BEST AVAILABLE RETROFIT TECHNOLOGY APPLICABILITY ANALYSIS

OWENS CORNING ▪ FAIRBURN MANUFACTURING FACILITY

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1. INTRODUCTION

Owens Corning (OC) operates a fiberglass manufacturing facility in Fairburn, Georgia located in Fulton County (OC Fairburn). The facility currently operates under Title V Operating Permit No. 3296-121-0021-V-01-0, issued by the Georgia Environmental Protection Division (EPD) on July 31, 2003, and Title V Operating Permit Amendment No. 3296-121-0021-V-01-1, effective December 14, 2005. The plant manufactures wool fiberglass insulation with varying characteristics such as R-value (measure of resistance to heat flow), loss on ignition or LOI (percent decrease in weight after ignition), and size. Raw materials are received by rail car and truck and are transferred to one of three glass melting furnaces at the facility. Molten glass from the furnace passes through a conditioning riser/channel into the forehearth, which then delivers the molten glass to the forming section where it is formed into a downward flowing veil of fibers. The veil is sprayed with water and coated with a phenol/formaldehyde resin-based binder solution and then collected, formed into a pack, and transferred to the curing oven. The pack then enters the cooling section prior to final product finishing operations, which can include trimming, cutting, printing, facing application, and bagging or rolling.

EPD considers the OC Fairburn facility eligible to be regulated under the Best Available Retrofit Technology (BART) provisions of the Regional Haze Rule. Once a source is deemed BART-eligible, air quality modeling is used to determine whether the emissions from the facility's BART-eligible sources cause or contribute to visibility impairment at any federally protected Class I area, and hence whether the facility is subject to BART and a BART determination is necessary. The BART applicability analysis presented in this report demonstrates that OC's Fairburn facility is not subject to BART requirements because the facility neither causes nor contributes to visibility impairment at any Class I area within 300 km of the facility.

OC submitted an initial source-specific BART Applicability Modeling Protocol on August 10, 2006, and subsequently received comments from EPD on August 29, 2006. In addition to these comments on the source-specific modeling protocol for the Fairburn facility, OC's evaluation of BART-eligibility and the modeling methods used to determine applicability of BART as described in this report are consistent with the following guidance documents:

- U.S. EPA, "Regional Haze Regulations and Guideline for Best Available Retrofit Technology (BART) Determinations," *Federal Register* Volume 70, Number 128, July 6, 2005.
- U.S. EPA, *Guidance for Tracking Progress under the Regional Haze Rule* (EPA-54/B-03-004), September 2003.
- U.S. EPA, *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule* (EPA-454/B-03-005), October 2003.
- U.S. EPA, *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report* (EPA-454/R-98-019), December 1998.
- U.S. EPA, *Guideline on Air Quality Models*, 40 CFR Part 51, Appendix W (Revised, November 9, 2005).

- VISTAS, *Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART), Revision 3.2*, August 31, 2006.
- VISTAS and U.S. EPA, "Q&A for Source by Source BART Rule" (Draft), October 28, 2005.
- Georgia EPD, electronic communication to BART-eligible sources, multiple dates.

The *VISTAS BART Modeling Protocol* as revised on August 31, 2006, is incorporated by reference for OC's source-specific modeling analyses, and is presented in Appendix A of this BART Applicability Analysis report. The *VISTAS BART Modeling Protocol* and related information (generally made available at the VISTAS BART website[1]) established common technical approaches for quantifying emissions from BART-eligible emission units and conducting screening and refined modeling analyses using the CALPUFF modeling system and common data resources. OC's analyses generally adhere to the recommendations made in the *VISTAS BART Modeling Protocol* as described in this report and adapted per EPD guidance to the source-specific analysis of visibility impacts attributable to the Fairburn Plant.

1.1 OVERVIEW OF REGIONAL HAZE RULE AND BART REQUIREMENTS

The Regional Haze Rule requires that major sources of visibility-affecting pollutants belonging to one or more of 26 specific industrial source categories evaluate BART if the source was "in existence" (i.e., built or reconstructed) before August 7, 1977 and began operation after August 7, 1962. Such sources are termed "BART-eligible sources." Major sources of visibility-affecting pollutants have the potential to emit 250 tons per year (tpy) of one or more of oxides of nitrogen (NO_X), sulfur dioxide (SO_2), and particulate matter less than 10 micrometers in aerodynamic diameter (PM_{10}). Glass fiber processing plants are one of the listed source categories, and include process units and support facilities that are considered to be part of major Standard Industrial Classification 32 – Stone, clay, glass, and concrete products. Hereafter, the "BART-eligible source" is taken to mean the collection of sources at a facility in existence during the relevant time period within one or more BART source categories that has potential emissions of one or more visibility-affecting pollutants in excess of 250 tpy. The BART-eligible source may include multiple emission units, but need not include the entire facility.

1.1.1 DETERMINATION OF BART-ELIGIBILITY

The U.S. EPA BART guidelines define the following three steps for determining which sources at a facility are BART-eligible:

1. Identify the emission units in the BART source categories.
2. Identify the start-up dates of those units.
3. Compare potential emissions to the 250 tpy cutoff.

EPD has determined that nineteen emission units comprise the BART-eligible sources at the OC Fairburn facility because the units operate at a glass fiber processing facility, were in existence on August 7, 1977, and began operation after August 7, 1962. This collection

[1] http://vistas-sesarm.org/BART/index.asp

of emission units has potential emissions of 1,049 tpy NO_X, 641 tpy PM_{10}, and 129 tpy SO_2. Accordingly, the BART-eligible emission units at OC's Fairburn facility were analyzed to evaluate whether the facility is exempt from BART. Specific information about these emission units is provided in Section 2 of this BART applicability report.

1.1.2 ASSESSMENT OF CONTRIBUTION TO VISIBILITY IMPAIRMENT AND BART APPLICABILITY

In its role as technical analysis coordinator, VISTAS developed a common modeling protocol and data resources for use by state regulatory agencies and BART-eligible sources. The final *VISTAS BART Modeling Protocol* was issued on December 22, 2005, was revised most recently on August 31, 2006, and prescribes modeling techniques and data resources to conduct screening and refined analyses to assess whether a BART-eligible source is subject to BART.

A BART-eligible source is determined to be subject to BART if the source causes or contributes to visibility impairment at a federally protected Class I area. Causation is defined as a single-source impact of 1.0 deciviews (dv) or more and contribution is defined as a single-source impact of 0.5 dv or more (each evaluated on a 24-hour average basis). The deciview is a metric used to represent normalized light extinction attributable to visibility-affecting pollutants. To determine whether a BART-eligible facility causes or contributes to visibility impairment, U.S. EPA guidance requires the use of an air quality model, specifically recommending the CALPUFF modeling system, to quantify the impacts attributable to a single BART-eligible source. Because contribution to visibility impairment is sufficient cause to require a BART determination, 0.5 dv is the critical threshold for assessment of BART applicability.

Regional haze is quantified using the light extinction coefficient (b_{ext}), which is expressed in terms of the haze index expressed in dv. The haze index (*HI*) is calculated as shown in the following equation.

$$HI = 10 \ln\left(\frac{b_{ext}}{10}\right)$$

The impact of a BART-eligible source is determined by comparing *HI* for estimated natural background conditions with the impact of the source and without the impact of the source. The background extinction coefficient $b_{\text{ext, background}}$ is affected by various chemical species and the Rayleigh scattering phenomenon and can be calculated as shown in the following equation.

$$b_{ext,background}(km^{-1}) = b_{SO_4} + b_{NO_3} + b_{OC} + b_{soil} + b_{coarse} + b_{ap} + b_{ray}$$

where,

$b_{SO4} = 3[(NH_4)_2SO_4]f(RH)$	$[(NH_4)_2SO_4]$ denotes the ammonium sulfate concentration
$b_{NO_3} = 3[NH_4NO_3]f(RH)$	$[NH_4NO_3]$ denotes the ammonium nitrate concentration
$b_{OC} = 4[OC]$	$[OC]$ denotes the concentration of organic carbon
$b_{Soil} = 1[Soil]$	$[Soil]$ denotes the concentration of fine soils
$b_{Coarse} = 0.6[\text{Coarse Mass}]$	$[\text{Coarse Mass}]$ denotes the concentration of coarse dusts
$b_{ap} = 10[EC]$	$[EC]$ denotes the concentration of elemental carbon
b_{Ray} = Rayleigh Scattering $(10\ Mm^{-1}$ by default$)$	Rayleigh Scattering is scattering due to air molecules
$f(RH)$ = Relative Humidity Function	
$[\ ]$ = Concentration in $\mu g/m^3$	

Values for the parameters listed above specific to the natural background conditions at the Class I areas considered in this modeling protocol are provided on an annual average basis in the U.S. EPA's *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*.[2] More detailed information about the natural background conditions particular to Class I areas potentially affected by OC's operations at the Fairburn Plant are provided in Section 3.5 of this modeling protocol.

Particulate species that affect visibility are emitted from anthropogenic sources in various phases and include coarse particulate matter (PMC), fine particulate matter (PMF), secondary organic aerosols (SOA), and elemental carbon (EC), as well as precursors to fine particulate matter such as SO_2 and NO_X. OC's calculation of speciated visibility-affecting pollutant emissions is presented in Section 2 of this applicability report. The extinction coefficient due to emissions of visibility-affecting pollutants from a single BART-eligible source $b_{ext,source}$ is calculated using an air quality model. The extinction due to the BART-eligible source is calculated as shown in the following equation.

[2] U.S. EPA, *Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule*, Table 2-1, Attachment A, September 2003, EPA-454/B-03-005.

$$b_{ext,source}\left(km^{-1}\right) = b_{SO_4} + b_{NO_3} + b_{PMC} + b_{PMF} + b_{SOA} + b_{EC}$$

where,

$$b_{SO_4} = 3\left[(NH_4)_2SO_4\right]f(RH)$$
$$b_{NO_3} = 3\left[NH_4NO_3\right]f(RH)$$
$$b_{SOA} = 4[SOA]$$
$$b_{PMF} = 1[PMF]$$
$$b_{PMC} = 0.6[PMC]$$
$$b_{EC} = 10[EC]$$

$f(RH)$ = Relative Humidity Function

$[\ ]$ = Concentration in $\mu g/m^3$

$[(NH_4)_2SO_4]$ denotes the ammonium sulfate concentration

$[NH_4NO_3]$ denotes the ammonium nitrate concentration

$[SOA]$ denotes the concentration of secondary organic aerosols

$[PMF]$ denotes the concentration of fine PM

$[PMC]$ denotes the concentration of coarse PM

$[EC]$ denotes the concentration of elemental carbon

1.1.3 POTENTIALLY AFFECTED CLASS I AREAS

OC used screening modeling techniques as described in the *VISTAS BART Modeling Protocol* to determine whether BART-eligible operations at the Fairburn manufacturing facility contribute to visibility impairment at any Class I areas. The *VISTAS BART Modeling Protocol* specifies that all Class I areas within 300 km of a BART-eligible source must be evaluated to determine whether the source contributes to visibility impairment. Table 1-1 summarizes the distances separating the OC Fairburn facility from all Class I areas within the VISTAS region and adjacent states. Consistent with the *VISTAS BART Modeling Protocol*, only those Class I areas within 300 km were considered further in the BART applicability modeling analysis.

TABLE 1-1. DISTANCES (KILOMETERS) SEPARATING CLASS I AREAS AND FAIRBURN FACILITY

Class I Area	Distance (km)
Breton (LA/MS)	561
Cape Romain (SC)	466
Chassahowitzka (FL)	563
Cohutta (GA)	**144**
Dolly Sods (WV)	759
Everglades (FL)	913
Great Smoky Mountains (NC/TN)	**223**
Hercules Glade (AR)	826
James River Face (VA)	642
Joyce Kilmer-Slickrock (NC)	**209**
Linville Gorge (NC)	352
Mammoth Cave (KY)	418
Mingo (MO)	630
Okefenokee (GA)	351
Otter Creek (WV)	741
Shenandoah (VA)	718
Shining Rock (NC)	**253**
Sipsey (AL)	**267**
St. Marks (FL)	380
Swanquarter (NC)	775
Wolf Island (GA)	392

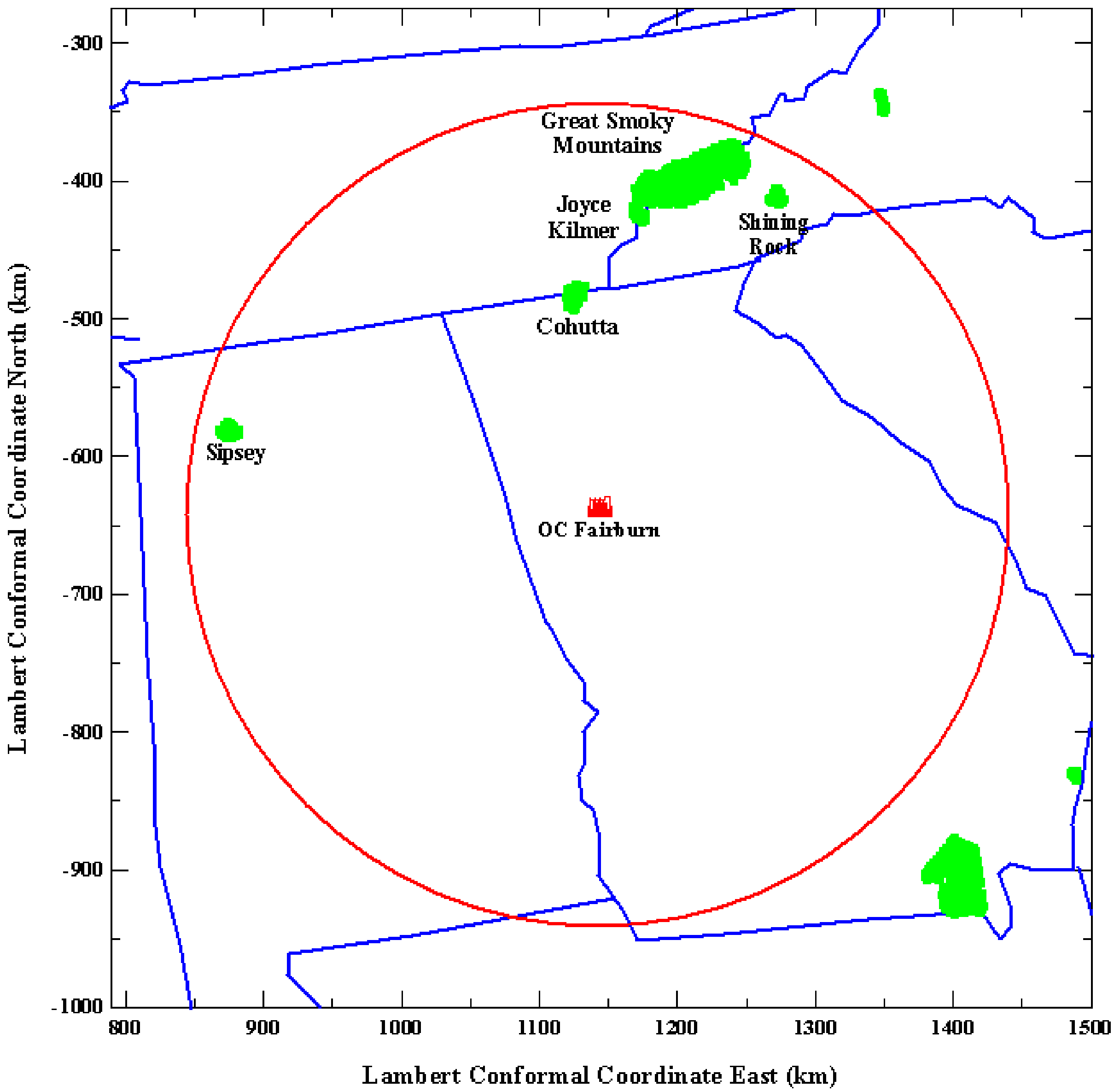
Figure 1-1 illustrates the location of the Fairburn facility and its location relative to the following federally protected Class I areas that are located within 300 km of OC's Fairburn operations:

- Cohutta Wilderness Area located approximately 144 km north of the Fairburn facility
- Great Smoky Mountains National Park located approximately 223 km north-northeast of the Fairburn facility
- Joyce Kilmer-Slickrock Wilderness Area located approximately 209 km north-northeast of the Fairburn facility
- Shining Rock Wilderness Area located approximately 253 km northeast of the Fairburn facility
- Sipsey Wilderness Area located approximately 267 km west-northwest of the Fairburn facility.

The locations of Class I areas and receptor locations evaluated in the modeling analysis were determined by, and obtained from, the U.S. Forest Service, which is the FLM for

Cohutta, Joyce Kilmer-Slickrock, Shining Rock, and Sipsey Wilderness Areas, and the National Park Service, which is the FLM for Great Smoky Mountains National Park.[3]

FIGURE 1-1. LOCATION OF OC'S FAIRBURN FACILITY RELATIVE TO CLASS I AREAS WITHIN 300 KM



[3] National Park Service compilation of Class I area receptors, http://www2.nature.nps.gov/air/maps/receptors/.

1.1.4 CALPUFF MODELING ANALYSES

As recommended by the U.S. EPA BART guidelines and VIST*AS BART Modeling Protocol*, the CALPUFF modeling system was used to compute the 24-hour average visibility impairment attributable to OC's Fairburn Plant to assess whether the 0.5 dv contribution threshold is exceeded, and if so, the frequency, duration, and magnitude of any exceedance events. CALPUFF is a refined air quality modeling system that is capable of simulating the dispersion, chemical transformation, and long-range transport of multiple visibility-affecting pollutant emissions from a single source and is therefore preferred for BART applicability and determination analyses. The CALPUFF modeling system is described in technical detail in the *VISTAS BART Modeling Protocol* as revised and its use in screening and refined analyses for BART applicability assessment of OC's Fairburn Plant was described in Sections 3, 4, and 5 of the source-specific modeling protocol prepared for the Fairburn Plant.

1.2 ORGANIZATION OF THE BART APPLICABILITY ANALYSIS REPORT

The remainder of this BART Applicability Analysis report is organized as follows.

- Section 2 describes the BART-eligible emission units at OC and the emission rates modeled in the BART Applicability Analysis.
- Section 3 describes the procedural and technical guidance for conducting Class I area analyses using the CALPUFF modeling system, including the data resources, technical modeling options, and quality assurance methods used in the CALMET, CALPUFF, and CALPOST analyses.
- Section 4 describes the results of the screening modeling analyses.
- Section 5 presents a summary of the BART Applicability Analysis and conclusion that the Fairburn facility is not subject to BART.

Supplemental information is provided in several appendices to this report. Appendix A contains the VISTAS BART Modeling Protocol. Appendix B contains sample model and postprocessing input and output files used for OC's analysis of the Fairburn Plant. Appendix C presents a comparative analysis demonstrating the explicit modeling approach used in CALPUFF. Electronic copies of model input and output files are provided on electronic media accompanying this BART Applicability Analysis Report, a file index for which is presented in Appendix D.

2. BART-ELIGIBLE SOURCE DESCRIPTION

This section of the BART Applicability Analysis modeling report describes the emission units that comprise the BART-eligible source at OC's Fairburn facility. Emissions and exhaust characteristics of each source are quantified to demonstrate how each source will be represented in the modeling analysis.

2.1 BART-ELIGIBLE EMISSION UNITS

OC reviewed the criteria for BART-eligibility and determined that the nineteen emission units described in Table 2-1 comprise the BART-eligible source at the Fairburn facility.

TABLE 2-1. SUMMARY OF BART-ELIGIBLE EMISSION UNITS

Unit ID	Name	Description	Date Built	Emits PM, NO_X, SO_2?	Include in BART Modeling?
FG11	**FG-1 Furnace**	**Electric Cold Top Melting Furnace**	**1971**	**Yes**	**Yes**
FG12	**FG-1 Risers**	**Flow Channel**	**1971**	**Yes**	**Yes**
FG13	**FG-1 Forehearth**	**Flow Channel**	**1971**	**Yes**	**Yes**
FG14	**FG-1 Forming Section**	**Molten Glass Spinning to Glass Fibers**	**1971**	**Yes**	**Yes**
FG15	**FG-1 Curing Oven**	**Insulation Binder Curing Oven**	**1971**	**Yes**	**Yes**
FG16	**FG-1 Cooling Section**	**Cooling with Ambient Air**	**1971**	**Yes**	**Yes**
FG17	FG-1 Flexographic Printing	Insulation Facing Flexographic Printer	1971	No	No - Emits only VOC
FG18	FG-1 Asphalt Application	Asphalt Coating of Paper or Foil	**1971**	**Yes**	**Yes**
FG21	**FG-2 Furnace**	**Electric Cold Top Melting Furnace**	**1972**	**Yes**	**Yes**
FG22	**FG-2 Risers**	**Flow Channel**	**1972**	**Yes**	**Yes**
FG23	**FG-2 Forehearth**	**Flow Channel**	**1972**	**Yes**	**Yes**
FG24	**FG-2 Forming Section**	**Molten Glass Spinning to Glass Fibers**	**1972**	**Yes**	**Yes**
FG25	**FG-2 Curing Oven**	**Insulation Binder Curing Oven**	**1972**	**Yes**	**Yes**
FG26	**FG-2 Cooling Section**	**Cooling with Ambient Air**	**1972**	**Yes**	**Yes**
FG27	FG-2 Flexographic Printing	Insulation Facing Flexographic Printer	1972	No	No - Emits only VOC
FG28	FG-2 Asphalt Application	Asphalt Coating of Paper or Foil	**1972**	**Yes**	**Yes**
FG31	**FG-3 Furnace**	**Electric Cold Top Melting Furnace**	**1974**	**Yes**	**Yes**
FG32	**FG-3 Risers**	**Flow Channel**	**1974**	**Yes**	**Yes**
FG33	**FG-3 Forehearth**	**Flow Channel**	**1974**	**Yes**	**Yes**
FG34	**FG-3 Forming Section**	**Molten Glass Spinning to Glass Fibers**	**1974**	**Yes**	**Yes**
FG35	**FG-3 Curing Oven**	**Insulation Binder Curing Oven**	**1974**	**Yes**	**Yes**
FG36	FG-3 Cooling Section	Cooling with Ambient Air	1991	Yes	No - Built after applicability date

Note that for the purposes of this BART Applicability Analysis, VISTAS and EPD have determined that volatile organic compounds (VOC) are not visibility-affecting pollutants. Section 4.1.3 of the *VISTAS BART Modeling Protocol* describes the regional modeling analyses showing that cumulative VOC emissions do not contribute to visibility impairment within the VISTAS region:

> *VOC emissions from all anthropogenic point sources in every VISTAS State were reduced by 100% (i.e., eliminated). The maximum 24-hr impact of all VOC emissions from all point sources throughout the VISTAS domain was thus determined to be less than 0.5 dv (compared to annual average natural background) at every Class I area in the VISTAS domain and in adjacent States. It follows that the impact of any one BART-eligible source would be much less than 0.5 dv. Based on these analyses, the VISTAS States have concluded that VOC emissions from BART sources do not cause*

or contribute to visibility impairment and do not need to be included in BART analyses.

As a result of this determination, emissions of VOC from OC's Fairburn facility were not further evaluated. The nineteen emission units indicated in Table 2-1 will be considered the BART-eligible sources at OC's Fairburn facility.

2.2 BART-ELIGIBLE SOURCE MODEL EMISSIONS INVENTORY

Whereas the BART eligibility determination relies on potential emissions of visibility-affecting pollutants, the BART Applicability Analysis utilizes maximum actual 24-hour average emission rates of NO_X, SO_2, and PM_{10}. The *VISTAS BART Modeling Protocol* specifies the following hierarchy of information resources to establish the maximum actual 24-hour average emission rate for BART applicability modeling over the prior three-to-five year period:

- 24-hour maximum emissions observed using a Continuous Emission Monitor (CEM) for the period 2001 through 2003
- 24-hour maximum emissions observed using a CEM for any representative period
- Facility stack test emissions
- Potential to emit
- Permit allowable emissions

OC used a combination of representative stack test data, potential emissions based on enforceable emissions and operating limits, and *AP-42* emission factors to determine the 24-hour average maximum actual emission rates of visibility-affecting pollutants. The estimated maximum actual emissions are equal to potential emissions at the Fairburn facility. Table 2-2 summarizes these emission rates from each BART-eligible emissions unit considered in the applicability modeling analysis.

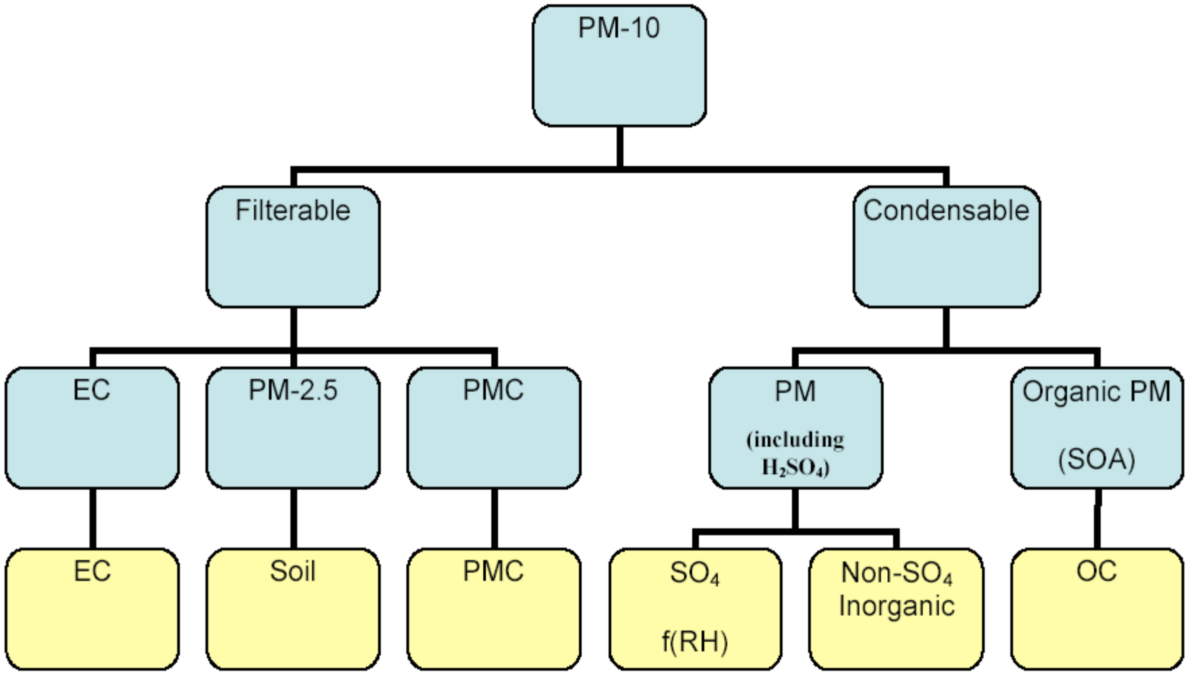
TABLE 2-2. SUMMARY OF 24-HOUR AVERAGE MAXIMUM ACTUAL EMISSION RATES

Emission Unit	EU ID	SO_2 Emissions (lb/hr)	NO_X Emissions (lb/hr)	Total PM_{10} Emissions (lb/hr)	Total $PM_{2.5}$ Emissions (lb/hr)	Primary SO_4 Emissions (lb/hr)
FG1 Furnace	FG11	2.26	86.52	4.85	2.51	0.05
FG1 Riser/Channel	FG12	0.13	0.29	7.63	3.83	0.03
FG1 Forehearth	FG12	0.07	0.50	2.01	1.02	1.3E-02
FG1 Mixing Chamber	-	6.23	35.81	60.00	54.00	0.38
FG1 Forming Section	FG14					
FG1 Curing Oven	FG15					
FG1 Cooling Section	FG16	-	-	5.49	4.94	0.03
FG1 Asphalt Application	FG18	-	-	0.09	0.09	-
FG2 Furnace - Process	FG21	5.23	56.71	4.76	2.48	0.05
FG2 Riser/Channel - Process	FG22	1.3E-02	-	0.25	0.12	6.8E-04
FG2 Forehearth - Process	FG23	1.7E-03	-	2.8E-02	1.4E-02	7.8E-05
FG2 Mixing Chamber	-	7.00	9.60	29.50	26.55	0.22
FG2 Forming Section - Process	FG24					
FG2 Curing Oven - Process	FG25					
FG2 Cooling Section	FG26	-	-	1.50	1.35	7.4E-03
FG2 Asphalt Application	FG28	-	-	0.09	0.09	-
FG3 Furnace - Process	FG31	1.15	44.58	2.51	1.33	0.03
FG3 Riser/Channel - Process	FG32	0.06	0.10	3.86	1.94	1.2E-02
FG3 Forehearth - Process	FG33	0.03	0.22	1.01	0.52	6.1E-03
FG3 Mixing Chamber	-	7.49	5.53	24.00	21.60	0.16
FG3 Forming Section - Process	FG34					
FG3 Curing Oven - Process	FG35					

* Emissions from each line's forming and curing sections are routed together in a mixing chamber prior to being released to the atmosphere. Emissions are quantified at the outlet of the mixing chamber.

Table 2-2 includes 24-hour maximum emission rates of primary sulfates (from process sources and combustion sources) and distinguishes the emission rates of Total PM_{10} (TPM_{10}), which includes emissions of $TPM_{2.5}$. Modeling of visibility impairment requires that the components of the exhaust stream be speciated because different types of particulate matter affect visibility to varying extents. The amount by which a mass of a certain species scatters or absorbs light is termed the *extinction efficiency* or *extinction coefficient*, and ranges from values of 0.6 m^2/g for coarse particulate matter to 10 m^2/g for elemental carbon. Fine particulate matter (1 m^2/g) and organic aerosols (4 m^2/g) scatter light with intermediate efficiencies, and ammonium sulfate and ammonium nitrate (that forms from precursor SO_2 and NO_X emissions in the presence of ambient ammonia) are hygroscopic species that are particularly efficient light scatters in the presence of ambient water vapor ($3f(RH)$ m^2/g, where $f(RH)$ is a function of the relative humidity). The size distribution of particle species is also important, since smaller particles may be transported longer distances than larger particles and dispersed differently under prevailing ambient conditions. Figure 2-1 depicts the speciation of visibility-affecting pollutant emissions as represented in the *VISTAS BART Modeling Protocol*.

FIGURE 2-1. PARTICULATE MATTER SPECIATION
(AFTER FIGURE 4-3 OF THE *VISTAS BART MODELING PROTOCOL*)



While few data are available to estimate speciated emissions, OC has reviewed what data are available to arrive at a conservative, yet reasonable estimate of speciated emissions. However, it should be noted that the data quality on PM speciation is inadequate for setting regulatory emission limits and are provided here solely as the best estimated data for a scientific analysis of potential impacts on visibility impairment at Class I areas using CALPUFF modeling. The following analysis does not represent source test results for specific sources at the Fairburn facility.

NO_X emissions from the Fairburn facility's BART-eligible sources result from process and combustion operations and are largely based on permit limits, source testing, and/or AP-42 emission factors. Similarly, SO_2 emissions emanate from both process and combustion sources, and are mostly based on source testing and/or AP-42 emission factors. Primary emissions of sulfuric acid mists or vapors, if any, are assumed to occur as only a small percentage of the primary $PM_{2.5}$ emissions using the SMOKE $PM_{2.5}$ speciation factors as given on the VISTAS website.[4] Because of the condensable nature of such emissions and the distinct effect on visibility caused by sulfates, primary sulfate is evaluated as a distinct, speciated particulate fraction. Further speciation of $PM_{2.5}$ emissions using the SMOKE $PM_{2.5}$ profiles was used to further partition both condensable and filterable emissions. Table 2-3 gives definitions for the nomenclature used herein.

[4] http://www.vistas-sesarm.org/BART/calpuff.asp

TABLE 2-3. NOMENCLATURE FOR EMISSIONS SPECIATION ANALYSIS

Nomenclature	Description
TSP	Total suspended particulate, filterable PM with an aerodynamic diameter < 30 μm
PM_{10}	Filterable particulate matter with an aerodynamic diameter < 10 μm
PM_{6-10}	Filterable particulate matter with an aerodynamic diameter > 6 and < 10 μm
$PM_{2.5-6}$	Filterable particulate matter with an aerodynamic diameter > 2.5 and < 6 μm
$PM_{2.5}$	Filterable particulate matter with an aerodynamic diameter < 2.5 μm
$PM_{1.25-2.5}$	Filterable particulate matter with an aerodynamic diameter > 1.25 and < 2.5 μm
$PM_{1-1.25}$	Filterable particulate matter with an aerodynamic diameter > 1.0 and < 1.25 μm
$PM_{0.625-1}$	Filterable particulate matter with an aerodynamic diameter > 0.625 and < 1.0 μm
$PM_{0.5-0.625}$	Filterable particulate matter with an aerodynamic diameter > 0.5 and < 0.625 μm
$PM_{<0.5}$	Filterable particulate matter with an aerodynamic diameter < 0.5 μm
CPM	Condensable particulate matter (organic and inorganic)
POC	Primary organic condensable emissions
PIC	Primary inorganic condensable emissions
POA	Primary organic aerosol
TPM_{10}	Filterable PM_{10} + CPM
$TPM_{2.5}$	Filterable $PM_{2.5}$ + CPM

These PM classifications are necessary in the Class I visibility analysis because each type of PM has a different effect on visibility as defined by the extinction efficiency. The emission rates of each of these particulate phases and size categories are modeled in CALPUFF and grouped according to visibility-affecting characteristics as was illustrated in Figure 2-1. Elemental carbon (EC), if emitted, typically results from unburned carbonaceous fuel and is distinguished from other PM types because of its light extinction characteristics. It is assumed that all EC falls within two particle size bins: $PM_{<0.5}$ and $PM_{0.5-0.625}$.[5] Coarse PM (PMC) comprises $PM_{2.5-6}$ and PM_{6-10}. Fine PM (PMF) comprises $PM_{<0.5}$, $PM_{0.5-0.625}$, $PM_{0.625-1}$, $PM_{1-1.25}$, and $PM_{1.25-2.5}$. Condensable particulate matter (CPM) comprises both organic and inorganic species. The organic fraction of CPM is represented in CALPUFF as primary organic condensable (POC) emissions, which are direct emissions but are sometimes referred to as secondary organic aerosols (SOA) by convention and due to the representation of their visibility-affecting characteristics in the light extinction equation. Primary emissions of inorganic CPM (PIC) may contain hygroscopic sulfates (SO_4) and nitrates (NO_3), as well as other salts (e.g., carbonates) that may be hygroscopic to a lesser degree, and hence are considered in a manner similar to PMF (i.e., as soil) in terms of light extinction.[6] Therefore, it is important to distinguish inorganic CPM since certain hygroscopic species (i.e., sulfate and nitrate species) will have a greater extinction coefficient than non-hygroscopic (i.e., non-sulfate and non-nitrate) species. Even the distinction between primary sulfate and nitrate emissions is important since primary nitrate emissions will be affected by the partitioning of nitrate and nitric acid in the presence of ambient ammonia, which is modeled explicitly in CALPUFF. OC distinguishes primary emissions of sulfates and nitrates, which would be

[5] Seinfeld, John H. and Spyros N. Pandis, *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, John Wiley & Sons, Inc., 1998, page 707.

[6] The U.S. EPA's *Guidance for Tracking Progress under the Regional Haze Rule* identifies carbonates, magnesium oxides, and sodium oxides as components of the soil mass concentration when analyzed to assess natural background visibility (Malm 1994).

assigned to the appropriate modeled PM type (i.e., SO_4 and NO_3, respectively), from non-hygroscopic species (e.g., carbonates), which would be modeled as non-hygroscopic PIC species. Inorganic condensable emissions are assumed to be PIC unless a specific emission factor for primary sulfate or nitrate emissions is available.

Table 2-4 summarizes the grouping of PM species and extinction coefficient of each component. A discussion of the PM speciation methodologies for each of the BART-eligible sources at the Fairburn facility is presented in the following sections of this protocol.

TABLE 2-4. ASSIGNMENT OF EMITTED PM SPECIES TO MODELED PM CATEGORIES

Modeled PM Category†	Components	Output Category‡	Extinction Coefficient (m^2/g)
PMC	Filterable coarse particles (PM_{6-10}, $PM_{2.5-6}$)	PMC	0.6
PMF	Filterable fine particles ($PM_{1.25-2.5}$, $PM_{1-1.25}$, $PM_{0.625-1}$, $PM_{0.5-0.625}$, $PM_{<0.5}$)	SOIL	1
PIC	Non-hygroscopic, primary inorganic condensable (PIC) emissions*	SOIL	1
SO4	Primary inorganic condensable emissions of sulfates	SO4	3*f*(RH)
NO3	Primary inorganic condensable emissions of nitrates*	NO3	3*f*(RH)
POC	Primary organic condensable emissions	SOA	4
EC	Uncombusted carbonaceous fuel	EC	10

* In the screening analyses, all condensable, non-sulfate inorganic emissions will be represented as PIC emissions. The refined analysis, if necessary, would distinguish between primary nitrate and other primary condensable inorganic emissions.

