transportation (ADOT) has exclusive control over state highways and all other state owned transportation systems (A.R.S. § 28-104). This includes the responsibility of multi-modal state transportation planning, cooperation with local governments, coordination of transportation planning with local governments, investigation of new transportation systems, and advising local governments concerning the development and operation of public transit systems (A.R.S. § 28-104).

The ADOT Director shall also enter into agreements on behalf of the state with political subdivisions for the improvement, maintenance and construction of mass transit systems, and shall provide rules for the application for and expenditure of all mass transit funds (A.R.S. § 28-108).

In addition, ADOT is authorized to conduct demonstration projects to evaluate the effectiveness of new, extended, improved or integrated public transportation services and carpooling or vanpooling activities in meeting regional transportation needs or in improving air quality (A.R.S. § 28-2611). These projects are funded by an annual distribution of $400,000 from the air quality fund (A.R.S. § 49-551). ADOT must also support ADEQ on reporting to the Legislature results of mobile source emissions Research, where applicable, per A.R.S. § 49-553.

The Maricopa County Environmental Quality and Community Services Agency (MC EQ&CSA) is the local air pollution control department for Maricopa County. The Agency has jurisdiction over air pollution sources not explicitly reserved for state jurisdiction (A.R.S. § 49-402); the Agency is delegated authority from the State of Arizona to regulate certain portable air pollution sources initially reserved for state jurisdiction (A.R.S. § 49-424); the Agency operates the Regional Travel Reduction Program (A.R.S. § 49-582 et seq), and is the principal government sponsor for the Voluntary No Drive Days Program (A.R.S. § 49-506). The Agency is also responsible for monitoring the ambient air quality of the region (A.R.S. § 49-473) through collecting and analyzing air quality data.

Within the Maricopa County Environmental Quality and Community Services Agency, the Assistant County Manager of the Agency is designated as the Air Pollution Control Officer. The Air Pollution Control Officer has the responsibility and authority to enforce the provisions of Article 3, Chapter 3, Title 49, "County Air Pollution Control", Arizona Revised Statutes. The Control Officer also has the responsibility for assuring adequate nonattainment plan implementation as prescribed by A.R.S. § 49-406.

The Maricopa Association of Governments (MAG) is a nonprofit Arizona corporation composed of elected officials from twenty-four cities and towns, Maricopa County, Gila River Indian Community, and the Arizona Department of Transportation. MAG has been designated by the Governor of Arizona as the lead planning organization for Maricopa County that, together with the State, is responsible for determining which elements of the State Implementation Plan revision will be planned, implemented, and enforced by State and local governments in Arizona (Governor Wesley Bolin, February 7, 1978; Clean Air Act § 174(a); and A.R.S. 49-406)). MAG is responsible for providing assistance to the Maricopa County Travel Reduction Regional Task Force and for recommending third and following year travel reduction targets, policies, standards and criteria for the Maricopa County Travel Reduction Program (A.R.S. § 49-582 and 49-588). Related directly to air quality, MAG is the official designated metropolitan transportation planning organization, and the designated agency for preparing population estimates and projections for the Maricopa County area. MAG is also responsible for making transportation/air quality conformity determinations, subject to the consultation procedures as provided by law (Clean Air Act § 176).

UNDERSTANDING/AGREEMENTS

In recognition and to facilitate the accomplishment of the foregoing, IT IS HEREBY AGREED that:

1. The Arizona Department of Environmental Quality; Arizona Department of Transportation; Maricopa County Environmental Quality and Community Services Agency; and Maricopa Association of Governments will work through a coordinated effort to prepare the MAG regional air quality plans as described in Attachments One, Three, Four, and Five. Attachment One contains a description of the generalized roles and areas of expertise of the agencies, the MAG Air Quality Planning Team, and the MAG Air Quality Policy Team. Attachment Three contains the general implementation authorities for measures in the air quality plans. Attachment Four includes provisions for tracking plan implementation; determining reasonable further progress; assurances for adequate plan implementation, and adoption of control measures. Attachment Five contains the Work Programs for Preparing Air Quality Plans.

2. The Maricopa Association of Governments will maintain the MAG Regional Air Quality Planning Process for decision making as described in Attachment Two. This Attachment contains the roles of the MAG Regional Council, MAG Management Committee, MAG Air Quality Policy Committee, and ad hoc Working Groups. MAG will coordinate the preparation of the NAPs. Representatives from ADEQ, ADOT and MC EQ&CSA will be included as ex-officio members of the MAG Air Quality Policy Committee, and active members of all working groups associated with this MAG committee.

3. The Arizona Department of Environmental Quality; Arizona Department of Transportation; Maricopa County Environmental Quality and Community Services Agency; Maricopa Association of Governments will pursue commitments to implement the measures in the NAPs. The aforementioned agencies will continue to evaluate and pursue the implementation of additional air pollution control measures as a result of the evaluations performed as described in Attachment Four.

EFFECTIVE DATE

The Agreement and all Amendments shall become effective on the date it has been signed by all parties to it.

TERM

This Agreement shall remain in effect from the effective date of the Agreement until such time it is terminated or superseded by a subsequent agreement. This Agreement may be terminated by any party to it, providing written notice of intent to terminate is provided to all other parties to the Agreement thirty days prior to the effective date of withdrawal of that party from the Agreement.

AMENDMENT

This Agreement may be amended at any time upon mutual written agreement of all parties. No agent, employee or other representative of any party to this Agreement is empowered to alter any of the terms of the Agreement, unless it is done in writing and signed by the Designated Officers of the respective parties, their authorized representatives, or duly appointed successors.

ATTEST

All terms of this Memorandum of Agreement are hereby acknowledged and agreed, as certified by the signatures of the Designated Officers affixed hereto:

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

By [signature]
Edward Z. Fox, Director, Arizona Department of Environmental Quality

Date Nov 9, 1992

ARIZONA DEPARTMENT OF TRANSPORTATION

By James O. Creedon [signature]
James Creedon, Acting Director, Arizona Department of Transportation

Date Nov 9, 1992

MARICOPA COUNTY, BY AND THROUGH THE MARICOPA COUNTY ENVIRONMENTAL QUALITY AND COMMUNITY SERVICES AGENCY

By Betsy Bayless [signature]
Betsy Bayless, Chairman, Maricopa County Board of Supervisors

Date 11-2-92

MARICOPA ASSOCIATION OF GOVERNMENTS

By J. J. DeBolske [signature]
John J. DeBolske, Secretary, Maricopa Association of Governments

Date 11-2-92

ATTACHMENT ONE

MAG REGIONAL AIR QUALITY PLANNING TECHNICAL PROCESS

- All MAG regional air quality plans are prepared through a coordinated effort among the Arizona Department of Environmental Quality, Arizona Department of Transportation, Maricopa County Environmental Quality and Community Services Agency, and Maricopa Association of Governments.

MAG AIR QUALITY POLICY TEAM

Composition: Director of Arizona Department of Environmental Quality; Director of Arizona Department of Transportation; Air Pollution Control Officer of Maricopa County; MAG Secretary

- Oversees preparation of plans and overall technical planning effort
- Resolves technical problems and issues

MAG AIR QUALITY PLANNING TEAM

Composition: Staff from the Arizona Department of Environmental Quality, Arizona Department of Transportation; Maricopa County Environmental Quality and Community Services Agency; Maricopa Association of Governments

Agency Roles

- Arizona Department of Environmental Quality - air quality modeling and technical assistance, mobile source emissions research and inventory, input for the comprehensive list of measures and feasibility analysis, information relating to the Vehicle Emission Inspection Maintenance Program, stationary and portable source control strategies, air quality research studies, State Air Quality Fund administration, adoption and submittal of State Implementation Plans to the Environmental Protection Agency, tracking plan implementation, assurances, special purpose air quality and meteorological monitoring for plan development and compliance
- Arizona Department of Transportation - State Transportation Improvement Program, other transportation plans and programs, input for the comprehensive list of measures and feasibility analysis
- Maricopa County Environmental Quality and Community Services Agency - stationary source emissions inventory and controls, coordinating the comprehensive emissions inventory, air quality monitoring data.input for comprehensive list of measures and feasibility analysis, mandatory travel reduction program, trip reduction data, voluntary no drive days program, tracking plan implementation, reasonable further progress, assurances, special purpose air quality and meteorological monitoring for plan development and compliance
- Maricopa Association of Governments - demographic projections and socioeconomic data, transportation modeling, air quality modeling, Regional Transportation Improvement Program, Regional Transportation Plan, other transportation plans and programs, congestion mangement system, conformity, input for comprehensive list of measures and feasibility analysis, development of the air quality plans, interface with state, county, and local entities, recommending future year travel reduction goals, policies, and standards to Maricopa County, assistance to Maricopa County for the mandatory travel reduction program, review reasonable further progress made to reduce air pollution and plan adjustments if necessary, review plan implementation

The technical planning work is closely coordinated with EPA Region IX staff, Federal Highway Administration, and Federal Transit Administration.

ATTACHMENT TWO

MAG REGIONAL AIR QUALITY PLANNING PROCESS

MAG REGIONAL COUNCIL

Composition: *Elected officials from 24 cities and towns, Maricopa County, Gila River Indian Community, and Arizona Department of Transportation, Regional Public Transportation Authority*

- Reviews all pertinent air quality data
- Adopts regional air quality plans
- Formally requests that state, county, local, and other appropriate agencies implement measures in the plans
- Approves trip reduction goals and policies and recommends to Maricopa County
- Determines conformity, subject to the consultation procedures as provided by law (Clean Air Act § 176)
- Maintains an air quality/transportation planning process consistent with federal law

MAG MANAGEMENT COMMITTEE

Composition: *Managers from 24 cities and towns, Maricopa County, Gila River Indian Community, and Arizona Department of Transportation, Regional Public Transportation Authority*

- Reviews all pertinent air quality and transportation data
- Recommends regional air quality and transportation plans
- Recommends trip reduction goals and policies

MAG AIR QUALITY POLICY COMMITTEE

Composition: *10 elected officials from cities and towns and Maricopa County and 9 citizen representatives + ex-officio representatives from Arizona Department of Environmental Quality, Arizona Department of Transportation, and Maricopa County Environmental Quality and Community Services Agency*

- Reviews all pertinent air quality data from the technical planning process
- Reviews air quality research studies conducted by MAG, Arizona Department of Environmental Quality, EPA, Maricopa County Environmental Quality and Community Services Agency, etc.
- Reviews related data generated from other MAG regional planning areas such as transportation, transit, population, regional development, water quality, solid waste, etc.
- Studies in detail a comprehensive list of control measures. Data on the measures includes: description of the measures, air quality impacts, complementary measures, implementation responsibility, costs, advantages and disadvantages, etc.
- Recommends air quality measures for the plans
- Conducts public hearings on the plans
- Formally recommends regional air quality plans and control measures
- Recommends trip reduction goals and policies
- Conducts conformity reviews, subject to the consultation procedures as provided by law (Clean Air Act § 176)
- Reviews reasonable further progress made to reduce air pollution and recommends plan adjustments if necessary
- Provides input on the MAG congestion management system

ADDITIONAL WORKING GROUPS AS NECESSARY

ATTACHMENT THREE

IMPLEMENTATION OF MAG REGIONAL AIR QUALITY PLANS
GENERAL IMPLEMENTATION AUTHORITIES

STATE - ARIZONA DEPARTMENT OF ADMINISTRATION

- Travel reduction and adjusted work hours for state employees

STATE - ARIZONA DEPARTMENT OF COMMERCE

- Capitol Ridesharing Program

STATE - ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

- Mobile source emissions controls
- Mobile source emissions research
- Portable and some major stationary source controls
- Ambient air quality monitoring and research
- Assurances

STATE - ARIZONA DEPARTMENT OF TRANSPORTATION

- State and interstate transportation system planning, development and management (includes High Occupancy Vehicle Lanes, Freeway Management Systems, etc.)
- Vehicle registration and licensing
- Transit Assistance Grants

STATE - ARIZONA DEPARTMENT OF WEIGHTS AND MEASURES

- Oxygenated fuels
- Other fuel quality regulation (e.g. Reid Vapor Pressure)
- Stage I and Stage II vapor recovery

MARICOPA COUNTY - ENVIRONMENTAL QUALITY AND COMMUNITY SERVICES AGENCY

- Stationary source controls
- Delegated portable source controls
- Area source controls (e.g. *de minimis* sources, materials storage and handling, construction)
- Open burning control
- Mandatory Travel Reduction Program (TRP) and Voluntary No Drive Days
- Other transportation control measures in unincorporated areas
- Ambient air monitoring
- County roadways system planning, development and management
- Planning and zoning (unincorporated areas)
- Assurances

MAG CITIES AND TOWNS

- Municipal roadways system planning, development and management
- Transportation control measures (besides TRP)
- Planning and zoning
- Some area source controls (e.g. vacant land, construction practices)
- Public transit (including Regional Public Transportation Authority)

MARICOPA ASSOCIATION OF GOVERNMENTS

- Future year travel reduction goals, policies, standards, and criteria
- Ridesharing program
- Conformity determinations, as provided by law (Clean Air Act § 176)
- Allocation of Congestion Mitigation Air Quality Improvement Program Funds and Surface Transportation Program Funds

* As noted in the MAG regional air quality plans, the action taken by the MAG Regional Council to approve the Suggested Measures and Adopted Plan Measures does not commit each jurisdiction to implement those measures. As indicated in the resolutions and commitments, each jurisdiction determines which measures are reasonably available for implementation by that jurisdiction.

OTHER IMPLEMENTATION AND ADOPTION FUNCTIONS

This attachment includes provisions for tracking plan implementation and determining reasonable further progress; assurances for adequate plan implementation, and procedures and responsibilities for adoption of control measures and emissions limitations.

TRACKING PLAN IMPLEMENTATION AND DETERMINING REASONABLE FURTHER PROGRESS

Each agency is afforded a review and comment period for each ongoing portion of a plan or revision to a plan being prepared by another agency. Every effort will be made to incorporate the comments of the reviewing agency into each portion of the plan being prepared by another agency.

Maricopa County will develop monitoring guidelines with respect to reasonable further progress which will be consistent with the needs of the Arizona Department of Environmental Quality and U.S. EPA. Maricopa County will be responsible for tracking emissions from point, area and non-road mobile sources and for tracking implementation of control strategies. MAG will be responsible for tracking on-road mobile source emissions and conformity. Maricopa County will integrate the MAG information and reports with the Maricopa County information and submit it to the Arizona Department of Environmental Quality.

For the EPA, the primary means of demonstrating the rate of progress will be through the periodic inventories (i.e., complete, actual inventories) submitted every 3 years. EPA has indicated in the General Preamble Section III.A.3 (d) that they currently intend to rely on existing reporting requirements such as emission statements, periodic inventories, annual Aerometric Information Retrieval System update, and conformity reviews.

ASSURANCES FOR ADEQUATE PLAN IMPLEMENTATION

In order to comply with the Clean Air Act, State law provides an approach for assurances that State and local committed measures will be adequately implemented (A.R.S. §49-406 L and J.). If any person (includes State, County, local governments, regional agencies, and other entities) fails to implement a committed measure, the County would file an action in Superior Court to have the court order that the measure be implemented. Likewise, the ADEQ Director will backstop the County if it fails to implement a committed measure or if the County fails to backstop the local governments and regional agencies.

Regarding committed measures, A.R.S. §49-406 G. requires that each agency that commits to implement any control measure contained in the State Implementation Plan must describe the commitment in a resolution. The resolution must be adopted by the appropriate governing body of the agency. State law also requires the resolution to specify the following: (1) Its authority for implementing the limitation or measure as provided in statute, ordinance or rule: (2) A program for the enforcement of the limitation or measure; and (3) The level of personnel and funding allocated to the implementation of the measure.

As noted in the MAG regional air quality plans, the action taken by the MAG Regional Council to approve the Suggested Measures and Adopted Plan Measures does not commit each jurisdiction to implement those measures. As indicated in the resolutions and commitments, each jurisdiction determines which measures are reasonably available for implementation by that jurisdiction.

PROCEDURES AND RESPONSIBILITIES FOR ADOPTION OF CONTROL MEASURES AND EMISSIONS LIMITATIONS

According to A.R.S. §49-404 B., the ADEQ Director may adopt rules that describe procedures for adoption of revisions to the State Implementation Plan. The State, in accordance with these rules, and the governing body of the metropolitan planning organization (MAG) are required to adopt the nonattainment area plans (A.R.S. §49-406 H.).

ATTACHMENT IV

EPA 40 CFR PART 51
REVISION TO THE GUIDELINE ON AIR QUALITY MODELS: ADOPTION OF A PREFERRED GENERAL PURPOSE (FLAT AND COMPLEX TERRAIN) DISPERSION MODEL AND OTHER REVISONS; FINAL RULE

Federal Register

Wednesday,
November 9, 2005

Part III

Environmental Protection Agency

40 CFR Part 51

Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 51

[AH–FRL–7990–9]

RIN 2060–AK60

Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: EPA's *Guideline on Air Quality Models* (''*Guideline*'') addresses the regulatory application of air quality models for assessing criteria pollutants under the Clean Air Act. In today's action we promulgate several additions and changes to the *Guideline.* We recommend a new dispersion model—AERMOD—for adoption in appendix A of the *Guideline.* AERMOD replaces the Industrial Source Complex (ISC3) model, applies to complex terrain, and incorporates a new downwash algorithm—PRIME. We remove an existing model—the Emissions Dispersion Modeling System (EDMS)—from appendix A. We also make various editorial changes to update and reorganize information.

DATES: This rule is effective December 9, 2005. As proposed, beginning November 9, 2006, the new model—AERMOD—*should be* used for appropriate application as replacement for ISC3. During the one-year period following this promulgation, protocols for modeling analyses based on ISC3 which are submitted in a timely manner *may be* approved at the discretion of the appropriate Reviewing Authority. Applicants are therefore encouraged to consult with the Reviewing Authority as soon as possible to assure acceptance during this period.

ADDRESSES: All documents relevant to this rule have been placed in Docket No. A–99–05 at the following address: Air Docket in the EPA Docket Center, (EPA/DC) EPA West (MC 6102T), 1301 Constitution Ave., NW., Washington, DC 20004. This docket is available for public inspection and copying between 8 a.m. and 5:30 p.m., Monday through Friday, at the address above.

FOR FURTHER INFORMATION CONTACT: Tyler J. Fox, Air Quality Modeling Group (MD–D243–01), Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711; telephone (919) 541–5562. (*Fox.Tyler@epa.gov*).

SUPPLEMENTARY INFORMATION:

Outline

I. General Information

A. How Can I Get Copies of Related Information?

EPA established an official public docket for this action under Docket No. A–99–05. The official public docket is the collection of materials that is available for public viewing at the Air Docket in the EPA Docket Center, (EPA/DC) EPA West (MC 6102T), 1301 Constitution Ave., NW., Washington, DC 20004. The EPA Docket Center Public Reading Room (B102) is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Reading Room is (202) 566–1744, and the telephone number for the Air Docket is (202) 566–1742. An electronic image of this docket may be accessed via Internet at *www.epa.gov/eDocket,* where Docket No. A–99–05 is indexed as OAR–2003–0201. Materials related to our Notice of Data Availability (published September 8, 2003) and public comments received pursuant to the notice were placed in eDocket OAR–2003–0201.[1]

Our Air Quality Modeling Group maintain an Internet website (Support Center for Regulatory Air Models—SCRAM) at: *www.epa.gov/scram001.* You may find codes and documentation for models referenced in today's action on the SCRAM Web site. We have also uploaded various support documents (*e.g.,* evaluation reports).

II. Background

The *Guideline* is used by EPA, States, and industry to prepare and review new source permits and State Implementation Plan revisions. The *Guideline* is intended to ensure consistent air quality analyses for activities regulated at 40 CFR 51.112, 51.117, 51.150, 51.160, 51.166, and 52.21. We originally published the *Guideline* in April 1978 and it was incorporated by reference in the regulations for the Prevention of Significant Deterioration (PSD) of Air Quality in June 1978. We revised the *Guideline* in 1986, and updated it with supplement A in 1987, supplement B in July 1993, and supplement C in August 1995. We published the *Guideline* as appendix W to 40 CFR part 51 when we issued supplement B. We republished the *Guideline* in August 1996 (61 FR 41838) to adopt the CFR system for labeling paragraphs. On April 21, 2000 we issued a Notice of Proposed Rulemaking (NPR) in the **Federal Register** (65 FR 21506), which was the original proposal for today's promulgation.

III. Public Hearing on the April 2000 Proposal

We held the 7th Conference on Air Quality Modeling (7th conference) in Washington, DC on June 28–29, 2000. As required by Section 320 of the Clean Air Act, these conferences take place approximately every three years to standardize modeling procedures, with special attention given to appropriate modeling practices for carrying out programs PSD (42 U.S.C. 7620). This conference served as the forum for receiving public comments on the *Guideline* revisions proposed in April 2000. The 7th conference featured presentations in several key modeling areas that support the revisions promulgated today. A presentation by the American Meteorological Society (AMS)/EPA Regulatory Model Improvement Committee (AERMIC) covered the enhanced Gaussian dispersion model with boundary layer parameterization: AERMOD.[2] Also at the 7th conference, the Electric Power Research Institute (EPRI) presented evaluation results from the recent research efforts to better define and characterize dispersion around

[1] *http://cascade.epa.gov/RightSite/dk_public_collection_detail.htm?ObjectType=dk_docket_collection&cid=OAR-2003-0201&ShowList=items&Action=view.*

[2] *A*MS/*E*PA *R*egulatory *MOD*el.

buildings (downwash effects). These efforts were part of a program called the Plume RIse Model Enhancements (PRIME). At the time, PRIME was integrated within ISC3ST (*ISC–PRIME*) and the results presented were within the ISC3 context. As discussed in today's rule, the PRIME algorithm has now been fully integrated into AERMOD.

We proposed an update to the Emissions and Dispersion Modeling System (EDMS 3.1), which is used for assessing air quality impacts from airports. A representative of the Federal Aviation Administration (FAA) presented a further upgrade to EDMS 4.0 that would include AERMOD and forthcoming performance evaluations for two airports.

The presentations were followed by a critical review/discussion of AERMOD and available performance evaluations, facilitated jointly by the Air & Waste Management Association's AB–3 Committee and the American Meteorological Society's Committee of Meteorological Aspects of Air Pollution.

For the new models and modeling techniques proposed in April 2000, we asked the public to address the following questions:

- Has the scientific merit of the models presented been established?
- Are the models' accuracy sufficiently documented?
- Are the proposed regulatory uses of individual models for specific applications appropriate and reasonable?
- Do significant implementation issues remain or is additional guidance needed?
- Are there serious resource constraints imposed by modeling systems presented?
- What additional analyses or information are needed?

We placed a transcript of the 7th conference proceedings and a copy of all written comments, many of which address the above questions, in Docket No. A–99–05. The comments on AERMOD were reviewed and nearly every commenter urged us to integrate aerodynamic downwash into AERMOD (i.e., not to require two models for some analyses). The only comments calling for further actions were associated with the need for documentation, evaluation and review of the suggested downwash enhancement to AERMOD.

As a result of American Meteorological Society (AMS)/EPA Regulatory Model Improvement Committee's (AERMIC) efforts to revise AERMOD, incorporating the PRIME algorithm and making certain other incidental modifications and to respond to public concerns, we believed that the revised AERMOD merited another public examination of performance results. Also, since the April 2000 NPR, the Federal Aviation Administration (FAA) decided to configure EDMS 3.1 to incorporate the AERMOD dispersion model. FAA presented this strategy at the 7th conference and performance evaluations at two airports were to be available before final promulgation. This was in response to public concern over lack of EDMS evaluation.

On April 15, 2003 we published a Notice of Final Rulemaking (NFR; 68 FR 18440) that adopted CALPUFF in appendix A of the *Guideline.* We also made various editorial changes to update and reorganize information, and removed obsolete models. We announced that action on AERMOD and the Emissions and Dispersion Model (EDMS) for assessing airport impacts was being deferred, and would be reconsidered in a separate action when new information became available for these models.

This deferred action took the form of a Notice of Data Availability (NDA), which was published on September 8, 2003 (68 FR 52934). In this notice, we made clear that the purpose of the NDA was to furnish pertinent technical details related to model changes since the April 2000 NPR. New performance data and evaluation of design concentration using the revised AERMOD are contained in reports cited later in this *preamble* (see section V). In our April 2003 NFR, we stated that results of EDMS 4.0 performance (with AERMOD) had recently become available. In the NDA we clarified that these results would not be provided because of FAA's decision to withdraw EDMS from the *Guideline's* appendix A, and we affirmed our support for this removal. We solicited public comments on the new data and information related to AERMOD.

IV. Discussion of Public Comments and Issues From Our April 21, 2000 Proposal

All comments submitted to Docket No. A–99–05 are filed in Category IV–D.[3] We summarized these comments, developed detailed responses, and documented conclusions on appropriate actions in a Response-to-Comments document.[4] In this document, we considered and discussed all significant comments. Whenever the comments revealed any new information or suggested any alternative solutions, we considered this prior to taking final action.

The remainder of this preamble section discusses the primary issues encountered by the Agency during the public comment period associated with the April 2000 proposal. This overview also serves in part to explain the changes to the *Guideline* in today's action, and the main technical and policy concerns addressed by the Agency.

A. AERMOD and PRIME

AERMOD is a best state-of-the-practice Gaussian plume dispersion model whose formulation is based on planetary boundary layer principles. AERMOD provides better characterization of plume dispersion than does ISC3. At the 7th conference, AERMIC members presented developmental and evaluation results of AERMOD. Comprehensive comments were submitted on the AERMOD code and formulation document and on the AERMET draft User's Guide (AERMET is the meteorological preprocessor for AERMOD).

As identified in the April 2000 **Federal Register** proposal, applications for which AERMOD was suited include assessment of plume impacts from stationary sources in simple, intermediate, and complex terrain, for *other than* downwash and deposition applications. We invited comments on whether technical concerns had been reasonably addressed and whether AERMOD is appropriate for its intended applications. Since AERMOD lacks a general (all-terrain) screening tool, we invited comment on the practicality of using SCREEN3 as an interim tool for AERMOD. We also sought comments on minor changes to the list of acceptable screening techniques for complex terrain.

PRIME was designed to incorporate the latest scientific algorithms for evaluating building downwash. At the time of the proposal, the PRIME algorithm for simulating aerodynamic downwash was not incorporated into AERMOD. For testing purposes, PRIME was implemented within ISC3ST (short-term average version of the Industrial Source Complex), which AERMOD was proposed to replace. This special model, called *ISC–PRIME,* was proposed for

[3] Additional comments received since we published the final rule on April 15, 2003 (discussed in the previous section) are filed in category IV–E. This category includes comments received pursuant to the Notice of Data Availability we published in September 2003.

[4] Summary of Public Comments and EPA Responses: AERMOD; 7th Conference on Air Quality Modeling; Washington, DC, June 28–29, 2000 AND Notice of Data Availability—September 8, 2003 (Air Docket A–99–05, Item V–C–2). This document may also be examined from EPA's SCRAM Web site at *www.epa.gov/scram001.*

aerodynamic downwash and dry deposition. We sought comment on the technical viability of AERMOD and ISC–PRIME for its intended applications.

Scientific merit and accuracy. Regarding the scientific merits of AERMOD, substantial support was expressed in public comments that AERMOD represents sound and significant advances over ISC3ST. The scientific merits of this approach have been documented both through scientific peer review and performance evaluations. The formulation of AERMOD has been subjected to an extensive, independent peer review.[5] Findings of the peer review panel suggest that AERMOD's scientific basis is ''state-of-the-science.'' Additionally, the model formulations used in AERMOD and the performance evaluations have been accepted for publication in two refereed journals.[6,7] Finally, the adequacy of AERMOD's complex terrain approach for regulatory applications is seen most directly in its performance. AERMOD's complex terrain component has been evaluated extensively by comparing model-estimated regulatory design values and concentration frequency distributions with observations. These comparisons have demonstrated AERMOD's superiority to ISC3ST and CTDMPLUS (Complex Terrain Dispersion Model PLUS unstable algorithms) in estimating those flat and complex terrain impacts of greatest regulatory importance.[8] For incidental and unique situations involving a well-defined hill or ridge and where a detailed dispersion analysis of the spatial pattern of plume impacts is of interest, CTDMPLUS in the *Guideline*'s appendix A remains available.

Public comments also supported our conclusion about the scientific merits of PRIME. A detailed article in a peer-reviewed journal has been published which contains all the basic equations with clear definitions of the variables, and the reasoning and references for the model assumptions.[9]

Although some comments asked for more detailed documentation and review, there were no comments which questioned the technical credibility of the PRIME model. In fact, almost every commenter asked for PRIME to be incorporated into AERMOD. As summarized above, we believe that the scientific merit of PRIME has been established via (1) model evaluation and documentation, (2) peer review within the submittal process to a technical journal, and (3) via the public review process.

Based on the external peer review of the evaluation report and the public review comments, we have concluded that: (1) AERMOD's accuracy is adequately documented; (2) AERMOD's accuracy is an improvement over ISC3ST's ability to predict measured concentrations; and (3) AERMOD is an acceptable regulatory air dispersion model replacement for ISC3ST.

Some commenters have identified what they perceived to be weaknesses in the evaluation and performance of ISC–PRIME,[10] and some concerns were raised about the scope of the PRIME evaluation. However, as shown by the overwhelming number of requests for the incorporation of PRIME into AERMOD, commenters were convinced that the accuracy of PRIME, as implemented within the ISC3ST framework, was reasonably documented and found acceptable for regulatory applications. Although some commenters requested more evaluations, practical limitations on the number of valid, available data sets prevented the inclusion of every source type and setting in the evaluation. All the data bases that were reasonably available were used in the development and evaluation of the model, and those data bases were sufficient to establish the basis for the evaluation. Based on our review of the documentation and the public comments, we conclude that the accuracy of PRIME is sufficiently documented and find it acceptable for use in a dispersion model recommended in the *Guideline.*

B. Appropriate for Proposed Use

Responding to a question posed in our April 2000 proposal, the majority of commenters questioned the reasonableness of requiring simultaneous use of two models (ISC–PRIME and AERMOD) for those sources with potential downwash concerns. Commenters urged the Agency to eliminate the need to use two models for evaluating the same source. In response to this request, AERMIC developed a version of AERMOD that incorporates PRIME: AERMOD (02222) and initiated an analysis to insure that concentration estimates by AERMOD (02222) are equivalent to ISC–PRIME predictions in areas affected by downwash before it replaces ISC–PRIME. Careful thought was given to the way that PRIME was incorporated into AERMOD, with the goal of making the merge seamless. While discontinuities from the concatenation of these two sets of algorithms were of concern, we mitigated this situation wherever possible (see part D of this preamble, and the Response to Comments document[4]). With regard to testing the performance of AERMOD (02222), we have carefully confirmed that the AERMOD (02222)'s air quality concentration predictions in the wake region reasonably compare to those predictions from ISC–PRIME. In fact, the results indicate that AERMOD (02222)'s performance matches the performance of ISC–PRIME, and are presented in an updated evaluation report[11] and analysis of regulatory design concentrations.[12] We discuss AERMOD (02222) performance in detail in part D.

Because the technical basis for the PRIME algorithms and the AERMOD formulations have been independently peer-reviewed, we believe that further peer review of the new model (AERMOD 02222) is not necessary. The scientific formulation of the PRIME algorithms has not been changed. However, the coding for the interface between PRIME and the accompanying dispersion model had to be modified somewhat to accommodate the different ways that ISC3ST and AERMOD simulate the atmosphere. The main public concern was the interaction between the two models and whether the behavior would be appropriate for all reasonable source settings. This concern was addressed through the extensive testing conducted within the performance evaluation[11] and analysis of design concentrations.[12] Both sets of

[5] U.S. Environmental Protection Agency, 2002. Compendium of Reports from the Peer Review Process for AERMOD. February 2002. Available at *www.epa.gov/scram001/.*

[6] Cimorelli, A. *et al.,* 2005. AERMOD: A Dispersion Model for Industrial Source Applications. Part I: General Model Formulation and Boundary Layer Characterization. *Journal of Applied Meteorology,* 44(5): 682–693.

[7] Perry, S. *et al.,* 2005. AERMOD: A Dispersion Model for Industrial Source Applications. Part II: Model Performance against 17 Field Study Databases. *Journal of Applied Meteorology,* 44(5): 694–708.

[8] Paine R. J. *et al.,* 1998. Evaluation Results for AERMOD, Draft Report. Docket No. A–99–05; II–A–05. Available at *www.epa.gov./scram001/.*

[9] Schulman, L.L. *et al.,* 2000. Development and Evaluation of the PRIME Plum Rise and Building Downwash Model. JAWMA 50: 378–390.

[10] Electric Power Research Institute, 1997. Results of the Independent Evaluation of ISCST3 and ISC–PRIME. Final Report, TR–2460026, November 1997. Available at *www.epa.gov/scram001/.*

[11] Environmental Protection Agency, 2003. AERMOD: Latest Features and Evaluation Results. Publication No. EPA–454/R–03–003. Available at *www.epa.gov/scram001/.*

[12] Environmental Protection Agency, 2003. Comparison of Regulatory Design Concentrations: AERMOD versus ISC3ST, CTDMPLUS, and ISC–PRIME. Final Report. Publication No. EPA–454/R–03–002. Available at *www.epa.gov/scram001/.*

analyses indicate that the new model is performing acceptably well and the results are similar to those obtained from the earlier performance evaluation [8] [10] and analysis of regulatory design concentrations (*i.e.*, for AERMOD (99351)).[13]

While dry deposition is treated in ISC3ST, time and resources did not allow its incorporation in AERMOD (99351). Since no recommendation for deposition is made for regulatory applications, we did not consider that the absence of this capability compromises the suitability of AERMOD for its intended purposes. Nevertheless, a number of commenters requested that deposition algorithms be added to AERMOD, and we developed an update to AERMOD (02222) that offers dry and wet deposition for both gases and particles as an option.

The version of AERMOD under review at the 7th Conference was AERMOD (99351) and, as mentioned above, AERMIC has made a number of changes to AERMOD (99351) following this conference. These changes were initiated in response to public comments and, after the release of a new draft version of the model, in response to the recommendations from the *beta* testers. Changes made to AERMOD include the following:

• Adding the PRIME algorithms to the model (response to public comments);

• Modifying the complex terrain algorithms to make AERMOD less sensitive to the selection of the domain of the study area (response to public comments);

• Modifying the urban dispersion for low-level emission sources, such as area sources, to produce a more realistic urban dispersion and, as a part of this change, changing the minimum layer depth used to calculate the effective dispersion parameters for all dispersion settings (scientific formulation correction which was requested by beta testers); and

• Upgrading AERMOD to include all the newest features that exist in the latest version of ISC3ST such as Fortran90 compliance and allocatable arrays, EVENTS processing and the TOXICS option (response to public comments).

In the follow-up quality control checking of the model and the source code, additional changes were identified as necessary and the following revisions were made:

• Adding meander treatment to: (1) Stable and unstable urban cases, and (2) the rural unstable dispersion settings (only the rural, stable dispersion setting considered meander in AERMOD (99351)—this change created a consistent treatment of air dispersion in all dispersion settings);

• Making some changes to the basic meander algorithms (improved scientific formulation); and

• Repairing miscellaneous coding errors.

As we mentioned earlier, the version of AERMOD that is being promulgated today—AERMOD (02222)—has been subjected to further performance evaluation [11] and analysis of design concentrations.[12]

C. Implementation Issues/Additional Guidance

Other than miscellaneous suggestions for certain enhancements for AERMOD (99351) such as a Fortran90 compilation of the source code, creation of allocatable arrays, and development of a Windows® graphical user interface, no significant implementation obstacles were identified in public comments.

For AERMET (meteorological preprocessor for AERMOD), we have implemented some enhancements that commenters suggested. For site-specific applications, several commenters cited AERMOD's requirements for NWS cloud cover data. In response, we revised the AERMET to incorporate the bulk Richardson number methodology. This approach uses temperature differences near the surface of the earth, which can be routinely monitored, and eliminates the need for the cloud cover data at night. We made a number of other revisions in response to public comments, enabling AERMET to: (1) Use the old and the new Forecasting Systems Laboratory formats, (2) use the Hourly U.S. Weather Observations/ Automated Surface Observing Stations (HUSWO/ASOS) data, (3) use site-specific solar radiation and temperature gradient data to eliminate the need for cloud cover data, (4) appropriately handle meteorological data from above the arctic circle, and (5) accept a wider range of reasonable friction velocities and reduce the number of warning messages. As mentioned earlier, we added a meander component to the treatment of stable and unstable urban conditions to consistently treat meander phenomena for all cases.

AERMAP (the terrain preprocessor for AERMOD) has been upgraded in response to public comments calling for it to: (1) Treat complex terrain receptors without a dependance on the selected domain, (2) accommodate the Spatial Data Transfer Standard (SDTS) data available from the U.S. Geological Survey (USGS), (3) appropriately use Digital Elevation Model (DEM) data with 2 different datums (NAD27 and NAD83); (4) accept all 7 digits of the North UTM coordinate, and (5) do more error-checking in the raw data (mostly checking for missing values, but not for harsh terrain changes in adjacent points). All of these recommendations have been implemented.

In response to comments about the selection of the domain affecting the results of the maximum concentrations in complex terrain and the way AERMAP estimates the effective hill height scale (h_C), the algorithms within AERMAP and AERMOD have been adjusted so that the hill height is less sensitive to the arbitrary selection of the domain. This adjustment has been evaluated against the entire set of evaluation data. The correction was found to substantially reduce the effect of the domain size upon the computation of controlling hill heights for each receptor. Application of this change to the evaluation databases did not materially affect the evaluation results.

In general, public comments that requested additional guidance were either obviated by revisions to AERMOD (99351) and its related preprocessors or deemed unnecessary. In the latter case, the reasons were explained in the Response-to-Comments document.[4]

Some public comments suggested additional testing of AERMOD (99351). In fact, after the model revisions that were described earlier were completed, AERMOD (02222) was subjected to additional testing.[11] [12] These new analyses will be discussed in part D.

With respect to a screening version of AERMOD, a tool called AERSCREEN is being developed with a beta version expected to be publicly available in Fall 2005. SCREEN3 is the current screening model in the *Guideline,* and since SCREEN3 has been successfully applied for a number of years, we believe that SCREEN3 produces an acceptable degree of conservatism for regulatory applications and may be used until AERSCREEN or a similar technique becomes available and tested for general application.

D. AERMOD Revision and Reanalyses Published In 2003

1. Performance Analysis for AERMOD (02222)

We have tested the performance of AERMOD (02222) by applying all of the original data sets used to support the version proposed in April, 2000: AERMOD (99351) [8] and ISC–PRIME.[10] These data sets include: 5 complex

[13] Peters, W.D. *et al.,* 1999. Comparison of Regulatory Design Concentrations: AERMOD vs. ISCST3 and CTDMPLUS, Draft Report. Docket No. A–99–05; II–A–15.

terrain data sets, 7 building downwash data sets, and 5 simple terrain data sets (see appendix A of the Response-to-Comments document[4]). This performance analysis, which is a check of the model's maximum concentration predictions against observed data, includes a comparison of the current version of the new model (AERMOD 02222) with ISC3ST or ISC–PRIME for downwash conditions. The results and conclusions of the performance analyses are presented in 2 sections: Non-downwash and downwash source scenarios.

a. Non-Downwash Cases

For the user community to obtain a full understanding of the impacts of today's proposal for the non-downwash source scenarios (flat and complex terrain), our performance evaluation of AERMOD (02222) must be discussed with respect to the old model, ISC3ST, and with respect to AERMOD (99351). Based on the evaluation, we have concluded that AERMOD (02222) significantly outperforms ISC3ST and that AERMOD (02222)'s performance is even better than that of AERMOD (99351).

Evaluation of AERMOD (99351)

Comparative performance statistics were calculated for both ISC3ST and AERMOD (99351) using data sets in non-downwash conditions. This analysis looked at combinations of test sites (flat and complex terrain), pollutants, and concentration averaging times. Comparisons indicated very significant improvements in performance when applying AERMOD (99351). In all but 1 of the total of 20 cases in which AERMOD (99351) could be compared to ISC3ST, AERMOD performed as well as (but generally better than) ISC3ST, that is, AERMOD predicted maximum concentrations that were closer to the measured maximum concentrations. In the most dramatic case (*i.e.*, Lovett; 24-hr) in which AERMOD performed better than ISC3ST, AERMOD's maximum concentration predictions were about the same as the measured concentrations while the ISC3ST's predicted maximum concentrations were about 9 times higher than the measured concentrations. In the one case (*i.e.*, Clifty Creek; 3-hr) where ISC3ST performed better than AERMOD (99351), ISC3ST's concentration predictions matched the observed data and the AERMOD concentration predictions were about 25% higher than the observed data. These results were reported in the supporting documentation for AERMOD (99351).

Evaluation of AERMOD (02222)

With the changes to AERMOD (99351) as outlined above, how has the performance of the AERMOD been affected? The performance of the current version of AERMOD is about the same or slightly better than the April 2000 version when a comparison is made over all the available data sets. There were examples of AERMOD (02222) showing better and poorer performance when compared to the performance results of AERMOD (99351). However, for those cases where AERMOD (02222)'s performance was degraded, the degradation was small. On the other side, there were more examples where AERMOD (02222) more closely predicted measured concentrations. The performance improvements were also rather small but, in general, were somewhat larger than the size of the performance degradations. There also were a number of cases where the performance remained unchanged between the 2 models. Thus, overall, there was a slight improvement in AERMOD's performance and, consequently, we believe that AERMOD (02222) significantly outperforms ISC3ST for non-downwash source scenarios.

For AERMOD (02222) with the 5 data bases examined for simple terrain, the ratios of modeled/observed Robust High Concentration ranged from 0.77 to 1.11 (1-hr average), 0.98 to 1.24 (3-hr average), 0.94 to 0.97 (24-hr average) and 0.30 to 0.97 (annual average). These ratios reflect better performance than ISC3ST for all cases.

