Air Dispersion Modeling Guidelines

For Oklahoma Air Quality Permits

Prepared by the Engineering Section of the Permitting Unit
Air Quality Division
Oklahoma Department of Environmental Quality

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1. Introduction

This is a guidance document on air dispersion modeling developed by the Air Quality Division (AQD) of the Oklahoma Department of Environmental Quality. The guidance provides assistance to applicants in demonstrating compliance with modeling requirements. These requirements protect the public's health, general welfare, physical property, and the natural environment.

Air dispersion modeling analyses may be required with an Air Quality permit application under Oklahoma Administrative Code (OAC) 252, Chapter 100, Subchapters 8, 31, and 42. This guidance clarifies existing practices, aids the modeler in developing an acceptable analysis, and assists AQD personnel in expediting the review process.

This document relies on modeling guidance contained in the *Guideline On Air Quality Models* as codified in 40 CFR Part 51, Appendix W, as well as guidance issued by the EPA Office of Air Quality Planning and Standards (OAQPS) and EPA Region VI.

The remainder of Sections 1 and 2 address general modeling concepts. Sections 3 and 4 address specific issues in modeling toxic air contaminates (TAC), per OAC 252:100-42, and modeling compliance with the National Ambient Air Quality Standards (NAAQS) and Increment consumption for Title V/Part 70, New Source Review (NSR), and Prevention of Significant Deterioration (PSD) permit applications. Appendix A contains a table of point source model input data (emissions) requirements for PSD and NSR compliance demonstrations. Appendix B provides a derivation for flare modeling guidance. Appendix C contains a checklist for modeling protocol submission. Appendix D contains a checklist for final modeling data submittal.

1.1 What is Air Dispersion Modeling

Air dispersion modeling is a method of predicting the ambient impact of one or more stationary sources of air pollutants. The algorithms used in the models are based both on the known physics of atmospheric processes and on empirical data. The results of an analysis are used by AQD staff to determine if a new or existing source of air pollutants can comply with state and federal maximum ambient concentration limits. The models are used to predict the highest concentrations expected from a source. For that reason, the models are designed to be conservative, i.e., over-predict ambient impacts. Because the models may over-predict the impact in an analysis, a modeled prediction alone does not mean that there will be a condition of air pollution. This prediction is a flag indicating potential air quality violations. AQD staff may require that the source perform more complex modeling or change physical or operational parameters of the source to reduce ambient impacts. If modeling continues to predict a violation, the AQD may require the source to conduct monitoring.

1.2 State and Federal Regulations Requiring Modeling

Various state and federal regulations require modeling. The Oklahoma Administrative Code, Title 252, Chapter 100 (OAC 252:100) codifies air regulations for the AQD. OAC 252:100-8 regulates major sources. Both the federal PSD and NSR construction permit programs and the federal Title V/Part 70 permit program are incorporated in Subchapter 8. These programs require modeling to demonstrate compliance with and to protect the NAAQS and Increment.

OAC 252:100-31 regulates emissions of sulfur (S) compounds from stationary sources in Oklahoma. This subchapter also limits the ambient concentrations of hydrogen sulfide (H_2S) from new and exiting sources and sulfur dioxide (SO_2) from existing sources and new petroleum and natural gas process facility with equipment subject OAC 252:100-31-26(a)(1).

OAC 252:100-42 regulates emissions and impacts of TAC and Areas of Concern (AOC). This subchapter provides the methodology for developing and promulgating Maximum Acceptable Ambient Concentrations (MAAC) for individual TAC. TAC and associated MAAC are listed in Appendix O of OAC 252:100. After an AOC has been designated modeling may be required as part of the compliance strategy for the AOC.

1.3 Levels of Modeling

1.3.1 Screen Modeling

Screening modeling analyses provide conservative estimates of source impacts with a minimum of input. The current EPA approved screening model is AERSCREEN. AERSCREEN is the screening model for AERMOD and replaced use of SCREEN3. The model will produce estimates of regulatory design concentrations using representative meteorological data and terrain data and is designed to produce concentrations that are equal to or greater than the estimates produced by AERMOD.

1.3.2 Refined Modeling

Refined modeling requires more detailed and precise input data and utilizes more complex models in order to provide more accurate estimates of ground level concentrations. Refined modeling may be required if the screening analysis results indicate that predicted concentrations from the evaluated sources could exceed a standard or a guideline. Refined modeling may also be requested if it is determined that a screening analysis will not adequately address the modeling scenario. It is usually the applicant's responsibility to perform refined modeling.

1.4 Acceptable Models

In general, AQD defers to the *Guideline on Air Quality Models*, 40 CFR Part 51, Appendix W on the issue of acceptable models. This document provides guidance on appropriate model applications. The document is updated as EPA approves new models. However, AQD reserves the option to evaluate the use of unapproved models on a case-by-case basis. Depending on circumstance, this evaluation may require concurrence by EPA Region VI and/or public review. The following models may be used as is appropriate.

1.4.1 AERSCREEN

AERSCREEN is the primary single-source screening model available from EPA. The model may be used for point, area, volume, and flare sources.

1.4.2 AERMOD

As of December 9, 2006, the AERMOD modeling system, a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources, has become the primary model used for refined modeling. AERMOD incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. There are two input data processors of the regulatory AERMOD modeling system: AERMET, a meteorological data preprocessor that incorporates planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data preprocessor that incorporates complex terrain using USGS Digital Elevation Data. The model code and supporting documents are not static but evolve to accommodate the best available science. Be sure to check the EPA SCRAM website often for updates.

1.4.3 CALPUFF

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model. The CALPUFF model should be used for long-range impacts (greater than 50 km), visibility (light extinction), and acid deposition in Class I areas. CALPUFF modeling is generally required for PSD source impacts on Class I areas.

1.4.4 Scheffe Tables

The Scheffe Tables are a screening method for predicting 1-hour ozone impacts from VOC dominated sources. Richard Scheffe developed the Scheffe Tables through use of the Reactive Plume Model (RPM). Since promulgation of the 8-hour standard, use of the Scheffe Tables has become questionable. Until EPA publishes guidelines for compliance for individual sources, large sources will be included in available photochemical modeling datasets and will be modeled with the Comprehensive Air Quality Model with extensions (CAMx) to assess impacts and demonstrate compliance with the standard.

1.5 Modeling Protocol

A modeling protocol is generally required prior to performing any refined modeling analysis for PSD and NSR applications. For PSD/NSR applications, the AQD requests that the protocol be available for review prior to pre-application meetings. The applicant should allow one to two weeks for review. If the applicant proposes to use an unapproved model, four to six weeks should be allowed for examination. Upon review, the applicant will receive written notification of acceptance of the modeling approach as well as guidance on any outstanding issues. However, the applicant should be aware that an approved modeling protocol does not necessarily limit the extent of the modeling that will be required to demonstrate compliance with the applicable standards. A general outline for a complete modeling protocol is available in Appendix C. The outline identifies the expected format and content of the submission.

2. Modeling Analysis

2.1 Source Type

2.1.1 Point Source

This is the most common type of source to be modeled. Emissions from point sources are released to the atmosphere through well-defined stacks, chimneys, or vents. Point sources are usually buoyant and have an upward velocity. The following stack parameters are needed to model point sources: emissions, inside diameter, height above ground level, velocity or flow rate, and temperature. Other parameters relating to neighboring structures (height, width, length, and location with respect to the stack) may also be needed to include effects from building downwash.

2.1.2 Area Source

The area source algorithms are used to model low level or ground level releases with no plume rise (e.g., storage piles, slag dumps, and lagoons). The area source may be used to specify a rectangular-shaped area source with arbitrary orientation, an irregularly-shaped polygon of up to 20 sides, a circular-shaped area source (modeled as an equal-area polygon of up to 20 sides).

Area sources use an emission rate per unit area instead of total emissions. Emissions for area sources should be the annual average emissions. The total emissions are divided by the total area in square meters. Detailed guidance for area sources is contained in the *User's Guide for the AMS/EPA Regulatory Model - AERMOD* (EPA-454/B-03-001, 9/2004) and February 2011 Addendum.

Caution: A 10:1 aspect ratio of length to width must be maintained when developing rectangular areas sources. If this ratio is to be exceeded, the area should be subdivided accordingly to achieve the target aspect ratio.

Note: AERMOD has not implemented plume meander for area sources. Please refer to the *AERMOD Implementation Guide* (March 19, 2009) for guidance concerning this issue.

2.1.3 Fugitive Sources

Fugitive dust usually refers to dust put into the air by the wind blowing over roads, fields, or piles. Reentrained dust is put into the air by vehicles traveling over dirt roads or dusty areas. Fugitive emissions include emissions that are not captured and vented through a stack but that are vented to the atmosphere through general building vents. These types of fugitive sources can be modeled as line, area, or volume sources. Fugitive sources modeled as “area” sources must have a significant degree of mechanically generated turbulence (e.g., sand and gravel operations, haul roads).

2.1.4 Volume Source

The volume source algorithms are used to model releases from a variety of industrial sources, such as building roof monitors, multiple vents, and conveyor belts. The following parameters are needed to characterize volume sources: emission rate, release height (h_e), and initial horizontal (σ_{Yo}) and vertical dimensions (σ_{Zo}).

The release height is the center of the volume above ground. Determination of the initial horizontal and vertical dimensions (initial sigmas) are based on the geometry and location of the source. The actual height, width, and depth of the release are used to calculate the initial horizontal and vertical dispersion parameters. Guidance for developing the initial sigmas is contained in Table 3-1 of the *User's Guide for the AMS/EPA Regulatory Model - AERMOD* (EPA-454/B-03-001, 9/2004) and is reproduced below.

The base of the volume source must be square. If the source is not square, model the source as a series of adjacent volume sources. For relatively uniform sources, determine the “Equivalent Square” by taking the square root of the area of the length and width of the volume base.

Table 3-1. Summary of Suggested Procedures for Estimating Initial Lateral Dimensions and Initial Vertical Dimensions for Volume and Line Sources

Type of Source	**Procedure for Obtaining Initial Dimension**
Initial Lateral Dimension (σ_{Yo})	
Single Volume Source	σ_{Yo} = length of side divided by 4.3
Line Source Represented by Adjacent Volume Sources	σ_{Yo} = length of side divided by 2.15
Line Source Represented by Separated Volume Sources	σ_{Yo} = center to center distance divided by 2.15
Initial Vertical Dimension (σ_{Zo})	
Surface-based Source (h_e~0)	σ_{Zo} = vertical dimension of source divided by 2.15
Elevated Source (h_e>0) on or adjacent to a Building	σ_{Zo} = building height divided by 2.15
Elevated Source (h_e>0) not on or adjacent to a building	σ_{Zo} = vertical dimension of source divided by 4.3

2.1.5 Road Emissions

The AQD may require fugitive dust from road emissions to be modeled. If modeling is required, the emissions should be modeled as a volume source.

2.1.5.1 Guidance

The following is some guidance concerning modeling of road emissions.

- Do not include road emissions in permit modeling analyses for short-term averaging periods - periods less than annual.
- Do not include road emissions in permit modeling analyses for an annual averaging period if they will not be generated in association with the transport, storage, or transfer of materials (raw, intermediate, and waste), including sand, gravel, caliche, or other road-base aggregates at the facility.

Volume Source Characterization: Follow the eight steps described in the following paragraphs:

Step 1: Determine the adjusted width of the road. The adjusted width is the actual width of the road plus 6 meters. The additional width represents turbulence caused by the vehicle as it moves along the road. This width will represent a side of the base of the volume.

Step 2: Determine the number of volume sources, N. Divide the length of the road by the adjusted width. The result is the maximum number of volume sources that could be used to represent the road.

Step 3: Determine the height of the volume. The height will be equal to twice the height of the vehicle generating the emissions; rounded to the nearest meter.