† Modeled PM Category denotes the input of emissions data into CALPUFF.

‡ Output Category denotes the assignment of modeled emissions in POSTUTIL for the visibility calculations in CALPOST.

2.2.1 ELECTRIC FURNACE PARTICULATE MATTER SPECIATION

To speciate PM emissions from the electric glass melting furnaces, the $PM_{2.5}$ portion of PM_{10} emissions was first calculated based on engineering estimates made by OC personnel.[7] Speciation factors from SMOKE $PM_{2.5}$, as provided by VISTAS, were then used to divide $PM_{2.5}$ emissions into various categories. It was assumed that emissions within a particular PM category are equally distributed to all size bins within that category. The relevant size bins are given within the "Revised BART Speciation Template" available on the VISTAS website.[8] Table 2-5 summarizes the applicable data for this source.

[7] E-mail communication from Mr. Franco Vigo (OC) to Ms. Melissa Antoine (Trinity Consultants) on July 23, 2006.

[8] http://www.vistas-sesarm.org/BART/calpuff.asp

TABLE 2-5. ELECTRIC GLASS MELTING FURNACE SPECIATION DATA

Speciation Data	Value	Reference
$PM_{2.5}$ as a % of PM_{10}	50.00%	Mr. Franco Vigo (OC)
Primary EC as a % of $PM_{2.5}$	2.00%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary $PM_{2.5}$ as a % of $PM_{2.5}$	63.30%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary NO_3 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary OA as a % of $PM_{2.5}$	33.60%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary SO_4 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033

Using the information presented in Table 2-5, OC first calculated process TPM_{10} emissions from each furnace by multiplying the maximum hourly TSP emission rate of 0.75 lb/ton of glass pulled by the glass pull rate of each furnace, which for the FG-1 Furnace, yields 4.69 lb/hr. For the glass melting furnaces, OC personnel estimate that approximately 50% of PM_{10} emissions are $PM_{2.5}$. Multiplying PM_{10} emissions by 50% results in $PM_{2.5}$ emissions from the FG-1 Furnace of 2.34 lb/hr.

Next, $PM_{2.5}$ is speciated into the categories given in Table 2-5. An example is provided below for process PEC emissions from the FG-1 Furnace.

$$\left(2.34\,\frac{\text{lb TPM}_{2.5}}{\text{hr}}\right)\times\left(2\%\,\frac{\text{PEC}}{\text{TPM}_{2.5}}\right)=0.05\,\frac{\text{lb PEC all size categories}}{\text{hour}}$$

Emissions are calculated for the remaining $PM_{2.5}$ categories listed in Table 2-5 in a similar manner.

The glass melting furnaces at the Fairburn facility are equipped with back-up natural gas burners. Normally, these burners do not operate; however, for conservatism in estimating maximum 24-hour emissions, it is assumed that the burners are firing at their rated capacity throughout a single 24-hour period. Combustion PM emissions are speciated using factors from SMOKE $PM_{2.5}$, as available on the VISTAS website. Table 2-6 presents the speciation factors for all combustion sources at the Fairburn facility.

TABLE 2-6. SPECIATION FACTORS FOR COMBUSTION SOURCES

Speciation Data	Value	Reference
$PM_{2.5}$ as a % of PM_{10}	100.00%	AP-42, Chapter 1.4, Table 1.4-2
Primary EC as a % of $PM_{2.5}$	0.00%	SMOKE $PM_{2.5}$, Speciation Profile 22004
Primary $PM_{2.5}$ as a % of $PM_{2.5}$	19.45%	SMOKE $PM_{2.5}$, Speciation Profile 22004
Primary NO_3 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22004
Primary OA as a % of $PM_{2.5}$	60.00%	SMOKE $PM_{2.5}$, Speciation Profile 22004
Primary SO_4 as a % of $PM_{2.5}$	20.00%	SMOKE $PM_{2.5}$, Speciation Profile 22004

Table 2-7 presents speciated PM emissions (combined process and combustion emissions) for the glass melting furnaces at the Fairburn facility.

TABLE 2-7. GLASS MELTING FURNACES SPECIATED PM EMISSIONS

Emission Unit	EU ID	Total PM_{10} (lb/hr)	Total $PM_{2.5}$ (lb/hr)	PM_{10} - $PM_{2.5}$ (lb/hr)	PEC (lb/hr)	$PPM_{2.5}$ (lb/hr)	PNO_3 (lb/hr)	POA (lb/hr)	PSO_4 (lb/hr)
FG1 Furnace	FG11	4.85	2.51	2.34	0.05	1.52	0.01	0.89	0.05
FG2 Furnace	FG21	4.76	2.48	2.27	0.05	1.48	0.01	0.89	0.05
FG3 Furnace	FG31	2.51	1.33	1.19	0.02	0.78	0.01	0.48	0.03

Figures 2-2, 2-3, and 2-4 present a graphical representation of the PM speciation for the glass melting furnaces at the Fairburn facility.

FIGURE 2-2. FG-1 FURNACE TPM_{10} SPECIATION (LB/HR)

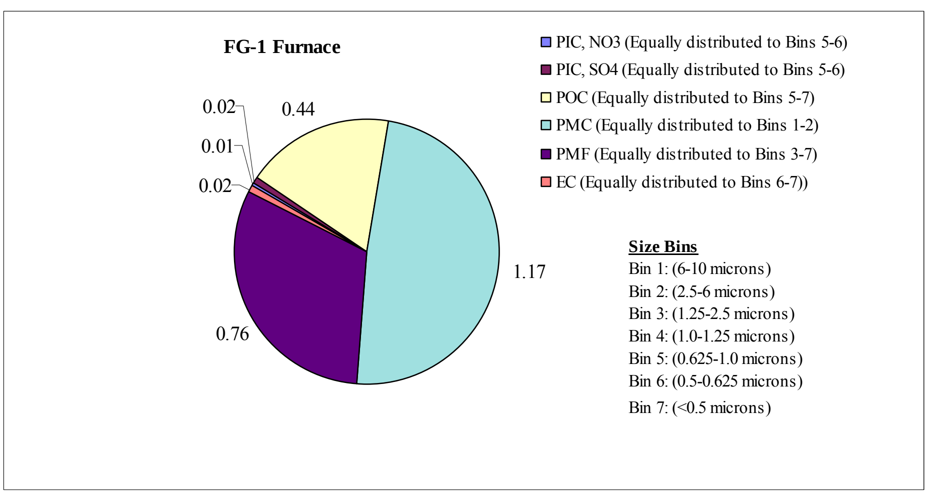


FIGURE 2-3. FG-2 FURNACE TPM_{10} SPECIATION (LB/HR)

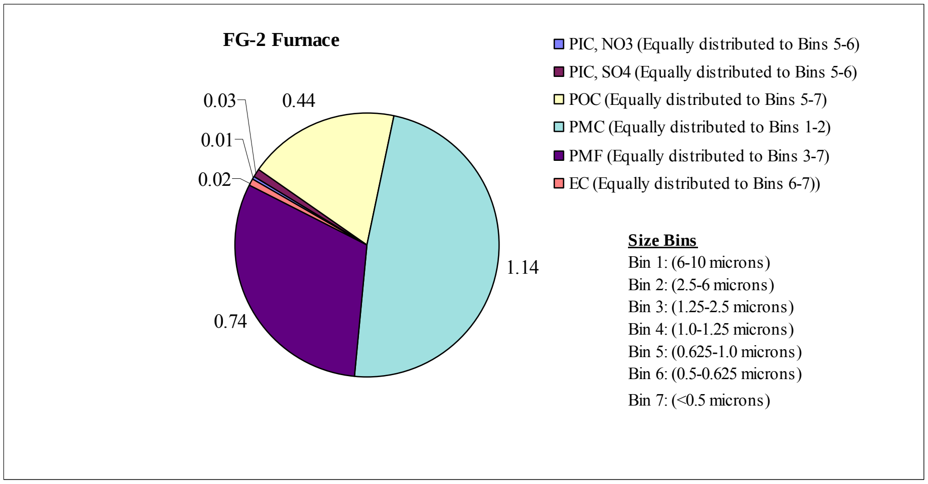
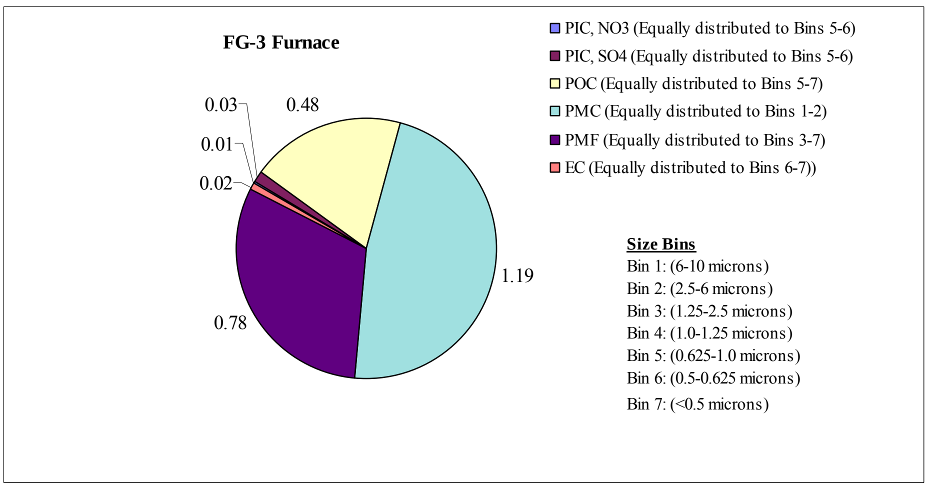


FIGURE 2-4. FG-3 FURNACE TPM_{10} SPECIATION (LB/HR)



2.2.2 RISER/CHANNEL AND FOREHEARTH PARTICULATE MATTER SPECIATION

To speciate PM emissions from the risers/channels and forehearths, the $PM_{2.5}$ portion of PM_{10} emissions was first calculated based on engineering estimates made by OC personnel.[9] Speciation factors from SMOKE $PM_{2.5}$, as provided by VISTAS, were then used to divide $PM_{2.5}$ emissions into various categories. It was assumed that emissions within a particular PM category are equally distributed to all size bins within that category. The relevant size bins are given within the "Revised BART Speciation Template" available on the VISTAS website.[10] Table 2-8 summarizes the applicable data for this source.

[9] E-mail communication from Mr. Franco Vigo (OC) to Ms. Melissa Antoine (Trinity Consultants) on July 23, 2006.

[10] http://www.vistas-sesarm.org/BART/calpuff.asp

TABLE 2-8. RISER/CHANNEL AND FOREHEARTH SPECIATION DATA

Speciation Data	Value	Reference
$PM_{2.5}$ as a % of PM_{10}	50.00%	Mr. Franco Vigo (OC)
Primary EC as a % of $PM_{2.5}$	2.00%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary $PM_{2.5}$ as a % of $PM_{2.5}$	63.30%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary NO_3 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary OA as a % of $PM_{2.5}$	33.60%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary SO_4 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033

Using the information presented in Table 2-8, OC first calculated process TPM_{10} emissions from each riser/channel and forehearth by multiplying the applicable maximum hourly TSP emission rate of by the glass pull rate of the corresponding glass melting furnace, which for the FG-1 Riser/Channel, yields 7.61 lb/hr, and for the FG-1 Forehearth, yields 1.97 lb/hr. Similar to the glass melting furnaces, OC personnel estimate that approximately 50% of PM_{10} emissions from the riser/channel and forehearth are $PM_{2.5}$. Multiplying process PM_{10} emissions by 50% results in $PM_{2.5}$ emissions from the FG-1 Riser/Channel of 3.81 lb/hr and from the FG-1 Forehearth of 0.98 lb/hr.

Next, $PM_{2.5}$ is speciated into the categories given in Table 2-8. An example is provided below for process PEC emissions from the FG-1 Riser/Channel.

$$\left(3.81\,\frac{\text{lb TPM}_{2.5}}{\text{hr}}\right)\times\left(2\%\,\frac{\text{PEC}}{\text{TPM}_{2.5}}\right)=0.08\,\frac{\text{lb PEC all size categories}}{\text{hour}}$$

Emissions are calculated for the remaining $PM_{2.5}$ categories listed in Table 2-8 in a similar manner. Combustion emissions from the risers/channels and forehearth are calculated using the previously described methodology and the speciation profile given in Table 2-6. Table 2-9 presents speciated PM emissions (combined process and combustion emissions) for the risers/channels and forehearths at the Fairburn facility.

TABLE 2-9. RISER/CHANNEL AND FOREHEARTH SPECIATED PM EMISSIONS

Emission Unit	EU ID	Total PM_{10} (lb/hr)	Total $PM_{2.5}$ (lb/hr)	PM_{10} - $PM_{2.5}$ (lb/hr)	PEC (lb/hr)	$PPM_{2.5}$ (lb/hr)	PNO_3 (lb/hr)	POA (lb/hr)	PSO_4 (lb/hr)
FG1 Riser/Channel	FG12	7.63	3.83	3.81	0.08	2.41	0.02	1.29	0.03
FG2 Riser/Channel	FG22	0.22	0.11	0.11	2.2E-03	0.07	6.0E-04	0.04	6.0E-04
FG3 Riser/Channel	FG32	3.86	1.94	1.93	0.04	1.22	0.01	0.65	0.01
FG1 Forehearth	FG12	2.01	1.02	0.98	0.02	0.63	0.01	0.35	0.01
FG2 Forehearth	FG23	0.03	0.01	0.01	2.8E-04	9.0E-03	7.8E-05	4.8E-03	7.8E-05
FG3 Forehearth	FG33	1.01	0.52	0.50	0.01	0.32	0.00	0.18	0.01

Figures 2-5, 2-6, and 2-7 present a graphical representation of the riser/channel and forehearth PM speciation at the Fairburn facility.

FIGURE 2-5. FG-1 RISER/CHANNEL & FOREHEARTH TPM_{10} SPECIATION (LB/HR)

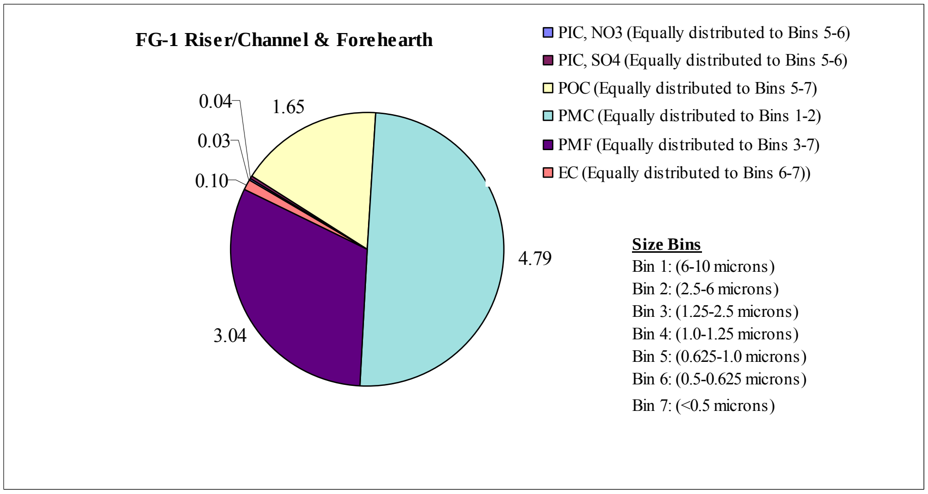


FIGURE 2-6. FG-2 RISER/CHANNEL & FOREHEARTH TPM_{10} SPECIATION (LB/HR)

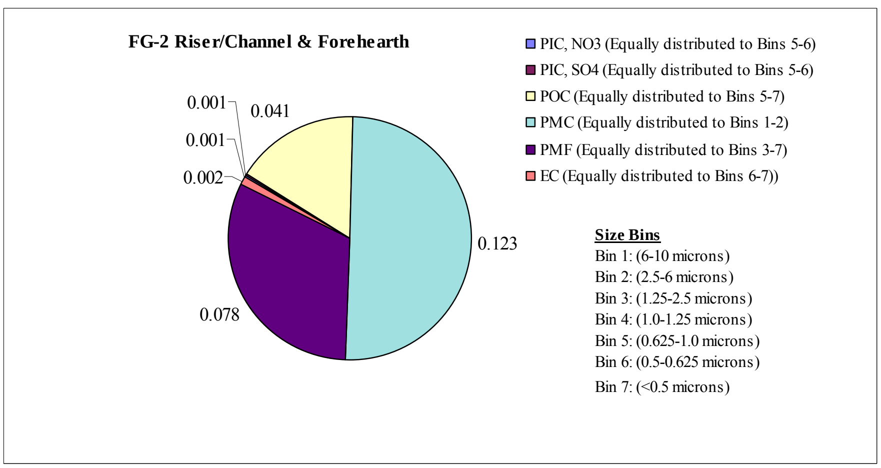
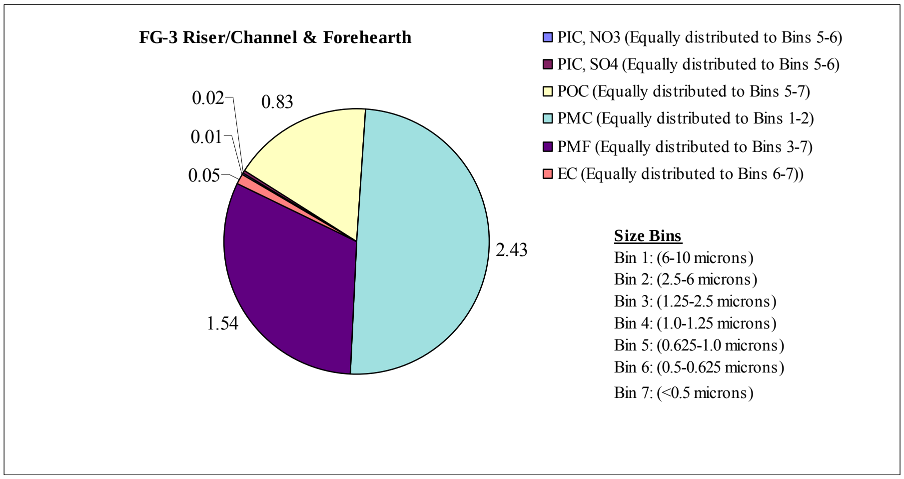


FIGURE 2-7. FG-3 RISER/CHANNEL & FOREHEARTH TPM_{10} SPECIATION (LB/HR)



2.2.3 FORMING AND CURING PARTICULATE MATTER SPECIATION

Air flow from the forming and curing sections are first routed together through a mixing chamber prior to being released to the atmosphere. As such, emissions from these process units are quantified together. To speciate PM emissions from the mixing chamber, the $PM_{2.5}$ portion of PM_{10} emissions was first calculated based on engineering estimates made by OC personnel.[11] Speciation factors from SMOKE $PM_{2.5}$, as provided by VISTAS, were then used to divide $PM_{2.5}$ emissions into various categories. It was assumed that emissions within a particular PM category are equally distributed to all size bins within that category. The relevant size bins are given within the "Revised BART Speciation Template" available on the VISTAS website.[12] Table 2-10 summarizes the applicable data for this source.

TABLE 2-10. MIXING CHAMBER SPECIATION DATA

Speciation Data	Value	Reference
$PM_{2.5}$ as a % of PM_{10}	90.00%	Mr. Franco Vigo (OC)
Primary EC as a % of $PM_{2.5}$	2.00%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary $PM_{2.5}$ as a % of $PM_{2.5}$	63.30%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary NO_3 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary OA as a % of $PM_{2.5}$	33.60%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary SO_4 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033

Using the information presented in Table 2-10, OC first calculated process TPM_{10} emissions from each mixing chamber by multiplying the applicable maximum hourly TSP

[11] E-mail communication from Mr. Franco Vigo (OC) to Ms. Melissa Antoine (Trinity Consultants) on July 23, 2006.

[12] http://www.vistas-sesarm.org/BART/calpuff.asp

emission rate of by the glass pull rate of the corresponding glass melting furnace, which for the FG-1 Mixing Chamber, yields 60.0 lb/hr. Note that because emissions are based on stack testing, this emission rate includes combustion emissions from the forming section fiberizers, the curing ovens burners, and the incinerator burners. OC personnel estimate that approximately 90% of PM_{10} emissions from the mixing chambers are $PM_{2.5}$. Multiplying process PM_{10} emissions by 90% results in $PM_{2.5}$ emissions from the FG-1 Mixing Chamber of 54.0 lb/hr.

Next, $PM_{2.5}$ is speciated into the categories given in Table 2-10. An example is provided below for process PEC emissions from the FG-1 Mixing Chamber.

$$\left(54.0\,\frac{\text{lb TPM}_{2.5}}{\text{hr}}\right)\times\left(2\%\,\frac{\text{PEC}}{\text{TPM}_{2.5}}\right)=1.08\,\frac{\text{lb PEC all size categories}}{\text{hour}}$$

Emissions are calculated for the remaining $PM_{2.5}$ categories listed in Table 2-10 in a similar manner. Table 2-11 presents speciated PM emissions for the mixing chambers at the Fairburn facility.

TABLE 2-11. MIXING CHAMBER SPECIATED PM EMISSIONS

Emission Unit	EU ID	Total PM_{10} (lb/hr)	Total $PM_{2.5}$ (lb/hr)	PM_{10} - $PM_{2.5}$ (lb/hr)	PEC (lb/hr)	$PPM_{2.5}$ (lb/hr)	PNO_3 (lb/hr)	POA (lb/hr)	PSO_4 (lb/hr)
FG1 Mixing Chamber	-	60.00	54.00	6.00	1.07	34.00	0.30	18.25	0.38
FG2 Mixing Chamber	-	29.50	26.55	2.95	0.52	16.65	0.15	9.02	0.22
FG3 Mixing Chamber	-	24.00	21.60	2.40	0.43	13.58	0.12	7.32	0.16

Figures 2-8, 2-9, and 2-10 present a graphical representation of the PM speciation for the mixing chambers at the Fairburn facility.

FIGURE 2-8. FG-1 MIXING CHAMBER TPM_{10} SPECIATION (LB/HR)

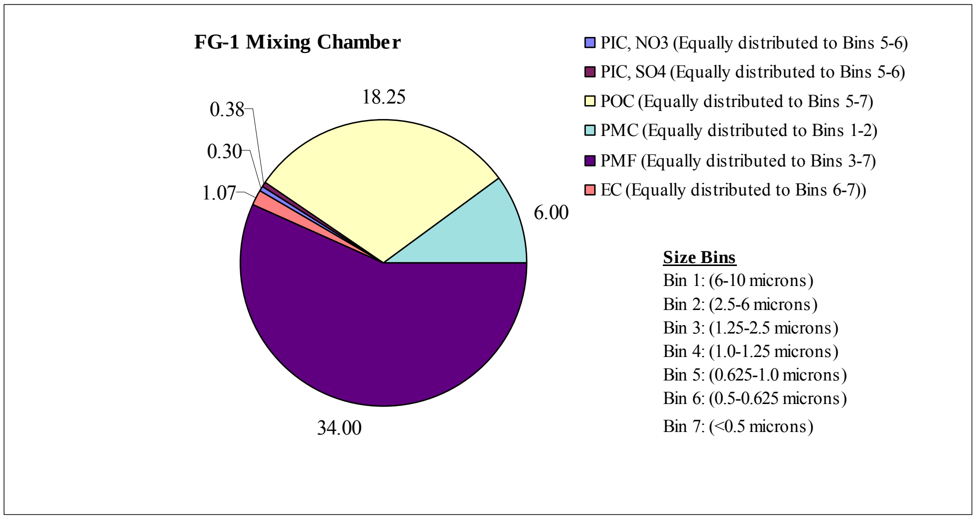


FIGURE 2-9. FG-2 MIXING CHAMBER TPM_{10} SPECIATION (LB/HR)

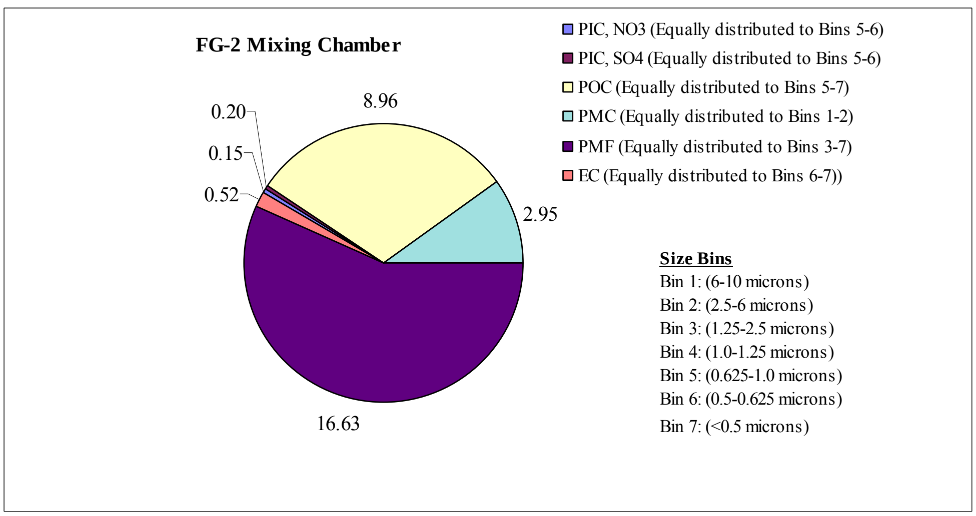
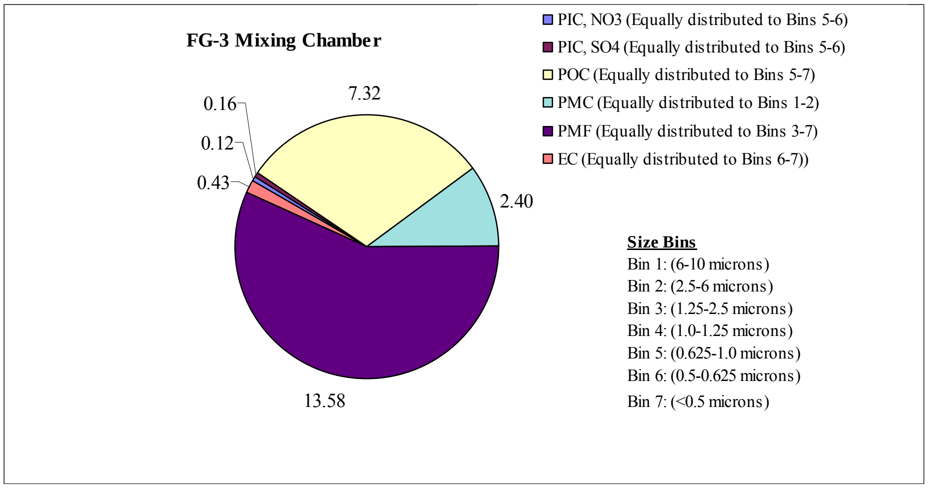


FIGURE 2-10. FG-3 MIXING CHAMBER TPM_{10} SPECIATION (LB/HR)



2.2.4 COOLING SECTION PARTICULATE MATTER SPECIATION

To speciate PM emissions from the cooling section, the $PM_{2.5}$ portion of PM_{10} emissions was first calculated based on engineering estimates made by OC personnel.[13] Speciation factors from SMOKE $PM_{2.5}$, as provided by VISTAS, were then used to divide $PM_{2.5}$ emissions into various categories. It was assumed that emissions within a particular PM category are equally distributed to all size bins within that category. The relevant size bins are given within the "Revised BART Speciation Template" available on the VISTAS website.[14] Table 2-12 summarizes the applicable data for this source.

TABLE 2-12. COOLING SECTION SPECIATION DATA

Speciation Data	Value	Reference
$PM_{2.5}$ as a % of PM_{10}	90.00%	Mr. Franco Vigo (OC)
Primary EC as a % of $PM_{2.5}$	2.00%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary $PM_{2.5}$ as a % of $PM_{2.5}$	63.30%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary NO_3 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary OA as a % of $PM_{2.5}$	33.60%	SMOKE $PM_{2.5}$, Speciation Profile 22033
Primary SO_4 as a % of $PM_{2.5}$	0.55%	SMOKE $PM_{2.5}$, Speciation Profile 22033

Using the information presented in Table 2-12, OC first calculated process TPM_{10} emissions from each applicable cooling section by multiplying the applicable maximum hourly TSP emission rate of by the glass pull rate of the corresponding glass melting

[13] E-mail communication from Mr. Franco Vigo (OC) to Ms. Melissa Antoine (Trinity Consultants) on July 23, 2006.

[14] http://www.vistas-sesarm.org/BART/calpuff.asp

furnace, which for the FG-1 Cooling Section, yields 5.49 lb/hr. OC personnel estimate that approximately 90% of PM_{10} emissions from the cooling section are $PM_{2.5}$. Multiplying process PM_{10} emissions by 90% results in $PM_{2.5}$ emissions from the FG-1 Cooling Section of 4.94 lb/hr.

Next, $PM_{2.5}$ is speciated into the categories given in Table 2-12. An example is provided below for process PEC emissions from the FG-1 Cooling Section.

$$\left(5.49\,\frac{\text{lb TPM}_{2.5}}{\text{hr}}\right)\times\left(2\%\,\frac{\text{PEC}}{\text{TPM}_{2.5}}\right)=0.11\,\frac{\text{lb PEC all size categories}}{\text{hour}}$$

Emissions are calculated for the remaining $PM_{2.5}$ categories listed in Table 2-12 in a similar manner. Table 2-13 presents speciated PM emissions for the applicable cooling sections at the Fairburn facility.

TABLE 2-13. COOLING SECTION SPECIATED PM EMISSIONS

Emission Unit	EU ID	Total PM_{10} (lb/hr)	Total $PM_{2.5}$ (lb/hr)	PM_{10} - $PM_{2.5}$ (lb/hr)	PEC (lb/hr)	$PPM_{2.5}$ (lb/hr)	PNO_3 (lb/hr)	POA (lb/hr)	PSO_4 (lb/hr)
FG1 Cooling Section	FG16	5.49	4.94	0.55	0.10	3.13	0.03	1.66	0.03
FG2 Cooling Section	FG26	1.50	1.35	0.15	0.03	0.85	7.4E-03	0.45	7.4E-03

Figures 2-11 and 2-12 present a graphical representation of the PM speciation for the FG-1 and FG-2 cooling sections at the Fairburn facility.

FIGURE 2-11. FG-1 COOLING SECTION TPM_{10} SPECIATION (LB/HR)

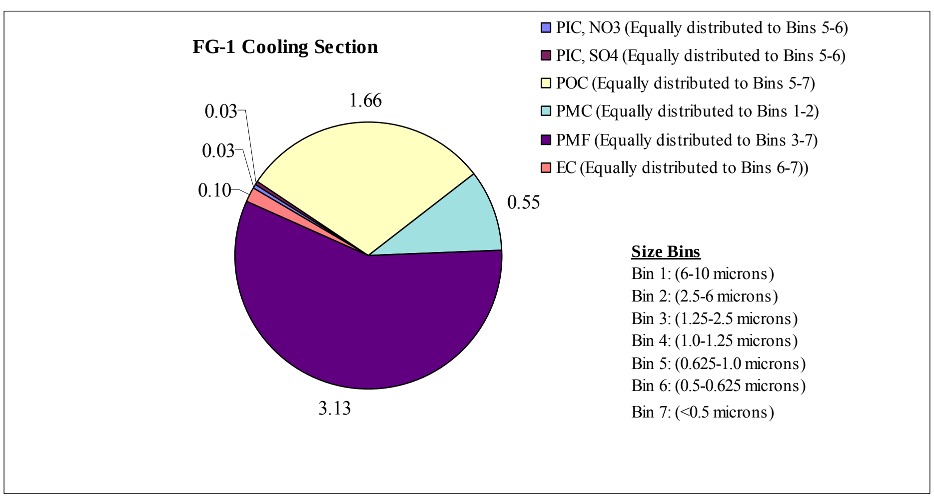
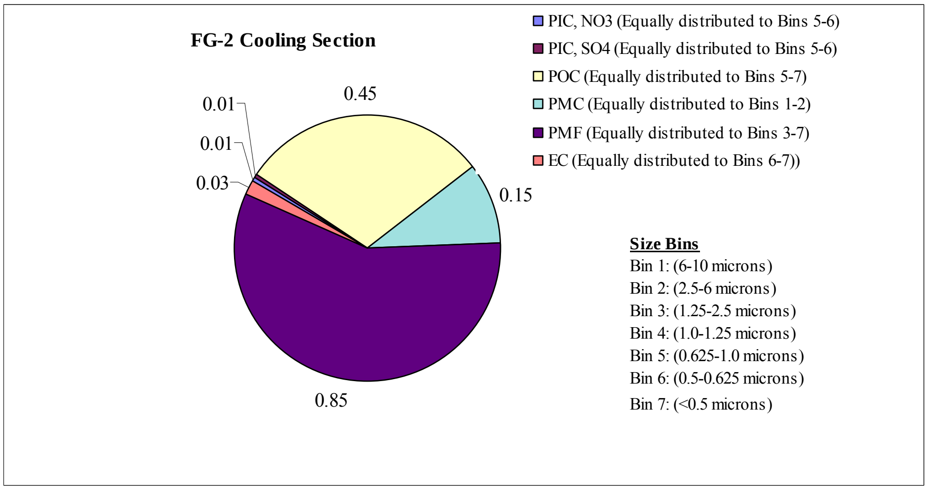


FIGURE 2-12. FG-2 COOLING SECTION TPM_{10} SPECIATION (LB/HR)



2.2.5 ASPHALT APPLICATION PARTICULATE MATTER SPECIATION

Emission estimates for the asphalt application processes are based on VOC testing conducted at similar OC facilities and OC's knowledge that the composition of asphalt is 22% PM and 78% VOC. It is assumed that all PM_{10} is $PM_{2.5}$. Further, it is assumed that all $PM_{2.5}$ is organic condensable and that emissions are equally distributable to the three size bins within this PM category. The relevant size bins are given within the "Revised BART Speciation Template" available on the VISTAS website.[15] Table 2-14 presents speciated PM emissions for the applicable asphalt application processes at the Fairburn facility.

TABLE 2-14. ASPHALT APPLICATION SPECIATED PM EMISSIONS

Emission Unit	EU ID	Total PM_{10} (lb/hr)	Total $PM_{2.5}$ (lb/hr)	PM_{10} - $PM_{2.5}$ (lb/hr)	PEC (lb/hr)	$PPM_{2.5}$ (lb/hr)	PNO_3 (lb/hr)	POA (lb/hr)	PSO_4 (lb/hr)
FG1 Asphalt Application	FG18	0.09	0.09	-	-	-	-	0.09	-
FG2 Asphalt Application	FG28	0.08	0.08	-	-	-	-	0.08	-

Figures 2-13 and 2-14 present a graphical representation of the PM speciation for the FG-1 and FG-2 asphalt application processes at the Fairburn facility.

[15] http://www.vistas-sesarm.org/BART/calpuff.asp

FIGURE 2-13. FG-1 ASPHALT APPLICATION TPM_{10} SPECIATION (LB/HR)

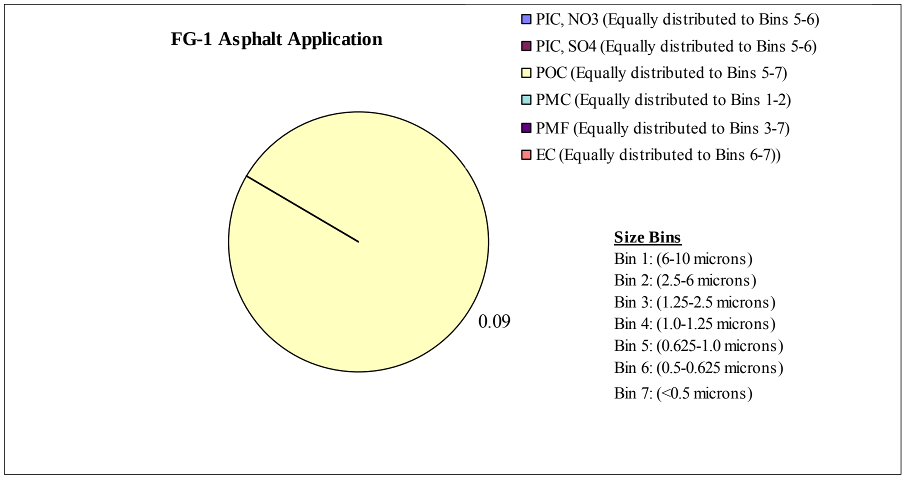
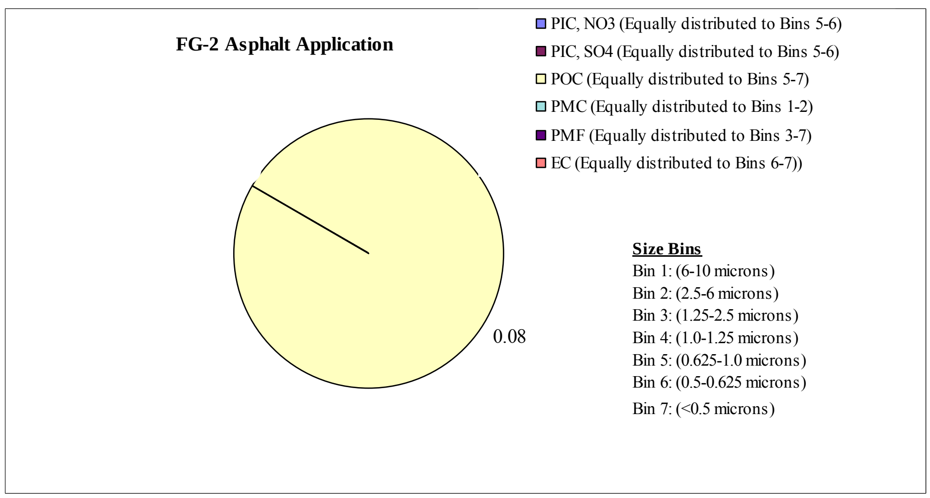


FIGURE 2-14. FG-2 ASPHALT APPLICATION TPM_{10} SPECIATION (LB/HR)



2.3 MODELED STACK PARAMETERS AND EMISSIONS

Actual stack parameters were input to the CALPUFF model to represent the point of visibility-affecting pollutant emissions. The location of each point source was represented consistently in the Lambert Conformal Coordinate system used for the screening and refined meteorological data analyses prepared by VISTAS. Each exhaust discharges vertically without obstruction. The effects of building downwash were not considered in the BART Applicability Analyses. Table 2-15 summarizes the stack parameters for BART-eligible emission units at OC's Fairburn facility.