For AERMOD (02222) with the 5 data bases examined for complex terrain, these ratios ranged from 1.03 to 1.12 (3-hr average), 0.67 to 1.78 (24-hr average) and 0.54 to 1.59 (annual average). At Tracy—the only site for which there are 1-hr data—AERMOD performed considerably better (ratio = 1.04) than either ISC3ST or CTDMPLUS. At three of the other four sites, AERMOD generally performed much better than either ISC3ST or (where applicable) alternative models for the 3-hr and 24-hr averaging times; results were comparable for Clifty Creek (for the 3-hr averaging times, AERMOD (02222) predictions were only about 5% higher than ISC3ST's—down from 25% for AERMOD (99351) as described earlier). At the two sites where annual peak comparisons are available, AERMOD performed much better than either ISC3ST or alternative models.

b. Downwash Cases

For the downwash data sets, there were combinations of test sites, pollutants, stack heights and averaging times where the proposed (ISC–PRIME) model performance could be compared to the performance of AERMOD (02222) with PRIME incorporated. There was an equal number of non-downwash cases where AERMOD performed better than ISC–PRIME and where ISC–PRIME performed better than AERMOD. There was only one case where there was a significant difference between the two models' performance, and AERMOD clearly performed better than ISC–PRIME in this case. In all other cases, the difference in the performance, whether an improvement or a degradation, was small. This comparison indicated that AERMOD (02222) performs very similarly, if not somewhat better, when compared to ISC–PRIME for downwash cases.

2. Analysis of Regulatory Design Concentrations for AERMOD (02222)

Although not a performance tool, the analysis of design concentrations (''consequence'' analysis) is designed to test model stability and continuity, and to help the user community understand the differences to be expected between air dispersion models. The consequences, or changes in the regulatory concentrations predicted when using the new model (AERMOD 02222) versus ISC3ST, cover 96 source scenarios and at least 3 averaging periods per source scenario, and are evaluated and summarized here. The purpose is to provide the user community with a sense of potential changes in their air dispersion analyses when applying the new model over a broad range of source types and settings. The *consequence analysis*, in which AERMOD was run for hundreds of source scenarios, also provides a check for model stability (abnormal halting of model executions when using valid control files and input data) and for spurious results (unusually high or low concentration predictions which are unexplained). The results are placed into 3 categories: non-downwash source scenarios in flat, simple terrain; downwash source scenarios in flat terrain; and, complex terrain source settings. The focus of this discussion is on how design concentrations change from those predicted by ISC3ST when applying the latest version of AERMOD versus applying the earlier version of AERMOD (99351).

a. Non-Downwash Cases

For the non-downwash situations, there were 48 cases covering a variety of source types (point, area, and volume sources), stack heights, terrain types (flat and simple), and dispersion settings (urban and rural). For each case in the consequence analysis, we calculated the ratio between AERMOD's regulatory concentration predictions and ISC3ST's regulatory concentration predictions. The average ratio of AERMOD to ISC3ST-predicted concentrations changed from 1.14 when applying AERMOD (99351) to 0.96 when applying AERMOD (02222).[14] Thus, in general, AERMOD (02222) tends to predict concentrations closer to ISC3ST than does version 99351 proposed in April 2000. Also, the variation of the differences between ISC3ST and AERMOD has decreased with AERMOD (02222). Comparing the earlier consequence analysis to the latest study with AERMOD (02222), we saw a 25% reduction in the number of cases where the AERMOD-predicted concentrations differed by over a factor of two from ISC3ST's predictions.

b. Downwash Cases

For the downwash analysis, there were 20 cases covering a range of stack heights, locations of stacks relative to the building, dispersion settings, and building shapes. As before, we calculated the ratio regulatory concentration predictions from AERMOD (02222 with PRIME) and compared them as ratios to those from ISC3ST for each case. For additional information, we also included ratios with ISC–PRIME that was also proposed in April 2000.

Calculated over all the 20 cases, and for all averaging times considered, the average ISC–PRIME to ISC3ST concentration ratio is about 0.86, whereas for AERMOD (PRIME) to ISC3ST, it is 0.82. The maximum value of the concentration ratios range from 2.24 for ISC–PRIME/ISC3ST to 3.67 for AERMOD (PRIME)/ISC3ST. Similarly, the minimum value of the concentration ratio range from 0.04 for ISC–PRIME/ISC3ST to 0.08 for AERMOD (PRIME)/ISC3ST. (See Table 4–5 in reference 12.)

Although results above for the two models that use PRIME—AERMOD (02222) and ISC–PRIME—show differences, we find that building downwash is not a significant factor in determining the maximum concentrations in some of the cases, *i.e.*, the PRIME algorithms do not predict a building cavity concentration. Of those cases where downwash was important, the average concentration ratios of ISC–PRIME/ISC3ST and AERMOD (02222)/ISC3ST are about 1. The maximum value of the concentration ratios range from 2.24 for ISC–PRIME/ISC3ST to 1.87 for AERMOD (02222)/ISC3ST and the minimum value of the concentration ratios range from 0.34 for ISC–PRIME/ISC3ST to 0.38 for AERMOD (02222)/ISC3ST. These results show relatively close agreement between the two PRIME models. (*See* Table 4–6 in reference 12.)

ISC3ST does not predict cavity concentrations but comparisons can be made between AERMOD and ISC–PRIME. The average AERMOD (02222) predicted 1-hour cavity concentration is about the same (112%) as the average ISC–PRIME 1-hour cavity concentration. In the extremes, the AERMOD (02222)-predicted cavity concentrations ranged from about 40% higher to 15% lower than the corresponding ISC–PRIME cavity concentration predictions. Thus, in general, where downwash is a significant factor, AERMOD (02222) and ISC–PRIME predict similar maximum concentrations. (*See* Table 4–8 in reference 12.)

Although the same downwash algorithms are used in both models, there are differences in the melding of PRIME with the core model, and differences in the way that these models simulate the atmosphere.[15] The downwash algorithm implementation therefore could not be exactly the same.

c. Complex Terrain

During the testing of AERMOD after modifications were made to the complex terrain algorithm (*see* discussion of hill height scale (h_C) in B. Appropriate for Proposed Use in this preamble), a small error was found in the original complex terrain code while conducting the consequence analysis. This error was subsequently repaired. Final testing indicated that the revised complex terrain code produced reasonable results for the consequence analysis, as described below.

The analysis of predicted design concentrations included a suite of complex terrain settings. There were 28 cases covering a variety of stack heights, stack gas buoyancy values, types of hills, and distances between source and terrain. The ratios between the AERMOD (02222 & 99351)—predicted maximum concentrations and the ISC3ST maximum concentrations were calculated for all cases for a series of averaging times. When comparing AERMOD (99351) to ISC3ST and then AERMOD (02222) to ISC3ST, the average maximum concentration ratio, the highest ratios and the lowest ratios were almost unchanged. There were no cases in either consequence analysis where AERMOD (02222 & 99351) predicted higher concentrations than those predicted by ISC3ST. Thus, in general, the consequences of moving from ISC3ST to AERMOD (02222) rather than to AERMOD (99351) in complex terrain were essentially the same. (*See* Table 4–9 in reference 12.)

E. Emission and Dispersion Modeling System (EDMS)

The Emissions and Dispersion Modeling System (EDMS) was developed jointly by the Federal Aviation Administration (FAA) and the U.S. Air Force in the late 1970s and first released in 1985 to assess the air quality of proposed airport development projects. EDMS has an emissions preprocessor and its dispersion module estimates concentrations for various averaging times for the following pollutants: CO, HC, NO_X, SO_X, and suspended particles (*e.g.*, PM–10). The first published application of EDMS was in December 1986 for Stapleton International Airport (FAA–EE–11–A/REV2).

In 1988, version 4a4 revised the dispersion module to include an integral dispersion submodel: GIMM (Graphical Input Microcomputer Model). This version was proposed for adoption in the *Guideline*'s appendix A in February 1991 (56 FR 5900). This version was included in appendix A in July 1993 (58 FR 38816) and recommended for limited applications for assessments of localized airport impacts on air quality. FAA later updated EDMS to Version 3.0.

In response to the growing needs of air quality analysts and changes in regulations (*e.g.*, conformity requirements from the Clean Air Act Amendment of 1990), FAA updated EDMS to version 3.1, which is based on the CALINE3[16] and PAL2 dispersion kernels. In our April 2000 NPR we proposed to adopt the version 3.1 update to EDMS. However, this update had not been subjected to performance evaluation and no studies of EDMS' performance have been cited in appendix A of the *Guideline*. Comment was invited on whether this compromises the viability of EDMS 3.1 as a recommended or preferred model and how this deficiency can be corrected.

Several commenters expressed concern about EDMS 3.1 as a recommended model in appendix A. Indeed, there were concerns that EDMS

[14] A ratio of 1.00 indicates that the two models are predicting the same concentrations. See Table 4.1 in reference 12.

[15] AERMOD uses more complex techniques to estimate temperature profiles which, in turn, affect the calculation of the plume rise. Plume rise may affect the cavity and downwash concentrations.

[16] Currently listed in appendix A of the *Guideline*.

3.1 had not been as well validated as other models, nor subjected to peer review, as required by the *Guideline*'s subsection 3.1.1. One of these commenters suggested that EDMS 3.1 should be presented only as one of several alternative models.

At the 7th Conference, FAA proposed for appendix A adoption an even newer, enhanced version of EDMS—version 4.0, which incorporates the AERMOD dispersion kernel (without alteration). In this system, the latest version of AERMOD would be employed as a standalone component of EDMS. This dispersion kernel was to replace PAL2 and CALINE3 currently in EDMS 3.1. There were no public comments specific to FAA's proposed AERMOD-based enhancements to EDMS announced after our April 2000 NPR.

In response to written comments on our April 2000 NPR, at the 7th Conference (transcript) FAA promised a complete evaluation process that would include sensitivity testing, intermodel comparison, and analysis of EDMS predictions against field observations. The intermodel comparisons were proposed for the UK's Atmospheric Dispersion Modeling System (ADMS).[17]

As we explained in our September 8, 2003 Notice of Data Availability, FAA has decided to withdraw EDMS from the *Guideline*'s appendix A. We stated that no new information was therefore provided in that notice, and we affirmed support for EDMS' removal from appendix A. This removal, which we promulgate today, obviates the need for EDMS' documentation and evaluation at this time.

V. Discussion of Public Comments on Our September 8, 2003 Notice of Data Availability

As mentioned in section III, after AERMOD was revised pursuant to comments received on the April 21, 2000 proposal, a Notice of Data Availability (NDA) was issued on September 8, 2003 to explain the modifications and to reveal AERMOD's new evaluation data. Public comments were solicited for 30 days and posted electronically in eDocket OAR–2003–0201.[1] (As mentioned in section IV, additional comments received since we published the final rule on April 15, 2003 are filed in Docket A–99–05; category IV–E.) We summarized these comments and developed detailed responses; these appear as appendix C to the Response-to-Comments document.[4] In appendix C, we considered and discussed all significant comments, developed responses, and documented conclusions on appropriate actions for today's notice. Whenever the comments revealed any new information or suggested any alternative solutions, we considered them in our final action and made corrections or enhancements where appropriate.

In the remainder of this preamble section we highlight the main issues raised by the commenters who reviewed the NDA, and summarize our responses. These comments broadly fall into two categories: technical/operational, and administrative.

The technical/operational comments were varied. One commenter thought EPA's sensitivity studies for simulating area sources were too limited, and noted that AERMOD, when used to simulate an area source adjacent to gently sloping terrain, produced ground-level concentrations not unlike those from ISC3ST. In response we explained qualitatively how AERMOD interprets this situation and cautioned that reviewing authorities should be consulted in such scenarios for guidance on switch settings. Other commenters believed that AERMOD exhibited unrealistic treatment of complex terrain elements and offered supporting data. In response, AERMIC concluded that AERMOD does exhibit terrain amplification factors on the windward side of isolated hills, where impacts are expected to be greatest. Commenters also presented evidence that the PRIME algorithm in AERMOD misbehaves in its treatment of building wake and wind incidence. Another model was cited as having better skill in this regard. In response, we acknowledged this but established that AERMOD's capability was acceptable for handling the majority of building geometries encountered (see Response-to-Comments document[4] for more details).

A number of commenters addressed administrative or procedural matters. Some believed that the transition period for implementation—one year—is too short. We explained in response that one year is consistent with past practice and is adequate for most users and reviewing authorities given our previous experience with new models and the fact that AERMOD has been in the public domain for several years. Some were disappointed that the review period (30 days) for the NDA was too short. We believe that the period was adequate to review the two reports that presented updated information on the performance and practical consequences of the model as revised. Regarding the evaluation/comparison regime used for AERMOD, others objected to the methodology used to evaluate AERMOD (one that emphasizes Robust High Concentration), claiming it is ill-suited to the way dispersion models estimate ambient concentrations. We acknowledged that other methods are available that are designed to reflect the underlying physics and formulations of dispersion models, and may be more robust in their mechanisms to account for the stochastic nature of the atmosphere. In fact, we cited several recent cases from the literature in which such methods were applied in evaluations that included AERMOD. We also explained that the approach taken by AERMIC was based on existing guidance in section 9 of Appendix W, and expressed a commitment to explore other methods in the future, including an update to section 9. We believe however that the evaluation methodology used was reasonable for its intended purpose—examining a large array of concentrations for a wide variety of source types—and confers a measure of consistency given its past use. Other commenters expressed disappointment that AERMOD wasn't compared to state-of-the-science models as advised in its peer review report. In response, we cited a substantial list of studies in which AERMOD has, in fact, been compared to some of these models, *e.g.*, HPDM and ADMS (in various combinations). On the whole, as we noted in our response, AERMOD typically performed as well as HPDM and ADMS, and all of them generally performed better than ISC3ST. Still others expressed disappointment that the evaluation input data weren't posted on our Web site until January 22, 2004—three months after the close of the comment period. We acknowledge that the input data were not posted when the NDA was published. However, the actual evaluation input data for AERMOD had not been requested previously, and we did not believe they were required as a basis for reviewing the reports we released. Moreover, since the posting, we are unaware of any belated adverse comments from anyone attempting to access and use the data.

We believe we have carefully considered and responded to public comments and concerns regarding AERMOD. We have also made efforts to update appendix W to better reflect current practice in model solicitation, evaluation and selection. We also have made other technical revisions so the guidance conforms with the latest form of the PM–10 National Ambient Air Quality Standard.

[17] Cambridge Environmental Research Consultants; *http://www.cerc.co.uk/.*

VI. Final Action

In this section we explain the changes to the *Guideline* in today's action in terms of the main technical and policy concerns addressed by the Agency in its response to public comments (sections IV & V). Air quality modeling involves estimating ambient concentrations using scientific methodologies selected from a range of possible methods, and should utilize the most advanced practical technology that is available at a reasonable cost to users, keeping in mind the intended uses of the modeling and ensuring transparency to the public. With these changes, we believe that the *Guideline* continues to reflect recent advances in the field and balance these important considerations. Today's action amends Appendix W of 40 CFR part 51 as detailed below:

AERMOD

Based on the supporting information contained in the docket, and reflected in peer review and public comments, we find that the AERMOD modeling system and PRIME are based on sound scientific principles and provide significant improvements over the current regulatory model, ISC3ST. AERMOD characterizes plume dispersion better than ISC3ST. The accuracy of the AERMOD system is generally well-documented and superior to that of ISC3ST. We are adopting the model based on its performance and other factors.

Public comments on the April 2000 proposal expressed significant concern about the need to use two models (AERMOD and ISC–PRIME) to simulate just one source when downwash posed a potential impact. In response to this concern we incorporated PRIME into AERMOD and documented satisfactory tests of the algorithm. AERMOD, with the inclusion of PRIME, is now appropriate and practical for regulatory applications.

The state-of-the-science for modeling atmospheric deposition continues to evolve, the best techniques are currently being assessed, and their results are being compared with observations. Consequently, as we now say in *Guideline* paragraph 4.2.2(c), the approach taken for any regulatory purpose should be coordinated with the appropriate reviewing authority. We agreed with the public comments calling for the addition of state-of-the-science deposition algorithms, and developed a modification to AERMOD (02222) for *beta* testing. This model, AERMOD (04079) was posted on our Web site *http://www.epa.gov/scram001/tt25.htm#aermoddep* on March 19, 2004. The latest version of AERMOD may now be used for deposition analysis in special situations.

Since AERMOD treats dispersion in complex terrain, we have merged sections 4 and 5 of appendix W, as proposed in the April 2000 NPR. And while AERMOD produces acceptable regulatory design concentrations in complex terrain, it does not replace CTDMPLUS for detailed or receptor-oriented complex terrain analysis, as we have made clear in *Guideline* section 4.2.2. CTDMPLUS remains available for use in complex terrain.

We have implemented the majority of suggestions to improve the AERMET, AERMAP, and AERMOD source code to reflect all the latest features that have been available in ISC3ST and that are available in the latest versions of Fortran compilers. Also, the latest formats for meteorological and terrain input data are now accepted by the new versions of AERMET and AERMAP. Our guidance, documentation and users' guides have been modified in response to a number of detailed comments.

With respect to AERMOD (02222)'s performance, we have concluded that:

(1) AERMOD (99351), the version proposed in April 2000, performs significantly better than ISC3ST, and AERMOD (02222) performs slightly better than AERMOD (99351) in non-downwash settings in both simple and complex terrain;

(2) The performance evaluation indicates that AERMOD (02222) performs slightly better than ISC–PRIME for downwash cases.

With respect to changes in AERMOD's regulatory design concentrations compared to those for ISC3ST, we have concluded that:

- For non-downwash settings, AERMOD (02222), on average, tends to predict concentrations closer to ISC3ST, and with somewhat smaller variations, than the April 2000 proposal of AERMOD;
- Where downwash is a significant factor in the air dispersion analysis, AERMOD (02222) predicts maximum concentrations that are very similar to ISC–PRIME's predictions;
- For those source scenarios where maximum 1-hour cavity concentrations are calculated, the average AERMOD (02222)-predicted cavity concentration tends to be about the same as the average ISC–PRIME cavity concentrations; and
- In complex terrain, the consequences of using AERMOD (02222) instead of ISC3ST remained essentially unchanged in general, although they varied based on individual circumstances.

Since AERMOD (02222) was released, an updated version was posted on our Web site on March 22, 2004: AERMOD (04079). The version we are releasing pursuant to today's promulgation, however, is AERMOD (04300). This version, consonant with AERMOD (02222) in its formulations, addresses the following minor code issues:

- The area source algorithm in simple and complex terrain required a correction to the way the dividing streamline height is calculated.
- In PRIME, incorrect turbulence parameters were being passed to one of the numerical plume rise routines, and this has been corrected.
- A limit has been placed on plume cooling within PRIME to avoid supercooling, which had been causing runtime instability.
- A correction has been made to avoid AERMOD's termination under certain situations with capped stacks (i.e., where the routine was attempting to take a square root of a negative number). Our testing has demonstrated only very minor impacts from these corrections on the evaluation results or the consequence analysis.

AERMOD (04300) has other draft portions of code that represent options not required for regulatory applications. These include:

- Dry and wet deposition for both gases and particles;
- The ozone limiting method (OLM), referenced in section 5.2.4 (Models for Nitrogen Dioxide—Annual Average) of the *Guideline* for treating NO_X conversion; and
- The Plume Volume Molar Ratio Method (PVMRM) for treating NO_X conversion.
- The bulk Richardson number approach (discussed earlier) for using near-surface temperature difference has been corrected in AERMOD (04300).

Based on the technical information contained in the docket for this rule, and with consideration of the performance analysis in combination with the analysis of design concentrations, we believe that AERMOD is appropriate for regulatory use and we are revising the *Guideline* to adopt it as a refined model today.

In implementing the changes to the *Guideline*, we recognize that there may arise occasions in which the application of a new model can result in the discovery by a permit applicant of previously unknown violations of NAAQS or PSD increments due to emissions from existing nearby sources. This potential has been acknowledged previously and is addressed in existing EPA guidance (''Air Quality Analysis for Prevention of Significant Deterioration

(PSD),'' Gerald A. Emison, July 5, 1988). To summarize briefly, the guidance identifies three possible outcomes of modeling by a permit applicant and details actions that should be taken in response to each:

1. Where dispersion modeling shows no violation of a NAAQS or PSD increment in the impact area of the proposed source, a permit may be issued and no further action is required.

2. Where dispersion modeling predicts a violation of a NAAQS or PSD increment within the impact area but it is determined that the proposed source will not have a significant impact (i.e., will not be above de minimis levels) at the point and time of the modeled violation, then the permit may be issued immediately, but the State must take appropriate actions to remedy the violations within a timely manner.

3. Where dispersion modeling predicts a violation of a NAAQS or PSD increment within the impact area and it is determined that the proposed source will have a significant impact at the point and time of the modeled violation, then the permit may not be issued until the source owner or operator eliminates or reduces that impact below significance levels through additional controls or emissions offsets. Once it does so, then the permit may be issued even if the violation persists after the source owner or operator eliminates its contribution, but the State must take further appropriate actions at nearby sources to eliminate the violations within a timely manner.

In previous promulgations, we have traditionally allowed a one-year transition (''grandfather'') period for new refined techniques. Accordingly, for appropriate applications, AERMOD *may be* substituted for ISC3 during the one-year period following the promulgation of today's notice. Beginning one year after promulgation of today's notice, (1) applications of ISC3 with approved protocols may be accepted (see **DATES** section) and (2) AERMOD *should be* used for appropriate applications as a replacement for ISC3.

We separately issue guidance for use of modeling for facility-specific and community-scale air toxics risk assessments through the Air Toxics Risk Assessment Reference Library.[18] We recognize that the tools and approaches recommended therein will eventually reflect the improved formulations of the AERMOD modeling system and we expect to appropriately incorporate them as expeditiously as practicable. In the interim, as appropriate, we will consider the use of either ISC3 or AERMOD in air toxic risk assessment applications.

[18] *http://www.epa.gov/ttn/fera/risk_atra_main.html.*

EDMS

FAA has completed development of the new EDMS4.0 to incorporate AERMOD. The result is a conforming enhancement that offers a stronger scientific basis for air quality modeling. FAA has made this model available on its Web site, which we cite in an updated *Guideline* paragraph 7.2.4(c). As described earlier in this preamble, the summary description for EDMS will be removed from appendix A.

VII. Final Editorial Changes to Appendix W

Today's update of the *Guideline* takes the form of many revisions, and some of the text is unaltered. Therefore, as a purely practical matter, we have chosen to publish the new version of the entire text of appendix W and its appendix A. Guidance and editorial changes associated with the resolution of the issues discussed in the previous section are adopted in the appropriate sections of the *Guideline*, as follows:

Preface

You will note some minor revisions of appendix W to reflect current EPA practice.

Section 4

As mentioned earlier, we revised section 4 to present AERMOD as a refined regulatory modeling technique for particular applications.

Section 5

As mentioned above, we merged pertinent guidance in section 5 (Modeling in Complex Terrain) with that in section 4. With the anticipated widespread use of AERMOD for all terrain types, there is no longer any utility in the previous differentiation between simple and complex terrain for model selection. To further simplify, the list of acceptable, yet equivalent, screening techniques for complex terrain was removed. CTSCREEN and guidance for its use are retained; CTSCREEN remains acceptable for all terrain above stack top. The screening techniques whose descriptions we removed, i.e., Valley (as implemented in SCREEN3), COMPLEX I (as implemented in ISC3ST), and RTDM remain available for use in applicable cases where established/accepted procedures are used. Consultation with the appropriate reviewing authority is still advised for application of these screening models.

Section 6

As proposed, we renumbered this to become section 5. In subsection 5.1, we reference the Plume Volume Molar Ratio Method (PVMRM) for point sources of NO_X, and mention that it is currently being tested to determine suitability as a refined method.

Section 7

As proposed, we renumbered this to become section 6. We updated the reference to the Emissions and Dispersion Modeling System (EDMS).

Section 8

As proposed, we revised section 8 (renumbered to section 7) to provide guidance for using AERMET (AERMOD's meteorological preprocessor).

• In subsection 7.2.4, we introduce the atmospheric stability characterization for AERMOD.

• In subsection 7.2.5, we describe the plume rise approaches used by AERMOD.

Section 9

As proposed, we renumbered section 9 to become section 8. We added paragraphs 8.3.1.2(e) and 8.3.1.2(f) to clarify use of site specific meteorological data for driving CALMET in the separate circumstances of long range transport and for complex terrain applications.

Section 10

As proposed, we revised section 10 (renumbered section 9) to include AERMOD. In May 1999, the D.C. Court of Appeals vacated the PM–10 standard we promulgated in 1997, and this standard has since been removed from the CFR (69 FR 45592; July 30, 2004). Paragraph 10.2.3.2(a) has been corrected to be consistent with the current (original) PM–10 standard, which is based on expected exceedances.

Section 11

As proposed, we renumbered section 11 to become section 10.

Sections 12 & 13

We renumbered section 12 to become section 11, and section 13 (References) to become section 12. We revised renumbered section 12 by adding some references, deleting obsolete/superseded ones, and resequencing. You will note that the peer scientific review for AERMOD and latest evaluation references have been included.

Appendix A

We added AERMOD (with the PRIME downwash algorithm integrated) to appendix A. We removed EDMS from appendix A. We also updated the description for CALPUFF, and made minor updates to some of the other model descriptions.

Availability of Related Information

Our Air Quality Modeling Group maintains an Internet Web site (Support Center for Regulatory Air Models—SCRAM) at: *http://www.epa.gov/scram001.* You may find codes and documentation for models referenced in today's action on the SCRAM Web site. In addition, we have uploaded various support documents (e.g., evaluation reports).

VIII. Statutory and Executive Order Reviews

A. Executive Order 12866: Regulatory Planning and Review

Under Executive Order 12866 [58 FR 51735 (October 4, 1993)], the Agency must determine whether the regulatory action is ''significant'' and therefore subject to review by the Office of Management and Budget (OMB) and the requirements of the Executive Order. The Order defines ''significant regulatory action'' as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs of the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

It has been determined that this rule is not a ''significant regulatory action'' under the terms of Executive Order 12866 and is therefore not subject to EO 12866 review.

B. Paperwork Reduction Act

This final rule does not contain any information collection requirements subject to review by OMB under the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.*

Burden means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

An agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number. The OMB control numbers for EPA's regulations in 40 CFR are listed in 40 CFR part 9.

C. Regulatory Flexibility Act (RFA)

The RFA generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impact of today's rule on small entities, small entities are defined as: (1) A small business that meets the RFA default definitions for small business (based on Small Business Administration size standards), as described in 13 CFR 121.201; (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

After considering the economic impacts of today's final rule on small entities, I certify that this action will not have a significant economic impact on a substantial number of small entities. As this rule merely updates existing technical requirements for air quality modeling analyses mandated by various CAA programs (e.g., prevention of significant deterioration, new source review, State Implementation Plan revisions) and imposes no new regulatory burdens, there will be no additional impact on small entities regarding reporting, recordkeeping, and compliance requirements.

D. Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104–4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments and the private sector. Under section 202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with ''Federal mandates'' that may result in expenditures to State, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule for which a written statement is needed, section 205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows EPA to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the Administrator publishes with the final rule an explanation why that alternative was not adopted. Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including tribal governments, it must have developed under section 203 of the UMRA a small government agency plan.

The plan must provide for notifying potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant Federal intergovernmental mandates, and informing, educating, and advising small governments on compliance with the regulatory requirements.

Today's rule recommends a new modeling system, AERMOD, to replace ISC3ST as an analytical tool for use in SIP revisions and for calculating PSD increment consumption. AERMOD has been used for these purposes on a case-by-case basis (per *Guideline* subsection 3.2.2) for several years. Since the two modeling systems are comparable in scope and purpose, use of AERMOD itself does not involve any significant increase in costs. Moreover, modeling costs (which include those for input data acquisition) are typically among the implementation costs that are considered as part of the programs (*i.e.*, PSD) that establish and periodically revise requirements for compliance.

Any incremental modeling costs attributable to today's rule do not approach the $100 million threshold prescribed by UMRA. EPA has determined that this rule contains no regulatory requirements that might significantly or uniquely affect small governments. This rule therefore contains no Federal mandates (under the regulatory provisions of Title II of the UMRA) for State, local, or tribal governments or the private sector.

E. Executive Order 13132: Federalism

Executive Order 13132, entitled ''Federalism'' (64 FR 43255, August 10, 1999), requires EPA to develop an accountable process to ensure ''meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications.'' ''Policies that have federalism implications'' is defined in the Executive Order to include regulations that have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.''

This final rule does not have federalism implications. It will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. This rule does not create a mandate on State, local or tribal governments. The rule does not impose any enforceable duties on these entities (*see* D. Unfunded Mandates Reform Act of 1995, above). The rule would add better, more accurate techniques for air dispersion modeling analyses and does not impose any additional requirements for any of the affected parties covered under Executive Order 13132. Thus, Executive Order 13132 does not apply to this rule.

F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

Executive Order 13175, entitled ''Consultation and Coordination with Indian Tribal Governments'' (65 FR 67249, November 9, 2000), requires EPA to develop an accountable process to ensure ''meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.'' This final rule does not have tribal implications, as specified in Executive Order 13175. As stated above (*see* D. Unfunded Mandates Reform Act of 1995, above), the rule does not impose any new requirements for calculating PSD increment consumption, and does not impose any additional requirements for the regulated community, including Indian Tribal Governments. Thus, Executive Order 13175 does not apply to this rule.

Today's final rule does not significantly or uniquely affect the communities of Indian tribal governments. Accordingly, the requirements of section 3(b) of Executive Order 13175 do not apply to this rule.

G. Executive Order 13045: Protection of Children From Environmental Health and Safety Risks

Executive Order 13045 applies to any rule that EPA determines (1) to be ''economically significant'' as defined under Executive Order 12866, and (2) the environmental health or safety risk addressed by the rule has a disproportionate effect on children. If the regulatory action meets both the criteria, the Agency must evaluate the environmental health or safety effects of the planned rule on children; and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the Agency.

This final rule is not subject to Executive Order 13045, entitled ''Protection of Children from Environmental Health Risks and Safety Risks'' (62 FR 19885, April 23, 1997) because it does not impose an economically significant regulatory action as defined by Executive Order 12866 and the action does not involve decisions on environmental health or safety risks that may disproportionately affect children.

H. Executive Order 13211: Actions That Significantly Affect Energy Supply, Distribution, or Use

This rule is not subject to Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use'' (66 FR 28355 (May 22, 2001)) because it is not a significant regulatory action under Executive Order 12866.

I. National Technology Transfer and Advancement Act of 1995

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (''NTTAA''), Public Law 104–113, section 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (*e.g.*, materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. The NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

This action does not involve technical standards. Therefore, EPA did not consider the use of any voluntary consensus standards.

J. Congressional Review Act of 1998

The Congressional Review Act, 5 U.S.C. 801 *et seq.*, as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. A Major rule cannot take effect until 60 days after it is published in the **Federal Register**. This action is not a ''major rule'' as defined by 5 U.S.C. 804(2), and will be effective 30 days from the publication date of this notice.

List of Subjects in 40 CFR Part 51

Environmental protection, Administrative practice and procedure, Air pollution control, Carbon monoxide, Intergovernmental relations, Nitrogen oxides, Ozone, Particulate Matter, Reporting and recordkeeping requirements, Sulfur oxides.

Dated: October 21, 2005.

Stephen L. Johnson,

Administrator.

■ Part 51, chapter I, title 40 of the Code of Federal Regulations is amended as follows:

PART 51—REQUIREMENTS FOR PREPARATION, ADOPTION, AND SUBMITTAL OF IMPLEMENTATION PLANS

■ 1. The authority citation for part 51 continues to read as follows:

Authority: 23 U.S.C. 100; 42 U.S.C. 7401–7671q.

■ 2. Appendix W to Part 51 revised to read as follows:

Appendix W to Part 51—Guideline on Air Quality Models

Preface

a. Industry and control agencies have long expressed a need for consistency in the application of air quality models for regulatory purposes. In the 1977 Clean Air Act, Congress mandated such consistency and encouraged the standardization of model applications. The *Guideline on Air Quality Models* (hereafter, *Guideline*) was first published in April 1978 to satisfy these requirements by specifying models and providing guidance for their use. The *Guideline* provides a common basis for estimating the air quality concentrations of criteria pollutants used in assessing control strategies and developing emission limits.

b. The continuing development of new air quality models in response to regulatory requirements and the expanded requirements for models to cover even more complex problems have emphasized the need for periodic review and update of guidance on these techniques. Historically, three primary activities have provided direct input to revisions of the *Guideline*. The first is a series of annual EPA workshops conducted for the purpose of ensuring consistency and providing clarification in the application of models. The second activity was the solicitation and review of new models from the technical and user community. In the March 27, 1980 **Federal Register**, a procedure was outlined for the submittal to EPA of privately developed models. After extensive evaluation and scientific review, these models, as well as those made available by EPA, have been considered for recognition in the *Guideline*. The third activity is the extensive on-going research efforts by EPA and others in air quality and meteorological modeling.

c. Based primarily on these three activities, new sections and topics have been included as needed. EPA does not make changes to the guidance on a predetermined schedule, but rather on an as-needed basis. EPA believes that revisions of the *Guideline* should be timely and responsive to user needs and should involve public participation to the greatest possible extent. All future changes to the guidance will be proposed and finalized in the **Federal Register**. Information on the current status of modeling guidance can always be obtained from EPA's Regional Offices.

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LIST OF TABLES

1.0 Introduction

a. The *Guideline* recommends air quality modeling techniques that should be applied to State Implementation Plan (SIP) revisions for existing sources and to new source reviews (NSR), including prevention of significant deterioration (PSD).[1 2 3] Applicable only to criteria air pollutants, it is intended for use by EPA Regional Offices in judging the adequacy of modeling analyses performed by EPA, State and local agencies and by industry. The guidance is appropriate for use by other Federal agencies and by State agencies with air quality and land management responsibilities. The *Guideline* serves to identify, for all interested parties, those techniques and data bases EPA considers acceptable. The *Guideline* is not intended to be a compendium of modeling techniques. Rather, it should serve as a common measure of acceptable technical analysis when supported by sound scientific judgment.

b. Due to limitations in the spatial and temporal coverage of air quality measurements, monitoring data normally are not sufficient as the sole basis for demonstrating the adequacy of emission limits for existing sources. Also, the impacts of new sources that do not yet exist can only be determined through modeling. Thus, models, while uniquely filling one program need, have become a primary analytical tool in most air quality assessments. Air quality measurements can be used in a complementary manner to dispersion models, with due regard for the strengths and weaknesses of both analysis techniques. Measurements are particularly useful in assessing the accuracy of model estimates. The use of air quality measurements alone however could be preferable, as detailed in a later section of this document, when models are found to be unacceptable and monitoring data with sufficient spatial and temporal coverage are available.

c. It would be advantageous to categorize the various regulatory programs and to apply a designated model to each proposed source needing analysis under a given program. However, the diversity of the nation's topography and climate, and variations in source configurations and operating characteristics dictate against a strict modeling ''cookbook''. There is no one model capable of properly addressing all conceivable situations even within a broad category such as point sources. Meteorological phenomena associated with threats to air quality standards are rarely amenable to a single mathematical treatment; thus, case-by-case analysis and judgment are frequently required. As modeling efforts become more complex, it is increasingly important that they be directed by highly competent individuals with a broad range of experience and knowledge in air quality meteorology. Further, they should be coordinated closely with specialists in emissions characteristics, air monitoring and data processing. The judgment of experienced meteorologists and analysts is essential.

d. The model that most accurately estimates concentrations in the area of interest is always sought. However, it is clear from the needs expressed by the States and EPA Regional Offices, by many industries and trade associations, and also by the deliberations of Congress, that consistency in the selection and application of models and data bases should also be sought, even in case-by-case analyses. Consistency ensures that air quality control agencies and the general public have a common basis for estimating pollutant concentrations, assessing control strategies and specifying emission limits. Such consistency is not, however, promoted at the expense of model and data base accuracy. The *Guideline* provides a consistent basis for selection of the most accurate models and data bases for use in air quality assessments.

e. Recommendations are made in the *Guideline* concerning air quality models, data bases, requirements for concentration estimates, the use of measured data in lieu of model estimates, and model evaluation procedures. Models are identified for some specific applications. The guidance provided here should be followed in air quality analyses relative to State Implementation Plans and in supporting analyses required by EPA, State and local agency air programs. EPA may approve the use of another technique that can be demonstrated to be more appropriate than those recommended in this guide. This is discussed at greater length in Section 3. In all cases, the model applied to a given situation should be the one that provides the most accurate representation of atmospheric transport, dispersion, and chemical transformations in the area of interest. However, to ensure consistency, deviations from this guide should be carefully documented and fully supported.

f. From time to time situations arise requiring clarification of the intent of the guidance on a specific topic. Periodic workshops are held with the headquarters, Regional Office, State, and local agency modeling representatives to ensure consistency in modeling guidance and to promote the use of more accurate air quality models and data bases. The workshops serve to provide further explanations of *Guideline* requirements to the Regional Offices and workshop reports are issued with this clarifying information. In addition, findings from ongoing research programs, new model development, or results from model evaluations and applications are continuously evaluated. Based on this information changes in the guidance may be indicated.

g. All changes to the *Guideline* must follow rulemaking requirements since the *Guideline* is codified in Appendix W of Part 51. EPA will promulgate proposed and final rules in the **Federal Register** to amend this Appendix. Ample opportunity for public comment will be provided for each proposed change and public hearings scheduled if requested.

h. A wide range of topics on modeling and data bases are discussed in the *Guideline*. Section 2 gives an overview of models and their appropriate use. Section 3 provides specific guidance on the use of ''preferred'' air quality models and on the selection of alternative techniques. Sections 4 through 7 provide recommendations on modeling techniques for application to simple-terrain stationary source problems, complex terrain problems, and mobile source problems. Specific modeling requirements for selected regulatory issues are also addressed. Section 8 discusses issues common to many modeling analyses, including acceptable model components. Section 9 makes recommendations for data inputs to models including source, meteorological and background air quality data. Section 10 covers the uncertainty in model estimates and how that information can be useful to the regulatory decision-maker. The last chapter summarizes how estimates and measurements of air quality are used in assessing source impact and in evaluating control strategies.

i. Appendix W to 40 CFR Part 51 itself contains an appendix: Appendix A. Thus, when reference is made to ''Appendix A'' in this document, it refers to Appendix A to Appendix W to 40 CFR Part 51. Appendix A contains summaries of refined air quality models that are ''preferred'' for specific applications; both EPA models and models developed by others are included.

2.0 Overview of Model Use

a. Before attempting to implement the guidance contained in this document, the reader should be aware of certain general information concerning air quality models and their use. Such information is provided in this section.

2.1 Suitability of Models

a. The extent to which a specific air quality model is suitable for the evaluation of source impact depends upon several factors. These include: (1) The meteorological and topographic complexities of the area; (2) the level of detail and accuracy needed for the analysis; (3) the technical competence of those undertaking such simulation modeling; (4) the resources available; and (5) the detail and accuracy of the data base, *i.e.*, emissions inventory, meteorological data, and air quality data. Appropriate data should be available before any attempt is made to apply a model. A model that requires detailed, precise, input data should not be used when such data are unavailable. However, assuming the data are adequate, the greater the detail with which a model considers the spatial and temporal variations in emissions and meteorological conditions, the greater the ability to evaluate the source impact and to distinguish the effects of various control strategies.

b. Air quality models have been applied with the most accuracy, or the least degree of uncertainty, to simulations of long term averages in areas with relatively simple topography. Areas subject to major topographic influences experience meteorological complexities that are extremely difficult to simulate. Although models are available for such circumstances, they are frequently site specific and resource intensive. In the absence of a model capable of simulating such complexities, only a preliminary approximation may be feasible until such time as better models and data bases become available.

c. Models are highly specialized tools. Competent and experienced personnel are an essential prerequisite to the successful application of simulation models. The need for specialists is critical when the more sophisticated models are used or the area being investigated has complicated meteorological or topographic features. A model applied improperly, or with inappropriate data, can lead to serious misjudgements regarding the source impact or the effectiveness of a control strategy.

d. The resource demands generated by use of air quality models vary widely depending on the specific application. The resources required depend on the nature of the model and its complexity, the detail of the data base, the difficulty of the application, and the amount and level of expertise required. The costs of manpower and computational facilities may also be important factors in the selection and use of a model for a specific analysis. However, it should be recognized that under some sets of physical circumstances and accuracy requirements, no present model may be appropriate. Thus, consideration of these factors should lead to selection of an appropriate model.

2.2 Levels of Sophistication of Models

a. There are two levels of sophistication of models. The first level consists of relatively simple estimation techniques that generally use preset, worst-case meteorological conditions to provide conservative estimates of the air quality impact of a specific source, or source category. These are called screening techniques or screening models. The purpose of such techniques is to eliminate the need of more detailed modeling for those sources that clearly will not cause or contribute to ambient concentrations in excess of either the National Ambient Air Quality Standards (NAAQS)[4] or the allowable prevention of significant deterioration (PSD) concentration increments.[2 3] If a screening technique indicates that the concentration contributed by the source exceeds the PSD increment or the increment remaining to just meet the NAAQS, then the second level of more sophisticated models should be applied.

b. The second level consists of those analytical techniques that provide more detailed treatment of physical and chemical atmospheric processes, require more detailed and precise input data, and provide more specialized concentration estimates. As a result they provide a more refined and, at least theoretically, a more accurate estimate of source impact and the effectiveness of control strategies. These are referred to as refined models.

c. The use of screening techniques followed, as appropriate, by a more refined analysis is always desirable. However there are situations where the screening techniques are practically and technically the only viable option for estimating source impact. In such cases, an attempt should be made to acquire or improve the necessary data bases and to develop appropriate analytical techniques.

2.3 Availability of Models

a. For most of the screening and refined models discussed in the *Guideline*, codes, associated documentation and other useful information are available for download from EPA's Support Center for Regulatory Air Modeling (SCRAM) Internet Web site at *http://www.epa.gov/scram001*. A list of alternate models that can be used with case-by-case justification (subsection 3.2) and an example air quality analysis checklist are also posted on this Web site. This is a site with which modelers should become familiar.