Step 4: Determine the initial horizontal sigma for each volume.

- If the road is represented by a single volume, divide the adjusted width by 4.3.
- If the road is represented by adjacent volumes, divide the adjusted width by 2.15.

- If the road is represented by alternating volumes, divide twice the adjusted width, measured from the center point of the first volume to the center point of the next represented volume, by 2.15. Start with the volume nearest to the property line. This representation is often used for long roads.

Step 5: Determine the initial vertical sigma. Divide the height of the volume determined in Step 3 by 2.15.

Step 6: Determine the release point. Divide the height of the volume by two. This point is in the center of the volume.

Step 7: Determine the emission rate for each volume used to calculate the initial horizontal sigma in Step 4. Divide the total emission rate equally among the individual volumes used to represent the road, unless there is a known spatial variation in emissions.

Step 8: Determine the UTM coordinate for the release points. The release point location is in the center of each of the base of the volume. This location must be at least one meter from the nearest receptor. (TNRCC 1999)

2.1.6 Open Pits

The open pit source option is used to model particulate emissions from open pits, such as surface coal mines and rock quarries. The open pit source option uses an effective area for modeling pit emissions, based on meteorological conditions, and then utilizes the numerical integration area source algorithm to model the impact of emissions from the effective area sources. The AERMOD model accepts rectangular pits with an optional rotation angle specified relative to a north-south orientation. The rotation angle is specified relative to the vertex used to define the source location (e.g., the southwest corner). Open pit sources have no plume rise. The parameters needed are the open pit emission rate, the average release height, the lengths of the sides of the open pit, the volume of the open pit, and the orientation angle in degrees from the north. Please note the following:

- As with the area source, an emission rate per unit area is used.
- The release height parameter cannot exceed the effective depth of the pit, which is calculated by the model based on the length, width and volume of the pit.
- A release height of 0.0 indicates emissions that are released from the base of the pit.
- The length-to-width aspect ratio for open pit should be less than 10 to 1.
- Unlike the area source, the open pit cannot be subdivided. Characterize irregularly shaped pit areas by a rectangular shape of equal area.

2.1.7 Pseudo-Point Sources

Fugitive sources and non-standard stacks (stacks or vents with rain caps, and stacks or vents that release emissions horizontally) may be modeled as pseudo-point sources. Nonstandard point sources may have buoyancy or momentum and the modeling parameters used should provide representative impacts. Please refer to the *AERMOD Implementation Guide* (March 19, 2009) for guidance concerning this issue. Tilted stacks can take into account the vertical velocity of the plume using trigonometric factors where appropriate.

2.1.8 Flares

Flares are handled similarly to point sources; however, the heat release is used to calculate plume rise and effective stack diameter. For screening purposes, the flare option in AERSCREEN is acceptable. A flare option is not available in AERMOD. Therefore, in refined modeling, it is necessary to compute equivalent emission parameters to account for the buoyancy of the plume. There are several assumptions made in the AERSCREEN flare option, which form the basis of the equivalent parameter approach. The following parameters are assumed in AERSCREEN:

An ambient temperature of 293 K,
55% of the heat lost due to radiation,
a plume rise calculated from the top of the flame, assuming that the flame is bent 45 degrees from the vertical,
an effective stack exit velocity of 20 meters per second, and
an effective stack exit temperature of 1,273 K.

The stack height and inside diameter are adjusted to account for the flame height and the buoyancy of the plume by the following equations:

$$H_{equiv} = H_{actual} + 0.00128 Q_c^{0.478} \quad \text{(Eq. 1)}$$

$$D_{equiv} = 1.752 x 10^{-4} \sqrt{Q_c} \quad \text{(Eq. 2)}$$

Where:

H_{equiv}	= equivalent height of the flare, m
H_{actual}	= actual height of the stack from the ground, m
Q_c	= flared gas heat release, Btu/hr
D_{equiv}	= equivalent diameter of the flare, m

The derivation for the equations is available in Appendix B. The selection of effective stack parameters could influence the building downwash estimates. Therefore, if building downwash is of a concern then more realistic stack parameters should be evaluated. For this circumstance, please seek individual guidance from AQD.

2.1.9 Building Vents and Open Doors

Vents with a vertical discharge and no impediment to flow may be modeled as point sources. Horizontal vents or stacks with rain caps should be modeled as pseudo-point sources. Open doors may be modeled as pseudo-point sources with a stack height of two thirds (⅔) the total height of the opening. The stack height may be adjusted based on the release height within the building. Please seek specific guidance from the AQD.

2.2 Screening Procedures

2.2.1 Emission Rate

The maximum short-term emission rate should be used to demonstrate compliance with all short term averaging rates. Model emission input data for point sources has been defined by EPA in 40 CFR Part 51, Appendix W, Tables 8-1 and 8-2 and is reproduced in Appendix A.

Note: For equipment that may run under a variety of conditions that affect emission rates and dispersion modeling estimates, a series of screening analyses should be run to determine the worst-case impact. For example, turbines should be evaluated at varying loads and temperatures to determine the worst-case scenarios.

2.2.2 Terrain

If the terrain within five kilometers of the stack rises to more than 20% of the shortest, non-fugitive, on-site stack being modeled, then the terrain feature elevations should be included for the receptor grid. Terrain should be included in all refined modeling.

2.2.3 Met Data

When conducting screening using AERMOD, use the most recent (at least 2006-2010) Integrated Hourly Surface (ISH) data from the National Climatic Data Center (NCDC) and Upper Air (UA) data from the Forecast System Laboratories (FSL) may be used without incorporating data from the Oklahoma Mesonet. However, incorporation of Oklahoma Mesonet data will be required for refined modeling.

2.2.4 GEP Stack Height

Good Engineering Practice (GEP) stack height is the minimum stack height needed to prevent the stack exhaust plume from being entrained in the wake of nearby obstructions. If a proposed stack is below the GEP height, then the plume entrainment must be taken into account by modifying certain dispersion parameters used in air dispersion models. However, if the stack height equals or exceeds the calculated GEP stack height, then the stack height is considered the GEP stack height. Plume entrainment within the wake of nearby obstructions is unlikely and need not be considered when modeling stacks at the GEP stack height. The GEP stack height limitation set forth in OAC 252:100-8-1.5 applies in all cases.

2.2.5 Building Downwash

When one or more structures interrupt the wind flow, an area of turbulence called building downwash is created. Pollutants emitted from a fairly low level (e.g., a roof, vent or short stack) can be caught in this turbulence, affecting their dispersion. Modeling that includes calculations for building downwash gives a more accurate representation of pollutant impact than does modeling that omits consideration of downwash affects.

A building is any physical obstruction to airflow at the modeled facility. A structure is a building or group of buildings determined to be important in downwash considerations. The dominant downwash structure is the structure that renders the highest GEP recommended stack height. If a stack is at GEP or higher, then downwash is not a factor. GEP stack height is calculated according to the following equation.

$$H = h + 1.5L$$

where: H = Recommended stack height.
h = The distance from the highest point on a tier or building to ground level.
L = The lesser of the height or projected width for a particular tier or structure.

AERSCREEN calculates the maximum projected width as the greatest crosswind distance between two points in a building or structure. There are methods of determining the downwash structures and in fact the dominant downwash structure; however, if multiple downwash structures exist, the BPIP-Prime program should be used in conjunction with AERMOD.

2.2.6 Rural/Urban Classification

Dispersing plumes encounter more turbulence in urban areas than in rural areas, due to building wakes as well as the somewhat warmer temperatures in urban areas. For any given set of meteorological conditions, the urban plume dispersion coefficients should be larger than the rural plume dispersion coefficients. The higher coefficients cause an urban plume to spread more rapidly than a rural plume, and hence the maximum ground-level concentration of an urban plume occurs closer to the emission source than it does for a rural plume. (Beychok 1994)

All models allow for the selection of urban or rural dispersion coefficients. Determination of the applicability of urban or rural dispersion is based on land use or population density. The land use method is preferred.

2.2.6.1 Land Use

Circumscribe a 3 km radius circle about the source. If Auer land use types I1, I2, C1, R2, and R3 account for 50 percent or more of the area, select the urban option. Otherwise, use the rural option.

Auer Land Use Categories I1, I2, C1, & R2 (Auer 1978)

Type	Use and Structure	Vegetation
I1	Heavy Industrial	Grass and tree growth extremely rare; <5% vegetation
	Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs	
I2	Light-moderate industrial	Very limited grass, trees almost totally absent; <5% vegetation
	Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs	
C1	Commercial	Limited grass and trees; <15% vegetation
	Office and apartment buildings, hotels;>10 story heights, flat roofs	
R2	Compact Residential	Limited lawn sizes and shade trees; <30% vegetation
	Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways	

2.2.6.2 Population Density

Compute the average population density per square kilometer within the area as defined above. If the density is greater than 750 people/km use the urban option. Otherwise, use the rural option.

2.3 Refined Analysis

2.3.1 Emission Rate

The maximum short-term emission rate should be used to demonstrate compliance with all short term averaging rates. Model emission input data for point sources has been defined by EPA in 40 CFR Part 51, Appendix W, Tables 8-1 and 8-2 and is reproduced in Appendix A.

Note: For equipment that may run under a variety of conditions that may affect emission rates and dispersion modeling estimates, a series of screening analyses should be run to determine the worst-case impact. For example, turbines should be evaluated at varying loads and temperatures to determine the worst-case impact scenario.

2.3.2 Terrain

Terrain data should be included in all refined modeling analyses. Terrain data is available from United States Geological Survey (USGS) as Digital Elevation Modeling (DEM) or National Elevation Dataset (NED) data. The 7.5-minute DEM quadrangles are freely available in the new Spatial Data Transfer Standard (SDTS) format and will need to be converted to the DEM format. The 1/3-Arc Sec NED data is the preferred source for elevation data. NED data can be obtained from the USGS Seamless Data Server (http://seamless.usgs.gov/index.php). Be sure to modify the file format of the NED to GeoTIFF format for use in AERMAP.

Interpolation of receptor and source heights from the DEM data should be based on the current guidance contained in Section 4.4 of the *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)* (EPA-454/B-03-0003, 10/2004) and February 2009 Addendum. AERMAP uses a distance weighted bilinear interpolation method.

Oklahoma has three UTM zones (zones 13, 14, and 15). If the modeling domain crosses a UTM zone, source and receptor coordinates have to be translated to a common zone. The datum on which source coordinates and elevation data are based on must be reported in the application. The Army Corps of Engineers has developed a conversion program, which will translate data to a common zone and will also convert from one datum to another. The program is called Corpscon and may be obtained from the AQD.

2.3.3 Met Data

AQD is now requiring use of 2006-2010 Oklahoma Mesonet data, as on-site data, with NCDC ISH data, and FSL UA data, with all refined air dispersion modeling. AQD is incorporating use of the Oklahoma Mesonet data to help prevent adverse environmental impacts and to promote the use of good science by use of more recent, more accurate, and more representative data. Oklahoma Mesonet data was provided to the AQD courtesy of the Oklahoma Mesonet, a cooperative venture between Oklahoma State University (OSU) and the University of Oklahoma (OU) and supported by the taxpayers of Oklahoma. The Oklahoma Mesonet is a world-class network of meteorological monitoring stations. The Mesonet is unique in its capability to measure a large variety of meteorological conditions at so many sites across an area as large as Oklahoma. Standard Mesonet data includes: air temperature and relative humidity at one and a half meters, wind speed, wind direction, and the standard deviation of wind speed and wind direction at ten meters, the wind speed at two meters, the air temperature at nine meters, rainfall, barometric pressure, solar radiation, soil temperatures, and calibrated soil moisture and temperatures. At each site, these variables are continuously measured and packaged into 5-

minute observations. These 5-minute observations were processed by the AQD into a format that was able to be processed by AERMET. Soil measurements and the air temperature at nine meters were not included in the final data sets developed for use by AERMET. Some of the variables are not used by AERMET at this time but were incorporated into the data sets in hopes that they could be used in the future.