TABLE 2-15. STACK PARAMETERS FOR BART-ELIGIBLE EMISSION UNITS

Stack ID	Source	Description	UTM East (km)	UTM North (km)	UTM Zone	Stack Height (ft)	Base Elevation (ft)	Diameter (ft)	Gas Exit Velocity (ft/s)	Stack Gas Exit Temp. (deg F)
FG11A	FG-1 Furnace	Electric Cold Top Melting Furnace - Stack A	721.400	3713.442	16	68.63	1,031	4.00	10.96	102
FG11B	FG-1 Furnace	Electric Cold Top Melting Furnace - Stack B	721.407	3713.434	16	68.63	1,031	4.00	8.29	112
FG1MC[a]	FG-1 Mixing Chamber	Mixing Chamber	721.364	3713.399	16	61.01	1,031	9.50	48.71	165
FG12	FG-1 Riser/Channel	Flow Channel								
FG13	FG-1 Forehearth	Flow Channel								
FG14	FG-1 Forming Section	Molten Glass Spinning to Glass Fibers								
FG15	FG-1 Curing Oven	Insulation Binder Curing Oven								
FG16	FG-1 Cooling Section	Cooling with Ambient Air	721.341	3713.377	16	51.10	1,031	3.17	40.55	195
FG18	FG-1 Asphalt Application	Application of Asphalt to Product Backing	721.312	3713.590	16	37.12	1,031	1.33	95.97	100
FG21A	FG-2 Furnace	Electric Cold Top Melting Furnace - Stack A	721.416	3713.417	16	70.58	1,031	4.00	8.05	110
FG21B	FG-2 Furnace	Electric Cold Top Melting Furnace - Stack B	721.422	3713.409	16	70.58	1,031	4.00	8.72	111
FG2MC[a]	FG-2 Mixing Chamber	Mixing Chamber	721.371	3713.378	16	65.33	1,031	10.50	25.06	165
FG22	FG-2 Riser/Channel	Flow Channel								
FG23	FG-2 Forehearth	Flow Channel								
FG24	FG-2 Forming Section	Molten Glass Spinning to Glass Fibers								
FG25	FG-2 Curing Oven	Insulation Binder Curing Oven								
FG26	FG-2 Cooling Section	Cooling with Ambient Air	721.348	3713.358	16	51.10	1,031	2.62	40.55	170
FG28	FG-2 Asphalt Application	Application of Asphalt to Product Backing	721.321	3713.557	16	37.12	1,031	1.00	137.93	100
FG31	FG-3 Furnace	Electric Cold Top Melting Furnace	721.435	3713.399	16	68.75	1,031	4.00	10.59	107
FG3MC[a]	FG-3 Mixing Chamber	Mixing Chamber	721.407	3713.372	16	80.66	1,031	8.00	22.14	245
FG32	FG-3 Riser/Channel	Flow Channel								
FG33	FG-3 Forehearth	Flow Channel								
FG34	FG-3 Forming Section	Molten Glass Spinning to Glass Fibers								
FG35	FG-3 Curing Oven	Insulation Binder Curing Oven								

a. The Mixing Chamber includes emissions from the Forming and Curing Sections. It is assumed that emissions from the Riser/Channel and Forehearth are also routed through the Mixing Chamber.

3. AIR QUALITY MODELING ANALYSES

Section 3 of this BART Applicability Analysis report for OC's Fairburn facility describes the modeling methods, data resources, and technical options used to conduct screening analyses to assess visibility impacts. Air quality modeling was conducted generally following the methods described in the *VISTAS BART Modeling Protocol* as revised.

3.1 AIR QUALITY MODELING SYSTEM

CALPUFF is a multi-layer, multi-species, non-steady-state Lagrangian puff model, which can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. The modeling system is designed to handle the complexities posed by the complex terrain, the large source-receptor distances, chemical transformation and deposition, and other issues related to Class I visibility impacts. A complete description of the model formulation and capabilities is provided in the *User's Guides* for the CALPUFF modeling system and the *VISTAS BART Modeling Protocol*.

The CALPUFF modeling system has been adopted by the U.S. EPA as a recommended regulatory 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. CALPUFF is recommended for Class I area impact assessments by the Interagency Workgroup on Air Quality Models (IWAQM). The U.S. EPA's BART guidance recommends CALPUFF as "the best modeling application available for predicting a singe source's contribution to visibility impairment."

As a result of these recommendations, the *VISTAS BART Modeling Protocol* was based on the use of CALPUFF and was used by OC for the source-specific analysis of visibility impacts attributable to the Fairburn facility. Specifically, VISTAS CALMET Version 5.724 and CALPUFF Version 5.754 were used in the CALPUFF analyses for BART applicability assessment.

3.2 SCREENING AND REFINED ANALYSIS TECHNIQUES

The *VISTAS BART Modeling Protocol* distinguishes between screening and refined applications of the CALPUFF model for the purposes of BART Applicability Analyses. As the names of these techniques imply, screening analyses are intended to provide a conservative estimate of visibility impacts using computationally efficient techniques. The refined analyses utilize less conservative and more representative data and modeling methods to compute visibility impacts following U.S. EPA's BART guidelines. Screening analyses may be used to determine that a facility is not subject to BART using a conservative assessment, or to focus the scope of refined analyses by demonstrating that visibility impairment is not likely to occur at more distant Class I areas.

Although certain elements of the modeling analyses are identical regardless of which approach is used (e.g., representation of emissions sources, chemical transformation algorithms, Class I area receptors), the *VISTAS BART Modeling Protocol* makes several important distinctions between screening and refined analyses.

3.2.1 VISIBILITY ASSESSMENT METRIC

The U.S. EPA BART guidelines prescribe that the 98th percentile, 24-hour average visibility impact computed in a modeling analysis that evaluates three years of meteorological data should be compared to the contribution threshold of 0.5 dv to assess BART applicability. However, VISTAS prescribes that the *maximum* computed visibility impact be used as the basis for comparison in the screening analysis to ensure that the modeled result is a conservative representation of visibility impairment. The VISTAS refined approach prescribes that the 98th percentile impact be evaluated in refined analyses as the eighth-highest 24-hour average visibility impact of each of three years modeled, or the 22nd-highest 24-hour average visibility impact over the three years modeled, whichever is more conservative.

3.2.2 METEOROLOGICAL AND COMPUTATIONAL GRIDS

The *VISTAS BART Modeling Protocol* prescribes that screening analyses be conducted on a 12-km meteorological and computational grid and that refined analyses be conducted on a 4-km meteorological and computational grid. The resolution of the computational analysis dictates the extent to which geophysical (i.e., terrain and land use) and meteorological conditions are represented in the CALMET meteorological model, hence the advection, dispersion, and chemical transformation of visibility-affecting pollutants in the CALPUFF meteorological model. The VISTAS Technical Contractor conducted meteorological modeling using both screening 12-km and refined 4-km grids to provide common data resources to eligible sources conducting BART Applicability Analyses, which were used by OC, as necessary, to assess visibility impacts attributable to the Fairburn facility. The following section of this report describes the CALMET meteorological modeling in greater detail.

3.2.3 MODEL PROCESSING AND POSTPROCESSING METHODS

The IWAQM *Phase 2 Report* prescribes recommended default model processing options to be used in CALPUFF analyses, which are in most cases considered regulatory default options under U.S. EPA's *Guideline on Air Quality Models*. IWAQM default model options as described in the following section of this report were prescribed for use in both screening and refined analyses. The *VISTAS BART Modeling Protocol* and OC's source-specific modeling protocol envisioned the possible use of puff-splitting algorithms to represent wind shear effects and differential rates of transport of well-mixed puffs that grow beyond the size of a grid cell. Puff splitting algorithms are computationally demanding and for some applications may require changes to the default parameter settings in POSTUTIL to allow more than the default number of split puffs. Because of the conservative nature of OC's analyses, the default model option to disable puff splitting was used in BART Applicability Analyses.

In the postprocessing of CALPUFF-computed concentrations of visibility-affecting pollutants, the POSTUTIL postprocessing utility can be used to apply the ammonia limiting method by re-partitioning the distribution of HNO_3 and NO_3 concentrations at each Class I area as a function of the temperature and relative humidity during each hour. ALM processing is not run by default, and therefore was not used in the screening analyses.

3.3 CALMET METEOROLOGICAL PROCESSING

CALMET is the meteorological preprocessor that compiles three-dimensional meteorological fields from mesoscale model (MM) output, raw observations of surface and upper air conditions, precipitation measurements, and geophysical parameters into a single hourly, gridded data set for input to CALPUFF. The *CALMET User's Guide* and *VISTAS BART Modeling Protocol* provide a detailed description of the model's formulation and capabilities.

The federal *Guideline* for CALPUFF processing provides the following recommendations for the meteorological data period at Section 9.3.1.2:

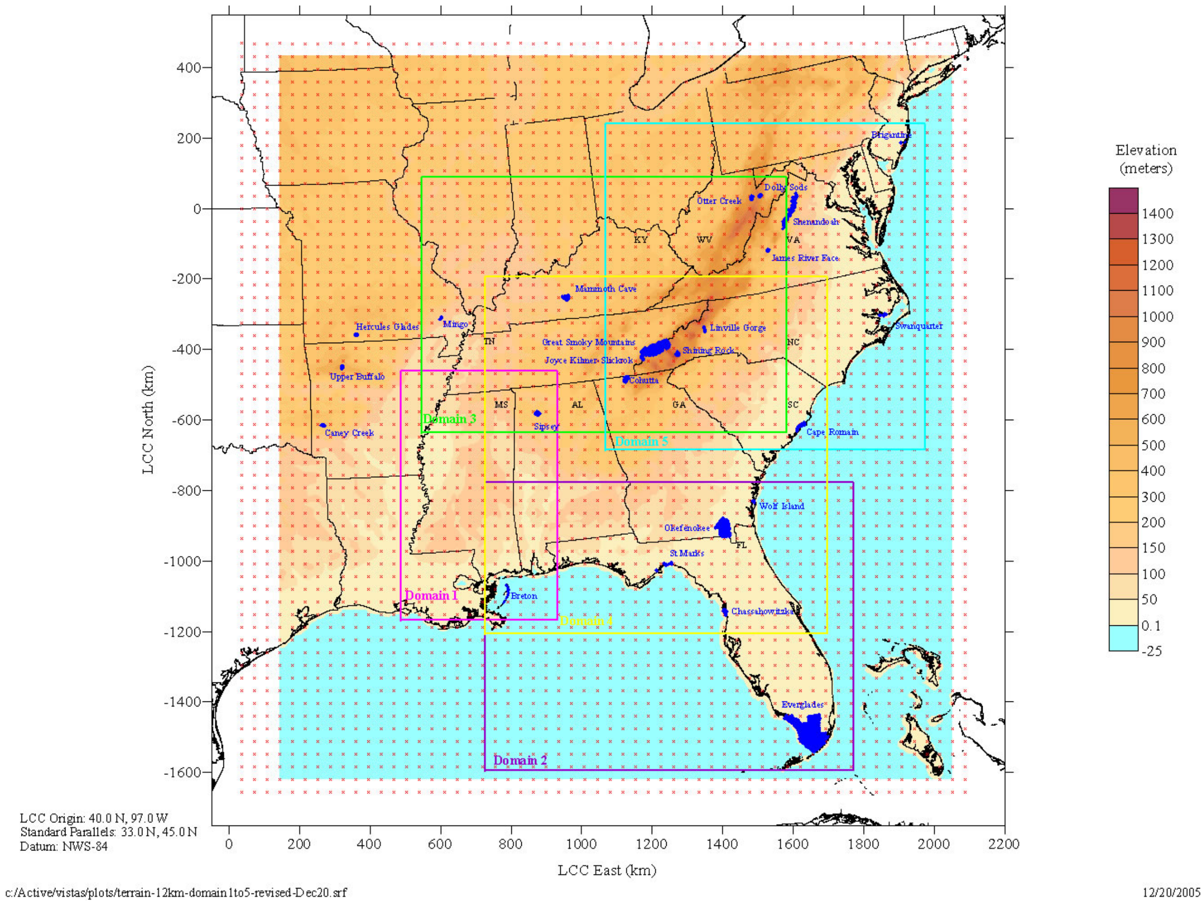
> *Less than five, but at least three, years of meteorological data (need not be consecutive) may be used if mesoscale meteorological fields are available, as discussed in paragraph 9.3(c). These mesoscale meteorological fields should be used in conjunction with available standard [National Weather Service] NWS or comparable meteorological observations within and near the modeling domain.*

The *VISTAS BART Modeling Protocol* prescribes the years 2001 through 2003 for BART Applicability Analyses. The primary basis for this data analysis period was the availability of quality assured MM5 data for the entire VISTAS area. For its BART Applicability Analyses, OC utilized 12-km screening CALMET data prepared by the VISTAS Technical Contractor using the following data resources and CALMET modeling techniques. It was not necessary to use the 4-km refined CALMET data to show that OC's Fairburn facility does not cause visibility impacts at the Class I areas of interest.

3.3.1 CALMET METEOROLOGICAL DOMAINS

12-km screening and 4-km refined CALMET meteorological data sets were prepared for the domains depicted in Figures 3-1. OC's BART Applicability Analyses utilized the Regional Screening Domain 0 for 12-km screening analyses, and refined analyses were not required using the 4-km data. The CALPUFF computational domains were selected as a subset of the screening domain as described in the following section of this report.

FIGURE 3-1. 12-KM REGIONAL SCREENING ANALYSIS AND 4-KM SUB-REGIONAL REFINED ANALYSIS CALMET DOMAINS



The VISTAS regional modeling domain was designed to allow any Class I areas within the VISTAS area to be evaluated with a single meteorological database and consistent CALPUFF modeling options. The horizontal domain is comprised of grid cells, each containing a central grid point at which meteorological and computational parameters are calculated at each time step. For the initial regional analysis, a grid spacing interval of 12 km was selected. The LCC projection system is used to describe the horizontal grid, with origin at 40 degrees North latitude and 97 degrees West longitude. Standard parallels for the projection were set at 33 degrees North and 45 degrees North.

Table 3-1 summarizes the vertical grid structure selected for this analysis, which comprises ten vertical layers. The cell face height of each layer indicates its vertical extent. The vertical domain is composed of terrain-following grid cells, the number and size of which are chosen so as to constrain the boundary layer in which dispersion and chemical transformations take place. The highest cell face was selected to be 4,000 meters to constrain the default maximum mixing height of 3,000 meters.

TABLE 3-1. VERTICAL GRID STRUCTURE

Vertical Grid Cell	Cell Face Height (meters)
1	20
2	40
3	80
4	160
5	320
6	640
7	1,200
8	2,000
9	3,000
10	4,000

3.3.2 MM5 SIMULATIONS

MM data are used as "observed" or "first-guess" fields in CALMET due to its high-resolution representation of meteorological conditions on a uniform three-dimensional grid. The following three years of MM5 meteorological data were assembled by VISTAS for use in the regional CALPUFF modeling effort:

- 2001 MM5 dataset at 12 km and 36 km grid (developed for EPA)
- 2002 MM5 dataset at 12 km and 36 km grid (developed by VISTAS)
- 2003 MM5 dataset at 36 km grid (developed by the Midwest Regional Planning Organization).

These data sets were provided to the VISTAS Technical Contractor, which produced three-dimensional, CALMET-ready meteorological files for the VISTAS domain, which were subsequently used to run CALMET for the 12-km screening analyses.

3.3.3 GEOPHYSICAL DATA

According to the *VISTAS BART Modeling Protocol*, terrain elevations within the modeling domain were processed from SRTM-GTOPO30 digital terrain data format with 30-arcsec resolution. SRTM30 is a digital elevation data set that spans the globe from 60° north latitude to 56° south latitude, approximately from the southern tip of Greenland to below the southern tip of South America. It has a horizontal grid spacing of 30 arc-seconds (approximately 1 kilometer). GTOPO30 is a global digital elevation model with a horizontal grid spacing of 30 arc-seconds (approximately 1 kilometer) that was derived from several raster and vector sources of topographic information that include U.S. Geological Survey (USGS) digital elevation models. The VISTAS Technical Contractor used data preprocessors to format and assimilate these data into a single geophysical data file for processing by CALMET to generate the 12-km screening data set.

Land use and land cover (LULC) within the modeling domain was assimilated by the VISTAS technical contractor into a single geophysical data file for processing by CALMET using Composite Theme Grid (CTG) data archived by the USGS at a resolution of 200 meters. CALMET was used to calculate the fractional land use types within each cell of the CALMET grid. LULC in each grid cell was used by CALMET to compute the micrometeorological parameters (i.e., surface roughness, Bowen ratio, albedo, soil heat flux) that affect turbulent dispersion in the boundary layer. According to the *VISTAS BART Modeling Protocol*, 200-meter CTG LULC data were utilized for the 12-km screening analyses.

3.3.4 12-km Screening Analysis CALMET Processing

The development of the regional screening CALMET meteorological fields from MM5 data were conducted in No-Observations ("No-Obs") mode since the MM5 data already reflect assimilation of observational data and are likely to adequately characterize regional wind patterns that are consistent with the 12-km grid scale.

When the 12-km MM5 (2001 and 2002) data are used, the diagnostic CALMET terrain adjustments were turned off since the grid resolution of the MM5 data is the same as the CALMET grid and the terrain adjustments on the 12-km grid scale will already be reflected in the MM5 dataset. In this case, the MM5 winds will be interpolated by CALMET to the CALMET layers and CALMET's boundary layer modules computed mixing heights, turbulence parameters, and other meteorological parameters that are required by CALPUFF. For 2003, the 36-km MM5 data were used as CALMET's initial guess field and then the CALMET diagnostic terrain adjustments (see Section 3.1.1 of the *VISTAS BART Modeling Protocol*) were applied to reflect terrain on the scale of the CALMET grid (i.e., 12 km).

3.3.5 Quality Assurance of CALMET Analyses

OC's BART Applicability Analyses were conducted using 12-km screening CALMET data prepared by the VISTAS Technical Contractor. The *VISTAS BART Modeling Protocol* describes quality assurance techniques used by the contractor to validate the model's performance.

3.4 CALPUFF Model Processing

CALPUFF analyses to assess the visibility impacts attributable to OC's Fairburn facility were conducted generally in accordance with the recommendations of IWAQM *Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*, Appendix B of which provides recommended default CALPUFF parameters. Appendix B of this BART Applicability Analysis report contains sample 12-km screening CALPUFF input files that can be compared to the IWAQM recommendations to demonstrate that default options were used, including the following important model options.

3.4.1 MODELED EMISSIONS AND CHEMICAL TRANSFORMATIONS

Section 2 of this BART Applicability Analysis report described the BART-eligible emission units operated at OC's Fairburn facility and the visibility-affecting pollutants considered in the CALPUFF analysis. Emission rates were calculated following U.S. EPA and Georgia EPD BART guidance for primary emissions of SO_2, H_2SO_4, NO_X and PM_{10}. PM was further speciated into size categories of less than 0.5 µm, 0.5-0.625 µm, 0.625-1.0 µm, 1.0-1.25 µm, 1.25-2.5 µm, 2.5-6.0 µm and 6-10 µm aerodynamic diameters. OC-specific and AP-42 emission factors were utilized to analyze the phase, size, and character of PM emissions as described in Section 2 of this report. Non-sulfate condensable emissions were considered as primary fine particulate matter and allocated equally to the three sub-micrometer particle size classes. In addition to species emitted directly from the OC Fairburn facility, secondary formation of HNO_3, NO_3, and SO_4 was simulated using the MESOPUFF-II chemical transformation algorithms, which are considered the default for regulatory CALPUFF modeling. Background levels of ozone and ammonia, which drive the simulated chemical transformation of emitted pollutants into visibility affecting species, were input to the model as described in subsequent sections of this report.

OC operates nineteen BART-eligible emission units at the Fairburn facility evaluated in this BART Applicability Analysis, as described in Section 2 of this report as having distinct emission release points and characteristics. Sample model processing files provided by the VISTAS Technical Contractor demonstrate modeling of a single point source using CALPUFF, POSTUTIL, and CALPOST to assess visibility change.[16] The sample approach simulates actual emissions of each of three gaseous pollutants (SO_2, SO_4, and NO_X) and unit emissions (e.g., 1 g/s) of each of seven generic particle categories distinguished and designated by size: PM800, PM425, PM187, PM112, PM081, PM056, and PM025, to represent PM_{6-10}, $PM_{2.5-6}$, $PM_{1.25-2.5}$, $PM_{1-1.25}$, $PM_{0.625-1}$, $PM_{0.5-0.625}$, and $PM_{<0.5}$, respectively. The size distribution is the only distinguishing feature of these particle categories. Table 3-2 summarizes the relevant model input parameters for each size category.

[16] http://www.src.com/verio/download/sample_files.htm#EXAMPLE_BART

TABLE 3-2. REPRESENTATION OF PM SIZE CATEGORIES IN CALPUFF

Model Species	Computed Deposition Mode	Geometric Mass Mean Diameter (microns)	Geometric Standard Deviation (microns)*	Precipitation Scavenging Coefficient Liquid (s^{-1})	Frozen (s^{-1})
PM800	Particle	8.00	0	1.0×10^{-4}	3.0×10^{-5}
PM425	Particle	4.25	0	1.0×10^{-4}	3.0×10^{-5}
PM187	Particle	1.87	0	1.0×10^{-4}	3.0×10^{-5}
PM112	Particle	1.12	0	1.0×10^{-4}	3.0×10^{-5}
PM081	Particle	0.81	0	1.0×10^{-4}	3.0×10^{-5}
PM056	Particle	0.56	0	1.0×10^{-4}	3.0×10^{-5}
PM025	Particle	0.25	0	1.0×10^{-4}	3.0×10^{-5}

* Zero geometric standard deviation indicates that CALPUFF utilizes the deposition velocity associated with the geometric mass mean diameter.

Because unit emission rates were modeled from the single point source in the sample approach, actual emission rates were used in the POSTUTIL postprocessing step to combine PM types and sizes into light scattering groups by scaling the modeled concentrations up or down by the multiplicative factor of the actual emission rate of each PM size category, which includes multiple types of PM (e.g., coarse filterable PM, fine filterable PM, organic condensable PM, inorganic condensable PM, and elemental carbon). The output concentration file from POSTUTIL was then input to CALPOST to calculate visibility change attributable to emissions from the point source in the sample analysis.

The preceding approach is reasonable for modeling a single point source; however, for facilities with multiple emission point sources, the preceding approach is not appropriate. Specifically, for sources with multiple emission points that have different exhaust characteristics (e.g., stack height, diameter, velocity, and temperature) and/or different emissions profiles of speciated PM, the use of unit emission rates is not appropriate since the CALPUFF output concentrations at particular receptors will not distinguish which source(s) contribute to the PM concentrations. Therefore, the POSTUTIL source profile technique cannot be applied. One alternative to this approach for sources with multiple emission points is to model each emission point individually in multiple CALPUFF runs using unit emission rates, then run POSTUTIL to combine the PM concentrations at each receptor for each modeled emission point, finally running the CALSUM postprocessing utility to combine the impacts of all sources. This approach, though conceptually appropriate, is undesirable due to substantial additional computer runtime required to model and post-process each emission point individually.

As a computationally efficient alternative to the preceding approaches, the BART Applicability Analysis for OC's Fairburn facility was conducted by explicitly modeling in CALPUFF the actual emission rate of each of 15 particle species defined as described in Table 3-3. The nomenclature used in Table 3-3 is analogous to that used to describe the emissions from OC's BART-eligible emission units in Section 2 of this report.

TABLE 3-3. EXPLICIT MODELING OF PM TYPES AND SIZE CATEGORIES

Modeled PM Category	Components
PMC800 PMC425	Filterable coarse particles divided between two size categories (PM_{6-10}, $PM_{2.5-6}$)
PMF187 PMF112 PMF081 PMF056 PMF025	Filterable fine particles divided among five size categories ($PM_{1.25-2.5}$, $PM_{1-1.25}$, $PM_{0.625-1}$, $PM_{0.5-0.625}$, $PM_{<0.5}$)
POC081 POC056 POC025	Primary condensable organic emissions divided between three size categories ($PM_{0.625-1}$, $PM_{0.5-0.625}$, $PM_{<0.5}$)
PIC081 PIC056 PIC025	Primary condensable inorganic emissions divided between two size categories ($PM_{0.625-1}$, $PM_{0.5-0.625}$, $PM_{<0.5}$)
EC056 EC025	Primary elemental carbon emissions divided among two size categories ($PM_{0.5-0.625}$, $PM_{<0.5}$)

So that explicit modeling of the 15 particle species and sizes could be conducted equivalently to the unit emissions approach, identical model processing options for each PM size category were enabled as summarized in Table 3-4.

TABLE 3-4. REPRESENTATION OF EXPLICITLY MODELED PM SIZE CATEGORIES IN CALPUFF

Model Species	Computed Deposition Mode	Geometric Mass Mean Diameter (microns)	Geometric Standard Deviation (microns)*	Precipitation Scavenging Coefficient Liquid (s^{-1})	Precipitation Scavenging Coefficient Frozen (s^{-1})
PMC800	Particle	8.0	0	1.0×10^{-4}	3.0×10^{-5}
PMC425	Particle	4.25	0	1.0×10^{-4}	3.0×10^{-5}
PMF187	Particle	1.87	0	1.0×10^{-4}	3.0×10^{-5}
PMF112	Particle	1.12	0	1.0×10^{-4}	3.0×10^{-5}
PMF081 POC081 PIC081	Particle	0.81	0	1.0×10^{-4}	3.0×10^{-5}
PMF056 POC056 PIC056 EC056	Particle	0.56	0	1.0×10^{-4}	3.0×10^{-5}
PMF025 POC025 PIC025 EC025	Particle	0.25	0	1.0×10^{-4}	3.0×10^{-5}

* Zero geometric standard deviation indicates that CALPUFF utilizes the deposition velocity associated with the geometric mass mean diameter.

To post-process the CALPUFF output concentrations that result from explicitly modeled multiple emission points, POSTUTIL was used only to group modeled PM into light extinction groups. Unit scaling factors were used in POSTUTIL and there was no adjustment to the explicitly modeled emission rate. Table 3-5 summarizes the POSTUTIL grouping of modeled PM species into light extinction groups, and the light extinction coefficient subsequently used in CALPOST to compute light extinction due to the multiple emission points at the source.

TABLE 3-5. ASSIGNMENT OF MODELED PM SPECIES TO LIGHT EXTINCTION GROUPS

Modeled Components	CALPOST Light Extinction Group	Extinction Coefficient (m^2/g)
PMC800 PMC425	PMC	0.6
PMF187 PMF112 PMF081 PMF056 PMF025 PIC081 PIC056 PIC025	SOIL	1
POC081 POC056 POC025	SOA	4
EC056 EC025	EC	10

Implementation of the explicit modeling approach required minor changes to the parameter declaration file and re-compilation of the CALPUFF model executable file. Note that this approach does not require changes to the FORTRAN model code, only the parameter declaration limits. Explicit modeling of the 15 PM types and sizes plus the SO_2, SO_4, NO_X, HNO_3, and NO_3 species results in a total of 20 modeled species, which is equal to the default parameter limit of species modeled (MXSPEC). However, the parameter for particle species deposited (MXPDEP) was increased from 9 to 20 to accommodate the greater number (17, including SO_4 and NO_3) of particle species simulated in the model.

This modified approach follows conceptually the steps outlined in the revised *VISTAS BART Modeling Protocol* as evidenced between comparisons between the two methods. Results using the explicit method for multiple emission points and the sample method using a single point source with PM speciation (PMF, PMC, SOA, EC) applied during the POSTUTIL step provides equivalent results. The model input and output files of a comparative analysis are further described in Appendix C and included with the electronic media provided with this BART Applicability Analysis report.

3.4.2 CALPUFF DISPERSION ALGORITHMS

As specified in a March 16, 2006 U.S. EPA memorandum[17] and the most recent revision to the *VISTAS BART Modeling Protocol*, the use of Pasquill-Gifford (ISC-like) dispersion coefficients was enabled as the default option in screening and refined CALPUFF analyses.

3.4.3 BUILDING DOWNWASH

Per Georgia EPD comments on OC's source-specific modeling protocol for the Fairburn facility, the effects of building downwash were not considered in the BART Applicability Analyses.

3.4.4 CALPUFF MODELING DOMAINS AND CLASS I AREA RECEPTORS

CALPUFF modeling for 12-km screening analyses was performed on a computational domain that is a subset of the VISTAS Regional Domain 0. The size of each computational domain was selected to encompass the Fairburn facility and the five relevant Class I areas, and to extend at least 50 km beyond in all directions. The size of the domain allows for the possible recirculation of puffs beyond the facility and areas being evaluated. Computational domains use the same vertical grid structure as described in the CALMET model formulation in Section 3.3 of this report. Figures 3-2 through 3-4 illustrate the locations of, and terrain elevations and land use within, the 12-km screening computational domain used in OC's BART Applicability Analyses.

[17] U.S. EPA Memorandum "Dispersion Coefficients for Regulatory Air Quality Modeling in CALPUFF" from Mr. Dennis Atkinson and Mr. Tyler Fox (Air Quality Modeling Group) to Ms. Kay Prince (Regulatory Planning Branch) dated March 16, 2006.

FIGURE 3-2. 12-KM SCREENING ANALYSIS COMPUTATIONAL DOMAIN

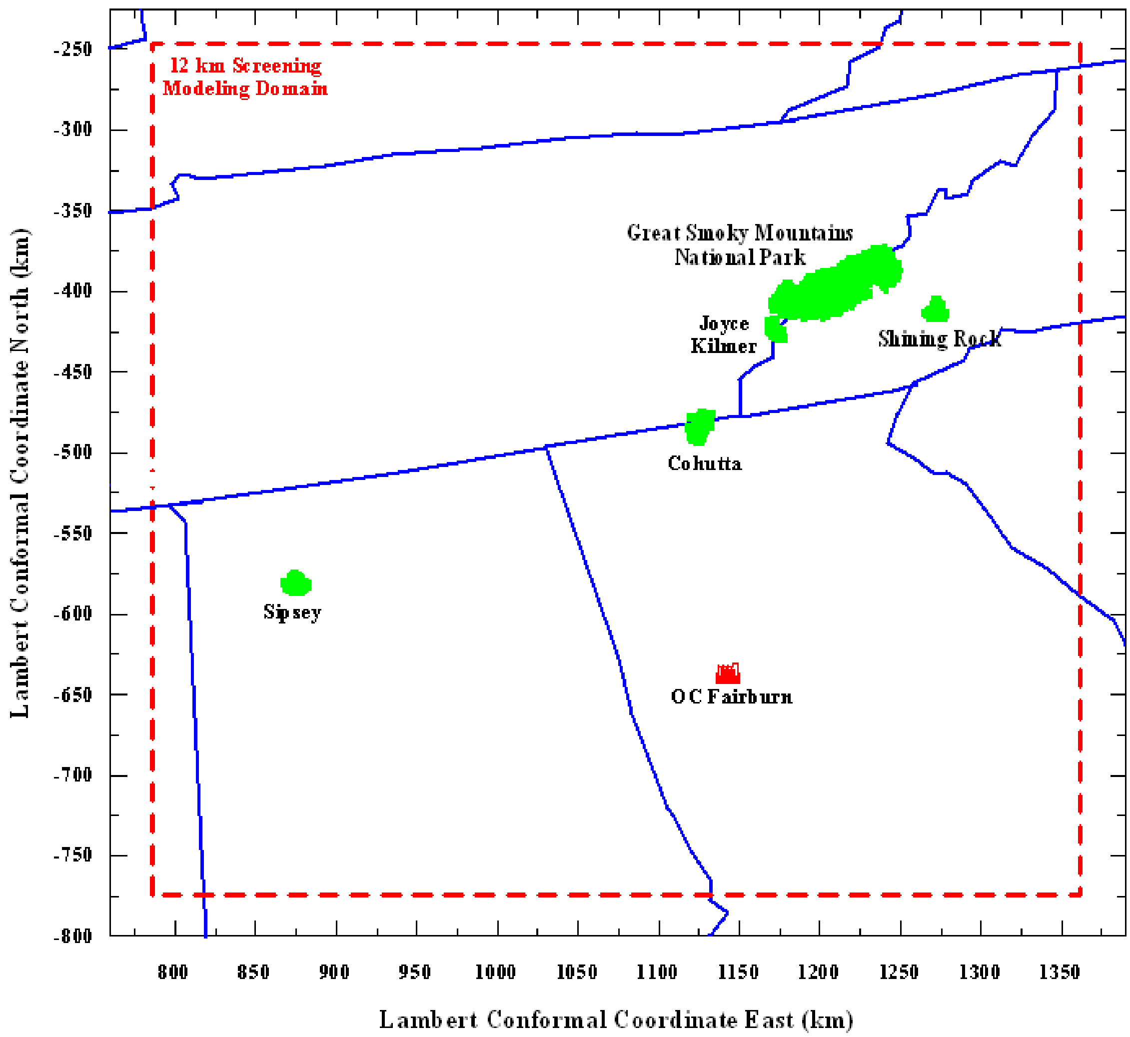


FIGURE 3-3. TERRAIN REPRESENTATION IN THE 12-KM REGIONAL SCREENING GRID (AFTER FIGURE 4-2 OF THE *VISTAS BART MODELING PROTOCOL*)

