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Blythe, CA 92226

March 19, 2003

Mr. Don Codding
National Park Service
Air Resources Division
P.O. Box 25287
Denver CO 80225

Subject: **Blythe Energy Project – Phase 2**
Air Quality Impact Analysis

Dear Mr. Codding:

Caithness Blythe 2, LLC (CB 2) has completed additional modeling which was performed using the protocol approved by the National Park Service (NPS). Please find enclosed two (2) copies of the final report prepared by our consultant, Earth Tech.

We believe this report addresses the comments and concerns presented by NPS last year and we request your review and concurrence. If you require, we can set up a conference call in the next days to discuss any questions you or your consultants may have. Please let me know in advance as Mr. Scire of Earth Tech is often traveling.

If you have any questions, please do not hesitate to call me at (262) 474-2015 or (262) 853-3777 (cell).

Very truly yours,

Thomas Cameron
Project Manager
Caithness Blythe 2

cc: Mr. William Pfanner (California Energy Commission)
Mr. Alan DeSalvio (Mohave Desert Air Quality Management District)

Attachment: Assessment of Air Quality Impacts from the Proposed Blythe II Energy Project at the Joshua Tree National Park – March 2003

Assessment of Air Quality Impacts from the Proposed Blythe II Energy Project at the Joshua Tree National Park

March 2003

Prepared For:

Caithness Blythe II, LLC
Blythe, California

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Earth Tech, Inc., on behalf of Caithness Blythe II, LLC, has conducted an air quality analysis for the proposed Blythe Energy Project II, in Blythe California. This proposed facility will have an electrical generating capacity 520 megawatts (MW) and will be located adjacent to the existing Blythe Energy Project. It will fire natural gas.

This modeling analysis evaluates air quality and visibility impacts at the Joshua Tree National Park Class I Area. The purpose of the modeling is to assess the ambient air quality impacts of sulfur dioxide (SO_2), particular matter with an equivalent diameter less than or equal to 10 microns (PM_{10}), and nitrogen oxides (NO_x) emissions. Predicted concentrations due to the proposed net emissions are compared to the Class I Area Significant Impact Level (SIL) concentration. In addition, the impacts of the facility on visibility and other air quality related values in the Class I area are evaluated. The Joshua Tree National Park is located approximately 65 km to the northwest of the proposed facility.

A non-steady-state modeling approach which evaluates the effects of spatial changes in the meteorological and surface characteristics is necessary to properly evaluate the air quality impacts of the emissions sources. The "No Observations" (No-Obs) version of the CALMET and CALPUFF non-steady-state models (Scire et al., 2000a,b) was used for the modeling analysis. The U.S. Environmental Protection Agency (EPA) has proposed the CALPUFF modeling system as a Guideline Model for Class I impact assessments and other long range transport applications or, on a case-by-case basis, for use in near-field applications involving complex flows (USEPA, 2000). CALPUFF is recommended by both the Federal Land Managers Air Quality Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (IWAQM, 1998).

CALMET is a diagnostic meteorological model that produces three-dimensional wind fields based on parameterized treatments of terrain effects such as slope flows, terrain blocking effects, and kinematic effects. The No-Obs version of CALMET is used here for an advanced screening level analysis and together with CALPUFF determined the potential for significant air quality impacts within the Joshua Tree National Park. This version of CALMET only requires gridded hourly three-dimensional meteorological data from a prognostic numerical model and does not require observations. The gridded data produced by the Penn State/NCAR Fourth/Fifth Generation Mesoscale Model (MM4/MM5) was used by CALMET to help define the initial estimate of the wind fields. Fine scale terrain effects are determined by the diagnostic wind module in CALMET. The CALMET and CALPUFF simulations were conducted for three years for which gridded prognostic meteorological data are available. These data are available for 1990 (MM4), 1992

(MM5), and 1996 (MM5). If this advanced screening analysis would show the potential for large air quality impacts then a more refined analysis using the prognostic data as well as all available surface observations and upper air soundings would be performed.

CALPUFF is a non-steady-state puff dispersion model. It accounts for spatial changes in the CALMET-produced meteorological fields, variability in surface conditions (elevation, surface roughness, vegetation type, etc.), chemical transformation, wet removal due to rain and snow, dry deposition, and terrain influences on plume interaction with the surface. CALPUFF contains a module to compute visibility effects, based on a humidity-dependent relationship between particulate matter concentrations and light extinction, as well as wet and dry deposition fluxes. Meteorological and dispersion modeling simulations were conducted for the three separate years (1990, 1992, and 1996) corresponding to the CALMET simulation periods. These years were selected based on the availability of the MM4 or MM5 data sets from the U.S. Environmental Protection Agency (USEPA) and the National Park Service (NPS). Short-term and long-term average concentrations of SO_2, PM_{10}, NO_x, and their secondary products resulting from emissions from the proposed sources were predicted by the model at receptors in the Joshua Tree National Park Class I area. In addition, the impacts on visibility and other air quality related values in the Class I area were determined.

This report outlines the techniques and data sources used in the Class I impact analyses. In Section 2, a general description of the source configuration and emissions are provided. Descriptions of the modeling domain and the data bases (meteorological, geophysical, and aerometric) used in the analysis are provided in Section 3. Section 4 includes an overview of the CALMET and CALPUFF models and the results are presented in Section 5. Appendix A and B provide sample CALMET and CALPUFF control files, respectively. Appendix C provides documentation of the NPS procedures for defining particulate emissions and species.

2. SOURCE DESCRIPTION

2.1 Source Data

Caithness Blythe II, LLC is proposing the Blythe II Energy Project, an electrical generating facility, to be located in Blythe California directly adjacent to the existing Blythe Energy Project facility. This new facility will be located about 100 meters south of the existing Blythe Energy project and will have an electrical generating capacity of 520 MW. It will consist of two combustion turbine generator (CTG) units firing natural gas, two heat recovery steam generator (HRSG) units with supplemental firing, one steam turbine generator (STG) unit and eight mechanical draft wet cooling towers. The CTG units will be equipped with selective catalytic reduction (SCR) to control NO_x emissions.

Table 2-1 shows the stack parameters and emission rates used in the modeling analysis. Stacks 1 and 2 will vent emissions from the CTG/HRSG units. For modeling purposes the cooling towers were treated as a single stack with emissions equal to the total emissions from all eight cooling towers. These cooling tower emissions were vented through stack 3.

The NO_x emission rates were computed by Greystone Environmental Consultants, Inc. based on the assumption of one cold start and five hot starts during a 24-hour period with no downtime between startups. This will result in maximum NO_x emissions from the CTG/HRSG units. For SO_2 and PM_{10}, the emissions are based on continuous full-load operation because this results in the maximum emission rates of these pollutants.

A portion of the SO_2 emissions is defined as SO_4 emissions according to a procedure recommended by the NPS for gas-fired combustion turbines. This procedure, documented in Appendix C, specifies that the SO_4 emissions can be estimated as 1/3 of the unpartitioned SO_2 emissions, adjusted for molecular weight differences. The SO_4 emissions component are subtracted from the original SO_2 emission estimate, so that the actual SO_2 emissions modeled are the remaining 2/3 of the original unpartitioned SO_2 emissions from the combustion turbines.

The NPS procedures also specify how to define the particulate emissions from the combustion turbines. All particulates from gas-fired combustion turbines are assumed to have a size of 1 micron or less and are distributed over six size categories. Table 2-2 shows the size characteristics of the six particulate size categories as well as for sulfate and nitrate. The particulate emissions from the cooling towers are assumed to be PM_{10} with size distribution as indicated.

The emissions of particulate matter are partitioned into three separate components as recommended by the NPS (see Appendix C). It is assumed that 25 percent of the

total particulate emissions is filterable and 75 percent in condensable. The filterable portion of the particulate emissions is assumed to be elemental carbon (EC). The organic carbon (OC) portion of the emissions is determined as the condensable particulate matter minus the SO_4 emissions. OC emissions are assumed to form secondary organic aerosols (SOA). Following this procedure we find the EC emissions to be 0.188 g/s while the OC emissions are 0.413 g/s.

Building dimension data developed by Greystone Environmental Consultants was provided to Earth Tech and these data were used in the CALPUFF modeling simulations.

Table 2-1. Point Source Parameters and Emissions[1]

Source Description	UTM[2] Coordinate East	UTM[2] Coordinate North	Stack Height	Base Elevation	Stack Diameter	Exit Velocity	Exit Temperature	SO_2 Emission Rate[3]	SO_4 Emission Rate[3]	NO_x Emission Rate	PM_{10} Emission Rate[4]
	(km)	(km)	(m)	(m)	(m)	(m/s)	(K)	(g/s)	(g/s)	(g/s)	(g/s)
1	714.315	3721.351	39.62	100.0	5.64	16.99	366.3	0.20	0.15	15.27	0.75
2	714.284	3721.351	39.62	100.0	5.64	16.99	366.3	0.20	0.15	15.27	0.75
3	714.184	3721.358	12.19	100.0	10.07	8.06	309.4	0.00	0.00	0.00	0.0785

[1] Stack parameters and emissions data provided by Greystone Environmental Consultants.

[2] Coordinates in UTM Zone 11 and based on WGS84 datum.

[3] SO_4 emissions are 1/3 of the unpartitioned SO_2 emissions (i.e. 0.30 g/s) adjusted by the molecular weight. The SO_2 emissions are the remaining 2/3 of the unpartitioned SO_2 emissions. This procedure is recommended by the National Park Service and is documented in an email from Don Codding dated February 4, 2003 (see Appendix C).

4 The PM_{10} emission rate listed in this table includes the SO_4 emissions. Non-sulfate emissions of particulate matter (EC, OC) is 0.60 g/s.

Table 2-2 Particle Size Distribution Data[1]

Species Name	Cumulative Size Distribution (%)	Particulate Size Fraction	Geometric Mass Mean Diameter (microns)	Geometric Standard Deviation (microns)
SO_4	100	1.00	0.48	0.50
NO_3	100	1.00	0.48	0.50
PM0005	15	0.15	0.05	0.00
PM0010	40	0.25	0.10	0.00
PM0015	63	0.23	0.15	0.00
PM0020	78	0.15	0.20	0.00
PM0025	89	0.11	0.25	0.00
PM0100	100	0.11	1.00	0.00
PM10 [2]	100	1.00	0.48	2.00

[1] Assumes that all particles from combustion turbines are 1 micron or less and all particles from cooling towers are 10 microns or less.

[2] Cooling tower particulate matter emissions

3. GEOPHYSICAL AND METEOROLOGICAL DATA

3.1 Modeling Domain and Terrain

Gridded terrain elevations for the modeling domain are derived from 3 arc-second digital elevation models (DEMs) produced by the United States Geological Survey (USGS). Data are provided in files covering 1 degree by 1 degree blocks of latitude and longitude. The 1-degree DEMs are produced by the Defense Mapping Agency using cartographic and photographic sources. USGS 1:250,000 scale topographic maps are the primary source of 1-degree DEMs.

One degree DEM data consists of an array of 1201 by 1201 elevations referenced on the geographic (latitude/longitude) coordinate system of the World Geodetic System 1984 Datum. Elevations are in meters relative to mean sea level, and the spacing of the elevations along each profile is 3 arc-seconds, which corresponds to a spacing of approximately 90 meters.

The CALMET computational domain shown in Figure 3-1 is located in the southern portion of California. The entire domain covers an area of 300 km by 250 km. A resolution of 2 km in the horizontal is used to resolve the variations of the terrain elevations in the area. The USGS elevation records located within each grid cell in the computational domain are averaged to produce a mean elevation at each grid point. A 2 km resolution produces a workable number of grid cells (151 x 126) and allows adequate representation of the important terrain features.

Figure 3-1 shows contours of the terrain averaged to 2 km grid cells. There are significant topographical features in the western part of the domain, reaching peaks of near 3000 meters while the terrain elevations within Joshua Tree National Park range from approximately 400 meters to as high as 1300 meters. The base elevation of the proposed facility is 100 m.

The CALPUFF computational domain is the same as the CALMET domain. The domain extends at least 50 km beyond the boundary of Joshua Tree National Park and 50 km from the facility in order to provide an adequate buffer zone at the boundaries, and to allow the effects of flow curvature and possible small-scale re-circulation to be evaluated.

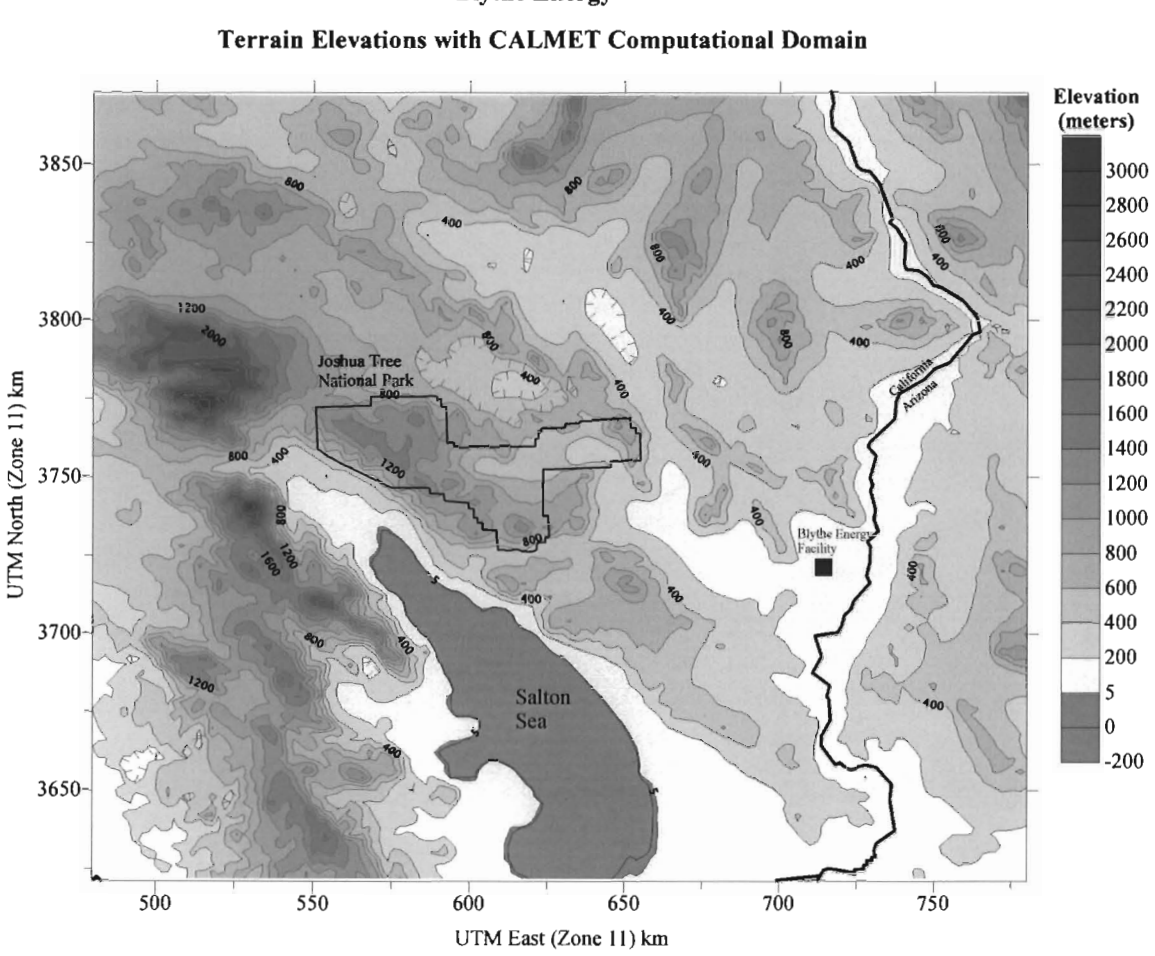

Figure 3-1. Terrain elevations for the CALMET/CALPUFF computational domain. The Joshua Tree National Park Class I area and the facility site are also shown.

3.2 Land Use

The USGS Land Use data within the CALMET/CALPUFF domain have been used to produce a gridded field of dominant land use categories. The land use data were obtained in Composite Theme Grid format (CTG) from the USGS, with a resolution of 200 m.

Land use data were processed to produce a 2 km resolution gridded field of fractional land use categories. The 37 USGS land use categories were then mapped into 14 CALMET land use categories. Surface properties such as albedo, Bowen ratio, roughness length, and leaf area index were computed proportionally to the fractional land use. The USGS land use categories are described in Table 3-1. Table 3-2 displays the 14 CALMET land use categories and their associated geophysical parameters. Figure 3-2 shows the dominant land use categories for each CALMET grid cell in the modeling domain.

3.3 Meteorological Data Base

A special version of CALMET called "No Observations" (No-Obs) version of CALMET was used for this analysis. This version of CALMET uses three dimensional gridded data sets from a prognostic numerical weather prediction model only and does not require meteorological observations. This approach represents an advanced screening technique, to assess the potential for significant air quality impacts at the Joshua Tree National Park Class I Area. More refined CALMET simulations would be performed using both three-dimensional gridded prognostic model data as well as all available surface observations and upper air soundings if this screening analysis would show the potential for large air quality or visibility impacts.

The three dimensional gridded prognostic meteorological data produced by the USEPA and the National Park Service for the years 1990, 1992, and 1996 were used in the analysis. The prognostic MM4 and MM5 data sets consist of hourly values of wind speed, wind direction, temperature, dew-point depression, and pressure on a three-dimensional grid. These data also include hourly precipitation at each grid point. For 1990 (MM4) and 1992 (MM5) the horizontal resolution is 80 km while for 1996 (MM5) the horizontal resolution is 36 km. These data sets cover the entire continental United States, Southern Canada and Northern Mexico.

Table 3-1. U.S. Geological Survey Land Use and Land Cover Classification System

Level I		Level II	
10	Urban or Built-up Land	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Urban or Built-up Land
20	Agricultural Land	21	Cropland and Pasture
		22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
		23	Confined Feeding Operations
		24	Other Agricultural Land
30	Rangeland	31	Herbaceous Rangeland
		32	Shrub and Brush Rangeland
		33	Mixed Rangeland
40	Forest Land	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
50	Water	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
		55	Oceans and Seas
60	Wetland	61	Forested Wetland
		62	Nonforested Wetland
70	Barren Land	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas Other than Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		76	Transitional Areas
		77	Mixed Barren Land
80	Tundra	81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground
		84	Wet Tundra
		85	Mixed Tundra
90	Perennial Snow or Ice	91	Perennial Snowfields
		92	Glaciers

Table 3-2. Default CALMET Land Use Categories and Associated Geophysical Parameters Based on the U.S. Geological Survey Land Use Classification System (14-Category System)

Land Use Type	Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index
10	Urban or Built-up Land	1.0	0.18	1.5	.25	0.0	0.2
20	Agricultural Land - Unirrigated	0.25	0.15	1.0	.15	0.0	3.0
-20*	Agricultural Land - Irrigated	0.25	0.15	0.5	.15	0.0	3.0
30	Rangeland	0.05	0.25	1.0	.15	0.0	0.5
40	Forest Land	1.0	0.10	1.0	.15	0.0	7.0
50	Water	0.001	0.10	0.0	1.0	0.0	0.0
54	Small Water Body	0.001	0.10	0.0	1.0	0.0	0.0
55	Large Water Body	0.001	0.10	0.0	1.0	0.0	0.0
60	Wetland	1.0	0.10	0.5	.25	0.0	2.0
61	Forested Wetland	1.0	0.1	0.5	0.25	0.0	2.0
62	Nonforested Wetland	0.2	0.1	0.1	0.25	0.0	1.0
70	Barren Land	0.05	0.30	1.0	.15	0.0	0.05
80	Tundra	.20	0.30	0.5	.15	0.0	0.0
90	Perennial Snow or Ice	.05	0.70	0.5	.15	0.0	0.0

* Negative values indicate "irrigated" land use

Figure 3-3 shows the grid points for the 1990 (MM4) and 1992 (MM5) data relative to the CALMET modeling domain. Figure 3-4 shows the MM5 grid points for the 1996 data set.