The National Weather Service operates 52 automated weather stations in Oklahoma. These stations usually take atmospheric measurements once every hour. The Oklahoma Mesonet consists of 120 stations with at least one station in each of Oklahoma's 77 counties and measures the variables once every five minutes which provides more frequent and more localized information. Data from the Oklahoma Mesonet will help make more accurate forecasts of ambient impacts from stationary sources located in Oklahoma. A table of the current Oklahoma Mesonet sites is shown in Appendix E along with the assigned surface and upper air sites.

The raw data obtained from the Oklahoma Mesonet came in daily 5-minute data files that contained all of the standard data from all of the sites for that day. The first part of formatting the data was to create a single file for each of the Mesonet sites that contained all of the data from that site. This was done using a Pearl script. The data from each site formatted for use by AERMET. The individual tasks performed on the Mesonet data are listed below:

1. Import Mesonet data (Data not imported: WMAX, TS10, TB10, TS05, TB05, TS30, TA9M & WVEC).
2. Change all missing value codes to -999 (Missing Values: -995,-996,-997,-998,-999).
3. Change the format of the year from YYYY to YY.
4. Calculate the precipitation for each hour. Mesonet precipitation data is the sum of precipitation during the day. To determine the precipitation for a specified period, the difference between that period and the previous period was determined unless it was the first period of the day.
5. Convert time from minutes to hours by dividing the minutes by 60.
6. Change pressure from hPa (mb) to dPa (mb x 10).
7. Resize all columns to a fixed width of 8.
8. Format the variables to the correct number of significant digits as floating point numbers. TAIR, WSPD, WSSD, WDSD, & WS2M each were established with one significant digit. PRES, RELH & WDIR each established with zero significant digits. PAMT was established with 2 significant digits.
9. Arrange all the columns in the correct order (single and multi-level variables).
10. Sort the columns by year, month, day and then hour.
11. Replace all solar radiation values of -1 with zero.

No missing data interpolation was performed for the 5-minute data sets. AERMET should be set to run so that NWS data is used when on-site data is missing so that the most complete data set can be used when conducting the modeling.

Processed Oklahoma Mesonet data should be combined with NCDC ISH data and FSL UA rawinsonde observation (RAOB) data using AERMET to produce the surface and profile files used by AERMOD. NCDC ISH data sites and UA rawinsode data sites were assigned to each

Mesonet site. Generally the closest ISH or UA site was chosen. However, when there were two or more sites that were about the same distance from a Mesonet site, climate regions, topography, meteorology, and other factors were taken into account when designating the applicable ISH or UA data site for the corresponding Mesonet data site. The ISH data sites were reviewed for completeness and if there was a significant amount of missing data then those sites were not considered when assigning them to Mesonet data sites. All UA data was reviewed for missing data, if there was missing data it was replaced using data from a site with similar thermodynamic profiles. Each UA site was assigned a primary and a secondary UA site. When there was a sounding missing from the data it was replaced with a sounding from the primary UA data site. If a sounding was not available from the primary UA data site, then a sounding from the secondary UA site was used.

2.3.4 Selection of Surface Characteristics for Met Data Processing

When using AERMET to prepare the meteorological data for AERMOD, you must input three surface characteristics: Albedo, Bowen Ratio, and Surface Roughness Length. These values should be determined using the AERSURFACE tool version 08009. The guidelines in the *AERSURFACE User's Guide* (EPA-454/B-08-001, 1/2008) should be followed when using the AERSURFACE tool. For facilities wanting to use different surface characteristics and or met data, site-specific surface analysis, sensitivity analysis, and/or meteorological data may be required. The following are AQD's guidance on specific prompts from the AERSURFACE tool:

- "Enter the type of coordinate used to define the center of the study area.
  'UTM' for Universal Transverse Mercator coordinates;
  'LATLON' for Latitude and Longitude coordinates.
  (Note: User responses are not case-sensitive.)"

The user should enter "LATLON" for this question. The user will then be prompted to enter the Latitude (in decimal degrees) and then the Longitude (in decimal degrees), using a negative number for west longitude. The user must also specify the horizontal reference datum (NAD83 or NAD27). The user should use the latitude and longitude of the applicable Mesonet data site as shown in Appendix E. The latitude and longitude for each site is based on the NAD83 horizontal reference datum. Appendix E also contains the call signs of the ISH data sites and the UA data sites to be used with each Mesonet data site.

- "Enter the radius (in km) of the study area used for surface roughness (0.1 – 5.0 km). The recommended default value is 1 km."

The user should enter the default value. If a radius other than the recommended default value of 1km is used, it should be documented and justified in a modeling protocol prior to conducting the modeling.

- "Do you want to define the surface roughness length for multiple sectors?"

The user should enter "N" for this question. When determining the surface characteristics for each Mesonet site the applicant should only define one sector.

- "Define the temporal resolution of surface characteristic outputs (ANNUAL, SEASONAL or MONTHLY). … Enter 'A' for ANNUAL, 'S' for SEASONAL, or 'M' for MONTHLY:"

The user should enter "M" for this question. The temporal resolution of the surface characteristics for each Mesonet site should be determined on a monthly basis.

- "Does the site experience continuous snow cover for most of the winter?"

The user should enter "N" for this question due intermittent snowfall in Oklahoma.

- "Is this site at an airport?"

The user should enter "N" for this question.

- "Is this site in an arid region?"

The user should enter "N" for this question.

- "Characterize the surface moisture condition at the site relative to climatological normals, to be applied for all periods. Enter 'A' for Average, 'W' for Wet, or 'D' for Dry."

The user should run the program three times one for each of the surface moisture conditions (A, W, & D). Then based on the information in Appendix F assign the correct Bowen Ratio based on month and condition to the correct temporal period. To determine the surface moisture conditions for each Oklahoma Mesonet site during each month, percent of normal precipitation graphs for each month were reviewed for the full five years of met data. Based on the precipitation data each site was marked as wet or dry, as applicable. If the data indicated average conditions the period for that site was left blank.

After the applicant determines the surface characteristics to use for the applicable Mesonet site, the applicant should submit all AERSURFACE (.dat) and (.log) files with either the modeling protocol or the modeling submittal.

2.3.5 Nearby Sources

Existing nearby sources are required to be included in PSD and NSR NAAQS and Increment analyses. The AQD allows the use of a modified "10-D Rule" to narrow the list of sources to only those that have the potential to significantly impact the modeling domain. The "10-D Rule" eliminates sources from the modeling review when the source's emissions (TPY) are less than 10 times the distance (in kilometers) from the modeled facility. These sources are designated as background sources and should not be modeled. Stated differently, any minor source (100 TPY or less), which is 10 km or more from the source in question, may be excluded.

Upon request, the AQD will provide a list of sources within a defined radius from a facility that should be included in a modeling review. The list will include stack parameters as reported annually in emission inventories and potential emissions. If required, actual emissions for use in more refined increment consumption modeling will be provided at a later date. All sources and emissions provided to the applicant by AQD should be included in the modeling analysis. For large inventories, the AQD may request that the applicant provide some assistance in obtaining potential and actual emissions for some of the sources to be modeled. This may require the applicant to review permits and permit applications for the sources. Permits usually are available from the AQD in electronic format. The applicant should submit with the application a final list of sources included in the modeling analysis.

2.3.5 Background Monitoring

Background concentrations must be added to PSD and NSR NAAQS analyses. If the modeled impacts from the facility are less than the monitoring de minims levels, ambient monitoring data from the appropriate monitoring sites should be obtained and used by the applicant. Monitoring data should be obtained from the EPA air data web site: http://www.epa.gov/air/data/index.html. Concurrence of the AQD should be obtained on the appropriate monitor location and concentrations. If a monitoring de minimis level is exceeded, the applicant should provide justification for use of existing monitoring based on the guidance provided in the *Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)* (EPA-450/4-87-007, 5/1987). If the facility is unable to meet the guidelines provided, pre-construction ambient monitoring to determine the background concentrations may be required depending on the size and location of the area where the de minimis level is exceeded. Post construction ambient monitoring may also be required or used to show compliance with the NAAQS.

Background concentrations should be based on the monitoring data available for the most recent complete year(s) of data. Background concentrations for short term standards should be based on the highest second highest (H2H) value, except for the PM_{10} 24-hour standard, which should be based on the highest fourth highest (H4H) value from the most recent three years of data, the new NO_2 and SO_2 1-hour standards, and new $PM_{2.5}$ 24-hour standard which should be based on the design values for those standards. Background concentrations for annual standards should be based on the annual mean value, except for PM_{10} which should be based on the average of the annual mean from the most recent three years of data.

For compliance with the recently promulgated 1-hour standards for NO_2 and SO_2 and $PM_{2.5}$ standard, the applicant should follow the current EPA guidance indicated in the following documents which are available on the EPA SCRAM web site:

- *Modeling Procedures for Demonstrating Compliance with the $PM_{2.5}$ NAAQS* (March 23, 2010);
- *Guidance Concerning the Implementation of the 1-hour NO_2 NAAQS for the Prevention of Significant Deterioration Program* and *Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS* (June 29, 2010);
- *Guidance Concerning the Implementation of the 1-hour SO_2 NAAQS for the Prevention of Significant Deterioration Program* and *Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS* (August 23, 2010); and
- *Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS* (March 1, 2011);

2.3.6 GEP Stack Height

The Good Engineering Practice (GEP) stack height limitation of OAC 252:100-8-1.5 applies in all cases. The Building Parameter Input Program Plume Rise Model Enhancements (BPIP-PRIME) should be used for AERMOD.

2.3.7 Receptor Grids

100 meter spacing is usually sufficient for most purposes except preliminary coarse-grid modeling. While Cartesian Grids are preferred, polar grids will be acceptable so long as the receptor distances do not exceed grid spacing requirements. Before a final receptor grid formation may be established, concentrations modeled on an initial coarse grid should be evaluated. Areas of maximum concentration should be established and a fine grid (100 meter spacing) should be used uniformly throughout those areas and extending to 1 kilometer beyond the areas of maximum concentration. It is the applicant's responsibility to demonstrate that the grid is sufficiently compact to identify the maximum concentration for each averaging period.

The receptor grid used should extend far enough to determine the maximum impact from all of the sources at the facility. The receptor grid for each modeling analysis is different due to the local meteorology, terrain, and source makeup. The draft New Source Review Workshop Manual Prevention of Significant Deterioration and Nonattainment Area Permitting (EPA, 10/1990) NSR workshop manual indicates that in general a grid extending out to 10 km will be "adequate to identify areas of maximum concentration. However, the total number of receptors will vary based on the specific air quality analysis performed." AQD has developed a generalized acceptable grid spacing of 100 m out to 1 km, 250 m out to 2.5 km, 500 m out to 5 km, 750 m out to 7.5 km, and 1 km out to 10 km from the facility. Appendix W to 40 CFR Part 51 indicates that maximum impacts occur on calm days as the plumes encounter hills at or near the same height as the stacks. Terrain surrounding a facility should be evaluated to determine if there are hills in the area and if the receptor grid should be extended to include them. The domain for the receptor grid should follow the guidance in Section 2.2.1 of *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)* (EPA-454/B-03-0003, 10/2004) and February 2009 Addendum.

As indicated in the March 1, 2011, clarification memo *Additional Clarification Regarding Applicability of Appendix W Guidance for the 1-hour NO2 NAAQS*,

> "While not common practice in the past, given the more complex analysis procedures associated with the form of the 1-hour NO_2 NAAQS, we deem it appropriate and acceptable in most cases to limit the cumulative impact analysis to only those receptors that have been shown to have significant impacts from a proposed new source based on the initial SIL analysis, assuming that the design of the original receptor grid was adequate to determine all areas of ambient air where the source could contribute significantly to modeled violations."