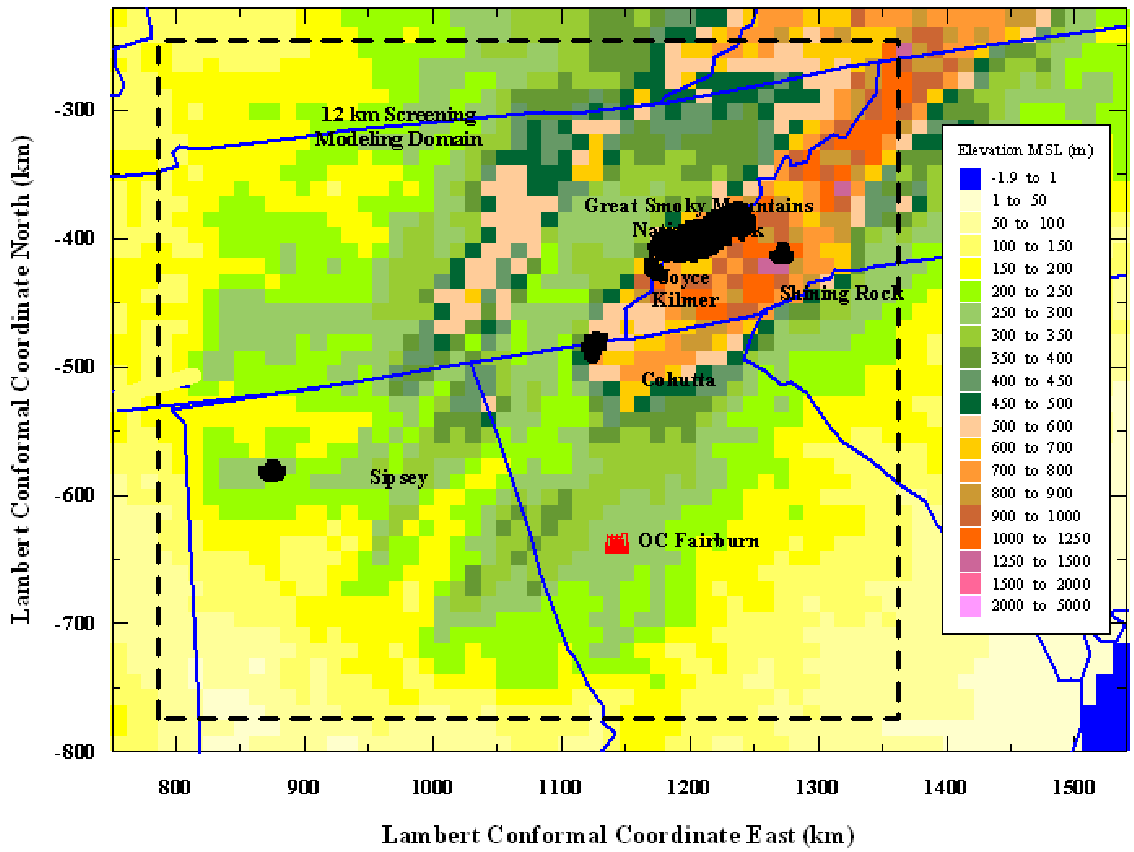
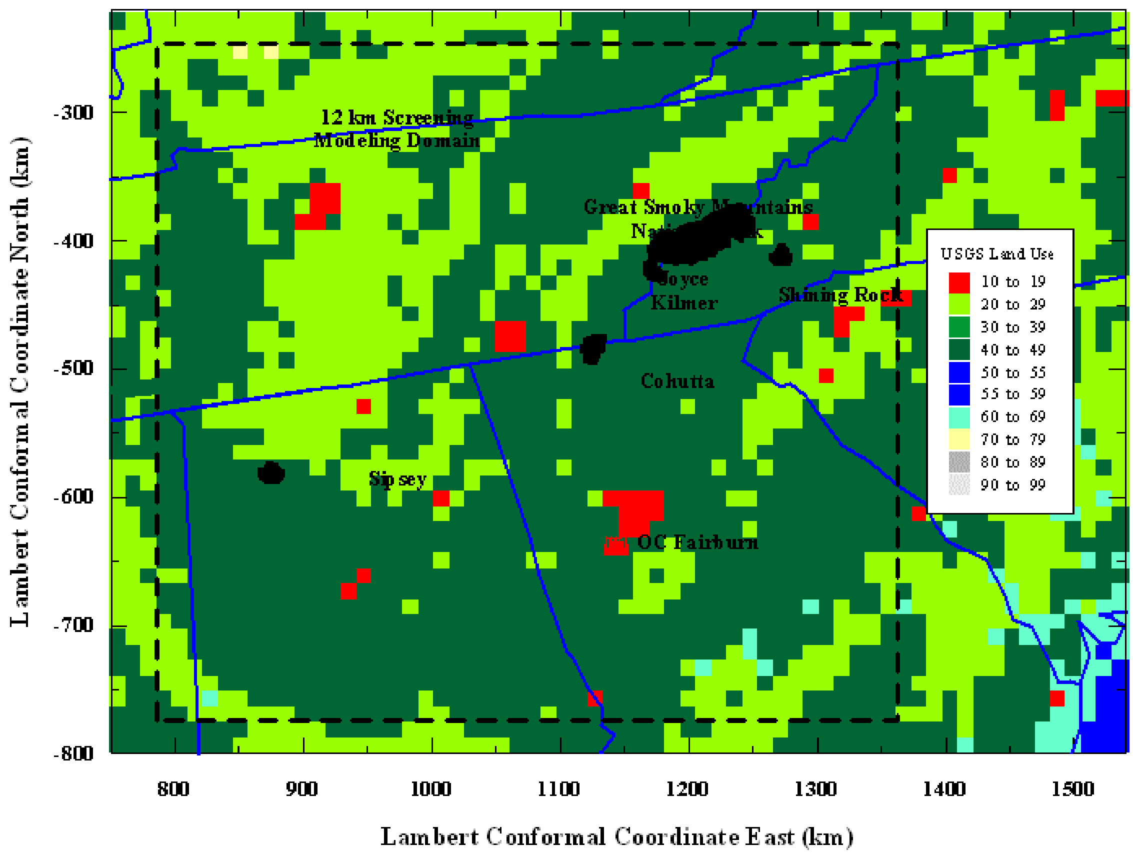


FIGURE 3-4. LAND USE AND COVER WITHIN THE 12-KM COMPUTATIONAL DOMAIN

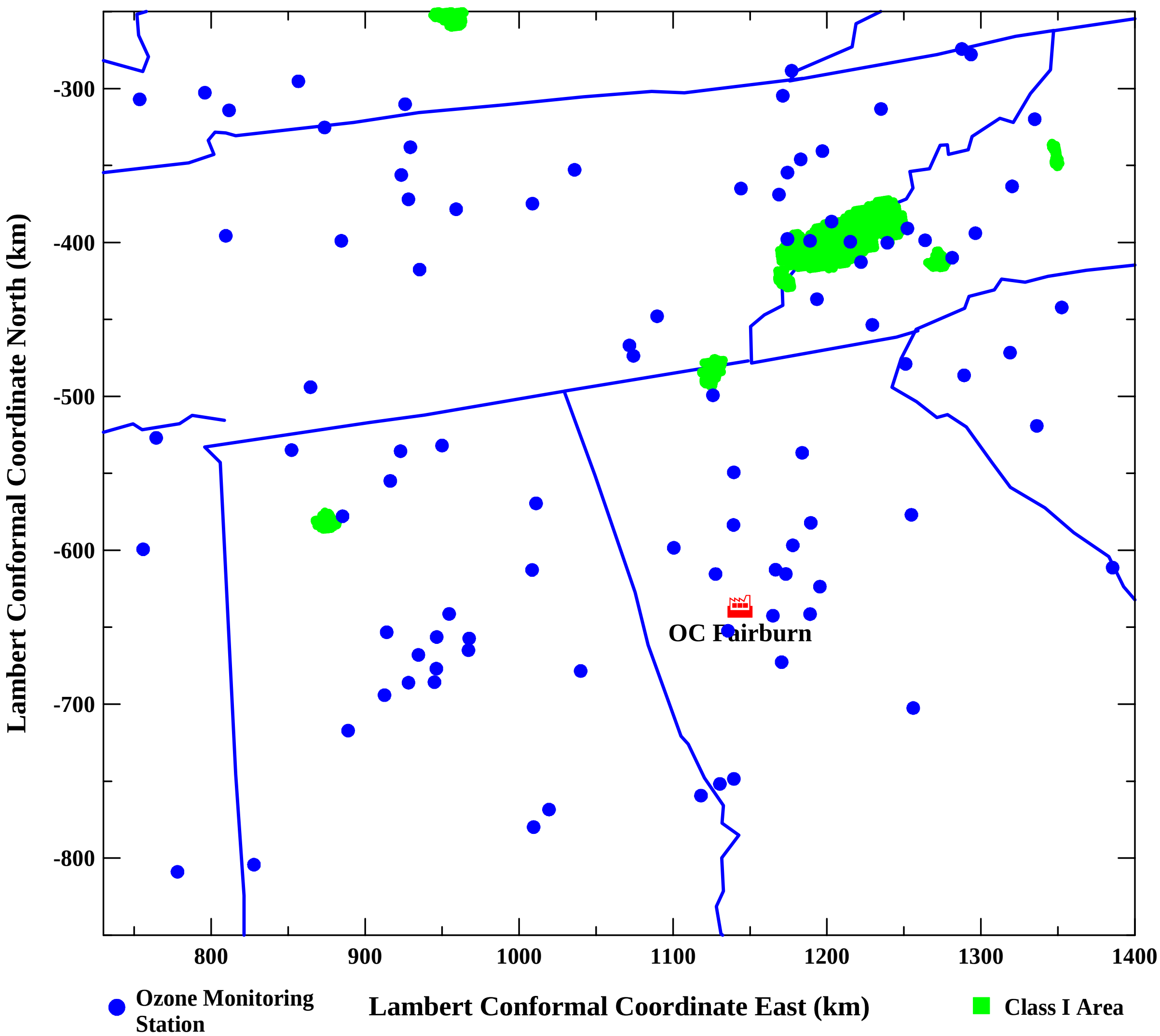


3.4.5 BACKGROUND OZONE AND AMMONIA CONCENTRATIONS

The CALPUFF model is capable of simulating linear chemical transformation effects by using pseudo-first-order chemical reaction mechanisms for the conversions of SO_2 to SO_4, and NO_X, which consists of nitrogen oxide (NO) and nitrogen dioxide (NO_2), to NO_3 and HNO_3. In this study, chemical transformations involving five species (SO_2, SO_4, NO_X, HNO_3, and NO_3) were modeled using the MESOPUFF II chemical transformation scheme. Ambient concentrations of ammonia and ozone concentrations as represented in the model drive the MESOPUFF II chemical transformation simulation.

The screening analyses utilized observed ozone data for 2001 through 2003 from non-urban CASTNet and AIRS stations compiled by the VISTAS Technical Contractor for the regional domain. OC extracted data from ozone observation stations in and near the modeling domains, as illustrated in Figure 3-5.

FIGURE 3-5. OZONE DATA STATIONS UTILIZED IN OC'S BART APPLICABILITY ANALYSES



Should all observations be missing for a particular hour of the dataset, monthly average ozone background values computed based on daytime average ozone concentrations from all ozone monitors in the VISTAS region and for all three years combined are substituted. Table 3-6 summarizes the monthly average ozone values computed for this substitution.

TABLE 3-6. MONTHLY AVERAGE SUBSTITUTE OZONE VALUES

Month	Substitute Ozone Values (ppb)
January	23.28
February	26.79
March	30.14
April	36.73
May	36.40
June	34.65
July	33.11
August	32.68
September	29.82
October	25.23
November	26.15
December	22.19

A constant ammonia background value of 0.5 ppb was input to the CALPUFF model, as only screening analyses were required.

3.4.6 PUFF REPRESENTATION

As recommended by the *VISTAS BART Modeling Protocol*, the default integrated puff sampling methodology was enabled for the screening CALPUFF analyses. The default setting to disable puff splitting algorithms was retained.

3.4.7 QUALITY ASSURANCE OF CALPUFF ANALYSES

Sample CALPUFF input files for the screening analyses are presented in Appendix B of this report and copies of all input and output files are included on the electronic media enclosed with this report. Comparison of the CALPUFF model inputs indicates that default values, as prescribed by IWAQM (Appendix B) and in the *VISTAS BART Modeling Protocol*, were used with the exception of the source-specific model options described in this report. Source parameters input for each BART-eligible emissions unit were verified with the information presented in Section 2 of this report. The location and elevations of Class I area receptors were verified by comparison to NPS maps.

3.5 CALPOST POSTPROCESSING AND NATURAL BACKGROUND CONDITIONS FOR LIGHT EXTINCTION AND HAZE INDEX CALCULATIONS

Using the concentrations of visibility-affecting pollutants computed by CALPUFF, two postprocessors, POSTUTIL and CALPOST, were used to compute light extinction attributable to OC's Fairburn facility and the relevant metrics for the BART Applicability Analysis determination. The computation of light extinction attributable to the natural background and source was generally described in Section 1.1.2 of this report.

3.5.1 POSTUTIL PROCESSING

The first postprocessing step involves running POSTUTIL to calculate the concentrations of visibility-affecting species SO_4, NO_3, SOA, EC, PMF, and PMC, as described in Section 3.4.1 of this report. Specifically, POSTUTIL is used to group modeled species into visibility-affecting pollutant groups as originally shown as Table 3-5, reproduced here as Table 3-7.

TABLE 3-7. ASSIGNMENT OF MODELED PM SPECIES TO LIGHT EXTINCTION GROUPS IN POSTUTIL

Modeled Components	CALPOST Light Extinction Group	Extinction Coefficient (m^2/g)
PMC800 PMC425	PMC	0.6
PMF187 PMF112 PMF081 PMF056 PMF025 PIC081 PIC056 PIC025	SOIL	1
POC081 POC056 POC025	SOA	4
EC056 EC025	EC	10

3.5.2 CLASS I AREA-SPECIFIC NATURAL BACKGROUND CONDITIONS

The visibility goal of the Clean Air Act is both the remedying of existing visibility impairment and prevention of future visibility impairment. In its *BART Implementation Guidance*, U.S. EPA affirms that it interprets the goal to mean return atmospheric conditions to "natural visibility conditions." For the purposes of BART analyses, the U.S. EPA has determined that it "did not intend to limit States to the use of the 20% best visibility days…States may use 20% best visibility days or annual average" to assess BART applicability.[18] The August 31, 2006 revision to the *VISTAS BART Modeling Protocol* indicates that several options are available at the discretion of the state including (1) a single annual average natural background condition for each Class I area; (2), a single value representing the average haze index on the 20% estimated best visibility days at each Class I area; or, (3) monthly average natural background conditions computed from estimated components of visibility-affecting pollutants and monthly average relative

[18] U.S. EPA Memorandum from Mr. Joseph Paisie to Ms. Kay Prince, as Attachment A to a proposed settlement agreement between the Utility Air Regulatory Group and U.S. EPA, published at 71 Federal Register No. 84, pp. 25,838-25,840, May 2, 2006.

humidity values specific to each Class I area. The Option (1) annual average natural background condition appears to be the preferred approach since analyses conducted by the VISTAS Technical Contractor for certain sources in the region used this method exclusively.

For the five Class I areas within 300 km of the Fairburn facility and potentially affected by OC's operations, Table 3-8 summarizes the default natural background conditions as tabulated in Appendix B of U.S. EPA's *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule* and were used to calculate natural background conditions for the preceding three approaches.

TABLE 3-8. NATURAL BACKGROUND CONCENTRATIONS FOR CLASS I AREAS POTENTIALLY AFFECTED BY THE FAIRBURN FACILITY

Class I Area	b_{ext} (Mm^{-1})	Annual Average Haze Index (dv)	Best Days Haze Index (dv)	Worst Days Haze Index (dv)
Cohutta	21.39	7.60	3.76	11.44
Great Smoky Mtns.	21.39	7.60	3.76	11.44
Slickrock	21.40	7.61	3.77	11.45
Shining Rock	21.40	7.61	3.77	11.45
Sipsey	21.28	7.55	3.71	11.39

* As tabulated in Appendix B of U.S. EPA's Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule (2003).

To represent natural conditions in the absence of anthropogenic sources of sulfates and nitrates using Option (1), the monthly background extinction coefficient is expressed in terms of Rayleigh scattering and scattering due to soils (i.e., fine particles) based on the annual average haze index, and is calculated using the following equations.

$$b_{back} = 10 \exp\left(\frac{HI}{10}\right),$$

where *HI* is Haze Index expressed in units of deciviews (dv). Therefore, total b_{back} for the best days at the relevant Class I areas, including the Rayleigh scattering coefficient is calculated as shown in the following equations.

For Cohutta and Great Smoky Mountains:

$$b_{back} = 10 \exp\left(\frac{7.60}{10}\right) = 21.39 \text{ Mm}^{-1} = b_{ray} + b_{soil} = 10 \text{ Mm}^{-1} + b_{soil} \Rightarrow b_{soil} = 11.39 \text{ Mm}^{-1}$$

For Slickrock and Shining Rock:

$$b_{back} = 10 \exp\left(\frac{7.61}{10}\right) = 21.40 \text{ Mm}^{-1} = b_{ray} + b_{soil} = 10 \text{ Mm}^{-1} + b_{soil} \Rightarrow b_{soil} = 11.40 \text{ Mm}^{-1}$$

For Sipsey:

$$b_{back} = 10\exp\left(\frac{7.55}{10}\right) = 21.28\ \text{Mm}^{-1} = b_{ray} + b_{soil} = 10\ \text{Mm}^{-1} + b_{soil} \Rightarrow b_{soil} = 11.28\ \text{Mm}^{-1}$$

If the same approach were used to define the natural background for the 20% best visibility days in terms of soils under Option (2), the following equation would be used.

$$b_{back} = 10\exp\left(\frac{3.76}{10}\right) = 14.56\ \text{Mm}^{-1} = b_{ray} + b_{soil} = 10\ \text{Mm}^{-1} + b_{soil} \Rightarrow b_{soil} = 4.56\ \text{Mm}^{-1}\ \text{for Cohutta}$$

Alternatively under Option (3), Table 3-9 summarizes the default natural background conditions using average natural concentrations of sulfate, nitrate, and particulate species for areas in the Eastern U.S. as tabulated in Table 2-1 of U.S. EPA's *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule*.

TABLE 3-9. NATURAL BACKGROUND CONCENTRATIONS OF VISIBILITY-AFFECTING POLLUTANTS

Component	West ($\mu g/m^3$)	East ($\mu g/m^3$)	Error Factor	Dry Extinction Efficiency (m^2/g)
Ammonium sulfate	0.12	0.23	2	3
Ammonium nitrate	0.1	0.1	2	3
Organic carbon mass	0.47	1.4	2	4
Elemental carbon	0.02	0.02	2-3	10
Soil	0.5	0.5	1½ - 2	1
Coarse Mass	3	3	1½ - 2	0.6

The values presented in Table 3-9 are more appropriate for the determination of natural background conditions, since this approach includes all visibility-affecting species and does not rely only on soil dust concentrations to define the natural background conditions. Ammonium sulfates and nitrates as well as organic and elemental carbon are appropriate to represent as part of the natural background due to emissions from naturally occurring biogenic sources (e.g., vegetation and wildfire biomass burning). The "East" values were utilized in OC's analysis with monthly variable relative humidity values specific to each Class I area.

The effects of relative humidity to amplify the visibility impairment of hygroscopic sulfates and nitrates were characterized using CALPOST "Method 6," which computes Δb_{ext} using a *monthly average* relative humidity adjustment particular to each Class I area applied to background and modeled sulfate and nitrate. Table 3-10 summarizes the monthly average humidity values that were applied for the three Class I areas considered in this analysis, as tabulated in Table A-3 of U.S. EPA's *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule*.

TABLE 3-10. MONTHLY AVERAGE *f*(RH) FOR SELECTED CLASS I AREA*

Class I Area	January	February	March	April	May	June	July	August	September	October	November	December
Cohutta	3.3	3.1	3.0	2.8	3.4	3.8	4.0	4.2	4.2	3.8	3.4	3.5
Great Smoky Mtns.	3.3	3.0	2.9	2.7	3.2	3.9	3.8	4.0	4.2	3.8	3.3	3.4
Slickrock	3.3	3.1	2.9	2.7	3.3	3.8	4.0	4.2	4.2	3.8	3.3	3.5
Shining Rock	3.3	3.0	2.9	2.7	3.4	3.9	4.1	4.5	4.4	3.8	3.3	3.4
Sipsey	3.4	3.1	2.9	2.8	3.3	3.7	3.9	3.9	3.9	3.6	3.3	3.4

* As tabulated in Table A-3 of U.S. EPA's *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule* (2003).

Natural background conditions for each Class I area were calculated using three visibility processing options, the data summarized in Tables 3-7, 3-8, 3-9, and 3-10, and the default IMPROVE light extinction formula, which is summarized in the following equation.

$$b_{ext,background}\left(Mm^{-1}\right) = b_{SO_4} + b_{NO_3} + b_{OC} + b_{Soil} + b_{Coarse} + b_{ap} + b_{Ray}$$

where,

$b_{SO_4} = 3[(\mathrm{NH_4})_2\mathrm{SO_4}]f(RH)$
$b_{NO_3} = 3[\mathrm{NH_4NO_3}]f(RH)$
$b_{OC} = 4[\mathrm{OC}]$
$b_{Soil} = 1[\mathrm{Soil}]$
$b_{Coarse} = 0.6[\mathrm{Coarse\ Mass}]$
$b_{ap} = 10[\mathrm{EC}]$
$b_{Ray} = \text{Rayleigh Scattering } (10\ \mathrm{Mm}^{-1} \text{ by default})$
$f(RH) = \text{Relative Humidity Function}$
$[\ ] = \text{Concentration in } \mu\mathrm{g/m^3}$

$[(\mathrm{NH_4})_2\mathrm{SO_4}]$ denotes the ammonium sulfate concentration
$[\mathrm{NH_4NO_3}]$ denotes the ammonium nitrate concentration
$[\mathrm{OC}]$ denotes the concentration of organic carbon
$[\mathrm{Soil}]$ denotes the concentration of fine soils
$[\mathrm{Coarse\ Mass}]$ denotes the concentration of coarse dusts
$[\mathrm{EC}]$ denotes the concentration of elemental carbon
Rayleigh Scattering is scattering due to air molecules

3.5.3 FURTHER REFINEMENTS

As noted in the revised VISTAS BART Modeling Protocol, the U.S. EPA and the Regional Planning Organizations (including VISTAS) are evaluating whether refinements are warranted to the methods recommended in U.S. EPA's guidance to calculate default estimates of natural background visibility. In addition, the Interagency Monitoring of Protected Visual Environments (IMPROVE) work group has recently approved an alternative to the default formula used to estimate extinction from particle concentration measurements.[19] Refinements in the revised IMPROVE formula include the following:

[19] Pitchford, M., W. Malm, B. Schichtel, N. Kumar, D. Lowenthal, and J. Hand, 2005. *Revised IMPROVE Algorithm for Estimating Light Extinction from Particle Speciation Data*. Report to IMPROVE Steering Committee, November 2005.

- Adding a site-specific Rayleigh scattering term to the formula
- Adding a sea salt term, including a growth factor due to relative humidity

For the purposes of calculating current, future, and natural background visibility at Class I areas as part of its reasonable progress analyses, VISTAS intends to present regional air quality modeling results using both the current U.S. EPA recommended assumptions and the newly revised IMPROVE light extinction formula. The results presented in this analysis rely on the current U.S. EPA recommended assumptions and are not based on the newly revised IMPROVE light extinction formula.

3.5.4 VISIBILITY IMPACT CALCULATION

CALPOST is run separately for each Class I area to obtain the necessary visibility statistics for evaluating compliance with the BART visibility impairment thresholds. The inputs to CALPOST involve selection of the visibility method (i.e., Method 6) and entry of Class I area-specific data for computing background extinction and monthly relative humidity factors for hygroscopic aerosols as described in Section 3.5.2. CALPOST contains a receptor selection option that allow subsets of a receptor network modeling in CALPUFF to be selected for processing in a given CALPOST run. This selection specifies which receptors representing a single Class I area are selected for processing from a CALPUFF output file that may contain receptors from several Class I areas.

For screening analyses, the peak 24-hour average visibility impact for each year and Class I area was tabulated. Option (1) was used to quantify visibility impacts relative to natural background conditions using the annual average approach.

3.5.5 QUALITY ASSURANCE OF POSTPROCESSING ANALYSES

Quality assurance of postprocessing analyses was conducted by verifying the sequence of postprocessing (i.e., POSTUTIL followed by CALPOST) and that appropriate data files are referenced throughout the calculation sequence. The CALPOST inputs that were checked include the following:

- Visibility technique (Method 6)
- Monthly Class I-specific relative humidity factors for Method 6
- Background light extinction values calculated as appropriate using natural background options (1), (2), and (3)
- Inclusion of all appropriate species from modeled sources (e.g., sulfate, nitrate, organics), coarse and fine particulate matter, and elemental carbon.
- Appropriate species names for coarse PM used
- Extinction efficiencies for each species
- Screen to select appropriate Class I receptors for each CALPOST simulation.

4. Screening Analysis Results

Screening analyses of visibility impacts attributable to OC's Fairburn facility were conducted to determine whether the facility is subject to BART using a conservative assessment, and to focus the scope of refined analyses (if necessary) by demonstrating that visibility impairment is not likely to occur at more distant Class I areas. The screening analyses were conducted using the emissions data represented in Section 2 of this report, the screening CALMET and CALPUFF methods described in Sections 3.2, 3.3, and 3.4 of this report, and the postprocessing methods described in Section 3.5.

4.1 Screening Analysis Impacts at Cohutta

Table 4-1 summarizes the modeled peak, 24-hour average visibility impacts at Cohutta Wilderness Area attributable to OC's Fairburn facility. This table summarizes the results calculated using Option (1) described in Section 3.5 for representing natural background conditions (i.e., annual average). Results are presented in terms of visibility impact and the total number of days exceeding the 1.0 dv causation and 0.5 dv contribution thresholds, respectively.

Table 4-1. Peak 24-hour Average Visibility Impacts at Cohutta

Natural Background Method	2001 Δdv (> 1.0 dv, > 0.5 dv)	2002 Δdv (> 1.0 dv, > 0.5 dv)	2003 Δdv (> 1.0 dv, > 0.5 dv)
Annual Average	0.126 (0,0)	0.134 (0,0)	0.119 (0,0)

The results presented in Table 4-1 indicate that refined analyses were not necessary to evaluate visibility impacts at Cohutta since peak visibility impacts do not exceed the contribution threshold.

4.2 Screening Analysis Impacts at Great Smoky Mountains

Table 4-2 summarizes the modeled peak, 24-hour average visibility impacts at Great Smoky Mountains National Park attributable to OC's Fairburn facility. This table summarizes the results calculated using Option (1) described in Section 3.5 for representing natural background conditions (i.e., annual average). Results are presented in terms of visibility impact and the total number of days exceeding the 1.0 dv causation and 0.5 dv contribution thresholds, respectively.

Table 4-2. Peak 24-hour Average Visibility Impacts at Great Smoky Mountains

Natural Background Method	2001 Δdv (> 1.0 dv, > 0.5 dv)	2002 Δdv (> 1.0 dv, > 0.5 dv)	2003 Δdv (> 1.0 dv, > 0.5 dv)
Annual Average	0.147 (0,0)	0.043 (0,0)	0.051 (0,0)

The results presented in Table 4-2 indicate that refined analyses were not necessary to evaluate visibility impacts at the Great Smoky Mountains National Park since peak visibility impacts do not exceed the contribution threshold.

4.3 SCREENING ANALYSIS IMPACTS AT JOYCE KILMER

Table 4-3 summarizes the modeled peak, 24-hour average visibility impacts at Joyce Kilmer-Slickrock Wilderness Area attributable to OC's Fairburn facility. This table summarizes the results calculated using Option (1) described in Section 3.5 for representing natural background conditions (i.e., annual average). Results are presented in terms of visibility impact and the total number of days exceeding the 1.0 dv causation and 0.5 dv contribution thresholds, respectively.

TABLE 4-3. PEAK 24-HOUR AVERAGE VISIBILITY IMPACTS AT JOYCE KILMER-SLICKROCK WILDERNESS AREA

Natural Background Method	2001 Δdv (> 1.0 dv, > 0.5 dv)	2002 Δdv (> 1.0 dv, > 0.5 dv)	2003 Δdv (> 1.0 dv, > 0.5 dv)
Annual Average	0.073 (0,0)	0.047 (0,0)	0.056 (0,0)

The results presented in Table 4-3 indicate that refined analyses were not necessary to evaluate visibility impacts at Joyce Kilmer-Slickrock Wilderness Area since peak visibility impacts do not exceed the contribution threshold.

4.4 SCREENING ANALYSIS IMPACTS AT SHINING ROCK

Table 4-4 summarizes the modeled peak, 24-hour average visibility impacts at Shining Rock Wilderness Area attributable to OC's Fairburn facility. This table summarizes the results calculated using Option (1) described in Section 3.5 for representing natural background conditions (i.e., annual average). Results are presented in terms of visibility impact and the total number of days exceeding the 1.0 dv causation and 0.5 dv contribution thresholds, respectively.

TABLE 4-4. PEAK 24-HOUR AVERAGE VISIBILITY IMPACTS AT SHINING ROCK WILDERNESS AREA

Natural Background Method	2001 Δdv (> 1.0 dv, > 0.5 dv)	2002 Δdv (> 1.0 dv, > 0.5 dv)	2003 Δdv (> 1.0 dv, > 0.5 dv)
Annual Average	0.052 (0,0)	0.090 (0,0)	0.072 (0,0)

The results presented in Table 4-4 indicate that refined analyses were not necessary to evaluate visibility impacts at Shining Rock Wilderness Area since peak visibility impacts do not exceed the contribution threshold.

4.5 SCREENING ANALYSIS IMPACTS AT SIPSEY

Table 4-5 summarizes the modeled peak, 24-hour average visibility impacts at Sipsey Wilderness Area attributable to OC's Fairburn facility. This table summarizes the results calculated using Option (1) described in Section 3.5 for representing natural background conditions (i.e., annual average). Results are presented in terms of visibility impact and the total number of days exceeding the 1.0 dv causation and 0.5 dv contribution thresholds, respectively.

TABLE 4-5. PEAK 24-HOUR AVERAGE VISIBILITY IMPACTS AT SIPSEY WILDERNESS AREA

Natural Background Method	2001 Δdv (> 1.0 dv, > 0.5 dv)	2002 Δdv (> 1.0 dv, > 0.5 dv)	2003 Δdv (> 1.0 dv, > 0.5 dv)
Annual Average	0.083 (0,0)	0.173 (0,0)	0.054 (0,0)

The results presented in Table 4-5 indicate that refined analyses were not necessary to evaluate visibility impacts at Sipsey Wilderness Area since peak visibility impacts do not exceed the contribution threshold.

4.6 SUMMARY OF SCREENING ANALYSES

The results presented in this section of the BART Applicability Analyses conclude that OC's Fairburn facility does not contribute to visibility impairment at any of the five Class I areas analyzed because the maximum annual visibility impacts for all three years does not exceed the 0.5 dv contribution threshold.

5. CONCLUSIONS

Using analysis methods prescribed by the U.S. EPA, VISTAS, and Georgia EPD, OC conducted BART Applicability Analyses of emissions of visibility-affecting pollutants from BART-eligible emission units at the Fairburn facility. The results of this analysis indicate that OC is not subject to BART because the BART-eligible source does not contribute to visibility impairment at Cohutta Wilderness Area, Great Smoky Mountains National Park, Joyce Kilmer-Slickrock Wilderness Area, Shining Rock Wilderness Area, or Sipsey Wilderness Area, as demonstrated by a screening modeling analysis that quantified the maximum annual visibility impact as being less than the 0.5 dv contribution threshold.

Since the modeling analyses indicate that the OC Fairburn facility is not subject to BART, OC does not intend to submit a BART Determination Analysis and Permit Application.

OC anticipates maintaining close communication with Georgia EPD to discuss additional information, data resources, and/or revisions to VISTAS modeling methods that may affect the BART applicability determination described in this report. OC reserves the right to revise the applicability analyses and determinations described in this report if such methods are approved for regulatory use by U.S. EPA and Georgia EPD and change the outcome of this analysis.

APPENDIX A

VISTAS BART MODELING PROTOCOL (REVISION 3.2, AUGUST 31, 2006)

Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART)

December 22, 2005

(Revision 3.2 – 8/31/06)

Visibility Improvement State and Tribal Association of the Southeast (VISTAS)

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SUMMARY

This Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART) for the VISTAS Regional Planning Organization (RPO) describes common procedures for carrying out air quality modeling to support BART determinations that are consistent with guidelines of the U.S. Environmental Protection Agency in 40 CFR Part 51 Appendix W and Appendix Y. The Protocol is intended to serve as the basis for a common understanding among the organizations that will be performing BART analyses or reviewing the BART modeling results in the VISTAS region.

Background

Best Available Retrofit Technology is required for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. According to 40 CFR Part 51 Appendix Y, “*You can use dispersion modeling to determine that an individual source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area and thus is not subject to BART*.” In the “individual source attribution approach,” a BART-eligible source that is responsible for a 1.0 deciview (dv) change or more is considered to “cause” visibility impairment. A BART-eligible source that is responsible for a 0.5 dv change or more is considered to “contribute” to visibility impairment in a Class I area. Any source determined to cause or contribute to visibility impairment in any Class I area is subject to BART.

The member states of the VISTAS RPO agreed to develop a common BART Modeling Protocol to guide them, their sources, and reviewers in the BART determination and review effort. The Protocol has been in preparation within VISTAS since January 2005. The original authors are Pat Brewer, VISTAS Technical Coordinator, and Ivar Tombach, VISTAS Technical Advisor. The VISTAS state BART contacts, particularly Tom Rogers, FL, Chris Arrington, WV, Leigh Bacon, AL, and Michael Kiss, VA, have directed and extensively reviewed the Protocol. The Protocol was enhanced and completed with the assistance of Joseph Scire, Christelle Escoffier-Czaja and Jelena Popovic of Earth Tech, Inc. and it has received extensive contributions and review from the VISTAS federal partners: Federal Land Managers and US EPA. The VISTAS RPO held a meeting on September 21, 2005 in Research Triangle Park, NC to discuss the Protocol with participants before starting a public comment period. The Protocol underwent formal external review during the period between September 26, 2005 and October 31, 2005. Numerous comments were received. All comments were carefully considered and discussed with VISTAS participants and federal partners. VISTAS gratefully acknowledges the very useful contributions of those that provided comments. On November 1st, 2005 VISTAS held another meeting with its participants in Nashville, TN to present and discuss the comments being considered for inclusion in the Protocol. No formal document will be prepared to address all the comments received on the Protocol.

Objectives

The objectives of the Protocol (discussed in Chapter 1) are to provide:

- A consistent approach to determine if a source is subject to BART
- A consistent model (CALPUFF) and modeling guidelines for BART determinations
- Clearly delineated modeling steps
- A common CALPUFF configuration
- Guidance for site-specific modeling
- Common expectations for reporting model results

The Protocol is not intended to define the engineering analyses required by the US EPA's BART Guidance, nor address model alternatives to the CALPUFF model, nor address emissions trading.

Chapter 2 is intended to provide summary background on EPA's guidance for BART modeling. The CALPUFF model system is reviewed in Chapter 3, while specific recommendations for applying the CALPUFF model for BART purposes appear in Chapter 4. Chapter 5 describes the specific information that should be included in site-specific protocols. Chapter 6 describes the quality assurance requirements for BART analyses in the VISTAS RPO.

Recommendations

The major recommendations for VISTAS BART modeling included in this Protocol are:

I. Process

Follow the BART process steps discussed in Chapter 2:

1. Identify BART eligible sources
2. Identify which pollutants have greater than *de minimis* emission levels
3. Identify sources that are subject to BART
4. Identify baseline visibility impact of each BART source
5. Identify feasible controls and emission changes
6. Identify the change in visibility impact for each candidate BART control option
7. Compare the visibility improvement of BART control options to other statutory factors in the engineering analysis

II. CALPUFF Model Configuration

Use the CALPUFF dispersion modeling system, as described in Chapter 4, to determine if a single source is subject to BART. VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and are maintained on the CALPUFF website (www.src.com) for public access.

VISTAS is making publicly available 12-km CALMET output files for the entire VISTAS modeling domain (eastern United States) and intends to also provide CALMET output files for five 4-km grid subdomains covering the VISTAS states and VISTAS Class I areas. To create the CALMET input files, Earth Tech used the MM5 databases developed by EPA for 2001, VISTAS for 2002, and Midwest RPO for 2003. For the 12 km grid large domain covering the entire VISTAS region, Earth Tech used the No-Obs setting (i.e., did not include additional surface and upper air observations beyond those incorporated in the MM5 calculations). For finer resolution subdomains (4 km grid or less), available surface and upper air observations will be used in addition to MM5 meteorological model outputs. The specific model settings will be provided with the CALMET files and via the CALPUFF website so that users can review or replicate the work.

For CALPUFF modeling, source emissions should be defined using the maximum 24-hour actual emission rate during normal operation for the most recent 3 or 5 years. If maximum 24-hr actual emissions are not available, continuous emissions data, permit allowable emissions, potential emissions, and emissions factors from AP-42 source profiles may be used as available.

Key points from comments received on the specific CALPUFF, CALPOST, and POSTUTIL configurations are highlighted below.

- After running CALPUFF for an individual facility, repartition NO_3 in POSTUTIL.[1]
- Use ozone data from non-urban monitors as the background ozone input.
- Use the Pasquill-Gifford dispersion method.[2]

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[1] The original intent, as expressed in the Final VISTAS BART Modeling Protocol (22 December 2005) was to use CMAQ-derived background data for SO_2, NO_3 and NH_3 in POSTUTIL. After extensive discussion with the EPA and FLMs in early 2006, EPA did not approve the recommended approach so background gaseous concentrations from CMAQ 2002 modeling will not be provided by VISTAS for use in POSTUTIL. Rather the standard default NH_3 concentrations specified on page 14 of the IWAQM Phase 2 report (IWAQM, 1998) will be used.

[2] The Final VISTAS BART Modeling Protocol (Dec. 22, 2005) recommended using turbulence-based AERMOD dispersion methods, citing EPA's *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005. Subsequently, EPA Region IV notified the VISTAS states that using turbulence-

- In CALPOST, use Method 6 with monthly average RH for calculating extinction, as recommended by the EPA.

- Use EPA default calculations of light extinction under current and natural background conditions. In addition to the default assumptions, a source may choose to also calculate visibility using the recently revised IMPROVE algorithm described by Pitchford, et al., (2005).