3.4 Air Quality Monitoring Data

CALPUFF uses ozone concentration measurements in the chemical transformation rates (SO_2 to SO_4, NO_x to HNO_3/NO_3). The ambient ozone measurements are used in determining SO_2 loss rates due to chemical transformation to sulfate and in determining NO_x loss rates to nitrate. The ambient ozone monitoring data used in this analysis is from the Joshua Tree CASTNET station. This CASTNET monitoring station is located within Joshua Tree National Park and this is depicted in Figure 3-5. Data from this station was used to develop the monthly average ozone values used in the CALPUFF simulations. The monthly ozone values in parts per billion are 39, 42, 51, 55, 65, 65, 64, 59, 54, 51, 42, and 38 for January through December, respectively. These monthly average ozone values were computed using five years of hourly ozone concentrations (1996-2001) during daylight hours only. For this analysis it is assumed that daylight hours occur between 6:00 AM and 6:00 PM.

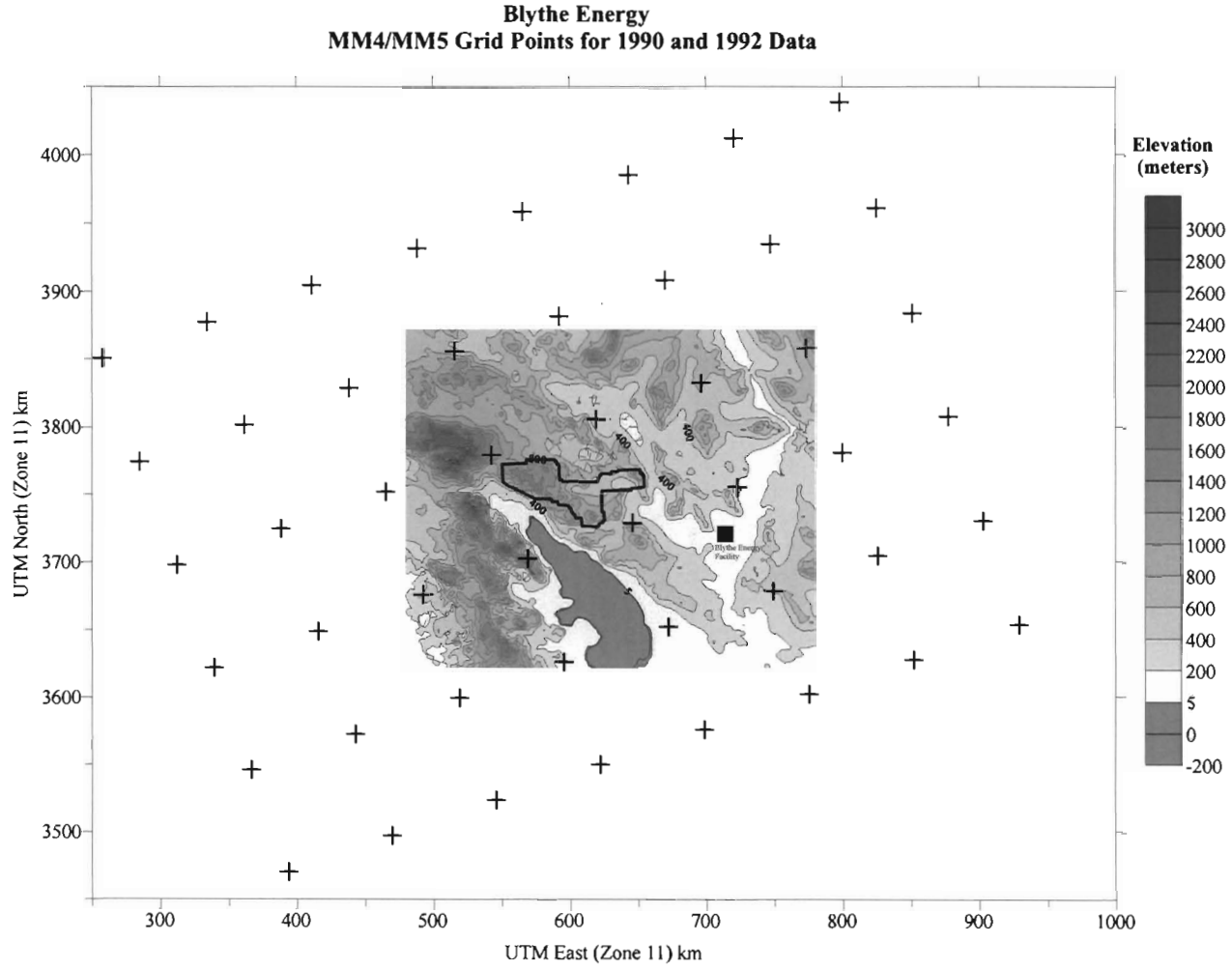

Figure 3-3. Location of the CALMET/CALPUFF computational domain and grid points for the 1990 (MM4) and 1992 (MM5) data sets. The horizontal resolution of both data sets is 80 km.

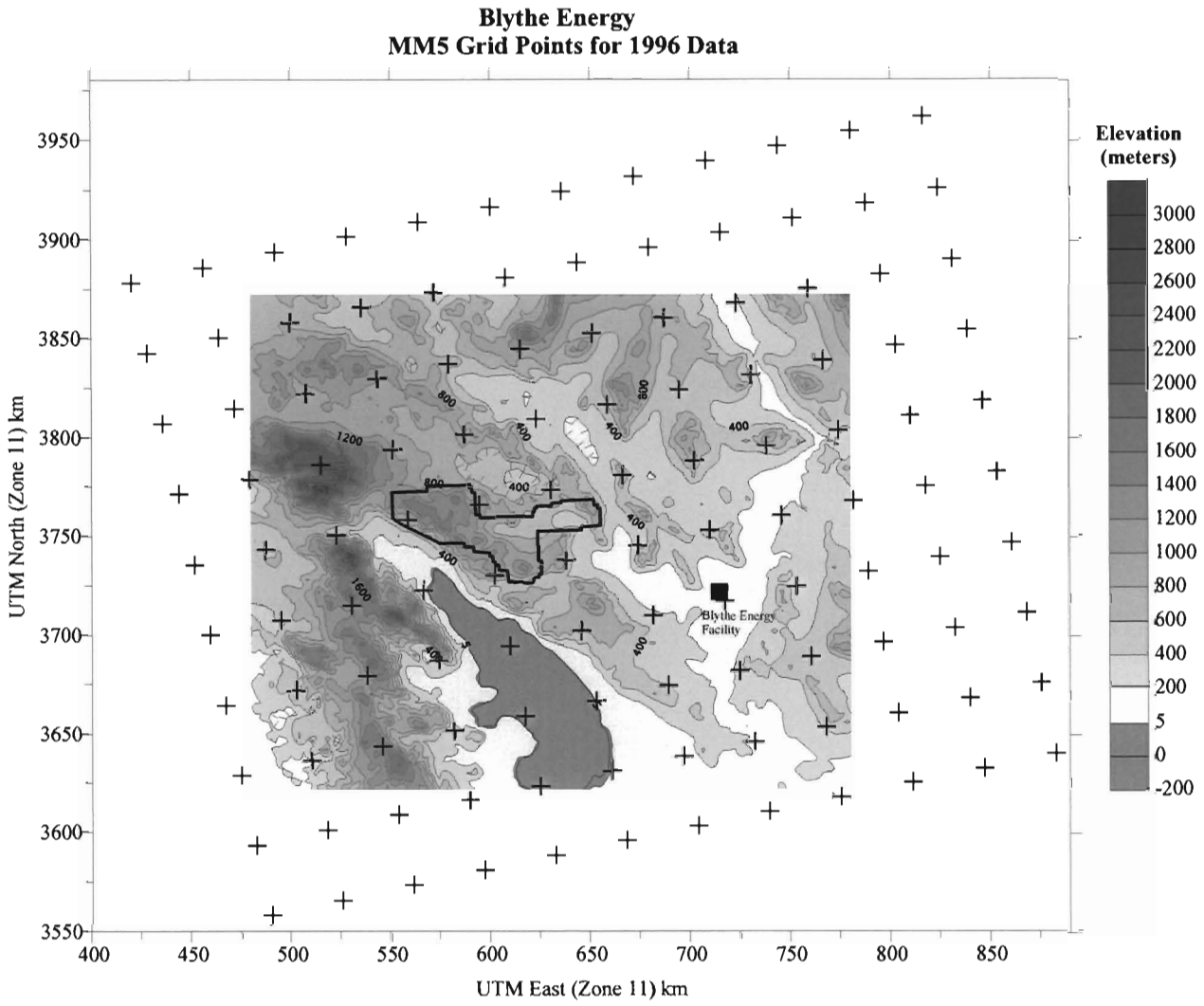

Figure 3-4. Location of the CALMET/CALPUFF computational domain and grid points for the 1996 MM5 data set. The horizontal resolution of the 1996 data is 36 km.

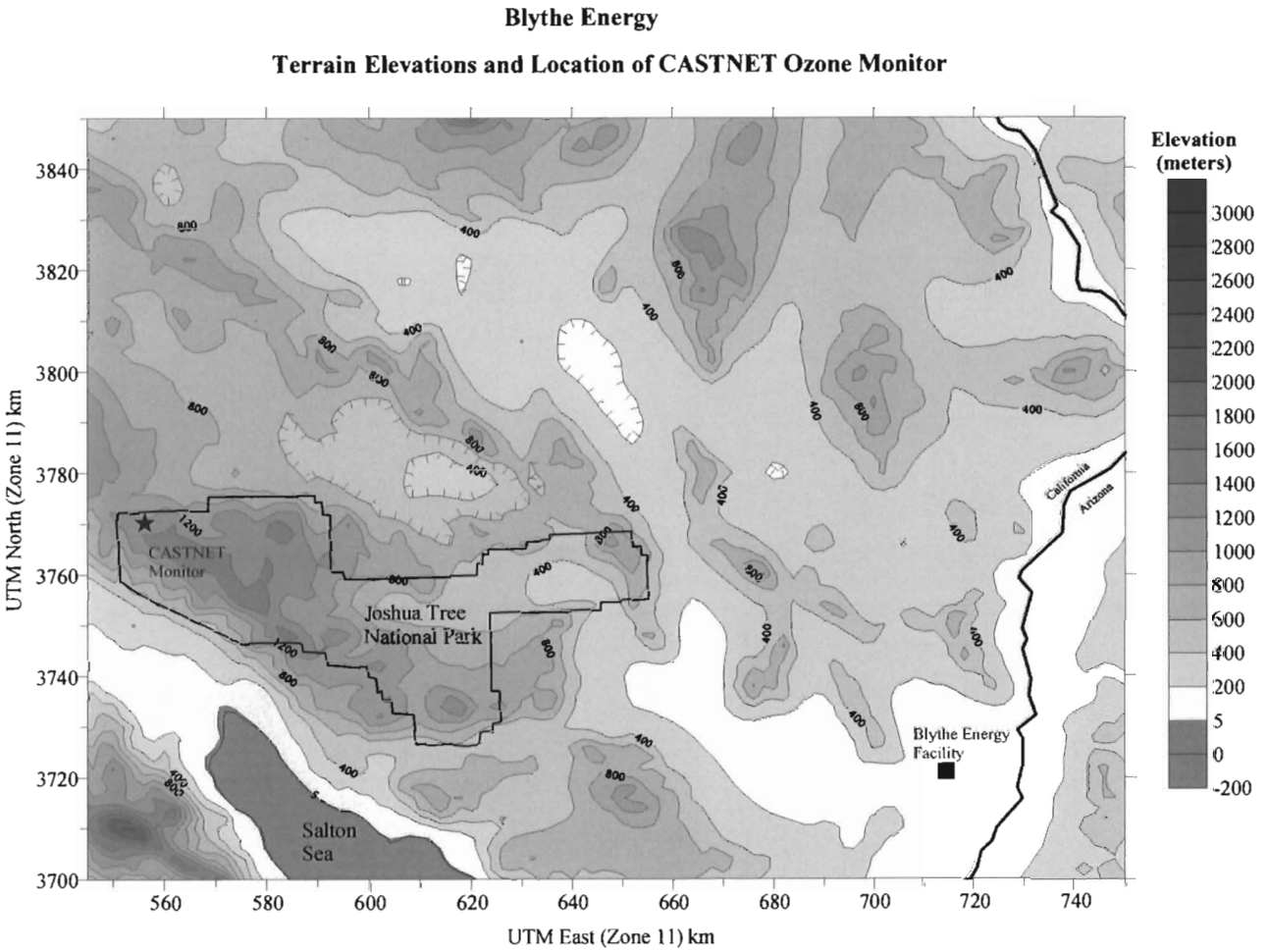

Figure 3-5. Location of the CASTNET ozone monitoring station. The CASTNET station is depicted by a green star.

4. AIR QUALITY MODELING METHODOLOGY

4.1 Model Selection

The No-Obs version of the CALMET/CALPUFF modeling system (Scire et al., 2000a,b) was used for an initial advanced screening analysis. If the results of this screening analysis would indicate that significant air quality impacts occur then a refined level CALMET/CALPUFF modeling analysis would be performed in which all available observations would be included in the CALMET simulations. CALPUFF and its meteorological model CALMET, are designed to handle the complexities posed by the complex terrain, the long source receptor distances, chemical transformation and deposition, and other issues related to Class I impacts. The CALPUFF modeling system has been proposed by the U.S. EPA as a Guideline Model for source-receptor distances greater than 50 km, and for use on a case-by-case basis in complex flow situations for shorter distances (Federal Register, April 21, 2000). CALPUFF is recommended for Class I impact assessments by the Federal Land Managers Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (IWAQM, 1998).

CALMET is a diagnostic meteorological model that is used to drive the CALPUFF dispersion model. It produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. It contains slope flow effects, terrain channeling, and kinematic effects of terrain. CALPUFF is a non-steady-state Gaussian puff model that includes algorithms for building downwash effects as well as chemical transformation, wet deposition, and dry deposition. One capability of CALPUFF not found in many specialized models such as CTDMPLUS is the ability to treat the combined effects of multiple processes (e.g., building downwash effects in complex terrain; dry deposition and overwater dispersion, etc.). A complete summary of the capabilities and features of CALMET and CALPUFF is provided in Sections 4.1.1 and 4.1.2.

4.1.1 Major Features of CALMET

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. When using large domains, the user has the option to adjust input winds to a Lambert Conformal Projection coordinate system to account for Earth's curvature. The diagnostic wind field module uses a two step approach to the computation of the wind fields (Douglas and Kessler, 1988). In the first step, an initial-guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. The available MM4/MM5 gridded data for the years 1990, 1992, and 1996 were used to define the initial guess field. The second step consists of an objective analysis procedure to introduce observational data into the

Step 1 wind field to produce a final wind field. However, this step is not performed for the No-Obs version of CALMET.

The major features and options of the meteorological model are summarized in Table 4-1. The techniques used in the CALMET model are briefly described below.

Step 1 Wind Field

Kinematic Effects of Terrain: The approach of Liu and Yocke (1980) is used to evaluate kinematic terrain effects. The domain-scale winds are used to compute a terrain-forced vertical velocity, subject to an exponential, stability-dependent decay function. The kinematic effects of terrain on the horizontal wind components are evaluated by applying a divergence-minimization scheme to the initial guess wind field. The divergence minimization scheme is applied iteratively until the three-dimensional divergence is less than a threshold value.

Slope Flows: The slope flow algorithm in CALMET has recently been upgraded (Scire and Robe, 1997). It is based on the shooting flow algorithm of Mahrt (1982). This scheme includes both advective-gravity and equilibrium flow regimes. At night, the slope flow model parameterizes the flow down the sides of the valley walls into the floor of the valley, and during the day, upslope flows are parameterized. The magnitude of the slope flow depends on the local surface sensible heat flux and local terrain gradients. The slope flow wind components are added to the wind field adjusted for kinematic effects.

Blocking Effects: The thermodynamic blocking effects of terrain on the wind flow are parameterized in terms of the local Froude number (Allwine and Whiteman, 1985). If the Froude number at a particular grid point is less than a critical value and the wind has an uphill component, the wind direction is adjusted to be tangent to the terrain.

Step 2 Wind Field

The wind field resulting from the adjustments described above of the initial-guess wind is the Step 1 wind field. The second step of the procedure involves the introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse-distance squared interpolation scheme is used which weighs observational data heavily in the vicinity of the observational station, while the Step 1 wind field dominates the interpolated wind field in regions with no observational data. The resulting wind field is subject to smoothing, an optional adjustment of vertical velocities based on the O'Brien (1970) method, and divergence minimization to produce a final Step 2 wind field. This step is not used in the No-obs version of CALMET.

Table 4-1. Major Features of the CALMET Meteorological Model

- **Boundary Layer Modules of CALMET**
  - Overland Boundary Layer - Energy Balance Method
  - Overwater Boundary Layer - Profile Method
  - Produces Gridded Fields of:
    - Surface Friction Velocity
    - Convective Velocity Scale
    - Monin-Obukhov Length
    - Mixing Height
    - PGT Stability Class
    - Air Temperature (3-D)
    - Precipitation Rate

- **Diagnostic Wind Field Module of CALMET**
  - Slope Flows
  - Kinematic Terrain Effects
  - Terrain Blocking Effects
  - Divergence Minimization
  - Produces Gridded Fields of U, V, W Wind Components
  - Inputs Include Domain-Scale Winds, Observations, and (optionally) Coarse-Grid Prognostic Model Winds
    - Lambert Conformal Projection Capability

CALMET Boundary Layer Models

The CALMET model contains two boundary layer models for application to overland and overwater grid cells.

Overland Boundary Layer Model: Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface friction velocity, Monin-Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). Gridded fields of PGT stability class and optional hourly precipitation rates are also determined by the model.

Overwater Boundary Layer Model: The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique, using air-sea temperature differences, is used in CALMET to compute the micro-meteorological parameters in the marine boundary layer.