3.0 Recommended Air Quality Models

a. This section recommends the approach to be taken in determining refined modeling techniques for use in regulatory air quality programs. The status of models developed by EPA, as well as those submitted to EPA for review and possible inclusion in this guidance, is discussed. The section also addresses the selection of models for individual cases and provides recommendations for situations where the preferred models are not applicable. Two additional sources of modeling guidance are the Model Clearinghouse [5] and periodic Regional/State/Local Modelers workshops.

b. In this guidance, when approval is required for a particular modeling technique or analytical procedure, we often refer to the *''appropriate reviewing authority''*. In some EPA regions, authority for NSR and PSD permitting and related activities has been delegated to State and even local agencies. In these cases, such agencies are *''representatives''* of the respective regions. Even in these circumstances, the Regional Office retains the ultimate authority in decisions and approvals. Therefore, as discussed above and depending on the circumstances, the appropriate reviewing authority may be the Regional Office, Federal Land Manager(s), State agency(ies), or perhaps local agency(ies). In cases where review and approval comes solely from the Regional Office (sometimes stated as *''Regional Administrator''*), this will be stipulated. If there is any question as to the appropriate reviewing authority, you should contact the Regional modeling contact (*http://www.epa.gov/scram001/tt28.htm#regionalmodelingcontacts*) in the appropriate EPA Regional Office, whose jurisdiction generally includes the physical location of the source in question and its expected impacts.

c. In all regulatory analyses, especially if other-than-preferred models are selected for use, early discussions among Regional Office staff, State and local control agencies, industry representatives, and where appropriate, the Federal Land Manager, are invaluable and are encouraged. Agreement on the data base(s) to be used, modeling techniques to be applied and the overall technical approach, prior to the actual analyses, helps avoid misunderstandings concerning the final results and may reduce the later need for additional analyses. The use of an air quality analysis checklist, such as is posted on EPA's Internet SCRAM Web site (subsection 2.3), and the preparation of a written protocol help to keep misunderstandings at a minimum.

d. It should not be construed that the preferred models identified here are to be permanently used to the exclusion of all others or that they are the only models available for relating emissions to air quality. The model that most accurately estimates concentrations in the area of interest is always sought. However, designation of specific models is needed to promote consistency in model selection and application.

e. The 1980 solicitation of new or different models from the technical community [6] and the program whereby these models were evaluated, established a means by which new models are identified, reviewed and made available in the *Guideline*. There is a pressing need for the development of models for a wide range of regulatory applications. Refined models that more realistically simulate the physical and chemical process in the atmosphere and that more reliably estimate pollutant concentrations are needed.

3.1 Preferred Modeling Techniques

3.1.1 Discussion

a. EPA has developed models suitable for regulatory application. Other models have been submitted by private developers for possible inclusion in the *Guideline*. Refined models which are preferred and recommended by EPA have undergone evaluation exercises [7 8 9 10] that include statistical measures of model performance in comparison with measured air quality data as suggested by the American Meteorological Society [11] and, where possible, peer scientific reviews.[12 13 14]

b. When a single model is found to perform better than others, it is recommended for application as a preferred model and listed in Appendix A. If no one model is found to clearly perform better through the evaluation exercise, then the preferred model listed in Appendix A may be selected on the basis of other factors such as past use, public familiarity, cost or resource requirements, and availability. Accordingly, dispersion models listed in Appendix A meet these conditions:

i. The model must be written in a common programming language, and the executable(s) must run on a common computer platform.

ii. The model must be documented in a user's guide which identifies the mathematics of the model, data requirements and program operating characteristics at a level of detail comparable to that available for other recommended models in Appendix A.

iii. The model must be accompanied by a complete test data set including input parameters and output results. The test data must be packaged with the model in computer-readable form.

iv. The model must be useful to typical users, e.g., State air pollution control agencies, for specific air quality control problems. Such users should be able to operate the computer program(s) from available documentation.

v. The model documentation must include a comparison with air quality data (and/or tracer measurements) or with other well-established analytical techniques.

vi. The developer must be willing to make the model and source code available to users at reasonable cost or make them available for public access through the Internet or National Technical Information Service: The model and its code cannot be proprietary.

c. The evaluation process includes a determination of technical merit, in accordance with the above six items including the practicality of the model for use in ongoing regulatory programs. Each model will also be subjected to a performance evaluation for an appropriate data base and to a peer scientific review. Models for wide use (not just an isolated case) that are found to perform better will be proposed for inclusion as preferred models in future *Guideline* revisions.

d. No further evaluation of a preferred model is required for a particular application if the EPA recommendations for regulatory use specified for the model in the *Guideline* are followed. Alternative models to those listed in Appendix A should generally be compared with measured air quality data when they are used for regulatory applications consistent with recommendations in subsection 3.2.

3.1.2 Recommendations

a. Appendix A identifies refined models that are preferred for use in regulatory applications. If a model is required for a particular application, the user should select a model from that appendix. These models may be used without a formal demonstration of applicability as long as they are used as indicated in each model summary of Appendix A. Further recommendations for the application of these models to specific source problems are found in subsequent sections of the *Guideline*.

b. If changes are made to a preferred model without affecting the concentration estimates, the preferred status of the model is unchanged. Examples of modifications that do not affect concentrations are those made to enable use of a different computer platform or those that affect only the format or averaging time of the model results. However, when any changes are made, the Regional Administrator should require a test case example to demonstrate that the concentration estimates are not affected.

c. A preferred model should be operated with the options listed in Appendix A as ''Recommendations for Regulatory Use.'' If other options are exercised, the model is no longer ''preferred.'' Any other modification to a preferred model that would result in a change in the concentration estimates likewise alters its status as a preferred model. Use of the model must then be justified on a case-by-case basis.

3.2 Use of Alternative Models

3.2.1 Discussion

a. Selection of the best techniques for each individual air quality analysis is always encouraged, but the selection should be done in a consistent manner. A simple listing of models in this *Guideline* cannot alone achieve that consistency nor can it necessarily provide the best model for all possible situations. An EPA reference [15] provides a statistical technique for evaluating model performance for predicting peak concentration values, as might be observed at individual monitoring locations. This protocol is available to assist in developing a consistent approach when justifying the use of other-than-preferred modeling techniques recommended in the *Guideline*. The procedures in this protocol provide a general framework for objective decision-making on the acceptability of an alternative model for a given regulatory application. These objective procedures may be used for conducting both the technical evaluation of the model and the field test or performance evaluation. An ASTM reference [16] provides a general philosophy for developing and implementing advanced statistical evaluations of atmospheric dispersion models, and provides an example statistical technique to illustrate the application of this philosophy.

b. This section discusses the use of alternate modeling techniques and defines three situations when alternative models may be used.

3.2.2 Recommendations

a. Determination of acceptability of a model is a Regional Office responsibility. Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the recommendations of this subsection. This finding will normally result from a determination that (1) a preferred air quality model is not appropriate for the particular application; or (2) a more appropriate model or analytical procedure is available and applicable.

b. An alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use. There are three separate conditions under which such a model may normally be approved for use: (1) If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model; (2) if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A; or (3) if the preferred model is less appropriate for the specific application, or there is no preferred model. Any one of these three separate conditions may make use of an alternative model acceptable. Some known alternative models that are applicable for selected situations are listed on EPA's SCRAM Internet Web site (subsection 2.3). However, inclusion there does not confer any unique status relative to other alternative models that are being or will be developed in the future.

c. Equivalency, condition (1) in paragraph (b) of this subsection, is established by demonstrating that the maximum or highest, second highest concentrations are within 2 percent of the estimates obtained from the preferred model. The option to show equivalency is intended as a simple demonstration of acceptability for an alternative model that is so nearly identical (or contains options that can make it identical) to a preferred model that it can be treated for practical purposes as the preferred model. Two percent was selected as the basis for equivalency since it is a rough approximation of the fraction that PSD Class I increments are of the NAAQS for SO_2, i.e., the difference in concentrations that is judged to be significant. However, notwithstanding this demonstration, models that are not equivalent may be used when one of the two other conditions described in paragraphs (d) and (e) of this subsection are satisfied.

d. For condition (2) in paragraph (b) of this subsection, established procedures and techniques [15,16] for determining the acceptability of a model for an individual case based on superior performance should be followed, as appropriate. Preparation and implementation of an evaluation protocol which is acceptable to both control agencies and regulated industry is an important element in such an evaluation.

e. Finally, for condition (3) in paragraph (b) of this subsection, an alternative refined model may be used provided that:

i. The model has received a scientific peer review;

ii. The model can be demonstrated to be applicable to the problem on a theoretical basis;

iii. The data bases which are necessary to perform the analysis are available and adequate;

iv. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and

v. A protocol on methods and procedures to be followed has been established.

3.3 Availability of Supplementary Modeling Guidance

a. The Regional Administrator has the authority to select models that are appropriate for use in a given situation. However, there is a need for assistance and guidance in the selection process so that fairness and consistency in modeling decisions is fostered among the various Regional Offices and the States. To satisfy that need, EPA established the Model Clearinghouse [5] and also holds periodic workshops with headquarters, Regional Office, State, and local agency modeling representatives.

b. The Regional Office should always be consulted for information and guidance concerning modeling methods and interpretations of modeling guidance, and to ensure that the air quality model user has available the latest most up-to-date policy and procedures. As appropriate, the Regional Office may request assistance from the Model Clearinghouse after an initial evaluation and decision has been reached concerning the application of a model, analytical technique or data base in a particular regulatory action.

4.0 Traditional Stationary Source Models

4.1 Discussion

a. Guidance in this section applies to modeling analyses for which the predominant meteorological conditions that control the design concentration are steady state and for which the transport distances are nominally 50km or less. The models recommended in this section are generally used in the air quality impact analysis of stationary sources for most criteria pollutants. The averaging time of the concentration estimates produced by these models ranges from 1 hour to an annual average.

b. Simple terrain, as used here, is considered to be an area where terrain features are all lower in elevation than the top of the stack of the source(s) in question. Complex terrain is defined as terrain exceeding the height of the stack being modeled.

c. In the early 1980s, model evaluation exercises were conducted to determine the ''best, most appropriate point source model'' for use in simple terrain.[12] No one model was found to be clearly superior and, based on past use, public familiarity, and availability, ISC (predecessor to ISC3 [17]) became the recommended model for a wide range of regulatory applications. Other refined models which also employed the same basic Gaussian kernel as in ISC, i.e., BLP, CALINE3 and OCD, were developed for specialized applications (Appendix A). Performance evaluations were also made for these models, which are identified below.

d. Encouraged by the development of pragmatic methods for better characterization of plume dispersion [18,19,20,21] the AMS/EPA Regulatory Model Improvement Committee (AERMIC) developed AERMOD.[22] AERMOD employs best state-of-practice parameterizations for characterizing the meteorological influences and dispersion. The model utilizes a probability density function (pdf) and the superposition of several Gaussian plumes to characterize the distinctly non-Gaussian nature of the vertical pollutant distribution for elevated plumes during convective conditions; otherwise the distribution is Gaussian. Also, nighttime urban boundary layers (and plumes within them) have the turbulence enhanced by AERMOD to simulate the influence of the urban heat island. AERMOD has been evaluated using a variety of data sets and has been found to perform better than ISC3 for many applications, and as well or better than CTDMPLUS for several complex terrain data sets (Section A.1; subsection n). The current version of AERMOD has been modified to include an algorithm for dry and wet deposition for both gases and particles. Note that when deposition is invoked, mass in the plume is depleted. Availability of this version is described in Section A.1, and is subject to applicable guidance published in the *Guideline*.

e. A new building downwash algorithm [23] was developed and tested within AERMOD. The PRIME algorithm has been evaluated using a variety of data sets and has been found to perform better than the downwash algorithm that is in ISC3, and has been shown to perform acceptably in tests within AERMOD (Section A.1; subsection n).

4.2 Recommendations

4.2.1 Screening Techniques

4.2.1.1 Simple Terrain

a. Where a preliminary or conservative estimate is desired, point source screening techniques are an acceptable approach to air quality analyses. EPA has published guidance for screening procedures.[24 25]

b. All screening procedures should be adjusted to the site and problem at hand. Close attention should be paid to whether the area should be classified urban or rural in accordance with Section 7.2.3. The climatology of the area should be studied to help define the worst-case meteorological conditions. Agreement should be reached between the model user and the appropriate reviewing authority on the choice of the screening model for each analysis, and on the input data as well as the ultimate use of the results.

4.2.1.2 Complex Terrain

a. CTSCREEN [26] can be used to obtain conservative, yet realistic, worst-case estimates for receptors located on terrain above stack height. CTSCREEN accounts for the three-dimensional nature of plume and terrain interaction and requires detailed terrain data representative of the modeling domain. The model description and user's instructions are contained in the user's guide.[26] The terrain data must be digitized in the same manner as for CTDMPLUS and a terrain processor is available.[27] A discussion of the model's performance characteristics is provided in a technical paper.[28] CTSCREEN is designed to execute a fixed matrix of meteorological values for wind speed (u), standard deviation of horizontal and vertical wind speeds (σ_v, σ_w), vertical potential temperature gradient (dθ/dz), friction velocity (u_*), Monin-Obukhov length (L), mixing height (z_i) as a function of terrain height, and wind directions for both neutral/stable conditions and unstable convective conditions. Table 4–1 contains the matrix of meteorological variables that is used for each CTSCREEN analysis. There are 96 combinations, including exceptions, for each wind direction for the neutral/stable case, and 108 combinations for the unstable case. The specification of wind direction, however, is handled internally, based on the source and terrain geometry. Although CTSCREEN is designed to address a single source scenario, there are a number of options that can be selected on a case-by-case basis to address multi-source situations. However, the appropriate reviewing authority should be consulted, and concurrence obtained, on the protocol for modeling multiple sources with CTSCREEN to ensure that the worst case is identified and assessed. The maximum concentration output from CTSCREEN represents a worst-case 1-hour concentration. Time-scaling factors of 0.7 for 3-hour, 0.15 for 24-hour and 0.03 for annual concentration averages are applied internally by CTSCREEN to the highest 1-hour concentration calculated by the model.

b. Placement of receptors requires very careful attention when modeling in complex terrain. Often the highest concentrations are predicted to occur under very stable conditions, when the plume is near, or impinges on, the terrain. The plume under such conditions may be quite narrow in the vertical, so that even relatively small changes in a receptor's location may substantially affect the predicted concentration. Receptors within about a kilometer of the source may be even more sensitive to location. Thus, a dense array of receptors may be required in some cases. In order to avoid excessively large computer runs due to such a large array of receptors, it is often desirable to model the area twice. The first model run would use a moderate number of receptors carefully located over the area of interest. The second model run would use a more dense array of receptors in areas showing potential for high concentrations, as indicated by the results of the first model run.

c. As mentioned above, digitized contour data must be preprocessed [27] to provide hill shape parameters in suitable input format. The user then supplies receptors either through an interactive program that is part of the model or directly, by using a text editor; using both methods to select receptors will generally be necessary to assure that the maximum concentrations are estimated by either model. In cases where a terrain feature may ''appear to the plume'' as smaller, multiple hills, it may be necessary to model the terrain both as a single feature and as multiple hills to determine design concentrations.

d. Other screening techniques [17 25 29] may be acceptable for complex terrain cases where established procedures are used. The user is encouraged to confer with the appropriate reviewing authority if any unresolvable problems are encountered, *e.g.*, applicability, meteorological data, receptor siting, or terrain contour processing issues.

4.2.2 Refined Analytical Techniques

a. A brief description of each preferred model for refined applications is found in Appendix A. Also listed in that appendix are availability, the model input requirements, the standard options that should be selected when running the program, and output options.

b. For a wide range of regulatory applications in all types of terrain, the recommended model is AERMOD. This recommendation is based on extensive developmental and performance evaluation (Section A.1; subsection n). Differentiation of simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the well-known dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions.

c. If aerodynamic building downwash is important for the modeling analysis, *e.g.*, paragraph 6.2.2(b), then the recommended model is AERMOD. The state-of-the-science for modeling atmospheric deposition is evolving and the best techniques are currently being assessed and their results are being compared with observations. Consequently, while deposition treatment is available in AERMOD, the approach taken for any purpose should be coordinated with the appropriate reviewing authority. Line sources can be simulated with AERMOD if point or volume sources are appropriately combined. If buoyant plume rise from line sources is important for the modeling analysis, the recommended model is BLP. For other special modeling applications, CALINE3 (or CAL3QHCR on a case-by-case basis), OCD, and EDMS are available as described in Sections 5 and 6.

d. If the modeling application involves a well defined hill or ridge and a detailed dispersion analysis of the spatial pattern of plume impacts is of interest, CTDMPLUS, listed in Appendix A, is available. CDTMPLUS provides greater resolution of concentrations about the contour of the hill feature than does AERMOD through a different plume-terrain interaction algorithm.

TABLE 4–1A.—NEUTRAL/STABLE METEOROLOGICAL MATRIX FOR CTSCREEN

Variable	Specific values				
U (m/s)	1.0	2.0	3.0	4.0	5.0
σ_v (m/s)	0.3	0.75			
σ_w (m/s)	0.08	0.15	0.30	0.75	
Δθ/Δz (K/m)	0.01	0.02	0.035		
WD	(Wind direction is optimized internally for each meteorological combination.)				

Exceptions:

(1) If U ≤ 2 m/s and σ_v ≤ 0.3 m/s, then include σ_w = 0.04 m/s.

(2) If σ_w = 0.75 m/s and U ≥ 3.0 m/s, then $\Delta\theta/\Delta z$ is limited to ≤ 0.01 K/m.

(3) If U ≥ 4 m/s, then σ_w ≥ 0.15 m/s.

(4) $\sigma_w \leq \sigma_v$

TABLE 4–1B.—UNSTABLE/CONVECTIVE METEOROLOGICAL MATRIX FOR CTSCREEN

Variable	Specific values				
U (m/s)	1.0	2.0	3.0	4.0	5.0
U_* (m/s)	0.1	0.3	0.5		
L (m)	−10	−50	−90		
$\Delta\theta/\Delta z$ (K/m)	0.030	(potential temperature gradient above Z_i)			
Z_i (m)	0.5h	1.0h	1.5h	(h = terrain height)	

5.0 Models for Ozone, Particulate Matter, Carbon Monoxide, Nitrogen Dioxide, and Lead

5.1 Discussion

a. This section identifies modeling approaches or models appropriate for addressing ozone (O_3)[a], carbon monoxide (CO), nitrogen dioxide (NO_2), particulates (PM–2.5[a] and PM–10), and lead. These pollutants are often associated with emissions from numerous sources. Generally, mobile sources contribute significantly to emissions of these pollutants or their precursors. For cases where it is of interest to estimate concentrations of CO or NO_2 near a single or small group of stationary sources, refer to Section 4. (Modeling approaches for SO_2 are discussed in Section 4.)

b. Several of the pollutants mentioned in the preceding paragraph are closely related to each other in that they share common sources of emissions and/or are subject to chemical transformations of similar precursors.[30 31] For example, strategies designed to reduce ozone could have an effect on the secondary component of PM–2.5 and vice versa. Thus, it makes sense to use models which take into account the chemical coupling between O_3 and PM–2.5, when feasible. This should promote consistency among methods used to evaluate strategies for reducing different pollutants as well as consistency among the strategies themselves. Regulatory requirements for the different pollutants are likely to be due at different times. Thus, the following paragraphs identify appropriate modeling approaches for pollutants individually.

c. The NAAQS for ozone was revised on July 18, 1997 and is now based on an 8-hour averaging period. Models for ozone are needed primarily to guide choice of strategies to correct an observed ozone problem in an area not attaining the NAAQS for ozone. Use of photochemical grid models is the recommended means for identifying strategies needed to correct high ozone concentrations in such areas. Such models need to consider emissions of volatile organic compounds (VOC), nitrogen oxides (NO_X) and carbon monoxide (CO), as well as means for generating meteorological data governing transport and dispersion of ozone and its precursors. Other approaches, such as Lagrangian or observational models may be used to guide choice of appropriate strategies to consider with a photochemical grid model. These other approaches may be sufficient to address ozone in an area where observed concentrations are near the NAAQS or only slightly above it. Such a decision needs to be made on a case-by-case basis in concert with the Regional Office.

d. A control agency with jurisdiction over one or more areas with significant ozone problems should review available ambient air quality data to assess whether the problem is likely to be significantly impacted by regional transport.[32] Choice of a modeling approach depends on the outcome of this review. In cases where transport is considered significant, use of a nested regional model may be the preferred approach. If the observed problem is believed to be primarily of local origin, use of a model with a single horizontal grid resolution and geographical coverage that is less than that of a regional model may suffice.

e. The fine particulate matter NAAQS, promulgated on July 18, 1997, includes particles with an aerodynamic diameter nominally less than or equal to 2.5 micrometers (PM–2.5). Models for PM–2.5 are needed to assess adequacy of a proposed strategy for meeting annual and/or 24-hour NAAQS for PM–2.5. PM–2.5 is a mixture consisting of several diverse components. Because chemical/physical properties and origins of each component differ, it may be appropriate to use either a single model capable of addressing several of the important components or to model primary and secondary components using different models. Effects of a control strategy on PM–2.5 is estimated from the sum of the effects on the components composing PM–2.5. Model users may refer to guidance[33] for further details concerning appropriate modeling approaches.

f. A control agency with jurisdiction over one or more areas with PM–2.5 problems should review available ambient air quality data to assess which components of PM–2.5 are likely to be major contributors to the problem. If it is determined that regional transport of secondary particulates, such as sulfates or nitrates, is likely to contribute significantly to the problem, use of a regional model may be the preferred approach. Otherwise, coverage may be limited to a domain that is urban scale or less. Special care should be taken to select appropriate geographical coverage for a modeling application.[33]

g. The NAAQS for PM–10 was promulgated in July 1987 (40 CFR 50.6). A SIP development guide[34] is available to assist in PM–10 analyses and control strategy development. EPA promulgated regulations for PSD increments measured as PM–10 in a notice published on June 3, 1993 (40 CFR 51.166(c)). As an aid to assessing the impact on ambient air quality of particulate matter generated from prescribed burning activities, a reference[35] is available.

h. Models for assessing the impacts of particulate matter may involve dispersion models or receptor models, or a combination (depending on the circumstances). Receptor models focus on the behavior of the ambient environment at the point of impact as opposed to source-oriented dispersion models, which focus on the transport, diffusion, and transformation that begin at the source and continue to the receptor site. Receptor models attempt to identify and apportion sources by relating known sample compositions at receptors to measured or inferred compositions of source emissions. When complete and accurate emission inventories or meteorological characterization are unavailable, or unknown pollutant sources exist, receptor modeling may be necessary.

i. Models for assessing the impact of CO emissions are needed for a number of different purposes. Examples include evaluating effects of point sources, congested intersections and highways, as well as the cumulative effect of numerous sources of CO in an urban area.

j. Models for assessing the impact of sources on ambient NO_2 concentrations are primarily needed to meet new source review requirements, such as addressing the effect of a proposed source on PSD increments for annual concentrations of NO_2. Impact of an individual source on ambient NO_2 depends, in part, on the chemical environment into which the source's plume is to be emitted. There are several approaches for estimating effects of an individual source on ambient NO_2. One approach is through use of a plume-in-grid algorithm imbedded within a photochemical grid model. However, because of the rigor and complexity involved, and because this approach may not be capable of defining sub-grid concentration gradients, the plume-in-grid approach may be impractical for estimating effects on an annual PSD increment. A second approach which does not have this limitation and accommodates

[a] Modeling for attainment demonstrations for O_3 and PM–2.5 should be conducted in time to meet required SIP submission dates as provided for in the respective implementation rules. Information on implementation of the 8-hr O_3 and PM–2.5 standards is available at: *http://www.epa.gov/ttn/naags/.*

distance-dependent conversion ratios—the Plume Volume Molar Ratio Method (PVMRM) [36]—is currently being tested to determine suitability as a refined method. A third (screening) approach is to develop site specific (domain-wide) conversion factors based on measurements. If it is not possible to develop site specific conversion factors and use of the plume-in-grid algorithm is also not feasible, other screening procedures may be considered.

k. In January 1999 (40 CFR Part 58, Appendix D), EPA gave notice that concern about ambient lead impacts was being shifted away from roadways and toward a focus on stationary point sources. EPA has also issued guidance on siting ambient monitors in the vicinity of such sources.[37] For lead, the SIP should contain an air quality analysis to determine the maximum quarterly lead concentration resulting from major lead point sources, such as smelters, gasoline additive plants, etc. General guidance for lead SIP development is also available.[38]

5.2 Recommendations

5.2.1 Models for Ozone

a. *Choice of Models for Multi-source Applications*. Simulation of ozone formation and transport is a highly complex and resource intensive exercise. Control agencies with jurisdiction over areas with ozone problems are encouraged to use photochemical grid models, such as the Models-3/Community Multi-scale Air Quality (CMAQ) modeling system,[39] to evaluate the relationship between precursor species and ozone. Judgement on the suitability of a model for a given application should consider factors that include use of the model in an attainment test, development of emissions and meteorological inputs to the model and choice of episodes to model.[32] Similar models for the 8-hour NAAQS and for the 1-hour NAAQS are appropriate.

b. *Choice of Models to Complement Photochemical Grid Models*. As previously noted, observational models, Lagrangian models, or the refined version of the Ozone Isopleth Plotting Program (OZIPR) [40] may be used to help guide choice of strategies to simulate with a photochemical grid model and to corroborate results obtained with a grid model. Receptor models have also been used to apportion sources of ozone precursors (*e.g.*, VOC) in urban domains. EPA has issued guidance [32] in selecting appropriate techniques.

c. *Estimating the Impact of Individual Sources*. Choice of methods used to assess the impact of an individual source depends on the nature of the source and its emissions. Thus, model users should consult with the Regional Office to determine the most suitable approach on a case-by-case basis (subsection 3.2.2).

5.2.2 Models for Particulate Matter

5.2.2.1 PM–2.5

a. *Choice of Models for Multi-source Applications*. Simulation of phenomena resulting in high ambient PM–2.5 can be a multi-faceted and complex problem resulting from PM–2.5's existence as an aerosol mixture. Treating secondary components of PM–2.5, such as sulfates and nitrates, can be a highly complex and resource-intensive exercise. Control agencies with jurisdiction over areas with secondary PM–2.5 problems are encouraged to use models which integrate chemical and physical processes important in the formation, decay and transport of these species (*e.g.*, Models-3/CMAQ [38] or REMSAD [41]). Primary components can be simulated using less resource-intensive techniques. Suitability of a modeling approach or mix of modeling approaches for a given application requires technical judgement,[33] as well as professional experience in choice of models, use of the model(s) in an attainment test, development of emissions and meteorological inputs to the model and selection of days to model.

b. *Choice of Analysis Techniques to Complement Air Quality Simulation Models*. Receptor models may be used to corroborate predictions obtained with one or more air quality simulation models. They may also be potentially useful in helping to define specific source categories contributing to major components of PM–2.5.[33]

c. *Estimating the Impact of Individual Sources*. Choice of methods used to assess the impact of an individual source depends on the nature of the source and its emissions. Thus, model users should consult with the Regional Office to determine the most suitable approach on a case-by-case basis (subsection 3.2.2).

5.2.2.2 PM–10

a. Screening techniques like those identified in subsection 4.2.1 are applicable to PM–10. Conservative assumptions which do not allow removal or transformation are suggested for screening. Thus, it is recommended that subjectively determined values for ''half-life'' or pollutant decay not be used as a surrogate for particle removal. Proportional models (rollback/forward) may not be applied for screening analysis, unless such techniques are used in conjunction with receptor modeling.[34]

b. Refined models such as those discussed in subsection 4.2.2 are recommended for PM–10. However, where possible, particle size, gas-to-particle formation, and their effect on ambient concentrations may be considered. For point sources of small particles and for source-specific analyses of complicated sources, use the appropriate recommended steady-state plume dispersion model (subsection 4.2.2).

c. Receptor models have proven useful for helping validate emission inventories and for corroborating source-specific impacts estimated by dispersion models. The Chemical Mass Balance (CMB) model is useful for apportioning impacts from localized sources.[42 43 44] Other receptor models, *e.g.*, the Positive Matrix Factorization (PMF) model [45] and Unmix,[46] which don't share some of CMB's constraints, have also been applied. In regulatory applications, dispersion models have been used in conjunction with receptor models to attribute source (or source category) contributions. Guidance is available for PM–10 sampling and analysis applicable to receptor modeling.[47]

d. Under certain conditions, recommended dispersion models may not be reliable. In such circumstances, the modeling approach should be approved by the Regional Office on a case-by-case basis. Analyses involving model calculations for stagnation conditions should also be justified on a case-by-case basis (subsection 7.2.8).

e. Fugitive dust usually refers to dust put into the atmosphere by the wind blowing over plowed fields, dirt roads or desert or sandy areas with little or no vegetation. Reentrained dust is that which is put into the air by reason of vehicles driving over dirt roads (or dirty roads) and dusty areas. Such sources can be characterized as line, area or volume sources. Emission rates may be based on site specific data or values from the general literature. Fugitive emissions include the emissions resulting from the industrial process that are not captured and vented through a stack but may be released from various locations within the complex. In some unique cases a model developed specifically for the situation may be needed. Due to the difficult nature of characterizing and modeling fugitive dust and fugitive emissions, it is recommended that the proposed procedure be cleared by the Regional Office for each specific situation before the modeling exercise is begun.

5.2.3 Models for Carbon Monoxide

a. Guidance is available for analyzing CO impacts at roadway intersections.[48] The recommended screening model for such analyses is CAL3QHC.[49 50] This model combines CALINE3 (listed in Appendix A) with a traffic model to calculate delays and queues that occur at signalized intersections. The screening approach is described in reference 48; a refined approach may be considered on a case-by-case basis with CAL3QHCR.[51] The latest version of the MOBILE (mobile source emission factor) model should be used for emissions input to intersection models.

b. For analyses of highways characterized by uninterrupted traffic flows, CALINE3 is recommended, with emissions input from the latest version of the MOBILE model. A scientific review article for line source models is available.[52]

c. For urban area wide analyses of CO, an Eulerian grid model should be used. Information on SIP development and requirements for using such models can be found in several references.[48 53 54 55]

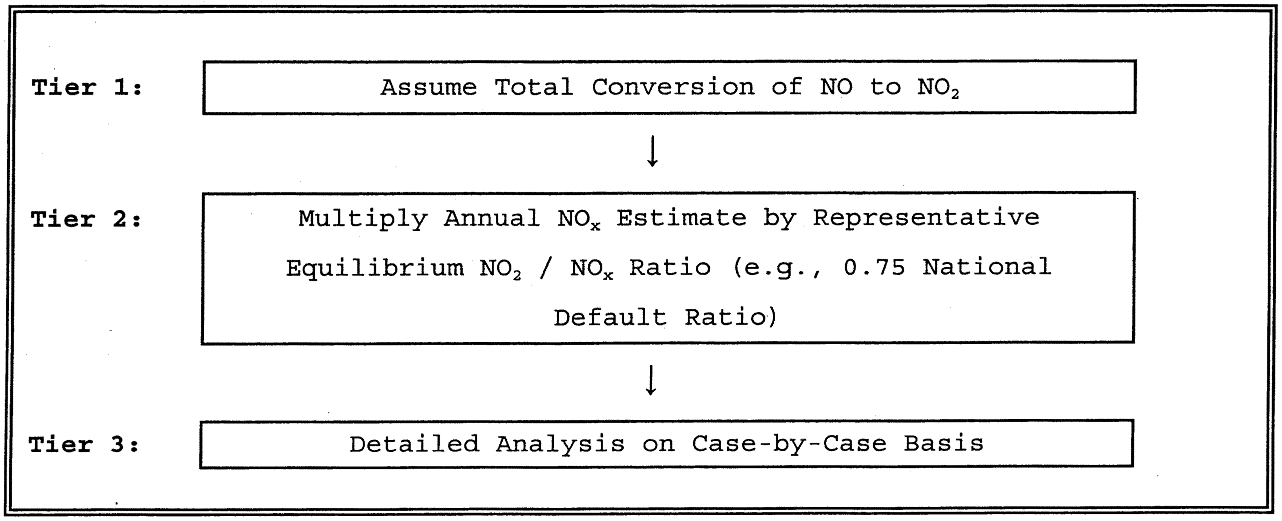
d. Where point sources of CO are of concern, they should be treated using the screening and refined techniques described in Section 4.

5.2.4 Models for Nitrogen Dioxide (Annual Average)

a. A tiered screening approach is recommended to obtain annual average estimates of NO_2 from point sources for New Source Review analysis, including PSD, and for SIP planning purposes. This multi-tiered approach is conceptually shown in Figure 5–1 and described in paragraphs b through d of this subsection:

Figure 5–1

Multi-tiered screening approach for Estimating Annual NO_2 Concentrations from Point Sources



b. For Tier 1 (the initial screen), use an appropriate model in subsection 4.2.2 to estimate the maximum annual average concentration and assume a total conversion of NO to NO_2. If the concentration exceeds the NAAQS and/or PSD increments for NO_2, proceed to the 2nd level screen.

c. For Tier 2 (2nd level) screening analysis, multiply the Tier 1 estimate(s) by an empirically derived NO_2/NO_X value of 0.75 (annual national default).[56] The reviewing agency may establish an alternative default NO_2/NO_X ratio based on ambient annual average NO_2 and annual average NO_X data representative of area wide quasi-equilibrium conditions. Alternative default NO_2/NO_X ratios should be based on data satisfying quality assurance procedures that ensure data accuracy for both NO_2 and NO_X within the typical range of measured values. In areas with relatively low NO_X concentrations, the quality assurance procedures used to determine compliance with the NO_2 national ambient air quality standard may not be adequate. In addition, default NO_2/NO_X ratios, including the 0.75 national default value, can underestimate long range NO_2 impacts and should be used with caution in long range transport scenarios.

d. For Tier 3 (3rd level) analysis, a detailed screening method may be selected on a case-by-case basis. For point source modeling, detailed screening techniques such as the Ozone Limiting Method [57] may also be considered. Also, a site specific NO_2/NO_X ratio may be used as a detailed screening method if it meets the same restrictions as described for alternative default NO_2/NO_X ratios. Ambient NO_X monitors used to develop a site specific ratio should be sited to obtain the NO_2 and NO_X concentrations under quasi-equilibrium conditions. Data obtained from monitors sited at the maximum NO_X impact site, as may be required in a PSD pre-construction monitoring program, likely reflect transitional NO_X conditions. Therefore, NO_X data from maximum impact sites may not be suitable for determining a site specific NO_2/NO_X ratio that is applicable for the entire modeling analysis. A site specific ratio derived from maximum impact data can only be used to estimate NO_2 impacts at receptors located within the same distance of the source as the source-to-monitor distance.

e. In urban areas (subsection 7.2.3), a proportional model may be used as a preliminary assessment to evaluate control strategies to meet the NAAQS for multiple minor sources, *i.e.*, minor point, area and mobile sources of NO_X; concentrations resulting from major point sources should be estimated separately as discussed above, then added to the impact of the minor sources. An acceptable screening technique for urban complexes is to assume that all NO_X is emitted in the form of NO_2 and to use a model from Appendix A for nonreactive pollutants to estimate NO_2 concentrations. A more accurate estimate can be obtained by: (1) Calculating the annual average concentrations of NO_X with an urban model, and (2) converting these estimates to NO_2 concentrations using an empirically derived annual NO_2/NO_X ratio. A value of 0.75 is recommended for this ratio. However, a spatially averaged alternative default annual NO_2/NO_X ratio may be determined from an existing air quality monitoring network and used in lieu of the 0.75 value if it is determined to be representative of prevailing ratios in the urban area by the reviewing agency. To ensure use of appropriate locally derived annual average NO_2/NO_X ratios, monitoring data under consideration should be limited to those collected at monitors meeting siting criteria defined in 40 CFR Part 58, Appendix D as representative of ''neighborhood'', ''urban'', or ''regional'' scales. Furthermore, the highest annual spatially averaged NO_2/NO_X ratio from the most recent 3 years of complete data should be used to foster conservatism in estimated impacts.

f. To demonstrate compliance with NO_2 PSD increments in urban areas, emissions from major and minor sources should be included in the modeling analysis. Point and area source emissions should be modeled as discussed above. If mobile source emissions do not contribute to localized areas of high ambient NO_2 concentrations, they should be modeled as area sources. When modeled as area sources, mobile source emissions should be assumed uniform over the entire highway link and allocated to each area source grid square based on the portion of highway link within each grid square. If localized areas of high concentrations are likely, then mobile sources should be modeled as line sources using an appropriate steady-state plume dispersion model (*e.g.*, CAL3QHCR; subsection 5.2.3).

g. More refined techniques to handle special circumstances may be considered on a case-by-case basis and agreement with the appropriate reviewing authority (paragraph 3.0(b)) should be obtained. Such techniques should consider individual quantities of NO and NO_2 emissions, atmospheric transport and dispersion, and atmospheric transformation of NO to NO_2. Where they are available, site specific data on the conversion of NO to NO_2 may be used. Photochemical dispersion models, if used for other pollutants in the area, may also be applied to the NO_X problem.

5.2.5 Models for Lead

a. For major lead point sources, such as smelters, which contribute fugitive emissions and for which deposition is important, professional judgement should be used, and there should be coordination with the appropriate reviewing authority (paragraph 3.0(b)). To model an entire major urban area or to model areas without significant sources of lead emissions, as a minimum a proportional (rollback) model may be used for air quality analysis. The rollback philosophy assumes that measured pollutant concentrations are proportional to emissions. However, urban or other dispersion models are encouraged in these circumstances where the use of such models is feasible.

b. In modeling the effect of traditional line sources (such as a specific roadway or highway) on lead air quality, dispersion models applied for other pollutants can be used. Dispersion models such as CALINE3 and CAL3QHCR have been used for modeling carbon monoxide emissions from highways and intersections (subsection 5.2.3). Where there is a point source in the middle of a substantial road network, the lead concentrations that result from the road network should be treated as background (subsection 8.2); the point source and any nearby major roadways should be modeled separately using the appropriate recommended steady-state plume dispersion model (subsection 4.2.2).

6.0 Other Model Requirements

6.1 Discussion

a. This section covers those cases where specific techniques have been developed for special regulatory programs. Most of the programs have, or will have when fully developed, separate guidance documents that cover the program and a discussion of the tools that are needed. The following paragraphs reference those guidance documents, when they are available. No attempt has been made to provide a comprehensive discussion of each topic since the reference documents were designed to do that. This section will undergo periodic revision as new programs are added and new techniques are developed.

b. Other Federal agencies have also developed specific modeling approaches for their own regulatory or other requirements.[58] Although such regulatory requirements and manuals may have come about because of EPA rules or standards, the implementation of such regulations and the use of the modeling techniques is under the jurisdiction of the agency issuing the manual or directive.

c. The need to estimate impacts at distances greater than 50km (the nominal distance to which EPA considers most steady-state Gaussian plume models are applicable) is an important one especially when considering the effects from secondary pollutants. Unfortunately, models originally available to EPA had not undergone sufficient field evaluation to be recommended for general use. Data bases from field studies at mesoscale and long range transport distances were limited in detail. This limitation was a result of the expense to perform the field studies required to verify and improve mesoscale and long range transport models. Meteorological data adequate for generating three-dimensional wind fields were particularly sparse. Application of models to complicated terrain compounds the difficulty of making good assessments of long range transport impacts. EPA completed limited evaluation of several long range transport (LRT) models against two sets of field data and evaluated results.[59] Based on the results, EPA concluded that long range and mesoscale transport models were limited for regulatory use to a case-by-case basis. However a more recent series of comparisons has been completed for a new model, CALPUFF (Section A.3). Several of these field studies involved three-to-four hour releases of tracer gas sampled along arcs of receptors at distances greater than 50km downwind. In some cases, short-term concentration sampling was available, such that the transport of the tracer puff as it passed the arc could be monitored. Differences on the order of 10 to 20 degrees were found between the location of the simulated and observed center of mass of the tracer puff. Most of the simulated centerline concentration maxima along each arc were within a factor of two of those observed. It was concluded from these case studies that the CALPUFF dispersion model had performed in a reasonable manner, and had no apparent bias toward over or under prediction, so long as the transport distance was limited to less than 300km.[60]

6.2 Recommendations

6.2.1 Visibility

a. Visibility in important natural areas (e.g., Federal Class I areas) is protected under a number of provisions of the Clean Air Act, including Sections 169A and 169B (addressing impacts primarily from existing sources) and Section 165 (new source review). Visibility impairment is caused by light scattering and light absorption associated with particles and gases in the atmosphere. In most areas of the country, light scattering by PM–2.5 is the most significant component of visibility impairment. The key components of PM–2.5 contributing to visibility impairment include sulfates, nitrates, organic carbon, elemental carbon, and crustal material.

b. The visibility regulations as promulgated in December 1980 (40 CFR 51.300–307) require States to mitigate visibility impairment, in any of the 156 mandatory Federal Class I areas, that is found to be ''reasonably attributable'' to a single source or a small group of sources. In 1985, EPA promulgated Federal Implementation Plans (FIPs) for several States without approved visibility provisions in their SIPs. The IMPROVE (Interagency Monitoring for Protected Visual Environments) monitoring network, a cooperative effort between EPA, the States, and Federal land management agencies, was established to implement the monitoring requirements in these FIPs. Data has been collected by the IMPROVE network since 1988.

c. In 1999, EPA issued revisions to the 1980 regulations to address visibility impairment in the form of regional haze, which is caused by numerous, diverse sources (e.g., stationary, mobile, and area sources) located across a broad region (40 CFR 51.308–309). The state of relevant scientific knowledge has expanded significantly since the Clean Air Act Amendments of 1977. A number of studies and reports[61 62] have concluded that long range transport (e.g., up to hundreds of kilometers) of fine particulate matter plays a significant role in visibility impairment across the country. Section 169A of the Act requires states to develop SIPs containing long-term strategies for remedying existing and preventing future visibility impairment in 156 mandatory Class I federal areas. In order to develop long-term strategies to address regional haze, many States will need to conduct regional-scale modeling of fine particulate concentrations and associated visibility impairment (e.g., light extinction and deciview metrics).

d. To calculate the potential impact of a plume of specified emissions for specific transport and dispersion conditions (''plume blight''), a screening model, VISCREEN, and guidance are available.[63] If a more comprehensive analysis is required, a refined model should be selected . The model selection (VISCREEN vs. PLUVUE II or some other refined model), procedures, and analyses should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected Federal Land Manager (FLM). FLMs are responsible for determining whether there is an adverse effect by a plume on a Class I area.

e. CALPUFF (Section A.3) may be applied when assessment is needed of reasonably attributable haze impairment or atmospheric deposition due to one or a small group of sources. This situation may involve more sources and larger modeling domains than that to which VISCREEN ideally may be applied. The procedures and analyses should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s).

f. Regional scale models are used by EPA to develop and evaluate national policy and assist State and local control agencies. Two such models which can be used to assess visibility impacts from source emissions are Models-3/CMAQ[38] and REMSAD.[41] Model users should consult with the appropriate reviewing authority (paragraph 3.0(b)), which in this instance would include FLMs.