Provide results in tables as illustrated in Chapter 4 that describe, for each source:

- Number of receptors within a single Class I area with impact > 0.5 dv

- Number of days at all receptors in the Class I area with impact > 0.5 dv

- Number of Class I areas with impacts > 0.5 dv

III. CALPUFF Application for BART

For determining if a BART-eligible source is subject to BART CALPUFF modeling, use a two-tier approach. For the initial exemption modeling use CALPUFF with 12-km grid CALMET. For finer resolution of meteorological fields, use CALPUFF with CALMET of 4-km or smaller grid size.

VISTAS States are accepting EPA guidance that the threshold value to establish that a source contributes to visibility impairment is 0.5 deciview.

VISTAS States are using emissions (tons per year) divided by distance (km) from a Class I area boundary (Q/d) as a presumptive indicator that a BART-eligible source is subject to BART. If Q/d for SO_2 is greater than 10 for 2002 actual annual emissions, then the State presumes that the source is subject to BART and no exemption modeling will be performed using VISTAS funds. If the source agrees with this presumption, then the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and perform the engineering analyses. If a source disagrees, the source may perform fine grid modeling to determine if its impact is <0.5 dv.

For sources with Q/d less than or equal to 10, VISTAS intends to fund TRC Environmental Corp.[3] to assist States with the initial CALPUFF exemption modeling. Each State will prioritize which sources will be offered modeling by VISTAS. Modeling of these sources will be conducted in priority order to first accommodate States with nearer term timing constraints in their SIP development process. To conserve VISTAS resources, modeling will begin with sources at lower Q/d values and continue with sources with higher Q/d values until a Q/d value

based dispersion methods would be considered a non-guideline application of CALPUFF. Thus this Protocol has been revised to indicate Pasquill-Gifford dispersion coefficients should be used.

[3] In April 2006, Earth Tech's CALPUFF modeling staff became part of TRC Environmental Corporation. References to Earth Tech and to TRC in this protocol refer to the same technical staff, just at different times.

that consistently results in a greater than 0.5 dv impact is identified. Chapter 4 addresses the number of VISTAS sources eligible for BART based on Q/d analysis.

Note that VISTAS does not propose to use Q/d to exempt BART-eligible sources, but only to prioritize sources for modeling purposes. Thus this application is consistent with EPA guidance not to use Q/d for exemption purposes.

For the 12-km initial modeling exemption test, compare the highest single 24-hour average value across all receptors in the Class I area to the threshold value of 0.5 dv. If the highest 24-hr average value is below 0.5 dv at all Class I areas, then the source is not subject to BART. If the highest 24-hr average value is greater than 0.5 dv, then the source may choose to perform finer grid modeling for exemption purposes or may accept determination that the source is subject to BART and proceed to establish visibility impacts prior to and after BART controls. If using the single highest 24-hr average value proves, after initial 12-km grid CALPUFF modeling, to be too conservative a screening level, VISTAS may allow some exceedances of the threshold value for exemption purposes, up to no more than the 98^{th} percentile value.

The 12-km modeling results can be used to focus finer grid modeling for exemption purposes on only those Class I areas where impacts greater than 0.5 dv were projected in the 12-km modeling.

For finer grid (4 km or less) analyses, use the 98^{th} percentile impact value for the 24-hr average. Use either the 8^{th} highest day in each year or the 22^{nd} highest day in the 3-year period, whichever is more conservative, for comparison to the exemption threshold.

Use the same model assumptions for pre-BART visibility impact and for BART control options modeling: establish baseline visibility from the pre-BART run; change one control at a time; and evaluate the change in visibility impact, i.e. the delta-deciview. Note that “no control” may constitute BART.

Visibility impact is one of the five factors considered in the engineering analysis required under the USEPA BART guideline. If a source accepts to institute the most stringent control, the engineering analyses are not required.

This common VISTAS Protocol consistently recommends conservative assumptions. Individual States ultimately have responsibility to determine which, if any, BART controls are recommended in their State Implementation Plans (SIPs).

1. INTRODUCTION AND PROTOCOL OBJECTIVES

1.1 Background

Under regional haze regulations, the Environmental Protection Agency (EPA) has issued final guidelines dated July 6, 2005 for Best Available Retrofit Technology (BART) determinations (70 FR 39104-39172). The regional haze rule includes a requirement for BART for certain large stationary sources. Sources are BART-eligible if they meet three criteria including potential emissions of at least 250 tons per year of a visibility-impairing pollutant, were put in place between August 7, 1962 and August 7, 1977, and fall within one of the 26 listed source categories in the guidance. A BART engineering evaluation using five statutory factors -- 1) existing controls; 2) cost; 3) energy and non-air environmental impacts; 4) remaining useful life of the source; 5) degree of visibility improvement expected from the application of controls -- is required for any BART-eligible source that can be reasonably expected to cause or contribute to impairment of visibility in any of the 156 federal parks and wilderness (Class I) areas protected under the regional haze rule. (Note that, depending on the five factors, the evaluation may result in no control.) Air quality modeling is an important tool available to the States to determine whether a source can be reasonably expected to contribute to visibility impairment in a Class I area.

Throughout this document the term "BART-eligible emission unit" is defined as any single emission unit that meets the criteria described above. A "BART-eligible source" is defined as the total of all BART-eligible emission units at a single facility. If a source has several emission units, only those that meet the BART-eligible criteria are included in the definition "BART-eligible source".

One of the listed categories is steam electric plants of more than 250 million BTU/hr heat input. To determine if such a plant has greater than 250 million BTU/hr heat input and is potentially subject to BART, the boiler capacities of all electric generating units (EGUs) should be added together regardless of construction date. In this category, electric generating sources greater than 750 MW have presumptive SO_2 and NO_x emission limits. States may presume the same limits for EGU sources between 250-750 MW. However, units at those sources constructed after the BART-eligibility dates are not subject to a BART engineering evaluation. EPA, in the Clean Air Interstate Rule (CAIR), determined that an EGU participating in the CAIR trading program satisfies the BART requirements for SO_2 and NO_x. VISTAS states are tentatively accepting this guidance. CAIR does not cover PM so EGUs would still need to evaluate impacts of PM if PM emissions are above *de minimis* values.

As illustrated in Table 1-1, as of December 5, 2005, VISTAS States had identified a total of 274 BART-eligible sources that fall into 20 of the 26 BART source categories. Of the 274 sources with BART-eligible units, 84 sources are utility EGUs and 190 are non-EGU industrial sources. (Note that these numbers are not final and are subject to slight adjustments and refinements.) No BART sources are located on Tribal lands.

Table 1-1. VISTAS BART Eligible Sources (not updated since December 2005)

State	Total Number of Sources	EGU Sources	Non-EGU Sources
AL	48	8	40
FL	50	23	27
GA	24	10	14
KY	29	12	17
MS	18	8	10
NC	16	5	11
SC	31	6	25
TN	13	2	11
VA	18	3	15
WV	26	7	19
Total	**273**	**84**	**189**

1.2 Objective of this Protocol

The objective of this VISTAS' BART Modeling Protocol is to describe common procedures for air quality modeling to support BART determinations that are consistent with the EPA guidelines. The protocol will serve as the basis for establishing a common understanding among the organizations who will be performing the BART analyses or reviewing the BART modeling results, including VISTAS State and Local air regulatory agencies, EPA, Federal Land Managers (FLMs), source operators, and contractors for the sources. This final protocol incorporates EPA final guidance and comments that were received on VISTAS' draft protocol[4] and provides additional description of modeling procedures. The original final protocol of 22 December 2005 has been revised since then to clarify items, resolve technical issues, and reflect decisions by the EPA and FLMs. This document is the third revision.

The VISTAS States have accepted EPA's guidance to use the CALPUFF modeling system to comply with the BART modeling requirements of the regional haze rule. A BART-eligible source will be required to submit a site-specific modeling protocol to the State for review and approval prior to performing CALPUFF modeling. States will consult with FLMs and the EPA when evaluating the site-specific BART protocols. The site-specific protocol will include the

[4] *Draft Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART). VISTAS*, March 22, 2005 and September 20, 2005.

source-specific data on source location, stack parameters, and emissions. The methods of the VISTAS common modeling protocol will be followed in the site-specific protocol unless the source proposes to the State, and the State approves, alternative methods or assumptions.

Each VISTAS State or Local agency retains responsibility for the specific procedures and processes it will follow in working with the BART sources under its jurisdiction, the FLMs, EPA, and public to determine BART controls for sources in the State. Nothing in the VISTAS process replaces States' responsibility to determine BART controls.

The remainder of this document describes the CALPUFF modeling system and the application of CALPUFF to two situations:

- Air quality modeling to determine whether a BART-eligible source is "subject to BART" and therefore the BART analysis process must be applied to its operations.

- Air quality modeling of emissions from sources that have been found to be subject to BART, to evaluate regional haze benefits of alternative control options and to document the benefits of the preferred option.

Chapters 2 and 3 of this document are intended to provide background information on EPA's guidance for BART analysis modeling and on the CALPUFF modeling system. Subsequent chapters include more specific recommendations. Chapter 2 of this document reviews EPA's guidance for regional haze BART analysis modeling, as outlined in the 6 July 2005 Federal Register notice. The CALPUFF model is the preferred model recommended by the EPA for BART modeling analyses and its characteristics and limitations are discussed in Chapter 3. The specific steps to determine whether a BART-eligible source is subject to BART and to evaluate BART controls are described in Chapter 4. The procedures include initial modeling of BART-eligible sources using CALPUFF run in a conservative mode with regional meteorological datasets. For sources determined to be subject to BART based on these first modeling analyses, further finer grid CALPUFF analyses would be performed. The model configuration for the common modeling protocol is described in Chapter 4. Details of the source-specific protocol are described in Chapter 5. A quality assurance plan is outlined in Chapter 6.

EPA's guidance allows for the use of appropriate alternative models, however VISTAS will not develop a protocol for alternative models. This protocol focuses on guidance for the application of the preferred CALPUFF modeling approach. If a source wants to use an alternative model in its BART demonstration, the source will need to submit a detailed written justification to the State for review and approval. The State will provide the documentation to the EPA and Federal Land Managers for their review.

Also, this protocol does not address a preferred modeling approach to demonstrate the effectiveness of an optional emissions cap and trade program. Such a cap and trade program is not required, but can be implemented in lieu of BART if desired by the VISTAS States. VISTAS

States are not pursuing a regional trading alternative under the proposed EPA trading guidance (70 FR 44154-44175) that is to be promulgated in 2006.

2. REVIEW OF EPA'S GUIDANCE FOR BART MODELING

The final guidance for regional haze BART determinations was published in the Federal Register on 6 July 2005 (70 FR 39104 to 39172). It prescribes the modeling approaches that are to be used for various stages of the BART analysis process.

This chapter provides a summary of EPA's guidance for BART modeling. It is not intended to provide a comprehensive review of the guidance. Nor does this chapter address specific recommendations for VISTAS' approach to CALPUFF BART modeling. Those recommendations appear in Chapter 4.

2.1 Overview of the Regional Haze BART Process

The process of establishing BART emission limitations consists of four steps:

1) Identify whether a source is "BART-eligible" based on its source category, when it was put in service, and the magnitude of its emissions of one or more "visibility-impairing" air pollutants. The BART guidelines list 26 source categories of stationary sources that are BART-eligible. Sources must have been put in service between August 7, 1962 and August 7, 1977 in order to be BART-eligible. Finally, a source is eligible for BART if potential emissions of visibility-impairing air pollutants are greater than 250 tons per year. Qualifying pollutants include primary particulate matter (PM_{10}) and gaseous precursors to secondary fine particulate matter, such as SO_2 and NO_x. Whether ammonia or volatile organic compounds (VOCs) should be included as visibility-impairing pollutants for BART eligibility is left for the States to determine on a case-by-case basis. The guidance states that high molecular weight VOCs with 25 or more carbon atoms and low vapor pressure should be considered as primary $PM_{2.5}$ emissions and not VOCs for BART purposes.

(Note: If the source is subject to BART because one visibility impairing pollutant has potential emissions > 250 TPY, the State may determine that other visibility impairing pollutants are not subject to BART if their potential emissions are less than the *de minimis* levels (40 TPY for SO_2 and NO_x and 15 TPY of PM_{10} or $PM_{2.5}$. This assumes that the other BART-eligibility criteria are met.)

2) Determine whether a BART-eligible source can be excluded from BART controls by demonstrating that the source cannot be reasonably expected to cause or contribute to visibility impairment in a Class I area. The preferred approach is an assessment with an air quality model such as CALPUFF or other appropriate model followed by comparison of the estimated 24-hr visibility impacts against a threshold above estimated natural conditions to be determined by the States.[5] The threshold to determine whether a single source "causes" visibility impairment is set at

[5] A recent draft settlement agreement with the EPA (to be published in the *Federal Register* for public comment) provides that a State has the discretion to decide whether annual average or 20% best natural conditions are to be used as the reference. This ruling resolves an ambiguity in EPA's BART guidance, where the BART guideline

1.0 deciview change from natural conditions over a 24-hour averaging period in the final BART rule (70 FR 39118). The guidance also states that the proposed threshold at which a source may "contribute" to visibility impairment should not be higher than 0.5 deciviews although, depending on factors affecting a specific Class I area, it may be set lower than 0.5 deciviews. The test against the threshold is "driven" by the contribution level, since if a source "causes", by definition it "contributes".

EPA recommends that the 98th percentile value from the modeling be compared to the contribution threshold of 0.5 deciviews (or a lower level set by a State) to determine if a source does not contribute to visibility impairment and therefore is not subject to BART. Whether or not the 98th percentile value exceeds the threshold must be determined at each Class I area. Over an annual period, this implies the 8th highest 24-hr value at a particular Class I area is compared to the contribution threshold. Over a 3-year modeling period, the 98th percentile value may be interpreted as the highest of the three annual 98th percentile values at a particular Class I area or the 22nd highest value in the combined three year record, whichever is more conservative.

Alternatively, States have the option of considering that all BART-eligible sources within the State are subject to BART and skipping the initial impact analysis. In rare cases, a State might be able to do exactly the opposite, and use regional modeling to conclude that all BART-eligible sources in the State do not cumulatively contribute to "measurable" visibility impairment in any Class I areas. Also, the States have an option to exempt individual sources based on model plant analysis conducted by EPA in finalizing the BART rule. Under this option, sources with potential emissions of SO_2 plus NO_x of less than 500 tons and a distance from any Class I area greater than 50 kilometers or sources with SO_2 plus NO_x potential emissions of less than 1000 tons and a distance from any Class I area greater than 100 kilometers can be exempted. PM emissions are not specifically addressed in the model plant analysis, but subsequent discussions with EPA staff indicate that PM may be considered along with SO_2 and NO_x, so that a plant could be exempted if the combined potential emissions of SO_2, NO_x, plus PM meet the criteria above.

3) Determine BART controls for the source by considering various control options and selecting the "best" alternative, taking into consideration:

a) Any pollution control equipment in use at the source (which affects the availability of options and their impacts),

b) The costs of compliance with control options,

c) The remaining useful life of the facility,

d) The energy and non air-quality environmental impacts of compliance, and

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text says "natural conditions" at 70 FR 39162, col. 3, while the preamble to the BART rule says "natural visibility baseline for the 20% best visibility days" at 70 FR 39125, col. 1.

e) The degree of improvement in visibility that may reasonably be anticipated to result from the use of such technology.

Note that if a source agrees to apply the most stringent controls available to BART-eligible units, the BART analysis is essentially complete and no further analysis is necessary (70 FR 39165).

4) Incorporate the BART determination into the State Implementation Plan for Regional Haze, which is due by December 2007.

Instead of applying BART on a source-by-source basis, a State (or a group of States) has the option of implementing an emissions trading program that is designed to achieve regional haze improvements that are greater than the visibility improvements that could be expected from BART. If the geographic distributions of emissions under the two approaches are similar, determining whether trading is "better than BART" may be possible by simply comparing emissions expected under the trading program against the emissions that could be expected if BART was applied to eligible sources. If the geographic distributions of emissions are likely to be different, however, air quality modeling comparing the expected improvements in visibility from the trading program and from BART would be required. (See the proposed BART Alternative rule, at 70 FR 44160.) EPA suggests that regional modeling using a photochemical grid model may be more appropriate than CALPUFF for this purpose.

Note that EPA has indicated in the BART rule (70 FR 39138-39139) that emissions reductions under the Clean Air Interstate Rule (CAIR) meet the BART requirement for SO_2 and NO_x control for those EGUs subject to BART. However, PM emissions from EGUs are not addressed by CAIR and therefore a BART analysis may still be required for PM.

2.2 Model Recommendations for the BART Analysis

To evaluate the visibility impacts of a BART-eligible source at Class I areas beyond 50 km from the source, the EPA guidance recommends the use of the CALPUFF model as "the best regulatory modeling application currently available for predicting a single source's contribution to visibility impairment" (70 FR 39162). The use of another "appropriate model" is allowed although the EPA prefers the use of CALPUFF. If a source wants to use an alternative model, the source needs to submit a written justification and source-specific modeling protocol to its State for review and approval. As part of the consultation process, the State will provide documentation to EPA and FLM.

For modeling the impact of a source closer than 50 km to a Class I area, EPA's BART guidance recommends that expert modeling judgment be used, "giving consideration to both CALPUFF and other methods." The PLUVUE-II plume visibility model is mentioned as a possible model to consider instead of CALPUFF for a source within less than 50 km of a Class I area.

The EPA guidance notes that "regional scale photochemical grid models may have merit, but such models have been designed to assess cumulative impacts, not impacts from individual sources" and they are "very resource intensive and time consuming relative to CALPUFF", but States may consider their use for SIP development in the future as they may be adapted and "demonstrated to be appropriate for single source applications" (70 FR 39123). Photochemical grid models may be more appropriate for cumulative modeling options such as in the determination of the aggregate contribution of all-BART-eligible sources to visibility impairment, but such use should involve consultation with the appropriate EPA Regional Office (70 FR 39163).

According to the BART guidance, a modeling protocol should be submitted for all modeling demonstrations regardless of the distance from the BART-eligible source to the Class I area. EPA's role in the development of the protocol is only advisory as the "States better understand the BART-eligible source configurations" and factors affecting their particular Class I areas (70 FR 39126).

In the BART modeling analyses the EPA recommends that the State use the highest 24-hour average actual emission rate for the most recent three to five-year period of record. Emissions on days influenced by periods of start-up, shutdown and malfunction are not to be considered in determining the appropriate emission rates. (70 FR 39129).

If a source is found to be subject to BART, CALPUFF or another appropriate model should be used to evaluate the improvement in visibility resulting from the application of BART controls. Visibility improvements may be evaluated on a pollutant-specific basis in the BART determination (70 FR 39129).

For evaluating the improvement in visibility resulting from the application of BART, the EPA guidelines state that States are "encouraged to account for the magnitude, frequency, and duration of the contributions to visibility impairment caused by the source based on the natural variability of meteorology" (70 FR 39129).

2.3 Performance of a Cap and Trade Program

If a State or States elect to pursue an optional cap and trade program, they are required to demonstrate greater "reasonable progress" in reducing haze than would result if BART were applied to the same sources. In some cases, a State may simply be able to demonstrate that a trading program that achieves greater progress at reducing emissions will also achieve greater progress at reducing haze. Such would be the case if the likely geographic distribution of emissions under the trading program would not be greatly different from the distribution if BART was in place.

If the expected distribution of emissions is different under the two approaches, then "dispersion modeling" of all sources must be used to determine the difference in visibility at each impacted Class I area, in order to establish that the optional trading program will result in visibility improvements aggregated over all Class I areas that are "better than BART" (70 FR 39137-39138). The BART guidance does not specify the method to be used for this modeling. From a technical perspective, either applying CALPUFF to every source or using a regional photochemical model would satisfy the need.

A rulemaking procedure is currently underway to establish final guidance for such alternatives to BART (70 FR 44154-44175). The rule is expected to be finalized in 2006.

3. OVERVIEW OF THE CALPUFF MODELING SYSTEM

This chapter contains a general description of the CALPUFF modeling system and its capabilities and limitations. It does not include specific recommendations regarding the use of the model for BART analysis in the VISTAS region. These specific recommendations can be found in Chapter 4.

3.1 Capabilities and features of CALPUFF

The CALPUFF modeling system (Scire et al., 2000a, b) is recommended as the preferred modeling approach for use in the BART analyses. CALPUFF and its meteorological model, CALMET, are designed to handle the complexities posed by the complex terrain, the large source-receptor distances, chemical transformation and deposition, and other issues related to Class I visibility impacts. The CALPUFF modeling system has been adopted by the 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 (68 FR 18440-18482). 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) (EPA 1998). The final BART guidance recommends CALPUFF as "the best modeling application available for predicting a singe source's contribution to visibility impairment" (70 FR 39122). As a result of these recommendations, the VISTAS modeling protocol is based on the use of CALPUFF for its BART determinations.

The main components of the CALPUFF modeling system are shown in Figure 3-1. 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. CALMET includes special algorithms for treating the overwater boundary layer and coastal interaction effects. CALMET can use meteorological observational data and/or three-dimensional output from prognostic numerical meteorological models such as MM5 (Grell et al., 1995) or RUC (Benjamin et al., 2004) in the developments of its fine-scale meteorological fields.

CALPUFF is a non-steady-state Lagrangian puff transport and dispersion model that advects Gaussian puffs of multiple pollutants from modeled sources. CALPUFF's algorithms have been designed to be applicable on spatial scales from a few tens of meters to hundreds of kilometers from a source. It includes algorithms for near-field effects such as building downwash, stack tip downwash and transitional plume rise as well as processes important in the far-field such as chemical transformation, wet deposition, and dry deposition. CALPUFF contains an option to allow puff splitting in the horizontal and vertical directions, which extends the distance range of the model. The primary outputs from CALPUFF are hourly concentrations and hourly deposition fluxes evaluated at user-specified receptor locations.

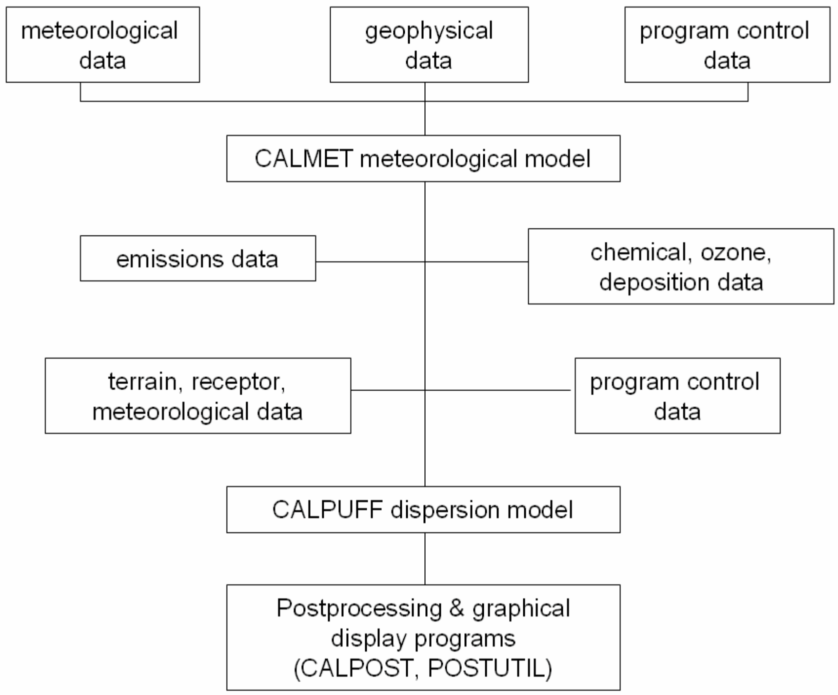

Figure 3-1. CALPUFF modeling system components.

A set of postprocessing programs associated with CALPUFF computes visibility effects and allows cumulative source impacts to be assessed, including potential non-linear effects of ammonia limitation on nitrate formation. The CALPOST postprocessor contains several options for computing change in extinction and deciviews for visibility assessments. The POSTUTIL postprocessor includes options for summing contributions of individual sources or groups of sources to assess cumulative impacts. POSTUTIL also contains CALPUFF's nitric acid-nitrate chemical equilibrium module, which allows the cumulative effects of ammonia consumption by background sources to be assessed in the postprocessor. In addition, the combination of CALPUFF and POSTUTIL allows the effects of source emissions of ammonia to be incrementally added to background ammonia levels when determining nitrate formation.

The rest of this chapter summarizes the capabilities and features of the CALPUFF modeling components in more detail.

3.1.1 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 modeling a large geographical area, as would be necessary for the regional VISTAS domain, the user has the option to use a Lambert Conformal Projection coordinate system to account for Earth's curvature.

The major features and options of the meteorological model are summarized in Table 3-1. The techniques used in the CALMET model are briefly described below.

Table 3-1. Major Features of the CALMET Meteorological Model

- **Boundary Layer Modules of CALMET**
  - Overland Boundary Layer - Energy Balance Method
  - Overwater Boundary Layer - Profile Method
    - -- COARE algorithm
    - -- OCD-based 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). The model also determines gridded fields of Pasquill-Gifford-Turner (PGT) stability class and hourly precipitation rates.

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. The version of CALMET being used by VISTAS contains improvements in the overwater boundary layer parameterizations (Fairall et al., 2003) based on the Coupled Ocean Atmosphere Response Experiment (COARE) and enhancements in the calculation of overwater mixed layer heights (Batchvarova and Gryning, 1991, 1994). Further details and the results of an evaluation of the model containing these enhancements are described in Scire et al. (2005). An upwind-looking spatial averaging scheme is optionally applied to the mixing heights and three-dimensional temperature fields in order to account for important advective effects.

Diagnostic Wind Field Module

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. Gridded MM5 can be 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.

Step 1 Wind Field. Development of the Step 1 wind field begins with the initial guess field defined by the MM5 prognostic meteorological model. Normally, the CALMET computational domain is specified to be at finer grid resolution than the MM5 dataset used to initialize the initial guess field. For example, 36-km MM5 data available for VISTAS modeling may be used to develop the initial guess field on a 12-km or even a 1-km CALMET grid. The Step 1 algorithms in CALMET described below apply terrain adjustments to the initial guess field on the fine-scale CALMET grid. Thus, the CALMET winds are adjusted to respond to fine-scale terrain features not necessarily seen by the coarser scale MM5 model.

Kinematic Effects of Terrain: The approach of Liu and Yocke (1980) is used to evaluate the effects of the terrain on the wind field. The initial guess field winds are used to compute a terrain-forced vertical velocity, subject to an exponential, stability-dependent decay function. The 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 original slope flow algorithm in CALMET has been upgraded (Scire and Robe, 1997) 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 above adjustments of the initial-guess wind is the Step 1 wind field. The second step of the procedure may involve introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse-distance squared interpolation scheme is used which weights 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.

The introduction of observational data in the Step 2 calculation is an option. It is also possible to run the model in "no observations" (No-Obs) mode, which involves the use only of MM5 gridded data for the initial guess field followed by fine-scale terrain adjustments by CALMET. In No-Obs mode, observational data are not used in the Step 2 calculations. The No-Obs mode is appropriate when the MM5 simulations adequately characterize the regional wind patterns and when local observations, especially surface observations, reflect local conditions on a scale smaller than that of the CALMET domain and hence their spatial representativeness may be limited. Such situations are most likely to occur when the CALMET grid scale is relatively large i.e., coarser than the scale of variation of the true wind field, which is particularly likely to occur in complex terrain or along the seashore,

3.1.2 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 3-2 at the end of this subsection. 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 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 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 is 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. The PRIME building downwash model (Schulman et al., 2000) is also included in CALPUFF as an option.

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 CTDM. Options are provided to apply an averaging time correction or surface roughness length adjustments to the PG coefficients. In version 5.754 of CALPUFF being used by VISTAS, an option is provided to use the AERMOD turbulence profiles for determining dispersion rates, which is the most recent approach to dispersion in EPA-approved regulatory modeling. In addition, turbulence advection is included. For additional details on these features, see Scire et al. (2005).

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 that occur at the coastline of a major body of water.

Dry Deposition: A 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. For particles, source-specific mass distributions may be provided for use in the resistance model. Of particular interest for BART analyses is the ability to separately model the deposition of fine particulate matter (< 2.5 μm diameter) from coarse particulate matter (2.5-10 μm diameter).

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. Puffs may also be split in the horizontal when the puff size becomes large relative to the grid size, to account for wind shear across the puffs.

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. The MESOPUFF II scheme is recommended by IWAQM. It produces secondary fine particulate matter (sulfate and nitrate) from emissions of SO_2 and NO_x and thus allows analyses of visibility impacts. Ambient ozone concentrations are used in the parameterized chemical transformation module as a surrogate for OH radicals during daylight hours. Ambient ammonia concentrations are used together with a temperature and relative humidity-dependent equilibrium relationship to partition nitric acid and nitrate on an hour-by-hour and receptor-by-receptor basis.

Table 3-2. Major Features of the CALPUFF Dispersion 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
    - -- AERMOD turbulence profiles
    - -- Original turbulence profiles
  - 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
  - PRIME 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 3-2. Major Features of the CALPUFF Dispersion 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 (COARE algorithm or OCD-based method)
  - 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

3.1.3 Major Features of Postprocessors (CALPOST and POSTUTIL)

The two main postprocessors of interest for BART applications are the CALPOST and POSTUTIL programs. CALPOST is used to process the CALPUFF outputs, producing tabulations that summarize the results of the simulations, identifying, for example, the highest and second-highest hourly-average concentrations at each receptor. When performing visibility-related modeling, CALPOST uses concentrations from CALPUFF to compute light extinction and related measures of visibility (haze index in deciviews), reporting these for a 24-hour averaging time.

The CALPOST processor contains several options for evaluating visibility impacts, including the method described in the BART guidance, which uses monthly average relative humidity values. CALPOST contains implementations of the IWAQM-recommended and FLAG-recommended visibility techniques and additional options to evaluate the impact of natural weather events (fog, rain and snow) on background visibility and visibility impacts from modeled sources.

The POSTUTIL processor is a program that allows the cumulative impacts of multiple sources from different simulations to be summed, can compute the difference between two sets of predicted impacts (useful for evaluating the benefits of BART controls), and contains a chemistry module to evaluate the equilibrium relationship between nitric acid and nitrate aerosols. This capability allows the potential non-linear effects of ammonia scavenging by sulfate and nitrate sources to be evaluated in the formation of nitrate from an individual source. CALPUFF makes the full ambient ammonia concentration available to each puff without regard for any scavenging by other puffs. POSTUTIL corrects for such scavenging when the puffs generated by the CALPUFF model overlap, as could be the case for a single source when the wind speed is low, or when nitrate formation is to be attributed to each of several sources that are in a cluster and whose plumes overlap,

POSTUTIL will also compute the impacts of individual sources or groups of sources on sulfur and nitrogen deposition into aquatic, forest and coastal ecosystems. The postprocessor allows the changes in deposition fluxes resulting from changes in emissions to be quantified. For example the output of POSTUTIL and CALPOST can be used as input into an Acid Neutralizing Capacity (ANC) analysis, or for comparison to Deposition Analysis Thresholds (DATs).

3.2 Discussion of CALPUFF Applicability and Limitations

3.2.1 Transport and Diffusion

According to the IWAQM Phase 2 report (page 18), "CALPUFF is recommended for transport distances of 200 km or less. Use of CALPUFF for characterizing transport beyond 200 to 300 km should be done cautiously with an awareness of the likely problems involved."[6]

IWAQM's 200-km limitation derives from the observation that, when compared to the data of the Cross Appalachian Tracer Experiment (CAPTEX), the basic configuration of CALPUFF overestimated inert tracer concentrations by factors of 3 to 4 at receptors that were 300 to 1000 km from the source. The apparent reason was insufficient horizontal dispersion of the simulated plume, presumably because an actual large plume does not remain coherent in the presence of vertical wind shears that typically occur, especially during the night, and of horizontal wind shears over the large puffs that arise over long transport distances.

To better represent such situations, an optional puff splitting algorithm has since been added to CALPUFF to simulate wind shear effects across a well-mixed individual puff by dividing the puff horizontally and vertically into two or more pieces. Differential rates of transport among the new puffs thus generated can increase the horizontal spread of the material in the plume due to vertical wind speed shear and wind direction shear. The horizontal puff splitting algorithm is

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[6] The IWAQM presentation at EPA's 6th Modeling Conference provides the background for this recommendation: "The IWAQM concludes that CALPUFF be recommended as providing unbiased estimates of concentration impacts for transport distances of order 200 km and less, and for transport times of order 12 hours or less. For larger transport times and distances, our experience thus far is that CALPUFF tends to underestimate the horizontal extent of the dispersion and hence tends to overestimate the surface-level concentration maxima. This does not preclude the use of CALPUFF for transport beyond 300 km, but it does suggest that results in such instances be used cautiously and with some understanding." (From page D-12 of the IWAQM Phase 2 report.)

designed to allow large puffs that may grow to be several grid cells or more in size to split into smaller puffs that can then more accurately respond to variations in the local wind field across the original large puff. This will also tend to increase horizontal dispersion of the plume. Since the creation of additional puffs via puff splitting will increase the computational requirements of the model, possibly substantially, puff splitting is not enabled by default, but can be turned on at the option of the user. Puff splitting may be appropriate for transport distances over 200 to 300 km, or possibly over shorter distances in complex terrain.

Turning to the shorter distance end of the transport range, the CALPUFF section of Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states, "CALPUFF is intended for use on scales from tens of meters from a source to hundreds of kilometers." This is supported by the IWAQM Phase 2 report, which indicates that the diffusion algorithms in CALPUFF were designed to be suitable for both short and long distances. In this regard, CALPUFF does contain algorithms for such near-field effects as plume rise, building downwash, and terrain impingement and includes routines that deal with the computational difficulties encountered when applying a puff model in the field near to a source.

The recommendations for regulatory use in Appendix A of the *Guideline on Air Quality Models* state, "CALPUFF is appropriate for long range transport (source-receptor distance of 50 to several hundred kilometers)", but provisions for using CALPUFF in the near-field in "complex flow" situations are also included in the regulatory guidance. Complex flow situations may include complex terrain, coastal areas, situations where plume fumigation is likely, and areas where stagnation, flow reversals, recirculation or spatial variability in wind fields (e.g., as due to changes in valley orientation) are important.

The tracer studies with which CALPUFF transport and diffusion capabilities were evaluated in the IWAQM Phase 2 report were generally over distances greater than 50 km. More recently, additional studies of model performance have been performed at shorter distances, including at a power plant in New York state in complex terrain (at source-receptor distances of 2 to 8.5 km) and a second power plant in Illinois in simple terrain (at source-receptor distances in arcs ranging from 0.5 km to 50 km from the stack) (Strimaitis et al., 1998). Other CALPUFF evaluation studies over short-distances include ones by Chang et al. (2001) and Morrison et al. (2003). These studies demonstrate good model performance over source-receptor distances from a few hundred meters to 50 km.

An important factor in the performance of CALPUFF is the choice of dispersion coefficients. The EPA has defined the "regulatory default" option in CALPUFF to allow either Pasquill-Gifford (PG) or turbulence-based dispersion coefficients. CALPUFF has been evaluated and shown to perform better using turbulence-based dispersion for tall stacks (Strimaitis et al, 1998). CALPUFF with turbulence-based dispersion has also been evaluated for overwater transport and coastal situations (Scire et al., 2005). In many other studies, including AERMOD evaluation studies conducted by EPA, the use of PG-dispersion, or more specifically the lack of a convective probability density function (pdf) module, has been demonstrated to result in underprediction of peak concentrations.

In November 2005, EPA approved the AERMOD model, which relies on turbulence-based dispersion, as a regulatory Guideline Model[7]. The ISCST3 model and its PG dispersion coefficients are being phased out as an acceptable regulatory approach. However, EPA Region IV has indicated that the application of turbulence-based dispersion coefficients in CALPUFF needs to be further demonstrated before they are approved for BART application. They will consider accepting the use of turbulence dispersion coefficients on a case-by-case basis for sources that are close to Class I areas.

For regional haze light extinction calculations, use of a plume-simulating model such as CALPUFF is appropriate only when the plume is sufficiently diffuse that it is not visually discernible as a plume *per se*, but nevertheless its presence could alter the visibility through the background haze. The IWAQM Phase 2 report states that such conditions occur starting 30 to 50 km from a source. In this light, the BART guidance strongly recommends using CALPUFF for source-receptor distances greater than 50 km but also presents CALPUFF as an option that can be considered for shorter transport distances.

As discussed above, there do not appear to be any scientific reasons why CALPUFF cannot be used for even shorter transport distances than 30 km, though, as long as the scale of the plume is larger than the scale of the output grid so that the maximum concentrations and the width of the plume are adequately represented and so that the sub-grid details of plume structure can be ignored when estimating effects on light extinction. The standard 1-km output grid that has been established for Class I area analyses should serve down to source-receptor distances somewhat under 30 km; how much closer than 30 km will depend on the topography and meteorology of the area and should be evaluated on a case-by-case basis. For extremely short transport distances, depiction of the concentration distribution will require a grid that is finer than 1 km. (For reference, the width of a Gaussian plume, $2\sigma_y$, is roughly 1 km after 10 km of travel distance, assuming Pasquill-Gifford dispersion rates under neutral conditions.)