AQD will allow removal of receptors outside the radius of impact when modeling compliance with the new 1-hour NO_2 and SO_2 NAAQS. However, we still require modeling for other standards to include receptors outside the ROI for all other pollutants and averaging times. Since the NAAQS and Increment analyses include sources which were not included in the significant impact level analyses, modeling using a receptor grid which only includes those receptors at which a significant impact occurs may not ensure that the maximum impact from the "facility" or from other surrounding sources is determined. If the NAAQS or increment is violated, then the facility can show that the modification does not have a significant impact at those receptors and a permit may be issued for that modification. If there is a "potential" exceedance of a standard in a particular area, whether it is due to the facility or not, AQD can use the modeling to determine the potential causes of the potential exceedance and can take measures to mitigate or alleviate those issues.

2.3.8 NO_2 Modeling Guidance

Section 5.2.4 of Appendix W, 40 CFR Part 51, implements a tiered screening approach to obtain estimates of NO_2 impacts from point sources for PSD and NSR analyses. Use of Tier I (conversion of all NO_X to NO_2) and Tier II (Use of the ambient ratio method (ARM)) of this multi-tiered approach are approved by AQD for all NO_2 modeling. Use of a Tier III analysis by an applicant should be approved by AQD prior to modeling submittal and requires submittal of an official protocol to EPA for approval. Modeling for the new 1-hour standard should comply with the EPA's June 28, 2010, and March 1, 2011, memos referenced in section 2.3.5. Modeling for the annual NAAQS and Increment are still required since these standards have not been vacated.

2.3.9 $PM_{2.5}$/PM_{10} Modeling Guidance

The determination of PM_{10} design values is briefly discussed Appendix W, 40 CFR Part 51 and is explained in the *PM_{10} SIP Development Guideline* (EPA-450/2-86-001, 1986). Since incorporation of the new $PM_{2.5}$ standards, the modeled design concentration for the $PM_{2.5}$ 24-hour NAAQS should be based on EPA's March 23, 2010, *Modeling Procedures for Demonstrating Compliance with the $PM_{2.5}$ NAAQS*. Impacts for the 24-hour PM_{10} NAAQS are still based on the highest sixth high (H6H) concentration over a 5-year period at any receptor. The MULTYEAR keyword in the control (CO) pathway in the AERMOD model can be used to obtain the H6H concentration in 5 years. However, compliance with the PM_{10} 24-hour Increment are based on the Highest Second Highest (H2H) value and compliance with the PM_{10} Annual Increment is based on the highest annual average. Modeling for the PM_{10} annual NAAQS is no longer required since it has been vacated. The PM_{10} surrogate policy is no longer accepted to show compliance with the $PM_{2.5}$ NAAQS.

2.3.10 SO_2 Modeling Guidance

Modeling for the new 1-hour standard should comply with the EPA's August 23, 2010, and March 1, 2011, memos referenced in section 2.3.5 and if applicable the March 25, 2011, guidance memo *Area Designations for the 2010 Revised Primary SO_2 NAAQS*. Modeling for the 24-hour standard and annual NAAQS is not required since they were vacated. However, modeling for compliance with the 3-hr NAAQS and Increment is required since they were not vacated.

2.3.11 Ozone Modeling Guidance-Sheffe Tables

Previously, under guidance from EPA, AQD has conservatively required the use of the Scheffe tables to evaluate ozone impacts from PSD sources with VOC emissions greater than 100 tons per year. The Scheffe tables are a tabular result of photochemical modeling conducted with the

Reactive Plume Model, and VOC speciation assumptions for both rural and urban areas. The tables are used as a conservative screening analysis.

Since promulgation of the 8-hour standard use of the Scheffe Tables has become questionable. Until EPA publishes guidelines for compliance for individual sources, large sources will be included in available photochemical modeling datasets and will be modeled with CAMx to assess impacts and demonstrate compliance with the standard. However, an applicant may be required to conduct more extensive modeling using models such as the CAMx, or the Community Multiscale Air Quality Modeling System (CMAQ), which are acceptable for determining ozone impacts.

2.3.12 Deposition

The *Addendum to the User's Guide For The AMS/EPA Regulatory Model – AERMOD* (EPA-454/B-03-001, 10/2004) explains the deposition algorithms and specifies the source parameters for use of deposition. All additional data used for an air dispersion analysis that incorporates deposition should be provided to and approved by AQD.

The wet deposition option should not be used for regulatory modeling analysis. Wet deposition is not a guideline feature of AERMOD. Per EPA guidance, dry gas deposition is not usually required for PM_{10} evaluations because of negligible settling velocities. However, AQD reserves the right to request a dry deposition evaluation for any PM emissions, but most specifically for TAC.

3. State Required Modeling

3.1 TAC Modeling

The AQD as part of the compliance strategy for an AOC may require owners or operators of applicable stationary sources within an AOC to perform ambient air modeling for the TAC of concern to demonstrate compliance with the applicable MAAC established per OAC 252:100-42. All applications of air quality modeling shall be based on the applicable models, databases, and other requirements specified in Appendix W of 40 CFR Part 51. Modification or substitution of approved models will be considered on a case-by-case basis. Owners or operators of facilities located in an AOC shall not be required to demonstrate compliance with the TAC MAAC within the boundaries of their facilities.

3.2 SO_2 Modeling

Subchapter 31 controls emissions of sulfur compounds from stationary sources. Per OAC 252:100-31-7(a) emissions of SO_2 from any existing facility or any new petroleum and natural gas process facility with equipment subject to OAC 252:100-31-26(a)(1) shall not impact existing ambient air concentrations of SO_2 at any given point by more than:

	Concentration	
Averaging period	**$\mu g/m^3$**	**ppmv**
5-minute	1,300	0.50
1-hour	1,200	0.46
3-hour	650	0.25

	Concentration	
Averaging period	**μg/m³**	**ppmv**
24-hour	130	0.05
Annual	80	0.03

Per OAC 252:100-31-7(b) emissions of hydrogen sulfide (H_2S) from any new or existing source shall not result in a 24-hour average ambient air concentration H_2S at any given point of 0.2 ppmv or greater.

Facilities with emissions of SO_2 and/or H_2S are required to show compliance with the ambient standards using EPA approved atmospheric dispersion models. Facilities must demonstrate compliance with the ambient air standards taking into account emissions from all the sources at the facility. Per OAC 252:100-31(c) the ambient standards do not apply to ambient air concentrations or impacts occurring on the property from which such emission occurs, providing such property, from the emission point to the point of any such concentration, is controlled by the person responsible for such emission. Ambient impacts calculated from modeling compliance with Subchapter 31 shall not exceed the new SO_2 1-hour NAAQS unless additional modeling is submitted indicating compliance with the NAAQS using the 5-year average of the 99th-percentile of the annual distribution of daily maximum 1-hour concentrations.

3.3 TV (Major Source/Modification) Modeling

Criteria pollutant modeling to demonstrate NAAQS and Increment compliance is required of any new major source or modification to an existing major source with a net increase of 100 TPY of a single criteria pollutant. NAAQS modeling should be conducted by evaluating the total source impact with an appropriate monitored background concentration added. Concurrence from the AQD should be obtained on which monitor will provide adequate background concentrations. Increment modeling should be conducted by evaluating the total source impact of increment consuming sources. Temporary sources of emissions are not required to be included in the modeling analyses as long as they do not impact a Class I area or an area where an applicable increment is known to be violated.

Note: If modeling demonstrates that the source will exceed PSD monitoring thresholds, post-construction monitoring though not specifically required under the Title V/Part 70 regulations may be required under the general authorizations of the DEQ. This decision will be made on a case-by-case basis and will depend on the extent of the impact area as well as the extent to which the NAAQS or Increment are threatened by the source.

4. PSD Modeling

A checklist for PSD modeling submittals is available in Appendix D.

4.1 Significant Impact Level (SIL) Analysis

A significant impact analysis is the first level of modeling performed in a PSD evaluation. For each applicable pollutant, the analysis must include all stack emissions and quantifiable fugitive emissions resulting from the proposed source. For a proposed modification, the determination includes contemporaneous emissions increases and decreases, with emissions decreases input as negative emissions in the model. The EPA allows for the exclusion of temporary emissions such as those associated with construction. The applicant is required to compare results to the SIL as defined in 40 CFR Part 51.165(b)(2). If the highest modeled concentration over five years of meteorological data or the Highest First High (H1H) is less than or equal to the SIL, then the demonstration is complete. Per EPA guidance, the source is not considered to cause or contribute to an exceedance of the NAAQS or consume increment if the modeled impact is at or below the SIL. If the highest modeled concentration is greater than the SIL, the applicant is required to perform additional refined modeling or reduce the impact to below the SIL. If the modeled impacts remain above the SIL, a ROI is defined. The ROI extends from the center of the proposed facility to the farthest receptor that shows an impact at or above the significance levels.

4.2 Increment Analysis

For compliance with the Increment, the design concentration for the short term standards (3-hour and 24-hour) is based on the H2H and the highest annual average for the annual standards. The AQD maintains a record of county/area baseline dates; however, a database of increment consumers is not available. Upon request, the AQD will provide the applicant with a list of sources within the ROI plus fifty kilometers. The list will include stack parameters as reported annually in emission inventories and potential emissions. Increment consuming sources will be indicated in the list. When there are a large number of increment consuming sources, the AQD may request assistance from the applicant in determining actual emissions. The applicant should always submit a list of sources included in the modeling analysis with the application.

A Tiered approach is taken towards modeling increment consuming sources. For Tier 1, the increment consuming sources should be modeled using their potential emissions. If the applicant is unable to show compliance with the increments using potential emissions, the next tier would be used. For Tier II, actual emissions may be used to show compliance with the Increment. The applicant should make a separate request for actual emissions from sources. Actual emissions are generally based on actual operating hours, production rates, and types of materials stored, processed, or combusted and will be determined based on a two year average. For short term increments, if no hourly data exists for a particular source then actual emissions should be based on potential emissions.

If the proposed site is within 50 kilometers of another state, the applicant must obtain a list of sources to be evaluated from that state. If the ROI extends into another state, the applicant must confirm whether a baseline has been set in that region or not. If a baseline date has been set, the applicant must follow the guidance provided by that state for the evaluation of increment consumption within that state.

The following excerpt is taken directly from the draft New Source Review Workshop Manual Prevention of Significant Deterioration and Nonattainment Area Permitting (EPA, 10/1990).

> "For a PSD increment analysis, an estimate of the amount of increment consumed by existing point sources generally is based on increases in actual emissions occurring since the minor source baseline date. The exception, of course, is for major stationary sources whose actual emissions have increased (as a result of construction) before the minor source baseline date but on or after the major source baseline date. For any increment-consuming

(or increment-expanding) emissions unit, the actual ***emissions limit***, ***operating level***, and ***operating factor*** may all be determined from source records and other information (e.g., state emission files), when available, reflecting actual source operation. For the annual averaging period, the change in the actual ***emissions rate*** should be calculated as the difference between:

- *the current average actual* **emissions rate**, and
- *the average actual* **emissions rate** *as of the minor source baseline date (or major source baseline date for major stationary sources).*

In each case, the average rate is calculated as the average over the previous 2-year period (unless the permitting agency determines that a different time period is more representative of normal source operation). For each short-term averaging period (24 hours and less), the change in the actual ***emissions rate*** for the particular averaging period is calculated as the difference between:

- *the current maximum actual* **emissions rate***, and*
- *the maximum actual* **emissions rate** *as of the minor source baseline date (or major source baseline date for applicable major stationary sources undergoing construction before the minor source baseline date).*

In each case, the maximum rate is the highest occurrence for that averaging period during the previous 2 years of operation."

If an exceedance of the Increment is identified and the applicant has a significant impact on that receptor, the situation must be rectified. The AQD cannot issue a permit that violates the Increment.