6.2.2 Good Engineering Practice Stack Height

a. The use of stack height credit in excess of Good Engineering Practice (GEP) stack height or credit resulting from any other dispersion technique is prohibited in the development of emission limitations by 40 CFR 51.118 and 40 CFR 51.164. The definitions of GEP stack height and dispersion technique are contained in 40 CFR 51.100. Methods and procedures for making the appropriate stack height calculations, determining stack height credits and an example of applying those techniques are found in several references[64 65 66 67], which provide a great deal of additional information for evaluating and describing building cavity and wake effects.

b. If stacks for new or existing major sources are found to be less than the height defined by EPA's refined formula for determining GEP height, then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined. The EPA refined formula height is defined as H + 1.5L (*see* reference 66). Detailed downwash screening procedures[24] for both the cavity and wake regions should be followed. If more refined concentration estimates are required, the recommended steady-state plume dispersion model in subsection 4.2.2 contains algorithms for building wake calculations and should be used.

6.2.3 Long Range Transport (LRT) (*i.e.,* Beyond 50km)

a. Section 165(d) of the Clean Air Act requires that suspected adverse impacts on PSD Class I areas be determined. However, 50km is the useful distance to which most steady-state Gaussian plume models are considered accurate for setting emission limits. Since in many cases PSD analyses show that Class I areas may be threatened at distances greater than 50km from new sources, some procedure is needed to (1) determine if an adverse impact will occur, and (2) identify the model to be used in setting an emission limit if the Class I increments are threatened. In addition to the situations just described, there are certain applications containing a mixture of both long range and short range source-receptor relationships in a large modeled domain (*e.g.,* several industrialized areas located along a river or valley). Historically, these applications have presented considerable difficulty to an analyst if impacts from sources having transport distances greater than 50km significantly contributed to the design concentrations. To properly analyze applications of this type, a modeling approach is needed which has the capability of combining, in a consistent manner, impacts involving both short and long range transport. The CALPUFF modeling system, listed in Appendix A, has been designed to accommodate both the Class I area LRT situation and the large modeling domain situation. Given the judgement and refinement involved, conducting a LRT modeling assessment will require significant consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s). The FLM has an affirmative responsibility to protect air quality related values (AQRVs) that may be affected, and to provide the appropriate procedures and analysis techniques. Where there is no increment violation, the ultimate decision on whether a Class I area is adversely affected is the responsibility of the appropriate reviewing authority (Section 165(d)(2)(C)(ii) of the Clean Air Act), taking into consideration any information on the impacts on AQRVs provided by the FLM. According to Section 165(d)(2)(C)(iii) of the Clean Air Act, if there is a Class I increment violation, the *source* must demonstrate to the satisfaction of the FLM that the emissions from the source will have no adverse impact on the AQRVs.

b. If LRT is determined to be important, then refined estimates utilizing the CALPUFF modeling system should be obtained. A screening approach [60 68] is also available for use on a case-by-case basis that generally provides concentrations that are higher than those obtained using refined characterizations of the meteorological conditions. The meteorological input data requirements for developing the time and space varying three-dimensional winds and dispersion meteorology for refined analyses are discussed in paragraph 8.3.1.2(d). Additional information on applying this model is contained in Appendix A. To facilitate use of complex air quality and meteorological modeling systems, a written protocol approved by the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s) may be considered for developing consensus in the methods and procedures to be followed.

6.2.4 Modeling Guidance for Other Governmental Programs

a. When using the models recommended or discussed in the *Guideline* in support of programmatic requirements not specifically covered by EPA regulations, the model user should consult the appropriate Federal or State agency to ensure the proper application and use of the models. For modeling associated with PSD permit applications that involve a Class I area, the appropriate Federal Land Manager should be consulted on all modeling questions.

b. The Offshore and Coastal Dispersion (OCD) model, described in Appendix A, was developed by the Minerals Management Service and is recommended for estimating air quality impact from offshore sources on onshore, flat terrain areas. The OCD model is not recommended for use in air quality impact assessments for onshore sources. Sources located on or just inland of a shoreline where fumigation is expected should be treated in accordance with subsection 7.2.8.

c. The latest version of the Emissions and Dispersion Modeling System (EDMS), was developed and is supported by the Federal Aviation Administration (FAA), and is appropriate for air quality assessment of primary pollutant impacts at airports or air bases. EDMS has adopted AERMOD for treating dispersion. Application of EDMS is intended for estimating the collective impact of changes in aircraft operations, point source, and mobile source emissions on pollutant concentrations. It is not intended for PSD, SIP, or other regulatory air quality analyses of point or mobile sources at or peripheral to airport property that are unrelated to airport operations. If changes in other than aircraft operations are associated with analyses, a model recommended in Chapter 4 or 5 should be used. The latest version of EDMS may be obtained from FAA at its Web site: *http://www.aee.faa.gov/emissions/edms/edmshome.htm.*

7.0 General Modeling Considerations

7.1 Discussion

a. This section contains recommendations concerning a number of different issues not explicitly covered in other sections of this guide. The topics covered here are not specific to any one program or modeling area but are common to nearly all modeling analyses for criteria pollutants.

7.2 Recommendations

7.2.1 Design Concentrations (*See Also* Subsection 10.2.3.1)

7.2.1.1 Design Concentrations for SO_2, PM–10, CO, Pb, and NO_2

a. An air quality analysis for SO_2, PM–10, CO, Pb, and NO_2 is required to determine if the source will (1) cause a violation of the NAAQS, or (2) cause or contribute to air quality deterioration greater than the specified allowable PSD increment. For the former, background concentration (subsection 8.2) should be added to the estimated impact of the source to determine the design concentration. For the latter, the design concentration includes impact from all increment consuming sources.

b. If the air quality analyses are conducted using the period of meteorological input data recommended in subsection 8.3.1.2 (*e.g.*, 5 years of National Weather Service (NWS) data or at least 1 year of site specific data; subsection 8.3.3), then the design concentration based on the highest, second-highest short term concentration over the entire receptor network for each year modeled or the highest long term average (whichever is controlling) should be used to determine emission limitations to assess compliance with the NAAQS and PSD increments. For the 24-hour PM–10 NAAQS (which is a probabilistic standard)—when multiple years are modeled, they collectively represent a single period. Thus, if 5 years of NWS data are modeled, then the highest sixth highest concentration for the whole period becomes the design value. And in general, when n years are modeled, the (n+1)th highest concentration over the n-year period is the design value, since this represents an average or expected exceedance rate of one per year.

c. When sufficient and representative data exist for less than a 5-year period from a nearby NWS site, or when site specific data have been collected for less than a full continuous year, or when it has been determined that the site specific data may not be temporally representative (subsection 8.3.3), then the highest concentration estimate should be considered the design value. This is because the length of the data record may be too short to assure that the conditions producing worst-case estimates have been adequately sampled. The highest value is then a surrogate for the concentration that is not to be exceeded more than once per year (the wording of the deterministic standards). Also, the highest concentration should be used whenever selected worst-case conditions are input to a screening technique, as described in EPA guidance.[24]

d. If the controlling concentration is an annual average value and multiple years of data (site specific or NWS) are used, then the design value is the highest of the annual averages calculated for the individual years. If the controlling concentration is a quarterly average and multiple years are used, then the highest individual quarterly average should be considered the design value.

e. As long a period of record as possible should be used in making estimates to determine design values and PSD increments. If more than 1 year of site specific data is available, it should be used.

7.2.1.2 Design Concentrations for O_3 and PM–2.5

a. Guidance and specific instructions for the determination of the 1-hr and 8-hr design concentrations for ozone are provided in Appendix H and I (respectively) of reference 4. Appendix H explains how to determine when the expected number of days per calendar year with maximum hourly concentrations above the NAAQS is equal to or less than 1. Appendix I explains the data handling conventions and computations necessary for determining whether the 8-hour primary and secondary NAAQS are met at an ambient monitoring site. For PM–2.5, Appendix N of reference 4, and supplementary guidance,[69] explain the data handling conventions and computations necessary for determining when the annual and 24-hour primary and secondary NAAQS are met. For all SIP revisions the user should check with the Regional Office to obtain the most recent guidance documents and policy memoranda concerning the pollutant in question. There are currently no PSD increments for O_3 and PM–2.5.

7.2.2 Critical Receptor Sites

a. Receptor sites for refined modeling should be utilized in sufficient detail to estimate the highest concentrations and possible violations of a NAAQS or a PSD increment. In designing a receptor network, the emphasis should be placed on receptor resolution and location, not total number of receptors. The selection of receptor sites should be a case-by-case determination taking into consideration the topography, the climatology, monitor sites, and the results of the initial screening procedure.

7.2.3 Dispersion Coefficients

a. Steady-state Gaussian plume models used in most applications should employ dispersion coefficients consistent with those contained in the preferred models in Appendix A. Factors such as averaging time, urban/rural surroundings (*see* paragraphs (b)—(f) of this subsection), and type of source (point vs. line) may dictate the selection of specific coefficients. Coefficients used in some Appendix A models are identical to, or at least based on, Pasquill-Gifford coefficients [70] in rural areas and McElroy-Pooler [71] coefficients in urban areas. A key feature of AERMOD's formulation is the use of directly observed variables of the boundary layer to parameterize dispersion.[22]

b. The selection of either rural or urban dispersion coefficients in a specific application should follow one of the procedures suggested by Irwin [72] and briefly described in paragraphs (c)—(f) of this subsection. These include a land use classification procedure or a population based procedure to determine whether the character of an area is primarily urban or rural.

c. Land Use Procedure: (1) Classify the land use within the total area, A_o, circumscribed by a 3km radius circle about the source using the meteorological land use typing scheme proposed by Auer [73]; (2) if land use types I1, I2, C1, R2, and R3 account for 50 percent or more of A_o, use urban dispersion coefficients; otherwise, use appropriate rural dispersion coefficients.

d. Population Density Procedure: (1) Compute the average population density, $\bar{p}$ per square kilometer with A_o as defined above; (2) If $\bar{p}$ is greater than 750 people/km_2, use urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients.

e. Of the two methods, the land use procedure is considered more definitive. Population density should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied. In this case, the classification should already be ''urban'' and urban dispersion parameters should be used.

f. Sources located in an area defined as urban should be modeled using urban dispersion parameters. Sources located in areas defined as rural should be modeled using the rural dispersion parameters. For analyses of whole urban complexes, the entire area should be modeled as an urban region if most of the sources are located in areas classified as urban.

g. Buoyancy-induced dispersion (BID), as identified by Pasquill [74], is included in the preferred models and should be used where buoyant sources, *e.g.*, those involving fuel combustion, are involved.

7.2.4 Stability Categories

a. The Pasquill approach to classifying stability is commonly used in preferred models (Appendix A). The Pasquill method, as modified by Turner [75], was developed for use with commonly observed meteorological data from the National Weather Service and is based on cloud cover, insolation and wind speed.

b. Procedures to determine Pasquill stability categories from other than NWS data are found in subsection 8.3. Any other method to determine Pasquill stability categories must be justified on a case-by-case basis.

c. For a given model application where stability categories are the basis for selecting dispersion coefficients, both σ_y and σ_z should be determined from the same stability category. ''Split sigmas'' in that instance are not recommended. Sector averaging, which eliminates the σ_y term, is commonly acceptable in complex terrain screening methods.

d. AERMOD, also a preferred model in Appendix A, uses a planetary boundary layer scaling parameter to characterize stability.[22] This approach represents a departure from the discrete, hourly stability categories estimated under the Pasquill-Gifford-Turner scheme.

7.2.5 Plume Rise

a. The plume rise methods of Briggs [76 77] are incorporated in many of the preferred models and are recommended for use in many modeling applications. In AERMOD,[22] for the stable boundary layer, plume rise is estimated using an iterative approach, similar to that in the CTDMPLUS model. In the convective boundary layer, plume rise is superposed on the displacements by random convective velocities.[78] In AERMOD, plume rise is computed using the methods of Briggs excepting cases involving building downwash, in which a numerical solution of the mass, energy, and momentum conservation laws is performed.[23] No explicit provisions in these models are made for multistack plume rise enhancement or the handling of such special plumes as flares; these problems should be considered on a case-by-case basis.

b. Gradual plume rise is generally recommended where its use is appropriate: (1) In AERMOD; (2) in complex terrain screening procedures to determine close-in impacts and (3) when calculating the effects of building wakes. The building wake algorithm in AERMOD incorporates and exercises the thermodynamically based gradual plume rise calculations as described in (a) above. If the building wake is calculated to affect the plume for any hour, gradual plume rise is also used in downwind dispersion calculations to the distance of final plume rise, after which final plume rise is used. Plumes captured by the near wake are re-emitted to the far wake as a ground-level volume source.

c. Stack tip downwash generally occurs with poorly constructed stacks and when the ratio of the stack exit velocity to wind speed is small. An algorithm developed by Briggs [77] is the recommended technique for this situation and is used in preferred models for point sources.

7.2.6 Chemical Transformation

a. The chemical transformation of SO_2 emitted from point sources or single industrial plants in rural areas is generally assumed to be relatively unimportant to the estimation of maximum concentrations when travel time is limited to a few hours. However, in urban areas, where synergistic effects among pollutants are of considerable consequence, chemical transformation rates may be of concern. In urban area applications, a half-life of 4 hours [75] may be applied to the analysis of SO_2 emissions. Calculations of transformation coefficients from site specific studies can be used to define a ''half-life'' to be used in a steady-state Gaussian plume model with any travel time, or in any application, if appropriate documentation is provided. Such conversion factors for pollutant half-life should not be used with screening analyses.

b. Use of models incorporating complex chemical mechanisms should be considered only on a case-by-case basis with proper demonstration of applicability. These are generally regional models not designed for the evaluation of individual sources but used primarily for region-wide evaluations. Visibility models also incorporate chemical transformation mechanisms which are an integral part of the visibility model itself and should be used in visibility assessments.

7.2.7 Gravitational Settling and Deposition

a. An ''infinite half-life'' should be used for estimates of particle concentrations when steady-state Gaussian plume models containing only exponential decay terms for treating settling and deposition are used.

b. Gravitational settling and deposition may be directly included in a model if either is a significant factor. When particulate matter sources can be quantified and settling and dry deposition are problems, professional judgement should be used, and there should be coordination with the appropriate reviewing authority (paragraph 3.0(b)).

7.2.8 Complex Winds

a. *Inhomogeneous Local Winds.* In many parts of the United States, the ground is neither flat nor is the ground cover (or land use) uniform. These geographical variations can generate local winds and circulations, and modify the prevailing ambient winds and circulations. Geographic effects are most apparent when the ambient winds are light or calm.[79] In general these geographically induced wind circulation effects are named after the source location of the winds, *e.g.*, lake and sea breezes, and mountain and valley winds. In very rugged hilly or mountainous terrain, along coastlines, or near large land use variations, the characterization of the winds is a balance of various forces, such that the assumptions of steady-state straight-line transport both in time and space are inappropriate. In the special cases described, the CALPUFF modeling system (described in Appendix A) may be applied on a case-by-case basis for air quality estimates in such complex non-steady-state meteorological conditions. The purpose of choosing a modeling system like CALPUFF is to fully treat the time and space variations of meteorology effects on transport and dispersion. The setup and application of the model should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) consistent with limitations of paragraph 3.2.2(e). The meteorological input data requirements for developing the time and space varying three-dimensional winds and dispersion meteorology for these situations are discussed in paragraphs 8.3.1.2(d) and 8.3.1.2(f). Examples of inhomogeneous winds include, but aren't limited to, situations described in the following paragraphs (i)—(iii):

i. *Inversion Breakup Fumigation.* Inversion breakup fumigation occurs when a plume (or multiple plumes) is emitted into a stable layer of air and that layer is subsequently mixed to the ground through convective transfer of heat from the surface or because of advection to less stable surroundings. Fumigation may cause excessively high concentrations but is usually rather short-lived at a given receptor. There are no recommended refined techniques to model this phenomenon. There are, however, screening procedures [24] that may be used to approximate the concentrations. Considerable care should be exercised in using the results obtained from the screening techniques.

ii. *Shoreline Fumigation.* Fumigation can be an important phenomenon on and near the shoreline of bodies of water. This can affect both individual plumes and area-wide emissions. When fumigation conditions are expected to occur from a source or sources with tall stacks located on or just inland of a shoreline, this should be addressed in the air quality modeling analysis. The Shoreline Dispersion Model (SDM) listed on EPA's Internet SCRAM Web site (subsection 2.3) may be applied on a case-by-case basis when air quality estimates under shoreline fumigation conditions are needed.[80] Information on the results of EPA's evaluation of this model together with other coastal fumigation models is available.[81] Selection of the appropriate model for applications where shoreline fumigation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

iii. *Stagnation.* Stagnation conditions are characterized by calm or very low wind speeds, and variable wind directions. These stagnant meteorological conditions may persist for several hours to several days. During stagnation conditions, the dispersion of air pollutants, especially those from low-level emissions sources, tends to be minimized, potentially leading to relatively high ground-level concentrations. If point sources are of interest, users should note the guidance provided for CALPUFF in paragraph (a) of this subsection. Selection of the appropriate model for applications where stagnation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

7.2.9 Calibration of Models

a. Calibration of models is not common practice and is subject to much error and misunderstanding. There have been attempts by some to compare model estimates and measurements on an event-by-event basis and then to calibrate a model with results of that comparison. This approach is severely limited by uncertainties in both source and meteorological data and therefore it is difficult to precisely estimate the concentration at an exact location for a specific increment of time. Such uncertainties make calibration of models of questionable benefit. Therefore, model calibration is unacceptable.

8.0 Model Input Data

a. Data bases and related procedures for estimating input parameters are an integral part of the modeling procedure. The most appropriate data available should always be selected for use in modeling analyses. Concentrations can vary widely depending on the source data or meteorological data used. Input data are a major source of uncertainties in any modeling analysis. This section attempts to minimize the uncertainty associated with data base selection and use by identifying requirements for data used in modeling. A checklist of input data requirements for modeling analyses is posted on EPA's Internet SCRAM Web site (subsection 2.3). More specific data requirements and the format required for the individual models are described in detail in the users' guide for each model.

8.1 Source Data

8.1.1 Discussion

a. Sources of pollutants can be classified as point, line and area/volume sources. Point sources are defined in terms of size and may vary between regulatory programs. The line sources most frequently considered are roadways and streets along which there are well-defined movements of motor vehicles, but they may be lines of roof vents or stacks such as in aluminum refineries. Area and volume sources are often collections of a multitude of minor sources with individually small emissions that are impractical to consider as separate point or line sources. Large area sources are typically treated as a grid network of square areas, with pollutant emissions distributed uniformly within each grid square.

b. Emission factors are compiled in an EPA publication commonly known as AP–42 [82]; an indication of the quality and amount of data on which many of the factors are based is also provided. Other information concerning emissions is available in EPA publications relating to specific source categories. The appropriate reviewing authority (paragraph 3.0(b)) should be consulted to determine appropriate source definitions and for guidance concerning the determination of emissions from and techniques for modeling the various source types.

8.1.2 Recommendations

a. For point source applications the load or operating condition that causes maximum ground-level concentrations should be established. As a minimum, the source should be modeled using the design capacity (100 percent load). If a source operates at greater than design capacity for periods that could result in violations of the standards or PSD increments, this load) [a] should be modeled. Where the source operates at substantially less than design capacity, and the changes in the stack parameters associated with the operating conditions could lead to higher ground level concentrations, loads such as 50 percent and 75 percent of capacity should also be modeled. A range of operating conditions should be considered in screening analyses; the load causing the highest concentration, in addition to the design load, should be included in refined modeling. For a steam power plant, the following (b–h) is typical of the kind of data on source characteristics and operating conditions that may be needed. Generally, input data requirements for air quality models necessitate the use of metric units; where English units are common for engineering usage, a conversion to metric is required.

b. *Plant layout.* The connection scheme between boilers and stacks, and the distance and direction between stacks, building parameters (length, width, height, location and orientation relative to stacks) for plant structures which house boilers, control equipment, and surrounding buildings within a distance of approximately five stack heights.

c. *Stack parameters.* For all stacks, the stack height and inside diameter (meters), and the temperature (K) and volume flow rate (actual cubic meters per second) or exit gas velocity (meters per second) for operation at 100 percent, 75 percent and 50 percent load.

d. *Boiler size.* For all boilers, the associated megawatts, 10^6 BTU/hr, and pounds of steam per hour, and the design and/or actual fuel consumption rate for 100 percent load for coal (tons/hour), oil (barrels/hour), and natural gas (thousand cubic feet/hour).

e. *Boiler parameters.* For all boilers, the percent excess air used, the boiler type (e.g., wet bottom, cyclone, etc.), and the type of firing (e.g., pulverized coal, front firing, etc.).

f. *Operating conditions.* For all boilers, the type, amount and pollutant contents of fuel, the total hours of boiler operation and the boiler capacity factor during the year, and the percent load for peak conditions.

g. *Pollution control equipment parameters.* For each boiler served and each pollutant affected, the type of emission control equipment, the year of its installation, its design efficiency and mass emission rate, the date of the last test and the tested efficiency, the number of hours of operation during the latest year, and the best engineering estimate of its projected efficiency if used in conjunction with coal combustion; data for any anticipated modifications or additions.

h. *Data for new boilers or stacks.* For all new boilers and stacks under construction

[a] Malfunctions which may result in excess emissions are not considered to be a normal operating condition. They generally should not be considered in determining allowable emissions. However, if the excess emissions are the result of poor maintenance, careless operation, or other preventable conditions, it may be necessary to consider them in determining source impact.

and for all planned modifications to existing boilers or stacks, the scheduled date of completion, and the data or best estimates available for items (b) through (g) of this subsection following completion of construction or modification.

i. In stationary point source applications for compliance with short term ambient standards, SIP control strategies should be tested using the emission input shown on Table 8–1. When using a refined model, sources should be modeled sequentially with these loads for every hour of the year. To evaluate SIPs for compliance with quarterly and annual standards, emission input data shown in Table 8–1 should again be used. Emissions from area sources should generally be based on annual average conditions. The source input information in each model user's guide should be carefully consulted and the checklist (paragraph 8.0(a)) should also be consulted for other possible emission data that could be helpful. NAAQS compliance demonstrations in a PSD analysis should follow the emission input data shown in Table 8–2. For purposes of emissions trading, new source review and demonstrations, refer to current EPA policy and guidance to establish input data.

j. Line source modeling of streets and highways requires data on the width of the roadway and the median strip, the types and amounts of pollutant emissions, the number of lanes, the emissions from each lane and the height of emissions. The location of the ends of the straight roadway segments should be specified by appropriate grid coordinates. Detailed information and data requirements for modeling mobile sources of pollution are provided in the user's manuals for each of the models applicable to mobile sources.

k. The impact of growth on emissions should be considered in all modeling analyses covering existing sources. Increases in emissions due to planned expansion or planned fuel switches should be identified. Increases in emissions at individual sources that may be associated with a general industrial/commercial/residential expansion in multi-source urban areas should also be treated. For new sources the impact of growth on emissions should generally be considered for the period prior to the start-up date for the source. Such changes in emissions should treat increased area source emissions, changes in existing point source emissions which were not subject to preconstruction review, and emissions due to sources with permits to construct that have not yet started operation.

TABLE 8–1.—MODEL EMISSION INPUT DATA FOR POINT SOURCES [1]

Averaging time	Emission limit (#/MMBtu) [2]	×	Operating level (MMBtu/hr) [2]	×	Operating factor (e.g., hr/yr, hr/day)
Stationary Point Source(s) Subject to SIP Emission Limit(s) Evaluation for Compliance with Ambient Standards (Including Areawide Demonstrations)					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.		Actual operating factor averaged over most recent 2 years.[3]
Short term	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.[4]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]
Nearby Source(s) [6 7]					
Same input requirements as for stationary point source(s) above.					
Other Source(s) [7]					
If modeled (subsection 8.2.3), input data requirements are defined below.					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.[6]		Annual level when actually operating, averaged over the most recent 2 years.[3]		Actual operating factor averaged over the most recent 2 years.[3]
Short term	Maximum allowable emission limit or federally enforceable permit limit.[6]		Annual level when actually operating, averaged over the most recent 2 years.[3]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]

[1] The model input data requirements shown on this table apply to stationary source control strategies for STATE IMPLEMENTATION PLANS. For purposes of emissions trading, new source review, or prevention of significant deterioration, other model input criteria may apply. Refer to the policy and guidance for these programs to establish the input data.

[2] Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.

[3] Unless it is determined that this period is not representative.

[4] Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.

[5] If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8 a.m. to 4 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.)

[6] See paragraph 8.2.3(c).

[7] See paragraph 8.2.3(d).

TABLE 8–2.—POINT SOURCE MODEL EMISSION INPUT DATA FOR NAAQS COMPLIANCE IN PSD DEMONSTRATIONS

Averaging time	Emission limit (#/MMBtu) [1]	×	Operating level (MMBtu/hr) [1]	×	Operating factor (e.g., hr/yr, hr/day)
Proposed Major New or Modified Source					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.		Continuous operation (i.e., 8760 hours).[2]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.[3]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[2]
Nearby Source(s) [4 6]					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.[5]		Actual or design capacity (whichever is greater), or federally enforceable permit condition.		Actual operating factor averaged over the most recent 2 years.[7 8]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.[5]		Actual or design capacity (whichever is greater), or federally enforceable permit condition.[3]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[2]
Other Source(s) [6 9]					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.[5]		Annual level when actually operating, averaged over the most recent 2 years.[7]		Actual operating factor averaged over the most recent 2 years.[7 8]
Short term (≤ 24 hours)	Maximum allowable emission limit or federally enforceable permit limit.[5]		Annual level when actually operating, averaged over the most recent 2 years.[7]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[2]

[1] Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.
[2] If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8 a.m. to 4 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.
[3] Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.
[4] Includes existing facility to which modification is proposed if the emissions from the existing facility will not be affected by the modification. Otherwise use the same parameters as for major modification.
[5] See paragraph 8.2.3(c).
[6] See paragraph 8.2.3(d).
[7] Unless it is determined that this period is not representative.
[8] For those permitted sources not in operation or that have not established an appropriate factor, continuous operation (i.e., 8760) should be used.
[9] Generally, the ambient impacts from non-nearby (background) sources can be represented by air quality data unless adequate data do not exist.

8.2 Background Concentrations

8.2.1 Discussion

a. Background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts. Background air quality includes pollutant concentrations due to: (1) Natural sources; (2) nearby sources other than the one(s) currently under consideration; and (3) unidentified sources.

b. Typically, air quality data should be used to establish background concentrations in the vicinity of the source(s) under consideration. The monitoring network used for background determinations should conform to the same quality assurance and other requirements as those networks established for PSD purposes.[83] An appropriate data validation procedure should be applied to the data prior to use.

c. If the source is not isolated, it may be necessary to use a multi-source model to establish the impact of nearby sources. Since sources don't typically operate at their maximum allowable capacity (which may include the use of ''dirtier'' fuels), modeling is necessary to express the potential contribution of background sources, and this impact would not be captured via monitoring. Background concentrations should be determined for each critical (concentration) averaging time.

8.2.2 Recommendations (Isolated Single Source)

a. Two options (paragraph (b) or (c) of this section) are available to determine the background concentration near isolated sources.

b. Use air quality data collected in the vicinity of the source to determine the background concentration for the averaging times of concern. Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors not impacted by the source in question, should be averaged for each separate averaging time to determine the average background value. Monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact. One hour concentrations may be added and averaged to determine longer averaging periods.

c. If there are no monitors located in the vicinity of the source, a ''regional site'' may be used to determine background. A ''regional site'' is one that is located away from the area of interest but is impacted by similar natural and distant man-made sources.

8.2.3 Recommendations (Multi-Source Areas)

a. In multi-source areas, two components of background should be determined: contributions from nearby sources and contributions from other sources.

b. *Nearby Sources:* All sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration for emission limit(s) should be explicitly modeled. The number of such sources is expected to be small except in unusual situations. Owing to both the uniqueness of each modeling situation and the large number of variables involved in identifying nearby sources, no attempt is made here to comprehensively define this term. Rather, identification of nearby sources calls for the exercise of professional judgement by the appropriate reviewing authority (paragraph 3.0(b)). This guidance is not intended to alter the exercise of that judgement or to comprehensively define which sources are nearby sources.

c. For compliance with the short-term and annual ambient standards, the nearby sources as well as the primary source(s) should be evaluated using an appropriate Appendix A model with the emission input data shown in Table 8–1 or 8–2. When modeling a nearby source that does not have a permit and the emission limit contained in the SIP for a particular source category is greater than the emissions possible given the source's maximum physical capacity to emit, the ''maximum allowable emission limit'' for such a nearby source may be calculated as the emission rate representative of the nearby source's maximum physical capacity to emit, considering its design specifications and allowable fuels and process materials. However, the burden is on the permit applicant to sufficiently document what the maximum physical capacity to emit is for such a nearby source.

d. It is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) being modeled. Where a primary source believes that a nearby source does not, by its nature, operate at the same time as the primary source being modeled, the burden is on the primary source to demonstrate to the satisfaction of the appropriate reviewing authority (paragraph 3.0(b)) that this is, in fact, the case. Whether or not the primary source has adequately demonstrated that fact is a matter of professional judgement left to the discretion of the appropriate reviewing authority. The following examples illustrate two cases in which a nearby source may be shown not to operate at the same time as the primary source(s) being modeled. Some sources are only used during certain seasons of the year. Those sources would not be modeled as nearby sources during times in which they do not operate. Similarly, emergency backup generators that never operate simultaneously with the sources that they back up would not be modeled as nearby sources. To reiterate, in these examples and other appropriate cases, the burden is on the primary source being modeled to make the appropriate demonstration to the satisfaction of the appropriate reviewing authority.

e. The impact of the nearby sources should be examined at locations where interactions between the plume of the point source under consideration and those of nearby sources (plus natural background) can occur. Significant locations include: (1) the area of maximum impact of the point source; (2) the area of maximum impact of nearby sources; and (3) the area where all sources combine to cause maximum impact. These locations may be identified through trial and error analyses.

f. *Other Sources:* That portion of the background attributable to all other sources (*e.g.*, natural sources, minor sources and distant major sources) should be determined by the procedures found in subsection 89.2.2 or by application of a model using Table 8–1 or 8–2.

8.3 Meteorological Input Data

a. The meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern. The representativeness of the data is dependent on: (1) The proximity of the meteorological monitoring site to the area under consideration; (2) the complexity of the terrain; (3) the exposure of the meteorological monitoring site; and (4) the period of time during which data are collected. The spatial representativeness of the data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area. Temporal representativeness is a function of the year-to-year variations in weather conditions. Where appropriate, data representativeness should be viewed in terms of the appropriateness of the data for constructing realistic boundary layer profiles and three dimensional meteorological fields, as described in paragraphs (c) and (d) below.

b. Model input data are normally obtained either from the National Weather Service or as part of a site specific measurement program. Local universities, Federal Aviation Administration (FAA), military stations, industry and pollution control agencies may also be sources of such data. Some recommendations for the use of each type of data are included in this subsection.

c. Regulatory application of AERMOD requires careful consideration of minimum data for input to AERMET. Data representativeness, in the case of AERMOD, means utilizing data of an appropriate type for constructing realistic boundary layer profiles. Of paramount importance is the requirement that all meteorological data used as input to AERMOD must be both laterally and vertically representative of the transport and dispersion within the analysis domain. Where surface conditions vary significantly over the analysis domain, the emphasis in assessing representativeness should be given to adequate characterization of transport and dispersion between the source(s) of concern and areas where maximum design concentrations are anticipated to occur. The representativeness of data that were collected off-site should be judged, in part, by comparing the surface characteristics in the vicinity of the meteorological monitoring site with the surface characteristics that generally describe the analysis domain. The surface characteristics input to AERMET should be based on the topographic conditions in the vicinity of the meteorological tower. Furthermore, since the spatial scope of each variable could be different, representativeness should be judged for each variable separately. For example, for a variable such as wind direction, the data may need to be collected very near plume height to be adequately representative, whereas, for a variable such as temperature, data from a station several kilometers away from the source may in some cases be considered to be adequately representative.

d. For long range transport modeling assessments (subsection 6.2.3) or for assessments where the transport winds are complex and the application involves a non-steady-state dispersion model (subsection 7.2.8), use of output from prognostic mesoscale meteorological models is encouraged.[84 85 86] Some diagnostic meteorological processors are designed to appropriately blend available NWS comparable meteorological observations, local site specific meteorological observations, and prognostic mesoscale meteorological data, using empirical relationships, to diagnostically adjust the wind field for mesoscale and local-scale effects. These diagnostic adjustments can sometimes be improved through the use of strategically placed site specific meteorological observations. The placement of these special meteorological observations (often more than one location is needed) involves expert judgement, and is specific to the terrain and land use of the modeling domain. Acceptance for use of output from prognostic mesoscale meteorological models is contingent on concurrence by the appropriate reviewing authorities (paragraph 3.0(b)) that the data are of acceptable quality, which can be demonstrated through statistical comparisons with observations of winds aloft and at the surface at several appropriate locations.

8.3.1 Length of Record of Meteorological Data

8.3.1.1 Discussion

a. The model user should acquire enough meteorological data to ensure that worst-case meteorological conditions are adequately represented in the model results. The trend toward statistically based standards suggests a need for all meteorological conditions to be adequately represented in the data set selected for model input. The number of years of record needed to obtain a stable distribution of conditions depends on the variable being measured and has been estimated by Landsberg and Jacobs [87] for various parameters. Although that study indicates in excess of 10 years may be required to achieve stability in the frequency distributions of some meteorological variables, such long periods are not reasonable for model input data. This is due in part to the fact that hourly data in model input format are frequently not available for such periods and that hourly calculations of concentration for long periods may be prohibitively expensive. Another study [88] compared various periods from a 17-year data set to determine the minimum number of years of data needed to approximate the concentrations modeled with a 17-year period of meteorological data from one station. This study indicated that the variability of model estimates due to the meteorological data input was adequately reduced if a 5-year period of record of meteorological input was used.

8.3.1.2 Recommendations

a. Five years of representative meteorological data should be used when estimating concentrations with an air quality model. Consecutive years from the most recent, readily available 5-year period are preferred. The meteorological data should be *adequately representative*, and may be site specific or from a nearby NWS station. Where professional judgment indicates NWS-collected ASOS (automated surface observing stations) data are inadequate {for cloud cover observations}, the most recent 5 years of NWS data that are observer-based may be considered for use.

b. The use of 5 years of NWS meteorological data or at least l year of site specific data is required. If one year or more (including partial years), up to five years, of site specific data is available, these data are preferred for use in air quality analyses. Such data should have been subjected to quality assurance procedures as described in subsection 8.3.3.2.

c. For permitted sources whose emission limitations are based on a specific year of meteorological data, that year should be added to any longer period being used (*e.g.*, 5 years of NWS data) when modeling the facility at a later time.

d. For LRT situations (subsection 6.2.3) and for complex wind situations (paragraph 7.2.8(a)), if only NWS or comparable standard meteorological observations are employed, five years of meteorological data (within and near the modeling domain) should be used. Consecutive years from the most recent, readily available 5-year period are preferred. Less than five, but at least three, years of meteorological data (need not be consecutive) may be used if mesoscale meteorological fields are available, as discussed in paragraph 8.3(d). These mesoscale meteorological fields should be used in conjunction with available standard NWS or comparable meteorological observations within and near the modeling domain.

e. For solely LRT applications (subsection 6.2.3), if site specific meteorological data are available, these data may be helpful when used in conjunction with available standard NWS or comparable observations and mesoscale meteorological fields as described in paragraph 8.3.1.2(d).

f. For complex wind situations (paragraph 7.2.8(a)) where site specific meteorological data are being relied upon as the basis for characterizing the meteorological conditions, a data base of at least 1 full-year of meteorological data is required. If more data are available, they should be used. Site specific meteorological data may have to be collected at multiple locations. Such data should have been subjected to quality assurance procedures as described in paragraph 8.3.3.2(a), and should be reviewed for spatial and temporal representativeness.

8.3.2 National Weather Service Data

8.3.2.1 Discussion

a. The NWS meteorological data are routinely available and familiar to most model users. Although the NWS does not provide direct measurements of all the needed dispersion model input variables, methods have been developed and successfully used to translate the basic NWS data to the needed model input. Site specific measurements of model input parameters have been made for many modeling studies, and those methods and techniques are becoming more widely applied, especially in situations such as complex terrain applications, where available NWS data are not adequately representative. However, there are many model applications where NWS data are adequately representative, and the applications still rely heavily on the NWS data.

b. Many models use the standard hourly weather observations available from the National Climatic Data Center (NCDC). These observations are then preprocessed before they can be used in the models.

8.3.2.2 Recommendations

a. The preferred models listed in Appendix A all accept as input the NWS meteorological data preprocessed into model compatible form. If NWS data are judged to be adequately representative for a particular modeling application, they may be used. NCDC makes available surface [89,90] and upper air [91] meteorological data in CD–ROM format.

b. Although most NWS measurements are made at a standard height of 10 meters, the actual anemometer height should be used as input to the preferred model. Note that AERMOD at a minimum requires wind observations at a height above ground between seven times the local surface roughness height and 100 meters.

c. Wind directions observed by the National Weather Service are reported to the nearest 10 degrees. A specific set of randomly generated numbers has been developed for use with the preferred EPA models and should be used with NWS data to ensure a lack of bias in wind direction assignments within the models.

d. Data from universities, FAA, military stations, industry and pollution control agencies may be used if such data are equivalent in accuracy and detail to the NWS data, and they are judged to be adequately representative for the particular application.

8.3.3 Site Specific Data

8.3.3.1 Discussion

a. Spatial or geographical representativeness is best achieved by collection of all of the needed model input data in close proximity to the actual site of the source(s). Site specific measured data are therefore preferred as model input, provided that appropriate instrumentation and quality assurance procedures are followed and that the data collected are adequately representative (free from inappropriate local or microscale influences) and compatible with the input requirements of the model to be used. It should be noted that, while site specific measurements are frequently made ''on-property'' (*i.e.*, on the source's premises), acquisition of adequately representative site specific data does not preclude collection of data from a location off property. Conversely, collection of meteorological data on a source's property does not of itself guarantee adequate representativeness. For help in determining representativeness of site specific measurements, technical guidance [92] is available. Site specific data should always be reviewed for representativeness and consistency by a qualified meteorologist.