An upwind-looking spatial averaging scheme is optionally applied to the mixing heights and 3-dimensional temperature fields in order to account for important advective effects.

4.1.2 Major Features of CALPUFF

By its puff-based formulation and through the use of three-dimensional meteorological data developed by the CALMET meteorological model, CALPUFF can simulate the effects of time- and space-varying meteorological conditions on pollutant transport from sources in complex terrain. The major features and options of the CALPUFF model are summarized in Table 4-2. Some of the technical algorithms are briefly described below.

Complex Terrain: The effects of complex terrain on puff transport are derived from the CALMET winds. In addition, puff-terrain interactions at gridded and discrete receptor locations are simulated using one of two algorithms that modify the puff-height (either that of ISCST3 or a general "plume path coefficient" adjustment), or an algorithm that simulates enhanced vertical dispersion derived from the weakly-stratified flow and dispersion module of the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al., 1989). The puff-height adjustment algorithms rely on the receptor elevation (relative to the elevation at the source) and the height of the

Table 4-2. Major Features of the CALPUFF Model

- **Source types**
  - Point sources (constant or variable emissions)
  - Line sources (constant or variable emissions)
  - Volume sources (constant or variable emissions)
  - Area sources (constant or variable emissions)

- **Non-steady-state emissions and meteorological conditions**
  - Gridded 3-D fields of meteorological variables (winds, temperature)
  - Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
  - Vertically and horizontally-varying turbulence and dispersion rates
  - Time-dependent source and emissions data for point, area, and volume sources
  - Temporal or wind-dependent scaling factors for emission rates, for all source types

- **Interface to the Emissions Production Model (EPM)**
  - Time-varying heat flux and emissions from controlled burns and wildfires

- **Efficient sampling functions**
  - Integrated puff formulation
  - Elongated puff (slug) formulation

- **Dispersion coefficient (σ_y, σ_z) options**
  - Direct measurements of σ_v and σ_w
  - Estimated values of σ_v and σ_w based on similarity theory
  - Pasquill-Gifford (PG) dispersion coefficients (rural areas)
  - McElroy-Pooler (MP) dispersion coefficients (urban areas)
  - CTDM dispersion coefficients (neutral/stable)

- **Vertical wind shear**
  - Puff splitting
  - Differential advection and dispersion

- **Plume rise**
  - Buoyant and momentum rise
  - Stack tip effects
  - Building downwash effects
  - Partial penetration
  - Vertical wind shear

- **Building downwash**
  - Huber-Snyder method
  - Schulman-Scire method

- **Complex terrain**
  - Steering effects in CALMET wind field
  - Optional puff height adjustment: ISC3 or "plume path coefficient"
  - Optional enhanced vertical dispersion (neutral/weakly stable flow in CTDMPLUS)

Table 4-2. Major Features of the CALPUFF Model (Cont'd)

- **Subgrid scale complex terrain (CTSG option)**
  - Dividing streamline, H_d, as in CTDMPLUS:
    - Above H_d, material flows over the hill and experiences altered diffusion rates
    - Below H_d, material deflects around the hill, splits, and wraps around the hill

- **Dry Deposition**
  - Gases and particulate matter
  - Three options:
    - Full treatment of space and time variations of deposition with a resistance model
    - User-specified diurnal cycles for each pollutant
    - No dry deposition

- **Overwater and coastal interaction effects**
  - Overwater boundary layer parameters
  - Abrupt change in meteorological conditions, plume dispersion at coastal boundary
  - Plume fumigation

- **Chemical transformation options**
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^=$, NO_x, HNO_3, and NO_3^- (MESOPUFF II method)
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^=$, NO, NO_2 HNO_3, and NO_3^- (RIVAD/ARM3 method)
  - User-specified diurnal cycles of transformation rates
  - No chemical conversion

- **Wet Removal**
  - Scavenging coefficient approach
  - Removal rate a function of precipitation intensity and precipitation type

- **Graphical User Interface**
  - Point-and-click model setup and data input
  - Enhanced error checking of model inputs
  - On-line Help files

- **Interface Utilities**
  - Scan ISCST3 and AUSPLUME meteorological data files for problems

    Translate ISCST3 and AUSPLUME input files to CALPUFF input format

puff above the surface. The enhanced dispersion adjustment relies on the slope of the gridded terrain in the direction of transport during the time step.

Subgrid Scale Complex Terrain (CTSG): An optional module in CALPUFF, CTSG treats terrain features that are not resolved by the gridded terrain field, and is based on the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al., 1989). Plume impingement on subgrid-scale hills is evaluated at the CTSG subgroup of receptors using a dividing streamline height (H_d) to determine which pollutant material is deflected around the sides of a hill (below H_d) and which material is advected over the hill (above H_d). The local flow (near the feature) used to define H_d is taken from the gridded CALMET fields. As in CTDMPLUS, each feature is modeled in isolation with its own set of receptors.

Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines are included in CALPUFF which solve many of the computational difficulties encountered when applying a puff model to near-field releases. For near-field applications during rapidly-varying meteorological conditions, an elongated puff (slug) sampling function may be used. An integrated puff approach may be used during less demanding conditions. Both techniques reproduce continuous plume results under the appropriate steady state conditions.

Building Downwash: The Huber-Snyder and Schulman-Scire downwash models are both incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. Both algorithms have been implemented in such a way as to allow the use of wind direction specific building dimensions.

Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σ_v and σ_w), the use of similarity theory to estimate σ_v and σ_w from modeled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the Complex Terrain Dispersion Model (CTDM). Options are provided to apply an averaging time correction or surface roughness length adjustments to the PG coefficients.

Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains both overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes which occur at the coastline of a major body of water.

Dry Deposition: A full resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of

geophysical parameters, meteorological conditions, and pollutant species. Options are provided to allow user-specified, diurnally varying deposition velocities to be used for one or more pollutants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely. For particles, source-specific mass distributions may be provided for use in the resistance model.

Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport among the "new" puffs generated from the original, well-mixed puff can substantially increase the effective rate of horizontal spread of the material.

Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).

Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, $SO_4^=$, NO_x, HNO_3, and NO_3^-) employed in the MESOPUFF II model or a set of user-specified, diurnally-varying transformation rates.

4.2 Modeling Domain Configuration

The CALMET/CALPUFF computational domain consists of a uniform horizontal grid with a grid cell size of 2 kilometers in order to properly resolve spatial changes in flow fields and surface characteristics. In the vertical, a stretched grid was used with a fine resolution in the lower layers in order to resolve the mixed layer and a somewhat coarser resolution aloft. The ten vertical levels are centered at: 10, 30, 60, 120, 240, 460, 800, 1250, 1850, and 2600 meters.

4.3 Meteorological Modeling

The No-Obs version of CALMET is used in this advanced screening modeling analysis. This allows the meteorological fields to be driven by the use of prognostic meteorological fields only adjusted by CALMET for local (fine-scale) terrain effects. The diagnostic wind module in CALMET produces winds at a grid spacing of 2 km with 151 × 126 grid cells.

Initial Guess Field

The MM4/MM5 gridded meteorological data were used to define the initial guess field for the CALMET simulations. The MM4/MM5 data are available for the years 1990, 1992, and 1996 at a horizontal resolution of 80 km (1990 and 1992) and 36 km (1996). The 1990 data is based on MM4 simulations and the 1992 and 1996 data are based on MM5 simulations. The MM4/MM5 data sets contain 23 vertical levels.

Step 1 Field: Terrain Effects

In developing the Step 1 wind field, CALMET adjusts the initial guess field to reflect kinematic effects of the terrain, slope flows and blocking effects. Slope flows are a function of the local slope and altitude of the nearest crest. The crest is defined as the highest peak within a radius TERRAD around each grid point. The value of TERRAD was set to 12km based on an analysis of the scale of the terrain. The Step 1 field produces a flow field consistent with the fine-scale CALMET terrain resolution (2 km).

Step 2 Field: Objective Analysis

In Step 2, observations are incorporated into the Step 1 wind field to produce a final wind field. This step would only be performed if a refined level CALMET/CALPUFF analysis is required. Each observation site influences the final wind field within a radius of influence (parameters RMAX1 at the surface and RMAX2 aloft). Observations and Step 1 field are weighted by means of parameters R1 at the surface and R2 aloft: at a distance R1 from an observation site, the Step 1 wind field and the surface observations are weighted equally.

4.4 CALPUFF Computational Domain and Receptors

The CALPUFF computational grid is the same as the meteorological grid (i.e., 151 x 126 grid cells with a 2km resolution). The modeling domain includes a buffer zone of at least 50km from the facility and the border of the Class I area. This minimizes edge effects and allows pollutants involved in flow reversals to be brought back into the Class I area.

The receptor grid consists of a grid of discrete receptors within the Joshua Tree National Park Class I area and receptors along the boundary of this area. The receptors within the park boundary have a spacing of 2 km. Discrete receptors along the boundaries of the Class I area have a spacing of approximately 1 km. Figure 4-1 shows the distribution of the receptors within the Joshua Tree National Park. There are a total of 952 receptors.

4.5 Dispersion Modeling Options

The CALPUFF simulations were conducted using the following model options:

- Gaussian near-field distribution
- Transitional plume rise
- Stack tip downwash
- PG dispersion coefficients (rural areas), McElroy-Pooler coefficients (urban areas)
- Transition of σ_y to time-dependent (Heffter) growth rates
- Partial plume path adjustment for terrain
- Wet deposition, dry deposition, and chemical transformation using the MESOPUFF scheme

Two important computational parameters in CALPUFF are XMXLEN (maximum length of an emitted puff, in grid units) and XSAMLEN (maximum travel distance of a puff, in grid units, during one time step). Both of these variables are set to 1.0 in the CALPUFF simulations in order to allow the strong wind channeling effects to be accounted for in the puff trajectory calculations. The first parameter ensures that the length of an emitted puff does not become so large so that it cannot respond to changes in the wind field on the scale of the meteorological grid (2 km resolution). The model will automatically increase the frequency of puff releases to ensure the length of a single puff is not larger than the grid size. The second parameter will

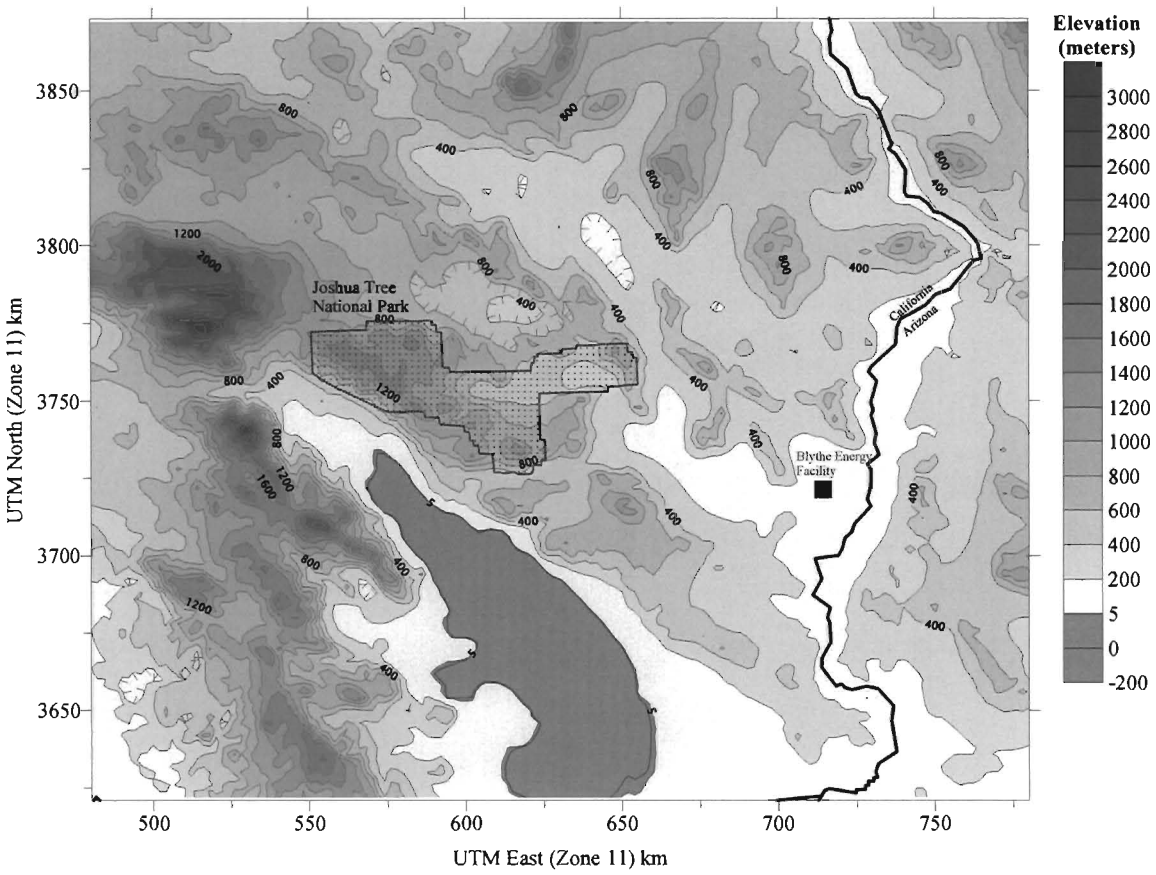

Figure 4-1. Plot of receptors within the Joshua Tree National Park used in the CALPUFF modeling. Receptor spacing is 2 km within the Class I area (blue) and 1 km along the boundary (orange).

decrease the internal time step to ensure the travel distance during one time step does not exceed the grid size.

The partial plume path adjustment option was used in CALPUFF for this analysis (MCTADJ=3). The CALMET wind field incorporates the effect of the terrain on the plume trajectories. The plume path coefficient is used to characterize the local effect on ground-level concentrations. The default plume path coefficients (PPC) are listed below:

Stability Class	A	B	C	D	E	F
PPC	0.5	0.5	0.5	0.5	0.35	0.35

Deposition and chemical transformation effects were modeled using the default dry deposition model, the scavenging coefficient wet removal module, and the default chemical transformation mechanism. Twelve species were modeled with CALPUFF for this analysis: SO_2, SO_4, NO_x, NO_3, HNO_3, PM0005, PM0010, PM0015, PM0020, PM0025, PM0100 and PM_{10}. The six species of PM (i.e. PM0005, PM0010, PM0015, PM0020, PM0025, and PM0100) define the six size categories used to define the particulate emissions from the CTG/HRSG units. Of these twelve species, two are not emitted but are generated through chemical transformation: HNO_3 and NO_3. The chemical mechanism computes transformation rates of SO_2 to SO_4 and NO_x to NO_3/HNO_3. Monthly average ozone concentrations measured at a CASTNET monitor within the Joshua Tree National Park are proposed for use with the chemical transformation module. These ozone concentrations, along with radiation intensity, are used as surrogates for the OH concentration during the day when the gas phase free radical chemistry is active. For the advanced screening simulations, a constant background NH_3 concentration of 1 ppb was assumed in CALPUFF

4.6 Visibility Calculations

The Interagency Workgroup on Air Quality Modeling (IWAQM) developed a set of procedures for use in evaluating visibility impacts (EPA, 1998) which are referenced in the Federal Land Managers workgroup guidance document on assessing air quality related values in Class I areas (FLAG, 2000). The procedures focus on the contribution of anthropogenically-generated fine particles such as sulfate and nitrate to visibility degradation. The procedures involve the use of an air quality model to obtain concentrations of particulate matter. The CALPUFF model is recommended for this type of application because of its ability to treat chemical conversion of SO_2 and NO_x, its treatment of wet and dry deposition and its ability to represent non-steady-state transport over longer range distances where the assumptions of steady-state models break down. A relative humidity correction is applied to the concentrations of hygroscopic particles which accounts for aerosol growth during

high humidity conditions. The extinction coefficient (b_{ext}) due to scattering by sulfate and nitrate is computed as:

$b_{SO4} = 1.375\ E_{dry}\ f(RH)\ [SO_4]$ (sulfate)

$b_{NO3} = 1.29\ E_{dry}\ f(RH)\ [NO_3]$ (nitrate)

where, E_{dry} is the dry extinction efficiency of 3.0 m^2/g,

f(RH) is a relative humidity adjustment factor, and

1.375 and 1.29 are molecular weight adjustments converting SO_4 and NO_3 to $(NH_4)_2SO_4$ and NH_4NO_3, respectively, and

$[SO_4]$, $[NO_3]$ are the concentrations of sulfate and nitrate, respectively expressed in $\mu g/m^3$.

The contribution of non-hygroscopic particulate matter (PM_{10}) to visibility degradation must also be taken into account. The most important types of particle matter for visibility calculations are organics, elemental carbon, soil, and coarse mass. Each of these components has their own dry extinction efficiency. Therefore, the extinction coefficient (b_{ext}) due to scattering by various types of PM_{10} is computed for each component as:

$b_{OC} = 4\ [OC]$ (organics)

$b_{soil} = 1\ [Soil]$ (soil)

$b_{coarse} = 0.6\ [Coarse\ mass]$ (coarse mass)

$b_{EC} = 10\ [EC]$ (elemental carbon)

where, [OC], [Soil], [Coarse mass], and [EC] are the concentrations of organics, soil, coarse mass, and elemental carbon, respectively, expressed in $\mu g/m^3$.

In addition, Rayleigh scattering of air molecules contributes to total extinction. The typical value for Rayleigh scattering recommended by FLAG (2000) is 10 Mm^{-1} (where Mm^{-1} stands for inverse megameters). Therefore,

$b_{ray} = 10\ Mm^{-1}$ (Rayleigh)

The total extinction is expressed as:

$b_{ext} = b_{SO4} + b_{NO3} + b_{OC} + b_{soil} + b_{coarse} + b_{EC} + b_{ray}$

The purpose of the visibility analysis is to calculate the change in extinction at each receptor for each day (24-hour period) of the year due to the proposed project sources. The visibility test looks for a change in extinction of 5 percent or greater for any day of the year. The fractional change in b_{ext} is calculated as follows:

$$\Delta b_{ext} = b_{source} / b_{back}$$

Processing of visibility impairment was carried out with the CALPUFF post-processing program CALPOST (Scire et al., 2000) using CALPOST Method 6. Method 6 uses monthly relative humidity adjustment factors in the calculation of extinction. The monthly relative humidity adjustment factors used in this analysis are provided in *Draft Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule* (USEPA, 2001). The values of background concentrations of pollutants detailed in Table 4-3 for the Joshua Tree National Park are from the FLAG (2000) report. Table 4-4 provides the monthly relative humidity adjustment factors for the Joshua Tree National Park.