4.2.1 Increment Analysis for Class I Areas

EPA requires an analysis of the increment for Class I areas if a facility is within 300 km of a Class I area. This analysis is a Tiered analysis to reduce the burden on the applicant. For the first tier, facilities can model the potential emissions increases from the modification using AERMOD out to 50 km. If the impact is below the proposed EPA Class I SIL then the facility is not required to do any additional modeling. Receptors only need to be placed along the direction of the Class I area. For the second tier, if applicants exceed the SIL at 50 km using AERMOD, the applicant can model the potential emission increases from the modification using CALPUFF and a single year of meteorological data. The facility only needs to model the receptors of the affected Class I area. If the impact is below the proposed EPA Class I SIL, then the facility is not required to do any additional modeling. However, if the facility still exceeds the SIL then CALPUFF modeling must be conducted using the current three year meteorological data set.

4.3 NAAQS Analysis

Upon request, the AQD will provide the applicant with a list of sources within the ROI plus fifty kilometers. The list will include stack parameters as reported annually in emission inventories and potential emissions. All sources and emissions provided to the applicant by AQD should be included in the modeling analysis. For large inventories, the AQD may request that the applicant provide some assistance in obtaining potential emissions for some of the sources to be modeled. This may require the applicant to review permits and permit applications for the sources. Permits may be available from the AQD electronically. The applicant should submit with the application a list of sources included in the modeling analysis.

If the proposed site is within 50 km of another state, the applicant must obtain a list of sources to be evaluated from that state. If the radius of impact extends into another state, the applicant must follow the guidance provided by that state for the evaluation of the NAAQS within that state.

Compliance with short term NAAQS (3-hour, 8-hour, and 24-hour) is based on the H2H for all pollutants except for PM_{10}, $PM_{2.5}$, and the new 1-hour NO_2 and SO_2 NAAQS. Compliance with the annual standard is based on the highest annual average concentration. For PM_{10}, compliance with the NAAQS 24-hours average is based on the H6H over five years of data. For $PM_{2.5}$ and the new 1-hour NO_2 and SO_2 NAAQS, follow the guidance mentioned in section 2.3.5.

4.4 Visibility Analyses

Visibility impact analyses are required for the area around the affected source and may be required for any Class I areas near the affected source. The current EPA guidance document *Workbook for Plume Visual Impact Screening and Analysis (Revised)* (EPA 454/R-92-023, 10/1992) describes how to evaluate plume visual impacts including use of the visual impact screening model (VISCREEN). VISCREEN can be applied in two successive screening modes without the need for extensive input. If screening calculations using VISCREEN demonstrate that during the worst case meteorological conditions a plume is imperceptible then it will not cause an adverse impact on visibility. To determine if a plume is perceptible, the impacts are compared to the screening criteria. If impacts exceed the screening criteria, further analysis may be required. The screening criteria are a change in relative sensitivity (ΔE) value of 2.0 and a green absolute contrast value of 0.05.

4.4.1 Class II Area Impact Analysis

VISCREEN should be used to address the visibility impacts of a source or modification within a Class II area. There are three levels of visibility analyses the first level is using the emissions and the default parameters defined by the program. The second level is where the user selects certain variables to get a more realistic view of the predicted impacts. The third level is a comprehensive analysis using PLUVUE.

Since VISCREEN was developed to over predict impacts and EPA's guidance was developed mainly for Class I areas, AQD was concerned that the low screening levels would cause applicants to be required to perform Level 3 analyses for Class II areas. In an effort to prevent potentially time consuming efforts which would not lead to a real improvement in air quality, AQD has determined that the Class II levels should be approximately three times the Class I screening levels. Therefore, when comparing visibility impacts in a Class II area the following levels should be used: a ΔE value of 6.0 and a green absolute contrast value of 0.15. If a Level 1 and Level 2 analysis exceeds these levels a comprehensive analysis should be performed.

There are some sensitive areas located in Class II areas. If your facility is located within 40 km of one of these sensitive areas, the boundaries of the sensitive area should be used in the visibility analysis. The sensitive areas include but are not limited to the following areas:

Sensitive Area	**Nearest Town**
Tall Grass Prairie Preserve	Pearson, OK
Great Salt Plains State Park	Jet, OK
Lake Optima Wildlife Refuge	Hardesty, OK
Rita Blanca National Grassland	Felt, OK
Black Kettle National Grassland	Strong City, OK
Arbuckle's Lake Recreational Area	Sulfur, OK
Tishomingo Wildlife Refuge	Tishomingo, OK
Deep Fork Wildlife Refuge	Okmulgee, OK
Ouachita National Forest	Big Cedar, OK
McCurtain County Wildlife Refuge	Hochatown, OK
Little River Wildlife Refuge	Idabel, OK

Notes: When using VISCREEN and there are no sensitive receptors located within 40 km of the facility, the distance from the source to the observer and the distance from the source to the closest Class I area boundary should be set equal to each other and can arbitrarily be set to 1 km, and the distance from the source to farthest Class I area boundary may be arbitrarily established as 10 km. NO_2 emissions can be estimated using the ambient ratio method.

4.4.2 Class I Area Impact Analysis

Sources seeking PSD permits in the state of Oklahoma may be required to perform an impact analysis on a Class I area. Contact information for the federal land managers (FLM) for a Class I area may be obtained from the AQD. There is one Class I area in the state of Oklahoma: The Wichita Mountain Wildlife Preserve managed by the U.S. Fish and Wildlife Service (FWS). Two Class I areas are located in the state of Arkansas (these areas may require evaluations from sources locating in eastern Oklahoma): The Caney Creek Wilderness Preserve and The Upper Buffalo Wilderness Preserve managed by the Forest Service (FS). Another Class I area is located in the state of Missouri (this area may require evaluations from sources locating in northeastern Oklahoma): The Hercules-Glade Wilderness Preserve managed by the FS. Visibility analyses for Class I areas located more than 50 km from a facility must be performed using CALPUFF.

The National Parks Service (NPS) - Air Resources Division, FWS - Air Quality Branch and FS - Air Quality Program have produced a guidance document entitled *Federal Land Managers' Air Quality Related Values Workgroup (Flag) Phase I Report – Revised* (2010). The guidance set forth in this document is followed in PSD review for Class I area impacts. This document may be obtained electronically from the AQD or the participating agencies.

Appendix A

Point Source Model Input Data For NAAQS Compliance in PSD Demonstrations

40 CFR Part 51, Appendix W, Table 8-2

Averaging Time	Emission Limit X (#/MMBTU)[1]	Operating Level X (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., 8,760 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 8:00 a.m. to 4:00 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 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 yet in operation or that have not established an appropriate factor, continuous operation (i.e., 8,760 hours) should be used.

[9] Generally, the ambient impacts from non-nearby background sources can be represented by air quality data unless adequate data does not exist.

Appendix B

Flare Calculation Derivation

An American Petroleum Institute (API) publication (API 1969) provides a correlation for flame length as a function of the flared gas heat release. This equation was republished and modified for a flame tilted at a 45° angle from the vertical in Fundamentals of Stack Gas Dispersion (Beychok 1994). The resulting equation provides the vertical height of a flare stack flame.

$$H_{fv} = 0.00128 Q_c^{0.478} \qquad \text{(Eq. 1)}$$

Where: H_{fv} = flare stack flame vertical height vector, m
Q_c = flared gas heat release, Btu/hr

The equivalent height is then found by summing the height of the flare with the vertical height vector of the flame.

$$H_{equiv} = H_{actual} + 0.00128 Q_c^{0.478} \qquad \text{(Eq. 2)}$$

Where: H_{equiv} = The equivalent height of the flare, m
H_{actual} = The actual height of the stack from the ground, m

The total plume rise is derived from the initial vertical velocity momentum and the initial buoyancy momentum. The buoyancy momentum is essentially a measure of the sensible heat emissions from the stack. However, the AERMOD program does not allow the user to directly input the heat release. The flux parameter is instead calculated from the temperature differential between the stack and ambient air. This is a problem for a flare analysis because the heat release is diminished due to radiant heat losses. Therefore, an equivalent diameter is chosen, which when combined with the temperature assumption will force the program to calculate a buoyancy flux that accounts for the radiant heat loss. This equivalent diameter is back calculated from the Briggs' buoyancy flux parameter, which is derived from the sensible heat emissions.

The Briggs' buoyancy flux parameter may be expressed by the following equivalent expressions, with the reasonable assumption that combusted stack gas has essentially the same molecular weight and specific heat as ambient air.

$$F = \frac{g v_s d^2 (T_s - T_a)}{4 T_s} \qquad \text{(Eq. 3)}$$

and

$$F = \frac{g Q s}{(\pi \, c_{pa} T_a \rho_a)} \qquad \text{(Eq. 4)}$$

Where: $g = 9.807$ m/sec^2
v_s = stack exit velocity, m/sec
d = stack exit diameter, m

Appendix B

Qs = stack sensible heat emission, cal/sec
c_{pa} = specific heat of ambient air, cal/(g-°C)
ρ_a = ambient air density, g/m^3
T_a = ambient air temperature, K
T_s = stack gas temperature, K
F = buoyancy flux parameter, m^4/sec^3

Since g and π are constants and since c_{pa}, T_a, and ρ_a are essentially constants, it may be inferred that the buoyancy flux parameter is a measure of the sensible heat emissions from the stack. So, assuming an average annual temperature of 68°F or 20°C, the equation 4 may be restated as follows:

$$F = (3.677x10^{-5})Qs(\text{cal/sec}) \qquad \text{(Eq. 5)}$$

and

$$F = (2.574x10^{-6})Qs(\text{BTU/hr}) \qquad \text{(Eq. 6)}$$

where: F = buoyancy flux parameter, m^4/sec^3

Because 55% of the heat is assumed to be lost due to radiation, equation 6 is adjusted specifically for flares.

$$F = (1.158x10^{-6})Qc(\text{BTU/hr}) \qquad \text{(Eq. 7)}$$

The equivalent diameter may now be found as a function of Q by setting equal equations 7 and 3 and solving for the radius (r).

$$D_{equiv} = 1.752x10^{-4}\sqrt{Qc(\text{BTU/hr})} \qquad \text{(Eq. 8)}$$

where: D_{equiv} = the equivalent diameter of the flare, m

The above guidance is consistent with guidance issued by the Ohio EPA. It differs from EPA Region V and Louisiana DEQ guidance with the inclusion of the stack height adjustment; however, this adjustment is made within the AERSCREEN flare option and is appropriate for the AERMOD point source option. It differs from Texas guidance with the inclusion of the stack height adjustment and an ambient temperature assumption. Texas guidance is based on an ambient temperature of 35°C. Because the ambient temperature is important in both the heat release calculation and the equivalent diameter calculation, care should be exercised in modeling specific events. Rather than using the standard guidance above, specific events should be modeled with equivalent parameters based on the actual ambient conditions.