8.3.3.2 Recommendations

a. EPA guidance [92] provides recommendations on the collection and use of site specific meteorological data. Recommendations on characteristics, siting, and exposure of meteorological instruments and on data recording, processing, completeness requirements, reporting, and archiving are also included. This publication should be used as a supplement to other limited guidance on these subjects.[83,93,94] Detailed information on quality assurance is also available.[95] As a minimum, site specific measurements of ambient air temperature, transport wind speed and direction, and the variables necessary to estimate atmospheric dispersion should be available in meteorological data sets to be used in modeling. Care should be taken to ensure that meteorological instruments are located to provide representative characterization of pollutant transport between sources and receptors of interest. The appropriate reviewing authority (paragraph 3.0(b)) is available to help determine the appropriateness of the measurement locations.

b. All site specific data should be reduced to hourly averages. Table 8–3 lists the wind related parameters and the averaging time requirements.

c. *Missing Data Substitution.* After valid data retrieval requirements have been met [92], hours in the record having missing data should be treated according to an established data substitution protocol provided that data from an adequately representative alternative site are available. Such protocols are usually part of the approved monitoring program plan. Data substitution guidance is provided in Section 5.3 of reference 92. If no representative alternative data are available for substitution, the absent data should be coded as missing using missing data codes appropriate to the applicable meteorological pre-processor. Appropriate model options for treating missing data, if available in the model, should be employed.

d. *Solar Radiation Measurements.* Total solar radiation or net radiation should be measured with a reliable pyranometer or net radiometer, sited and operated in accordance with established site specific meteorological guidance.[92 95]

e. *Temperature Measurements.* Temperature measurements should be made at standard shelter height (2m) in accordance with established site specific meteorological guidance.[92]

f. *Temperature Difference Measurements.* Temperature difference (ΔT) measurements should be obtained using matched thermometers or a reliable thermocouple system to achieve adequate accuracy. Siting, probe placement, and operation of ΔT systems should be based on guidance found in Chapter 3 of reference 92, and such guidance should be followed when obtaining vertical temperature gradient data. AERMET employs the Bulk Richardson scheme which requires measurements of temperature difference. To ensure correct application and acceptance, AERMOD users should consult with the appropriate Reviewing Authority before using the Bulk Richardson scheme for their analysis.

g. *Winds Aloft.* For simulation of plume rise and dispersion of a plume emitted from a stack, characterization of the wind profile up through the layer in which the plume disperses is required. This is especially important in complex terrain and/or complex wind situations where wind measurements at heights up to hundreds of meters above stack base may be required in some circumstances. For tall stacks when site specific data are needed, these winds have been obtained traditionally using meteorological sensors mounted on tall towers. A feasible alternative to tall towers is the use of meteorological remote sensing instruments (e.g., acoustic sounders or radar wind profilers) to provide winds aloft, coupled with 10-meter towers to provide the near-surface winds. (For specific requirements for AERMOD and CTDMPLUS, *see* Appendix A.) Specifications for wind measuring instruments and systems are contained in reference 92.

h. *Turbulence.* There are several dispersion models that are capable of using direct measurements of turbulence (wind fluctuations) in the characterization of the vertical and lateral dispersion (e.g., CTDMPLUS, AERMOD, and CALPUFF). For specific requirements for CTDMPLUS, AERMOD, and CALPUFF, see Appendix A. For technical guidance on measurement and processing of turbulence parameters, see reference 92. When turbulence data are used in this manner to directly characterize the vertical and lateral dispersion, the averaging time for the turbulence measurements should be one hour (Table 8–3). There are other dispersion models (e.g., BLP, and CALINE3) that employ P–G stability categories for the characterization of the vertical and lateral dispersion. Methods for using site specific turbulence data for the characterization of P–G stability categories are discussed in reference 92. When turbulence data are used in this manner to determine the P–G stability category, the averaging time for the turbulence measurements should be 15 minutes.

i. *Stability Categories.* For dispersion models that employ P–G stability categories for the characterization of the vertical and lateral dispersion, the P–G stability categories, as originally defined, couple near-surface measurements of wind speed with subjectively determined insolation assessments based on hourly cloud cover and ceiling height observations. The wind speed measurements are made at or near 10m. The insolation rate is typically assessed using observations of cloud cover and ceiling height based on criteria outlined by Turner.[70] It is recommended that the P–G stability category be estimated using the Turner method with site specific wind speed measured at or near 10m and representative cloud cover and ceiling height. Implementation of the Turner method, as well as considerations in determining representativeness of cloud cover and ceiling height in cases for which site specific cloud observations are unavailable, may be found in Section 6 of reference 92. In the absence of requisite data to implement the Turner method, the SRDT method or wind fluctuation statistics (i.e., the σ_E and σ_A methods) may be used.

j. The SRDT method, described in Section 6.4.4.2 of reference 92, is modified slightly from that published from earlier work[96] and has been evaluated with three site specific data bases.[97] The two methods of stability classification which use wind fluctuation statistics, the σ_E and σ_A methods, are also described in detail in Section 6.4.4 of reference 92 (note applicable tables in Section 6). For additional information on the wind fluctuation methods, several references are available.[98 99 100 101]

k. *Meteorological Data Preprocessors.* The following meteorological preprocessors are recommended by EPA: AERMET,[102] PCRAMMET,[103] MPRM,[104] METPRO,[105] and CALMET[106] AERMET, which is patterned after MPRM, should be used to preprocess all data for use with AERMOD. Except for applications that employ AERMOD, PCRAMMET is the recommended meteorological preprocessor for use in applications employing hourly NWS data. MPRM is a general purpose meteorological data preprocessor which supports regulatory models requiring PCRAMMET formatted (NWS) data. MPRM is available for use in applications employing site specific meteorological data. The latest version (MPRM 1.3) has been configured to implement the SRDT method for estimating P–G stability categories. METPRO is the required meteorological data preprocessor for use with CTDMPLUS. CALMET is available for use with applications of CALPUFF. All of the above mentioned data preprocessors are available for downloading from EPA's Internet SCRAM Web site (subsection 2.3).

TABLE 8–3.—AVERAGING TIMES FOR SITE SPECIFIC WIND AND TURBULENCE MEASUREMENTS

Parameter	Averaging time (hour)
Surface wind speed (for use in stability determinations)	1
Transport direction	1
Dilution wind speed	1
Turbulence measurements (σ_E and σ_A) for use in stability determinations	1[1]
Turbulence measurements for direct input to dispersion models	1

[1] To minimize meander effects in σ_A when wind conditions are light and/or variable, determine the hourly average σ value from four sequential 15-minute σ's according to the following formula:

$$\sigma_{1-hr} = \sqrt{\frac{\sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2}{4}}$$

8.3.4 Treatment of Near-Calms and Calms

8.3.4.1 Discussion

a. Treatment of calm or light and variable wind poses a special problem in model applications since steady-state Gaussian plume models assume that concentration is inversely proportional to wind speed. Furthermore, concentrations may become unrealistically large when wind speeds less than 1 m/s are input to the model. Procedures have been developed to prevent the occurrence of overly conservative concentration estimates during periods of calms. These procedures acknowledge that a steady-state Gaussian plume model does not apply during calm conditions, and that our knowledge of wind patterns and plume behavior during these conditions does not, at present, permit the development of a better technique. Therefore, the procedures disregard hours which are identified as calm. The hour is treated as missing and a convention for handling missing hours is recommended.

b. AERMOD, while fundamentally a steady-state Gaussian plume model, contains algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold. Required input to AERMET, the meteorological processor for AERMOD, includes a threshold wind speed and a reference wind speed. The threshold wind speed is typically the threshold of the instrument used to collect the wind speed data. The reference wind speed is selected by the model as the lowest level of non-missing wind speed and direction data where the speed is greater than the wind speed threshold, and the height of the measurement is between seven times the local surface roughness and 100 meters. If the only valid observation of the reference wind speed between these heights is less than the threshold, the hour is considered calm, and no concentration is calculated. None of the observed wind speeds in a measured wind profile that are less than the threshold speed are used in construction of the modeled wind speed profile in AERMOD.

8.3.4.2 Recommendations

a. Hourly concentrations calculated with steady-state Gaussian plume models using calms should not be considered valid; the wind and concentration estimates for these hours should be disregarded and considered to be missing. Critical concentrations for 3-, 8-, and 24-hour averages should be calculated by dividing the sum of the hourly concentrations for the period by the number of valid or non-missing hours. If the total number of valid hours is less than 18 for 24-hour averages, less than 6 for 8-hour averages or less than 3 for 3-hour averages, the total concentration should be divided by 18 for the 24-hour average, 6 for the 8-hour average and 3 for the 3-hour average. For annual averages, the sum of all valid hourly concentrations is divided by the number of non-calm hours during the year. AERMOD has been coded to implement these instructions. For models listed in Appendix A, a post-processor computer program, CALMPRO [107] has been prepared, is available on the SCRAM Internet Web site (subsection 2.3), and should be used.

b. Stagnant conditions that include extended periods of calms often produce high concentrations over wide areas for relatively long averaging periods. The standard steady-state Gaussian plume models are often not applicable to such situations. When stagnation conditions are of concern, other modeling techniques should be considered on a case-by-case basis (see also subsection 7.2.8).

c. When used in steady-state Gaussian plume models, measured site specific wind speeds of less than 1 m/s but higher than the response threshold of the instrument should be input as 1 m/s; the corresponding wind direction should also be input. Wind observations below the response threshold of the instrument should be set to zero, with the input file in ASCII format. For input to AERMOD, no adjustment should be made to the site specific wind data. In all cases involving steady-state Gaussian plume models, calm hours should be treated as missing, and concentrations should be calculated as in paragraph (a) of this subsection.

9.0 Accuracy and Uncertainty of Models

9.1 Discussion

a. Increasing reliance has been placed on concentration estimates from models as the primary basis for regulatory decisions concerning source permits and emission control requirements. In many situations, such as review of a proposed source, no practical alternative exists. Therefore, there is an obvious need to know how accurate models really are and how any uncertainty in the estimates affects regulatory decisions. During the 1980's, attempts were made to encourage development of standardized evaluation methods.[11 108] EPA recognized the need for incorporating such information and has sponsored workshops [109] on model accuracy, the possible ways to quantify accuracy, and on considerations in the incorporation of model accuracy and uncertainty in the regulatory process. The Second (EPA) Conference on Air Quality Modeling, August 1982 [110], was devoted to that subject.

b. To better deduce the statistical significance of differences seen in model performance in the face of unaccounted for uncertainties and variations, investigators have more recently explored the use of bootstrap techniques.[111 112] Work is underway to develop a new generation of evaluation metrics [16] that takes into account the statistical differences (in error distributions) between model predictions and observations.[113] Even though the procedures and measures are still evolving to describe performance of models that characterize atmospheric fate, transport and diffusion [114 115 116], there has been general acceptance of a need to address the uncertainties inherent in atmospheric processes.

9.1.1 Overview of Model Uncertainty

a. Dispersion models generally attempt to estimate concentrations at specific sites that really represent an ensemble average of numerous repetitions of the same event.[16] The event is characterized by measured or ''known'' conditions that are input to the models, *e.g.,* wind speed, mixed layer height, surface heat flux, emission characteristics, etc. However, in addition to the known conditions, there are unmeasured or unknown variations in the conditions of this event, *e.g.,* unresolved details of the atmospheric flow such as the turbulent velocity field. These unknown conditions, may vary among repetitions of the event. As a result, deviations in observed concentrations from their ensemble average, and from the concentrations estimated by the model, are likely to occur even though the known conditions are fixed. Even with a *perfect model* that predicts the correct ensemble average, there are likely to be deviations from the observed concentrations in individual repetitions of the event, due to variations in the unknown conditions. The statistics of these concentration residuals are termed ''inherent'' uncertainty. Available evidence suggests that this source of uncertainty alone may be responsible for a typical range of variation in concentrations of as much as ±50 percent.[117]

b. Moreover, there is ''reducible'' uncertainty [108] associated with the model and its input conditions; neither models nor data bases are perfect. Reducible uncertainties are caused by: (1) Uncertainties in the input values of the known conditions (*i.e.,* emission characteristics and meteorological data); (2) errors in the measured concentrations which are used to compute the concentration residuals; and (3) inadequate model physics and formulation. The ''reducible'' uncertainties can be minimized through better (more accurate and more representative) measurements and better model physics.

c. To use the terminology correctly, reference to model accuracy should be limited to that portion of reducible uncertainty which deals with the physics and the formulation of the model. The accuracy of the model is normally determined by an evaluation procedure which involves the comparison of model concentration estimates with measured air quality data.[118] The statement of accuracy is based on statistical tests or performance measures such as bias, noise, correlation, etc.[11] However, information that allows a distinction between contributions of the various elements of inherent and reducible uncertainty is only now beginning to emerge.[16] As a result most discussions of the accuracy of models make no quantitative distinction between (1) limitations of the model versus (2) limitations of the data base and of knowledge concerning atmospheric variability. The reader should be aware that statements on model accuracy and uncertainty may imply the need for improvements in model performance that even the ''perfect'' model could not satisfy.

9.1.2 Studies of Model Accuracy

a. A number of studies [119 120] have been conducted to examine model accuracy, particularly with respect to the reliability of short-term concentrations required for ambient standard and increment evaluations. The results of these studies are not surprising. Basically, they confirm what expert atmospheric scientists have said for some time: (1) Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and (2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ± 10 to 40 percent are found to be typical [121 122], *i.e.,* certainly well within the often quoted factor-of-two accuracy that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site, are poorly correlated with actually observed concentrations and are much less reliable.

b. As noted above, poor correlations between paired concentrations at fixed stations may be due to ''reducible'' uncertainties in knowledge of the precise plume location and to unquantified inherent uncertainties. For example, Pasquill [123] estimates that, apart from data input errors, maximum ground-level concentrations at a given hour for a point source in flat terrain could be in error by 50 percent due to these uncertainties. Uncertainty of five to 10 degrees in the measured wind direction, which transports the plume, can result in concentration errors of 20 to 70 percent for a particular time and location, depending on stability and station location. Such uncertainties do not indicate that an estimated concentration does not occur, only that the precise time and locations are in doubt.

9.1.3 Use of Uncertainty in Decision-Making

a. The accuracy of model estimates varies with the model used, the type of application, and site specific characteristics. Thus, it is desirable to quantify the accuracy or uncertainty associated with concentration estimates used in decision-making. Communications between modelers and decision-makers must be fostered and further developed. Communications concerning concentration estimates currently exist in most cases, but the communications dealing with the accuracy of models and its meaning to the decision-maker are limited by the lack of a technical basis for quantifying and directly including uncertainty in decisions. Procedures for quantifying and interpreting uncertainty in the practical application of such concepts are only beginning to evolve; much study is still required.[108 109 110 124 125]

b. In all applications of models an effort is encouraged to identify the reliability of the model estimates for that particular area and to determine the magnitude and sources of error associated with the use of the model. The analyst is responsible for recognizing and quantifying limitations in the accuracy, precision and sensitivity of the procedure. Information that might be useful to the decision-maker in recognizing the seriousness of potential air quality violations includes such model accuracy estimates as accuracy of peak predictions, bias, noise, correlation, frequency distribution, spatial extent of high concentration, etc. Both space/time pairing of estimates and measurements and unpaired comparisons are recommended. Emphasis should be on the highest concentrations and the averaging times of the standards or increments of concern. Where possible, confidence intervals about the statistical values should be provided. However, while such information can be provided by the modeler to the decision-maker, it is unclear how this information should be used to make an air pollution control decision. Given a range of possible outcomes, it is easiest and tends to ensure consistency if the decision-maker confines his judgement to use of the ''best estimate'' provided by the modeler (*i.e.,* the design concentration estimated by a model recommended in the *Guideline* or an alternate model of known accuracy). This is an indication of the practical limitations imposed by current abilities of the technical community.

c. To improve the basis for decision-making, EPA has developed and is continuing to study procedures for determining the accuracy of models, quantifying the uncertainty, and expressing confidence levels in decisions that are made concerning emissions controls.[126 127] However, work in this area involves ''breaking new ground'' with slow and sporadic progress likely. As a result, it may be necessary to continue using the ''best estimate'' until sufficient technical progress has been made to meaningfully implement such concepts dealing with uncertainty.

9.1.4 Evaluation of Models

a. A number of actions have been taken to ensure that the best model is used correctly for each regulatory application and that a model is not arbitrarily imposed. First, the *Guideline* clearly recommends the most appropriate model be used in each case. Preferred models, based on a number of factors, are identified for many uses. General guidance on using alternatives to the preferred models is also provided. Second, the models have been subjected to a systematic performance evaluation and a peer scientific review. Statistical performance measures, including measures of difference (or residuals) such as bias, variance of difference and gross variability of the difference, and measures of correlation such as time, space, and time and space combined as recommended by the AMS Woods Hole Workshop [11], were generally followed. Third, more specific information has been provided for justifying the site specific use of alternative models in previously cited EPA guidance [15], and new models are under consideration and review.[16] Together these documents provide methods that allow a judgement to be made as to what models are most appropriate for a specific application. For the present, performance and the theoretical evaluation of models are being used as an indirect means to quantify one element of uncertainty in air pollution regulatory decisions.

b. EPA has participated in a series of conferences entitled, ''Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes.'' [128] for the purpose of promoting the development of improved methods for the characterization of model performance. There is a consensus developing on what should be considered in the evaluation of air quality models [129], namely quality assurance planning, documentation and scrutiny should be consistent with the intended use, and should include:

- Scientific peer review;
- Supportive analyses (diagnostic evaluations, code verification, sensitivity and uncertainty analyses);
- Diagnostic and performance evaluations with data obtained in trial locations, and
- Statistical performance evaluations in the circumstances of the intended applications.

Performance evaluations and diagnostic evaluations assess different qualities of how well a model is performing, and both are needed to establish credibility within the client and scientific community. Performance evaluations allow us to decide how well the model simulates the average temporal and spatial patterns seen in the observations, and employ large spatial/temporal scale data sets (*e.g.,* national data sets). Performance evaluations also allow determination of relative performance of a model in comparison with alternative modeling systems. Diagnostic evaluations allow determination of a model capability to simulate individual processes that affect the results, and usually employ smaller spatial/temporal scale date sets (*e.g.,* field studies). Diagnostic evaluations allow us to decide if we get the right answer for the right reason. The objective comparison of modeled concentrations with observed field data provides only a partial means for assessing model performance. Due to the limited supply of evaluation data sets, there are severe practical limits in assessing model performance. For this reason, the conclusions reached in the science peer reviews and the supportive analyses have particular relevance in deciding whether a model will be useful for its intended purposes.

c. To extend information from diagnostic and performance evaluations, sensitivity and uncertainty analyses are encouraged since they can provide additional information on the effect of inaccuracies in the data bases and on the uncertainty in model estimates. Sensitivity analyses can aid in determining the effect of inaccuracies of variations or uncertainties in the data bases on the range of likely concentrations. Uncertainty analyses can aid in determining the range of likely concentration values, resulting from uncertainties in the model inputs, the model formulations, and parameterizations. Such information may be used to determine source impact and to evaluate control strategies. Where possible, information from such sensitivity analyses should be made available to the decision-maker with an appropriate interpretation of the effect on the critical concentrations.

9.2 Recommendations

a. No specific guidance on the quantification of model uncertainty for use in decision-making is being given at this time. As procedures for considering uncertainty develop and become implementable, this guidance will be changed and expanded. For the present, continued use of the ''best estimate'' is acceptable; however, in specific circumstances for O_3, PM–2.5 and regional haze, additional information and/or procedures may be appropriate.[32 33]

10.0 Regulatory Application of Models

10.1 Discussion

a. Procedures with respect to the review and analysis of air quality modeling and data analyses in support of SIP revisions, PSD permitting or other regulatory requirements need a certain amount of standardization to ensure consistency in the depth and comprehensiveness of both the review and the analysis itself. This section recommends procedures that permit some degree of standardization while at the same time allowing the flexibility needed to assure the technically best analysis for each regulatory application.

b. Dispersion model estimates, especially with the support of measured air quality data, are the preferred basis for air quality demonstrations. Nevertheless, there are instances where the performance of recommended dispersion modeling techniques, by comparison with observed air quality data, may be shown to be less than acceptable. Also, there may be no recommended modeling procedure suitable for the situation. In these instances, emission limitations may be established solely on the basis of observed air quality data as would be applied to a modeling analysis. The same care should be given to the analyses of the air quality data as would be applied to a modeling analysis.

c. The current NAAQS for SO_2 and CO are both stated in terms of a concentration not to be exceeded more than once a year. There is only an annual standard for NO_2 and a quarterly standard for Pb. Standards for fine particulate matter (PM–2.5) are expressed in terms of both long-term (annual) and short-term (daily) averages. The long-term standard is calculated using the three year average of the annual averages while the short-term standard is calculated using the three year average of the 98th percentile of the daily average concentration. For PM–10, the convention is to compare the arithmetic mean, averaged over 3 consecutive years, with the concentration specified in the NAAQS (50 µg/m^3). The 24-hour NAAQS (150 µg/m^3) is met if, over a 3-year period, there is (on average) no more than one exceedance per year. As noted in subsection 7.2.1.1, the modeled compliance for this NAAQS is based on the highest 6th highest concentration over 5 years. For ozone the short term 1-hour standard is expressed in terms of an expected exceedance limit while the short term 8-hour standard is expressed in terms of a three year average of the annual fourth highest daily maximum 8-hour value. The NAAQS are subjected to extensive review and possible revision every 5 years.

d. This section discusses general requirements for concentration estimates and identifies the relationship to emission limits. The following recommendations apply to: (1) Revisions of State Implementation Plans and (2) the review of new sources and the prevention of significant deterioration (PSD).

10.2 Recommendations

10.2.1 Analysis Requirements

a. Every effort should be made by the Regional Office to meet with all parties involved in either a SIP revision or a PSD permit application prior to the start of any work on such a project. During this meeting, a protocol should be established between the preparing and reviewing parties to define the procedures to be followed, the data to be collected, the model to be used, and the analysis of the source and concentration data. An example of requirements for such an effort is contained in the Air Quality Analysis Checklist posted on EPA's Internet SCRAM Web site (subsection 2.3). This checklist suggests the level of detail required to assess the air quality resulting from the proposed action. Special cases may require additional data collection or analysis and this should be determined and agreed upon at this preapplication meeting. The protocol should be written and agreed upon by the parties concerned, although a formal legal document is not intended. Changes in such a protocol are often required as the data collection and analysis progresses. However, the protocol establishes a common understanding of the requirements.

b. An air quality analysis should begin with a screening model to determine the potential of the proposed source or control strategy to violate the PSD increment or NAAQS. For traditional stationary sources, EPA guidance [24] should be followed. Guidance is also available for mobile sources.[48]

c. If the concentration estimates from screening techniques indicate a significant impact or that the PSD increment or NAAQS may be approached or exceeded, then a more refined modeling analysis is appropriate and the model user should select a model according to recommendations in Sections 4–8. In some instances, no refined technique may be specified in this guide for the situation. The model user is then encouraged to submit a model developed specifically for the case at hand. If that is not possible, a screening technique may supply the needed results.

d. Regional Offices should require permit applicants to incorporate the pollutant contributions of all sources into their analysis. Where necessary this may include emissions associated with growth in the area of impact of the new or modified source. PSD air quality assessments should consider the amount of the allowable air quality increment that has already been consumed by other sources. Therefore, the most recent source applicant should model the existing or permitted sources in addition to the one currently under consideration. This would permit the use of newly acquired data or improved modeling techniques if such have become available since the last source was permitted. When remodeling, the worst case used in the previous modeling analysis should be one set of conditions modeled in the new analysis. All sources should be modeled for each set of meteorological conditions selected.

10.2.2 Use of Measured Data in Lieu of Model Estimates

a. Modeling is the preferred method for determining emission limitations for both new and existing sources. When a preferred model is available, model results alone (including background) are sufficient. Monitoring will normally not be accepted as the sole basis for emission limitation. In some instances when the modeling technique available is only a screening technique, the addition of air quality data to the analysis may lend credence to model results.

b. There are circumstances where there is no applicable model, and measured data may need to be used. However, only in the case of a NAAQS assessment for an existing source should monitoring data alone be a basis for emission limits. In addition, the following items (i–vi) should be considered prior to the acceptance of the measured data:

i. Does a monitoring network exist for the pollutants and averaging times of concern?

ii. Has the monitoring network been designed to locate points of maximum concentration?

iii. Do the monitoring network and the data reduction and storage procedures meet EPA monitoring and quality assurance requirements?

iv. Do the data set and the analysis allow impact of the most important individual sources to be identified if more than one source or emission point is involved?

v. Is at least one full year of valid ambient data available?

vi. Can it be demonstrated through the comparison of monitored data with model results that available models are not applicable?

c. The number of monitors required is a function of the problem being considered. The source configuration, terrain configuration, and meteorological variations all have an impact on number and placement of monitors. Decisions can only be made on a case-by-case basis. Guidance is available for establishing criteria for demonstrating that a model is not applicable?

d. Sources should obtain approval from the appropriate reviewing authority (paragraph 3.0(b)) for the monitoring network prior to the start of monitoring. A monitoring protocol agreed to by all concerned parties is highly desirable. The design of the network, the number, type and location of the monitors, the sampling period, averaging time as well as the need for meteorological monitoring or the use of mobile sampling or plume tracking techniques, should all be specified in the protocol and agreed upon prior to start-up of the network.

10.2.3 Emission Limits

10.2.3.1 Design Concentrations

a. Emission limits should be based on concentration estimates for the averaging time that results in the most stringent control requirements. The concentration used in specifying emission limits is called the design value or design concentration and is a sum of the concentration contributed by the primary source, other applicable sources, and—for NAAQS assessments—the background concentration.

b. To determine the averaging time for the design value, the most restrictive NAAQS or PSD increment, as applicable, should be identified. For a NAAQS assessment, the averaging time for the design value is determined by calculating, for each averaging time, the ratio of the difference between the applicable NAAQS (S) and the background concentration (B) to the (model) predicted concentration (P) (*i.e.*, (S–B)/P). For a PSD increment assessment, the averaging time for the design value is determined by calculating, for each averaging time, the ratio of the applicable PSD increment (I) and the model-predicted concentration (P) (*i.e.*, I/P). The averaging time with the lowest ratio identifies the most restrictive standard or increment. If the annual average is the most restrictive, the highest estimated annual average concentration from one or a number of years of data is the design value. When short term standards are most restrictive, it may be necessary to consider a broader range of concentrations than the highest value. For example, for pollutants such as SO_2, the highest, second-highest concentration is the design value. For pollutants with statistically based NAAQS, the design value is found by determining the more restrictive of: (1) The short-term concentration over the period specified in the standard, or (2) the long-term concentration that is not expected to exceed the long-term NAAQS. Determination of design values for PM–10 is presented in more detail in EPA guidance.[34]

10.2.3.2 NAAQS Analyses for New or Modified Sources

a. For new or modified sources predicted to have a significant ambient impact [83] and to be located in areas designated attainment or unclassifiable for the SO_2, Pb, NO_2, or CO NAAQS, the demonstration as to whether the source will cause or contribute to an air quality violation should be based on: (1) The highest estimated annual average concentration determined from annual averages of individual years; or (2) the highest, second-highest estimated concentration for averaging times of 24-hours or less; and (3) the significance of the spatial and temporal contribution to any modeled violation. For Pb, the highest estimated concentration based on an individual calendar quarter averaging period should be used. Background concentrations should be added to the estimated impact of the source. The most restrictive standard should be used in all cases to assess the threat of an air quality violation. For new or modified sources predicted to have a significant ambient impact [83] in areas designated attainment or unclassifiable for the PM–10 NAAQS, the demonstration of whether or not the source will cause or contribute to an air quality violation should be based on sufficient data to show whether: (1) The projected 24-hour average concentrations will exceed the 24-hour NAAQS more than once per year, on average; (2) the expected (i.e., average) annual mean concentration will exceed the annual NAAQS; and (3) the source contributes significantly, in a temporal and spatial sense, to any modeled violation.

10.2.3.3 PSD Air Quality Increments and Impacts

a. The allowable PSD increments for criteria pollutants are established by regulation and cited in 40 CFR 51.166. These maximum allowable increases in pollutant concentrations may be exceeded once per year at each site, except for the annual increment that may not be exceeded. The highest, second-highest increase in estimated concentrations for the short term averages as determined by a model should be less than or equal to the permitted increment. The modeled annual averages should not exceed the increment.

b. Screening techniques defined in subsection 4.2.1 can sometimes be used to estimate short term incremental concentrations for the first new source that triggers the baseline in a given area. However, when multiple increment-consuming sources are involved in the calculation, the use of a refined model with at least 1 year of site specific or 5 years of (off-site) NWS data is normally required (subsection 8.3.1.2). In such cases, sequential modeling must demonstrate that the allowable increments are not exceeded temporally and spatially, *i.e.*, for all receptors for each time period throughout the year(s) (time period means the appropriate PSD averaging time, *e.g.*, 3-hour, 24-hour, *etc.*).

c. The PSD regulations require an estimation of the SO_2, particulate matter (PM–10), and NO_2 impact on any Class I area. Normally, steady-state Gaussian plume models should not be applied at distances greater than can be accommodated by the steady state assumptions inherent in such models. The maximum distance for refined steady-state Gaussian plume model application for regulatory purposes is generally considered to be 50km. Beyond the 50km range, screening techniques may be used to determine if more refined modeling is needed. If refined models are needed, long range transport models should be considered in accordance with subsection 6.2.3. As previously noted in Sections 3 and 7, the need to involve the Federal Land Manager in decisions on potential air quality impacts, particularly in relation to PSD Class I areas, cannot be overemphasized.

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APPENDIX A TO APPENDIX W OF PART 51—SUMMARIES OF PREFERRED AIR QUALITY MODELS

Table of Contents

A.0 Introduction and Availability

(1) This appendix summarizes key features of refined air quality models preferred for specific regulatory applications. For each model, information is provided on availability, approximate cost (where applicable), regulatory use, data input, output format and options, simulation of atmospheric physics, and accuracy. These models may be used without a formal demonstration of applicability provided they satisfy the recommendations for regulatory use; not all options in the models are necessarily recommended for regulatory use.

(2) Many of these models have been subjected to a performance evaluation using comparisons with observed air quality data. Where possible, several of the models contained herein have been subjected to evaluation exercises, including (1) statistical performance tests recommended by the American Meteorological Society and (2) peer scientific reviews. The models in this appendix have been selected on the basis of the results of the model evaluations, experience with previous use, familiarity of the model to various air quality programs, and the costs and resource requirements for use.

(3) Codes and documentation for all models listed in this appendix are available from EPA's Support Center for Regulatory Air Models (SCRAM) Web site at *http://www.epa.gov/scram001*. Documentation is also available from the National Technical Information Service (NTIS), *http://www.ntis.gov* or U.S. Department of Commerce, Springfield, VA 22161; phone: (800) 553–6847. Where possible, accession numbers are provided.

A.1 AMS/EPA Regulatory Model—AERMOD

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Availability

The model codes and associated documentation are available on EPA's Internet SCRAM Web site (Section A.0).

Abstract

AERMOD is a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources. AERMOD simulates transport and dispersion from multiple point, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer. Sources may be located in rural or urban areas, and receptors may be located in simple or complex terrain. AERMOD accounts for building wake effects (i.e., plume downwash) based on the PRIME building downwash algorithms. The model employs hourly sequential preprocessed meteorological data to estimate concentrations for averaging times from one hour to one year (also multiple years). AERMOD is designed to operate in concert with two pre-processor codes: AERMET processes meteorological data for input to AERMOD, and AERMAP processes terrain elevation data and generates receptor information for input to AERMOD.

a. Recommendations for Regulatory Use

(1) AERMOD is appropriate for the following applications:

• Point, volume, and area sources;
• Surface, near-surface, and elevated releases;
• Rural or urban areas;
• Simple and complex terrain;
• Transport distances over which steady-state assumptions are appropriate, up to 50km;
• 1-hour to annual averaging times; and
• Continuous toxic air emissions.

(2) For regulatory applications of AERMOD, the regulatory default option should be set, i.e., the parameter DFAULT should be employed in the MODELOPT record in the COntrol Pathway. The DFAULT option requires the use of terrain elevation data, stack-tip downwash, sequential date checking, and does not permit the use of the model in the SCREEN mode. In the regulatory default mode, pollutant half life or

decay options are not employed, except in the case of an urban source of sulfur dioxide where a four-hour half life is applied. Terrain elevation data from the U.S. Geological Survey 7.5-Minute Digital Elevation Model (*edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html*) or equivalent (approx. 30-meter resolution) should be used in all applications. In some cases, exceptions of the terrain data requirement may be made in consultation with the permit/SIP reviewing authority.

b. Input Requirements

(1) Source data: Required input includes source type, location, emission rate, stack height, stack inside diameter, stack gas exit velocity, stack gas temperature, area and volume source dimensions, and source elevation. Building dimensions and variable emission rates are optional.

(2) Meteorological data: The AERMET meteorological preprocessor requires input of surface characteristics, including surface roughness (zo), Bowen ratio, and albedo, as well as, hourly observations of wind speed between 7zo and 100m (reference wind speed measurement from which a vertical profile can be developed), wind direction, cloud cover, and temperature between zo and 100m (reference temperature measurement from which a vertical profile can be developed). Surface characteristics may be varied by wind sector and by season or month. A morning sounding (in National Weather Service format) from a representative upper air station, latitude, longitude, time zone, and wind speed threshold are also required in AERMET (instrument threshold is only required for site specific data). Additionally, measured profiles of wind, temperature, vertical and lateral turbulence may be required in certain applications (e.g., in complex terrain) to adequately represent the meteorology affecting plume transport and dispersion. Optionally, measurements of solar, or net radiation may be input to AERMET. Two files are produced by the AERMET meteorological preprocessor for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables, one record per hour. The profile file contains the observations made at each level of a meteorological tower (or remote sensor), or the one-level observations taken from other representative data (e.g., National Weather Service surface observations), one record per level per hour.

(i) Data used as input to AERMET should possess an adequate degree of representativeness to insure that the wind, temperature and turbulence profiles derived by AERMOD are both laterally and vertically representative of the source area. The adequacy of input data should be judged independently for each variable. The values for surface roughness, Bowen ratio, and albedo should reflect the surface characteristics in the vicinity of the meteorological tower, and should be adequately representative of the modeling domain. Finally, the primary atmospheric input variables including wind speed and direction, ambient temperature, cloud cover, and a morning upper air sounding should also be adequately representative of the source area.

(ii) For recommendations regarding the length of meteorological record needed to perform a regulatory analysis with AERMOD, see Section 8.3.1.

(3) Receptor data: Receptor coordinates, elevations, height above ground, and hill height scales are produced by the AERMAP terrain preprocessor for input to AERMOD. Discrete receptors and/or multiple receptor grids, Cartesian and/or polar, may be employed in AERMOD. AERMAP requires input of Digital Elevation Model (DEM) terrain data produced by the U.S. Geological Survey (USGS), or other equivalent data. AERMAP can be used optionally to estimate source elevations.

c. Output

Printed output options include input information, high concentration summary tables by receptor for user-specified averaging periods, maximum concentration summary tables, and concurrent values summarized by receptor for each day processed. Optional output files can be generated for: a listing of occurrences of exceedances of user-specified threshold value; a listing of concurrent (raw) results at each receptor for each hour modeled, suitable for post-processing; a listing of design values that can be imported into graphics software for plotting contours; an unformatted listing of raw results above a threshold value with a special structure for use with the TOXX model component of TOXST; a listing of concentrations by rank (e.g., for use in quantile-quantile plots); and, a listing of concentrations, including arc-maximum normalized concentrations, suitable for model evaluation studies.

d. Type of Model

AERMOD is a steady-state plume model, using Gaussian distributions in the vertical and horizontal for stable conditions, and in the horizontal for convective conditions. The vertical concentration distribution for convective conditions results from an assumed bi-Gaussian probability density function of the vertical velocity.

e. Pollutant Types

AERMOD is applicable to primary pollutants and continuous releases of toxic and hazardous waste pollutants. Chemical transformation is treated by simple exponential decay.

f. Source-Receptor Relationships

AERMOD applies user-specified locations for sources and receptors. Actual separation between each source-receptor pair is used. Source and receptor elevations are user input or are determined by AERMAP using USGS DEM terrain data. Receptors may be located at user-specified heights above ground level.

g. Plume Behavior

(1) In the convective boundary layer (CBL), the transport and dispersion of a plume is characterized as the superposition of three modeled plumes: The direct plume (from the stack), the indirect plume, and the penetrated plume, where the indirect plume accounts for the lofting of a buoyant plume near the top of the boundary layer, and the penetrated plume accounts for the portion of a plume that, due to its buoyancy, penetrates above the mixed layer, but can disperse downward and re-enter the mixed layer. In the CBL, plume rise is superposed on the displacements by random convective velocities (Weil *et al.*, 1997).

(2) In the stable boundary layer, plume rise is estimated using an iterative approach, similar to that in the CTDMPLUS model (see A.5 in this appendix).

(3) Stack-tip downwash and buoyancy induced dispersion effects are modeled. Building wake effects are simulated for stacks less than good engineering practice height using the methods contained in the PRIME downwash algorithms (Schulman, *et al.*, 2000). For plume rise affected by the presence of a building, the PRIME downwash algorithm uses a numerical solution of the mass, energy and momentum conservation laws (Zhang and Ghoniem, 1993). Streamline deflection and the position of the stack relative to the building affect plume trajectory and dispersion. Enhanced dispersion is based on the approach of Weil (1996). Plume mass captured by the cavity is well-mixed within the cavity. The captured plume mass is re-emitted to the far wake as a volume source.

(4) For elevated terrain, AERMOD incorporates the concept of the critical dividing streamline height, in which flow below this height remains horizontal, and flow above this height tends to rise up and over terrain (Snyder *et al.*, 1985). Plume concentration estimates are the weighted sum of these two limiting plume states. However, consistent with the steady-state assumption of uniform horizontal wind direction over the modeling domain, straight-line plume trajectories are assumed, with adjustment in the plume/receptor geometry used to account for the terrain effects.

h. Horizontal Winds

Vertical profiles of wind are calculated for each hour based on measurements and surface-layer similarity (scaling) relationships. At a given height above ground, for a given hour, winds are assumed constant over the modeling domain. The effect of the vertical variation in horizontal wind speed on dispersion is accounted for through simple averaging over the plume depth.

i. Vertical Wind Speed

In convective conditions, the effects of random vertical updraft and downdraft velocities are simulated with a bi-Gaussian probability density function. In both convective and stable conditions, the mean vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Gaussian horizontal dispersion coefficients are estimated as continuous functions of the parameterized (or measured) ambient lateral turbulence and also account for buoyancy-induced and building wake-induced turbulence. Vertical profiles of lateral turbulence are developed from measurements and similarity (scaling) relationships. Effective turbulence values are determined from the portion of the vertical profile of lateral turbulence between the plume height and the receptor height. The effective lateral turbulence is then used to estimate horizontal dispersion.

k. Vertical Dispersion

In the stable boundary layer, Gaussian vertical dispersion coefficients are estimated as continuous functions of parameterized vertical turbulence. In the convective boundary layer, vertical dispersion is characterized by a bi-Gaussian probability density function, and is also estimated as a continuous function of parameterized vertical turbulence. Vertical turbulence profiles are developed from measurements and similarity (scaling) relationships. These turbulence profiles account for both convective and mechanical turbulence. Effective turbulence values are determined from the portion of the vertical profile of vertical turbulence between the plume height and the receptor height. The effective vertical turbulence is then used to estimate vertical dispersion.

l. Chemical Transformation

Chemical transformations are generally not treated by AERMOD. However, AERMOD does contain an option to treat chemical transformation using simple exponential decay, although this option is typically not used in regulatory applications, except for sources of sulfur dioxide in urban areas. Either a decay coefficient or a half life is input by the user. Note also that the Plume Volume Molar Ratio Method (subsection 5.1) and the Ozone Limiting Method (subsection 5.2.4) and for point-source NO_2 analyses are available as non-regulatory options.

m. Physical Removal

AERMOD can be used to treat dry and wet deposition for both gases and particles.

n. Evaluation Studies

American Petroleum Institute, 1998. Evaluation of State of the Science of Air Quality Dispersion Model, Scientific Evaluation, prepared by Woodward-Clyde Consultants, Lexington, Massachusetts, for American Petroleum Institute, Washington, D.C., 20005–4070.

Brode, R.W., 2002. Implementation and Evaluation of PRIME in AERMOD. Preprints of the 12th Joint Conference on Applications of Air Pollution Meteorology, May 20–24, 2002; American Meteorological Society, Boston, MA.

Brode, R.W., 2004. Implementation and Evaluation of Bulk Richardson Number Scheme in AERMOD. 13th Joint Conference on Applications of Air Pollution Meteorology, August 23–26, 2004; American Meteorological Society, Boston, MA.

Environmental Protection Agency, 2003. AERMOD: Latest Features and Evaluation Results. Publication No. EPA–454/R–03–003. U.S. Environmental Protection Agency, Research Triangle Park, NC. Available at *http://www.epa.gov/scram001/.*

A.2 Buoyant Line and Point Source Dispersion Model (BLP)

Reference

Schulman, Lloyd L., and Joseph S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide. Document P–7304B. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 81–164642; also available at *http://www.epa.gov/scram001/*)

Availability

The computer code is available on EPA's Internet SCRAM Web site and also on diskette (as PB 2002–500051) from the National Technical Information Service (see Section A.0).

Abstract

BLP is a Gaussian plume dispersion model designed to handle unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary line sources are important.

a. Recommendations for Regulatory Use

(1) The BLP model is appropriate for the following applications:

- Aluminum reduction plants which contain buoyant, elevated line sources;
- Rural areas;
- Transport distances less than 50 kilometers;
- Simple terrain; and
- One hour to one year averaging times.

(2) The following options should be selected for regulatory applications:

(i) Rural (IRU=1) mixing height option;

(ii) Default (no selection) for plume rise wind shear (LSHEAR), transitional point source plume rise (LTRANS), vertical potential temperature gradient (DTHTA), vertical wind speed power law profile exponents (PEXP), maximum variation in number of stability classes per hour (IDELS), pollutant decay (DECFAC), the constant in Briggs' stable plume rise equation (CONST2), constant in Briggs' neutral plume rise equation (CONST3), convergence criterion for the line source calculations (CRIT), and maximum iterations allowed for line source calculations (MAXIT); and

(iii) Terrain option (TERAN) set equal to 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

(3) For other applications, BLP can be used if it can be demonstrated to give the same estimates as a recommended model for the same application, and will subsequently be executed in that mode.

(4) BLP can be used on a case-by-case basis with specific options not available in a recommended model if it can be demonstrated, using the criteria in Section 3.2, that the model is more appropriate for a specific application.

b. Input Requirements

(1) Source data: point sources require stack location, elevation of stack base, physical stack height, stack inside diameter, stack gas exit velocity, stack gas exit temperature, and pollutant emission rate. Line sources require coordinates of the end points of the line, release height, emission rate, average line source width, average building width, average spacing between buildings, and average line source buoyancy parameter.

(2) Meteorological data: surface weather data from a preprocessor such as PCRAMMET which provides hourly stability class, wind direction, wind speed, temperature, and mixing height.

(3) Receptor data: locations and elevations of receptors, or location and size of receptor grid or request automatically generated receptor grid.

c. Output

(1) Printed output (from a separate post-processor program) includes:

(2) Total concentration or, optionally, source contribution analysis; monthly and annual frequency distributions for 1-, 3-, and 24-hour average concentrations; tables of 1-, 3-, and 24-hour average concentrations at each receptor; table of the annual (or length of run) average concentrations at each receptor;

(3) Five highest 1-, 3-, and 24-hour average concentrations at each receptor; and

(4) Fifty highest 1-, 3-, and 24-hour concentrations over the receptor field.

d. Type of Model

BLP is a gaussian plume model.

e. Pollutant Types

BLP may be used to model primary pollutants. This model does not treat settling and deposition.

f. Source-Receptor Relationship

(1) BLP treats up to 50 point sources, 10 parallel line sources, and 100 receptors arbitrarily located.

(2) User-input topographic elevation is applied for each stack and each receptor.

g. Plume Behavior

(1) BLP uses plume rise formulas of Schulman and Scire (1980).

(2) Vertical potential temperature gradients of 0.02 Kelvin per meter for E stability and 0.035 Kelvin per meter are used for stable plume rise calculations. An option for user input values is included.

(3) Transitional rise is used for line sources.

(4) Option to suppress the use of transitional plume rise for point sources is included.

(5) The building downwash algorithm of Schulman and Scire (1980) is used.

h. Horizontal Winds

(1) Constant, uniform (steady-state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

(2) Wind speeds profile exponents of 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 are used for stability classes A through F, respectively. An option for user-defined values and an option to suppress the use of the wind speed profile feature are included.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

(1) Rural dispersion coefficients are from Turner (1969), with no adjustment made for variations in surface roughness or averaging time.