As an example of the visibility calculations performed in the screening analysis, consider the reference visibility conditions for the Joshua Tree National Park as detailed in Table 4-3. The reference 24-hour average visibility has a hygroscopic component (combined sulfate and nitrate) dry extinction coefficient $b_{SN} = 0.6$ Mm^{-1} (neglecting the effects of relative humidity), and a non-hygroscopic component (extinction coefficient due to scattering from the other components plus Rayleigh scattering), $b_{dry} = 14.5$ Mm^{-1}. The extinction coefficient is expressed in the form of

$$b_{back} = b_{SN}\ f(RH) + b_{dry}$$

where

$$b_{SN} = 3\ [\ (NH_4)_2SO_4 + NH_4NO_3\ ]$$

expresses the sulfate and nitrate contribution, and

$$b_{dry} = b_{OC} + b_{soil} + b_{coarse} + b_{EC} + b_{ray}$$

expresses the non-hygroscopic components. Therefore, the reference background extinction coefficient is

$$b_{back} = 0.6\ f(RH) + 14.5\ Mm^{-1}$$

If the f(RH) term for a particular day is 2.24, this yields an extinction coefficient of 15.84 Mm^{-1}. The modeling results for the project facility were compared with the reference condition each 24 hour averaging period. For this example, assume the project sources contribute 0.058 $\mu g/m^3$ of sulfate (SO_4) and 0.1 $\mu g/m^3$ of fine primary particulate matter (assumed to have optical properties similar to "soil"). The

contribution of sulfate to the total extinction (b_{SO4}) is calculated using the equation above. For a source impact of 0.058 g/m^3 of sulfate, the values of E_{dry} of 3.0 m^2/g, the value of f(RH) of 3.8, and the molecular weight conversion factor of 1.375, the resulting value of b_{SO4} is calculated to be:

$$b_{SO4} = (1.375)\,(3.0\ m^2/g)\,(2.24)\,(0.058\ g/m^3)$$

$$b_{SO4} = 0.54\ Mm^{-1}$$

In this example, a conversion of the mass of fine particulate matter (FPM) is not required, so we just multiply the FPM concentration (0.1 μg/m^3) by the extinction coefficient of soil (which is 1.0). This yields an extinction coefficient of 0.1 Mm^{-1}. Therefore following the form of the above equation, the source contribution is:

$$b_{source} = 0.54\ Mm^{-1} + 0.1\ Mm^{-1}$$

$$b_{source} = 0.64\ Mm^{-1}$$

The same f(RH) adjustment term that was applied to the extinction must be applied to the source contribution. For instance, if it is assumed that the 24-hour average f(RH) is 3.8, then b_{back} = 15.84 Mm^{-1} and b_{source} = 0.64 Mm^{-1}, and the resulting change in extinction is Δb_{ext} =4.0%. In this example, Δb_{ext} is below the screening level value (SLV) of 5%. This calculation is repeated for all days and receptors in the modeling domain.

Table 4-3. Reference Visibility Conditions at the Joshua Tree National Park Class I Area

Location	Components of Dry Extinction (Mm^{-1})		
	Non-Hygroscopic	Hygroscopic	Rayleigh
Joshua Tree National Park	4.5	0.6	10

Source: FLAG (2000)

Table 4-4. Monthly Values of Relative Humidity Adjustment Factors at Joshua Tree National Park

Month	Relative Humidity Adjustment Factor f(RH)
January	2.35
February	2.30
March	2.24
April	2.02
May	1.99
June	1.91
July	1.97
August	2.00
September	2.03
October	2.02
November	1.91
December	2.04

Source: Draft Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule (USEPA, 2001).

4.7 Deposition Calculations

Under the calculation procedure recommended by the National Park Service, sulfur and nitrogen deposition include contributions from other species besides SO_4 and NO_3. Sulfur deposition is the sum of the wet and dry sulfur deposition from SO_2 and SO_4 (with their appropriate molecular weight adjustments). Nitrogen deposition is due to HNO_3, NO_3, NO_x and SO_4 (note: sulfate represents $((NH_4)_2SO_4)$ and nitrate represents NH_4NO_3).

In CALPUFF, NO_x is weighed as NO_2, ammonium nitrate (NH_4NO_3) is weighed as NO_3, and ammonium sulfate ($(NH_4)_2SO_4$) is weighed as SO_4. Sulfate is assumed to contribute to N deposition as well as S deposition. The end result is:

total deposition = wet deposition + dry deposition.

total S deposition = 0.5 x (total SO_2 deposition) + 0.3333 x (total SO_4 deposition)

total N deposition = 0.291667 x (total SO_4 deposition) + 0.2222 x (total HNO_3 deposition) + 0.451613 x (total NO_3 deposition) + 0.3043 x (total NO_x deposition)

4.7.1 Calculation of Nitrogen Deposition

In CALPUFF nitrate is weighed as NO_3, but deposition is assumed to be in the form of (NH_4NO_3). Converting NO_3 to NH_4NO_3 results in:

$$D_{NH4NO3} = D_{NO3} \times (80/62)$$

$$D_N = D_{NO3} \times (28/62)$$

$$= 0.4516 \times D_{NO3}$$

where, D_{NO3} is the deposition flux of NO_3 (g $NO_3/m^2/s$)

D_{NH4NO3} is the deposition flux of NH_4NO_3 (g $NH_4NO_3/m^2/s$)

D_N is the deposition flux of N (g $N/m^2/s$)

(62, 80 and 14 are the molecular weights of NO_3, NH_4NO_3 and N respectively).

Nitrogen deposition from sulfate is as follows:

$$D_N = D_{SO4} \times (28/96)$$

$$= D_{SO4} \times 0.2917$$

where, D_{SO4} is the deposition flux of SO_4 (g $SO_4/m^2/s$)

Nitrogen deposition from nitric acid is as follows:

$$D_N = D_{HNO3} \times (14/63)$$

$$= D_{HNO3} \times 0.2222$$

where D_{HNO3} is the deposition flux of HNO_3 (g $HNO_3/m^2/s$)

Nitrogen deposition from NO_x is as follows:

$$D_N = D_{NOx} \times (14/46)$$

$$= D_{NOx} \times 0.3043$$

where, D_{NOx} is the deposition flux of D_{NOx} (g $NO_x/m^2/s$)

Thus the total nitrogen deposition (g $N/m^2/s$) is assumed to be:

$$D_N = 0.451613\ D_{NO3} + 0.291667\ D_{SO4} + 0.2222\ D_{HNO3} + 0.3043\ D_{NOx}$$

The deposition fluxes (D_{NO3}, D_{SO4}, D_{HNO3}, D_{NOx}) are derived from the total (wet + dry) deposition fluxes of these species produced by the CALPUFF model.

The SLV is 0.005 kg N/hectare/year, which applies to total nitrogen deposition (D_N).

4.7.2 Calculation of Sulfur Deposition

Sulfur deposition is calculated from the of SO_2 and SO_4 deposition fluxes as:

$$D_s = 0.3333\ D_{SO4} + 0.5000\ D_{SO2}$$

The sulfur deposition SLV is 0.005 kg S/hectare/year.

4.8 Analysis of Results

The CALPUFF modeling produces short term and annual average SO_2, NO_2 and PM_{10} concentrations in the Class I area due to the proposed sources. The predicted concentrations of PM_{10} and NO_2 was compared to the Class I Significant Impact Levels (SILs) to demonstrate that the proposed facility does not cause significant air quality impacts within the Joshua Tree National Park. The SO_2 SILs are 1.0 $\mu g/m^3$ for 3-hour averages, 0.2 $\mu g/m^3$ for 24-hour averages, and 0.1 $\mu g/m^3$ for annual averages. The NO_2 SIL is 0.1 $\mu g/m^3$ for annual averages. The PM_{10} SILs are 0.3 $\mu g/m^3$ for 24-hour averages, and 0.2 $\mu g/m^3$ for annual averages.

Visibility impacts were evaluated using CALPOST Method 6 with U.S. EPA-recommended monthly humidity factors (USEPA, 2001) to determine the percent change in light extinction. This percent change in light extinction is compared against the NPS Screening Level Value (SLV) of 5 percent. Predicted values less than 5 percent will not require any further analysis. Values between 5 and 10 percent will require a cumulative visibility impact assessment through the inclusion of background emission sources. Values greater than 10 percent will likely result in an objection to a permit by the Federal Land Managers. Predicted annual total deposition of both sulfur and nitrogen are compared to the NPS SLV of 0.005 kg/ha/year.

5. RESULTS

The No-Obs version of the CALMET meteorological model along with the CALPUFF dispersion model was used to perform an advanced screening analysis to determine the impacts of SO_2, NO_2, and PM_{10} within the Joshua Tree National Park for three separate years, 1990, 1992, and 1996, where MM4/MM5 gridded meteorological data are available. Predicted concentrations are compared to the Class I Area SIL's to demonstrate that significant air quality impacts do not occur within the Joshua Tree National Park

Both the short term and annual average SO_2 and PM_{10} concentrations and annual average NO_2 concentrations in the Class I area were computed. The resulting concentrations were compared to the Class I Significant Impact Levels (SILs). The SO_2 SILs are 1.00 $\mu g/m^3$ for the 3-hour average, 0.20 $\mu g/m^3$ for the 24-hour average, and 0.10 $\mu g/m^3$ for the annual average. The annual average NO_2 SIL is 0.10 $\mu g/m^3$, while the PM_{10} SILs are 0.30 $\mu g/m^3$ and 0.20 $\mu g/m^3$ for the 24-hour and annual average, respectively.

The change in light extinction due to emissions from Blythe II Energy Project was also computed using CALPOST Method 6 with monthly relative humidity adjustment factors to evaluate the visibility impacts. The change in light extinction is presented as the percent change in extinction from the reference values for the Joshua Tree National Park listed in the FLAG (2000) report. The predicted percent change in light extinction is compared to the NPS Class I SLV of 5 percent. In addition the total annual nitrogen and sulfur deposition (i.e. wet plus dry deposition) were also computed and compared to the corresponding NPS SLV of 0.005 kg/ha/year.

The results of the CALMET/CALPUFF simulations are given in Table 5-1 through Table 5-3. Predicted SO_2, NO_2, and PM_{10} concentrations with the corresponding Class I Area SIL is shown in Table 5-1, Table 5-2 summarizes the visibility impacts at the Joshua Tree National Park and Table 5-3 summarizes the CALPUFF predicted sulfur and nitrogen deposition for each of the three years modeled.

The predicted SO_2, NO_2, and PM_{10} concentrations (Table 5-1) at receptors within the Joshua Tree National Park are all less than the corresponding SIL's for all averaging periods for all three years included in the modeling analysis. The highest predicted short term SO_2 concentration was found in 1990 with predicted 3-hour and 24-hour concentrations of 0.016 $\mu g/m^3$ and 0.0044 $\mu g/m^3$ respectively. For SO_2, the highest annual average concentration of 0.0001 $\mu g/m^3$ was predicted in 1992. The same is true for NO_2, in which the highest predicted annual average concentration of 0.0024 $\mu g/m^3$ occurred in 1992. The predicted PM_{10} concentrations showed the highest 24-hour average of 0.018 $\mu g/m^3$ occurring in both 1990 and 1996 while the highest annual average PM_{10} concentration of 0.0006 $\mu g/m^3$ occurred in 1992. Since all of

these predicted short term and annual average concentrations are much less than the corresponding Class I Area SIL concentration, a cumulative impact analysis is not required. These results demonstrate that the proposed Blythe II Energy Project emissions results in insignificant air quality impacts within the Joshua Tree National Park. Further, this shows that the proposed facility is in compliance with the National Ambient Air Quality Standards and Class I PSD increments within the Joshua Tree National Park.

The predicted percent change in light extinction at receptors within the Joshua Tree National Park for each of the three years modeled is given in Table 5-2. The predicted values using CALPOST Method 6 were found to be 1.46, 1.73, and 2.05 percent for 1990, 1992, and 1996, respectively. For comparison, a sensitivity test was performed using Method 2. Method 2 uses hourly rather than monthly average relative humidity values in computing the humidity factor for hygroscopic aerosols. The results using Method 2 showed the predicted change in light extinction to be 1.15, 4.98, and 3.38 percent for 1990, 1992, and 1996, respectively. These results show that all predicted values of the percent change in light extinction are less than the NPS SLV of 5 percent. The CALPUFF predicted sulfur and nitrogen deposition over the Joshua Tree National Park is shown in Table 5-3 for each of the three years modeled. The maximum predicted annual deposition on sulfur occurred in both 1992 and 1996 with a value of 0.00002 kg S/ha/year while the maximum predicted annual nitrogen deposition is 0.00036 kg N/ha/year in both 1992 and 1996. These predicted annual sulfur and nitrogen deposition values for each of the three years modeled are all less than the corresponding NPS SLV of 0.005 kg S or N/ha/year.

Table 5-1 Summary of Maximum Predicted SO_2, NO_2, and PM_{10} Concentrations at the Joshua Tree National Park Due to Emissions from Proposed Blythe II Energy Project[a]

Pollutant	Averaging Period	Maximum Concentration	Receptor Location (UTM) East	Receptor Location (UTM) North	Class I Significant Impact Threshold	Exceedance of SIL Yes/No
		($\mu g/m^3$)	(km)	(km)	($\mu g/m^3$)	
1990						
SO_2	3 hours	0.016	651.269	3755.124	1.0	No
	24 hours	0.0044	654.125	3755.333	0.2	No
	Annual	0.00009	655.000	3757.000	0.1	No
NO_2	Annual	0.0022	655.645	3756.361	0.1	No
PM_{10}	24 hours	0.018	654.125	3755.333	0.3	No
	Annual	0.0005	655.000	3757.000	0.2	No
1992						
SO_2	3 hours	0.011	655.045	3756.361	1.0	No
	24 hours	0.0028	625.673	3730.926	0.2	No
	Annual	0.0001	655.077	3755.403	0.1	No
NO_2	Annual	0.0024	654.125	3755.333	0.1	No
PM_{10}	24 hours	0.012	655.077	3755.403	0.3	No
	Annual	0.0006	655.077	3755.403	0.2	No
1996						
SO_2	3 hours	0.008	625.673	3730.926	1.0	No
	24 hours	0.003	644.543	3753.164	0.2	No
	Annual	0.00008	655.077	3755.403	0.1	No
NO_2	Annual	0.0008	625.673	3730.926	0.1	No
PM_{10}	24 hours	0.018	645.505	3753.194	0.3	No
	Annual	0.0004	655.077	3755.403	0.2	No

Table 5-2 Summary of Percent Change in Light Extinction at Joshua Tree National Park Due to Emissions from Proposed Blythe II Energy Project[a] using CALPOST Method 6

Year	Averaging Period	Maximum Change in B_{ext} (%)	Number of days $\Delta b_{ext} > 5\%$	Number of days $\Delta b_{ext} > 10\%$
1990	24-hour	1.46	0	0
1992	24-hour	1.73	0	0
1996	24-hour	2.05	0	0

Table 5-3 Summary of Annual Sulfur and Nitrogen Deposition Fluxes at Joshua Tree National Park Due to Emissions from Proposed Blythe II Energy Project[a]

Pollutant	Maximum Annual Deposition	NPS Class I Screening Level Value	Exceedance of SLV Yes / No
	(kg /ha/yr)	(kg /ha/yr)	
1990			
Sulfur	0.00001	0.005	No
Nitrogen	0.00032	0.005	No
1992			
Sulfur	0.00002	0.005	No
Nitrogen	0.00036	0.005	No
1996			
Sulfur	0.00002	0.005	No
Nitrogen	0.00036	0.005	No

6. REFERENCES

Allwine, K.J. and C.D. Whiteman, 1985: MELSAR: A mesoscale air quality model for complex terrain: Volume 1--Overview, technical description and user's guide. Pacific Northwest Laboratory, Richland, Washington.

Carson, D.J., 1973: The development of a dry, inversion-capped, convectively unstable boundary layer. Quart. J. Roy. Meteor. Soc., **99**, 450-467.

Douglas, S. and R. Kessler, 1988: User's guide to the diagnostic wind model. California Air Resources Board, Sacramento, CA.

FLAG, 2000. Federal Land Manager' Air Quality Related Values Workgroup (FLAG). Phase I Report. U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service.

Holtslag, A.A.M. and A.P. van Ulden, 1983: A simple scheme for daytime estimates of the surface fluxes from routine weather data. J. Clim. and Appl. Meteor., **22**, 517-529.

Liu, M.K. and M. A. Yocke, 1980: Siting of wind turbine generators in complex terrain. J. Energy, **4**, 10:16.

Mahrt, L., 1982: Momentum Balance of Gravity Flows. Journal of Atmos. Sci., **39**, 2701-2711.

Maul, P.R., 1980: Atmospheric transport of sulfur compound pollutants. Central Electricity Generating Bureau MID/SSD/80/0026/R. Nottingham, England.

O'Brien, J.J., 1970: A note on the vertical structure of the eddy exchange coefficient in the planetary boundary layer. J. Atmos. Sci., **27**, 1213-1215.

Perry, S.G., D.J. Burns, L.H. Adams, R.J. Paine, M.G. Dennis, M.T. Mills, D.G. Strimaitis,

Scire, J.S. and F.R. Robe, 1997: Fine-Scale Application of the CALMET Meteorological Model to a Complex Terrain Site. Paper 97-A1313. Air & Waste Management Association 90th Annual Meeting & Exhibition, Toronto, Ontario, Canada. 8-13 June 1997.

Scire, J.S., D.G. Strimaitis, and R.J. Yamartino, 2000a: A User's Guide for the CALPUFF Dispersion Model (Version 5). Earth Tech, Inc., Concord, MA

Scire, J.S., F.R. Robe, M.E. Fernau, and R.J. Yamartino, 2000b: A User's Guide for the CALMET Meteorological Model (Version 5). Earth Tech, Inc., Concord, MA.

Smrz, R., 1998: Updated Class I Receptor List and SLVs. Tennessee Department of Environment and Conservation, Division of Air Pollution Control, Nashville, TN. April 6, 1998.

U.S. Environmental Protection Agency (EPA), 1998: Interagency Workgroup on Air Quality Modeling (IWAQM), Phase 2 Report: Summary Report and Recommendation for Modeling Long Range Transport and Impacts on Regional Visibility. EPA-454/R-98-019.

U.S. Environmental Protection Agency (EPA), 2000: Federal Register Notice dated April 21, 2000.

U.S. Environmental Protection Agency (EPA), 2001. Draft Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule, U.S. Environmental Protection Agency, Research Triangle Park, September 27, 2001.

Yamartino, R.J. and E.M. Insley, 1989: User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) Volume 1: Model Description and User Instructions. EPA/600/8-89/041, U.S. Environmental Protection Agency, Research Triangle Park, NC.