Appendix C

Modeling Protocol Submission Outline

1. **Project Overview**
   - **1.1.** Discussion of Plant Processes
   - **1.2.** References to Regulatory Applicability
2. **Emission Sources**
   - **2.1.** Source Description
   - **2.2.** Location of Emissions
   - **2.3.** Pollutants
3. **Impact Assessment Tools and Techniques**
   - **3.1.** Description of Models to Be Used
     - **3.1.1.** Version
     - **3.1.2.** Circumstance of use, i.e., SCREEN3 for initial toxic MAAC screening
   - **3.2.** Discussion on Use of Ratio method
   - **3.3.** Discussion on Merging Stacks
   - **3.4.** For PSD Analysis
     - **3.4.1.** Discussion on Use of "10 D Rule"
     - **3.4.2.** Discussion on method relied upon for Ozone impact assessment
     - **3.4.3.** Discussion on Use of Visibility Screening Tools for Class I Areas
4. **Area Maps and Facility Plot Plans (if available)**
   - **4.1.** Clearly Marked Scale
   - **4.2.** Property Lines
   - **4.3.** Fence Lines
   - **4.4.** Downwash Structures
   - **4.5.** True-north Arrow
   - **4.6.** UTM Coordinates for Vertical and Horizontal Borders
   - **4.7.** Reference UTM Coordinates and Locations of All Emission Points
   - **4.8.** Identification of Sensitive Receptors and Nearest Residents (Area Map Only)
   - **4.9.** For NAAQS Analysis Identification of Any State/Local/On-site Ambient Air Monitoring Sites Used for Background Concentrations
   - **4.10.** For PSD Applications, identification of PSD Class I areas within 300 km (186.4 miles) or within 10D of emissions.
   - **4.11.** Provide an Accompanying List of Structures with UTM Locations, Heights, and Model Labels or ID Numbers
5. **Modeling Emission Inventory**
   - **5.1.** On-Site Sources
     - **5.1.1.** Assumptions
     - **5.1.2.** Table of Source Input Data (if available)
   - **5.2.** Discussion of Methodology for Obtaining Off-property Modeling Parameters
6. **Air Quality Monitoring Data For NAAQS Compliance**
   - **6.1.** Discussion on the Issue of Pre-construction Monitoring
   - **6.2.** Proposed Monitoring Sites
   - **6.3.** Discussion on How Concentrations will be Adjusted for Background Sources Specifically Modeled.
7. **Land Use**

- **7.1.** Auer Land-use Analysis
- **7.2.** Copy of USGS map (if used in analysis)

8. Receptor Grid
- **8.1.** Discussion on Grid Type
- **8.2.** Discussion on Receptor Placement
- **8.3.** Diagram of Each Grid Type w/Labels

9. Meteorological Data
- **9.1.** Surface Station
- **9.2.** Upper-air Station
- **9.3.** Period of Record

10. Discussion on Method of Evaluation Additional Impacts Analysis (PSD)

11. Class I Area Impacts Analysis (PSD)
- **11.1.** Discussion of Method of Analysis
- **11.2.** AQRV of concern

Appendix D

Final Submission Outline

12. Project Overview
- **12.1.** Discussion of Plant Processes
- **12.2.** References to Regulatory Applicability

13. Emission Sources
- **13.1.** Source Description
- **13.2.** Location of Emissions
- **13.3.** Table of Emissions by Source and Pollutants

14. Impact Assessment Tools and Techniques
- **14.1.** Description of Models Used
  - **14.1.1.** Version
  - **14.1.2.** Circumstance of use, i.e., SCREEN3 for initial toxic MAAC screening
- **14.2.** Discussion on Use of Ratio method
- **14.3.** Discussion on Collocating Sources
- **14.4.** For PSD Analysis
  - **14.4.1.** Discussion on Use of "10 D Rule"
  - **14.4.2.** Discussion on method relied upon for Ozone impact assessment
  - **14.4.3.** Discussion on Use of Visibility Screening Tools for Class I Areas

15. Area Maps and Facility Plot Plans
- **15.1.** Clearly Marked Scale
- **15.2.** Property Lines
- **15.3.** Fence Lines
- **15.4.** Downwash Structures
- **15.5.** True-north Arrow
- **15.6.** UTM Coordinates for Vertical and Horizontal Borders
- **15.7.** Reference UTM Coordinates and Locations of All Emission Points
- **15.8.** Identification of Sensitive Receptors and Nearest Residents (Area Map Only)
- **15.9.** Identification of Any State/Local/On-site Ambient Air Monitoring Sites Used for Background Concentrations
- **15.10.** For PSD Applications, identification of PSD Class I areas within 300 km (186.4 miles) or within 10D of emissions.
- **15.11.** Provide an Accompanying List of Structures with UTM Locations, Heights, and Model Labels or ID Numbers

16. Air Quality Monitoring Data
- **16.1.** Discussion on the Issue of Pre-construction Monitoring
- **16.2.** Summary Information for Monitoring Sites
  - **16.2.1.** Year of Observation
  - **16.2.2.** Location
  - **16.2.3.** First, Second, and Fourth High Concentrations
  - **16.2.4.** Annual Arithmetic Mean Concentration
- **16.3.** Discussion on How Concentrations will be Adjusted for Background Sources Specifically Modeled.

17. Modeling Emission Inventory
- **17.1.** On-Site Sources

Appendix D

17.1.1. Assumptions
17.1.2. Table of Source Input Data
17.2. Background Sources for NAAQS and Increment Modeling
17.2.1. Discussion of Methodology for Obtaining Off-property Modeling Parameters
17.2.2. "10 D Rule" Table
17.2.2.1. All Sources Within 50 km
17.2.2.2. UTM Coordinates
17.2.2.3. Distance from Significant Impact Radius
17.2.2.4. Total Emissions
17.2.3. Table of Source Modeling Parameters

18. Land Use
18.1. Auer Land-use Analysis
18.2. Copy of USGS map (if used in analysis)

19. Receptor Grid
19.1. Terrain
19.1.1. Discussion on Terrain for Individual Receptors
19.1.2. For PSD Applications Attach Contour Plots
19.2. Design
19.2.1. Discussion on Grid Type
19.2.2. Diagram of Each Grid Type w/Labels

20. Meteorological Data
20.1. Surface Station
20.2. Upper-air Station
20.3. Period of Record

21. Modeling Results
21.1. Summary Table for Each Pollutant
21.1.1. Listing Standard, (NAAQS, Increment, or MAAC)
21.1.2. Listing Monitored Background Concentrations
21.2. For Each Standard, Receptor Grid Plots w/Appropriate Concentration
21.3. For PSD Applications, Area Plot w/Concentration Contour Plot

22. Additional Impacts Analysis (PSD)
22.1. Discussion on Method of Evaluation
22.2. Evaluation Results on Growth, Soils and Vegetation

23. Class I Area Impacts Analysis (PSD)
23.1. Discussion of Method of Analysis
23.2. Results of Analysis on effect on AQRV

24. Attached Disks of All Model Input and Output files

Appendix E – Mesonet Site Information & ISH and FLS Sites for each Mesonet Site

STID	NAME	CITY	COUNTY	LAT	LONG	ELEV	SFCS	UAS
ACME	Acme	Rush Springs	Grady	34.8083	-98.0233	397	KCHK	OUN
ADAX	Ada	Ada	Pontotoc	34.7985	-96.6691	295	KADH	OUN
ALTU	Altus	Altus	Jackson	34.5872	-99.3381	416	KLTS	OUN
ALV2	Alva	Alva	Woods	36.7082	-98.7097	439	KAVK[2]	OUN
ANTL	Antlers	Antlers	Pushmataha	34.2244	-95.7006	179	KAQR	FWD
APAC	Apache	Apache	Caddo	34.9142	-98.2922	440	KFSI	OUN
ARD2	Ardmore	Ardmore	Carter	34.1926	-97.0857	266	K1F0[1]	FWD
ARNE	Arnett	Arnett	Ellis	36.0720	-99.9031	719	KGAG	AMA
BEAV	Beaver	Beaver	Beaver	36.8025	-100.5301	758	KLBL	DDC
BESS	Bessie	Bessie	Washita	35.4019	-99.0585	511	KCSM	OUN
BIXB	Bixby	Bixby	Tulsa	35.9631	-95.8662	184	KRVS	OUN
BLAC	Blackwell	Blackwell	Kay	36.7544	-97.2545	304	KPNC[4]	OUN
BOIS	Boise City	Boise City	Cimarron	36.6926	-102.4971	1267	KDHT	AMA
BOWL	Bowlegs	Bowlegs	Seminole	35.1716	-96.6312	281	KADH	OUN
BREC	Breckinridge	Breckinridge	Garfield	36.4120	-97.6939	352	KWDG	OUN
BRIS	Bristow	Bristow	Creek	35.7805	-96.3540	239	KOKM	OUN
BUFF	Buffalo	Buffalo	Harper	36.8313	-99.6410	559	KWWR[3]	DDC
BURB	Burbank	Burbank	Osage	36.6346	-96.8105	301	KPNC[4]	OUN
BURN	Burneyville	Burneyville	Love	33.8938	-97.2692	228	KGLE	FWD
BUTL	Butler	Butler	Custer	35.5915	-99.2706	520	KCSM	OUN
BYAR	Byars	Byars	Garvin	34.8497	-97.0033	345	KPVJ	OUN
CALV	Calvin	Calvin	Hughes	34.9924	-96.3342	234	KADH	OUN
CAMA	Camargo	Camargo	Dewey	36.0287	-99.3465	589	KGAG	OUN
CARL	CB Lake	Orlando	Payne	36.1473	-97.2859	293	KSWO	OUN
CENT	Centrahoma	Centrahoma	Coal	34.6090	-96.3331	208	KAQR	OUN
CHAN	Chandler	Sparks	Lincoln	35.6528	-96.8041	291	KCUH	OUN
CHER	Cherokee	Cherokee	Alfalfa	36.7481	-98.3627	362	KAVK[2]	OUN
CHEY	Cheyenne	Cheyenne	Roger Mills	35.5462	-99.7279	694	KCSM	AMA
CHIC	Chickasha	Chickasha	Grady	35.0324	-97.9145	328	KCHK	OUN
CLAY	Clayton	Clayton	Pushmataha	34.6566	-95.3260	186	KMLC	OUN
CLOU	Cloudy	Cloudy	Pushmataha	34.2232	-95.2487	221	K4O4	SHV
CLRM	Claremore	Claremore	Rogers	36.3211	-95.6462	207	KGCM	OUN
COOK	Cookson	Marble City	Cherokee	35.6800	-94.8490	299	KTQH	SGF
COPA	Copan	Copan	Washington	36.9099	-95.8855	250	KBVO	SGF
DURA	Durant	Durant	Bryan	33.9208	-96.3203	197	KDUA	FWD
ELRE	El Reno	El Reno	Canadian	35.5485	-98.0365	419	KF28	OUN
ERIC	Erick	Erick	Beckham	35.2049	-99.8034	603	KCSM	AMA
EUFA	Eufaula	Eufaula	McIntosh	35.3032	-95.6571	200	KMLC	OUN
FAIR	Fairview	Fairview	Major	36.2635	-98.4977	405	KJWG	OUN
FITT	Fittstown	Fittstown	Pontotoc	34.5521	-96.7178	350	KADH	OUN
FORA	Foraker	Foraker	Osage	36.8405	-96.4278	330	KBVO	OUN
FREE	Freedom	Freedom	Woodward	36.7256	-99.1423	530	KAVK[2]	DDC
FTCB	Fort Cobb	Fort Cobb	Caddo	35.1489	-98.4661	422	KCHK	OUN
GOOD	Goodwell	Goodwell	Texas	36.6018	-101.6013	997	KGUY	AMA
GRA2	Grandfield	Grandfield	Tillman	34.2392	-98.7444	341	KFDR	OUN
GUTH	Guthrie	Guthrie	Logan	35.8489	-97.4798	330	KGOK	OUN
HASK	Haskell	Haskell	Muskogee	35.7480	-95.6405	183	KMKO	OUN
HECT	Hectorville	Hectorville	Okmulgee	35.8416	-96.0024	243	KOKM	OUN
HINT	Hinton	Hinton	Caddo	35.4844	-98.4815	493	KJWG	OUN
HOBA	Hobart	Hobart	Kiowa	34.9897	-99.0528	478	KHBR	OUN
HOLD	Holdenville	Holdenville	Hughes	35.0707	-96.3560	280	KADH	OUN
HOLL	Hollis	Gould	Harmon	34.6855	-99.8333	497	KAXS	AMA