As an additional consideration, if the plume width is small compared to the visual range, the atmospheric extinction along a typical sight path of tens of kilometers through the plume will be inhomogeneous and the simple CALPOST point estimate of regional light extinction at a receptor point will not be correct. However, the effect of averaging light extinction estimates for 24 hours, during which the plume location shifts over various receptor points, is likely to mitigate this problem to some degree and suggests that using CALPUFF at distances under 30 km will often be appropriate. For the narrow plumes that result from short transport distances, though, the modeled peak 24-hr average extinction at a receptor will tend to overstate the effect of the source on regional haze.

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[7] *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule.* 70 FR 68218-68261. 9 November 2005.

The U.S. EPA has suggested that the plume visibility model, PLUVUE-II, could be used in lieu of CALPUFF for simulating visibility effects at such short distances.[8] PLUVUE-II is a Gaussian model that simulates the dispersion, chemical conversion, and optical effects of emissions of particles, SO_2, and NO_x from a single source. Its outputs include the discoloration of the sky by the plume (so called "plume blight") and the effect of the plume on visibility along user-selected sight paths that pass through the plume. The impacts of the plume on visibility depend not only on the plume composition, but also on the sight path chosen and its direction relative to the axis of the plume and the location of the sun. It isn't clear how such sight-path dependent results could be compared to the 0.5 and 1.0 deciview thresholds in the BART guidance. Since CALPUFF is designed to be useful for short transport distances (with features such as the simulation of plume downwash caused by structures at the source), CALPUFF seems more appropriate than PLUVUE-II for evaluating source impact at short distances for BART assessment purposes.

3.2.2 Aerosol Constituents

Primary $PM_{2.5}$

Appendix A of the *Guideline on Air Quality Models* (40 CFR 51, Appendix W) states that CALPUFF can treat primary pollutants such as PM_{10}. In actuality, CALPUFF can simulate PM_{10} or $PM_{2.5}$ or some other size range, because the assumed size distribution of the particles is a user input. The smaller the particles, the more they disperse like an inert gas. In most cases, the dispersion of inert $PM_{2.5}$ particles will be only minutely different from that of an inert gas, but the behavior of larger particles will differ.

A particularly important contributor to PM concentrations is the rate of deposition to the surface. $PM_{2.5}$ particles, which have a mass median diameter around 0.5 µm, have an average net deposition velocity of about 1 cm/min (or about 14 m/day) and thus the deposition of fine particles is usually not significant except for ground-level emissions. On the other hand, coarse particles (those PM_{10} particles larger than $PM_{2.5}$) have an average deposition velocity of more than 1 m/min (or 1440 m/day), which is significant, even for emissions from elevated stacks.

CALPUFF includes parametric representations of particle and gas deposition in terms of atmospheric, deposition layer, and vegetation layer "resistances" and, for particles, the gravitational settling speed. Gravitational settling, which is of particular importance for the coarse fraction of PM_{10}, is accounted for in the calculation of the deposition velocity. Effects of inertial impaction (important for the upper part of the PM_{10} distribution) and Brownian motion (important for small, sub-micron particles) and wet scavenging are also addressed. The BART guidance recommends that fine particulate matter (less than 2.5 µm diameter), which has higher light extinction efficiency than coarse particulate matter (2.5-10 µm diameters), should be treated separately in the model. CALPUFF allows for user-specified size categories to be treated as

[8] However, for the reasons given in this paragraph, VISTAS does not recommend PLUVUE-II for BART application

separate species, which includes calculating size-specific dry deposition velocities for each size category.

A primary $PM_{2.5}$ emission from coal-fired electric generating units (EGUs) that is of relevance to visibility calculations is that of primary sulfate. Although primary sulfate emissions account for only a small fraction of the total sulfur emissions from such sources, it may be important to simulate their effect with CALPUFF, especially at shorter distances before significant formation of secondary sulfate conversion from SO_2 has taken place.

Sulfur Dioxide and Secondary Particulate Sulfate

The MESOPUFF-II chemistry algorithm used in CALPUFF[9] simulates the gas phase oxidation of sulfur dioxide to sulfate by a linear transformation rate that was developed using regression relationships derived from the analysis of chemical conversion rates produced by a complex photochemical box model (see Scire et al., 1984, for a description of the development of the chemical module). As in all empirically-derived models, the relationships are based on easily-computed or observed parameters that are used as surrogates for the factors that control SO_2 oxidation.

The surrogate factors included in the parameterized chemistry during the daytime hours include solar radiation intensity, ambient ozone concentration, and atmospheric stability class. For example, gas phase SO_2 oxidation is a function of OH radical concentrations. Ozone concentrations are correlated with OH radical concentrations during daytime hours, and their use in the daytime SO_2 conversion rate in CALPUFF is based on this correlation relationship. The philosophy is that OH radical measurements are not available and cannot easily be computed within a model like CALPUFF, but ozone is commonly measured throughout the country, so the use of the well-known surrogate variable (ozone) is more useful in the empirical relationship than factors that are unknown or have a high degree of uncertainty. The same logic applies to the other variables in the relationship. They are surrogates for factors that the regression analysis has shown to be important in SO_2 oxidation rates. At night, the SO_2 conversion is set to a constant low value (default is 0.2%/hr). Aqueous phase oxidation of SO_2 is represented by an additive term that varies with relative humidity and peaks at 3%/hr at 100% relative humidity. CALPUFF represents the chemical conversion as a linear process because it requires linear independence between puffs, although as explained below, non-linear behavior in nitrate formation can be modeled.

[9] CALPUFF offers two options for parameterizing chemical transformations: the 5 species (SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^-) MESOPUFF-II system and the 6 species RIVAD system (which treats NO and NO_2 separately). IWAQM recommends using the MESOPUFF-II system with CALPUFF. The RIVAD system is believed to be more appropriate for clean environments, however, and therefore was used in the Southwest Wyoming Regional CALPUFF Air Quality Modeling Study in 2001. For the VISTAS region, the IWAQM- and FLM-recommended MESOPUFF-II chemistry is most appropriate.

The IWAQM Phase 2 report concludes that this chemistry algorithm is adequate for representing the gas phase sulfate formation but that it does not adequately account for the aqueous phase oxidation of SO_2. Actual aqueous phase oxidation in clouds or fog can proceed at rates much greater than 3% per hour, leading IWAQM to suggest that sulfate might be underestimated in such situations. However, aqueous phase oxidation depends on liquid water content, not relative humidity. In reality, liquid water does not exist in the atmosphere at relative humidity much below 100%, while the CALPUFF aqueous reaction term produces sulfate at lower relative humidity. This can lead CALPUFF to overestimate sulfate concentrations when the humidity is high but the cloud water that enables aqueous conversion is not present. Therefore, the direction of the bias in the aqueous chemistry simulation of sulfate formation can vary.

Other potential sources of error in the sulfate formation mechanism of CALPUFF include (1) overestimation of sulfate formation when NO_x concentrations in the plume are high and in actuality they deplete the local availability of ozone and hydrogen peroxide for oxidizing the SO_2; and (2) lack of direct consideration of the effect of temperature on the conversion rates, which may cause the model to overstate sulfate formation on cold days (below 10C or 50°F) (Morris et al., 2003). However, in CALPUFF, the effects of temperature are, to some degree, compensated for indirectly by the use of the solar radiation surrogate variable in the empirical conversion equations.

Whether these potential errors are important will depend on the setting. For example, Figure 3-2 shows a comparison of predicted and observed 24-hour sulfate concentrations, due to a large number of SO_2 sources, at the Pinedale IMPROVE site in Wyoming for the 1995 period (Scire et al., 2001). Overall, in this case there was very little bias in the sulfate predictions. Whether CALPUFF predictions would compare as well with measurements in the Southeast remains to be seen.

CALPUFF does not identify the chemical form of the sulfate compound that results from its reactions, which will generally be some form of ammoniated sulfate whose degree of neutralization will depend on the availability of ammonia in the atmosphere. This consideration, which has been found to be relevant for calculating light extinction in the VISTAS region, is not addressed by CALPUFF or CALPOST.

In most applications, the ozone concentrations required for the sulfate formation calculations are derived from ambient measurements, although concentrations simulated by regional models can be used.

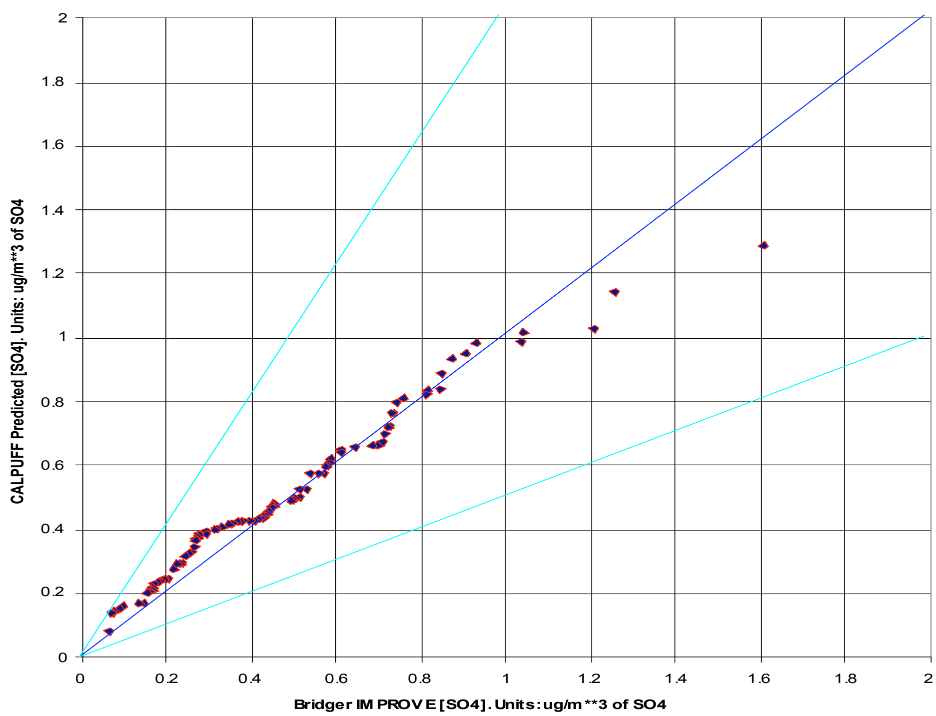

Figure 3-2. Observed vs. CALPUFF-predicted 24-hour sulfate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995.

NO_x and Secondary Ammonium Nitrate

The MESOPUFF-II chemistry algorithm used in CALPUFF simulates the oxidation of NO_x to nitric acid and organic nitrates (both gases) by transformation rates that depend on NO_x concentration, ambient ozone concentration, and atmospheric stability class during the day. The conversion rate at night is set at to a constant value (default is 2.0 %/hr). The temperature- and humidity-dependent equilibrium between nitric acid gas and ammonium nitrate particles is taken into account when estimating the ammonium nitrate particle concentration, an equilibrium that depends on the ambient concentration of ammonia. The user supplies the value of the ambient concentration of ammonia. CALPUFF assumes that the sulfate reacts preferentially with that ammonia to form ammonium sulfate and the left over ammonia is available to form ammonium nitrate.

The IWAQM Phase 2 report considers that this mechanism is adequate for representing nitrate chemistry. Potential situations where this assumption may not be correct, however, include (1) plumes with high concentrations of NO_x that deplete the ambient ozone and thus limit the transformation of NO_x to nitric acid in the plume; and (2) when ambient temperature is below 10 C, and thus the transformation rate is much slower and the nitrate concentration may be lower than that simulated by CALPUFF (Morris et al., 2003). In both cases, CALPUFF may overestimate the amount of nitrate that is produced. In particular, the impact of ammonium nitrate concentrations on visibility at Class I areas in the VISTAS region is greatest in the winter, when temperatures are lowest, the nitrate concentrations are the greatest, and the sulfate concentrations tend to be the least. CALPUFF may overstate the impacts of NO_x emissions at those times, especially in the colder northern states**.** This potential overestimate of nitrate was not evident, however, in an evaluation of CALPUFF-modeled nitrate against actual observational data in the Wyoming study, as shown in Figure 3-3a (Scire et al., 2001),

Another factor in the calculation of nitrate is that CALPUFF makes the full amount of the background concentration of ammonia available to each puff, and that amount is scavenged by the sulfate in the puff. If puffs overlap, then that approach could overstate the amount of ammonium nitrate that is formed in total if, in reality, the combined scavenging by the overlapping puffs at a location would deplete the available ammonia enough that the combined nitrate formation was limited by the availability of ammonia. This effect of such ammonia limiting can be large in summer; for a source 75 km west of Mammoth Cave National Park, one modeling analysis found the maximum light extinction impact of the source to be 7.4% (roughly 0.74 deciviews) at the park when CALPUFF was used without consideration of ammonia limiting and about 30% less, between 5.5 and 5.8% (roughly 0.55 to 0.58 dv), when the effect of ammonia limiting was considered (Escoffier-Czaja and Scire, 2002).

To address the issue, since 1999 (i.e., after the IWAQM Phase 2 report) the CALPUFF system has included the optional POSTUTIL postprocessing program, which repartitions the ammonia and nitric acid concentrations estimated by CALPUFF to reflect potential ammonia-limiting effects on the development of nitrate**.** This allows non-linearity associated with ammonia limiting effects to be included in the CALPUFF model estimates. POSTUTIL computes the total sulfate concentrations from all sources (modeled sources plus inflow boundary conditions) and estimates the amount of ammonia available for total nitrate formation after the preferential scavenging of ammonia by sulfate. That is, as new sulfate, nitrate or ammonia from the source of interest is added to an existing mix of pollutants, POSTUTIL will estimate both the nitrate formed from the new source and the change in background nitrate as a result of the incremental depletion of ammonia (due to the new sulfate and nitrate) or addition of ammonia (from a new source of ammonia).

Reliable estimates of the ambient concentrations of ammonia, especially with the temporal and spatial resolution that would be optimal for use with CALPUFF, are needed to take full advantage of the increased accuracy provided by POSTUTIL. The processor requires estimated concentrations of ammonia throughout the modeling domain and period. Such estimates can be inferred from CASTNet measurements, which are integrated over a week, from 24-hr SEARCH measurements, or from the output of a regional photochemical model such as CMAQ or CAMx. The CASTNet network is fairly sparse and the uncertainty in the ammonia measurements is large, so defining the ammonia concentration throughout the Southeast would require extensive interpolation or extrapolation from the measured values. The quality of the SEARCH measurements is much better, but there are only 8 sites and they do not cover the entire VISTAS domain. Modeled concentrations have the advantage of being resolved in space and time, but their accuracy should be evaluated by comparison with measurements wherever possible.

Benefit is obtained by considering seasonal trends of ammonia and using POSTUTIL to determine the diurnal variability in available ammonia due to the daily cycle of nitrate formation associated with temperature and relative humidity effects. For example, results of the Wyoming study (see Figure 3-3a) show that POSTUTIL adjustments produced daily average nitrate concentrations well within the factor of two lines and with very little mean bias. On the other hand, analysis of the same results with use of constant ammonia of 0.5 ppb or 1.0 ppb produced consistent overpredictions of nitrate by factors of 2-3 and 3-4, respectively, as shown in Figure 3-3b (Scire et al., 2003).

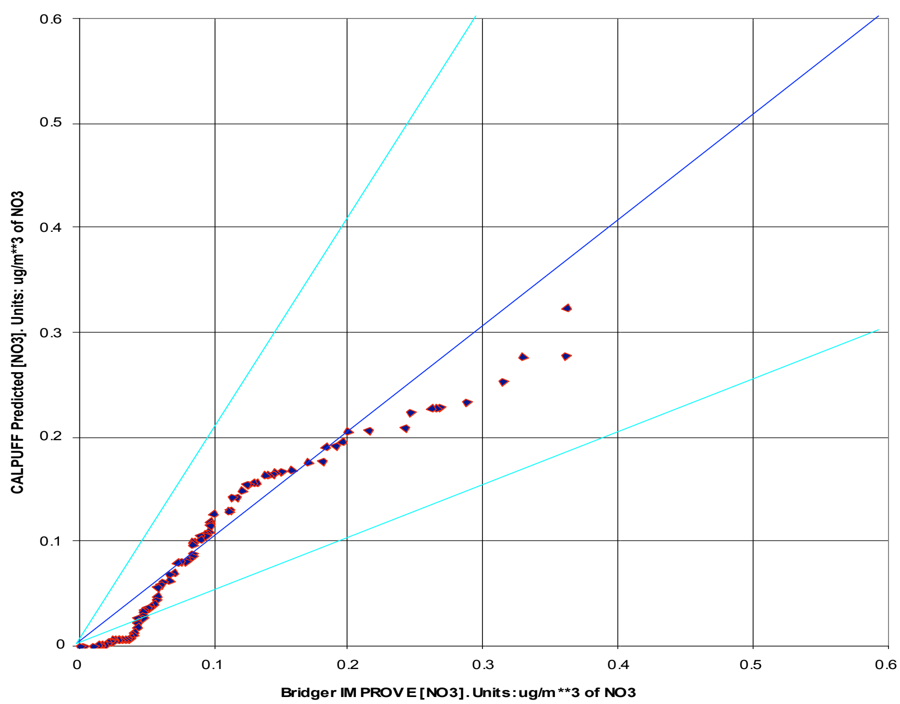

Figure 3-3a. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method. (Scire et al., 2001)

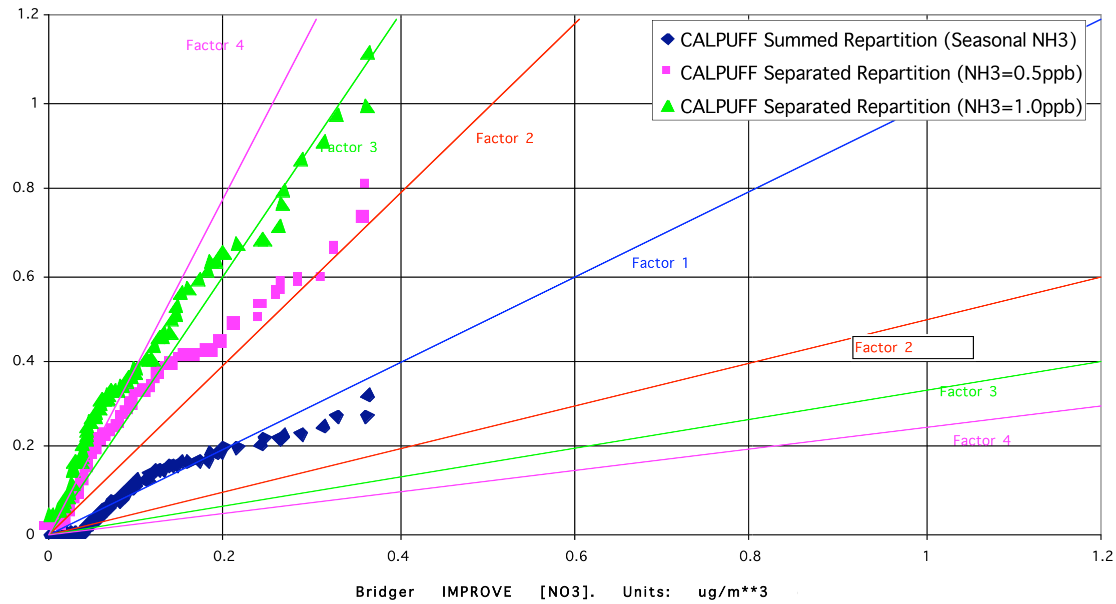

Figure 3-3b. Observed vs. CALPUFF-predicted 24-hour nitrate concentrations at the IMPROVE monitoring site in Pinedale, Wyoming for 1995 using the ammonia limiting method (blue), constant ammonia at 0.5 ppb (pink) and constant ammonia at 1.0 ppb (green). (Scire et al., 2003)

Secondary Organic Aerosol

Ongoing research studies at several Class I areas throughout the country (Fallon and Bench, 2004) and at SEARCH sites in the Southeast (Edgerton et al., 2004) are finding that, typically, 90 to 95% of the rural organic carbon fine particle concentration consists of modern carbon (e.g., that from the burning of vegetation and deriving from VOC emissions from vegetation) and only 5 to 10% is attributable to man's burning of fossil fuels. In addition, a field study at Great Smoky Mountains National Park in August 2002 (Tanner, et al., 2005) found that an average of 83% of the fine carbon was modern carbon

According to IMPROVE measurements, organics account for roughly 10% of the particle-caused light extinction in Class I areas in the Southeast. We can thus conclude that, in general, secondary organic carbon particles derived from anthropogenic fossil fuel burning emissions are unlikely to have a large impact (around 1%) on current visibility. (Man-caused burning of vegetation can have significant localized, short-term impacts, however.)

Current organic fine particle concentrations in the Southeast are typically within a factor of 2 of the 1.4 $\mu g/m^3$ concentration assumed for natural conditions by the EPA, which means that current fossil fuel burning would contribute less than 2% to visibility in an atmosphere that represents natural conditions. Thus, it is unlikely that VOC and organic particle contributions from BART sources will cause a large impact to visibility at Class I areas, but a 5% (0.5 dv) localized impact from a particularly large VOC source cannot be dismissed out of hand.

CALPUFF has only rudimentary capabilities for addressing formation of visibility-impairing organic particles from some forms of volatile organic carbon (VOC). The capabilities that do exist include the following.

First, PM_{10} emissions (such as from power plants) are often divided into filterable and condensable components, with the condensable mass being 100-200% of the filterable mass. For purposes of visibility analyses with CALPUFF, a fraction of the condensable part is typically treated as organic particles, i.e., it is assumed that a fraction of the condensable components in the PM_{10} emissions condense into organic $PM_{2.5}$ particles. The size of this organic fraction varies with process and process equipment, and can range from 20 to 100% of the condensable mass. These fine organic particles can be readily modeled by CALPUFF. (The remaining condensable material may be sulfuric, hydrochloric, or hydrofluoric acid.)

Second, a module that treats the formation of secondary organic particles from organic emissions was recently developed and is now part of the CALPUFF system. (Scire et al., 2001). This simplified secondary organic aerosol (SOA) module is a linear, parameterized representation that is currently considered best suited for biogenic organics. It relies on the conventional wisdom that only hydrocarbons with more than six carbon atoms can form significant SOA (Grosjean and Seinfeld, 1989). For example, according to this rule, isoprene (C_5H_8) does not make SOA but terpenes do, making pine trees more important biogenic contributors to SOA than oak trees.[10]

Limited evaluation of the performance of CALPUFF at simulating SOA with its biogenic SOA module at one IMPROVE site in a regional modeling study in Wyoming found that 95% of 101 estimated 24-hr SOA concentrations were within 2% of the measured values (Scire et al., 2001). This performance seems promising, although the developers view the SOA module as needing more testing and evaluation.

Thus, CALPUFF includes approaches for dealing with condensable VOC emissions that are characterized as condensable PM_{10} and with biogenic VOCs, although the soundness of concentration estimates by these approaches when modeling a plume from a single source is largely untested.[11] The CALPUFF simulation of VOC emissions from sources whose VOC emissions are predominantly anthropogenic is problematic, however. Perhaps the approach used for the simplified biogenic SOA module may be extended to anthropogenic VOCs when speciated VOC emissions information is available. If only those VOCs with more than six carbon atoms are presumed to be of importance, this eliminates many anthropogenic sources of VOC emissions. For example, the fugitive emissions of butane and ethane during petroleum processing

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[10] Recent research suggests that isoprene may be a SOA precursor, however.

[11] Note that neither of these VOC-related simulation approaches is described in the current (Version 5) CALPUFF User's Guide dated January 2001. See the Wyoming report referenced above for a description of this module.

are not important, while aromatic emissions (such as of toluene and xylene) are considered by the SOA module's mechanism. Development, testing, and evaluation would be needed before one could rely on such a module for estimating SOA from anthropogenic SOA emissions, though.

Therefore, to demonstrate the visibility impacts of VOC emissions from BART-eligible sources, means other than CALPUFF will be needed. A technical approach using a regional photochemical model to evaluate visibility impacts of VOC emissions is presented in Section 4.1.3. CALPUFF can be used to estimate the contribution from the primary condensable fraction of PM_{10} emissions, though.

3.2.3 Regional Haze

Calculation of the impact of the simulated plume particulate matter component concentrations on light extinction is carried out in the CALPOST postprocessor. The formula used is the usual IMPROVE/EPA formula, which is applied to determine a change in light extinction due to changes in component concentrations. Using the notation of CALPOST, the formula is the following:

$$b_{ext} = 3\,f(RH)\,[(NH_4)_2SO_4] + 3\,f(RH)\,[NH_4NO_3] + 4[OC] + 1[Soil] + \\ + 0.6[Coarse\ Mass] + 10[EC] + b_{Ray} \qquad (3\text{-}1)$$

The concentrations, in square brackets, are in $\mu g/m^3$ and b_{ext} is in units of Mm^{-1}. The Rayleigh scattering term (b_{Ray}) has a default value of 10 Mm^{-1}, as recommended in EPA guidance for tracking reasonable progress (EPA, 2003a).

There are a few important differences in detail and in notation between the CALPOST formula for estimating light extinction (i.e., Equation 3-1) and that of IMPROVE and EPA. First, the *OC* in the formula above represents organic carbonaceous matter (OMC in IMPROVE's notation), which is 1.4 times the *OC* (i.e., organic carbon alone) in the IMPROVE formula. The *EC* above is synonymous with *LAC* in the IMPROVE formula. CALPOST now offers the option of using the old IMPROVE *f(RH)* curve, whose values are documented in the December 2000 FLAG report, or the *f(RH)* now used by IMPROVE and EPA (as documented in EPA's regional haze guidance documents). Also, CALPOST sets the maximum *RH* at 98% by default (although the user can change it), while the EPA's guidance now caps it at 95%.

The haze index (HI) is calculated from the extinction coefficient via the following formula:

$$HI = 10\,\ln\,(b_{ext}/10) \qquad (3\text{-}2)$$

where *HI* is in units of deciviews (dv) and b_{ext} is in Mm^{-1}. The impact of a source is determined by comparing HI for estimated natural background conditions with the impact of the source and without the impact of the source.

CALPOST Methods

CALPOST uses Equation 3-1 to calculate the extinction increment due to the source of interest and provides various methods for estimating the background extinction against which the increment is compared in terms of percent or deciviews.

For background extinction, the CALPOST processor contains seven techniques for computing the change in light extinction due to a source or group of sources (called Methods 1-7). These are usually reported as 24-hour average values, consistent with EPA and FLM guidance. In addition, there are two techniques for computing the 24-hour average change in extinction (i.e., as the ratio of 24-hour average extinctions, or as the average of 24-hour ratios). A brief summary of the techniques is provided below. Method 2 is the current default, recommended by both IWAQM (EPA, 1998) and FLAG (2000) for refined analyses. Method 6 is recommended by EPA's BART guidance (70 FR 39162).

Methods 4 and 5 use optically measured hourly background extinctions, which represent current actual levels of extinction and thus are not consistent with the "natural conditions" the BART proposal says should be used as a baseline. Methods 1 through 3 and 6 and 7 allow for user inputs of estimated (e.g., natural conditions) background extinction or component concentrations, and thus are consistent with the BART proposal.

Method 1 allows the user to specify a single value of a "dry" background extinction coefficient for each receptor, specify that a certain fraction of that coefficient is due to hygroscopic species, and use relative humidity measurements to vary the extinction hourly via a 1993 IWAQM *f(RH)* curve or, optionally, the EPA regional haze f(RH) curve (EPA, 2003b). The *RH* is capped at 98% or a user-selected value (95% for the EPA curve). The same *f(RH)* is applied to both the modeled sulfate and nitrate.

For an example of the use of Method 1, one could use the dry particle extinction coefficient of 9.09 Mm^{-1} that results from EPA's default natural conditions concentrations, together with an assumption that for natural conditions, say, 0.9 Mm^{-1} (or 10%) of this amount results from hygroscopic ammonium sulfate and ammonium nitrate, and then apply *f(RH)* to this 10%.

In Method 2, user-specified, speciated monthly concentration values are used to describe the background. When applied to natural conditions, for which EPA's default natural conditions concentrations are annual averages, the same component concentrations would have to be used throughout the year (unless potential refinements to those default values resulted in concentrations that vary during the year). Hourly background extinction is then calculated using these concentrations and hourly, site-specific *f(RH)* from a 1993 IWAQM curve (a different one than that in Method 1) or, optionally, the EPA regional haze f(RH) curve.[12] Again the *RH* is capped at either 98% (default) or a user-selected value (most commonly at 95%).

Method 3 is the same as Method 2, except that any hour in which the RH exceeds 98% (or the selected maximum) is dropped from the analysis. When 24-hr extinction is computed, no fewer than 6 valid hours are accepted at each receptor; otherwise the value for the day is tabulated as "missing".

Method 6 is similar to Method 2, except monthly f(RH) values (e.g., EPA's monthly climatologically representative values in EPA (2003a, b)) are used in place of hourly values for calculating both the extinction impact of the source emissions and the background conditions extinction. Hourly source impacts, with the effect on extinction due to sulfates and nitrates calculated using the monthly-average relative humidity in f(RH), are compared against the monthly default natural background concentrations. Thus the monthly-averaged relative humidity is applied to the hygroscopic components (i.e., sulfate and nitrate) of both the source impact and the background extinction with Method 6.

Method 7 is a new variant of Method 2 that was developed as a result of a ruling by the Assistant Secretary of the Interior for Fish and Wildlife and Parks, in response to a New Source Review case in Montana, that "natural conditions" should reflect the visibility impairment caused by significant meteorological events such as fog, precipitation, or naturally occurring haze (DOI, 2003).[13] Under Method 7, during hours when visibility is obscured by meteorological conditions, the actual measured visibility is used to represent natural conditions instead of the value that is calculated from EPA's default natural conditions concentrations under Method 2. A recent modification developed in response to FLM comments on Method 7, in which the daily average natural extinction is calculated somewhat differently, is called Method 7', i.e., "7 prime".

Refined Estimates of Extinction and Natural Background Visibility

Separate from the BART discussions, IMPROVE, EPA, and the Regional Planning Organizations are evaluating whether refinements are warranted to the methods recommended in EPA's guidance to calculate default estimates of natural background visibility. In particular, IMPROVE has recently approved an alternative to the formula (Eq. 3-1) it uses to estimate extinction from particle concentration measurements (Pitchford et al., 2005).

Refinements in the revised IMPROVE formula include the following:

- Adding a sea salt term, including a growth factor due to relative humidity

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[12] Note that the hourly-varying natural background extinction in this method is not consistent with that prescribed by the EPA's natural conditions guidance (EPA, 2003b), for which a "climatologically-representative" f(RH) that only varies monthly is to be used. Method 6 uses these monthly average humidity values.

[13] The Secretary's guidance applies only to Federal Land Managers. EPA's position on this interpretation of natural conditions is unknown.

- Increasing the factor used to calculate the mass of particulate organic matter (OC in Eq. 3-1) from organic carbon measurements

- Modifying the relative humidity growth formula, f(RH), for sulfates and nitrates

- Revising the extinction efficiencies (the numerical constants in Equation 3-1) for sulfates, nitrates, and organic carbon so that they vary with concentration

- Adding a site-specific Rayleigh scattering term to the formula. Values will be calculated by IMPROVE for all Class I areas.

For the purposes of calculating current, future, and natural background visibility at VISTAS Class I areas as part of the reasonable progress analyses, VISTAS intends to present regional air quality modeling results using both the current EPA recommended assumptions and the newly revised aerosol extinction formula. If a BART-eligible source chooses to consider its projected impacts using the newly revised formula as well as the current formula, then modifications would need to be made to CALPOST to carry out calculations with the new algorithm.

4. VISTAS' COMMON MODELING PROTOCOL

4.1 Overview of Common Modeling Approach

In this section, guidance is provided on the use of the CALPUFF modeling system for two purposes:

1) Evaluating whether a BART-eligible source is exempt from BART controls because it is not reasonably expected to cause or contribute to impairment of visibility in Class I areas, and

2) Quantifying the visibility benefits of BART control options.

For purpose 1), States must determine whether a source emits any air pollutant (SO_2, NO_x, PM, and in certain cases VOC and NH_3) that "may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area. The States have 3 options to accomplish this:

A) Conclude that all BART-eligible sources in State are subject to BART.

B) Demonstrate that all BART-eligible sources in the State together do not cause or contribute to any visibility impairment

C) Determine if the impact from each individual BART-eligible source is greater than a threshold value.

VISTAS States intend to follow Option C (determine if the visibility impact from individual sources exceeds a contribution threshold) for SO_2 and NO_x emissions. The methods for Option C are described in Section 4.1.1. In early 2006, VISTAS pursued Option B (demonstrate that all BART eligible sources in a State do not impact visibility) for VOC, NH_3 and PM emissions. The approach and results for Option B are described in Section 4.1.3. As a result of this exercise, the VISTAS States have determined that the Option C exemption analyses should also include PM emissions and, for sources with large NH_3 emissions, NH_3. The States determined that anthropogenic VOC emissions do not cause or contribute to visibility impairment at VISTAS Class I areas and that VOC emissions do not need to be considered in BART analyses.

4.1.1 BART Exemption Analysis

As illustrated in Figure 4-1, three steps will evaluate whether a BART-eligible source of SO_2, NO_x, or PM is subject to BART:

1) VISTAS plans to use Q/d as a presumptive indicator that a source is subject to BART. If Q/d for SO_2 > 10 for 2002 actual emissions, then the State presumes that the source is subject to BART. If the source agrees with this presumption, then no exemption modeling is required and the source can proceed to the BART determination using CALPUFF to evaluate impacts of control options and can perform the engineering analyses. If a source disagrees, the source

may perform fine grid modeling as described in Section 4.4 to determine if its impact is < 0.5 dv.

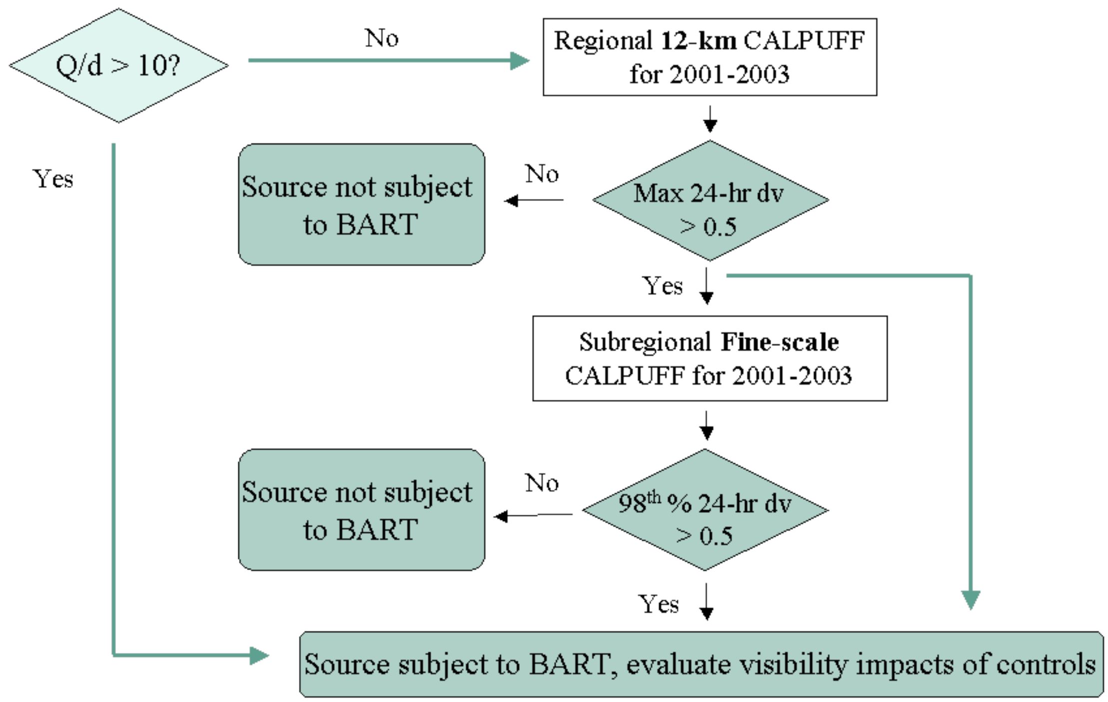

Figure 4-1. Flow chart showing the components of the VISTAS common modeling protocol. Assessment should be made for each Class I Area. (If a source agrees to install the most stringent controls then the modeling steps indicated above and engineering analyses and visibility impact modeling would not be required.)

2) An optional initial modeling assessment using the CALPUFF model with the coarse scale 12-km regional VISTAS domain can be used to answer questions whether (a) a particular source may be exempted from further BART analyses and (b) if finer grid CALPUFF analysis were to be undertaken, which Class I areas should be included. Assumptions for the initial modeling assessment are conservative so that a source that contributes to visibility impairment is not exempted in error. If a source is shown not to contribute to visibility impairment using the initial modeling assessment, the source would not be subject to BART and would be exempted from further BART analyses. If a source is shown to contribute to visibility impairment using the initial modeling assessment, the source has the option to undertake finer grid CALPUFF modeling to evaluate further whether it is subject to BART.