APPENDIX A

Sample CALMET Control File

```
Blythe Energy - CALMET Simulation at 2 km resolution, NO-OBS Mode
with MM5.dat data, Jan 1 - Dec 30, 1996, Period 01a January 1-15 1996
NOOBS=2 - ITPROG=2 - ICLOUD=3 - IPROG=14 - ISTEPPG=1
---------------- Run title (3 lines) ------------------------------------------

                    CALMET MODEL CONTROL FILE
                    -------------------------

------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

Subgroup (a)
------------
Default Name  Type           File Name
------------  ----           ---------
GEO.DAT       input    ! GEODAT=geo2km.dat       !
SURF.DAT      input    * SRFDAT=      *
CLOUD.DAT     input    * CLDDAT=      *
PRECIP.DAT    input    * PRCDAT=       *
MM4.DAT       input    ! MM4DAT=nps96.mm5    !
WT.DAT        input    * WTDAT=              *

CALMET.LST    output   ! METLST=met9601a.lst     !
CALMET.DAT    output   ! METDAT=met9601a.dat    !
PACOUT.DAT    output   * PACDAT=             *

All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = T !
         F = UPPER CASE

NUMBER OF UPPER AIR & OVERWATER STATIONS:

    Number of upper air stations (NUSTA)  No default     ! NUSTA =  0  !
    Number of overwater met stations
                                 (NOWSTA) No default     ! NOWSTA = 0  !

                       !END!
------------------------------------------------------------------------------
Subgroup (b)
--------------------------------
Upper air files (one per station)
--------------------------------
```

```
Default Name  Type       File Name
------------  ----       ---------
UP1.DAT       input    1   * UPDAT=    *     *END *
------------------------------------------------------------------------------
Subgroup (c)
----------------------------------------
Overwater station files (one per station)
----------------------------------------
Default Name  Type       File Name
------------  ----       ---------
SEA1.DAT       input     1  * SEADAT=   *     *END *
------------------------------------------------------------------------------
Subgroup (d)
----------------
Other file names
----------------

Default Name  Type       File Name
------------  ----       ---------
DIAG.DAT      input      * DIADAT=                  *
PROG.DAT      input      * PRGDAT=                  *

TEST.PRT      output     * TSTPRT=                  *
TEST.OUT      output     * TSTOUT=                  *
TEST.KIN      output     * TSTKIN=                  *
TEST.FRD      output     * TSTFRD=                  *
TEST.SLP      output     * TSTSLP=                  *

------------------------------------------------------------------------------
NOTES: (1) File/path names can be up to 70 characters in length
       (2) Subgroups (a) and (d) must have ONE 'END' (surround by
           delimiters) at the end of the group
       (3) Subgroups (b) and (c) must have an 'END' (surround by
           delimiters) at the end of EACH LINE

                        !END!

------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

     Starting date:   Year (IBYR) -- No default       ! IBYR=  1996  !
                     Month (IBMO) -- No default       ! IBMO=  1   !
                       Day (IBDY) -- No default       ! IBDY=  1   !
```

```
                    Hour (IBHR) -- No default        ! IBHR=  0   !

     Base time zone         (IBTZ) -- No default        ! IBTZ= 8   !
        PST = 08, MST = 07
        CST = 06, EST = 05

     Length of run (hours) (IRLG) -- No default        ! IRLG=  360   !

     Run type              (IRTYPE) -- Default: 1       ! IRTYPE=  1   !

        0 = Computes wind fields only
        1 = Computes wind fields and micrometeorological variables
            (u*, w*, L, zi, etc.)
        (IRTYPE must be 1 to run CALPUFF or CALGRID)

     Compute special data fields required
     by CALGRID (i.e., 3-D fields of W wind
     components and temperature)
     in additional to regular             Default: T     ! LCALGRD = T !
     fields ? (LCALGRD)
     (LCALGRD must be T to run CALGRID)

      Flag to stop run after
      SETUP phase (ITEST)              Default: 2        ! ITEST=  2    !
      (Used to allow checking
      of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of
                  COMPUTATIONAL phase after SETUP

!END!

--------------------------------------------------------------------------------

INPUT GROUP: 2 -- Grid control parameters
--------------

     HORIZONTAL GRID DEFINITION:

           No. X grid cells (NX)      No default      ! NX =   151   !
           No. Y grid cells (NY)      No default      ! NY =   126   !

     GRID SPACING (DGRIDKM)           No default      ! DGRIDKM = 2 !
                                      Units: km
```

```
REFERENCE COORDINATES
of SOUTHWEST corner of grid cell (1,1)

   X coordinate (XORIGKM)          No default      ! XORIGKM =  479.0 !
   Y coordinate (YORIGKM)          No default      ! YORIGKM = 3621.0 !
                                   Units: km
   Latitude  (XLAT0)               No default      ! XLAT0 =  32.728 !
   Longitude (XLON0)               No default      ! XLON0 = 117.224 !

UTM ZONE (IUTMZN)                  Default: 0      ! IUTMZN =  11  !

LAMBERT CONFORMAL PARAMETERS

Rotate input winds from true north to
map north using a Lambert conformal
projection? (LLCONF)               Default: F      ! LLCONF = F !

Latitude of 1st standard parallel   Default: 30.   ! XLAT1 = 30. !
Latitude of 2nd standard parallel   Default: 60.   ! XLAT2 = 60. !
(XLAT1 and XLAT2; + in NH, - in SH)

   Longitude (RLON0)                 Default = 90.  ! RLON0 = 90.0 !
   (used only if LLCONF = T)
   (Positive = W. Hemisphere;
    Negative = E. Hemisphere)
   Origin Latitude (RLAT0)           Default = 40.  ! RLAT0 = 40.0 !
   (used only if IPROG > 2)
   (Positive = N. Hemisphere;
    Negative = S. Hemisphere)

Vertical grid definition:

   No. of vertical layers (NZ)     No default      ! NZ =  10  !

   Cell face heights in arbitrary
   vertical grid (ZFACE(NZ+1))     No defaults
                                   Units: m
   ! ZFACE = 0.,20.,40.,80.,160.,300.,600.,1000.,1500.,2200.,3000.!

!END!
```

```
INPUT GROUP: 3 -- Output Options
--------------

    DISK OUTPUT OPTION

       Save met. fields in an unformatted
       output file ?              (LSAVE)  Default: T     ! LSAVE = T !
       (F = Do not save, T = Save)

       Type of unformatted output file:
       (IFORMO)                            Default: 1     ! IFORMO =  1  !

            1 = CALPUFF/CALGRID type file (CALMET.DAT)
            2 = MESOPUFF-II type file     (PACOUT.DAT)


    LINE PRINTER OUTPUT OPTIONS:

       Print met. fields ?  (LPRINT)       Default: F     ! LPRINT = F !
       (F = Do not print, T = Print)
       (NOTE: parameters below control which
              met. variables are printed)

       Print interval
       (IPRINF) in hours                   Default: 1     ! IPRINF =  1  !
       (Meteorological fields are printed
        every IPRINF hours)

       Specify which layers of U, V wind component
       to print (IUVOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T)        Defaults: NZ*0
       ! IUVOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !
       ------------------------

       Specify which levels of the W wind component to print
       (NOTE: W defined at TOP cell face --  10  values)
       (IWOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T & LCALGRD=T)
       ----------------------------------
                                           Defaults: NZ*0
        ! IWOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !
```

```
Specify which levels of the 3-D temperature field to print
(ITOUT(NZ)) -- NOTE: NZ values must be entered
(0=Do not print, 1=Print)
(used only if LPRINT=T & LCALGRD=T)
-----------------------------------
                                        Defaults: NZ*0
 ! ITOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !

Specify which meteorological fields
to print
(used only if LPRINT=T)             Defaults: 0 (all variables)
-----------------------

  Variable            Print ?
                    (0 = do not print,
                     1 = print)
  --------          ------------------
!  STABILITY  =           0           ! - PGT stability class
!  USTAR      =           0           ! - Friction velocity
!  MONIN      =           0           ! - Monin-Obukhov length
!  MIXHT      =           0           ! - Mixing height
!  WSTAR      =           0           ! - Convective velocity scale
!  PRECIP     =           0           ! - Precipitation rate
!  SENSHEAT   =           0           ! - Sensible heat flux
!  CONVZI     =           0           ! - Convective mixing ht.

Testing and debug print options for micrometeorological module

   Print input meteorological data and
   internal variables (LDB)         Default: F       ! LDB = F !
   (F = Do not print, T = print)
   (NOTE: this option produces large amounts of output)

   First time step for which debug data
   are printed (NN1)                Default: 1       ! NN1 =  1  !

   Last time step for which debug data
   are printed (NN2)                Default: 1       ! NN2 =  1  !

Testing and debug print options for wind field module
(all of the following print options control output to
 wind field module's output files: TEST.PRT, TEST.OUT,
 TEST.KIN, TEST.FRD, and TEST.SLP)
```

```
Control variable for writing the test/debug
wind fields to disk files (IOUTD)
(0=Do not write, 1=write)          Default: 0       ! IOUTD =  0  !

Number of levels, starting at the surface,
to print (NZPRN2)                  Default: 1       ! NZPRN2 =  0  !

Print the INTERPOLATED wind components ?
(IPR0) (0=no, 1=yes)               Default: 0       !  IPR0 =  0  !

Print the TERRAIN ADJUSTED surface wind
components ?
(IPR1) (0=no, 1=yes)               Default: 0       !  IPR1 =  0  !

Print the SMOOTHED wind components and
the INITIAL DIVERGENCE fields ?
(IPR2) (0=no, 1=yes)               Default: 0       !  IPR2 =  0  !

Print the FINAL wind speed and direction
fields ?
(IPR3) (0=no, 1=yes)               Default: 0       !  IPR3 =  0  !

Print the FINAL DIVERGENCE fields ?
(IPR4) (0=no, 1=yes)               Default: 0       !  IPR4 =  0  !

Print the winds after KINEMATIC effects
are added ?
(IPR5) (0=no, 1=yes)               Default: 0       !  IPR5 =  0  !

Print the winds after the FROUDE NUMBER
adjustment is made ?
(IPR6) (0=no, 1=yes)               Default: 0       !  IPR6 =  0  !

Print the winds after SLOPE FLOWS
are added ?
(IPR7) (0=no, 1=yes)               Default: 0       !  IPR7 =  0  !

Print the FINAL wind field components ?
(IPR8) (0=no, 1=yes)               Default: 0       !  IPR8 =  0  !

!END!
--------------------------------------------------------------------------------
```

```
INPUT GROUP: 4 -- Meteorological data options
--------------

    NO OBSERVATION MODE (NOOBS)           Default: 0      ! NOOBS = 2!
          0 = Use Surface and upper air stations
          1 = No upper air observations
              Use MM5 for upper air data
          2 = No surface or upper air observations
              Use MM5 for surface and upper air data

    NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

       Number of surface stations   (NSSTA)  No default     ! NSSTA =  0  !

       Number of precipitation stations
       (npsta=-1: flag for use of MM5 precip data)
                                    (NPSTA)  No default     ! NPSTA = 0 !
    CLOUD DATA OPTIONS
       Gridded cloud fields:
                                   (ICLOUD)  Default: 0     ! ICLOUD =  3  !
       ICLOUD = 0 - Gridded clouds not used
       ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
       ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT
       ICLOUD = 3 - Gridded cloud cover from Prognostic Rel. Humidity

    FILE FORMATS

       Surface meteorological data file format
                                   (IFORMS)  Default: 2     ! IFORMS =  2  !
       (1 = unformatted (e.g., SMERGE output))
       (2 = formatted   (free-formatted user input))

       Precipitation data file format
                                   (IFORMP)  Default: 2     ! IFORMP =  2  !
       (1 = unformatted (e.g., PMERGE output))
       (2 = formatted   (free-formatted user input))

       Cloud data file format
                                   (IFORMC)  Default: 2     ! IFORMC =  2  !
       (1 = unformatted - CALMET unformatted output)
       (2 = formatted   - free-formatted CALMET output or user input)

!END!
--------------------------------------------------------------------------------
```

```
INPUT GROUP: 5 -- Wind Field Options and Parameters
--------------

    WIND FIELD MODEL OPTIONS
       Model selection variable (IWFCOD)     Default: 1      ! IWFCOD =  1  !
          0 = Objective analysis only
          1 = Diagnostic wind module

       Compute Froude number adjustment
       effects ? (IFRADJ)                    Default: 1      ! IFRADJ =  1  !
       (0 = NO, 1 = YES)

       Compute kinematic effects ? (IKINE)   Default: 0      ! IKINE  =  0  !
       (0 = NO, 1 = YES)

       Use O'Brien procedure for adjustment
       of the vertical velocity ? (IOBR)     Default: 0      ! IOBR =  0  !
       (0 = NO, 1 = YES)

       Compute slope flow effects ? (ISLOPE) Default: 1      ! ISLOPE  =  1  !
       (0 = NO, 1 = YES)

       Extrapolate surface wind observations
       to upper layers ? (IEXTRP)            Default: -4     ! IEXTRP = -1  !
       (1 = no extrapolation is done,
        2 = power law extrapolation used,
        3 = user input multiplicative factors
            for layers 2 - NZ used (see FEXTRP array)
        4 = similarity theory used
        -1, -2, -3, -4 = same as above except layer 1 data
            at upper air stations are ignored

       Extrapolate surface winds even
       if calm? (ICALM)                      Default: 0      ! ICALM  =  0  !
       (0 = NO, 1 = YES)

       Layer-dependent biases modifying the weights of
       surface and upper air stations (BIAS(NZ))
         -1<=BIAS<=1
       Negative BIAS reduces the weight of upper air stations
         (e.g. BIAS=-0.1 reduces the weight of upper air stations
       by 10%; BIAS= -1, reduces their weight by 100 %)
       Positive BIAS reduces the weight of surface stations
```

```
  (e.g. BIAS= 0.2 reduces the weight of surface stations
by 20%; BIAS=1 reduces their weight by 100%)
Zero BIAS leaves weights unchanged (1/R**2 interpolation)
Default: NZ*0
       ! BIAS =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 !

Minimum distance from nearest upper air station
to surface station for which extrapolation
of surface winds at surface station will be allowed
(RMIN2: Set to -1 for IEXTRP = 4 or other situations
 where all surface stations should be extrapolated)
                                      Default: 4.    ! RMIN2 = -1.0 !

Use gridded prognostic wind field model
output fields as input to the diagnostic
wind field model (IPROG)              Default: 0     ! IPROG = 14  !
(0 = No, [IWFCOD = 0 or 1]
 1 = Yes, use CSUMM prog. winds as Step 1 field, [IWFCOD = 0]
 2 = Yes, use CSUMM prog. winds as initial guess field [IWFCOD = 1]
 3 = Yes, use winds from MM4.DAT file as Step 1 field [IWFCOD = 0]
 4 = Yes, use winds from MM4.DAT file as initial guess field [IWFCOD = 1]
 5 = Yes, use winds from MM4.DAT file as observations [IWFCOD =0,1]
 13 = Yes, use winds from MM5.DAT file as Step 1 field [IWFCOD = 0]
 14 = Yes, use winds from MM5.DAT file as initial guess field [IWFCOD = 1]
 15 = Yes, use winds from MM5.DAT file as observations [IWFCOD =0,1]

 Timestep of the prognostic data     Default: 1     ! ISTEPPG = 1  !
 (in hours)

RADIUS OF INFLUENCE PARAMETERS

Use varying radius of influence       Default: F     ! LVARY =  F !
(if no stations are found within RMAX1,RMAX2,
 or RMAX3, then the closest station will be used)

Maximum radius of influence over land
in the surface layer (RMAX1)          No default     ! RMAX1 = 40. !
                                      Units: km
Maximum radius of influence over land
aloft (RMAX2)                         No default     ! RMAX2 = 40. !
                                      Units: km
Maximum radius of influence over water
(RMAX3)                               No default     ! RMAX3 = 40. !
                                      Units: km
```

```
OTHER WIND FIELD INPUT PARAMETERS

    Minimum radius of influence used in
    the wind field interpolation (RMIN)   Default: 0.1     ! RMIN = 0.1 !
                                          Units: km

    Radius of influence of terrain
    features (TERRAD)                     No default      ! TERRAD = 12. !
                                          Units: km

    Relative weighting of the first
    guess field and observations in the
    SURFACE layer (R1)                    No default      ! R1 = 10. !
    (R1 is the distance from an           Units: km
    observational station at which the
    observation and first guess field are
    equally weighted)

    Relative weighting of the first
    guess field and observations in the
    layers ALOFT (R2)                     No default      ! R2 = 10. !
    (R2 is applied in the upper layers    Units: km
    in the same manner as R1 is used in
    the surface layer).

    Relative weighting parameter of the
    prognostic wind field data (RPROG)    No default      ! RPROG = 0. !
    (Used only if IPROG = 1, 3 or 13)      Units: km
    ------------------------

    Maximum acceptable divergence in the
    divergence minimization procedure
    (DIVLIM)                              Default: 5.E-6  ! DIVLIM= 5.0E-06 !

    Maximum number of iterations in the
    divergence min. procedure (NITER)     Default: 50     ! NITER =  50  !

    Number of passes in the smoothing
    procedure (NSMTH(NZ))
    NOTE: NZ values must be entered
         Default: 2,(mxnz-1)*4 ! NSMTH =
2 , 4 , 4 , 4 , 4 , 4 , 4 , 4 , 4 , 4 !

    Maximum number of stations used in
    each layer for the interpolation of
```

```
      data to a grid point (NINTR2(NZ))
      NOTE: NZ values must be entered       Default: 99.     ! NINTR2 =
99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99  !

      Critical Froude number (CRITFN)       Default: 1.0    ! CRITFN = 1. !

      Empirical factor controlling the
      influence of kinematic effects
      (ALPHA)                               Default: 0.1    ! ALPHA = 0.1 !

      Multiplicative scaling factor for
      extrapolation of surface observations
      to upper layers (FEXTR2(NZ))          Default: NZ*0.0
      ! FEXTR2 = 0., 0., 0., 0., 0., 0., 0., 0., 0., 0. !
      (Used only if IEXTRP = 3 or -3)

   BARRIER INFORMATION

      Number of barriers to interpolation
      of the wind fields (NBAR)             Default: 0      ! NBAR =  0  !

      THE FOLLOWING 4 VARIABLES ARE INCLUDED
      ONLY IF NBAR > 0
      NOTE: NBAR values must be entered     No defaults
            for each variable               Units: km

         X coordinate of BEGINNING
         of each barrier (XBBAR(NBAR))      ! XBBAR = 0. !
         Y coordinate of BEGINNING
         of each barrier (YBBAR(NBAR))      ! YBBAR = 0. !

         X coordinate of ENDING
         of each barrier (XEBAR(NBAR))      ! XEBAR = 0. !
         Y coordinate of ENDING
         of each barrier (YEBAR(NBAR))      ! YEBAR = 0. !

   DIAGNOSTIC MODULE DATA INPUT OPTIONS

      Surface temperature (IDIOPT1)         Default: 0      ! IDIOPT1 =  0  !
         0 = Compute internally from
             hourly surface observations
         1 = Read preprocessed values from
             a data file (DIAG.DAT)
```

```
   Surface met. station to use for
   the surface temperature (ISURFT)   No default      ! ISURFT =  4  !
   (Must be a value from 1 to NSSTA)
   (Used only if IDIOPT1 = 0)
   -------------------------

Domain-averaged temperature lapse
rate (IDIOPT2)                        Default: 0      ! IDIOPT2 =  0  !
   0 = Compute internally from
       twice-daily upper air observations
   1 = Read hourly preprocessed values
       from a data file (DIAG.DAT)

   Upper air station to use for
   the domain-scale lapse rate (IUPT) No default      ! IUPT   =  2  !
   (Must be a value from 1 to NUSTA)
   (Used only if IDIOPT2 = 0)
   -------------------------

   Depth through which the domain-scale
   lapse rate is computed (ZUPT)      Default: 200.  ! ZUPT = 200. !
   (Used only if IDIOPT2 = 0)         Units: meters
   -------------------------

Domain-averaged wind components
(IDIOPT3)                             Default: 0      ! IDIOPT3 =  0  !
   0 = Compute internally from
       twice-daily upper air observations
   1 = Read hourly preprocessed values
       a data file (DIAG.DAT)

   Upper air station to use for
   the domain-scale winds (IUPWND)    Default: -1     ! IUPWND = -1  !
   (Must be a value from -1 to NUSTA)
   (Used only if IDIOPT3 = 0)
   -------------------------

   Bottom and top of layer through
   which the domain-scale winds
   are computed
   (ZUPWND(1), ZUPWND(2))         Defaults: 1., 1000. ! ZUPWND= 1., 1000. !
   (Used only if IDIOPT3 = 0)     Units: meters
   -------------------------
```

```
Observed surface wind components
for wind field module (IDIOPT4)  Default: 0      ! IDIOPT4 =  0  !
   0 = Read WS, WD from a surface
       data file (SURF.DAT)
   1 = Read hourly preprocessed U, V from
       a data file (DIAG.DAT)

Observed upper air wind components
for wind field module (IDIOPT5)  Default: 0      ! IDIOPT5 =  0  !
   0 = Read WS, WD from an upper
       air data file (UP1.DAT, UP2.DAT, etc.)
   1 = Read hourly preprocessed U, V from
       a data file (DIAG.DAT)

LAKE BREEZE INFORMATION

   Use Lake Breeze Module  (LLBREZE)
                                   Default: F      ! LLBREZE = F !

    Number of lake breeze regions (NBOX)           ! NBOX =  0  !

 X Grid line 1 defining the region of interest
                                                   ! XG1 = 0. !
 X Grid line 2 defining the region of interest
                                                   ! XG2 = 0. !
 Y Grid line 1 defining the region of interest
                                                   ! YG1 = 0. !
 Y Grid line 2 defining the region of interest
                                                   ! YG2 = 0. !

  X Point defining the coastline (Straight line)
            (XBCST)  (KM)   Default: none    ! XBCST = 0. !

  Y Point defining the coastline (Straight line)
            (YBCST)  (KM)   Default: none    ! YBCST = 0. !

  X Point defining the coastline (Straight line)
            (XECST)  (KM)   Default: none    ! XECST = 0. !

  Y Point defining the coastline (Straight line)
            (YECST)  (KM)   Default: none    ! YECST = 0. !

Number of stations in the region     Default: none ! NLB = *1 !*
(Surface stations + upper air stations)
```

```
       Station ID's  in the region    (METBXID(NLB))
       (Surface stations first, then upper air stations)
         ! METBXID = *0 !*

!END!

----------------------------------------------------------------------------

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters
--------------

    EMPIRICAL MIXING HEIGHT CONSTANTS

       Neutral, mechanical equation
       (CONSTB)                          Default: 1.41    ! CONSTB = 1.41 !
       Convective mixing ht. equation
       (CONSTE)                          Default: 0.15    ! CONSTE = 0.15 !
       Stable mixing ht. equation
       (CONSTN)                          Default: 2400.   ! CONSTN = 2400.!
       Overwater mixing ht. equation
       (CONSTW)                          Default: 0.16    ! CONSTW = 0.16 !
       Absolute value of Coriolis
       parameter (FCORIOL)               Default: 1.E-4   ! FCORIOL = 1.0E-04!
                                         Units: (1/s)

 SPATIAL AVERAGING OF MIXING HEIGHTS

       Conduct spatial averaging
       (IAVEZI)  (0=no, 1=yes)           Default: 1       ! IAVEZI =  1  !

       Max. search radius in averaging
       process (MNMDAV)                  Default: 1       ! MNMDAV =  3  !
                                         Units: Grid
                                                cells
       Half-angle of upwind looking cone
       for averaging (HAFANG)            Default: 30.     ! HAFANG = 30. !
                                         Units: deg.
       Layer of winds used in upwind
       averaging (ILEVZI)                Default: 1       ! ILEVZI =  1  !
       (must be between 1 and NZ)
```

```
OTHER MIXING HEIGHT VARIABLES

   Minimum potential temperature lapse
   rate in the stable layer above the
   current convective mixing ht.          Default: 0.001  ! DPTMIN = 0.001 !
   (DPTMIN)                               Units: deg. K/m
   Depth of layer above current conv.
   mixing height through which lapse      Default: 200.   ! DZZI = 200. !
   rate is computed (DZZI)                Units: meters

   Minimum overland mixing height         Default:  50.   ! ZIMIN = 50. !
   (ZIMIN)                                Units: meters
   Maximum overland mixing height         Default: 3000.  ! ZIMAX = 3000. !
   (ZIMAX)                                Units: meters
   Minimum overwater mixing height        Default:   50.  ! ZIMINW = 50. !
   (ZIMINW) -- (Not used if observed      Units: meters
   overwater mixing hts. are used)
   Maximum overwater mixing height        Default: 3000.  ! ZIMAXW = 3000. !
   (ZIMAXW) -- (Not used if observed      Units: meters
   overwater mixing hts. are used)

TEMPERATURE PARAMETERS

   3D temperature from observations
   or from prognostic data
   (0: sf and upper obs;
    1: sf obs and upper MM5
    2: sf and upper MM5)                  Default:0         !ITPROG = 2 !

   Interpolation type
   (1 = 1/R ; 2 = 1/R**2)                 Default:1         ! IRAD =  1  !

   Radius of influence for temperature
   interpolation (TRADKM)                 Default: 500.     ! TRADKM = 20. !
                                          Units: km

   Maximum Number of stations to include
   in temperature interpolation (NUMTS)   Default: 5        ! NUMTS = 5  !

   Conduct spatial averaging of temp-
   eratures (IAVET)  (0=no, 1=yes)          Default: 1     ! IAVET =  1  !
   (will use mixing ht MNMDAV,HAFANG
    so make sure they are correct)
```

```
      Default temperature gradient        Default: -.0098 ! TGDEFB = -0.0098 !
      below the mixing height over
      water (K/m) (TGDEFB)

      Default temperature gradient        Default: -.0045 ! TGDEFA = -0.0045 !
      above the mixing height over
      water (K/m) (TGDEFA)

      Beginning (JWAT1) and ending (JWAT2)
      land use categories for temperature                  ! JWAT1 =  55  !
      interpolation over water -- Make                     ! JWAT2 =  55  !
      bigger than largest land use to disable

   PRECIP INTERPOLATION PARAMETERS

      Method of interpolation (NFLAGP)      Default = 2    ! NFLAGP =  2  !
       (1=1/R,2=1/R**2,3=EXP/R**2)
      Radius of Influence (km) (SIGMAP)     Default = 100.0  ! SIGMAP = 50. !
       (0.0 => use half dist. btwn
        nearest stns w & w/out
        precip when NFLAGP = 3)
      Minimum Precip. Rate Cutoff (mm/hr)   Default = 0.01  ! CUTP = 0.01 !
       (values < CUTP = 0.0 mm/hr)
!END!

-------------------------------------------------------------------------------

INPUT GROUP: 7 -- Surface meteorological station parameters
--------------

     SURFACE STATION VARIABLES
     (One record per station --  5  records in all)

           1     2
        Name   ID            X coord.   Y coord.   Time   Anem.
                              (km)       (km)      zone   Ht.(m)
       ------------------------------------------------------------
* SS1  ='BGR '   14606       514.500    4960.533    5     10 *
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)
      2
        Five digit integer for station ID
!END!
```

```
-------------------------------------------------------------------------------

INPUT GROUP: 8 -- Upper air meteorological station parameters
--------------
     UPPER AIR STATION VARIABLES
     (One record per station --  3  records in all)
             1     2
         Name    ID      X coord.   Y coord.  Time zone
                            (km)       (km)
        ---------------------------------------------
* US1  ='PWM '   14764    393.788   4833.627    5  *
--------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)
      2
        Five digit integer for station ID
!END!
-------------------------------------------------------------------------------
INPUT GROUP: 9 -- Precipitation station parameters
--------------
     PRECIPITATION STATION VARIABLES
     (One record per station -- 0  records in all)
     (NOT INCLUDED IF NPSTA = 0)

             1          2
          Name   Station    X coord.  Y coord.
                   Code       (km)      (km)
          ------------------------------------
* PS1  ='ME03'   170273    437.512   4905.276       *
--------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)
      2
        Six digit station code composed of state
        code (first 2 digits) and station ID (last
        4 digits)
```

```
!END!
```