Appendix E – Mesonet Site Information & ISH and FLS Sites for each Mesonet Site

STID	NAME	CITY	COUNTY	LAT	LONG	ELEV	SFCS	UAS
HOOK	Hooker	Hooker	Texas	36.8552	-101.2255	912	KLBL	DDC
HUGO	Hugo	Hugo	Choctaw	34.0308	-95.5401	175	KPRX	SHV
IDAB	Idabel	Idabel	McCurtain	33.8301	-94.8803	110	K4O4	SHV
INOL	Inola	Inola	Rogers	36.1425	-95.4507	190	KGCM	SGF
JAYX	Jay	Jay	Delaware	36.4821	-94.7829	304	KGMJ	SGF
KENT	Kenton	Kenton	Cimarron	36.8294	-102.8782	1322	KCAO	AMA
KETC	Ketchum Ranch	Velma	Stephens	34.5289	-97.7648	341	KDUC	OUN
KIN2	Kingfisher	Kingfisher	Kingfisher	35.8543	-97.9544	323	KF28	OUN
LAHO	Lahoma	Lahoma	Major	36.3844	-98.1114	396	KEND	OUN
LANE	Lane	Lane	Atoka	34.3088	-95.9972	181	KAQR	FWD
MADI	Madill	Lebanon	Marshall	34.0358	-96.9439	232	K1F0	FWD
MANG	Mangum	Mangum	Greer	34.8359	-99.4240	460	KAXS	OUN
MARE	Marena	Coyle	Payne	36.0643	-97.2127	327	KSWO	OUN
MAYR	May Ranch	Freedom	Woods	36.9871	-99.0111	555	KAVK[2]	DDC
MCAL	McAlester	McAlester	Pittsburg	34.8823	-95.7810	230	KMLC	OUN
MEDF	Medford	Medford	Grant	36.7924	-97.7458	332	KWDG	OUN
MEDI	Medicine Park	Medicine Park	Comanche	34.7292	-98.5694	487	KFSI	OUN
MIAM	Miami	Miami	Ottawa	36.8883	-94.8444	247	KJLN	SGF
MINC	Minco	Minco	Grady	35.2723	-97.9555	430	KF28	OUN
MRSH	Marshall	Marshall	Logan	36.1169	-97.6069	311	KWDG	OUN
MTHE	Mt Herman	Smithville	McCurtain	34.3107	-94.8228	285	KMEZ	SHV
NEWK	Newkirk	Newkirk	Kay	36.8981	-96.9104	366	KPNC[4]	OUN
NEWP	Newport	Ardmore	Carter	34.2281	-97.2014	283	K1F0	FWD
NINN	Ninnekah	Ninnekah	Grady	34.9677	-97.9520	356	KCHK	OUN
NOWA	Nowata	Delaware	Nowata	36.7437	-95.6080	206	KBVO	SGF
NRMN	Norman	Norman	Cleveland	35.2361	-97.4649	357	KOUN	OUN
OILT	Oilton	Oilton	Creek	36.0313	-96.4975	255	KCUH	OUN
OKCE	OKC East	OKC	Oklahoma	35.4723	-97.4641	355	KTIK	OUN
OKCN	OKC North	OKC	Oklahoma	35.5556	-97.5107	362	KPWA	OUN
OKCW	OKC West	OKC	Oklahoma	35.4711	-97.5825	366	KOKC	OUN
OKEM	Okemah	Okemah	Okfuskee	35.4317	-96.2627	263	KOKM	OUN
OKMU	Okmulgee	Morris	Okmulgee	35.5821	-95.9147	205	KOKM	OUN
PAUL	Pauls Valley	Pauls Valley	Garvin	34.7155	-97.2292	291	KPVJ	OUN
PAWN	Pawnee	Pawnee	Pawnee	36.3611	-96.7699	283	KSWO	OUN
PERK	Perkins	Perkins	Payne	35.9987	-97.0483	292	KSWO	OUN
PORT	Porter	Clarksville	Wagoner	35.8257	-95.5598	193	KMKO	OUN
PRYO	Pryor	Adair	Mayes	36.3691	-95.2714	201	KGCM	SGF
PUTN	Putnam	Putnam	Dewey	35.8990	-98.9604	589	KJWG	OUN
REDR	Red Rock	Red Rock	Noble	36.3559	-97.1531	293	KSWO	OUN
RETR	Retrop	Willow	Washita	35.1228	-99.3600	538	KCSM	OUN
RING	Ringling	Ringling	Jefferson	34.1937	-97.5881	283	K1F0	FWD
SALL	Sallisaw	Sallisaw	Sequoyah	35.4382	-94.7981	157	KJSV	LZK
SEIL	Seiling	Seiling	Woodward	36.1903	-99.0403	545	KWWR[3]	OUN
SHAW	Shawnee	Shawnee	Pottawatomie	35.3649	-96.9482	328	KSNL	OUN
SKIA	Skiatook	Skiatook	Osage	36.4153	-96.0371	282	KTUL	OUN
SLAP	Slapout	Slapout	Beaver	36.5975	-100.2619	774	KPYX	DDC
SPEN	Spencer	Spencer	Oklahoma	35.5421	-97.3415	373	KTIK	OUN
STIG	Stigler	Stigler	Haskell	35.2653	-95.1812	173	KJSV	LZK
STIL	Stillwater	Stillwater	Payne	36.1209	-97.0953	272	KSWO	OUN
STUA	Stuart	Stuart	Pittsburg	34.8764	-96.0698	256	KMLC	OUN
SULP	Sulphur	Sulphur	Murray	34.5661	-96.9505	320	KPVJ	OUN
TAHL	Tahlequah	Tahlequah	Cherokee	35.9724	-94.9867	290	KTQH	SGF

Appendix E – Mesonet Site Information & ISH and FLS Sites for each Mesonet Site

STID	NAME	CITY	COUNTY	LAT	LONG	ELEV	SFCS	UAS
TALI	Talihina	Talihina	LeFlore	34.7107	-95.0115	204	KMLC	LZK
TIPT	Tipton	Tipton	Tillman	34.4397	-99.1376	387	KFDR	OUN
TISH	Tishomingo	Tishomingo	Johnston	34.3326	-96.6790	268	KADM	FWD
VANO	Vanoss	Vanoss	Pontotoc	34.7915	-96.8438	320	KADH	OUN
VINI	Vinita	Centralia	Craig	36.7754	-95.2209	236	KCFV	SGF
WALT	Walters	Walters	Cotton	34.3647	-98.3203	308	KLAW	OUN
WASH	Washington	Washington	McClain	34.9822	-97.5211	345	KOUN	OUN
WATO	Watonga	Watonga	Blaine	35.8419	-98.5262	517	KJWG	OUN
WAUR	Waurika	Waurika	Jefferson	34.1678	-97.9882	283	KDUC	FWD
WEAT	Weatherford	Weatherford	Custer	35.5083	-98.7751	538	KCSM	OUN
WEBB	Webbers Falls	Webbers Falls	Muskogee	35.4730	-95.1321	145	KMKO	OUN
WEBR	Webbers Falls	Webbers Falls	Muskogee	35.4890	-95.1233	145	KMKO	OUN
WEST	Westville	Westville	Adair	36.0110	-94.6450	348	KSLG	SGF
WILB	Wilburton	Wilburton	Latimer	34.9009	-95.3481	199	KMLC	OUN
WIST	Wister	Wister	LeFlore	34.9843	-94.6878	143	KMEZ	LZK
WOOD	Woodward	Woodward	Woodward	36.4233	-99.4168	625	KWWR[3]	DDC
WYNO	Wynona	Wynona	Osage	36.5181	-96.3422	269	KBVO	OUN

STID – Mesonet Station ID; LAT, LONG – Latitude and Longitude in NAD83; ELEV – Elevation is in meters; SFCS – ISH Surface Station Call Identifier; UAS – Upper Air Station Call Identifier.

[1] – 2007 for K1F0 must be replaced with 2007 for KADM.

[2] – 2010 for KAVK must be replaced with 2010 for KP28.

[3] – 2009 for KWWR must be replaced with 2009 for KGAG.

[4] – 2010 for KPNC must be replaced with 2010 for KWLD.

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	6									2	0	0	7									2	0	0	8		
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**
ACME	D	D					D							D	W		W	W		W			D		D					
ADAX		D					D		D					D				W	W				D		D		W			
ALTU	D	D				D	D					W		D	W						D	D	D		D					
ALV2	D	D						W	D	D	D	W		D	W			W					D	W	D					
ANTL			W			D	D	D	D					D					W				D		D		W			
APAC	D	D		D			D							D	W		W	W		W	D		D		D					
ARD2	D	D				D	D							D				W					D		D		W			
ARNE	D	D		D							D	W			W						D	D	D		D		D			
BEAV	D	D		D							D	W			W				D		D	D	D	W	D		D			
BESS	D	D									D	W		D	W			W					D		D	W			D	
BIXB		D							D	D								W	W		W		D				W	W		
BLAC	D	D							D	D	D			D	W			W					D			W				W
BOIS	D	D		D	D			W			D	W					D		D	D	D	D	D		D			D		
BOWL		D							D					D				W	W				D		D					
BREC	D	D							D	D	D			D	W			W					D			W				W
BRIS	D	D							D	D				D				W	W				D		D			W		
BROK			W				D							D									D		D		W			
BUFF	D	D		D				W			D	W			W						D	D	D	W	D		D			
BURB	D	D							D	D								W					D			W				W
BURN		D				D	D							D				W					D				W			
BUTL	D	D									D	W			W							D	D		D	W			D	
BYAR		D												D			W	W	W				D		D					
CALV		D					D		D					D				W	W				D		D		W			
CAMA	D	D		D							D	W			W						D	D	D		D		D		D	
CARL	D	D			D				D	D				D				W	W				D							W
CENT		D				D	D	D	D					D				W	W				D		D		W			
CHAN	D	D							D	D				D				W	W				D		D					
CHER	D	D						W	D	D	d			D	W			W					D	W	D					W
CHEY	D	D		D							D	W			W						D	D	D		D		D		D	
CHIC	D	D												D	W		W	W		W			D		D					
CLAY		D					D	D						D	D				W	W			D		D		W			
CLOU			W				D	D						D					W				D		D		W			
CLRM		D							D	D								W	W		W		D				W	W		W
COOK		D											W		D				W				D				W	W		
COPA		D							D	D								W		D			D							W
DURA			W			D	D	D						D				W	W				D		D		W			

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	6									2	0	0	7									2	0	0	8		
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**
ELRE	D	D												D	W			W		W			D		D					
ERIC	D	D		D							D	W		D	W						D	D	D		D		D		D	
EUFA		D													D			W	W	W			D		D		W			
FAIR	D	D							D	D	D			D	W			W					D	W	D					W
FITT		D				D	D	D	D					D				W	W				D		D		W			
FORA	D	D							D	D								W					D							W
FREE	D	D						W	D	D	D	W		D	W						D		D	W	D		D			
FTCB	D	D												D	W			W		W	D		D		D					
GOOD	D	D		D	D						D	W			W		D		D	D	D	D	D		D		D	D		
GRA2	D	D		D		D	D							D				W					D		D					
GUTH	D	D							D	D				D	W			W	W				D		D					
HASK		D																W	W	W			D				W	W		
HECT		D							D					D				W	W				D		D		W	W		
HINT		D									D			D	W			W		W			D		D					
HOBA	D	D					D				D	W		D	W			W			D		D		D				D	
HOLD		D												D				W	W				D		D		W			
HOLL	D	D		D		D						W		D	W							D	D		D					
HOOK	D	D		D							D	W			W		D		D	D	D	D	D		D		D	D		
HUGO			W			D	D	D	D					D									D		D		W			
IDAB			W		D		D							D									D		D		W			
INOL		D								D								W	W		W		D				W	W		
JAYX		D								D					D			W					D				W			
KENT		D		D	D			W			D	W							D	D	D	D	D		D			D		
KETC		D					D							D			W	W					D		D					
KIN2	D	D								D				D	W			W					D		D					
LAHO	D	D							D	D	D			D	W			W					D	W	D					W
LANE		D				D	D	D	D					D				W	W				D		D		W			
MADI		D				D	D							D				W					D		D		W			
MANG	D	D				D	D				D	W		D	W						D	D	D		D				D	
MARE	D	D			D				D	D				D				W	W				D							
MAYR	D	D							D		D	W		D	W						D		D	W	D		D			
MCAL		D					D	D	D					D	D			W	W	W			D		D		W			
MEDF	D	D							D	D	D			D	W			W					D	W		W				W
MEDI	D	D		D			D							D	W			W		W	D		D		D					
MIAM		D							D	D								W					D				W			
MINC	D	D												D	W		W	W		W			D		D					