3) A finer grid CALPUFF modeling analysis using a subregional CALMET domain will be the definitive test as to whether a source is subject to BART.

For large sources that will clearly exceed the initial screening thresholds, this step can be skipped and the analysis may proceed directly to the finer grid modeling analysis, which is described in Section 4.4.

4.1.2 BART Control Evaluation

For sources that are determined to be subject to BART controls, part of the BART review process involves evaluating the visibility benefits of different BART control measures. These benefits will be determined by making additional CALPUFF simulations using the same CALMET and CALPUFF configuration as those used in the finer grid analysis of Step 2. The only exception is that the source and emissions data used in the CALPUFF control evaluation simulations will reflect the BART control measures being evaluated. Using the same model configuration will produce an "apples-to-apples" comparison, where differences in impacts are due to the effectiveness of the controls rather than model configuration differences. For example, a control scenario evaluation that uses more conservative assumptions than the base case simulation may produce results showing no or little improvement in visibility impacts. That control scenario run with the same model configuration as the base case may show significant visibility improvement. Therefore, in order to not obscure the response to predicted visibility improvements by differences in the modeling approach, the same model configuration should be used in the BART control evaluation simulation as in the base case simulation.

The base case to which the effectiveness of BART controls is to be compared is the "current emissions" scenario for which the finer grid Step 2 modeling was performed. The postprocessing steps and procedures are the same as in the BART eligibility simulation. Side-by-side comparison of the visibility impacts will be tabulated to quantify the effectiveness of each control scenario relative to the base case.

The modeling evaluation is a unit-by-unit evaluation and can be conducted on a pollutant specific basis. Modeling results are used with the other four statutory factors mentioned in Section 2.1 to decide which control technology, if any, is appropriate. Finally, if a source decides to use the most stringent control technology available, the BART control analysis, including modeling, is not necessary.

4.1.3 VISTAS' Treatment of VOC, NH_3, and PM

Volatile Organic Compounds

CALPUFF is currently not recommended for addressing visibility impacts from VOC because its capability to simulate secondary organic aerosol formation from VOC emissions is not adequately tested, especially for anthropogenic emissions. (Separately, condensable organic carbon can be calculated from PM_{10}.)

VISTAS has performed a weight of evidence analysis to demonstrate, using the CMAQ regional air quality model, that the combined VOC emissions from all point sources (BART-eligible and non-BART) in each State do not contribute to visibility impairment. Emissions sensitivity simulations run for VISTAS by Georgia Institute of Technology using VISTAS' 12 x 12 km grid and CMAQ v 4.3 for episodes in July 2001 and January 2002 demonstrated very low to no response of organic carbon levels and light extinction at Class I areas to changing VOC emissions from all anthropogenic sources in the VISTAS 12-km modeling domain (eastern US). Georgia Tech repeated the sensitivity analyses using the VISTAS 12-km domain and CMAQ v 4.4 with a refined SOA module for summer (Jun 1-Jul 10) and winter (Nov 19-Dec 19) periods in 2002. VOC emissions from all anthropogenic point sources in every VISTAS State were reduced by 100% (i.e., eliminated). The maximum 24-hr impact of all VOC emissions from all point sources throughout the VISTAS domain was thus determined to be less than 0.5 dv (compared to annual average natural background) at every Class I area in the VISTAS domain and in adjacent States. It follows that the impact of any one BART-eligible source would be much less than 0.5 dv. Based on these analyses, the VISTAS States have concluded that VOC emissions from BART sources do not cause or contribute to visibility impairment and do not need to be included in BART analyses.

Ammonia

EPA has given states the option to address ammonia (NH_3) emissions from BART-eligible sources. VISTAS also contracted with Georgia Tech to calculate NH_3 emissions sensitivities using CMAQ v 4.4 with a refined SOA module and the same Jun-Jul and Nov-Dec periods in 2002 that were used for the VOC sensitivity evaluation. The NH_3 emissions from all point sources (BART-eligible and not-BART) in every State were reduced by 100% for these analyses. This sensitivity evaluation showed that the collective impact of all VISTAS region point NH_3 emissions is greater than 0.5 dv (compared to annual average natural background) at several Class I areas. When the NH_3 emissions were scaled to represent 100% reduction from only the BART-eligible sources in each State, then the maximum impact of those sources was under 0.5 dv at most, but not all Class I areas. The high values appear to result primarily from emissions from 13 large NH_3 sources. In the absence of those 13 facilities, the scaled NH_3 emissions peak impacts at Class I areas were 0.3 dv or less. Based on these analyses, the VISTAS States recommended that, except for these 13 facilities, NH_3 emissions not be included in BART modeling. States will provide instructions to those 13 sources as to how to evaluate contributions of their NH_3 emissions to visibility impairment. For documentation purposes, in summer 2006 VISTAS is repeating the NH_3 emissions sensitivity calculations, using CMAQ v4.5 with Base F emissions and reducing 100% of NH_3 emissions from only the BART-eligible sources in the VISTAS states.

Primary Particulate Matter

Primary particulate matter is considered a visibility impairing pollutant. However, the extent to which primary PM from BART-eligible sources contributes to impairment at Class I areas in the southeastern US is not clear. For EGUs, the EPA has determined that emissions reductions of SO_2 and NO_x under the CAIR rule meet the BART requirements, but these EGUs may still be subject to BART for primary PM. To determine the potential impacts of PM from EGU and non-EGU sources in the VISTAS states, two CMAQ sensitivity runs for the first and third quarters of 2002 were carried out by VISTAS' CMAQ modeling team of ENVIRON, UCR, and Alpine

Geophysics In one run, all primary PM from EGUs was removed while in the other run all primary PM from non-EGU sources was removed. All other CMAQ modeling components were held constant. At almost all Class I areas in the VISTAS region, primary PM emissions contribute to regional haze, with the collective impact of all EGU and non-EGU point primary PM emissions being greater than 0.5 dv compared to annual average natural background. In fact, the impacts of EGU PM emissions alone or of non-EGU PM emissions alone were each mostly greater than 0.5 dv. Although the impacts of BART sources alone would be smaller, the VISTAS States have concluded that all BART-eligible sources need to consider the impacts of their PM emissions.

4.2 Optional Source-Specific Modeling

In some circumstances, a source may want to apply techniques designed to evaluate the impacts in a more detailed way than the standard VISTAS common protocol. A source may propose source-specific modeling procedures to address special issues to the State for State review. For example, sources very close to Class I areas may be better treated by a finer grid resolution that the generic Step 2 "fine" grid resolution meteorological fields provided by VISTAS. In some situations, higher resolution MM5 or other prognostic meteorological datasets may be available than the standard 12-km or 36-km MM5 datasets provided by VISTAS. Because it is not possible to anticipate all of the situations where there would be a benefit to conducting more detailed source-specific analyses, the option to pursue this option is left as an open issue, to be resolved and justified based on specific factors relevant for the source in question.

A source-specific modeling protocol is required for each source. This document should describe the data sources and model configuration, and provide rationale for any changes in the model approach from the common protocol. This source-specific protocol must be provided for review and approval by the State. The State will share the protocol with EPA and the Federal Land Managers for their review. Discussion of approaches to source-specific modeling and an outline of the typical contents of the source-specific protocol are presented in Chapter 5. Discussions with the regulatory authorities should be conducted prior to development of a source-specific protocol to ensure all of the relevant issues are included in the protocol.

4.3 Initial Procedure for BART Exemption

4.3.1 Overview of Initial Approach

The first step in the common protocol, the initial assessment in Figure 4-1, is a simple procedure to evaluate whether a source can be exempted from BART controls using a consistent set of meteorological and dispersion options. A pre-computed set of meteorological files and a pre-defined CALPUFF input option configuration, based on guidance in the final BART rule (70 FR 39104-39172) and other EPA and FLAG model guidance, will allow relatively simple initial simulations. The regional initial domain is designed to allow any Class I areas within the VISTAS area to be evaluated with a single meteorological database and consistent CALPUFF modeling options. The second important question that this first screening step will answer is, if initial modeling indicates a source may impact visibility significantly, what Class I areas should be included in a finer grid analysis? Due to the multitude of factors affecting the contribution of a source to visibility in a Class I area, simple screens or rules of thumb alone (such as that the closest Class I area will produce the controlling visibility impacts) are not likely to be universally reliable.

4.3.2 Discussion of 12-km Initial Exemption Modeling

Meteorological Fields

A regional initial domain and a set of pre-computed regional CALMET meteorological files will be prepared for VISTAS, to allow any Class I areas within the VISTAS area to be evaluated with a consistent meteorological database and consistent CALPUFF modeling options.

The following three years of MM5 meteorological data have been assembled by VISTAS for use in the regional CALPUFF modeling effort:

- 2001 MM5 dataset at 12 km and 36 km grid (developed for EPA)
- 2002 MM5 dataset at 12 km and 36 km grid (developed by VISTAS)
- 2003 MM5 dataset at 36 km grid (developed by the Midwest Regional Planning Organization).

These data sets have been provided to Earth Tech by VISTAS, and from them Earth Tech has produced annual CALMET meteorological files at 12-km grid resolution for the domain shown in Figure 4-2. The CALMET modeling output files in the form of CALPUFF-ready three-dimensional meteorological files will be available on external hard drives to the States and other parties.

The initial procedure to determine if a BART-eligible source is subject to BART uses the pre-computed CALMET meteorological fields for the years 2001-2003 on the 12-km CALMET domain in Figure 4-2 and simulates with CALPUFF any BART-eligible source to be screened. The CALMET simulations will be developed using the highest resolution MM5 data available for each year (i.e., 36-km MM5 data for 2003, 12-km MM5 data for 2001 and 2002).

The development of the regional CALMET meteorological fields from MM5 data will be conducted in No-Observations (“No-Obs”) mode. The MM5 data already reflect assimilation of observational data and are likely to adequately characterize regional wind patterns that are consistent with the 12-km grid scale. Blending of MM5 data with local observations (which are mainly at the surface) could lead to wind structures that may not be realistic under some conditions and may result in poorer characterization of the regional winds. Thus, the effort required to prepare observational data sets for CALMET for the large regional domain involves considerable effort that may not provide corresponding improvement of the wind field.

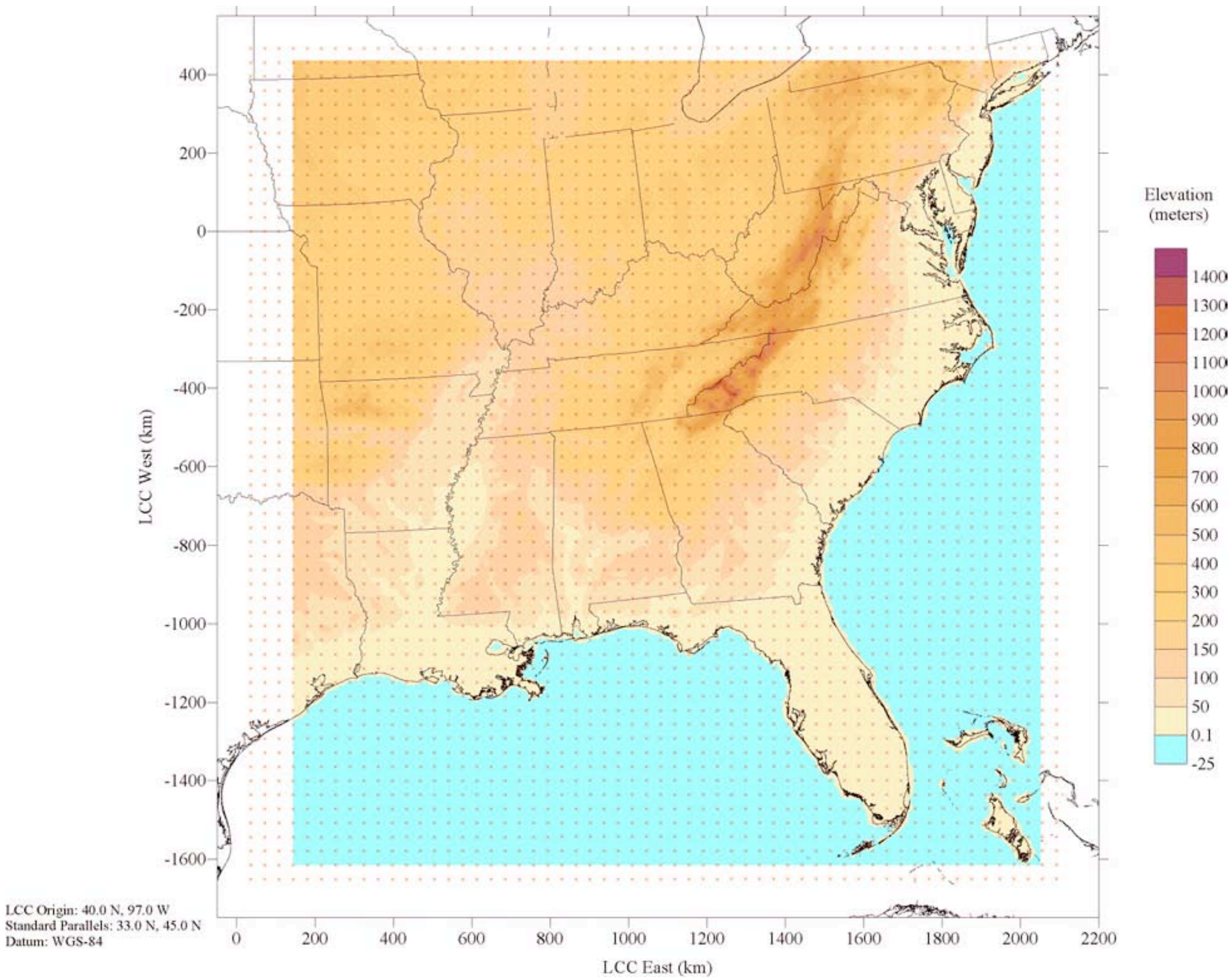

Figure 4-2. VISTAS Regional 12-km Resolution CALMET Modeling Domain (color area with terrain contours). The locations of the 36-km resolution MM5 grid points are shown on the plot.

For 2003, the 36-km MM5 data will be used as CALMET's initial guess field and then the CALMET diagnostic terrain adjustments (see Section 3.1.1) will be applied to reflect terrain on the scale of the CALMET grid (i.e., 12-km). When the 12-km MM5 (2001 and 2002) data are used, the diagnostic CALMET terrain adjustments will be turned off since the grid resolution of the MM5 data is the same as the CALMET grid and the terrain adjustments on the 12-km grid scale will already be reflected in the MM5 dataset. In this case, the MM5 winds will be interpolated by CALMET to the CALMET layers and CALMET's boundary layer modules will compute mixing heights, turbulence parameters and other meteorological parameters that are required by CALPUFF.

Impact Threshold

The final BART guidance recommends that the threshold value to define whether a source "contributes" to visibility impairment is 0.5 dv change from natural conditions[14] (although States may set a lower threshold). The 98th percentile (8th highest annual) 24-hr average predicted impact at the Class I area, as calculated using CALPOST Method 6 (monthly average relative humidity values), is to be compared to this contribution threshold value. For this comparison, the predicted impact at the Class I area on any day is taken to be the highest 24-hr average impact at any receptor in the Class I area on that day. (Note that the receptor where the highest impact occurs can change from day to day.) According to clarification of the BART guidance received from EPA, for a three-year simulation the modeling values to be compared with the threshold are the greatest of the three annual 8th highest values or the 22nd highest value over all three years combined, whichever is greater.

For the purposes of the initial analysis, however, the *highest value* over the three-year period (not the 98th percentile value) is to be compared to the contribution threshold. This ensures a significant measure of conservatism in the initial approach. VISTAS will evaluate the initial CALPUFF results to determine if using the single highest value provides too conservative a screen for exemption purposes. If so, VISTAS may increase the number of exceedances of the contribution threshold that would be allowed and still qualify to exempt a source.

4.3.3 Model Configuration and Settings for Initial Analysis

VISTAS will use CALPUFF Version 5.754 and CALMET Version 5.7. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They were developed by Earth Tech, Inc. and they are maintained on the CALPUFF website (www.src.com) for public access. This version includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

The initial analysis uses a CALPUFF computational domain that includes all Class I areas within 300 km of a source. These Class I areas are specified in the CALPUFF control file for analysis. States could decide to require a different value for the maximum distance threshold for the CALPUFF domain, depending on the locations of the Class I areas in their states and other factors such as meteorological conditions and the magnitudes of the emissions from BART-eligible sources. The regional CALMET domain will be unchanged by these adjustments.

Also, the initial approach is designed to significantly reduce the CALPUFF simulation time by restricting the CALPUFF computational domain size to include only areas where significant impacts are feasible rather than the entire regional domain. CALPUFF allows its computational domain to be specified as a subset of the CALMET meteorological domain by settings within the

[14] As described in Footnote 5 on page 6, States have the option of defining natural conditions as either the annual average default conditions or the average of the 20% best natural condition days.

CALPUFF input file. The advantage of selecting a smaller CALPUFF computational domain in the regional CALPUFF simulations is that CALPUFF run time is proportional to the number and residence time of the puffs on the domain (and other factors such as the number of receptors and the internal time step computed by the model). A CALPUFF domain covering an area 300 km from a source in all directions would involve only 50 x 50 12-km grid cells, which will require modest computational resources.

CALMET output files for the VISTAS regional domain shown in Figure 4-2 will be provided to VISTAS by Earth Tech. These files will be in CALPUFF-ready format, and as such, no CALMET user inputs will be required. An option in CALMET allows finer grid CALMET input files to be calculated from the 12-km CALMET files.

The basic characteristics of the CALMET, CALPUFF and CALPOST configurations for the initial analyses are listed below.

CALMET Modeling Configuration (12-km initial exemption modeling)

The CALMET model configuration for the regional CALMET simulations will be defined by Earth Tech in collaboration with the VISTAS States. The basic model configuration will follow the recommended IWAQM guidance (EPA, 1998; Pages A-1 through A-6), except as noted below.

The basic features of the modeling simulation are the following:

- Modeling period: 3 years (2001-2003)

- Meteorological inputs: MM5 data provide initial guess fields in CALMET

- CALMET grid resolution: 12-km (same Lambert Conformal coordinate system and grid cells as the 12-km 2001/2002 MM5 simulations)

- CALMET vertical layers: 10 layers. Cell face heights (meters): 0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000.

- CALMET mode: No-Observations mode including option to read overwater data directly from MM5.

- Diagnostic options: IWAQM default values, except as follows: diagnostic terrain blocking and slope flow algorithms used for 2003 simulations (using 36-km MM5 data), but no diagnostic terrain adjustments in 2001 and 2002 simulation (using 12-km MM5 data)

- CALMET options dealing with radius of influence parameters (R1, R2, RMAX1, RMAX2, RMAX3), BIAS, ICALM parameters are <u>not used</u> in No-Observations mode.

- TERRAD (terrain scale) is required for runs with diagnostic terrain adjustments (i.e., the 2003 simulations). Values of ~10-20 km will be tested, and an appropriate value determined.

- Land use defining water: JWAT1 = 55, JWAT2 = 55 (large bodies of water). This feature allows the temperature field over large bodies of water such as the Atlantic Ocean and the Great lakes to be properly characterized by buoy observations.

- Mixing height averaging parameter (MNMDAV) will be determined by Earth Tech for the regional simulations based on sensitivity tests. The purpose of the testing is to optimize the variable to allow spatial variability in the mixing height field, but without excessive noise.

- Geophysical data for regional runs: SRTM-GTOPO30 30-arcsec terrain data, Composite Theme Grid (CTG) USGS 200m land use dataset. References for these and other CALMET datasets can be found on the CALPUFF data page of the official CALPUFF site (www.src.com).

CALPUFF Modeling Configuration (Initial exemption modeling)

The CALPUFF model configuration for the regional CALPUFF initial simulations will follow the recommended IWAQM guidance (EPA, 1998; Pages B-1 through B-8), except as noted below:

- CALPUFF domain configured to include the source and all Class I areas within 300km of the source plus 50km buffer zone in each direction. CALPUFF is recommended for all source-receptor distances to be considered in the BART analyses.

- Chemical mechanism: MESOPUFF II module

- Species modeled: SO_2, SO_4, NO_x, HNO_3, NO_3 and particulate matter in size categories of <0.625 µm, 0.625-1.0 µm, 1.0-1.25 µm, 1.25-2.5 µm, 2.5-6.0 µm and 6-10 µm aerodynamic diameters. As noted below, the particulate matter emissions by size category will be combined into the appropriate species for the visibility analysis (i.e., elemental carbon (EC), fine PM or "soil" (< 2.5 µm in diameter), coarse PM (between 2.5-10 µm in diameter) and organics (called secondary organic aerosols (SOA) in the CALPOST postprocessor).

- Emission rates for modeling based on EPA BART guidance, i.e., maximum 24-hour actual emission rate with normal operations from the highest emitting day of the meteorological period modeled (excluding days where start-up, shutdown or malfunctions occurred sometime during the day.) Note that potential emissions are used to determine if a source is BART-eligible, but 24-hour average maximum emissions are used for modeling purposes (70 FR 39162). Pollutants considered include SO_2, H_2SO_4, NO_x and PM_{10}.

Condensable emissions are considered as primary fine particulate matter and allocated equally to the two submicrometer-particle size classes. If actual source emissions data are not available, the modeling should be based on permit limits. If source-specific size categories are not available, then AP-42 factors may be used for sources where AP-42 factors are available. For sources where AP-42 factors are not available, alternative approaches to speciation are given below.

Excluded from the modeling are pollutants with plant-wide emissions less than *de minimis* levels (40 tons per year for SO_2 and NO_x and 15 tons per year for PM_{10}). *De minimis* levels are plant wide for each visibility-impairing pollutant, so individual units may be modeled even if they have emissions below *de minimis* if the plant total is greater than *de minimis*.

- Particulate emissions speciation: Break down, as appropriate, filterable and condensable particulate matter into the following species categories: elemental carbon (soot), "soil" (fine PM < 2.5 µm diameter), coarse particulate matter (2.5-10 µm diameter) and organics. The process is illustrated in Figure 4-3. If source-specific speciated emissions factors are not available, AP-42 factors or speciation information developed by the National Park Service (http://www2.nature.nps.gov/air/permits/ect/index.cfm) can be used to estimate the PM speciation for many source sectors.

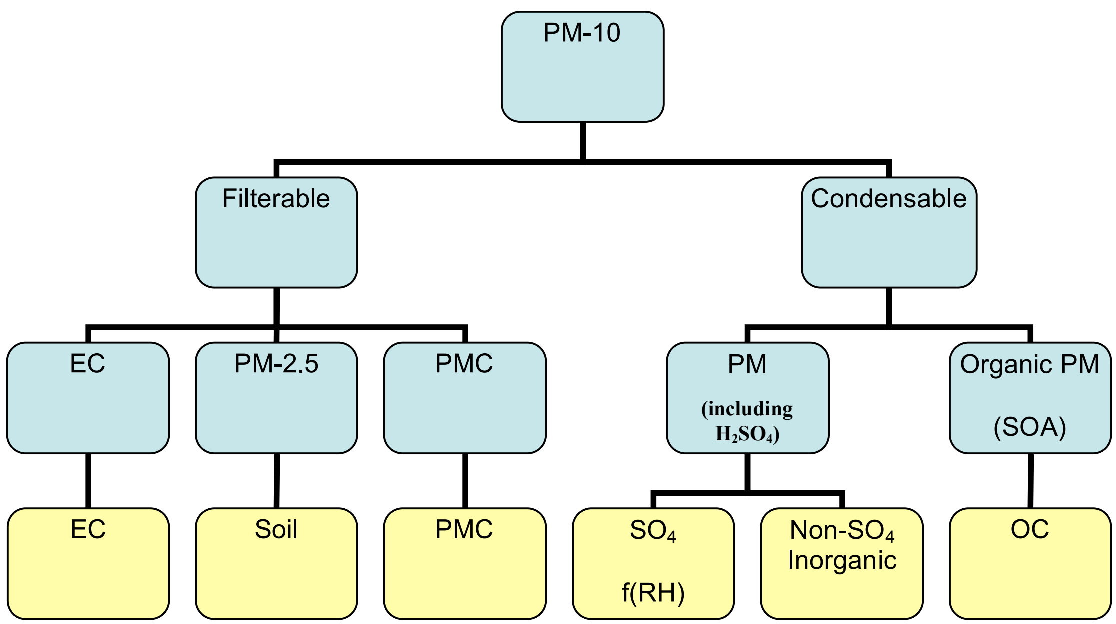

Figure 4-3. Speciation of PM-10 Emissions. (PMC is coarse particulate matter -- 2.5 to 10 µm diameter.)

Otherwise, assumptions will need to be proposed by the source, and reviewed and approved by the State. Possible acceptable alternative approaches to estimating speciation include the following:

- Speciation profiles developed by the SMOKE emissions model for use in VISTAS' CMAQ regional air quality modeling (available at http://www.vistas-sesarm.org/BART/calpuff.asp).

- The approach described in a memo available at http://www.vistas-sesarm.org/BART/calpuff.asp, which provides reasonably conservative estimates in situations where data are incomplete.

- Class I receptors: Use FLM Class I receptor list with receptor elevations provided (available from the NPS).

- CALPUFF model options: Use IWAQM (EPA, 1998) default guidance, including Pasquill-Gifford dispersion coefficients.

- Ozone dataset – use observed ozone data for 2001-2003 from CASTNet and AIRS stations. Only non-urban ozone stations should be used in the OZONE.DAT file. Monthly average ozone (backup) background values are to be computed based on daytime average ozone concentrations from the OZONE.DAT file (6am-6pm average ozone concentrations computed by month).

- Background ammonia concentration: In CALPUFF, use constant (0.5 ppb) value for ammonia.

- Puff representation: integrated puff sampling methodology.

- Building downwash: Ignore building downwash unless source is within 50-km of a Class I area and the State instructs the source to specifically consider building downwash.

CALPOST and POSTUTIL Configuration (Initial exemption modeling)

- Use Visibility Method 6 in CALPOST

- Species considered in visibility analysis: SO_4, NO_3, EC, SOA (i.e., condensable organic emissions), soil, coarse PM

- Natural background light extinction: Several options are acceptable at the discretion of the State: (1) A single annual average natural background extinction for each Class I area, as presented in Appendix B of EPA's natural conditions guidance (EPA, 2003b); (2) A single value that represents the average haze index on the 20% best natural conditions days, again as presented in the same Appendix B; or (3) A monthly average natural background as calculated by CALPOST under Method 6, based on annual average default natural conditions component concentrations and monthly average f(RH) values for the centroid of the Class I area, from Table A-3 in the natural conditions guidance document,.

A special procedure is needed for options 1 and 2, since CALPOST requires input of natural background concentrations of PM components while the backgrounds for options 1 and 2 are expressed in EPA's guidance document as extinction coefficients or haze indices (in deciviews). In order to produce the appropriate natural background in CALPOST for these options, use Equation 3-2 to calculate the extinction coefficient that corresponds to EPA's haze index value for the Class I area (if necessary), subtract the Rayleigh scattering value of 10 Mm^{-1}, and enter a soil concentration (in $\mu g/m^3$) into CALPOST that is numerically equal to this result. (Since the extinction efficiency of soil is 1 m^2/g, Equation 3-1 shows that this process produces a background extinction that equals the EPA's value.) Leave the concentrations of all other species blank, since the number that is entered represents extinction by all components.

- Light extinction efficiencies: Use EPA (2003a) values. If a source chooses, the new IMPROVE algorithm for calculating light extinction (see Section 3.2.3) may be used in addition to the default IMPROVE algorithm. (Calculations would need to be performed outside CALPOST or CALPOST would need to be modified to accommodate the new algorithm.)

- Nitrate repartitioning in POSTUTIL: Do not use for the initial modeling.

The initial run results will be based on the highest change in light extinction (deciviews) from natural conditions over the three-year modeling period for each Class I area considered. Predicted changes exceeding the "contribution" threshold (0.5 deciviews) will trigger a finer grid CALPUFF modeling analysis.

4.4 Finer Grid Modeling Procedures

4.4.1 Rationale for and Overview of Finer Grid Modeling Approach

There are two potential applications for finer grid CALPUFF modeling:

BART Exclusion Modeling. First, finer grid CALPUFF modeling can be used to demonstrate that a source does not cause or contribute to visibility impairment in any Class I areas, and thus can be excluded from BART controls. As shown in Figure 4-1, if the initial regional modeling results are not below the threshold for visibility impacts, the next step is to conduct modeling using a finer grid resolution for the meteorological fields and the treatment of terrain effects and land use variability. In the finer grid modeling the predicted visibility impairment that is compared to the threshold is based on the BART guidance of the 98^{th} percentile change in deciviews value rather than the more conservative highest value used in the initial analysis.

The BART guidance indicates that the emissions rate to be used for such modeling is the highest 24-hr rate during the modeling period. Depending on the availability of source data, the following emissions information (listed in order of priority) should be used with CALPUFF for BART exclusion modeling:

- 24 hr maximum value emissions for the period 2001-2003 (Continuous Emission Monitor, CEM data)
- 24 hr maximum value from continuous emissions monitoring data
- facility stack test emissions
- potential to emit
- permit allowable emissions, if available
- emissions factors from AP-42 source profiles

Quantify Benefits of BART. The second application of refined modeling is to quantify the visibility benefits from the BART control options. This is accomplished by running CALPUFF with the baseline emissions rates and again with emissions after BART controls. It is important that emission reductions be evaluated in the postprocessing step rather than by using "negative" emission rates in the CALPUFF model. The chemical scheme requires that emission rates always be positive.

For any of these applications, a source-specific modeling protocol that defines source properties and the specific model configuration is required. As discussed in Section 5, the source specific protocol should include source-specific emissions data and can refer to this document for all methods and assumptions that follow this common protocol.

4.4.2 Model Configuration and Settings for Finer Grid Modeling

Grid resolution substantially better than 12-km is needed for a finer grid CALPUFF assessment of visibility impacts in most cases involving Class I areas in complex terrain or coastal areas. Thus, the CALMET fine grid resolution in the subregional modeling domains used for finer grid modeling will depend on the terrain, land use (especially coastal boundaries), location of the source, distance of the source from Class I areas, and total size of the subregional modeling domain.

VISTAS States have 2001-2003 CALMET files for five 4-km sub-regional domains as illustrated in Figure 4-4. The subdomains are designed to address all BART eligible sources within each VISTAS states and all Class I areas within 300 km of the BART-eligible sources. For application for a single source, a smaller domain of roughly 200-300 km by 200-300 km is recommended. Requests to obtain the 4-km CALMET files should be made to the State BART representatives.

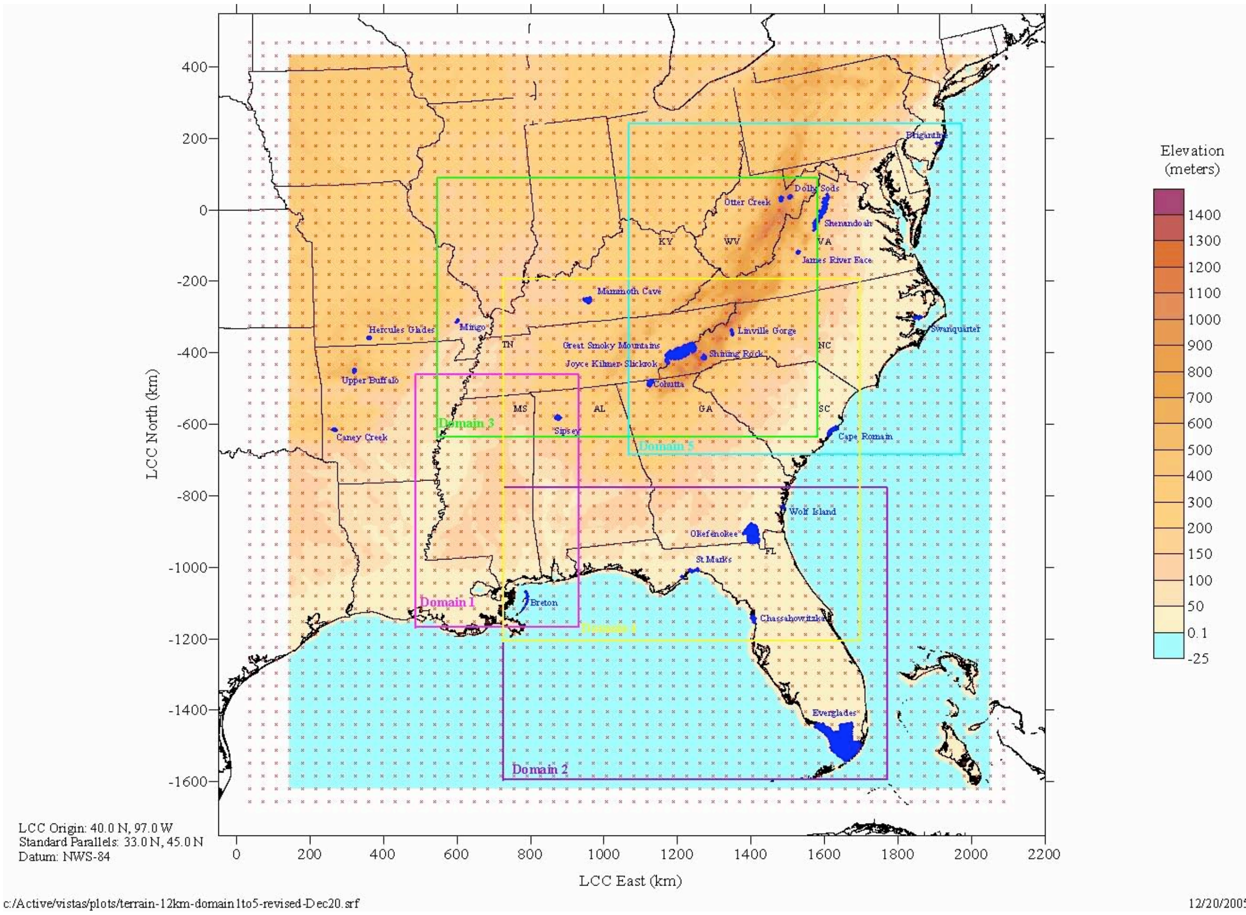

Figure 4-4. The five subregional domains for 4-km CALMET modeling.

In some instances, as part of the source-specific protocol, a source may propose to the State to use an even finer grid simulation to properly characterize the flow fields and land use changes that affect dispersion. An application for source-receptor distances within about 50 km may require a grid resolution less than 1 km if complex terrain effects are likely to be important. This determination should be made on a case-by-case basis. There is not a single distance at which a particular grid size is appropriate. It depends on factors such as the complexity of the terrain, the source-receptor distances involved, the location of the source relative to the terrain features, the physical stack parameters (e.g., a tall stack in complex terrain may be unaffected by the terrain-forced flow), proximity of the source and Class I area to a coastline, and other factors including availability of representative observational data.

The finer grid CALMET simulations were run in hybrid mode, using both MM5 data to define the initial guess fields and meteorological observational data in the Step 2 calculations. Overwater (buoy) data will be provided in addition to the hourly surface meteorological observations, precipitation observations and twice-daily upper air sounding data.

A domain-specific set of modeling parameters will be defined for each subregional domain. The proper selection of the CALMET diagnostic wind field parameters that are used to blend observations with the Step 1 wind field depends on factors such as the locations of the meteorological stations relative to terrain and coastal features (which affects the representativeness of the observational data), the terrain length scale, and the quality (resolution) of the MM5 data used to define the initial guess field and its ability to properly resolve wind flows on the fine-scale CALMET domain. The definition of the proper CALMET parameters is done as part of sensitivity testing where model performance is evaluated against available observations and expected terrain effects, such as channeling of flows within a valley.

In addition to the better grid resolution and the introduction of observational data in the finer grid simulations, several other modeling refinements can enhance the accuracy of the finer grid modeling. These include use of the higher resolution terrain DEM data (~3 arc sec USGS data) in defining the gridded terrain fields and application of the ammonia limiting method in the POSTUTIL post-processor. Otherwise, the source configuration, emissions, pollutant speciation, Class I receptors, ozone datasets and CALPUFF model options will be the same as in the initial runs. Similarly, CALPOST will be used in the same manner as for the initial analyses. However, POSTUTIL can be used to repartition nitrate in the finer grid modeling, using background ammonia concentrations according to the IWAQM Phase 2 report (IWAQM, 1998).

For the finer grid BART exclusion analysis, the test for evaluating whether a source is contributing to visibility impairment is based on the 98^{th} percentile modeled value (rather than the highest predicted value used for the initial evaluation), which is consistent with EPA's BART guidance.

4.5 Presentation of Modeling Results

The CALPOST processing computes the daily maximum change in deciviews. A sample of the summary table produced by CALPOST is shown in Table 4-1. For evaluating compliance with the VISTAS screening threshold, the highest change in extinction value, located at the bottom of the CALPOST list file is compared to the threshold value (e.g., 0.5 dv). For example, in the sample shown in Table 4-1, the summary at the bottom shows that the highest visibility impact is 1.219 dv, with 9 days over the year showing values greater than 0.5 dv. Therefore this source would not pass the initial analysis, and finer grid modeling would be required.