APPENDIX B

Sample CALPUFF Control File

```
BLYTHE 2 TURBINES
WITH NPS MM5 Data - 1996  Monthly Average Ozone (6:00AM-6:00PM) Stack 01
BLYTHE NOX AND SO2 PM10 IMPACTS AT JOSHUA TREE NP
---------------- Run title (3 lines) ------------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------
------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names
--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    * METDAT =             *
    or
ISCMET.DAT    input    * ISCDAT =23169-86.ASC   *
    or
PLMMET.DAT    input    * PLMDAT =             *
    or
PROFILE.DAT   input    * PRFDAT =             *
SURFACE.DAT   input    * SFCDAT =             *
RESTARTB.DAT  input    * RSTARTB=             *
------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =PF960101.LST  !
CONC.DAT      output   ! CONDAT =PF960101.CON  !
DFLX.DAT      output   ! DFDAT  =PF960101.DRY  !
WFLX.DAT      output   ! WFDAT  =PF960101.WET  !

VISB.DAT      output   ! VISDAT = vi960101.dat !
RESTARTE.DAT  output   ! RSTARTE= PF960101.RST !
------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEMARB.DAT  input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    * OZDAT  =             *
VD.DAT        input    * VDDAT  =             *
CHEM.DAT      input    * CHEMDAT=             *
H2O2.DAT      input    * H2O2DAT=             *
HILL.DAT      input    * HILDAT=              *
HILLRCT.DAT   input    * RCTDAT=              *
COASTLN.DAT   input    * CSTDAT=              *
FLUXBDY.DAT   input    * BDYDAT=              *
```

```
BCON.DAT      input    * BCNDAT=              *
DEBUG.DAT     output   * DEBUG =              *
MASSFLX.DAT   output   ! FLXDAT= pf960101.MBL !
MASSBAL.DAT   output   * BALDAT=              *
FOG.DAT       output   * FOGDAT=              *
-------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = T !
         F = UPPER CASE
NOTE: (1) file/path names can be up to 70 characters in length


Provision for multiple input files
----------------------------------

     Number of CALMET.DAT files for run (NMETDAT)
                                   Default: 1       ! NMETDAT =   24   !

     Number of PTEMARB.DAT files for run (NPTDAT)
                                   Default: 0       ! NPTDAT =  0  !

     Number of BAEMARB.DAT files for run (NARDAT)
                                   Default: 0       ! NARDAT =  0  !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                   Default: 0       ! NVOLDAT =  0  !

!END!

-------------
Subgroup (0a)
-------------
  The following CALMET.DAT filenames are processed in sequence if NMETDAT>1

Default Name  Type          File Name
------------  ----          ---------
 none         input    ! METDAT=e:\blythe\calmet\runs\met9601a.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9601b.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9602a.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9602b.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9603a.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9603b.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9604a.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9604b.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9605a.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9605b.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9606a.dat     !   !END!
 none         input    ! METDAT=e:\blythe\calmet\runs\met9606b.dat     !   !END!
```

```
none          input    ! METDAT=e:\blythe\calmet\runs\met9607a.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9607b.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9608a.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9608b.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9609a.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9609b.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9610a.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9610b.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9611a.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9611b.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9612a.dat     !   !END!
none          input    ! METDAT=e:\blythe\calmet\runs\met9612b.dat     !   !END!

-------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN =   0  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:   Year (IBYR) -- No default       ! IBYR =  1996  !
     (used only if   Month (IBMO) -- No default       ! IBMO =  1   !
      METRUN = 0)      Day (IBDY) -- No default       ! IBDY =  1   !
                      Hour (IBHR) -- No default       ! IBHR =  0   !

     Base time zone        (XBTZ) -- No default       ! XBTZ = 8.0  !
        PST = 8., MST = 7.
        CST = 6., EST = 5.

     Length of run (hours) (IRLG) -- No default       ! IRLG =  8752  !

     Number of chemical species (NSPEC)
                                  Default: 5       ! NSPEC =  12   !

     Number of chemical species
     to be emitted  (NSE)         Default: 3       ! NSE =  10   !

     Flag to stop run after
     SETUP phase (ITEST)          Default: 2       ! ITEST =  2   !
     (Used to allow checking
     of the model inputs, files, etc.)
           ITEST = 1 - STOPS program after SETUP phase
           ITEST = 2 - Continues with execution of program
                       after SETUP
```

```
   Restart Configuration:

      Control flag (MRESTART)      Default: 0       ! MRESTART =  2   !

         0 = Do not read or write a restart file
         1 = Read a restart file at the beginning of
             the run
         2 = Write a restart file during run
         3 = Read a restart file at beginning of run
             and write a restart file during run

      Number of periods in Restart
      output cycle (NRESPD)        Default: 0       ! NRESPD =  120   !

         0 = File written only at last period
        >0 = File updated every NRESPD periods

   Meteorological Data Format (METFM)
                                   Default: 1       ! METFM =  1   !

         METFM = 1 - CALMET binary file (CALMET.MET)
         METFM = 2 - ISC ASCII file (ISCMET.MET)
         METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
         METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                     surface parameters file (SURFACE.DAT)

   PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
   Averaging Time (minutes) (AVET)
                                   Default: 60.0    ! AVET = 60. !
   PG Averaging Time (minutes) (PGTIME)
                                   Default: 60.0    ! PGTIME = 60. !

!END!

------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------

   Vertical distribution used in the
   near field (MGAUSS)                 Default: 1     ! MGAUSS =  1   !
      0 = uniform
      1 = Gaussian

   Terrain adjustment method
   (MCTADJ)                            Default: 3     ! MCTADJ =  3   !
      0 = no adjustment
      1 = ISC-type of terrain adjustment
      2 = simple, CALPUFF-type of terrain
```

```
        adjustment
    3 = partial plume path adjustment

Subgrid-scale complex terrain
flag (MCTSG)                          Default: 0     ! MCTSG =  0   !
    0 = not modeled
    1 = modeled

Near-field puffs modeled as
elongated 0 (MSLUG)                   Default: 0     ! MSLUG =  0   !
    0 = no
    1 = yes (slug model used)

Transitional plume rise modeled ?
(MTRANS)                              Default: 1     ! MTRANS =  1   !
    0 = no  (i.e., final rise only)
    1 = yes (i.e., transitional rise computed)

Stack tip downwash? (MTIP)            Default: 1     ! MTIP =  1  !
    0 = no  (i.e., no stack tip downwash)
    1 = yes (i.e., use stack tip downwash)

Vertical wind shear modeled above
stack top? (MSHEAR)                   Default: 0     ! MSHEAR =  0  !
    0 = no  (i.e., vertical wind shear not modeled)
    1 = yes (i.e., vertical wind shear modeled)

Puff splitting allowed? (MSPLIT)      Default: 0     ! MSPLIT =  0  !
    0 = no (i.e., puffs not split)
    1 = yes (i.e., puffs are split)

Chemical mechanism flag (MCHEM)       Default: 1     ! MCHEM =  1   !
    0 = chemical transformation not
        modeled
    1 = transformation rates computed
        internally (MESOPUFF II scheme)
    2 = user-specified transformation
        rates used
    3 = transformation rates computed
        internally (RIVAD/ARM3 scheme)
    4 = secondary organic aerosol formation
        computed (MESOPUFF II scheme for OH)

Aqueous phase transformation flag (MAQCHEM)
(Used only if MCHEM = 1, or 3)        Default: 0     ! MAQCHEM =  0   !
    0 = aqueous phase transformation
        not modeled
    1 = transformation rates adjusted
        for aqueous phase reactions
```

```
Wet removal modeled ? (MWET)          Default: 1     ! MWET =  1   !
   0 = no
   1 = yes

Dry deposition modeled ? (MDRY)       Default: 1     ! MDRY =  1   !
   0 = no
   1 = yes
   (dry deposition method specified
    for each species in Input Group 3)

Method used to compute dispersion
coefficients (MDISP)                  Default: 3     ! MDISP =  3   !

   1 = dispersion coefficients computed from measured values
       of turbulence, sigma v, sigma w
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.
   5 = CTDM sigmas used for stable and neutral conditions.
       For unstable conditions, sigmas are computed as in
       MDISP = 3, described above.  MDISP = 5 assumes that
       measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)         Default: 3     ! MTURBVW =  0   !
   1 = use sigma-v or sigma-theta measurements
       from PROFILE.DAT to compute sigma-y
       (valid for METFM = 1, 2, 3, 4)
   2 = use sigma-w measurements
       from PROFILE.DAT to compute sigma-z
       (valid for METFM = 1, 2, 3, 4)
   3 = use both sigma-(v/theta) and sigma-w
       from PROFILE.DAT to compute sigma-y and sigma-z
       (valid for METFM = 1, 2, 3, 4)
   4 = use sigma-theta measurements
       from PLMMET.DAT to compute sigma-y
       (valid only if METFM = 3)

Back-up method used to compute dispersion
when measured turbulence data are
missing (MDISP2)                      Default: 3     ! MDISP2 =  3   !
(used only if MDISP = 1 or 5)
   2 = dispersion coefficients from internally calculated
```

```
        sigma v, sigma w using micrometeorological variables
        (u*, w*, L, etc.)
    3 = PG dispersion coefficients for RURAL areas (computed using
        the ISCST multi-segment approximation) and MP coefficients in
        urban areas
    4 = same as 3 except PG coefficients computed using
        the MESOPUFF II eqns.

PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH =  0  !
(MROUGH)
    0 = no
    1 = yes

Partial plume penetration of          Default: 1     ! MPARTL =  1  !
elevated inversion?
(MPARTL)
    0 = no
    1 = yes

Strength of temperature inversion     Default: 0     ! MTINV =  0  !
provided in PROFILE.DAT extended records?
(MTINV)
    0 = no (computed from measured/default gradients)
    1 = yes

PDF used for dispersion under convective conditions?
                                      Default: 0     ! MPDF =  0  !
(MPDF)
    0 = no
    1 = yes

Sub-Grid TIBL module used for shore line?
                                      Default: 0     ! MSGTIBL = 0  !
(MSGTIBL)
    0 = no
    1 = yes

Boundary conditions (concentration) modeled?
                                      Default: 0     ! MBCON = 0  !
(MBCON)
    0 = no
    1 = yes


Analyses of fogging and icing impacts due to emissions from
arrays of mechanically-forced cooling towers can be performed
using CALPUFF in conjunction with a cooling tower emissions
processor (CTEMISS) and its associated postprocessors.  Hourly
emissions of water vapor and temperature from each cooling tower
```

```
     cell are computed for the current cell configuration and ambient
     conditions by CTEMISS. CALPUFF models the dispersion of these
     emissions and provides cloud information in a specialized format
     for further analysis. Output to FOG.DAT is provided in either
     'plume mode' or 'receptor mode' format.

     Configure for FOG Model output?
                                          Default: 0      ! MFOG =  0    !
     (MFOG)
        0 = no
        1 = yes  - report results in PLUME Mode format
        2 = yes  - report results in RECEPTOR Mode format


     Test options specified to see if
     they conform to regulatory
     values? (MREG)                       Default: 1      ! MREG =  0    !

        0 = NO checks are made
        1 = Technical options must conform to USEPA
            Long Range Transport (LRT) guidance
                      METFM    1 or 2
                      AVET     60. (min)
                      PGTIME   60. (min)
                      MGAUSS   1
                      MCTADJ   3
                      MTRANS   1
                      MTIP     1
                      MCHEM    1 or 3 (if modeling SOx, NOx)
                      MWET     1
                      MDRY     1
                      MDISP    2 or 3
                      MPDF     0 if MDISP=3
                               1 if MDISP=2
                      MROUGH   0
                      MPARTL   1
                      SYTDEP   550. (m)
                      MHFTSZ   0

!END!

------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------
```

```
  The following species are modeled:

! CSPEC =           SO2 !          !END!
! CSPEC =           SO4 !          !END!
! CSPEC =           NOX !          !END!
! CSPEC =          HNO3 !          !END!
! CSPEC =           NO3 !          !END!
! CSPEC =         PM0005 !          !END!
! CSPEC =         PM0010 !          !END!
! CSPEC =         PM0015 !          !END!
! CSPEC =         PM0020 !          !END!
! CSPEC =         PM0025 !          !END!
! CSPEC =         PM0100 !          !END!
! CSPEC =         PM10   !          !END!

                                                      Dry                 OUTPUT GROUP
    SPECIES          MODELED          EMITTED       DEPOSITED              NUMBER
     NAME         (0=NO, 1=YES)    (0=NO, 1=YES)    (0=NO,               (0=NONE,
   (Limit: 12                                         1=COMPUTED-GAS       1=1st CGRUP,
    Characters                                        2=COMPUTED-PARTICLE  2=2nd CGRUP,
    in length)                                        3=USER-SPECIFIED)    3= etc.)

!          SO2  =          1,              1,          1,                  0   !
!          SO4  =          1,              1,          2,                  0   !
!          NOX  =          1,              1,          1,                  0   !
!         HNO3  =          1,              0,          1,                  0   !
!          NO3  =          1,              0,          2,                  0   !
!         PM0005  =        1,              1,          2,                  0   !
!         PM0010  =        1,              1,          2,                  0   !
!         PM0015  =        1,              1,          2,                  0   !
!         PM0020  =        1,              1,          2,                  0   !
!         PM0025  =        1,              1,          2,                  0   !
!         PM0100  =        1,              1,          2,                  0   !
!         PM10    =        1,              1,          2,                  0   !

!END!

-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
  by treating each size-range as a separate species.
  Order must be consistent with 3(a) above.
```

```
------------------------------------------------------------------------------

INPUT GROUP: 4 -- Grid control parameters
--------------

METEOROLOGICAL grid:

           No. X grid cells (NX)      No default     ! NX =  151   !
           No. Y grid cells (NY)      No default     ! NY =  126   !
        No. vertical layers (NZ)      No default     ! NZ =   10   !

          Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 2. !
                                      Units: km

               Cell face heights
                   (ZFACE(nz+1))      No defaults
                                      Units: m
  ! ZFACE = 0.,20.,40.,80.,160.,300.,600.,1000.,1500.,2200.,3000. !

          Reference Coordinates
          of SOUTHWEST corner of
               grid cell(1, 1):

          X coordinate (XORIGKM)      No default     ! XORIGKM =  479.000 !
          Y coordinate (YORIGKM)      No default     ! YORIGKM = 3621.000 !
                                     Units: km

               UTM zone (IUTMZN)      No default     ! IUTMZN =  11   !

   Reference coordinates of CENTER
        of the domain (used in the
    calculation of solar elevation
                          angles)

Computational grid:

     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET. grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP =  1   !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  1   !
                  (1 <= JBCOMP <= NY)
```

```
        X index of UR corner (IECOMP)      No default      ! IECOMP =  151   !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default      ! JECOMP =  126   !
                  (1 <= JECOMP <= NY)

SAMPLING GRID (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T      ! LSAMP = F !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default      ! IBSAMP =  0   !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default      ! JBSAMP =  0   !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default      ! IESAMP =  0   !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default      ! JESAMP =  0   !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1      ! MESHDN =  1  !
        (MESHDN is an integer >= 1)

!END!

--------------------------------------------------------------------------------

INPUT GROUP: 5 -- Output Options
--------------

                                          *                         *
     FILE                        DEFAULT VALUE             VALUE THIS RUN
     ----                        -------------             --------------

   Concentrations (ICON)               1                   !  ICON =  1   !
```

```
Dry Fluxes (IDRY)                  1                    !  IDRY =  1   !
Wet Fluxes (IWET)                  1                    !  IWET =  1   !
Relative Humidity (IVIS)           1                    !  IVIS =  1   !
 (relative humidity file is
  required for visibility
  analysis)
Use data compression option in output file?
(LCOMPRS)                          Default: T           ! LCOMPRS = T !

*
 0 = Do not create file, 1 = create file


 DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

    Mass flux across specified boundaries
    for selected species reported hourly?
    (IMFLX)                        Default: 0           ! IMFLX =  0  !
      0 = no
      1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
               are specified in Input Group 0)

    Mass balance for each species
    reported hourly?
    (IMBAL)                        Default: 0           ! IMBAL =  1  !
      0 = no
      1 = yes (MASSBAL.DAT filename is
           specified in Input Group 0)


 LINE PRINTER OUTPUT OPTIONS:

    Print concentrations (ICPRT)   Default: 0           ! ICPRT =  0   !
    Print dry fluxes (IDPRT)       Default: 0           ! IDPRT =  0   !
    Print wet fluxes (IWPRT)       Default: 0           ! IWPRT =  0   !
    (0 = Do not print, 1 = Print)

    Concentration print interval
    (ICFRQ) in hours               Default: 1           ! ICFRQ =  1   !
    Dry flux print interval
    (IDFRQ) in hours               Default: 1           ! IDFRQ =  1   !
    Wet flux print interval
    (IWFRQ) in hours               Default: 1           ! IWFRQ =  1   !

    Units for Line Printer Output
    (IPRTU)                        Default: 1           ! IPRTU =  3   !
                    for                for
                Concentration      Deposition
        1 =         g/m**3           g/m**2/s
```

```
            2 =       mg/m**3         mg/m**2/s
            3 =       ug/m**3         ug/m**2/s
            4 =       ng/m**3         ng/m**2/s
            5 =     Odour Units

        Messages tracking progress of run
        written to the screen ?
        (IMESG)                          Default: 2          ! IMESG =  2   !
          0 = no
          1 = yes (advection step, puff ID)
          2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)

     SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                 ---- CONCENTRATIONS ----    ------ DRY FLUXES ------    ------ WET FLUXES ------    -- MASS FLUX