(2) Six stability classes are used.

k. Vertical Dispersion

(1) Rural dispersion coefficients are from Turner (1969), with no adjustment made for variations in surface roughness.

(2) Six stability classes are used.

(3) Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the

mixing height; uniform mixing is assumed beyond that point.

(4) Perfect reflection at the ground is assumed.

l. Chemical Transformation

Chemical transformations are treated using linear decay. Decay rate is input by the user.

m. Physical Removal

Physical removal is not explicitly treated.

n. Evaluation Studies

Schulman, L.L. and J.S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide, P–7304B. Environmental Research and Technology, Inc., Concord, MA.

Scire, J.S. and L.L. Schulman, 1981. Evaluation of the BLP and ISC Models with SF_6 Tracer Data and SO_2 Measurements at Aluminum Reduction Plants. APCA Specialty Conference on Dispersion Modeling for Complex Sources, St. Louis, MO.

A.3 CALINE3

Reference

Benson, Paul E., 1979. CALINE3—A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets. Interim Report, Report Number FHWA/CA/TL–79/23. Federal Highway Administration, Washington, DC (NTIS No. PB 80–220841).

Availability

The CALINE3 model is available on diskette (as PB 95–502712) from NTIS. The source code and user's guide are also available on EPA's Internet SCRAM Web site (Section A.0).

Abstract

CALINE3 can be used to estimate the concentrations of nonreactive pollutants from highway traffic. This steady-state Gaussian model can be applied to determine air pollution concentrations at receptor locations downwind of ''at-grade,'' ''fill,'' ''bridge,'' and ''cut section'' highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation, and receptor location. The model has adjustments for averaging time and surface roughness, and can handle up to 20 links and 20 receptors. It also contains an algorithm for deposition and settling velocity so that particulate concentrations can be predicted.

a. Recommendations for Regulatory Use

CALINE–3 is appropriate for the following applications:

- Highway (line) sources;
- Urban or rural areas;
- Simple terrain;
- Transport distances less than 50 kilometers; and
- One-hour to 24-hour averaging times.

b. Input Requirements

(1) Source data: up to 20 highway links classed as ''at-grade,'' ''fill,'' ''bridge,'' or ''depressed''; coordinates of link end points; traffic volume; emission factor; source height; and mixing zone width.

(2) Meteorological data: wind speed, wind angle (measured in degrees clockwise from the Y axis), stability class, mixing height, ambient (background to the highway) concentration of pollutant.

(3) Receptor data: coordinates and height above ground for each receptor.

c. Output

Printed output includes concentration at each receptor for the specified meteorological condition.

d. Type of Model

CALINE–3 is a Gaussian plume model.

e. Pollutant Types

CALINE–3 may be used to model primary pollutants.

f. Source-Receptor Relationship

(1) Up to 20 highway links are treated.

(2) CALINE–3 applies user input location and emission rate for each link. User-input receptor locations are applied.

g. Plume Behavior

Plume rise is not treated.

h. Horizontal Winds

(1) User-input hourly wind speed and direction are applied.

(2) Constant, uniform (steady-state) wind is assumed for an hour.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

(1) Six stability classes are used.

(2) Rural dispersion coefficients from Turner (1969) are used, with adjustment for roughness length and averaging time.

(3) Initial traffic-induced dispersion is handled implicitly by plume size parameters.

k. Vertical Dispersion

(1) Six stability classes are used.

(2) Empirical dispersion coefficients from Benson (1979) are used including an adjustment for roughness length.

(3) Initial traffic-induced dispersion is handled implicitly by plume size parameters.

(4) Adjustment for averaging time is included.

l. Chemical Transformation

Not treated.

m. Physical Removal

Optional deposition calculations are included.

n. Evaluation Studies

Bemis, G.R. *et al.*, 1977. Air Pollution and Roadway Location, Design, and Operation—Project Overview. FHWA–CA–TL–7080–77–25, Federal Highway Administration, Washington, DC.

Cadle, S.H. *et al.*, 1976. Results of the General Motors Sulfate Dispersion Experiment, GMR–2107. General Motors Research Laboratories, Warren, MI.

Dabberdt, W.F., 1975. Studies of Air Quality on and Near Highways, Project 2761. Stanford Research Institute, Menlo Park, CA.

Environmental Protection Agency, 1986. Evaluation of Mobile Source Air Quality Simulation Models. EPA Publication No. EPA–450/4–86–002. Office of Air Quality Planning & Standards, Research Triangle Park, NC. (NTIS No. PB 86–167293)

A.4 CALPUFF

References

Scire, J.S., D.G. Strimaitis and R.J. Yamartino, 2000. A User's Guide for the CALPUFF Dispersion Model (Version 5.0). Earth Tech, Inc., Concord, MA.

Scire J.S., F.R. Robe, M.E. Fernau and R.J. Yamartino, 2000. A User's Guide for the CALMET Meteorological Model (Version 5.0). Earth Tech, Inc., Concord, MA.

Availability

The model code and its documentation are available at no cost for download from the model developers' Internet Web site: *http://www.src.com/calpuff/calpuff1.htm.* You may also contact Joseph Scire, Earth Tech, Inc., 196 Baker Avenue, Concord, MA 01742; Telephone: (978) 371–4270; Fax: (978) 371–2468; e-mail: *JScire@alum.mit.edu.*

Abstract

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion modeling system that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. CALPUFF is intended for use on scales from tens of meters from a source to hundreds of kilometers. It includes algorithms for near-field effects such as stack tip downwash, building downwash, transitional buoyant and momentum plume rise, rain cap effects, partial plume penetration, subgrid scale terrain and coastal interactions effects, and terrain impingement as well as longer range effects such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, vertical wind shear effects, overwater transport, plume fumigation, and visibility effects of particulate matter concentrations.

a. Recommendations for Regulatory Use

(1) CALPUFF is appropriate for long range transport (source-receptor distances of 50 to several hundred kilometers) of emissions from point, volume, area, and line sources. The meteorological input data should be fully characterized with time-and-space-varying three dimensional wind and meteorological conditions using CALMET, as discussed in paragraphs 8.3(d) and 8.3.1.2(d) of Appendix W.

(2) CALPUFF may also be used on a case-by-case basis if it can be demonstrated using the criteria in Section 3.2 that the model is more appropriate for the specific application. The purpose of choosing a modeling system like CALPUFF is to fully treat stagnation, wind reversals, and time and space variations of meteorological conditions on transport and dispersion, as discussed in paragraph 7.2.8(a).

(3) For regulatory applications of CALMET and CALPUFF, the regulatory default option should be used. Inevitably, some of the model control options will have to be set specific for the application using expert judgment and in consultation with the appropriate reviewing authorities.

b. Input Requirements

Source Data:

1. Point sources: Source location, stack height, diameter, exit velocity, exit temperature, base elevation, wind direction specific building dimensions (for building downwash calculations), and emission rates for each pollutant. Particle size distributions may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying point source parameters may be entered from an external file.

2. Area sources: Source location and shape, release height, base elevation, initial vertical distribution (σ_z) and emission rates for each pollutant. Particle size distributions may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying area source parameters may be entered from an external file. Area sources specified in the external file are allowed to be buoyant and their location, size, shape, and other source characteristics are allowed to change in time.

3. Volume sources: Source location, release height, base elevation, initial horizontal and vertical distributions (σ_y, σ_z) and emission rates for each pollutant. Particle size distributions may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying volume source parameters may be entered from an external file. Volume sources with buoyancy can be simulated by treating the source as a point source and entering initial plume size parameters—initial (σ_y, σ_z)—to define the initial size of the volume source.

4. Line sources: Source location, release height, base elevation, average buoyancy parameter, and emission rates for each pollutant. Building data may be entered for line source emissions experiencing building downwash effects. Particle size distributions may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying line source parameters may be entered from an external file.

Meteorological Data (different forms of meteorological input can be used by CALPUFF):

1. Time-dependent three-dimensional (3–D) meteorological fields generated by CALMET. This is the preferred mode for running CALPUFF. Data inputs used by CALMET include surface observations of wind speed, wind direction, temperature, cloud cover, ceiling height, relative humidity, surface pressure, and precipitation (type and amount), and upper air sounding data (wind speed, wind direction, temperature, and height) and air-sea temperature differences (over water). Optional 3–D meteorological prognostic model output (e.g., from models such as MM5, RUC, Eta and RAMS) can be used by CALMET as well (paragraph 8.3.1.2(d)). CALMET contains an option to be run in ''No-observations'' mode (Robe et al., 2002), which allows the 3–D CALMET meteorological fields to be based on prognostic model output alone, without observations. This allows CALMET and CALPUFF to be run in prognostic mode for forecast applications.

2. Single station surface and upper air meteorological data in CTDMPLUS data file formats (SURFACE.DAT and PROFILE.DAT files) or AERMOD data file formats. These options allow a vertical variation in the meteorological parameters but no horizontal spatial variability.

3. Single station meteorological data in ISCST3 data file format. This option does not account for variability of the meteorological parameters in the horizontal or vertical, except as provided for by the use of stability-dependent wind shear exponents and average temperature lapse rates.

Gridded terrain and land use data are required as input into CALMET when Option 1 is used. Geophysical processor programs are provided that interface the modeling system to standard terrain and land use data bases available from various sources such as the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA).

Receptor Data:

CALPUFF includes options for gridded and non-gridded (discrete) receptors. Special subgrid-scale receptors are used with the subgrid-scale complex terrain option. An option is provided for discrete receptors to be placed at ground-level or above the local ground level (i.e., flagpole receptors). Gridded and subgrid-scale receptors are placed at the local ground level only.

Other Input:

CALPUFF accepts hourly observations of ozone concentrations for use in its chemical transformation algorithm. Monthly concentrations of ammonia concentrations can be specified in the CALPUFF input file, although higher time-resolution ammonia variability can be computed using the POSTUTIL program. Subgrid-scale coastlines can be specified in its coastal boundary file. Optional, user-specified deposition velocities and chemical transformation rates can also be entered. CALPUFF accepts the CTDMPLUS terrain and receptor files for use in its subgrid-scale terrain algorithm. Inflow boundary conditions of modeled pollutants can be specified in a boundary condition file. Liquid water content variables including cloud water/ice and precipitation water/ice can be used as input for visibility analyses and other CALPUFF modules.

c. Output

CALPUFF produces files of hourly concentrations of ambient concentrations for each modeled species, wet deposition fluxes, dry deposition fluxes, and for visibility applications, extinction coefficients. Postprocessing programs (PRTMET, CALPOST, CALSUM, APPEND, and POSTUTIL) provide options for summing, scaling, analyzing and displaying the modeling results. CALPOST contains options for computing of light extinction (visibility) and POSTUTIL allows the re-partitioning of nitric acid and nitrate to account for the effects of ammonia limitation (Scire *et al.*, 2001; Escoffier-Czaja and Scire, 2002). CALPUFF contains an options to output liquid water concentrations for use in computing visible plume lengths and frequency of icing and fogging from cooling towers and other water vapor sources. The CALPRO Graphical User Interface (GUI) contains options for creating graphics such as contour plots, vector plots and other displays when linked to graphics software.

d. Type of Model

(1) CALPUFF is a non-steady-state time- and space-dependent Gaussian puff model. CALPUFF treats primary pollutants and simulates secondary pollutant formation using a parameterized, quasi-linear chemical conversion mechanism. Pollutants treated include SO_2, $SO_4^=$, NO_X (i.e., NO + NO_2), HNO_3, NO_3^-, NH_3, PM–10, PM–2.5, toxic pollutants and others pollutant species that are either inert or subject to quasi-linear chemical reactions. The model includes a resistance-based dry deposition model for both gaseous pollutants and particulate matter. Wet deposition is treated using a scavenging coefficient approach. The model has detailed parameterizations of complex terrain effects, including terrain impingement, side-wall scrapping, and steep-walled terrain influences on lateral plume growth. A subgrid-scale complex terrain module based on a dividing streamline concept divides the flow into a lift component traveling over the obstacle and a wrap component deflected around the obstacle.

(2) The meteorological fields used by CALPUFF are produced by the CALMET meteorological model. CALMET includes a diagnostic wind field model containing parameterized treatments of slope flows, valley flows, terrain blocking effects, and kinematic terrain effects, lake and sea breeze circulations, a divergence minimization procedure, and objective analysis of observational data. An energy-balance scheme is used to compute sensible and latent heat fluxes and turbulence parameters over land surfaces. A profile method is used over water. CALMET contains interfaces to prognostic meteorological models such as the Penn State/NCAR Mesoscale Model (e.g., MM5; Section 12.0, ref. 86), as well as the RAMS, Ruc and Eta models.

e. Pollutant Types

CALPUFF may be used to model gaseous pollutants or particulate matter that are inert or which undergo quasi-linear chemical reactions, such as SO_2, SO_4 =, NO_X (*i.e.*, NO + NO_2), HNO_3, NO_3-, NH_3, PM–10, PM–2.5 and toxic pollutants. For regional haze analyses, sulfate and nitrate particulate components are explicitly treated.

f. Source-Receptor Relationships

CALPUFF contains no fundamental limitations on the number of sources or receptors. Parameter files are provided that allow the user to specify the maximum number of sources, receptors, puffs, species, grid cells, vertical layers, and other model parameters. Its algorithms are designed to be suitable for source-receptor distances from tens of meters to hundreds of kilometers.

g. Plume Behavior

Momentum and buoyant plume rise is treated according to the plume rise equations of Briggs (1975) for non-downwashing point sources, Schulman and Scire (1980) for line sources and point sources subject to building downwash effects using the Schulman-Scire downwash algorithm, and Zhang (1993) for buoyant area sources and point sources affected by building downwash when using the PRIME building downwash method. Stack tip downwash effects and partial plume penetration into elevated temperature inversions are included. An algorithm to treat horizontally-oriented vents and stacks with rain caps is included.

h. Horizontal Winds

A three-dimensional wind field is computed by the CALMET meteorological model. CALMET combines an objective analysis procedure using wind observations with parameterized treatments of slope flows, valley flows, terrain kinematic effects, terrain blocking effects, and sea/lake breeze circulations. CALPUFF may optionally use single station (horizontally-constant) wind fields in the CTDMPLUS, AERMOD or ISCST3 data formats.

i. Vertical Wind Speed

Vertical wind speeds are not used explicitly by CALPUFF. Vertical winds are used in the development of the horizontal wind components by CALMET.

j. Horizontal Dispersion

Turbulence-based dispersion coefficients provide estimates of horizontal plume dispersion based on measured or computed values of σ_v. The effects of building downwash and buoyancy-induced dispersion are included. The effects of vertical wind shear are included through the puff splitting algorithm. Options are provided to use Pasquill-Gifford (rural) and McElroy-Pooler (urban) dispersion coefficients. Initial plume size from area or volume sources is allowed.

k. Vertical Dispersion

Turbulence-based dispersion coefficients provide estimates of vertical plume dispersion based on measured or computed values of σ_w. The effects of building downwash and buoyancy-induced dispersion are included. Vertical dispersion during convective conditions is simulated with a probability density function (pdf) model based on Weil *et al.* (1997). Options are provided to use Pasquill-Gifford (rural) and McElroy-Pooler (urban) dispersion coefficients. Initial plume size from area or volume sources is allowed.

l. Chemical Transformation

Gas phase chemical transformations are treated using parameterized models of SO_2 conversion to SO_4= and NO conversion to NO_3-, HNO_3, and NO_2. Organic aerosol formation is treated. The POSTUTIL program contains an option to re-partition HNO_3 and NO_3- in order to treat the effects of ammonia limitation.

m. Physical Removal

Dry deposition of gaseous pollutants and particulate matter is parameterized in terms of a resistance-based deposition model. Gravitational settling, inertial impaction, and Brownian motion effects on deposition of particulate matter is included. CALPUFF contains an option to evaluate the effects of plume tilt resulting from gravitational settling. Wet deposition of gases and particulate matter is parameterized in terms of a scavenging coefficient approach.

n. Evaluation Studies

Berman, S., J.Y. Ku, J. Zhang and S.T. Rao, 1977. Uncertainties in estimating the mixing depth—Comparing three mixing depth models with profiler measurements, *Atmospheric Environment,* 31: 3023–3039.

Chang, J.C., P. Franzese, K. Chayantrakom and S.R. Hanna, 2001. Evaluations of CALPUFF, HPAC and VLSTRACK with Two Mesoscale Field Datasets. *Journal of Applied Meteorology,* 42(4): 453–466.

Environmental Protection Agency, 1998. Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long-Range Transport Impacts. EPA Publication No. EPA–454/R–98–019. Office of Air Quality Planning & Standards, Research Triangle Park, NC.

Irwin, J.S., 1997. A Comparison of CALPUFF Modeling Results with 1997 INEL Field Data Results. In *Air Pollution Modeling and its Application, XII.* Edited by S.E. Gyrning and N. Chaumerliac. Plenum Press, New York, NY.

Irwin, J.S., J.S. Scire and D.G. Strimaitis, 1996. A Comparison of CALPUFF Modeling Results with CAPTEX Field Data Results. In *Air Pollution Modeling and its Application, XI.* Edited by S.E. Gyrning and F.A. Schiermeier. Plenum Press, New York, NY.

Morrison, K, Z–X Wu, J.S. Scire, J. Chenier and T. Jeffs-Schonewille, 2003. CALPUFF-Based Predictive and Reactive Emission Control System. 96th A&WMA Annual Conference & Exhibition, 22–26 June 2003; San Diego, CA.

Schulman, L.L., D.G. Strimaitis and J.S. Scire, 2000. Development and evaluation of the PRIME Plume Rise and Building Downwash Model. JAWMA, 50: 378–390.

Scire, J.S., Z–X Wu, D.G. Strimaitis and G.E. Moore, 2001. The Southwest Wyoming Regional CALPUFF Air Quality Modeling Study—Volume I. Prepared for the Wyoming Dept. of Environmental Quality. Available from Earth Tech at *http://www.src.com.*

Strimaitis, D.G., J.S. Scire and J.C. Chang, 1998. Evaluation of the CALPUFF Dispersion Model with Two Power Plant Data Sets. Tenth Joint Conference on the Application of Air Pollution Meteorology, Phoenix, Arizona. American Meteorological Society, Boston, MA. January 11–16, 1998.

A.5 Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS)

Reference

Perry, S.G., D.J. Burns, L.H. Adams, R.J. Paine, M.G. Dennis, M.T. Mills, D.G. Strimaitis, R.J. Yamartino and E.M. Insley, 1989. User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS). Volume 1: Model Descriptions and User Instructions. EPA Publication No. EPA–600/8–89–041. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89–181424)

Perry, S.G., 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part I: Technical Formulations. *Journal of Applied Meteorology,* 31(7): 633–645.

Availability

This model code is available on EPA's Internet SCRAM Web site and also on diskette (as PB 90–504119) from the National Technical Information Service (Section A.0).

Abstract

CTDMPLUS is a refined point source Gaussian air quality model for use in all stability conditions for complex terrain applications. The model contains, in its entirety, the technology of CTDM for stable and neutral conditions. However, CTDMPLUS can also simulate daytime, unstable conditions, and has a number of additional capabilities for improved user friendliness. Its use of meteorological data and terrain information is different from other EPA models; considerable detail for both types of input data is required and is supplied by preprocessors specifically designed for CTDMPLUS. CTDMPLUS requires the parameterization of individual hill shapes using the terrain preprocessor and the association of each model receptor with a particular hill.

a. Recommendation for Regulatory Use

CTDMPLUS is appropriate for the following applications:

- Elevated point sources;
- Terrain elevations above stack top;
- Rural or urban areas;
- Transport distances less than 50 kilometers; and
- One hour to annual averaging times when used with a post-processor program such as CHAVG.

b. Input Requirements

(1) Source data: For each source, user supplies source location, height, stack diameter, stack exit velocity, stack exit temperature, and emission rate; if variable emissions are appropriate, the user supplies hourly values for emission rate, stack exit velocity, and stack exit temperature.

(2) Meteorological data: For applications of CTDMPLUS, multiple level (typically three or more) measurements of wind speed and direction, temperature and turbulence (wind fluctuation statistics) are required to create the basic meteorological data file (''PROFILE''). Such measurements should be obtained up to the representative plume height(s) of interest (*i.e.*, the plume height(s) under those conditions important to the determination of the design concentration). The representative plume height(s) of interest should be determined using an appropriate complex terrain screening procedure (*e.g.*, CTSCREEN) and should be documented in the monitoring/modeling protocol. The necessary meteorological measurements should be obtained from an appropriately

sited meteorological tower augmented by SODAR and/or RASS if the representative plume height(s) of interest is above the levels represented by the tower measurements. Meteorological preprocessors then create a SURFACE data file (hourly values of mixed layer heights, surface friction velocity, Monin-Obukhov length and surface roughness length) and a RAWINsonde data file (upper air measurements of pressure, temperature, wind direction, and wind speed).

(3) Receptor data: receptor names (up to 400) and coordinates, and hill number (each receptor must have a hill number assigned).

(4) Terrain data: user inputs digitized contour information to the terrain preprocessor which creates the TERRAIN data file (for up to 25 hills).

c. Output

(1) When CTDMPLUS is run, it produces a concentration file, in either binary or text format (user's choice), and a list file containing a verification of model inputs, *i.e.*,

• Input meteorological data from ''SURFACE'' and ''PROFILE''.
• Stack data for each source.
• Terrain information.
• Receptor information.
• Source-receptor location (line printer map).

(2) In addition, if the case-study option is selected, the listing includes:

• Meteorological variables at plume height.
• Geometrical relationships between the source and the hill.
• Plume characteristics at each receptor, *i.e.*,

—Distance in along-flow and cross flow direction
—Effective plume-receptor height difference
—Effective σ_y & σ_z values, both flat terrain and hill induced (the difference shows the effect of the hill)
—Concentration components due to WRAP, LIFT and FLAT.

(3) If the user selects the TOPN option, a summary table of the top 4 concentrations at each receptor is given. If the ISOR option is selected, a source contribution table for every hour will be printed.

(4) A separate disk file of predicted (1-hour only) concentrations (''CONC'') is written if the user chooses this option. Three forms of output are possible:

(i) A binary file of concentrations, one value for each receptor in the hourly sequence as run;

(ii) A text file of concentrations, one value for each receptor in the hourly sequence as run; or

(iii) A text file as described above, but with a listing of receptor information (names, positions, hill number) at the beginning of the file.

(3) Hourly information provided to these files besides the concentrations themselves includes the year, month, day, and hour information as well as the receptor number with the highest concentration.

d. Type of Model

CTDMPLUS is a refined steady-state, point source plume model for use in all stability conditions for complex terrain applications.

e. Pollutant Types

CTDMPLUS may be used to model non-reactive, primary pollutants.

f. Source-Receptor Relationship

Up to 40 point sources, 400 receptors and 25 hills may be used. Receptors and sources are allowed at any location. Hill slopes are assumed not to exceed 15°, so that the linearized equation of motion for Boussinesq flow are applicable. Receptors upwind of the impingement point, or those associated with any of the hills in the modeling domain, require separate treatment.

g. Plume Behavior

(1) As in CTDM, the basic plume rise algorithms are based on Briggs' (1975) recommendations.

(2) A central feature of CTDMPLUS for neutral/stable conditions is its use of a critical dividing-streamline height (H_c) to separate the flow in the vicinity of a hill into two separate layers. The plume component in the upper layer has sufficient kinetic energy to pass over the top of the hill while streamlines in the lower portion are constrained to flow in a horizontal plane around the hill. Two separate components of CTDMPLUS compute ground-level concentrations resulting from plume material in each of these flows.

(3) The model calculates on an hourly (or appropriate steady averaging period) basis how the plume trajectory (and, in stable/neutral conditions, the shape) is deformed by each hill. Hourly profiles of wind and temperature measurements are used by CTDMPLUS to compute plume rise, plume penetration (a formulation is included to handle penetration into elevated stable layers, based on Briggs (1984)), convective scaling parameters, the value of H_c, and the Froude number above H_c.

h. Horizontal Winds

CTDMPLUS does not simulate calm meteorological conditions. Both scalar and vector wind speed observations can be read by the model. If vector wind speed is unavailable, it is calculated from the scalar wind speed. The assignment of wind speed (either vector or scalar) at plume height is done by either:

• Interpolating between observations above and below the plume height, or
• Extrapolating (within the surface layer) from the nearest measurement height to the plume height.

i. Vertical Wind Speed

Vertical flow is treated for the plume component above the critical dividing streamline height (H_c); see ''Plume Behavior''.

j. Horizontal Dispersion

Horizontal dispersion for stable/neutral conditions is related to the turbulence velocity scale for lateral fluctuations, σ_v, for which a minimum value of 0.2 m/s is used. Convective scaling formulations are used to estimate horizontal dispersion for unstable conditions.

k. Vertical Dispersion

Direct estimates of vertical dispersion for stable/neutral conditions are based on observed vertical turbulence intensity, *e.g.*, σ_w (standard deviation of the vertical velocity fluctuation). In simulating unstable (convective) conditions, CTDMPLUS relies on a skewed, bi-Gaussian probability density function (pdf) description of the vertical velocities to estimate the vertical distribution of pollutant concentration.

l. Chemical Transformation

Chemical transformation is not treated by CTDMPLUS.

m. Physical Removal

Physical removal is not treated by CTDMPLUS (complete reflection at the ground/hill surface is assumed).

n. Evaluation Studies

Burns, D.J., L.H. Adams and S.G. Perry, 1990. Testing and Evaluation of the CTDMPLUS Dispersion Model: Daytime Convective Conditions. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J.O., S.G. Perry and D.J. Burns, 1990. An Analysis of CTDMPLUS Model Predictions with the Lovett Power Plant Data Base. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J.O., S.G. Perry and D.J. Burns, 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part II: Performance Characteristics. *Journal of Applied Meteorology,* 31(7): 646–660.

A.6 Offshore and Coastal Dispersion Model (OCD)

Reference

DiCristofaro, D.C. and S.R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model, Version 4. Volume I: User's Guide, and Volume II: Appendices. Sigma Research Corporation, Westford, MA. (NTIS Nos. PB 93–144384 and PB 93–144392; also available at *http://www.epa.gov/scram001/*)

Availability

This model code is available on EPA's Internet SCRAM Web site and also on diskette (as PB 91–505230) from the National Technical Information Service (see Section A.0). Official contact at Minerals Management Service: Mr. Dirk Herkhof, Parkway Atrium Building, 381 Elden Street, Herndon, VA 20170, Phone: (703) 787–1735.

Abstract

(1) OCD is a straight-line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations. These include water surface temperature, overwater air temperature, mixing height, and relative humidity.

(2) Some of the key features include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation.

a. Recommendations for Regulatory Use

OCD has been recommended for use by the Minerals Management Service for emissions located on the Outer Continental Shelf (50 FR 12248; 28 March 1985). OCD is applicable for overwater sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. Input Requirements

(1) Source data: Point, area or line source location, pollutant emission rate, building height, stack height, stack gas temperature, stack inside diameter, stack gas exit velocity, stack angle from vertical, elevation of stack base above water surface and gridded specification of the land/water surfaces. As an option, emission rate, stack gas exit velocity and temperature can be varied hourly.

(2) Meteorological data (over water): Wind direction, wind speed, mixing height, relative humidity, air temperature, water surface temperature, vertical wind direction shear (optional), vertical temperature gradient (optional), turbulence intensities (optional).

(2) Meteorological data:

Over land: Surface weather data from a preprocessor such as PCRAMMET which provides hourly stability class, wind direction, wind speed, ambient temperature, and mixing height are required.

Over water: Hourly values for mixing height, relative humidity, air temperature, and water surface temperature are required; if wind speed/direction are missing, values over land will be used (if available); vertical wind direction shear, vertical temperature gradient, and turbulence intensities are optional.

(3) Receptor data: Location, height above local ground-level, ground-level elevation above the water surface.

c. Output

(1) All input options, specification of sources, receptors and land/water map including locations of sources and receptors.

(2) Summary tables of five highest concentrations at each receptor for each averaging period, and average concentration for entire run period at each receptor.

(3) Optional case study printout with hourly plume and receptor characteristics. Optional table of annual impact assessment from non-permanent activities.

(4) Concentration files written to disk or tape can be used by ANALYSIS postprocessor to produce the highest concentrations for each receptor, the cumulative frequency distributions for each receptor, the tabulation of all concentrations exceeding a given threshold, and the manipulation of hourly concentration files.

d. Type of Model

OCD is a Gaussian plume model constructed on the framework of the MPTER model.

e. Pollutant Types

OCD may be used to model primary pollutants. Settling and deposition are not treated.

f. Source-Receptor Relationship

(1) Up to 250 point sources, 5 area sources, or 1 line source and 180 receptors may be used.

(2) Receptors and sources are allowed at any location.

(3) The coastal configuration is determined by a grid of up to 3600 rectangles. Each element of the grid is designated as either land or water to identify the coastline.

g. Plume Behavior

(1) As in ISC, the basic plume rise algorithms are based on Briggs' recommendations.

(2) Momentum rise includes consideration of the stack angle from the vertical.

(3) The effect of drilling platforms, ships, or any overwater obstructions near the source are used to decrease plume rise using a revised platform downwash algorithm based on laboratory experiments.

(4) Partial plume penetration of elevated inversions is included using the suggestions of Briggs (1975) and Weil and Brower (1984).

(5) Continuous shoreline fumigation is parameterized using the Turner method where complete vertical mixing through the thermal internal boundary layer (TIBL) occurs as soon as the plume intercepts the TIBL.

h. Horizontal Winds

(1) Constant, uniform wind is assumed for each hour.

(2) Overwater wind speed can be estimated from overland wind speed using relationship of Hsu (1981).

(3) Wind speed profiles are estimated using similarity theory (Businger, 1973). Surface layer fluxes for these formulas are calculated from bulk aerodynamic methods.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

(1) Lateral turbulence intensity is recommended as a direct estimate of horizontal dispersion. If lateral turbulence intensity is not available, it is estimated from boundary layer theory. For wind speeds less than 8 m/s, lateral turbulence intensity is assumed inversely proportional to wind speed.

(2) Horizontal dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

(3) Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement and wind direction shear enhancement.

(4) At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either lateral turbulence intensity or Pasquill-Gifford curves. The change is implemented where the plume intercepts the rising internal boundary layer.

k. Vertical Dispersion

(1) Observed vertical turbulence intensity is not recommended as a direct estimate of vertical dispersion. Turbulence intensity should be estimated from boundary layer theory as default in the model. For very stable conditions, vertical dispersion is also a function of lapse rate.

(2) Vertical dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

(3) Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement.

(4) At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either vertical turbulence intensity or the Pasquill-Gifford coefficients. The change is implemented where the plume intercepts the rising internal boundary layer.

1. Chemical Transformation

Chemical transformations are treated using exponential decay. Different rates can be specified by month and by day or night.

m. Physical Removal

Physical removal is also treated using exponential decay.

n. Evaluation Studies

DiCristofaro, D.C. and S.R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model. Volume I: User's Guide. Sigma Research Corporation, Westford, MA.

Hanna, S.R., L.L. Schulman, R.J. Paine and J.E. Pleim, 1984. The Offshore and Coastal Dispersion (OCD) Model User's Guide, Revised. OCS Study, MMS 84–0069. Environmental Research & Technology, Inc., Concord, MA. (NTIS No. PB 86–159803).

Hanna, S.R., L.L. Schulman, R.J. Paine, J.E. Pleim and M. Baer, 1985. Development and Evaluation of the Offshore and Coastal Dispersion (OCD) Model. *Journal of the Air Pollution Control Association,* 35: 1039–1047.

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ATTACHMENT V

WEATHER MAPS

The following charts are derived from the former National Weather Service publication, "Daily Weather Map." Figures B1 to B4 show the weather charts for four days, two of which were selected as design days for PM-10 modeling. The charts presented include the Surface Weather Map, the 500-Millibar Height Contours, the Highest and Lowest Temperatures, and the Precipitation Areas and Amounts. All charts are derived from the operational weather maps prepared at the National Centers for Environmental Prediction, Hydrometeorological Prediction Center, National Weather Service. The symbols on the Surface Weather Map and the 500-Millibar Height contours are standard international symbols. The Surface Weather Map shows station data and the analysis for 7:00 a.m. EST. Areas of precipitation are indicated by shading. The weather reports displayed here are only a fraction of those on which the analyses are based. Occasional apparent discrepancies between the printed station data and the analyses result from the absence of station reports not included here because of a lack of space (Source: http://www.hpc.ncep.noaa.gov/dailywxmap).

The 500-Millibar Height Contours chart shows height contours (solid lines), temperatures (dashed lines) and winds (arrows) at the 500-Millibar pressure level at 7:00 a.m. EST. The height contours show the height of the 500-millibar pressure level in dekameters above sea level and isotherms, the lines of constant temperature, are shown in degrees Celsius. Arrows show the wind direction and speed at the 500-millibar level. The Highest and Lowest Temperature chart shows the maximum temperature for a period from 7:00 a.m. EST the previous day through 1 a.m. EST and the minimum temperature for the period from 7:00 p.m. EST the previous day through 1 p.m. The maximum temperature is plotted above the station location and the minimum temperature is plotted below. The Precipitation Areas and Amounts chart shows areas (shaded) that had precipitation during the 24 hours ending at 7:00 a.m. EST, with amounts to the nearest hundredth of an inch.