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	6									2	0	0	7									2	0	0	8		
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**
MRSH	D	D			D				D	D				D	W			W	W				D		D					W
MTHE			W				D							D	D								D		D		W			
NEWK	D	D							D	D	D				W			W					D			W				W
NEWP		D				D	D							D				W					D		D					
NINN	D	D												D	W		W	W		W			D		D					
NOWA		D							D	D								W		D			D					W		W
NRMN	D	D												D	W		W	W	W				D		D					
OILT	D	D							D	D				D				W	W				D					W		
OKCE	D	D												D	W		W	W	W				D		D					
OKCN	D	D								D				D	W		W	W	W				D		D					
OKCW	D	D												D	W		W	W	W				D		D					
OKEM		D							D					D				W	W				D		D		W	W		
OKMU		D							D					D				W	W	W			D		D		W	W		
PAUL		D												D			W	W	W				D		D					
PAWN	D	D			D				D					D				W	W				D							W
PERK	D	D			D				D	D				D				W	W				D							
PORT		D								D								W	W	W	W		D				W	W		
PRYO		D							D	D								W	W				D				W	W		
PUTN	D	D									D	W		D	W			W					D		D	W				
REDR	D	D			D				D	D				D				W	W				D			W				W
RETR	D	D									D	W		D	W						D	D	D		D				D	
RING		D				D	D							D			W	W					D		D					
SALL		D					D						W		D				W			W	D				W	W		
SEIL	D	D								D	D	W		D	W			W					D	W	D					
SHAW		D							D					D			W	W	W				D		D					
SKIA		D							D	D								W	W				D					W		W
SLAP	D	D		D							D	W			W						D	D	D	W	D		D			
SPEN	D	D												D	W		W	W	W				D		D					
STIG		D					D								D				W	W			D		D		W	W		
STIL	D	D			D				D	D				D				W	W				D							
STUA		D					D	D	D					D				W	W	W			D		D		W			
SULP		D				D	D							D			W	W	W				D		D		W			
TAHL		D													D				W				D				W	W		
TALI		D					D						W		D				W				D		D		W			
TIPT	D	D				D	D					W		D				W			D	D	D		D					
TISH		D				D	D	D	D									W	W				D		D		W			

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	6									2	0	0	7									2	0	0	8		
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**
VANO		D							D					D			W	W	W				D		D					
VINI		D							D	D								W					D				W			
WALT	D	D		D			D							D				W					D		D					
WASH	D	D												D	W		W	W	W	W			D		D					
WATO	D	D								D	D			D	W			W					D		D					
WAUR	D	D				D	D							D			W	W					D		D					
WEAT	D	D									D	W		D	W			W					D		D	W				
WEBR		D													D				W	W			D				W	W		
WEST		D											W		D								D				W	W		
WILB		D					D								D				W	W			D		D		W			
WIST		D					D						W		D				W				D		D		W	W		
WOOD	D	D		D						D	D	W			W						D	D	D	W	D		D			
WYNO	D	D							D	D								W	W				D					W		W

If no value is assigned to the time period then it is considered average surface moisture.

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	8			2	0	0	9									2	0	1	0								
	J	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
ACME		W	D	D	D		D			W		D				W	D		W		D				W	D			D	D
ADAX			D	D	D	D	D				W	D	W			W	D									D		D		
ALTU					D	D	D	D		W			W				D				D		D		W	D				D
ALV2				W	D	D	D	D			D						D	D			D									D
ANTL	D			D	D	D										W	D							D		D		D		
APAC		W	D		D		D			W		D					D		W		D		D		W				D	D
ARD2		W	D	D	D	D	D				W					W	D									D				
ARNE				W	D	D	D	D	D		D	D					D	D			D						D		W	D
BEAV			D	W	D	D	D	D		W	D					W	D	D									D		W	D
BESS			D		D	D	D	D				D	W				D	D			D		D		W	D				D
BIXB		W		D												W	D											D		D
BLAC		D					D							W			D	D										D		D
BOIS			D	W	D	D	D				D		W	D		W	D	D		W	W							D		
BOWL		W	D	D		D	D					D	W			W	D									D		D		D
BREC		D					D				D			W	D		D	D												D
BRIS			D	D		D							W			W	D											D		D
BROK	D	W			D	D						D		W		W	D									D		D		D
BUFF				W	D	D	D	D	D		D					W	D	D			D								W	D
BURB							D							W			D	D										D	D	D
BURN	D	W	D	D	D	D	D				W					W	D									D		D	D	
BUTL					D	D	D	D	D			D	W				D	D			D				W		D			D
BYAR			D	D		D	D				W	D	W			W	D									D		D		D
CALV		W	D	D	D	D										W	D									D		D		
CAMA				W	D	D	D	D	D		D		W				D	D			D				W				W	D
CARL			D				D					D	W	W			D	D			D							D		D
CENT		W	D	D	D	D	D				W					W	D									D		D		
CHAN		W	D	D		D	D					D	W	W			D											D		D
CHER					D	D	D	D			D			W			D	D			D									D
CHEY				W	D	D	D	D			D	D	W				D	D			D				W		D		W	D
CHIC		W	D	D			D			W		D				W	D		W		D				W	D			D	D
CLAY				D		D										W	D									D		D		
CLOU	D	W		D	D	D						D		W		W	D									D		D		
CLRM		W														W	D								W			D		D
COOK		W			D											W										D		D		D
COPA							D										D								W			D		D

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	8			2	0	0	9									2	0	1	0								
	J	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
DURA			D	D		D	D				W					W	D							D		D		D		
ELRE		W	D				D					D		W			D	D	W		D				W					D
ERIC				W	D	D	D	D			D	D	W				D	D			D				W		D			D
EUFA		W		D	D	D										W	D									D		D		
FAIR					D	D	D	D			D			W			D	D			D				W					D
FITT		W	D	D	D	D	D				W	D				W	D									D		D		
FORA							D							W			D								W			D	D	D
FREE				W	D	D	D	D	D		D						D	D			D								W	D
FTCB		W	D		D		D			W		D					D	D	W		D		D		W	D				D
GOOD			D	W	D	D	D			W	D					W	D	D									D	D		D
GRA2		W	D		D		D	D	D	W							D						D		W	D			D	D
GUTH		W	D	D		D	D					D	W	W			D	D			D							D		D
HASK		W		D	D											W	D									D		D		D
HECT		W		D		D										W	D											D		D
HINT		W	D		D		D					D					D	D			D				W					D
HOBA			D		D	D	D	D		W							D	D			D		D		W	D				D
HOLD		W	D	D	D	D										W	D									D		D		
HOLL				W	D	D	D	D		W	D		W				D				D	W			W	D				D
HOOK			D	W	D	D	D	D		W	D					W	D	D									D			D
HUGO	D			D	D	D						D				W	D							D		D		D		
IDAB	D	W			D	D						D		W		W	D									D		D		D
INOL		W			D											W	D											D		D
JAYX					D											W	D									D		D		D
KENT			D	W	D	D	D				D		W	D		W	D	D		W	W							D		
KETC		W	D	D	D		D		D	W		D					D								W	D			D	D
KIN2		W	D				D					D		W			D	D			D				W					D
LAHO					D		D				D			W	D		D	D												D
LANE			D	D	D	D										W	D									D		D		
MADI	D	W	D	D	D	D	D				W					W	D									D		D		
MANG					D	D	D	D		W			W				D	D			D		D		W	D				D
MARE			D	D		D	D					D	W	W			D	D			D							D		D
MAYR				W	D	D	D	D			D						D	D			D								W	D
MCAL				D	D	D										W	D									D		D		
MEDF		D					D				D			W			D	D												D
MEDI		W	D		D		D		D	W		D					D		W		D		D		W	D			D	D
MIAM					D											W	D					D			W	D		D		D

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	8			2	0	0	9									2	0	1	0								
	J	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MINC		W	D				D			W		D		W			D		W		D				W	D			D	D
MRSH			D				D					D		W			D	D			D									D
MTHE	D	W			D	D						D		W		W	D									D		D		
NEWK							D							W			D	D										D	D	D
NEWP		W	D	D	D	D	D				W					W	D									D			D	D
NINN		W	D	D	D		D			W		D				W	D		W		D				W	D			D	D
NOWA																W	D								W			D		D
NRMN		W	D	D		D	D			W		D	W	W		W	D				D				W	D		D	D	D
OILT			D	D			D						W	W			D											D		D
OKCE		W	D	D		D	D					D	W	W			D	D			D				W	D		D	D	D
OKCN		W	D	D		D	D					D	W	W			D	D			D				W	D		D	D	D
OKCW		W	D	D		D	D					D	W	W			D	D			D				W	D		D	D	D
OKEM		W	D	D		D							W			W	D									D		D		D
OKMU		W		D	D	D										W	D									D		D		D
PAUL		W	D	D		D	D				W	D				W	D									D			D	D
PAWN							D						W	W			D	D										D	D	D
PERK			D	D		D	D					D	W	W			D	D			D							D		D
PORT		W		D	D											W	D									D		D		D
PRYO		W			D											W	D								W	D		D		D
PUTN					D	D	D	D	D								D	D			D				W					D
REDR							D						W	W			D				D							D		D
RETR					D	D	D	D					W				D	D			D		D		W	D	D			D
RING		W	D	D	D	D	D		D	W	W					W	D									D			D	D
SALL		W			D											W	D									D		D		
SEIL				W	D	D	D	D	D								D	D			D				W					D
SHAW		W	D	D		D	D					D	W	W		W	D									D		D		D
SKIA																	D								W			D		D
SLAP				W	D	D	D	D		W	D					W	D	D			D						D		W	D
SPEN		W	D	D		D	D					D	W	W			D	D			D					D		D	D	D
STIG		W		D	D											W										D		D		
STIL			D				D					D	W	W			D	D			D							D		D
STUA			D	D	D	D										W	D									D		D		
SULP		W	D	D	D	D	D				W	D				W	D									D				
TAHL		W			D												D									D		D		D
TALI		W			D	D								W		W	D									D		D		
TIPT					D	D	D	D		W							D				D		D		W	D				D

Appendix F – Surface Moisture Conditions for each Month

	2	0	0	8			2	0	0	9									2	0	1	0								
	J	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
TISH		W	D	D	D	D	D				W					W	D									D		D		
VANO			D	D		D	D				W	D	W			W	D									D		D		
VINI					D											W	D					D			W	D		D		D
WALT		W	D		D		D		D	W							D		W				D		W				D	D
WASH		W	D	D		D	D			W		D				W	D				D				W	D			D	D
WATO		W			D		D							W			D	D			D				W					D
WAUR		W	D	D	D		D		D	W						W	D								W				D	D
WEAT		W	D		D	D	D	D				D					D	D			D				W					D
WEBR		W			D											W										D		D		D
WEST		W			D											W	D									D		D		D
WILB				D	D	D										W	D									D		D		
WIST		W			D									W	W	W	D									D		D		
WOOD				W	D	D	D	D	D		D							D			D								W	D
WYNO							D																		W			D	D	D

If no value is assigned to the time period then it is considered average surface moisture.

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