--
   SPECIES
   /GROUP          PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   SAVED ON
DISK?
   -------        ------------------------   ------------------------   ------------------------   -------------
--
!          SO2 =       0,          1,          0,          1,          0,          1,          0   !
!          SO4 =       0,          1,          0,          1,          0,          1,          0   !
!          NOX =       0,          1,          0,          1,          0,          0,          0   !
!         HNO3 =       0,          1,          0,          1,          0,          1,          0   !
!          NO3 =       0,          1,          0,          1,          0,          1,          0   !
!         PM0005 =     0,          1,          0,          1,          0,          1,          0   !
!         PM0010 =     0,          1,          0,          1,          0,          1,          0   !
!         PM0015 =     0,          1,          0,          1,          0,          1,          0   !
!         PM0020 =     0,          1,          0,          1,          0,          1,          0   !
!         PM0025 =     0,          1,          0,          1,          0,          1,          0   !
!         PM0100 =     0,          1,          0,          1,          0,          1,          0   !
!         PM10   =     0,          1,          0,          1,          0,          1,          0   !

     OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

        Logical for debug output
        (LDEBUG)                                 Default: F      ! LDEBUG = F !

        First puff to track
        (IPFDEB)                                 Default: 1      ! IPFDEB =  1  !

        Number of puffs to track
        (NPFDEB)                                 Default: 1      ! NPFDEB =  1  !

        Met. period to start output
        (NN1)                                    Default: 1      ! NN1 =  1   !

        Met. period to end output
        (NN2)                                    Default: 10     ! NN2 =  10  !

!END!
```

```
--------------------------------------------------------------------------------


INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
      Number of terrain features (NHILL)       Default: 0     ! NHILL =  0   !

      Number of special complex terrain
      receptors  (NCTREC)                      Default: 0     ! NCTREC =  0   !

      Terrain and CTSG Receptor data for
      CTSG hills input in CTDM format ?
      (MHILL)                                  No Default     ! MHILL =  0   !
      1 = Hill and Receptor data created
          by CTDM processors & read from
          HILL.DAT and HILLRCT.DAT files
      2 = Hill data created by OPTHILL &
          input below in Subgroup (6b);
          Receptor data in Subgroup (6c)

      Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M = 1. !
      to meters (MHILL=1)

      Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 1. !
      to meters (MHILL=1)

      X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0.0E00 !
      CALPUFF coordinate system, in Kilometers (MHILL=1)

      Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0.0E00 !
      CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------
```

```
                    1 **
     HILL information


HILL            XC         YC        THETAH   ZGRID   RELIEF     EXPO 1     EXPO 2     SCALE 1     SCALE 2
AMAX1      AMAX2
 NO.           (km)       (km)       (deg.)    (m)      (m)        (m)        (m)         (m)          (m)
(m)         (m)
----           ----       ----       ------   -----   ------     ------     ------     -------     -------
-----       -----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                     XRCT         YRCT         ZRCT          XHH
                     (km)         (km)          (m)
                    ------       -----       ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------
```

INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases

SPECIES NAME	DIFFUSIVITY (cm**2/s)	ALPHA STAR	REACTIVITY	MESOPHYLL RESISTANCE (s/cm)	HENRY'S LAW COEFFICIENT (dimensionless)
SO2 =	0.1509,	1000.,	8.,	0.,	0.04 !
NOX =	0.1656,	1.,	8.,	5.,	3.5 !
HNO3 =	0.1628,	1.,	18.,	0.,	0.00000008 !

!END!

INPUT GROUP: 8 -- Size parameters for dry deposition of particles

For SINGLE SPECIES, the mean and standard deviation are used to compute a deposition velocity for NINT (see group 9) size-ranges, and these are then averaged to obtain a mean deposition velocity.

For GROUPED SPECIES, the size distribution should be explicitly specified (by the 'species' in the group), and the standard deviation for each should be entered as 0. The model will then use the deposition velocity for the stated mean diameter.

SPECIES NAME	GEOMETRIC MASS MEAN DIAMETER (microns)	GEOMETRIC STANDARD DEVIATION (microns)
SO4 =	0.48,	0.50 !
NO3 =	0.48,	0.50 !
PM0005 =	0.05,	0.00 !
PM0010 =	0.10,	0.00 !
PM0015 =	0.15,	0.00 !
PM0020 =	0.20,	0.00 !
PM0025 =	0.25,	0.00 !
PM0100 =	1.00,	0.00 !
PM10 =	0.48,	2.00 !

!END!

```
INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                          Default: 30    !  RCUTR = 30.0 !
     Reference ground resistance  (s/cm)
     (RGR)                            Default: 10    !    RGR = 10.0 !
     Reference pollutant reactivity
     (REACTR)                         Default: 8     ! REACTR = 8.0 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                           Default: 9     !   NINT =  9   !

     Vegetation state in unirrigated areas
     (IVEG)                           Default: 1     !   IVEG =  1   !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!

-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------

                     Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------
!          SO2 =         3.0E-05,             0.0E00 !
!          SO4 =         1.0E-04,            3.0E-05 !
!         HNO3 =         6.0E-05,             0.0E00 !
!          NO3 =         1.0E-04,            3.0E-05 !
!         PM0005 =         1.0E-04,             3.0E-05 !
!         PM0010 =         1.0E-04,             3.0E-05 !
!         PM0015 =         1.0E-04,             3.0E-05 !
!         PM0020 =         1.0E-04,             3.0E-05 !
!         PM0025 =         1.0E-04,             3.0E-05 !
!         PM0100 =         1.0E-04,             3.0E-05 !
!          PM10  =         1.0E-04,             3.0E-05 !

!END!
```

```
------------------------------------------------------------------------------

INPUT GROUP: 11 -- Chemistry Parameters
---------------
     Ozone data input option (MOZ)     Default: 1            ! MOZ =  0   !
     (Used only if MCHEM = 1, 3, or 4)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations
     (Used only if MCHEM = 1, 3, or 4 and
      MOZ = 0 or MOZ = 1 and all hourly O3 data missing)
     (BCKO3) in ppb                    Default: 12*80.
     !  BCKO3 = 39.0, 42.0, 51.0, 55.0, 65.0, 65.0, 64.0, 59.0, 54.0, 51.0, 42.0, 38.0  !

     Monthly ammonia concentrations
     (Used only if MCHEM = 1, or 3)
     (BCKNH3) in ppb                   Default: 12*10.
     !  BCKNH3 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !

     Nighttime SO2 loss rate (RNITE1)
     in percent/hour                   Default: 0.2          ! RNITE1 = .2 !

     Nighttime NOx loss rate (RNITE2)
     in percent/hour                   Default: 2.0          ! RNITE2 = 2.0 !

     Nighttime HNO3 formation rate (RNITE3)
     in percent/hour                   Default: 2.0          ! RNITE3 = 2.0 !

     H2O2 data input option (MH2O2)    Default: 1            ! MH2O2 =  1   !
     (Used only if MAQCHEM = 1)
        0 = use a monthly background H2O2 value
        1 = read hourly H2O2 concentrations from
            the H2O2.DAT data file

     Monthly H2O2 concentrations
     (Used only if MQACHEM = 1 and
      MH2O2 = 0 or MH2O2 = 1 and all hourly H2O2 data missing)
     (BCKH2O2) in ppb                  Default: 12*1.
     !  BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !


  --- Data for SECONDARY ORGANIC AEROSOL (SOA) Option
     (used only if MCHEM = 4)

     The SOA module uses monthly values of:
```

```
      Fine particulate concentration in ug/m^3 (BCKPMF)
      Organic fraction of fine particulate     (OFRAC)
      VOC / NOX ratio (after reaction)         (VCNX)
   to characterize the air mass when computing
   the formation of SOA from VOC emissions.
   Typical values for several distinct air mass types are:

      Month    1    2    3    4    5    6    7    8    9   10   11   12
              Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

   Clean Continental
      BCKPMF   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
      OFRAC  .15  .15  .20  .20  .20  .20  .20  .20  .20  .20  .20  .15
      VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

   Clean Marine (surface)
      BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
      OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
      VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

   Urban - low biogenic (controls present)
      BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
      OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
      VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

   Urban - high biogenic (controls present)
      BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
      OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
      VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

   Regional Plume
      BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
      OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
      VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

   Urban - no controls present
      BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
      OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
      VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

   Default: Clean Continental
   !  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
   !  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
   !  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00,
50.00 !


!END!
```

```
------------------------------------------------------------------------------

INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                          Default: 550.    ! SYTDEP = 5.5E02 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                  Default: 0       ! MHFTSZ =  0    !

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                              Default: 5       ! JSUP =  5    !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)    Default: 0.01    ! CONK1 = .01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                   Default: 0.1     ! CONK2 = .1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs < Hb + TBD * HL)
     (TBD)                                     Default: 0.5     ! TBD = .5 !
        TBD < 0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point

     Range of land use categories for which
     urban dispersion is assumed
     (IURB1, IURB2)                            Default: 10      ! IURB1 =  10  !
                                                        19      ! IURB2 =  19  !

     Site characterization parameters for single-point Met data files ---------
     (needed for METFM = 2,3,4)

        Land use category for modeling domain
        (ILANDUIN)                             Default: 20      ! ILANDUIN =  30  !

        Roughness length (m) for modeling domain
        (Z0IN)                                 Default: 0.25    ! Z0IN = .05 !

        Leaf area index for modeling domain
```

```
   (XLAIIN)                                  Default: 3.0     ! XLAIIN = .5 !

   Elevation above sea level (m)
   (ELEVIN)                                  Default: 0.0     ! ELEVIN = 100.0 !

   Latitude (degrees) for met location
   (XLATIN)                                  Default: -999.   ! XLATIN = 35.0 !

   Longitude (degrees) for met location
   (XLONIN)                                  Default: -999.   ! XLONIN = 115.0 !

Specialized information for interpreting single-point Met data files -----

   Anemometer height (m) (Used only if METFM = 2,3)
   (ANEMHT)                                  Default: 10.     ! ANEMHT = 6.1 !

   Form of lateral turbulance data in PROFILE.DAT file
   (Used only if METFM = 4 or MTURBVW = 1 or 3)
   (ISIGMAV)                                 Default: 1       ! ISIGMAV =  1   !
       0 = read sigma-theta
       1 = read sigma-v

   Choice of mixing heights (Used only if METFM = 4)
   (IMIXCTDM)                                Default: 0       ! IMIXCTDM =  0   !
       0 = read PREDICTED mixing heights
       1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN)                                     Default: 1.0     ! XMXLEN = 1.0 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN)                                    Default: 1.0     ! XSAMLEN = 1.0 !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW)                                      Default: 99      ! MXNEW =  99    !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM)                                      Default: 99      ! MXSAM =  99    !

Number of iterations used when computing
the transport wind for a sampling step
that includes gradual rise (for CALMET
and PROFILE winds)
(NCOUNT)                                     Default: 2       ! NCOUNT =  2    !

Minimum sigma y for a new puff/slug (m)
```

```
(SYMIN)                                    Default: 1.0    ! SYMIN = 1.0  !

Minimum sigma z for a new puff/slug (m)
(SZMIN)                                    Default: 1.0    ! SZMIN = 1.0  !

Default minimum turbulence velocities
sigma-v and sigma-w for each
stability class (m/s)
(SVMIN(6) and SWMIN(6))      Default SVMIN : .50,  .50,  .50,  .50,  .50,  .50
                             Default SWMIN : .20,  .12,  .08,  .06,  .03,  .016

                           Stability Class :  A     B     C     D     E     F
                                              ---   ---   ---   ---   ---   ---
                                  ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500!
                                  ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016!

Divergence criterion for dw/dz across puff
used to initiate adjustment for horizontal
convergence (1/s)
Partial adjustment starts at CDIV(1), and
full adjustment is reached at CDIV(2)
(CDIV(2))                                  Default: 0.0,0.0  ! CDIV = .0, .0 !

Minimum wind speed (m/s) allowed for
non-calm conditions. Also used as minimum
speed returned when using power-law
extrapolation toward surface
(WSCALM)                                   Default: 0.5    ! WSCALM = 0.5 !

Maximum mixing height (m)
(XMAXZI)                                   Default: 3000.  ! XMAXZI = 3000.0 !

Minimum mixing height (m)
(XMINZI)                                   Default: 50.    ! XMINZI = 50.0 !

Default wind speed classes --
5 upper bounds (m/s) are entered;
the 6th class has no upper limit
(WSCAT(5))                       Default   :
                                 ISC RURAL : 1.54, 3.09, 5.14, 8.23, 10.8 (10.8+)

                             Wind Speed Class :  1     2     3     4     5
                                                 ---   ---   ---   ---   ---
                                    ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !

Default wind speed profile power-law
exponents for stabilities 1-6
(PLX0(6))                        Default   : ISC RURAL values
                                 ISC RURAL : .07, .07, .10, .15, .35, .55
```

```
                                ISC URBAN : .15, .15, .20, .25, .30, .30

                              Stability Class :  A     B     C     D     E     F
                                                ---   ---   ---   ---   ---   ---
                                   ! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 !

Default potential temperature gradient
for stable classes E, F (degK/m)
(PTG0(2))                          Default: 0.020, 0.035
                                      ! PTG0 = 0.020,   0.035 !

Default plume path coefficients for
each stability class (used when option
for partial plume height terrain adjustment
is selected -- MCTADJ=3)
(PPC(6))                       Stability Class :  A     B     C     D     E     F
                                  Default  PPC : .50,  .50,  .50,  .50,  .35,  .35
                                                ---   ---   ---   ---   ---   ---
                                   !  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35 !

Slug-to-puff transition criterion factor
equal to sigma-y/length of slug
(SL2PF)                                Default: 10.        ! SL2PF = 10.0 !

Puff-splitting control variables ------------------------

  VERTICAL SPLIT
  --------------

  Number of puffs that result every time a puff
  is split - nsplit=2 means that 1 puff splits
  into 2
  (NSPLIT)                             Default:   3        ! NSPLIT =  3  !

  Time(s) of a day when split puffs are eligible to
  be split once again; this is typically set once
  per day, around sunset before nocturnal shear develops.
  24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
  0=do not re-split    1=eligible for re-split
  (IRESPLIT(24))                       Default:  Hour 17 = 1
  !  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

  Split is allowed only if last hour's mixing
  height (m) exceeds a minimum value
  (ZISPLIT)                            Default: 100.       ! ZISPLIT = 100.0 !

  Split is allowed only if ratio of last hour's
  mixing ht to the maximum mixing ht experienced
  by the puff is less than a maximum value (this
```

```
      postpones a split until a nocturnal layer develops)
      (ROLDMAX)                          Default: 0.25       ! ROLDMAX = 0.25 !


      HORIZONTAL SPLIT
      ----------------

      Number of puffs that result every time a puff
      is split - nsplith=5 means that 1 puff splits
      into 5
      (NSPLITH)                          Default:   5        ! NSPLITH =  5  !

      Minimum sigma-y (Grid Cells Units) of puff
      before it may be split
      (SYSPLITH)                         Default:  1.0       ! SYSPLITH = 1.0 !

      Minimum puff elongation rate (SYSPLITH/hr) due to
      wind shear, before it may be split
      (SHSPLITH)                         Default:  2.        ! SHSPLITH = 2.0 !

      Minimum concentration (g/m^3) of each
      species in puff before it may be split
      Enter array of NSPEC values; if a single value is
      entered, it will be used for ALL species
      (CNSPLITH)                         Default:  1.0E-07   ! CNSPLITH = 1.0E-07 !

    Integration control variables ------------------------

      Fractional convergence criterion for numerical SLUG
      sampling integration
      (EPSSLUG)                          Default:   1.0e-04  ! EPSSLUG = 1.0E-04 !

      Fractional convergence criterion for numerical AREA
      source integration
      (EPSAREA)                          Default:   1.0e-06  ! EPSAREA = 1.0E-06 !

      Trajectory step-length (m) used for numerical rise
      integration
      (DSRISE)                           Default:   1.0      ! DSRISE = 1.0 !

!END!


-------------------------------------------------------------------------------

INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
---------------------------------
```

```
---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  1  !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =  1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                    a
          POINT SOURCE: CONSTANT DATA
          ---------------------------
                                                                                b          c
  Source      X UTM      Y UTM      Stack    Base      Stack     Exit   Exit     Bldg.   Emission
   No.     Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.    Dwash    Rates
              (km)       (km)       (m)       (m)        (m)   (m/s) (deg. K)
  ------   ---------- ---------- ------  ------   -------- ----- -------- ----- --------
   1 ! SRCNAM = 0001 !
   1 ! X =  714.315, 3721.351,   39.62, 100.0,      5.64, 16.99,  366.3,  1.0, 0.200, 0.150, 1.527E01,
       0.0E00,  0.0E00, 0.150, 0.250, 0.230, 0.150, 0.110, 0.110, 0.00 !
   1 ! FMFAC  =      1.0 !   !END!


--------
```