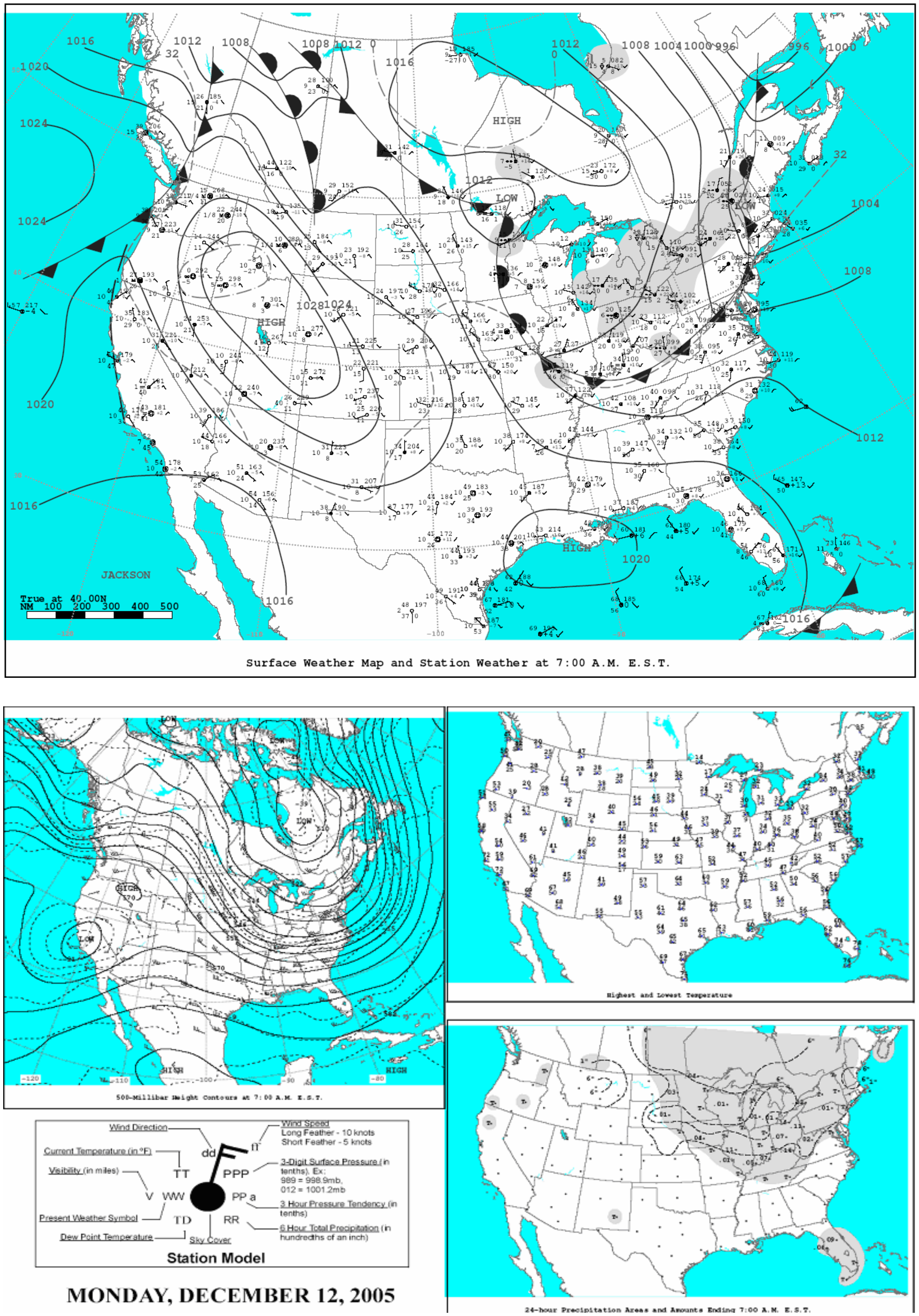

Figure 1. Weather Map for December 12, 2005

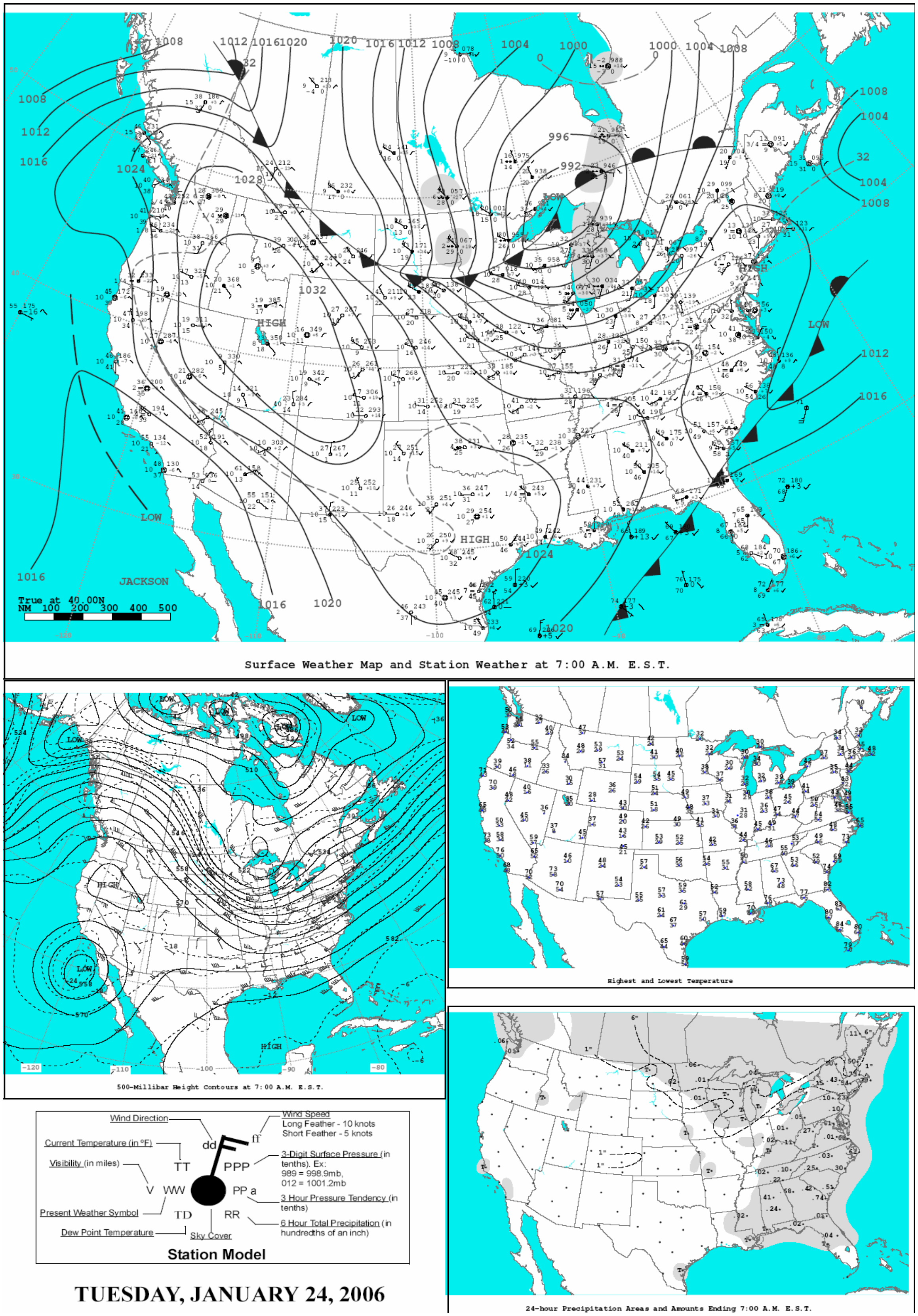

Figure 2. Weather Map for January 24, 2006

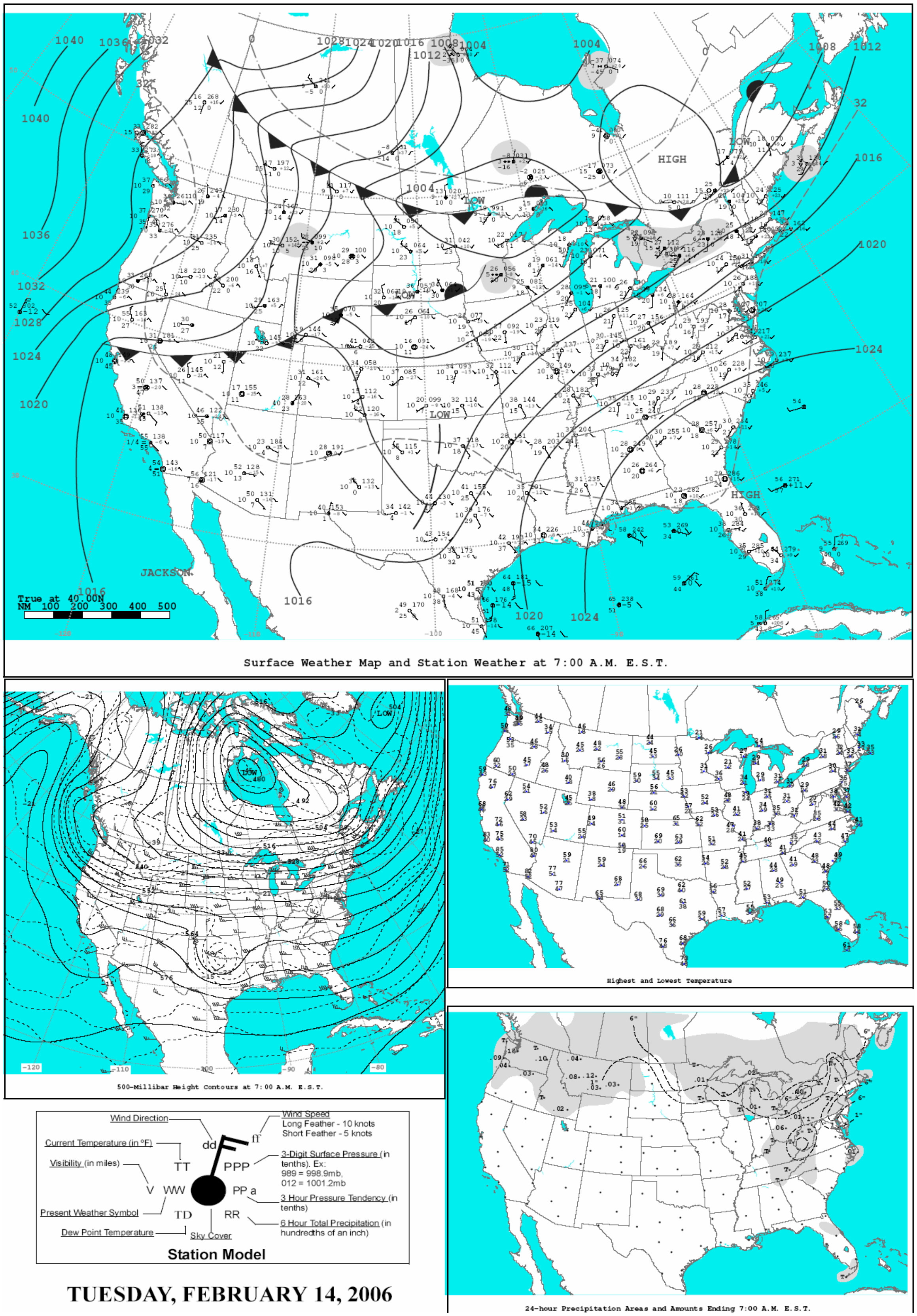

Figure 3. Weather Map for February 14, 2006

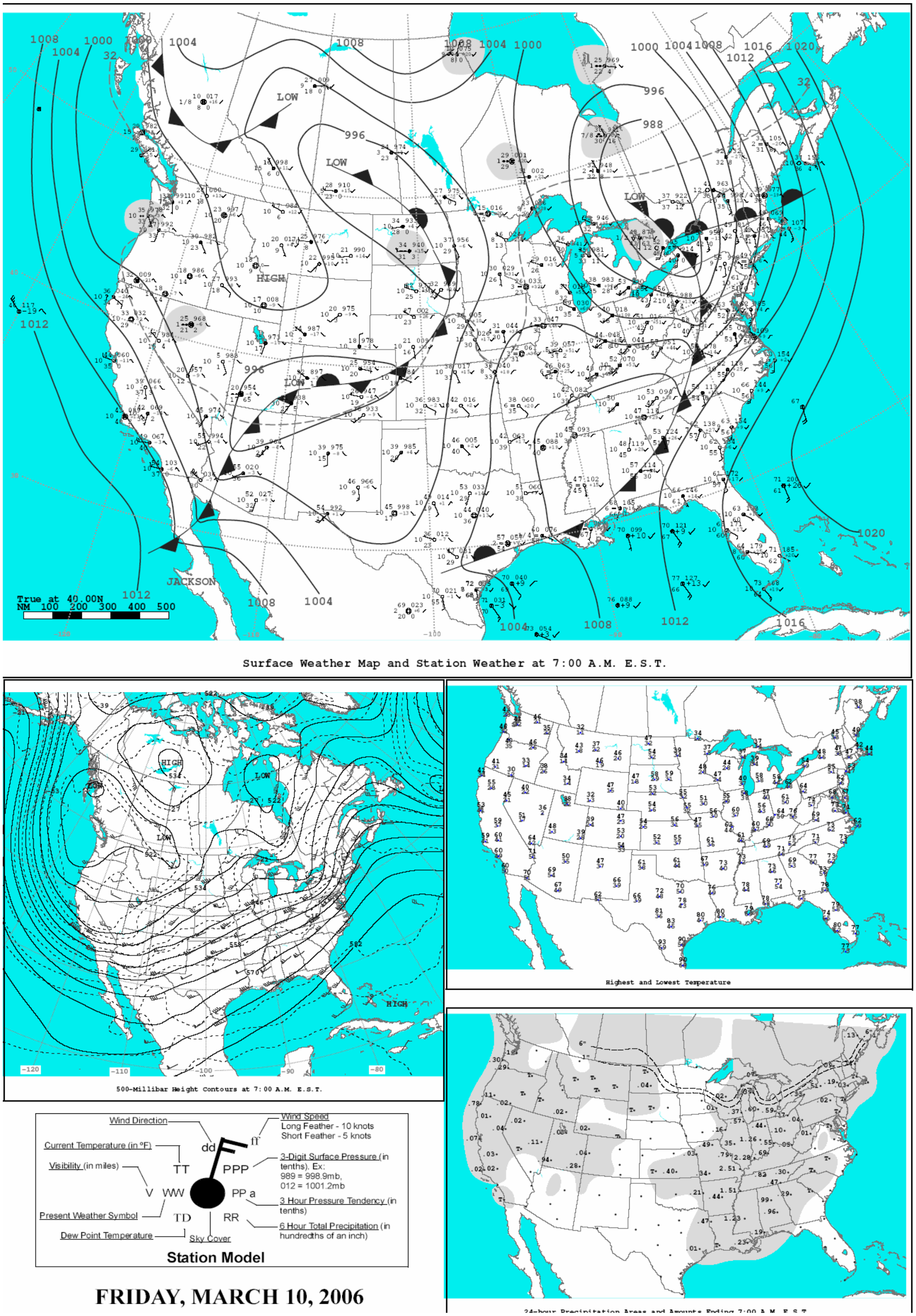

Figure 4. Weather Map for March 10, 2006

ATTACHMENT VI

CONCEPTUAL DESCRIPTION FOR THE SELECTED HIGH PM-10 DAYS

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Nomenclature

EPA	Environmental Protection Agency
MCAQD	Maricopa County Air Quality Department
NAAQS	National Ambient Air Quality Standards
NA	Nonattainment Area

1. Conceptual Description

This conceptual description follows EPA's *Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 24-hour PM-10 NAAQS* and provides additional information on the Maricopa County PM-10 nonattainment problem.

1.1 Do violations of the NAAQS occur at several monitoring sites throughout the nonattainment area, or are they confined to one or a small number of sites in proximity to one another?

As shown in Figures 1.~3., violations of the NAAQS occur at a limited number of sites throughout the PM-10 nonattainment area. Buckeye, Durango Complex, Higley, and West 43rd Avenue are the monitoring stations that had at least four PM-10 exceedances during the period January 2004 through March 2006[1]. The site with the highest number of exceedance days for each year is circled in blue.

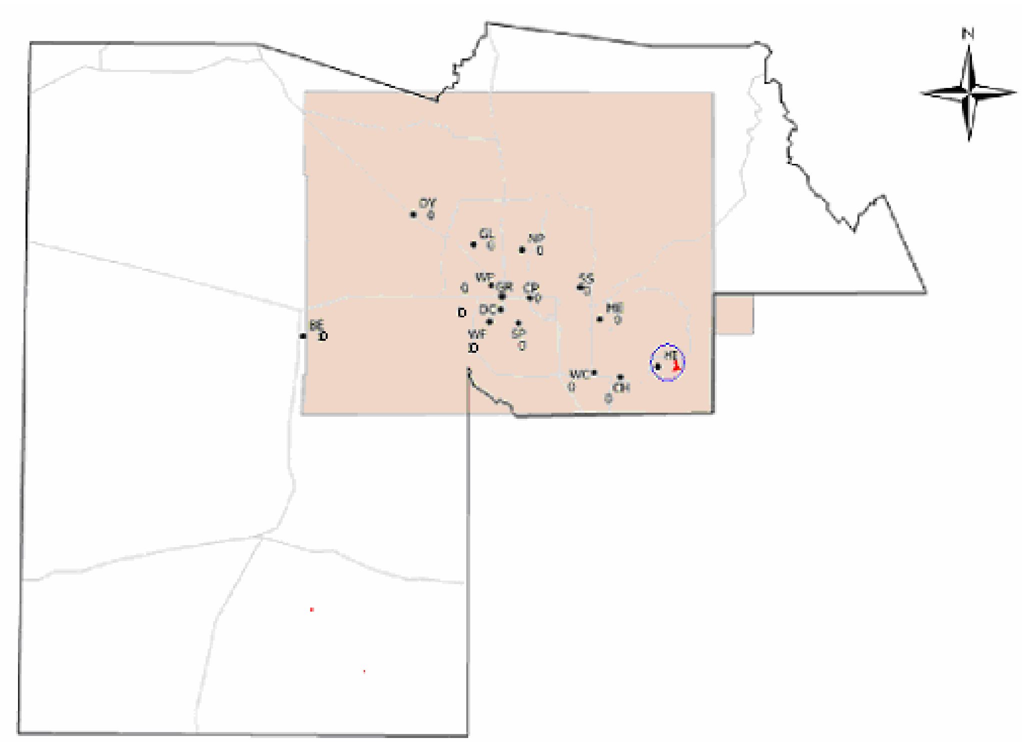


Figure 1. Spatial Distribution of 24-hour PM10 Exceedances in 2004[1]

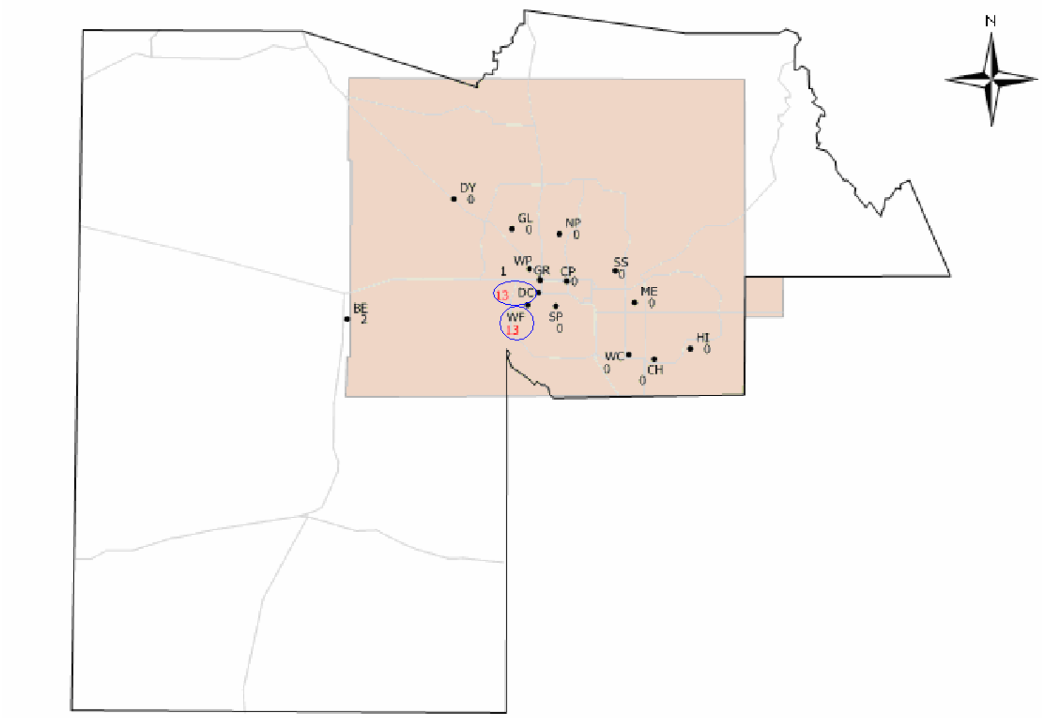
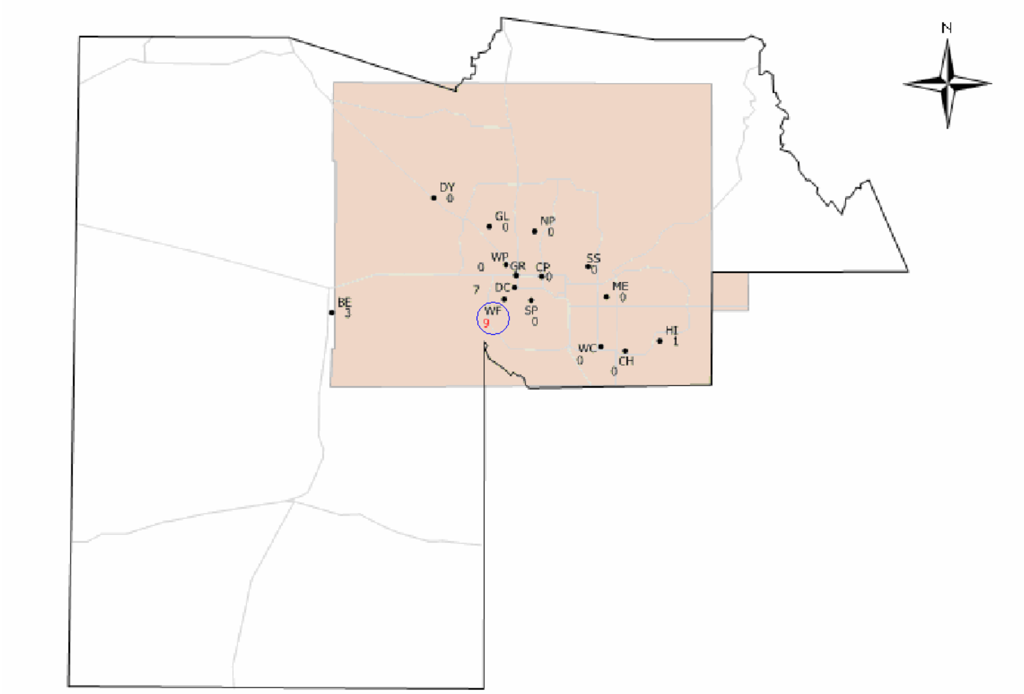


Figure 2. Spatial Distribution of 24-hour PM10 Exceedances in 2005[2]



Figures 3. Spatial Distribution of 24-hour PM10 Exceedances in 2006 (through March 2006)[3]

1.2 Do observed 24-hour average PM10 concentrations exceed 155 μg/m³ frequently or just on a few occasions?

The frequency of 24-hour PM-10 average exceedances varies among the monitors as shown in Table 1. The West 43rd Avenue and Durango Complex sites had the highest number of 24-hour PM-10 exceedances, 13 days, in 2005. It is important to note that the exceedances prior to 2005 were recorded at monitors that were sampled once every six days. Therefore, each of these exceedances represents an expected daily exceedance rate that is six times the value shown. All monitors that exceeded the standard in 2005, including West 43rd and Durango, have been converted to a daily sampling schedule.

Table 1. Number of Days Exceeding 154μg/m³ of 24-hour PM-10 Concentration [1,2]

24-Hour average greater than 154 ug/m³								
City Location	2000	2001	2002	2003	2004	2005	2006*	Maximum
#Buckeye	-	-	-	-	-	2	3	3
Chandler	1	0	0	1	0	0	0	1
W. Chandler	0	0	0	2	0	0	0	2
#Dysart	-	-	-	0	0	0		
Glendale	0	0	0	0	0	0	0	0
Goodyear/Estrella	0	0	0	0	0	0	0	0
Higley	1	1	0	1	1	0	1	1
#Maryvale	1	0	0	0	0	Shutdown	-	1
Mesa	0	0	0	1	0	0	0	1
Palo Verde	0	0	0	1	0	0	0	1
Durango Complex	2	1	2	1	0	13	7	13
South Phoenix	1	0	0	1	0	0	0	1
W. 43rd Ave.		Not operating	1	2	0	13	9	13
West Phoenix	0	0	0	1	0	1	1	1
#Salt River	6	6	2	Shutdown	-	-	-	6
Central Phoenix	0	0	0	0	0	0	0	0
North Phoenix	0	0	0	1	0	0	0	1
JLG Super Site	0	0	0	1	0	0	0	1
Greenwood	2	0	0	1	0	1	1	2
South Scottsdale	0	0	0	1	0	0	0	1
Tempe	0	0	0	0	0	0	0	1
#Surprise	0	0	0	Shutdown	-	-	-	0
Bethune Elementary	-	-	-	-	0	0		0

*Note: 2006 data is through March 2006 and has not been validated by MCAQD. Some of the days in 2006 may be flagged as natural events.

Maryvale (Closed 04/01/2004), Salt River (Closed in 2002), Surprise (Closed 7/15/03), Bethune Elementary School (Opened 10/19/2004), Buckeye (Opened 8/01/2004), and Dysart (Opened 7/16/03).

1.3 When 24-hour average PM-10 in excess of 154 μg/m^3 occurs, is there an accompanying characteristic spatial pattern, or is there a variety of spatial patterns?

These patterns, grouped by the blue lines, are summarized in Figure 4.~7. Most exceedances occur at a small number of sites in proximity to one another in a partial region of the PM-10 nonattainment area [1,2].

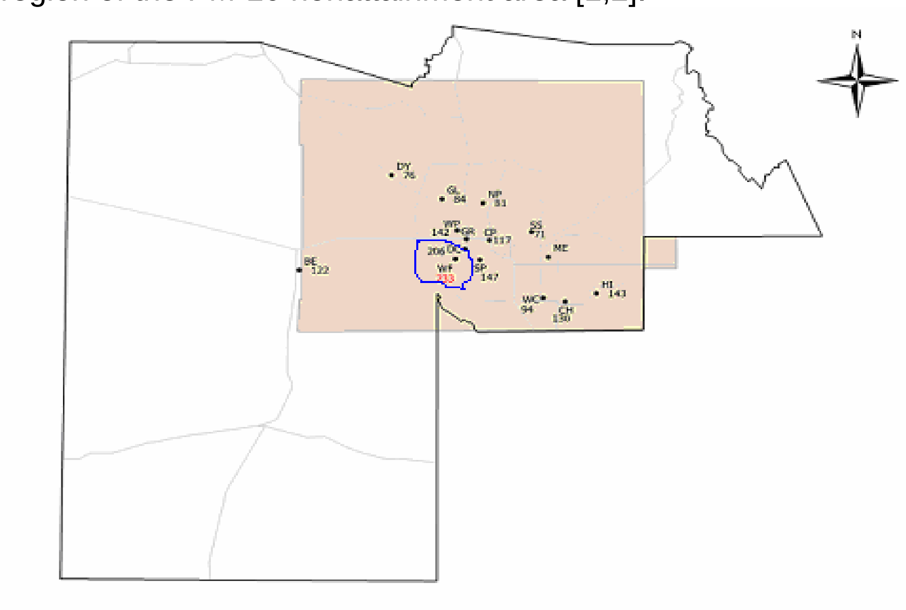


Figure 4. Spatial Patterns when 24-hour PM-10 Average in Excess of 154 μg/m^3 Occurred on December 12, 2005

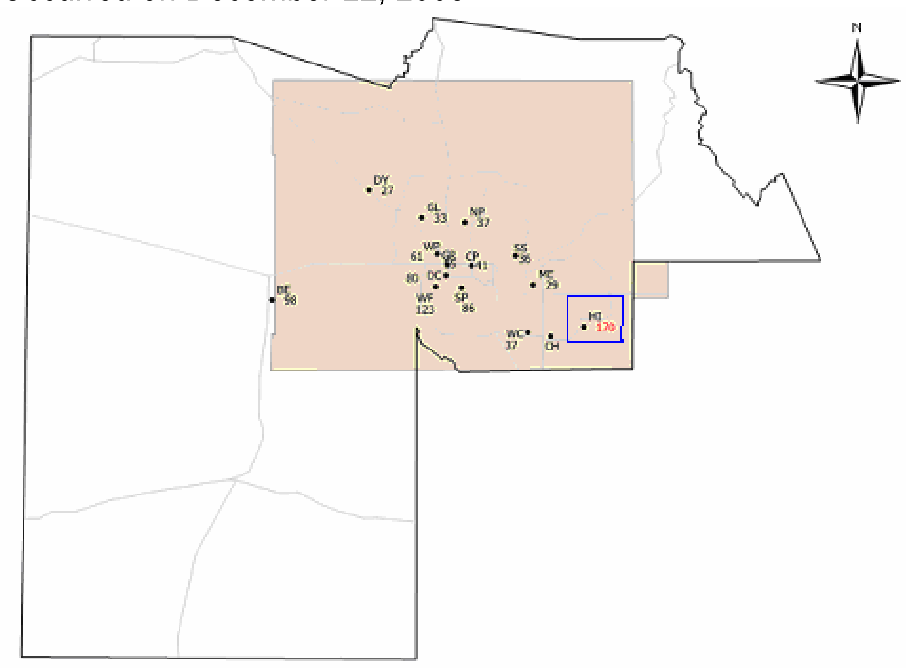


Figure 5. Spatial Patterns when 24-hour PM-10 Average in Excess of 154 μg/m^3 Occurred on January 24, 2006

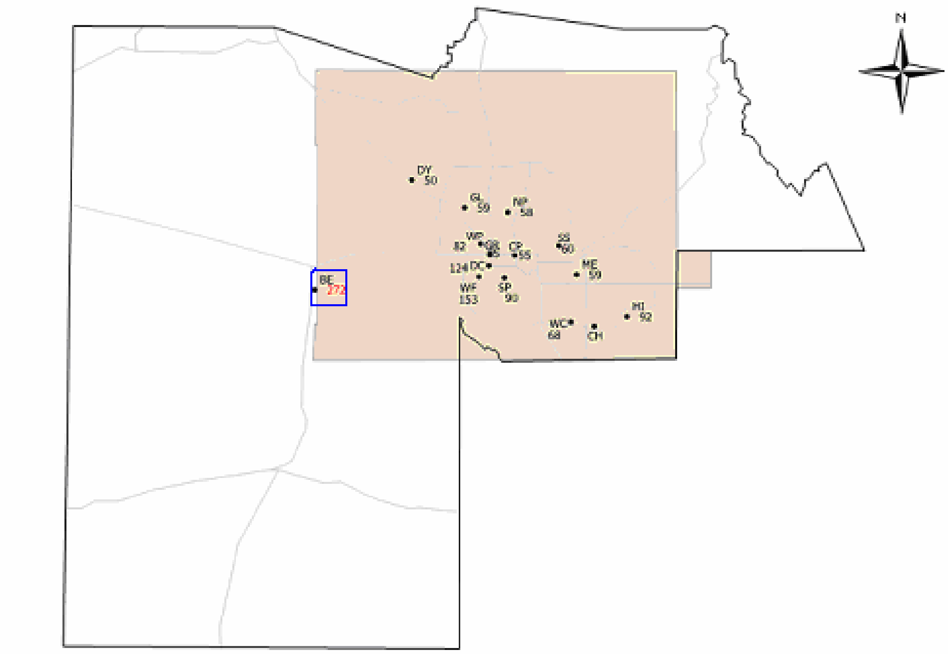


Figure 6. Spatial Patterns when 24-hour PM-10 Average in Excess of 154 $\mu g/m^3$ Occurred on February 14, 2006 [3]

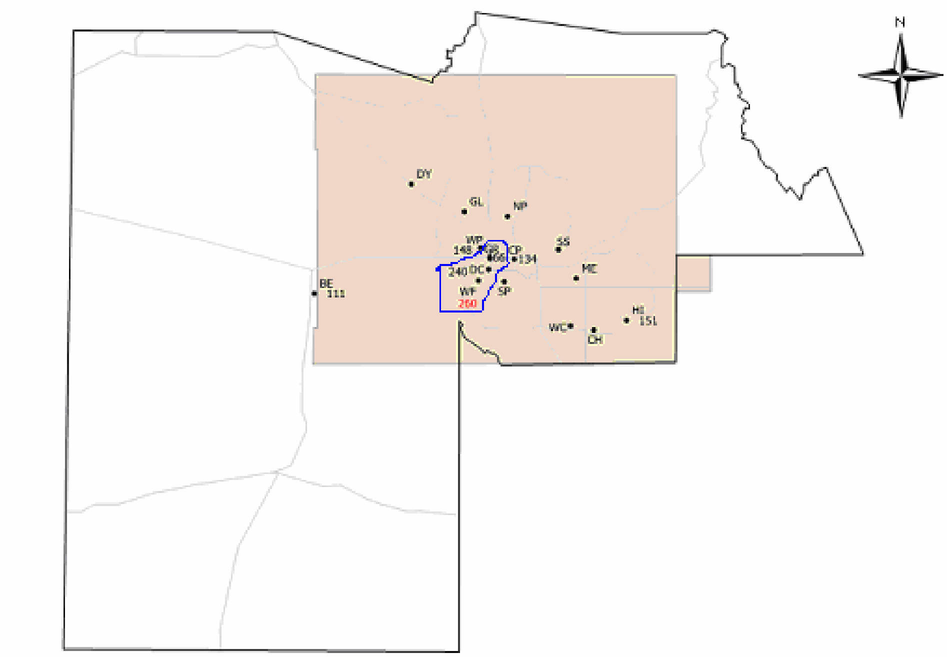


Figure 7. Spatial Patterns when 24-hour PM-10 Average in Excess of 154 $\mu g/m^3$ Occurred on March 10, 2006 [3]

1.4 Do monitored violations occur at locations subject to mesoscale wind patterns which may differ from the general wind flow?

Hourly surface wind direction and wind speed data on high and low wind days at the West 43rd site are summarized in Figure 8. Morning winds are predominantly calm and afternoon winds are westerly on days with 24-hour PM-10 averages greater than 155 $\mu g/m^3$ (both low and high wind days). This is similar to low PM-10 days when afternoon winds are predominantly westerly. The PM-10 nonattainment area has apparent morning afternoon (westerly) wind patterns regardless of days with high or low PM-10 concentrations. Figures 8. to 9. show the wind roses for all of the PM-10 exceedance days (low wind) from March 2005 through March 2006. Figure 10. to 11. shows the wind roses for all of the PM-10 exceedance days (high wind) from March 2005 through March 2006. Figures 12. to 13. show the wind roses for all of the PM-10 non-exceedance days from March 2005 through March 2006.

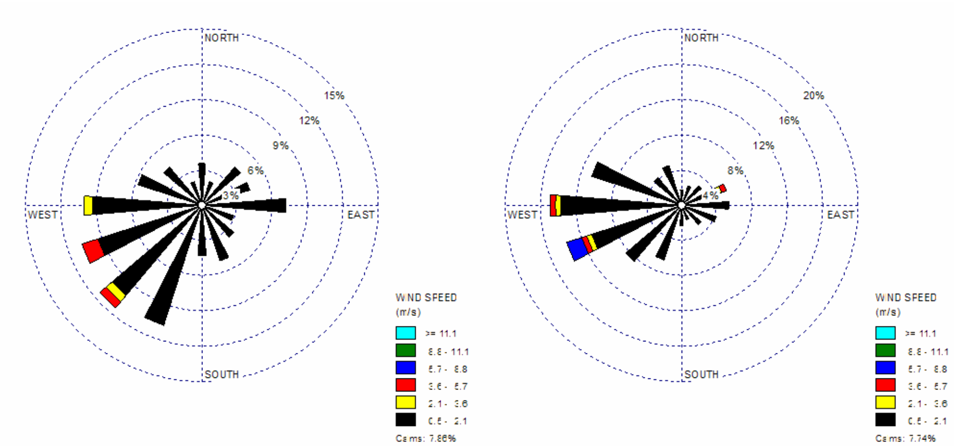


Figure 8. Wind Roses for Low Wind PM-10 Exceedance Days (March 2005- March 2006) at West 43rd site: 0:00-04:00 (left) and 05:00-10:00 (right)

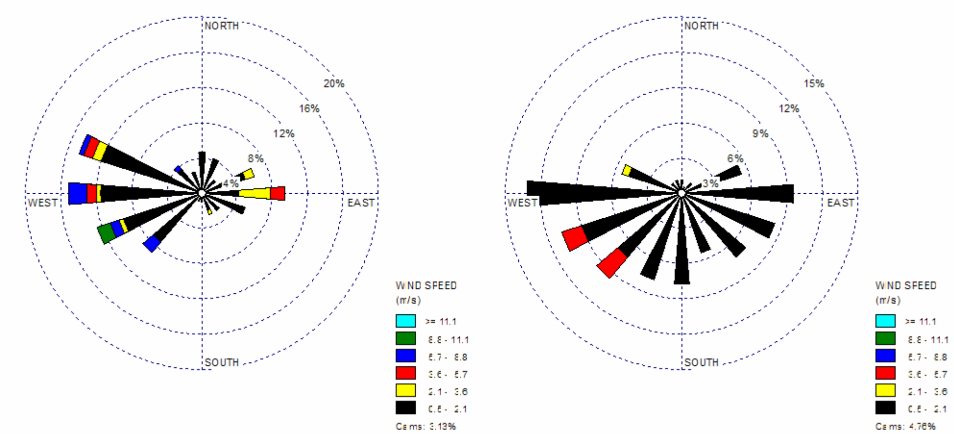


Figure 9. Wind Roses for Low Wind PM-10 Exceedance Days (March 2005- March 2006) at West 43rd site: 11:00-17:00 (left) and 18:00-23:00 (right)

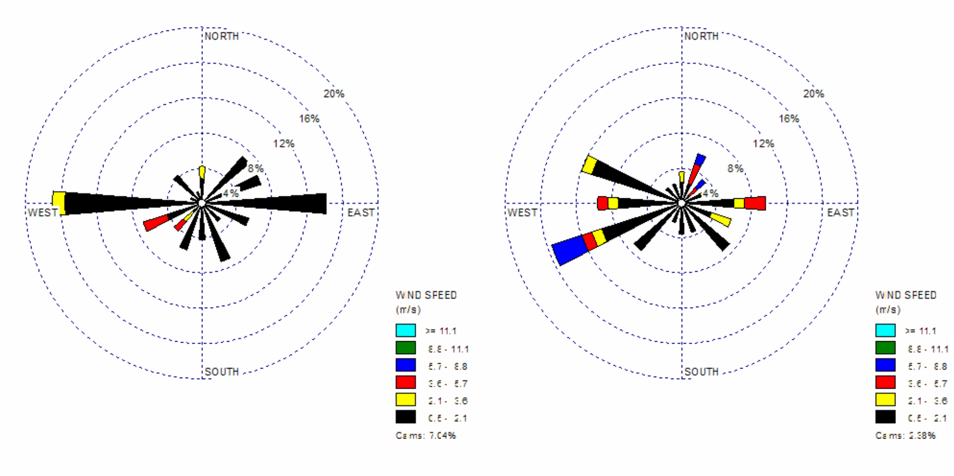


Figure 10. Wind Roses for High Wind PM-10 Exceedance Days (March 2005- March 2006) at West 43rd site: 0:00-04:00 (left) and 05:00-10:00 (right)

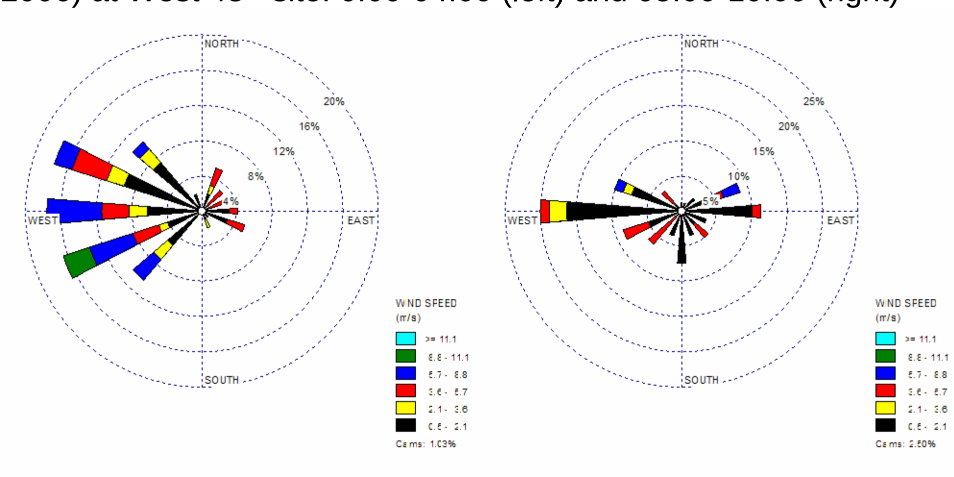


Figure 11. Wind Roses for High Wind PM-10 Exceedance Days (March 2005- March 2006) at West 43rd site: 11:00-17:00 (left) and 18:00-23:00 (right)

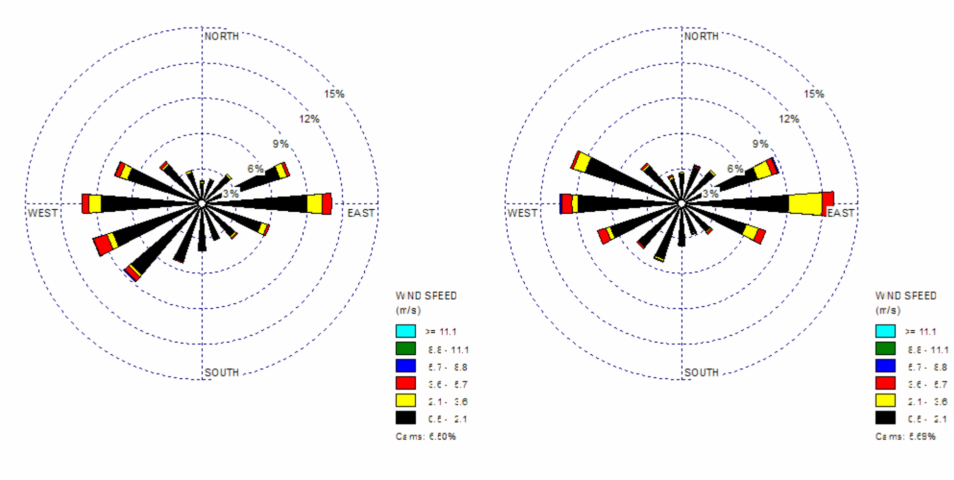


Figure 12. Wind Roses for Low PM-10 Days (March 2005-March 2006) at West 43rd site: 0:00-04:00 (left) and 05:00-10:00 (right)

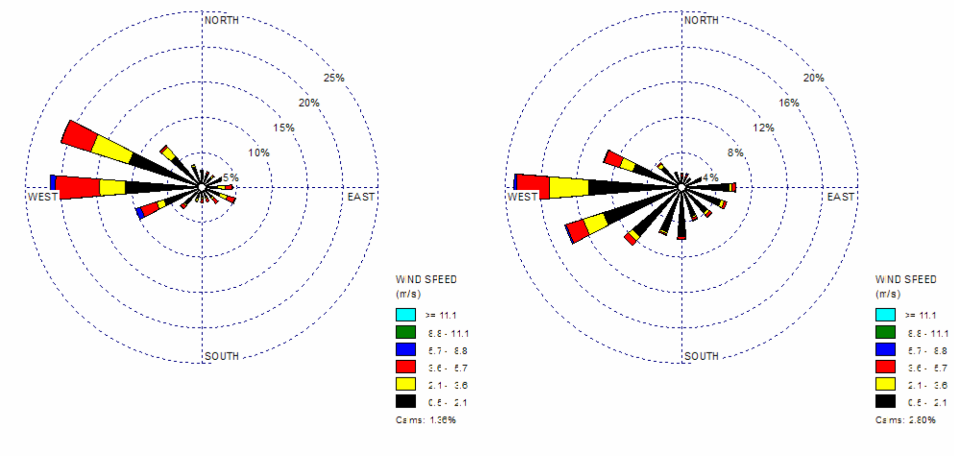


Figure 13. Wind Roses for Low PM-10 Days (March 2005-March 2006) at West 43rd site: 11:00-17:00 (left) and 18:00-23:00 (right)

1.5 Have there been any recent major changes in emissions of PM-10 in or near the nonattainment area? If so, what changes have occurred?

Periodic emissions inventories for PM-10 are prepared every three years by the Maricopa County Air Quality Department (MCAQD). Table 2 summarizes annual PM-10 emissions for the nonattainment area in 1994 and 2002 [5]. It can be concluded from this comparison that the point source emissions remain relatively constant and the onroad mobile source emissions are declining. The differences in 1994 and 2002 nonroad and area source emissions are obfuscated by shifts in the categorization of sources. However, the sum of the area and nonroad emissions is slightly higher in 2002 than 1994. The overall decrease in emissions may be explained by implementation of PM-10 control measures that between 1994 and 2002, that were part of the Serious Area PM-10 Plan[4]. We are not aware of any significant changes in emissions of PM-10 in or near the nonattainment area since 2002.

Table 2. Summary of Annual PM-10 Emissions by Source Category for the PM-10 Nonattainment Area (tons/year)

Source Category	Periodic Emissions Inventory	Periodic Emissions Inventory
Year	**1994**	**2002**
Point	1,238	1,037
Area	10,460	23,086*
Nonroad Mobile	13,851	3,035**
Onroad Mobile	37,015	30,231
Total Emissions	62,564	57,389

*With windblown sources removed, because windblown dust was not included in the 1994 inventory.
**Adjusted to correct the error in aircraft emissions.

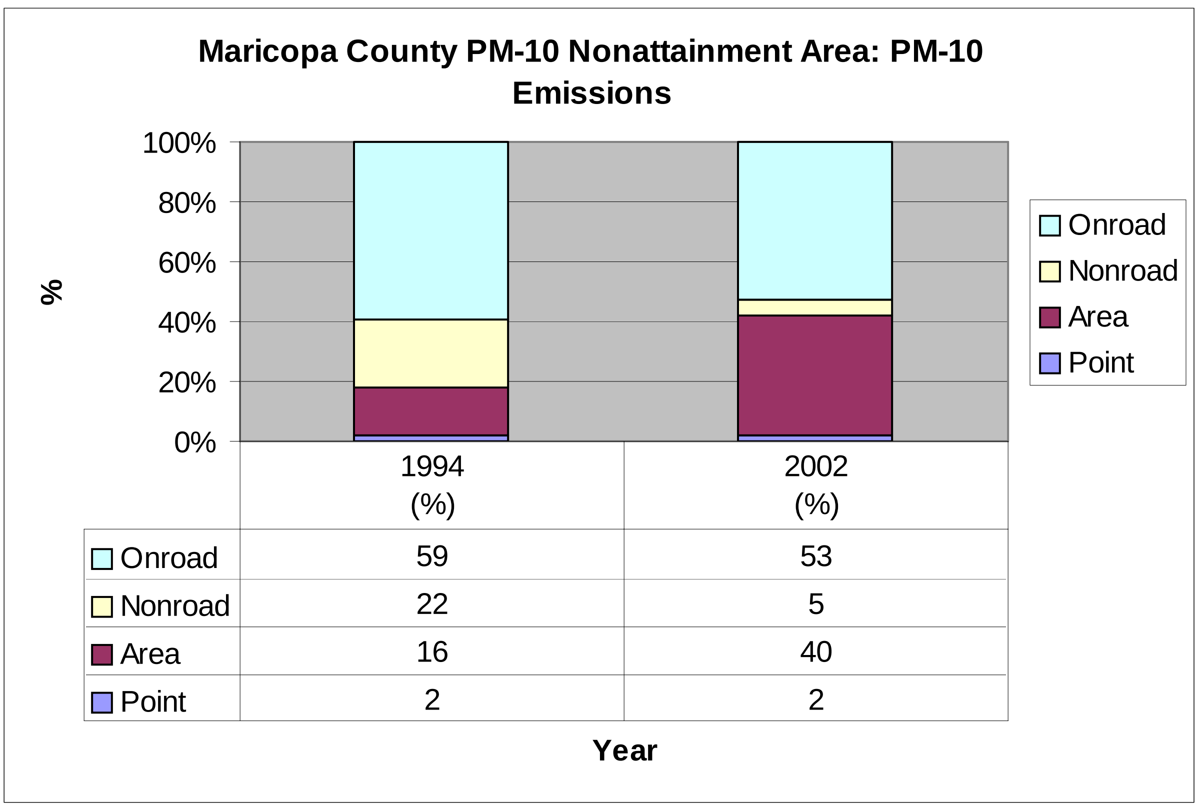


Figure 14. Summary of 1994 and 2002 PM-10 Emissions by Major Source Categories in Maricopa County PM-10 Nonattainment Area (tons/year)

1.6 Are there discernible trends in design values or other air quality indicators, which have accompanied a change in emissions?

Figure 15. shows the 2001-2005 trends in the highest 24-hour PM-10 average at monitoring sites in the PM-10 nonattainment area. In general, trends are similar over all sites, with relatively bad years in 2003 and 2005, and relatively "clean" years in 2001, 2002, and 2004. These trends seem to be largely due to meteorological conditions, e.g., level of annual precipitation and number of high wind days.