a

Data for each source are treated as a separate input subgroup
and therefore must end with an input group terminator.

SRCNAM is a 12-character name for a source
(No default)

X is an array holding the source data listed by the column headings
(No default)

SIGYZI is an array holding the initial sigma-y and sigma-z (m)
(Default: 0.,0.)

FMFAC is a vertical momentum flux factor (0. or 1.0) used to represent
the effect of rain-caps or other physical configurations that
reduce momentum rise associated with the actual exit velocity.
(Default: 1.0 -- full momentum used)

b

0. = No building downwash modeled, 1. = downwash modeled
NOTE: must be entered as a REAL number (i.e., with decimal point)

c

An emission rate must be entered for every pollutant modeled.
Enter emission rate of zero for secondary pollutants that are
modeled, but not emitted. Units are specified by IPTU
(e.g. 1 for g/s).

Subgroup (13c)

BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH

Source a
No. Effective building width and height (in meters) every 10 degrees

---

```
 1    ! SRCNAM  =   0001 !
 1    ! HEIGHT  =  27.43,   27.43,   27.43,   27.43,   27.43,   27.43,
                   27.43,    .0,    .0,   27.43,   27.43,   27.43,
                   27.43,   27.43,   27.43,   27.43,   27.43,   27.43,
                   27.43,   27.43,   27.43,   27.43,   27.43,   27.43,
                   27.43,    .0,    .0,   27.43,   27.43,   27.43,
                   27.43,   27.43,   27.43,   27.43,   27.43,   27.43!
 1    ! WIDTH   =  50.28,   52.03,   52.2,   50.79,   27.9,   27.92,
                   37.69,    .0,    .0,   30.81,   37.69,   27.92,
                   27.9,   50.79,   52.2,   52.03,   50.28,   47.0,
                   50.28,   52.03,   52.2,   50.79,   27.9,   27.92,
                   37.69,    .0,    .0,   30.81,   37.69,   27.92,
                   27.9,   50.79,   52.2,   52.03,   50.28,   47.0!
!END!
```

```
--------

    a
     Each pair of width and height values is treated as a separate input
     subgroup and therefore must end with an input group terminator.

---------------
Subgroup (13d)
---------------
                                                a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          -------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)

--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.

-------------------------------------------------------------------------------

INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
-------------------------------

---------------
Subgroup (14a)
---------------
```

```
     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  0   !

     Units used for area source
     emissions below            (IARU)       Default: 1  !  IARU =   1  !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  !  NAR2 =  0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                    a
          AREA SOURCE: CONSTANT DATA
          --------------------------
                                                          b
Source           Effect.    Base      Initial    Emission
 No.             Height   Elevation   Sigma z     Rates
                   (m)       (m)        (m)
-------          ------    ------     --------   ---------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).
```

Subgroup (14c)

COORDINATES (UTM-km) FOR EACH VERTEX(4) OF EACH POLYGON

Source No.	Ordered list of X followed by list of Y, grouped by source [a]

---

[a] Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

Subgroup (14d)

AREA SOURCE: VARIABLE EMISSIONS DATA [a]

Use this subgroup to describe temporal variations in the emission rates given in 14b. Factors entered multiply the rates in 14b. Skip sources here that have constant emissions. For more elaborate variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

IVARY determines the type of variation, and is source-specific:
(IVARY) Default: 0

- 0 = Constant
- 1 = Diurnal cycle (24 scaling factors: hours 1-24)
- 2 = Monthly cycle (12 scaling factors: months 1-12)
- 3 = Hour & Season (4 groups of 24 hourly scaling factors, where first group is DEC-JAN-FEB)
- 4 = Speed & Stab. (6 groups of 6 scaling factors, where first group is Stability Class A, and the speed classes have upper bounds (m/s) defined in Group 12
- 5 = Temperature (12 scaling factors, where temperature classes have upper bounds (C) of: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 50+)

---

[a] Data for each species are treated as a separate input subgroup and therefore must end with an input group terminator.

```
------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                              No default  !  NLN2 =  0   !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)

     Number of buoyant line sources (NLINES)        No default   ! NLINES =  0  !

     Units used for line source
     emissions below               (ILNU)           Default: 1  !  ILNU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (15c)        (NSLN1) Default: 0  !  NSLN1 =  0  !

     Maximum number of segments used to model
     each line (MXNSEG)                             Default: 7   ! MXNSEG =  7  !

     The following variables are required only if NLINES > 0.  They are
     used in the buoyant line source plume rise calculations.

        Number of distances at which                Default: 6   ! NLRISE =  6  !
        transitional rise is computed

        Average building length (XL)                No default   ! XL = .0 !
                                                    (in meters)

        Average building height (HBL)               No default   ! HBL = .0 !
                                                    (in meters)
```

```
        Average building width (WBL)                No default    ! WBL = .0 !
                                                    (in meters)

        Average line source width (WML)             No default    ! WML = .0 !
                                                    (in meters)

        Average separation between buildings (DXL)  No default    ! DXL = .0 !
                                                    (in meters)

        Average buoyancy parameter (FPRIMEL)        No default    ! FPRIMEL = .0 !
                                                    (in m**4/s**3)

!END!

---------------
Subgroup (15b)
---------------

          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------
```

a

Source No.	Beg. X Coordinate (km)	Beg. Y Coordinate (km)	End. X Coordinate (km)	End. Y Coordinate (km)	Release Height (m)	Base Elevation (m)	Emission Rates

```
--------
```

a
Data for each source are treated as a separate input subgroup
and therefore must end with an input group terminator.

b
An emission rate must be entered for every pollutant modeled.
Enter emission rate of zero for secondary pollutants that are
modeled, but not emitted. Units are specified by ILNTU
(e.g. 1 for g/s).

```
---------------
Subgroup (15c)
---------------
```

a

```
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.
```

```
     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)
--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.

------------------------------------------------------------------------------

INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Number of volume sources with
     variable location and emission
```

```
     parameters                    (NVL2)      No default   !  NVL2 =    0    !

     (If NVL2 > 0, ALL parameter data for
      these sources are read from the VOLEMARB.DAT file(s) )

!END!

---------------
Subgroup (16b)
---------------
                                      a
           VOLUME SOURCE: CONSTANT DATA
           ----------------------------
                                                                              b
        X UTM       Y UTM       Effect.    Base      Initial     Initial     Emission
     Coordinate  Coordinate    Height    Elevation  Sigma y     Sigma z      Rates
        (km)        (km)         (m)        (m)        (m)         (m)
     ----------  ----------    ------     ------    --------    --------    --------

--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).

---------------
Subgroup (16c)
---------------
                                            a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                 Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
```

```
          4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                   first group is Stability Class A,
                                   and the speed classes have upper
                                   bounds (m/s) defined in Group 12
          5 =       Temperature   (12 scaling factors, where temperature
                                   classes have upper bounds (C) of:
                                   0, 5, 10, 15, 20, 25, 30, 35, 40,
                                   45, 50, 50+)
--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.

------------------------------------------------------------------------------

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
-----------------------

---------------
Subgroup (17a)
---------------

     Number of non-gridded receptors (NREC)  No default  !  NREC =  952   !

!END!
---------------
Subgroup (17b)
---------------
                                              a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                  X UTM       Y UTM        Ground        Height   b
Receptor       Coordinate  Coordinate   Elevation   Above Ground
  No.             (km)        (km)          (m)           (m)
--------       ----------  ----------   ---------   ------------
  112  ! X =       611.000,    3727.000,   609.000,  0.00       ! !END!
  113  ! X =       613.000,    3727.000,   628.000,  0.00       ! !END!
  114  ! X =       615.000,    3727.000,   792.000,  0.00       ! !END!

                      •
                      •
-------------
    a     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```

APPENDIX C

National Park Service Procedures for Defining Particulate Emissions and Species

Don Shepherd

02/03/2003 04:43 PM MST

To: Don Codding/DENVER/NPS@NPS
cc: John Notar/DENVER/NPS@NPS
Subject: particle speciation

Combustion turbine particle speciation for modeling

Following is our current thinking on particle speciation for combustion turbines. We plan to apply this approach to all new modeling protocols received as of 9/05/02 and until we make further modifications if new information warrants such changes:

Applicants with significant sulfur dioxide emissions should also include sulfuric acid mist emissions in visibility and sulfur deposition calculations. In future visibility analyses for Class I areas, combustion turbine applicants should apply the following recommendations:

Particle Size:

(See attached file: Revised PM size example.xls)

For Natural Gas-fired Combustion Turbines:*

Apportionment of PM between filterables and condensibles--25% of PM will be assumed to be filterable, and 75% condensible.

Nature of filterables--all filterable PM will be considered Elemental Carbon

Nature of condensibles.

- Sulfur emissions from a NG-fired combustion turbine should be estimated on a case-by-case basis.

Ideally, the applicant would supply emission rates for both SO2 and SO4 based upon the actual sulfur content of the NG to be burned. (In this case, all condensible emissions would be assumed to be Organic Carbon.)

- If only SO2 emission estimates are provided, for AQRV analyses, one-third of the applicant's estimated SO2 emissions would be carved-out and adjusted for differences in molecular weights to represent SO4 emissions. Estimate the organic component of the condensibles (expressed as Organic Carbon) by subtracting the SO4 from the condensible fraction.

Example--how approach would be applied to a typical gas turbine when only PM10 and SO2 emissions are provided by the applicant.
(See attached file: Edited Revised Consensus Gas CT example.xls)

Implementation--begin implementing this guidance for gas CTs with the next submittals of modeling protocols after 9/05/02. Existing protocols would be "grandfathered."

*The emissions modeled must ultimately be reflected in the permit.

For Oil-fired Combustion Turbines:*

Apportionment of PM between filterables and condensibles--37% of PM will be assumed to be filterable, and 63% condensible.

Nature of filterables--half of all filterable PM will be considered Elemental Carbon, and half Soils.

Nature of condensibles.

- Sulfur emissions from a oil-fired combustion turbine should be estimated on a case-by-case basis.
- Ideally, the applicant would supply emission rates for both SO2 and SO4 based upon the actual sulfur content of the oil to be burned. (In this case, all condensible emissions would be assumed to be Organic Carbon.)
- If only SO2 emission estimates are provided, for AQRV analyses, 40% of the applicant's estimated SO2 emissions would be carved-out and adjusted for differences in molecular weights to represent SO4 emissions. Estimate the organic component of the condensibles (expressed as Organic Carbon) by subtracting the SO4 from the condensible fraction.

Example--how approach would be applied to a typical gas turbine when only PM10 and SO2 emissions are provided by the applicant.
(See attached file: Oil-fired CT example.xls)

Implementation--begin implementing this guidance for gas CTs with the next submittals of modeling protocols after 9/05/02. Existing protocols would be "grandfathered."

*The emissions modeled must ultimately be reflected in the permit.

Caveats.
This represents our best guesses based upon available information. We encourage states/locals and turbine vendors/operators to investigate the actual nature of these emissions and provide that data to EPA and the FLMs.

The emissions modeled must ultimately be reflected in the permit.

Spreadsheet "Edited Revised Consensus Gas CT Example.xls" obtained from National Park Service

Consensus Gas-fired Turbine Example

Example of Consensus Approach where H2SO4 emissions are not provided by applicant
Applicant's estimates are in **BOLD**.

	Heat Input	Filterable PM (25% Estimate)		Condensible PM (75% Estimate)		Total PM (Applicant)		SO2 (Applicant)		
Turbine	(mmBtu/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(gr/100scf)		(lb/hr)
GE 7FA	**1887**		2.43		7.28		**9.70**	2.0		**3.10**

SO4
(lb/hr)
1.55

SO2 (Applicant-33%)
(lb/hr)
2.07

Organic Carbon
(lb/hr)
5.73

Impact of Consensus Combined Cycle Turbine Example on Extinction

Type		Name	Extinction Coef.	f(RH)*	Efficiency	Emissions (lb/hr)	Total Relative bext 1/Mm	
Filterable		EC	10		10	2.43	24.25	
Inorganic CPM		SOIL	1		1		0.00	
Inorganic CPM		SO4	3	2	6	1.55	9.30	* f(RH) will vary
Organic CPM		SOA	4		4	5.73	22.90	
							56.45	

comparison from AP-42

	Heat Input	Filterable PM (AP-42)		Condensible PM (AP-42)		Total PM (AP-42)		SO2 (AP-42)		
Turbine	(mmBtu/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	(lb/hr)	(lb/mmBtu)	%S	(lb/hr)
GE 7FA	1887	0.0019	3.59	0.0047	8.87	0.0066	12.45	0.94	0.004	6.42

Spreadsheet "Revised PM Size Sample.xls" obtained from the National Park Service

Particle size.

We will assume that all particles are one micron or less.

For SINGLE SPECIES, the mean and standard deviation are used to compute a deposition velocity for NINT (see group 9) size-ranges, and these are then averaged to obtain a mean deposition velocity.

For GROUPED SPECIES, the size distribution should be explicitly specified (by the 'species' in the group), and the standard deviation for each should be entered as 0. The model will then use the deposition velocity for the stated mean diameter.

	Size	Geometric Mass	Geometric
Species	Distribution	Mean Diameter	Std. Deviation
Name	(%)	(microns)	(microns)
SO4	100	0.48	0.50
NO3	100	0.48	0.50
PM0005	15	0.05	0.00
PM0010	40	0.10	0.00
PM0015	63	0.15	0.00
PM0020	78	0.20	0.00
PM0025	89	0.25	0.00
PM0100	100	1.00	0.00