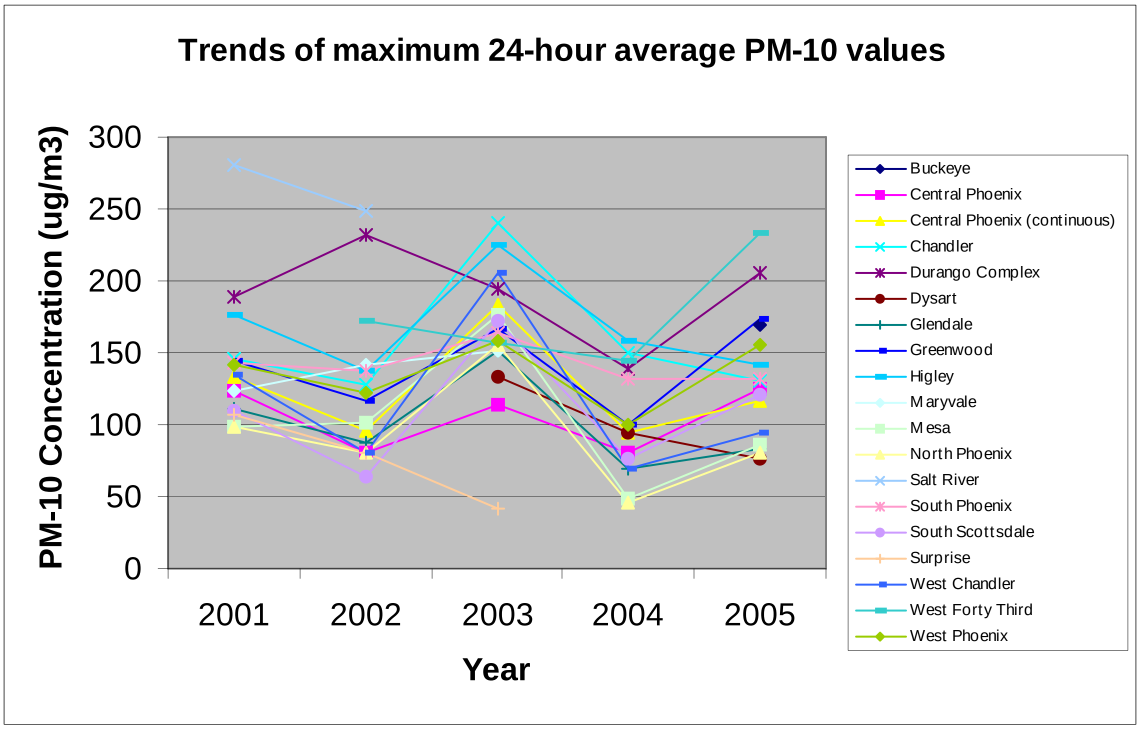


Figure 15. Trends in Maximum 24-hour Average PM-10 Values

1.7 is there any apparent spatial pattern to the trends in design values?

There are two apparent spatial patterns to the trends in design values when the area is divided into two different parts (north and south), as shown in Figure 16. (the blue line). Overall, sites to the south of this line violated the 24-hour PM-10 standard during the period 2001 through March 2006, while none of the sites to the north of the line exceeded the 24-hour PM-10 standard during this period.

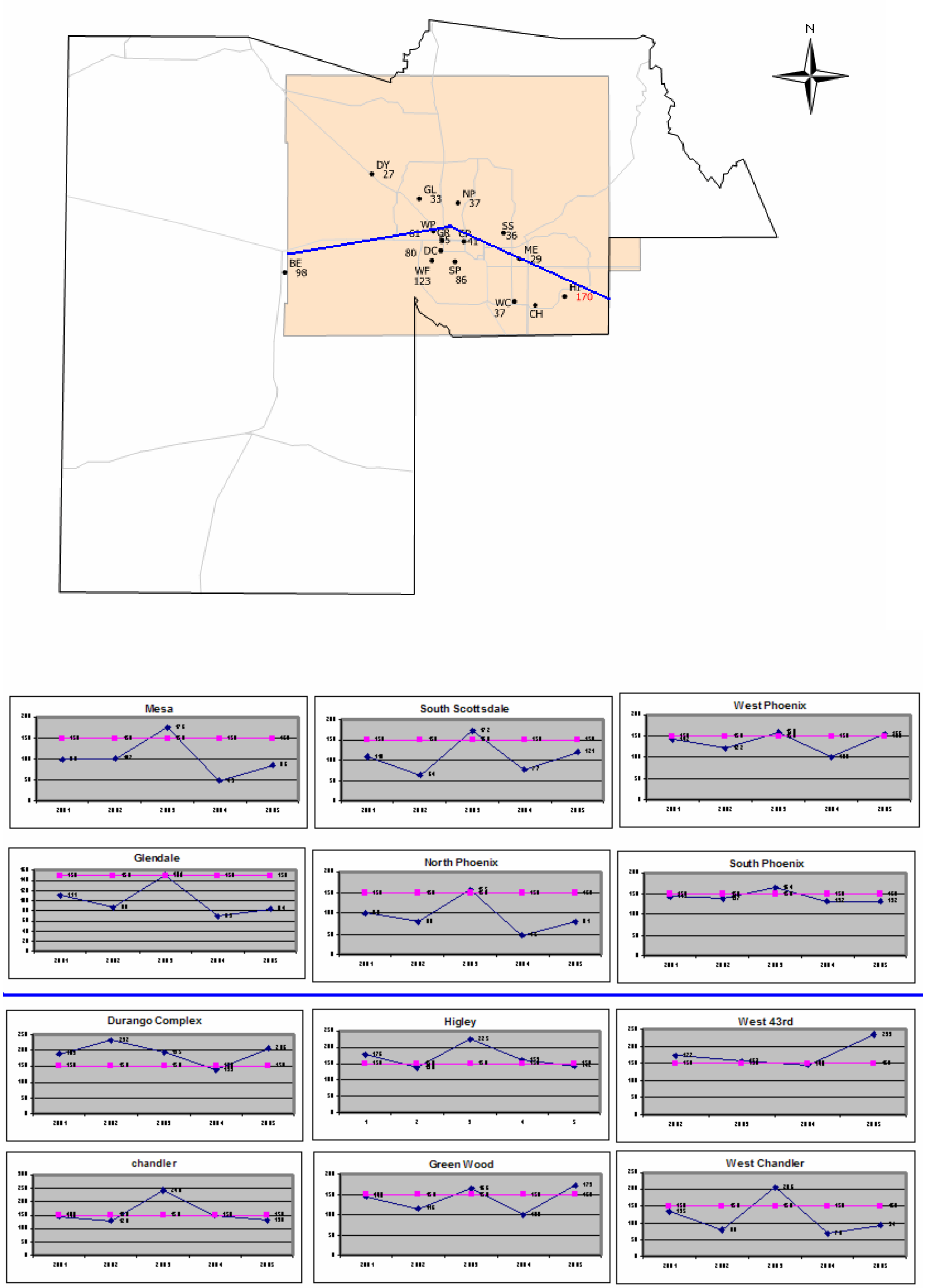


Figure 16. Spatially Distributed Trends of 24-hour PM-10 Highest Values at Maricopa County Monitoring Sites: 2001- March 2006

1.8 Is the nonattainment problem primarily a local one or are regional factors important?

To figure out if regional factors influence the problem in the PM-10 nonattainment area, it is useful to check if there are other nonattainment areas within one day's transport range. Figure 17. shows 24-hour PM-10 nonattainment area counties in the U.S. This figure indicates that the closest nonattainment areas are in southern Arizona and southern California. Analysis of 36-hour back trajectories confirms on the design days (See Attachment II), the PM-10 transport is limited primarily to local and intra-urban transport [6,7].

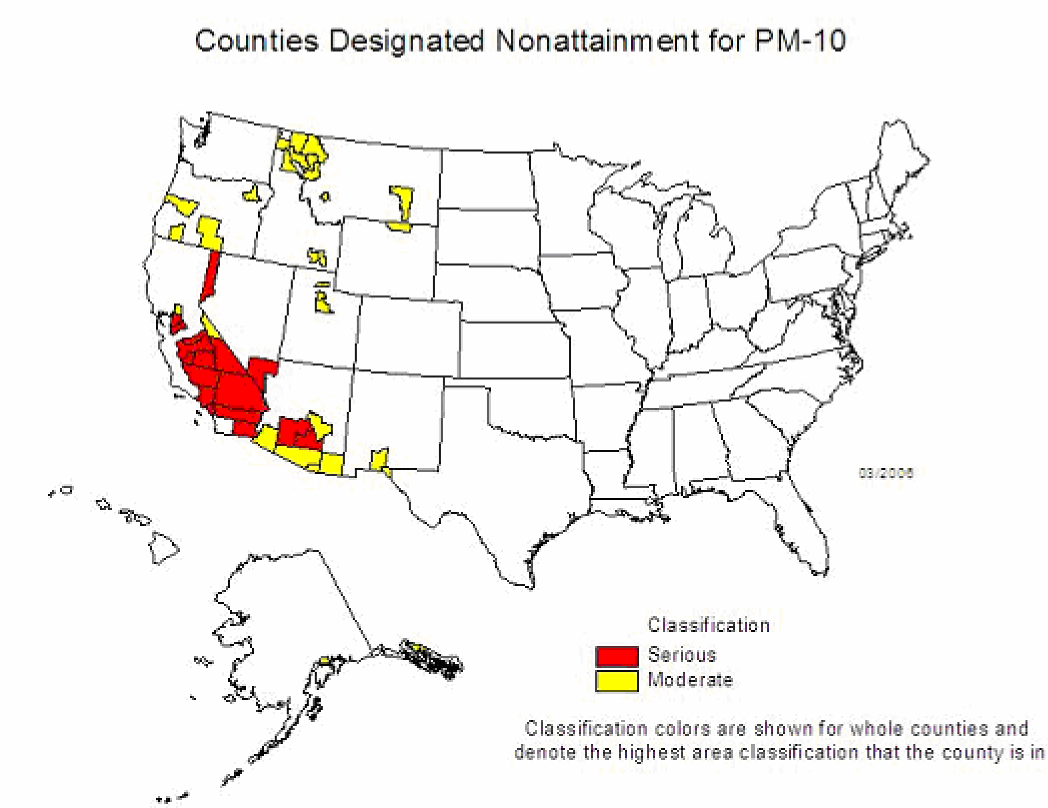


Figure 17. 24-Hour PM-10 Area County Map (source: U.S.EPA, http://www.epa.gov/air/oaqps/greenbk/mappm10.html)

1.9 Are there any distinctive meteorological measurements at the surface or aloft which appear to coincide with occasions with 24-hour daily maxima greater than 154 $\mu g/m^3$?

Identification and classification of high PM-10 days are based on high winds and low winds. The dependence of high PM-10 concentrations on meteorological parameters is explained in more detail in Attachment 1.

References

[1] 2004 Network Review, Air Quality Division, Maricopa County Environmental Services Department, May 2005.

[2] 2005 Network Review, Air Quality Division, Maricopa County Environmental Services Department, May 2006.

[3] Data obtained from Ronald Pope, Air Monitoring Data Coordinator, Maricopa County Air Quality Department, March 2006.

[4] Revised MAG 1999 Serious Area Particulate Plan for PM-10 for the Maricopa County Nonattainment Area, Maricopa Association of Governments, February 2000.

[5] 2002 Periodic Emission Inventory for PM-10, Maricopa County Air Quality Department, Revised March 2006.

[6] Modeling of episodic particular matter events using a 3-D air quality model with fine grid: Applications to a pair of cities in the U.S./Mexico border , Yu-Jin Choi*, Peter Hyde +, and H. J. S. Fernando*, *Environmental Fluid Dynamics Program, Department of Mechanical and Aerospace Engineering, Arizona State University, Tempe, AZ 85285, +Arizona Department of Environmental Quality, Phoenix, AZ 85102, USA, Submitted to Atmospheric Environment, November 15, 2005.

[7] Revised PM-10 State Implementation Plan for the Salt River Area, Technical Support Document, Air Quality Division, Arizona Department of Environmental Quality, June 2005.

ATTACHMENT VII

COMMENTS AND RESPONSES ON THE DRAFT MODELING PROTOCOL IN SUPPORT OF A FIVE PERCENT PLAN FOR PM-10 FOR THE MARICOPA COUNTY NONATTAINMENT AREA, PREPARED BY THE MARICOPA ASSOCIATION OF GOVERNMENTS, JULY 10, 2006

COMMENTS FROM SCOTT BOHNING, EPA REGION 9 (E-mail dated August 29, 2006)

<u>Comment</u>: 2.2.1 Modeling Inventories - In the SIP submittal, it would be desirable to have maps showing the spatial surrogates used to apportion emissions into the modeling grid squares, and/or emission density plots for important source categories. Also, for peak modeling concentration and for other local maxima, it would be desirable to show the percent contribution from each modeled source category.

<u>Response</u>: The following text has been added to the protocol document: Maps showing the spatial surrogates used to apportion emissions into the modeling grids and emission density plots of significant source categories will be included in the Technical Support Document. The percent contribution from each modeled source category will also be provided for the peak modeling concentrations.

<u>Comment</u>: 2.3 Meteorological data - Since AERMOD can use only one meteorological station at a time, exactly which station will be used, or else what is the procedure for choosing?

<u>Response</u>: The following text has been added to the protocol document: The choice of meteorological data to be used to model the Salt River Area will take into consideration the availability and accuracy of meteorological data for December 11-13, 2005; meteorology at the monitors with the highest PM-10 concentrations during this period (i.e., West 43rd Avenue and Durango Complex); and the wind speeds and directions that best simulate the transport of emissions during the modeled event. The PM-10 Source Attribution Study will also provide insights as to the appropriate meteorology to be used as inputs to AERMOD.

<u>Comment</u>: 2.4 Modeling domains - Section number should be 2.4, not 2.3.

<u>Response</u>: This correction has been made.

<u>Comment</u>: 2.4 Modeling domains - It is not clear whether you are relying on idea that the selected modeling domains are representative of other locations in the Maricopa nonattainment, as opposed to just focusing on subareas currently above the NAAQS, for their own sake.

<u>Response</u>: The following text has been added to the protocol document: Due to the diversity and number of PM-10 sources in the Salt River Area, this area is considered to be a worst-case representation of sources throughout the nonattainment area.

<u>Comment</u>: 2.4 Modeling domains - You should repeat ADEQ's original rationale for SRSA domain choice (basically that it covers the main exceedance and emitting areas contributing to those).

Response: The following text has been added to the protocol document: This area has the highest density of PM-10 emissions in the nonattainment area. In addition, all major sources of PM-10 emissions, except unpaved roads, are represented in the area. These sources include: light and heavy dust-generating industries, active agricultural land, active construction sites, vacant lots, and unpaved parking areas. The area also includes four monitors, two of which typically record the highest PM-10 concentrations in the nonattainment area.

Comment: 2.4 Modeling domains - ADEQ used 400 m grids, which seems rather coarse given the small overall domain; you should consider a smaller size for greater resolution.

Response: The following text has been added to the protocol document: While ADEQ used 400 m grids to model the Salt River Study Area, MAG will consider using a smaller size if the MAG PM-10 Source Attribution and Deposition Study recommends this adjustment. The Study will update the PM-10 emissions inventory for the area and perform additional meteorological and particulate matter monitoring during the fall of 2006. A recommendation to reduce the grid size for AERMOD modeling could result from the emissions inventory update and saturation monitoring.

Comment: 2.4 Modeling domains - The protocol states that Greenwood and West Phoenix will be assumed to attain if Durango and West 43rd do, since the latter have higher concentrations. This argument should be bolstered, as it would seem easy to challenge the assumption as not being enough for an attainment demonstration. You should consider the most direct way to meet this criticism, which would be to extend the domain north to include Greenwood and West Phoenix. I understand that this would add to the expense, and that those sites have only a few exceedances. But absent a larger domain, there would have to be a fairly strong argument about source mix near those monitors being similar to that within the SRSA, or some other assurance that region-wide controls will in fact address the exceedances at those monitors.

Response: The following text has been added to the protocol document: Preliminary analyses of monitoring data from the Durango and West Phoenix sites during January and February 2006 indicate that the ratio of PM-2.5 to PM-10 at these two continuous monitors remains relatively constant over the day. This suggests that the high readings at these two monitors are attributable to similar sources. The MAG PM-10 Source Attribution and Deposition Study will confirm this finding through saturation monitoring during November and December 2006. The Technical Support Document will describe the source mix around the Greenwood and West Phoenix monitors and will demonstrate that regionally implemented control measures will eliminate the small number of exceedances at these two monitors north of the Salt River Area. The TSD will provide convincing evidence that attainment of the PM-10 standard within the Salt River Area will also result in attainment at the Greenwood and West Phoenix monitors.

Comment: 2.4 Modeling domains - The protocol states that the rollback areas may be expanded; how would one know if larger rollback areas are needed?

Response: The following text has been added to the protocol document: Prior studies performed by ADEQ and Clark County, Nevada, will be examined to determine the distance of influence for PM-10 sources. In addition, field work being performed by the MAG PM-10 Source Attribution and Deposition Study will provide additional insights into PM-10 deposition rates in the nonattainment area. The size of the modeling domain for the Higley monitor may be increased if these studies and/or aerial and satellite imagery and meteorological data indicate that there are significant contributing sources outside of the 2 km x 2 km modeling area.

Comment: 2.4 Modeling domains - You might note that the single exceedances for the Buckeye and Higley bolster the argument that their cause is local, and so that rollback over a small domain is OK.

Response: The following text has been added to the protocol document: There is significant acreage of vacant disturbed land adjacent to the Higley monitor that is likely to be the primary source of PM-10 emissions that caused the single exceedance at this monitor.

Comment**:** 2.5 Design day selection - How is it possible to have 16 exceedances on the same day at Durango and West 43rd? (Or am I misreading this?)

Response: The text in the protocol document has been changed as follows: Sixteen of the exceedances at Durango and West 43rd occurred on the same day.

Comment: 2.6 Ambient Monitoring Data - It would be good to have some details, or at least an overall description, of how background values will be calculated, and how they will be handled in the attainment demonstration. How local modeled impacts are separated from the urban component and the pristine natural background could have a big effect on how easy it is to show attainment. (See e.g. ADEQ's direction-specific and seasonal average approaches in Salt River and Yuma plans for some ideas.)

Response: The following text has been added to the protocol document: Saturation monitoring to be performed as part of the MAG PM-10 Source Attribution and Deposition Study during the fall of 2006 will assist in quantifying the contribution of the urban transport component to PM-10 concentrations in the Salt River Study Area. Monitoring data from pristine locations such as Organ Pipe National Monument will be utilized to identify the rural background component of the PM-10 transported into the area.

Comment: ATTACHMENT II Model domain selection - 1.6.2 Rollback Modeling Domains A2-23 - It would be good to cite previous ADEQ/Clark County modeling work showing distance of influence of sources; that could provide some justification for the rather small 2 km domain size. A small domain is also justifiable if emissions are spatially uniform, or if relative contributions of source categories remain about the same when domain is expanded; i.e. mix of sources is constant over an area significantly larger than the domain. It would be good to have something explicit on source mix over the larger area. From satellite photographs, it seems pretty clear that Buckeye area is uniform, agricultural sources. The Higley photo is less clear but seems to show a relatively constant proportion of agricultural land and developed area.

Response: The following text has been added to the protocol document and Attachment II: Prior studies performed by ADEQ and Clark County, Nevada, will be examined to determine the distance of influence for PM-10 sources. In addition, field work being performed by the MAG PM-10 Source Attribution and Deposition Study in the fall of 2006 will provide additional insights into PM-10 deposition rates in the nonattainment area. The size of the modeling domain for the Higley monitor may be increased if these studies and/or aerial and satellite imagery and meteorological data indicate that there are significant contributing sources outside of the 2 km x 2 km modeling area.

COMMENTS FROM PETER HYDE, ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY, (Letter dated September 5, 2006)

Comment: 1. PM_{10} from Outside the Salt River Study Area - Two lines of experimental evidence, as well as anecdotal observations and the general failure to meet PM_{10} standards in the Salt River Study Area despite enhanced dust-control regulations and compliance efforts, suggest that an appreciable fraction of elevated PM_{10} concentrations originates from outside the area. Speciated fine and coarse PM concentrations have been analyzed to calculate the percentage of "foreign" PM. This would appear to be about 45%. The calculations are explained in the first table, and are presented in the second.

The calculations follow the IMPROVE method, in which species are given operative definitions. These are followed by the definitions for "% foreign fine", % foreign coarse", and "% foreign PM_{10}", which are based on monitoring arguments.

Species or %	Equation	Assumption or Explanation
Sulfate (SO4)	4.125[S]	All elemental sulfur (S) is from sulfate, which is all ammonium sulfate.
Nitrate (NO3)	1.29[NO3]	All nitrate is ammonium nitrate.
Elemental Carbon (EC)	1.0[EC]	All high temperature carbon is elemental.
Organic Carbon (OC)	1.4[OC]	Average organic molecule is 70% carbon.
Soil	2.2[Al]+2.19[Si]+1.63[Ca]+ 2.42[Fe]+1.94[Ti]	Soil accounts for the assumed molecular formulas for oxides, with corrections for MgO, Na2O, water, and carbonate.
Reconstructed Mass (RCM)	[SO4] + [NO3] + [EC] + [OC] + [Soil]	Reconstructed mass is the sum of SO4, NO3, EC, OC, and Soil
Secondary PM (second)	Second = [SO4] + [NO3] + 0.30* [OC]	
Primary Carbon (prim OCEC)	Prim OCEC = [EC] + 0.70 * [OC]	
% Foreign Fine	% second + % primOCEC + 0.10 * [Soil]	
% Foreign Coarse	% second + % primOCEC + 0.254 * [Soil]	
% Foreign PM_{10}	([PMcoarse]*%foreign coarse + [PMfine]*%foreign fine)/([PMfine]+[PMcoarse])	

The goal here is to estimate what fraction of PM_{10} in PM_{10} the Salt River Study Area comes from outside the area. The value of % foreign PM_{10} is the percentage of ambient PM in the Salt Area from outside the area. The assumptions behind this calculation are that:

1. All sulfate, all nitrate, and 30% of organic carbon are secondary and come from outside the area.

2. All elemental carbon and 70% of organic carbon are primary and come from outside the area.

3. 90% of the fine soil comes from outside the area.

4. 25.4% of coarse soil comes from outside the area. This percentage is the ratio of PMcoarse during the study period between WF and Organ Pipe.

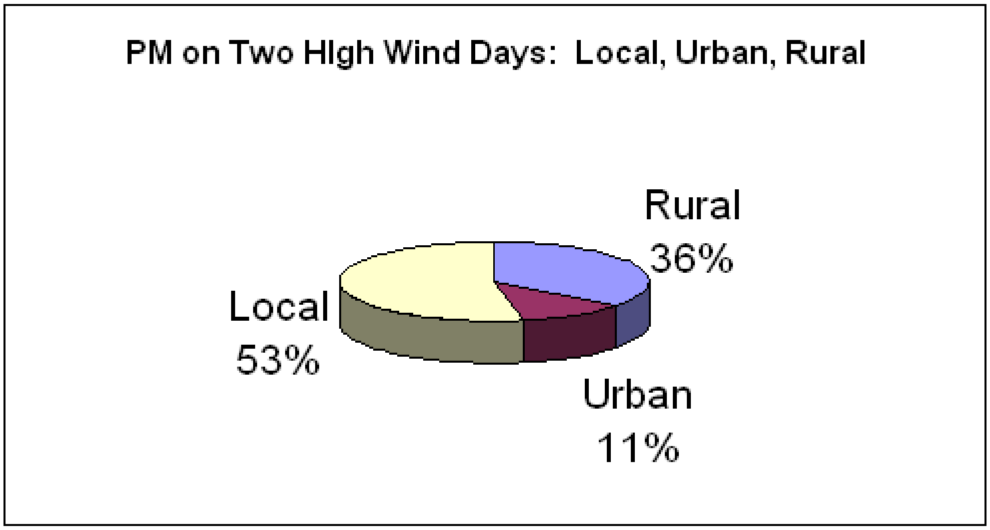
The table below presents the results of these calculations.

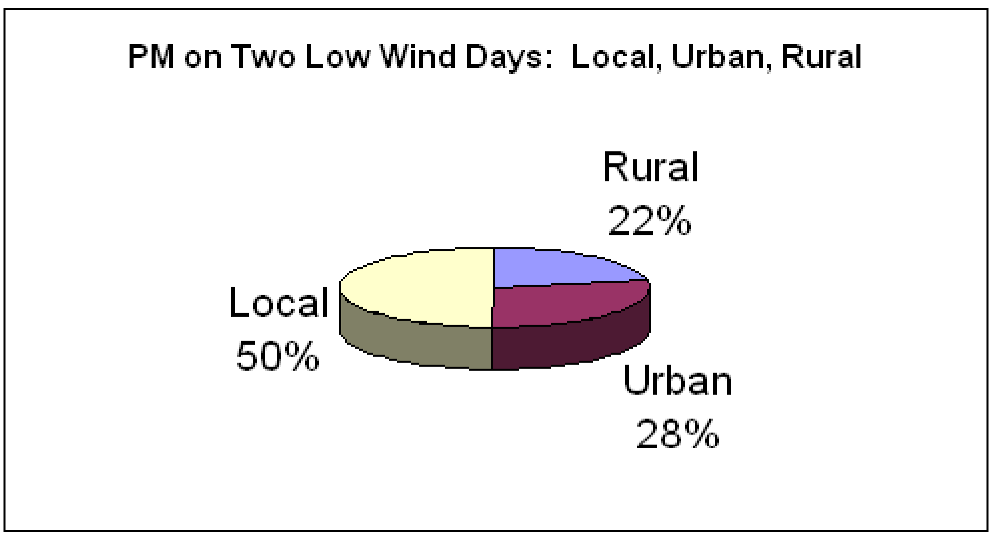
Site	**n**	**Size**	**RCM**	**Second**	**% Second**	**% Soil**	**% Prim OCEC**	**RCM/Mass**	**%Foreign**
			(ug/m3)	**(ug/m3)**	**Percent**	**Percent**	**Percent**	**Percent**	**Percent**
Salt	16	10	43.77	4.76	12.15	82.15	5.70	76.97	**44.08**
Salt	16	C	37.34	2.35	6.50	91.70	1.80	99.39	31.59
Salt	16	F	9.13	2.56	31.20	48.38	20.42	41.28	95.16
West 43rd	17	10	35.33	4.25	12.71	81.63	5.66	71.99	**46.27**
West 43rd	17	C	29.59	2.13	7.40	90.36	2.24	89.93	32.59
West 43rd	17	F	8.39	2.20	28.67	54.74	16.59	44.05	94.53
Supersite	6	10	17.86	2.92	17.02	77.29	5.69	64.82	35.96
Supersite	6	C	15.02	1.44	9.75	88.29	1.96	96.11	20.54
Supersite	6	F	3.82	1.65	45.56	34.61	19.83	30.05	96.54

The second line of evidence, described in the "Technical Support Document for the Revised PM_{10} State Implementation Plan for the Salt River Area", June 2005, page 5-24, is based on continuous PM_{10} monitoring at West 43rd Ave and at two sites east and west of the study area. The percentage of "boundary" PM_{10} from this work is about 50% (46.9 to 50.8% for four design dates), in agreement with the "foreign" PM estimated from the speciated measurements.

Both of these methods have their weaknesses, chiefly in their small sample sizes and in the various assumptions built into the speciation calculations. Nonetheless, they represent our best guess at present of how much of the Salt River PM_{10} comes from outside the area

Yet another facet of these "boundary" and "foreign" contributions needs to be understood. Not all of this PM_{10} comes from the metropolitan Phoenix area; a considerable portion is actually "rural background". Page 6-5 of the above-cited technical support document gives the details for three 2002 design dates: the rural background contribution varies from 31 to 76% of the "boundary" or "foreign" PM_{10} concentrations. The division of PM_{10} measured in the Salt River Study Area into concentrations from local emissions, from urban transport, and from rural background is shown in the figures below. Note that under high wind conditions, the rural contribution is considerably higher than under low wind conditions, consistent with widespread elevated dust levels in a regional wind storm. The protocol needs to describe how the rural background and boundary concentrations will be determined.





If these estimates are taken at their face value, then any modeling analyses of the area, based primarily on dispersion model estimates of the study area emissions, ought to include some means to account for both the rural background and the influx of urban emissions. The only two ways to accomplish this are with a regional, grid-based model or with independent calculations, such as those above, based on monitoring. The protocol should address this issue and explain how this will be done.

Response: We appreciate the time and effort that ADEQ has expended to analyze the PM-10 problem in the Salt River Area. The information provided by ADEQ, along with monitoring to be performed in the fall of 2006 for the MAG PM-10 Source Attribution and Deposition Study, will be useful in quantifying the rural background, urban transport, and local components of PM-10 that will be used in modeling attainment in the Salt River Study Area.

Comment: 2. A Single Day for AERMOD Analysis - While the December 12, 2005, date is an excellent one, there's no reason to believe that the precise wind and vertical ventilation patterns on this date took place on all the other exceedance days. More design dates are needed to assure that the specific controls envisioned and modeled would be equally effective in achieving 2009 compliance in a variety of wind regimes. One way to select these days would be to generate hourly pollution roses for each site and date. A single date from each group of two or more design dates with similar pollution rose patterns should be modeled.

Response: The protocol now proposes that a three day period, December 11-13, 2005, be modeled with AERMOD in the Salt River Study Area. The West 43rd Avenue and Durango Complex monitors exceeded the standard on both December 12 and 13 during this period.

Comment: 3. High Wind PM_{10} Modeling - Attempts to model high-wind PM_{10} concentrations by ADEQ have not been particularly fruitful. There are several reasons for this, but, chief among them is the lack of a sufficiently time-resolved emissions model that faithfully tracks the episodic suspension of dust in the turbulent conditions of high and gusty winds throughout the duration of the high-wind event. The weakness of the emissions model is coupled with the limited resolution of the satellite-image based methods of assigning different erodibilities to different types of land surface. Attempts to simulate concentrations of PM_{10} measured during high winds in the Salt River Study Area and in Yuma have not been successful. This kind of modeling is a sink hole for unproductive work without a firm experimental or theoretical basis to describe the phenomenon. I wish I had some answers for this one, but, the only one I know of would be to close your eyes and use the model in a relative sense. This promises to be a grand headache.

Response: Since the March 10, 2006 has been eliminated due to its classification as a natural event, the only high wind event that is being proposed for modeling is January 24, 2006 at the Higley monitor. The protocol proposes that this event be modeled with rollback, which will significantly reduce the effort required when compared with application of AERMOD.

Comment: 4. Annual PM_{10} Standard - I found no mention of the annual standard in the protocol. The figure below would suggest that some attention is needed along these lines: only 10 of the 40 monitoring years have met the standard.

Response: EPA revoked the annual PM-10 standard on September 21, 2006. (http://epa.gov/pm/standards.html).

Comment: 5. Control Evaluation - Care needs to be exercised here because the rural contribution is largely constant and cannot be reduced. The urban-wide reductions would apply to the urban transport contributions (11 to 28% of the total). Salt River area reductions, which may be proportionally greater than the urban, at least for the industrial and street sweeping sectors, would be calculated separately for input into AERMOD but would be consistent with any urban-wide regulatory strengthening. The protocol should describe how prospective controls will be evaluated to account for the constant rural contribution, the urban transport contribution, and the local Salt River area emissions contribution.

Response: The Technical Support Document for the Five Percent Plan will detail how prospective control measures are evaluated relative to the rural background, urban transport and local Salt River area emissions.

COMMENTS FROM JO CRUMBAKER, MARICOPA COUNTY AIR QUALITY DEPARTMENT (Letter dated August 29, 2006)

General comments:

Comment: The document would benefit from additional detail to standardization throughout the main doc and attachments. (For instance, the same graphic – a map of monitoring sites – appears in the main document and in Attachment II, but with different figure captions.)

Response: Additional effort has been expended to standardize the contents of the document. For example, the titles of the map of monitoring sites in the protocol and Attachment are now identical.

Comment: In several places, the draft document appears to use uncertified (i.e., without QA) monitoring data in its analyses. Maricopa County urges that adequate care be taken to ensure that only certified air quality data (i.e., identical to the data sets provided by MCAQD to EPA/AQS) are used in future analyses undertaken for the Five Percent Plan modeling efforts. Ben Davis, MCAQD Air Monitoring Division Manager, would be happy to provide further details to your staff on how to retrieve this data in the most efficient manner.

Response: The analysis of monitoring data for the modeling protocol began in April 2006 when the data on 2005 and 2006 exceedances were available, but had not been quality assured. All monitoring data were obtained from Ron Pope of the MCAQD Air Monitoring Division. For the Five Percent Plan, certified air quality data from the EPA AQS will be utilized, if it is available. MAG staff has written software to assist in downloading certified air quality data from AQS.

Specific comments:

Comment: 1.2 Conceptual Model (p.2) – First para., next to last sentence: Some quantification of the "small fraction" that PM2.5 comprises on high PM10 days would strengthen the argument proposed here.

Response: The text in the protocol document has been changed to read: The co-located PM-10 and PM-2.5 monitors at the Durango Complex site indicate that PM-2.5 readings on days with high PM-10 concentrations range from 6 to 15 percent of the PM-10 on high wind days and 14 to 22 percent, on low wind days.

Comment: 1.5 Schedule (p.6) – The references to "M6L[1]ink" should be standardized.

Response: This correction has been made.

Comment: 1.5 Schedule (p.6) – The addition of milestone dates in the text description would facilitate comprehension, so the reader does not have to flip back and forth to the following figure to determine dates, e.g.:
"July 2006: 1. Prepare the protocol describing the purpose, background, and procedures to be followed in modeling for the Five Percent Plan for PM10."

Response: This change has been made.

Comment: 1.5 Schedule (p.6) – Figure 1.3 (p.7): The figure caption should read "…PM10".

Response: This correction has been made.

Comment: Schedule (p.8) – Fourth para., first sentence: add the word "the": " A grid-based dispersion model is proposed for application to **the** area analyzed…"

Response: This correction has been made.

Comment: 2.1.1 AERMOD (p.9) – Fourth para., beginning: "AERMOD has a proven track record..". The foundation and purpose of this statement are unclear, as the paragraph then goes on to discuss ISCST3.

Response: As the next sentence in the protocol indicates, ISCST3 is the predecessor of AERMOD. That is, AERMOD is the latest version of ISCST3.

Comment: 2.1.1 AERMOD (p.9) – This section discusses at length the importance of the results of the source attribution and deposition study. A sentence describing the planned timetable for this project would be helpful.

Response: The planned timetable for the MAG PM-10 Source Attribution and Deposition Study (i.e., June 2006-May 2007) has been added.

Comment: 2.1.2 Rollback (p.12) – In the next to last sentence of this section, replace the term "major sources" with "significant sources" to increase clarity.

Response: This change has been made.

Comment: 2.2.2 Five Percent Inventories (pp. 13-14) – In the first sentence, replace the phrase "highest monitors" with "monitors with readings that exceed the 24-hr PM-10 NAAQS" or similar wording, to enhance clarity.

Response: This change has been made.

Comment: 2.2.2 Five Percent Inventories (pp. 13-14) – The last paragraph in 2.2.2 states that the onroad mobile source component of the 2009 emission with committed control measures will provide the basis of a new PM-10 conformity budget and includes road construction in the list of PM-10 sources contributing to this budget. Road construction is included in the Periodic Emissions Inventory for PM-10 within the construction area source category?????

Response: Transportation conformity requirements indicate that road construction must be included in the conformity budget if the source is deemed to be significant in the emissions inventory. In the Serious Area PM-10 Plan, the source was considered to be significant and this emissions category was included in the conformity budget. The protocol document is assuming that road construction will continue to be a significant source of PM-10 emissions in the 2005 PM-10 periodic emissions inventory.

Comment: Table 2-2 (pp 15-16) – The present placement of the table is somewhat confusing, as it precedes any discussions in the text.

Response: The text that references the table has been moved to precede the table.

Comment: 2.3 Meteorological Data (p.17) – The document states that upper air sounding data will be obtained from the Tucson Airport. Isn't Phoenix data available?

Response: Upper air sounding data comparable to the Tucson data is not available in Phoenix. However, sodar monitoring of mixing heights will be performed at the West 43rd Avenue site as part of the MAG PM-10 Source Attribution and Deposition Study.

Comment: 2.4 Modeling Domains (pp. 17-18) – This section is mis-numbered (as 2.3) in the present draft.

Response: This correction has been made.

Comment: 2.4 Modeling Domains (pp. 17-18) – A reference to Figure 2-4 (map of monitoring sites) early in this section would aid readability.

Response: This change has been made.

Comment: 2.4 Modeling Domains (pp. 17-18) – p.17 There is a disconnect between the first sentence: "The Salt River Study Area is shown in Figure 2-1" and the figure caption.

Response: The title of the figure has been changed.

Comment: 2.4 Modeling Domains (pp. 17-18) – p.18 In the second sentence of this section, replace the term "major sources" with "significant sources" to increase clarity.

Response: This change has been made.

Comment: Design Day Selection – (p.18) The bottom paragraph discusses PM-10 readings at the Durango and West 43rd Ave. monitoring sites. The next to last sentence, "Sixteen of these exceedances were recorded…" is unclear as written.

Response: This sentence has been changed to: Sixteen of the exceedances at Durango and West 43rd occurred on the same day.

Comment: Design Day Selection – (p.20) Second para., last sentence. The verb "infer" is used here; perhaps "imply" is more precise.

Response: This sentence has been deleted, because it refers to the March 10 exceedance day, which has been eliminated from consideration for modeling because it has been classified as a natural event by ADEQ.

Comment: 2.6 Ambient Monitoring Data (p.21) – Second paragraph. To be consistent with rest of the document (and most governmental entities), the noun “data” should be treated as plural.

Response: The verbs in this paragraph have been changed.

Comment: Table 2-3 (p.22) – The top row is redundant with the table title, and could be deleted to improve clarity.

Response: This change has been made.

Comment: Figure 2-4 (p.23) – The map includes one Pinal Co. monitoring and should be labeled “PM-10 Monitoring Sites In/near the Maricopa County PM-10 Nonattainment Area as of 12/31/2005.”

Response: This change has been made.

Comment: Figure 2-4 (p.23) – The map could be better scaled to facilitate interpretation of the central-Phoenix area sites; which site names match which symbol are currently unclear.

Response: The draft map has been replaced with one of higher resolution so that the site names are more clearly readable.

Comment: Table 2-4 (p.24) – The table title indicates that the table presents “Design Values for Maricopa County PM-10 Monitors”, but it’s unclear what the remaining columns (2003) through 2006) denote.

Response: Text has been added and the table revised to clarify that the design values are based on the highest PM-10 concentration over the period 2003 through 2005, excluding natural events, where there are at least three years of valid data. Invalid data occurs when less than 75 percent of the monitoring data is recovered in one or more calendar quarters.

Comment: Table 2-4 (p.24) – Units need to identified, in the table title or elsewhere.

Response: Units (i.e., ug/m3) have been added to the title.

Comment: Table 2-4 (p.24) – Why are sites with no data included in the table?

Response: Sites without data did not have a complete year of valid data; these have been deleted from the table.

Comment: Table 2-4 (p.24) – The difference between a blank cell and “N/A” is unclear.

Response: The N/As have been removed from the table.

Comment: Table 2-4 (p.24) – "W.43rd Ave.23" contains a typo.

Response: This correction has been made.

Comment: Table 2-4 (p.24) – In general, the nomenclature for site names, location, etc. should be consistent across all tables and figures.

Response: This change has been made.

Comment: Table 2-4 (p.24) – Additional columns indicating the site operator (as in Table 2-3), and a "comments" column listing opening/closing dates where relevant, would improve readablility. The Salt River site closed 12/31/2002.

Response: The table has been expanded to include a notes column with opening and closing dates.

Comment: Table 2-4 (p.24) – The 2005 network review has been published; the first para. On p.24 should refer the reader to http://www.maricopa.gov/aq/status/REVIEW04.pdf.

Response: This change has been made.

Comment: 3. AERMOD Performance Evaluation (p.25) – Third para., first sentence. Missing period at end of sentence.

Response: This correction has been made.

Comment: 4.2 Identification of Control Measures (p.26) – This section could be strengthened by including some discussion of how the emissions reductions to be achieved by any suggested measure will be estimated.

Response: An additional sentence has been added to indicate that the emission reductions will be based on the latest available information from EPA and other sources (e.g., WRAP Fugitive Dust Handbook).

Comment: References (p.28) – Please update reference [3] to read as follows: 2002 Periodic Emissions Inventory for PM-10 for the Maricopa County, Arizona, Nonattainment Area. Maricopa County Air Quality Department, June 2004 (revised March 2006).

Response: This change has been made.

Comment: APPENDIX A1-A – The 12/12/2005 exceedance at the West Phoenix site (155.0 ug/m3) should be included. Note that this was measured on a 1-6 day (one sample every six days) schedule.

Response: This exceedance is not included in Appendix A1-B, because the West Phoenix site is outside the Salt River Study Area and is not being modeled for the Five Percent Plan for PM-10.

Comment: APPENDIX A1-A – Additionally, there was another exceedance (177.6 ug/m3) at the West Phoenix site on 4/14/06, measured on a daily (hourly) schedule.

Response: The data reviewed for this protocol included March 2005 through March 2006.

Comment: APPENDIX A1-B – PM-10 Exceedance Days the TEMP and DELT columns have the incorrect units. The proper units are degrees Fahrenheit (F).

Response: This correction has been made.

Comment: ATTACHMENT VI – The page numbering in the Table of Contents should include the prefix "A6-", to mach the page numbering throughout the body of the document.

Response: This correction has been made.

Comment: ATTACHMENT VI – (p.A6-3) – The document states "The frequency of 24-hour PM-10 average exceedances varies among the monitors as shown in Table 1. The West 43rd Avenue and Durango Complex sites had the highest number of 24-hour PM-10 exceedances, 13 days, in 2005." The graph (Table 1) is misleading because prior to 2005 all PM-10 monitoring was done on a 1-6 day schedule. In 2005 all of our most elevated sites were converted to daily schedule (hourly). The EPA multiplies any exceedance measured on a 1-6 day schedule by six. There is no multiplier to exceedances on a daily schedule.

Response: The following text has been added to clarify the table: It is important to note that the exceedances prior to 2005 were recorded at monitors that were sampled once every six days. Therefore, each of these exceedances represents an expected daily exceedance rate that is six times the value shown. All monitors that exceeded the standard in 2005, including West 43rd and Durango, have been converted to a daily sampling schedule.

Comment: ATTACHMENT VI – Consider using a graph with two y-axes to better present the data (see following illustrative example).

Response: This change has been made.

Comment: ATTACHMENT I (pp. A1-14 thru A1-16) – An additional note is needed to state the incremented factor or the DELT.

Response: Since the graphs have been changed to the format suggested, the footnote is not needed.

Comment: ATTACHMENT I (pp. A1-14 thru A1-16) – The units of DELT should be in degrees Fahrenheit (F).

Response: This correction has been made.