In addition to the highest change in deciview value on each day over all the receptors in a particular Class I area, the CALPOST summary table in Table 4-1 contains the coordinates of the receptor, receptor type (D indicates discrete receptors), the total haze level (background + source, in dv), the background haze in deciviews, the change in haziness (delta dv), the humidity term applied to hygroscopic aerosols (f(RH)), and the contribution of each species to light extinction (in percent of the total source contribution) for SO_4, NO_3, organics, elemental carbon, coarse and fine particulate matter.

Table 4-1. Example of CALPOST Output, Showing Maximum Daily Impacts of Source and Locations of Those Impacts.

YEAR	DAY	HR	RECEPTOR	COORDINATES (km)		TYPE	DV(Total)	DV(BKG)	DELTA DV	F(RH)	%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF
2001	2	0	3	20.540	79.782	D	5.397	5.358	0.039	4.314	44.33	47.22	3.07	1.07	0.00	4.30
2001	3	0	9	31.680	79.822	D	4.566	4.421	0.145	1.767	40.75	33.89	9.19	3.24	0.00	12.94
2001	4	0	1	24.723	77.951	D	4.540	4.540	0.000	2.076	0.00	0.00	0.00	0.00	0.00	0.00
2001	5	0	77	30.228	94.571	D	4.950	4.939	0.011	3.144	43.13	44.74	4.64	1.45	0.00	6.05
2001	6	0	1	24.723	77.951	D	5.181	5.166	0.015	3.772	38.58	56.05	1.90	0.70	0.00	2.76
2001	7	0	3	20.540	79.782	D	6.366	5.745	0.620	5.439	44.98	44.99	3.69	1.26	0.00	5.08
.																
.																
.																
2001	363	0	113	27.414	103.782	D	5.725	5.652	0.073	5.164	53.49	35.51	4.03	1.39	0.00	5.58
2001	364	0	113	27.414	103.782	D	6.554	6.521	0.033	7.826	48.12	47.09	1.67	0.64	0.00	2.48
2001	365	0	1	24.723	77.951	D	6.499	6.499	0.000	7.757	0.00	0.00	0.00	0.00	0.00	0.00

```
 --- Number of days with Delta-Deciview  =>   0.50:         9
 --- Number of days with Delta-Deciview  =>   1.00:         2
 ---             Largest Delta-Deciview  =             1.219
```

For the finer grid analysis, the data in the table can be imported into a spreadsheet and sorted on the delta dv column. Table 4-2 shows an example of the ranked visibility impacts (change in dv) for each of three years at six different Class I areas. The 98th percentile (8th highest value) in the sorted table would be compared to the contribution threshold (e.g., 0.5 dv). In the example shown in this table, the source passes the finer grid analysis because the highest 98th percentile visibility impact is below the contribution threshold of 0.5 dv.

The Results section of the CALPUFF modeling report should contain the following information:

1. Map of source location and Class I areas within 300 km of the source

2. For the VISTAS 12-km CALPUFF initial exemption modeling domain, a table listing all Class I areas in the VISTAS domain and those in neighboring states and impacts at those Class I areas within 300 km of the source, as illustrated in Table 4-3**.**

3. A discussion of the number of Class I areas with visibility impairment from the source on 98th percentile days in each year greater than 0.5 dv (total visibility impairment minus impairment on 20% best days for natural background visibility equals delta-dv, the visibility impact attributed to the source).

4. For the Class I area with the maximum impact, discussion of the number of days below the 98th percentile that the impact of the source exceeds 0.5 dv, the number of receptors in the Class I area where the impact exceeds 0.5 dv, and the maximum impact.

5. For finer grid CALPUFF exemption modeling, results for those Class I areas for which impacts of the source exceeded 0.5 dv in the 12-km initial exemption modeling. Report same results as provided for 12-km initial exemption modeling.

6. For control option modeling, each control option tested should be listed in tabular format. For each control option and for each Class I area where the impact of the source exceeded 0.5 dv, report the change in pollutant emissions and the change in visibility impact from the source as a result of the control option. The effectiveness of candidate control options are to be compared to each other, not to a specific target improvement.

   States will provide further guidance on graphic presentation of results to simplify evaluation of effectiveness of control measures. For example, a temporal plot of the change in deciviews between the controlled and uncontrolled cases could be developed for the receptor with the maximum modeled impact in each Class I area.

7. Copies of all input files and input data in electronic format for the CALMET, CALPUFF, CALPOST and POSTUTIL runs should be archived and provided to the State.

Table 4-2. Example of Visibility Impact Rankings at Six Class I Areas

Class I Area	2001	2002	2003
	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8	Delta-Deciview Ranks 1-8
Great Smoky NP	0.99	0.95	1.20
	0.88	0.63	0.90
	0.62	0.51	0.73
	0.59	0.50	0.72
	0.55	0.46	0.59
	0.52	0.42	0.47
	0.48	0.37	0.45
	0.47	0.36	0.42
Linville Gorge	0.67	0.81	0.76
	0.45	0.69	0.47
	0.43	0.65	0.37
	0.33	0.50	0.35
	0.29	0.45	0.31
	0.27	0.33	0.30
	0.25	0.31	0.28
	0.23	0.29	0.28
Shining Rock	0.66	0.73	0.75
	0.43	0.69	0.45
	0.41	0.63	0.36
	0.35	0.52	0.34
	0.26	0.46	0.28
	0.24	0.34	0.27
	0.23	0.29	0.26
	0.22	0.26	0.25
Cohutta	0.26	0.54	0.61
	0.23	0.47	0.42
	0.22	0.43	0.30
	0.21	0.37	0.29
	0.20	0.37	0.28
	0.19	0.31	0.28
	0.18	0.31	0.25
	0.16	0.30	0.25
Joyce Kilmer-Slickrock	0.34	0.52	0.27
	0.33	0.43	0.24
	0.31	0.32	0.23
	0.26	0.31	0.20
	0.24	0.30	0.14
	0.20	0.28	0.13
	0.18	0.24	0.11
	0.17	0.24	0.10
Mammoth Cave NP	0.56	0.57	0.50
	0.44	0.56	0.37
	0.38	0.53	0.36
	0.29	0.35	0.35
	0.25	0.33	0.31
	0.24	0.33	0.24
	0.22	0.30	0.21
	0.21	0.29	0.19

Table 4-3. Format of Summary of Results for CALPUFF Modeling in VISTAS' 12-km Modeling Domain to Determine if a BART Eligible Source is Subject to BART.

Class I area	Distance (km) from source to Class I area boundary	# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2001		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2002		# of days[1] and # of receptors with impact > 0.5 dv in Class I area: 2003		# of days[1] and # of receptors with impact > 1.0 dv in Class I area for 3-yr period		Max. 24-hr impact over 3-yr period
Dolly Sods, WV										
Shenandoah, VA										
James River Face, VA										
Mammoth Cave, KY										
Sipsey, AL										
Great Smoky Mtns, TN										
Cohutta, GA										
Shining Rock, NC										
Linville Gorge, NC										
Swanquarter, NC										
Cape Romain, SC										
Okefenokee, GA										
Saint Marks, FL										
Chassahowitzka, FL										
Everglades, FL										
Brigantine, NJ										
Breton Island, LA										
Caney Creek, AR										
Upper Buffalo, AR										
Mingo, MO										
Hercules Glade, MO										

[1]Days below the 98^{th} percentile of days in each year or the three-year modeling period, as appropriate

4.6 VISTAS Contribution to CALPUFF Modeling of BART Eligible Sources

VISTAS will provide updates and supporting information concerning the Common Modeling Protocol (this document) on the VISTAS website. In addition, VISTAS will make publicly available the following data bases developed by Earth Tech:

- VISTAS version of the CALPUFF modeling system, maintained on the CALPUFF website. Version 5.754 includes CALMET, CALPUFF, CALPOST, and POSTUTIL files, updated in December 2005. The last update in this VISTAS version is a CALMET update that addresses over water dispersion, which was developed for the Minerals Management Service (MMS) in fall 2005. This VISTAS version of CALPUFF will not be updated further unless errors are found in the code, except that a new one-step POSTUTIL procedure will be incorporated. BART-eligible sources in the VISTAS states will be able to use this VISTAS version throughout the BART modeling exercise.

- 12-km CALMET output files for 2001, 2002, and 2003 produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the CALPUFF website.

- CALMET will include a software modification to allow the meteorological data inputs into CALMET to be used to generate finer grid CALMET files without having to go back to the original MM5 output files

- Five 4-km CALMET subdomains for 2001, 2002, and 2003, produced as described in previous sections. Further detail on model configuration and settings will be provided with the output files and will be made available on the website.

- File with CALPUFF model configuration and settings sufficient to replicate CALPUFF modeling done for VISTAS using 12 km CALMET, including

    - Ozone data used to run CALPUFF

    - Ammonia concentrations used to run CALPUFF.

    - All other set up files used in VISTAS 12-km CALPUFF run

Samples of these data files and examples of their application with CALPUFF for BART screening analyses can be found on the CALPUFF web site at (http://www.src.com/verio/download/sample_files.htm).

5. SOURCE-SPECIFIC MODELING PROTOCOL

Sources are required to submit a source-specific protocol to the State for review and approval prior to source-specific modeling. States will provide the documentation to EPA and FLM for their review. An outline of the typical contents of the site-specific protocol is provided in Table 5-1.

If a source-specific modeling approach is proposed that differs from the common approach in Chapter 4, a more-detailed modeling protocol than that required under the common procedures is required. This protocol must explain the data sources, model configuration, and rationale for changes in the model approach from the common protocol and must be approved by the State.

Unit-specific source data include the following parameters:

- Location (e.g., UTM coordinates, UTM zone and datum)
- Stack height above the ground
- Stack diameter
- Exit velocity
- Exit temperature
- Emission rates (SO_2, H_2SO_4, NO_x and PM_{10}).

Additional building dimension information (building width, length, height and corner locations) is needed for short stacks that are less than Good Engineering Practice (GEP) height. This information is used in providing effective structure dimensions for building downwash calculations. (The requirement to conduct building downwash modeling may be waived by individual States or if the transport distance is greater than 50 km.)

The source coordinates must be expressed in the coordinate system used to define the CALMET and CALPUFF modeling domains. For the regional screening simulations, a Lambert Conformal Conic (LCC) coordinate system will be used. The required parameters to define an LCC coordinate include two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin. Subregional and source-specific domains may be using either an LCC or UTM projection.

The CALPUFF Graphical User Interface (GUI) system provides software (called COORDS) to compute to/from latitude/longitude, LCC and UTM coordinates for a large number of datums. In addition, the CALVIEW graphics feature allows the use of georeferenced satellite or aerial photographs to be used as base maps to confirm source locations. Links to sources of suitable base maps can be found on the CALPUFF data site (www.src.com) in the section on "Aerial Photos".

Table 5-1. Sample Table of Contents of a Source-Specific Fine-Scale Modeling Protocol.

An example of the data that need to be reported is provided in Table 5-2. More detail on the stack data, emissions species, and particulate size fractions to be reported will be made available on the CALPUFF website, www.src.com, Check with your State for the more detailed format of Table 5-2 that is to be used.

Discussions with the regulatory authorities should be conducted prior to development of a protocol to ensure all of the relevant issues are included in the protocol.

Table 5-2. Example of Source Documentation for BART Eligible Source.

Unit name and/or description	**Start-up dates**	**SO_2 potential emissions (tpy)**	**NO_x potential emissions (tpy)**	**Total PM potential emissions (tpy)**
Emissions source name				
…				
Total emissions				
Potential BART-eligible emissions				

6. QUALITY ASSURANCE

6.1 Scope and Purpose of the QA program

Air quality modeling covered under this protocol is an important tool for use in determining whether a BART-eligible source can be reasonable expected to cause or contribute to visibility impairment in a Class I area, and therefore whether this source should be subject to BART controls, and if so, to determine the relative benefits of various BART controls. The purpose of the quality assurance (QA) program is to establish procedures for ensuring that products produced by the application of the modeling techniques for BART studies satisfy the regulatory objectives of the BART program.

The scope of the QA program affects different users differently. Common features of most applications will be the setup and execution of the CALPUFF air quality model and processing of modeling results to determine if a source contributes to visibility impairment at a Class I area. In many cases, users will be provided meteorological datasets that have been developed with VISTAS funding under a suitable QA program for use in the BART modeling. Other users will be involved in site-specific or source-specific analyses that will use additional datasets and potentially different modeling options and/or tools. More extensive quality assurance will be required in these latter types of applications. It is the responsibility of the modeler to ensure that an adequate QA protocol is in place for a particular application.

The CALPUFF modeling system contains built-in features to facilitate quality assurance of the modeling results. These include the automatic production of "QA" files for various datasets, including geophysical fields, sources and receptors, and imbedded tracking of model options and switches within the output files from the major modeling units of the modeling system. The Graphical User Interface system (GUI) provided as part of the latest CALPUFF modeling system allows these QA files to be displayed graphically.

In addition, a detailed software management system is in place to track version and level numbers associated each program and utility within the CALPUFF modeling system. This information is carried forward in all of the output files to create an audit trail of software versions and major model options used that can be retrieved and displayed from the model output files.

Because the required QA procedures will depend heavily on the exact application, there will be differences among different users and different applications.

In addition, the BART modeling process involves multiple organizations. The States have overall responsibility for the process and may also execute some or all of the modeling. VISTAS is contributing general guidance via this protocol and is preparing meteorological fields and performing modeling under the guidance of the States. The sources that are BART-eligible need to provide process information and emissions data for use in the analyses. In addition, those sources that are involved in BART assessments will need to be actively involved in control technology decisions and assessments. Finally, some of the modeling steps may be carried out by contractors on behalf of VISTAS, a State, or a source.

Each of these organizations has a responsibility to ensure that it is providing correct information to others and to evaluate the quality of any analyses it is performing, whether with data of its own or from others. This chapter provides general guidance and information on those aspects of quality assurance that are specific to the CALPUFF modeling effort, irrespective of which organization is carrying out the effort. The focus is on the common protocol efforts described in Chapter 4. As described in Section 6.3, more comprehensive QA may be needed for the unique aspects of the source-specific modeling described in Chapter 5.

6.2 QA Procedures for Common Protocol Modeling

The VISTAS common protocol (Section 4) describes the methods and procedures for use in conducting regional scale screening modeling to determine the whether a particular source or group of sources is subject to BART controls. In the initial application, the regional CALPUFF-ready meteorological data files will be provided by VISTAS. The amount of effort for end-users performing QA of these pre-defined meteorological fields will be reduced from what is required in developing source-specific meteorological fields, as described below. Also, VISTAS is planning to provide five subregional CALMET meteorological datasets in a CALPUFF-ready format. The development of these CALMET datasets will be subject to a QA program as part of their development, so the necessary quality assurance activity of end-users is again reduced from what would be required in the development of the dataset. It is not expected that the quality assurance steps in the development will be repeated in each application. The VISTAS-provided regional and subregional meteorological fields will include a test case simulation for demonstrating that expected modeling results are obtained on the user's computer platform. This test should be repeated by every user.

Although the CALPUFF modeling system is recommended by the U.S. Environmental Protection Agency for application to BART analyses, a considerable amount of expertise and modeling judgment is needed at certain stages of the analysis. The modeling is not a "cookbook" exercise, a fact that was recognized by the U.S. EPA in describing the expertise needed for CALMET modeling (EPA, 1998; pp. 9-10,). Current methods for performing refined chemistry calculation also require an understanding of the chemical and meteorological processing affecting ammonium nitrate formation. VISTAS has committed to provide appropriate CALPUFF training to assist States in obtaining the necessary expertise with the latest CALPUFF modeling tools and techniques. An appropriate level of knowledge of the model formulation, technical approach and assumptions is essential for successful BART modeling.

6.2.1 Quality Control of Input Data

The input data required by the model depends on the application. At a minimum, source data is required by CALPUFF (see Section 6.2.3) along with a list of choices made about model options and switches. Most of the modeling option choices are specified or recommended by regulatory guidance and default values (see references in Section 4.3.3). However, remodeling of the boundary conditions is not required for VISTAS-provided finer grid domains so the expertise level is not as high as it would be for development of the boundary conditions files from scratch.

To the extent that modeling applications are using pre-defined CALMET files and CALPUFF templates, the quality assurance will be straightforward. More detailed steps are needed for the setup of modeling files for source-specific applications of subregional domains finer than 4 km.

The basic procedures that will apply to all CALPUFF model applications will include a confirmation of the source data, including units, verification of the correct source and receptor locations, including datum and projection, confirmation of the switch selections relative to modeling guidance, checks of the program switches and file names for the various processing steps, and confirmation of the use of the proper version and level of each model program. It is a common and recommended procedure for an independent modeler not involved in the setup of the modeling files to independently confirm the model switches and data entry in the actual model input files and to conduct an independent run of the worst case event as a confirmation check.

In addition, common practice requires that a model project CD (or DVD or set of DVDs) be created that contains all of the data and program files needed to reproduce the model results presented in a report. The model list files from each step are included on the project CD. This information allows independent checking and confirmation of the modeling process.

6.2.2 Quality Control of Application of CALMET

For users of the VISTAS CALPUFF-ready CALMET meteorological files, a number of large datafiles will be provided by VISTAS on external USB2 or Firewire hard drives in a format ready for use with the CALPUFF model. The QA steps associated with the development of the VISTAS common datasets will be provided separately as part of the modeling documentation. It is not expected that the QA steps conducted in the development of the meteorological datasets will be repeated in each application, although tests to confirm that the dataset is suitable for the application for which it is being used should be performed as part of the QA. This is discussed in more detail below.

The regional screening CALMET grid is defined in Chapter 4 on a 12-km Lambert Conformal Conic (LCC) grid system. The subregional and source-specific domains may be defined in either LCC or Universal Transverse Mercator (UTM) coordinates. In the case of the LCC projection, two matching parallels, latitude/longitude of the projection origin, coordinate datum, and false Easting and Northing (if used) of the projection origin must also be defined. For any domains in UTM coordinates, the UTM zone (see Appendix D of the CALMET User's Guide) and datum must be defined. The appropriate projection and map factors are provided as part of the definition of the VISTAS regional grid system. For a source-specific domain, the grid parameters will be provided as part of the source-specific protocol.

Appendix A of the IWAQM report (EPA, 1998) contains a list of recommended CALMET switch settings. Except as modified in Chapter 4 of this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALMET simulations. The CALMET model obtains the switch settings from an ASCII "control file" with a default name of CALMET.INP. Whether the model is run using a GUI or from the control line in a DOS, Linux, or Unix window, it is essential that the control file be reviewed as part of the CALMET QA analysis. The CALMET GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. This includes the default value for each variable, a text description of the variable, the meaning of each variable option, the units of the variable and inter-relationships among variables indicating if/when the variable is used. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

Part of the CALPUFF modeling system's built-in QA capabilities is a variable tracking system that retains the control file inputs for CALMET and CALPUFF in the output files create by the models. This information includes the Version and Level numbers of the processor codes and main model codes used in the simulations as well as the control files from the main models (CALMET and CALPUFF). The information from the preprocessing steps and the CALMET and CALPUFF model simulations is all carried forward and saved in the CALPUFF/postprocessor output files so that the final concentration/flux files contain a history of the model options and switch settings. This allows a user or reviewing agency to confirm the switch settings provided in a control file with that actually used in the model simulations. An optional switch in the CALPOST processor creates a complete listing of the QA data. This step requires access to the output CALPUFF concentration and/or flux files, which are normally practical to store on CDs or DVDs and to provide a part of the Project CD/DVD set.

6.2.3 Quality Control of Application of CALPUFF

The quality assurance of the source and emissions data is a major component of the CALPUFF modeling. Also, many errors are found in source coordinates and related projection/datum parameters, so confirmation of the source location is an important part of the modeling QA.

The locations of the Class I area receptors are another important CALPUFF input. The use of pre-defined receptors as provided by the National Park Service (NPS) receptor dataset is recommended in the VISTAS common protocol. However, although the latitude and longitude of each receptor point is provided, it is necessary to ensure that the proper UTM or LCC coordinates have been computed for computational domain selected. In particular, the datum of the NPS conversion software is not specified, so it is recommended that coordinates be checked using the CALPUFF GUI's COORDS software or another comparable coordinate translation software package that recognizes various datums.

Most of the CALPUFF input variables contain default values. Appendix B of the IWAQM report contains a list of recommended CALPUFF switch settings. Except as modified in Chapter 4 of this protocol or in a source-specific protocol, the IWAQM guidance should be used in setting up the CALPUFF simulations. The CALPUFF model obtains the switch settings from an ASCII “control file” with a default name called the CALPUFF.INP file. As is the case with the comparable CALMET file, it is essential that the control file be reviewed manually as part of the CALPUFF QA analysis. To facilitate this process, as was the case with the CALMET GUI, the CALPUFF GUI retains all of the input descriptive information that is part of the standard CALPUFF.INP file structure. Some third-party commercial GUIs strip out this descriptive information, which makes the QA step more difficult, although it is essential for perform nonetheless using the variable names as references for the variables in the file.

6.2.4 Quality Control of Application of CALPOST and POSTUTIL

CALPOST is run separately for each Class I area in order to obtain the necessary visibility statistics for evaluating compliance with the BART screening and finer grid modeling thresholds. The inputs to CALPOST involve selection of the visibility method (Method 6 in the standard EPA BART guidance), entry of Class I area-specific data for computing background extinction (either average or best 20% natural conditions, as prescribed by the State) and monthly relative humidity factors for hygroscopic aerosols. CALPOST contains a receptor screening that allow subsets of a receptor network modeling in CALPUFF to be selected for processing in a given CALPOST run. This is how receptors within a single Class I area are selected for processing from a CALPUFF output file that may contain receptors from several Class I areas. CALPOST contains options for creating plot files that will help in the confirmation that the proper receptor subset is extracted.

The CALPOST output file contains a listing of the highest visibility impact each day of the model simulation over all receptors included in CALPOST analysis. Receptors will normally be selected in each CALPOST run so that each CALPOST run represents the impacts at a single Class I area. The table includes the data shown in the example in Table 4-1. For a screening assessment, the peak value of the change in extinction is shown at the bottom of the visibility table (see Table 4-1). For a finer grid simulation, the 98th percentile value (8th highest day) is used for comparison against the BART threshold of 0.5 deciviews. It is necessary to import the results of the CALPOST table into a sorting program such as a spreadsheet to rank the daily change in extinction values such as is presented in Table 4-2.

The CALPOST inputs that need to be carefully checked as part of the CALPOST quality assurance are:

- Visibility technique (Method 6 in the common VISTAS protocol)

- Monthly Class I-specific relative humidity factors for Method 6

- Background light extinction values

- Inclusion of all appropriate species from modeled sources (e.g., sulfate, nitrate, organics, (as SOA), coarse and fine particulate matter and elemental carbon.

- Appropriate species names for coarse PM used

- Extinction efficiencies for each species

- Appropriate Rayleigh scattering term (10 Mm^{-1} for screening modeling but Class I area specific value for finer grid modeling)

- Screen to select appropriate Class I receptors for each CALPOST simulation.

The CALPOST program produces plot files compatible with CALVIEW that allow confirmation of receptor locations that is useful in evaluating the receptor screening step.

POSTUTIL allows the user to sum the contributions of sources from different CALPUFF simulations into a total concentration file. In addition, it contains options to scale the concentrations from different modeled species (e.g., different particle sizes) into species-dependent size distributions for the particulate matter. For example, PM is often simulated with unit emission rates for each particle size category and, in the POSTUTIL stage, the contributions of each size category based on the species being considered (e.g., elemental carbon, coarse particulate matter, etc.) are combined to form the species concentrations for input into CALPOST. This process, although simple, requires a careful review of the weighting factors for each source. POSTUTIL also allows a repartitioning of nitric acid and nitrate to account for the effects of ammonia limiting conditions.

If source-specific modeling is performed using different sources of data or different techniques, the source-specific modeling protocol should provide justification for deviations from the VISTAS common protocol, and a QA plan specific for the application provided to address the quality assurance of the data used.

6.3 Additional QA Issues for Alternative Source-Specific Modeling

The level of QA required for application of source-specific protocols will be substantially higher than for the use of datasets that have already been subject to a QA procedure. For example, source-specific protocols may include the use of on-site meteorological datasets, the use of higher resolution prognostic meteorological (e.g., MM5) datasets, alternative visibility calculations, different extinction coefficients, or other changes to the common protocol. In addition to providing a source-specific modeling protocol describing and justifying the changes to the modeling approach from the VISTAS common protocol, the site-specific applications should include the development of a QA plan to properly evaluate the data used in the site-specific modeling.

The critical CALMET input parameters depend on the mode in which the model is run (observations mode, hybrid mode or no-observations mode), and the location and spatial representativeness of any observational data. In a site specific protocol involving the development of a meteorological dataset, the elements of the QA process include preparation of wind rose (using observed, MM5 and CALMET-derived data), including examination of the data as a function of season and time of day (e.g., 4am, 10am, 4pm wind roses), time series analyses, and presentation of 2-D vector plots illustrating terrain effects/sea breeze circulation or other features of the flow expected to occur within the domain. For example, 2-D vector plots produced during light wind speed stable conditions (e.g., early morning such as 4 am) are good for assessing the performance of the CALMET model configuration and switches in reproducing terrain effects because these conditions are likely to maximize the terrain impacts in the model. Season wind roses at 4 am, 10 am and 4 pm would be expected to show the development of sea breeze circulations that may be important for certain applications. Customization of the QA process for the individual site-specific domain based on the availability of data and the physical processes expected to be important at that location should be conducted as part of the site-specific QA plan development.

If site-specific CALPUFF simulations involving the Ammonia Limiting Method are conducted, performance of the model in reproducing observed CASTNet or IMPROVE sulfate and nitrate concentrations at measurement sites within the site-specific modeling domain should be evaluated. The use of alternative ammonia concentration data (e.g., CMAQ output rather than derived ammonia based on aerosol measurements) will require an evaluation of the model performance relative to the techniques in the VISTAS common protocol.

In any site-specific protocol a site-specific QA plan should be prepared.

6.4 Assessment of Uncertainty in Modeling Results

Chapter 3 discussed the uncertainties and known limitations in CALPUFF. The source specific modeling report does not need to repeat the uncertainties listed in Chapter 3, but the reviewer should interpret results in light of these limitations. It is expected that the performance of the model will be better in predicting changes in visibility impacts due to BART controls than in predicting absolute visibility values. This is because uncertainties in meteorological conditions transport and dispersion are expected to be less important in evaluating a change in impact, since a comparable effect will be included in both the base and sensitivity simulations.

7. REFERENCES

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SAMPLE CALPUFF, POSTUTIL, AND CALPOST INPUT FILES

CALPUFF BATCH PROCESSING FILE

12-KM SCREENING ANALYSES

```
REM OCFRBGA
REM BART APPLICABILITY ANALYSIS WITH UPDATED 12 KM CALMET
REM JBH 10.08.06

REM RUN 2001
CALL CALPUFFL.EXE OCFRBGA01.INP
CALL POSTUTILL.EXE OCFRBGAUT01.INP
CALL CALPOSTL.EXE OCFRBGAVANSI01.INP
CALL CALPOSTL.EXE OCFRBGAVANJK01.INP
CALL CALPOSTL.EXE OCFRBGAVANGS01.INP
CALL CALPOSTL.EXE OCFRBGAVANCO01.INP
CALL CALPOSTL.EXE OCFRBGAVANSR01.INP


REM RUN 2002
CALL CALPUFFL.EXE OCFRBGA02.INP
CALL POSTUTILL.EXE OCFRBGAUT02.INP
CALL CALPOSTL.EXE OCFRBGAVANSI02.INP
CALL CALPOSTL.EXE OCFRBGAVANSR02.INP
CALL CALPOSTL.EXE OCFRBGAVANJK02.INP
CALL CALPOSTL.EXE OCFRBGAVANGS02.INP
CALL CALPOSTL.EXE OCFRBGAVANCO02.INP


REM RUN 2003
CALL CALPUFFL.EXE OCFRBGA03.INP
CALL POSTUTILL.EXE OCFRBGAUT03.INP
CALL CALPOSTL.EXE OCFRBGAVANSI03.INP
CALL CALPOSTL.EXE OCFRBGAVANSR03.INP
CALL CALPOSTL.EXE OCFRBGAVANJK03.INP
CALL CALPOSTL.EXE OCFRBGAVANGS03.INP
CALL CALPOSTL.EXE OCFRBGAVANCO03.INP

PAUSE
```

SAMPLE CALPUFF INPUT FILE

OCFRBGA01.INP
12-KM SCREENING ANALYSIS YEAR 2001

```
OC FAIRBURN GEORGIA
BART APPLICABILITY ANALYSIS 2001
SIPSEY/JOYCE KILMER/GREAT SMOKEY MOUNTAINS/COHUTTA/SHINING ROCK
---------------- 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 =            *
    or
PLMMET.DAT    input    * PLMDAT =            *
    or
PROFILE.DAT   input    * PRFDAT =            *
SURFACE.DAT   input    * SFCDAT =            *
RESTARTB.DAT  input    * RSTARTB=            *
--------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =T:\BART\OCFRBGA\12KM\OCFRBGA01.LST  !
CONC.DAT      output   ! CONDAT =T:\BART\OCFRBGA\12KM\OCFRBGA01.CON     !
DFLX.DAT      output   ! DFDAT  =T:\BART\OCFRBGA\12KM\OCFRBGA01.DRY     !
WFLX.DAT      output   ! WFDAT  =T:\BART\OCFRBGA\12KM\OCFRBGA01.WET     !

VISB.DAT      output   ! VISDAT =T:\BART\OCFRBGA\12KM\OCFRBGA01.VIS     !
RESTARTE.DAT  output   ! RSTARTE=T:\BART\OCFRBGA\12KM\OCFRBGA01.RES     !
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =            *
VOLEMARB.DAT  input    * VOLDAT =            *
BAEMARB.DAT   input    * ARDAT  =            *
LNEMARB.DAT   input    * LNDAT  =            *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    ! OZDAT  =T:\BART\OCFRBGA\OZONE\OZONE2001DOM4.DAT    !
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=            *
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 =   12   !

     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=T:\VISTAS\DOMAIN0-2001\MET2001-01R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-02R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-03R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-04R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-05R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-06R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-07R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-08R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-09R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-10R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-11R.DAT     !
 !END!
 none         input    ! METDAT=T:\VISTAS\DOMAIN0-2001\MET2001-12R.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 =  2001  !
     (used only if   Month (IBMO) -- No default       ! IBMO =  1  !
```

```
 METRUN = 0)      Day (IBDY) -- No default       ! IBDY =  1  !
                 Hour (IBHR) -- No default       ! IBHR =  1  !

Base time zone        (XBTZ) -- No default       ! XBTZ = 5.0  !
   PST = 8., MST = 7.
   CST = 6., EST = 5.

Length of run (hours) (IRLG) -- No default       ! IRLG =  8760  !

Number of chemical species (NSPEC)
                                Default: 5       ! NSPEC =  19   !

Number of chemical species
to be emitted  (NSE)            Default: 3       ! NSE =  16   !

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 =  0   !

      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 =  0   !

      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)
      METFM = 5 - AERMET tower file (PROFILE.DAT) and
                  surface parameters file (SURFACE.DAT)

Meteorological Profile Data Format (MPRFFM)
       (used only for METFM = 1, 2, 3)
                                Default: 1       ! MPRFFM =  1   !

      MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
      MPRFFM = 2 - AERMET tower file (PROFILE.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 slugs? (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)

     Method used to simulate building
     downwash? (MBDW)                       Default: 1     ! MBDW =   1  !
        1 = ISC method
        2 = PRIME method

     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)


     Gravitational settling (plume tilt)
     modeled ? (MTILT)                      Default: 0     ! MTILT =  0   !
        0 = no
        1 = yes
        (puff center falls at the gravitational
         settling velocity for 1 particle species)

     Restrictions:
         - MDRY  = 1
         - NSPEC = 1  (must be particle species as well)
         - sg    = 0  GEOMETRIC STANDARD DEVIATION in Group 8 is
                      set to zero for a single particle diameter

     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 =  3  !
        1 = use sigma-v or sigma-theta measurements
            from PROFILE.DAT to compute sigma-y
            (valid for METFM = 1, 2, 3, 4, 5)
        2 = use sigma-w measurements
            from PROFILE.DAT to compute sigma-z
            (valid for METFM = 1, 2, 3, 4, 5)
        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, 5)
        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.

     [DIAGNOSTIC FEATURE]
     Method used for Lagrangian timescale for Sigma-y
     (used only if MDISP=1,2 or MDISP2=1,2)
     (MTAULY)                            Default: 0     ! MTAULY =  0  !
        0 = Draxler default 617.284 (s)
        1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
       10 < Direct user input (s)             -- e.g., 306.9


     [DIAGNOSTIC FEATURE]
     Method used for Advective-Decay timescale for Turbulence
     (used only if MDISP=2 or MDISP2=2)
     (MTAUADV)                           Default: 0     ! MTAUADV =  0  !
        0 = No turbulence advection
        1 = Computed (OPTION NOT IMPLEMENTED)
       10 < Direct user input (s)   -- e.g., 300


     Method used to compute turbulence sigma-v &
     sigma-w using micrometeorological variables
     (Used only if MDISP = 2 or MDISP2 = 2)
     (MCTURB)                            Default: 1     ! MCTURB =  1  !
        1 = Standard CALPUFF subroutines
        2 = AERMOD subroutines

     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, using formatted BCON.DAT file
        2 = yes, using unformatted CONC.DAT file


     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 =  1   !

        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 =        POC081 !          !END!
! CSPEC =        POC056 !          !END!
! CSPEC =        POC030 !          !END!
! CSPEC =        PIC081 !          !END!
! CSPEC =        PIC056 !          !END!
! CSPEC =        PMC800 !          !END!
! CSPEC =        PMC425 !          !END!
! CSPEC =        PMF187 !          !END!
! CSPEC =        PMF112 !          !END!
! CSPEC =        PMF081 !          !END!
! CSPEC =        PMF056 !          !END!
! CSPEC =        PMF030 !          !END!
! CSPEC =         EC056 !          !END!
! CSPEC =         EC030 !          !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,                1,           2,                  0
!
!       POC081  =          1,                1,           2,                  0
!
!       POC056  =          1,                1,           2,                  0
!
!       POC030  =          1,                1,           2,                  0
!
!       PIC081  =          1,                0,           2,                  0
!
!       PIC056  =          1,                0,           2,                  0
!
!       PMC800  =          1,                1,           2,                  0
!
!       PMC425  =          1,                1,           2,                  0
!
!       PMF187  =          1,                1,           2,                  0
!
!       PMF112  =          1,                1,           2,                  0
!
!       PMF081  =          1,                1,           2,                  0
!
!       PMF056  =          1,                1,           2,                  0
!
!       PMF030  =          1,                1,           2,                  0
!
!        EC056  =          1,                1,           2,                  0
!
!        EC030  =          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 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = LCC  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  0   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = N  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 = 40N  !
     (RLON0)                    No Default      ! RLON0 = 97W  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane
```

```
     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 = 33N  !
     (XLAT2)                    No Default      ! XLAT2 = 45N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and
         XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery
     and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)

     --------------------------------------------------------------------------
     -----
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS
     (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                    Default: WGS-84    ! DATUM = NWS-84  !


METEOROLOGICAL Grid:

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =  160   !
            No. Y grid cells (NY)      No default     ! NY =  172   !
        No. vertical layers (NZ)      No default     ! NZ =  10   !

          Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 12. !
                                      Units: km

               Cell face heights
                   (ZFACE(nz+1))      No defaults
                                      Units: m
   ! ZFACE = 0., 20., 40., 80., 160., 320., 640., 1200., 2000., 3000.,
             4000. !

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

```
            X coordinate (XORIGKM)     No default     ! XORIGKM = 137.973 !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = -1625.974 !
                                      Units: km


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 =  55   !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  72   !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP =  102   !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP =  115   !
                  (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 =  1   !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP =  1   !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP =  1   !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =  1   !
         (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 =  0   !
  Wet Fluxes (IWET)                  1                  !  IWET =  0   !
  Relative Humidity (IVIS)           1                  !  IVIS =  0   !
   (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 =  0  !
        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,         0,         0,
0,        0   !
!        SO4 =    0,         1,         0,         0,         0,
0,        0   !
!        NOX =    0,         1,         0,         0,         0,
0,        0   !
!       HNO3 =    0,         1,         0,         0,         0,
0,        0   !
!        NO3 =    0,         1,         0,         0,         0,
0,        0   !
!     POC081 =    0,         1,         0,         0,         0,
0,        0   !
!     POC056 =    0,         1,         0,         0,         0,
0,        0   !
!     POC030 =    0,         1,         0,         0,         0,
0,        0   !
!     PIC081 =    0,         1,         0,         0,         0,
0,        0   !
!     PIC056 =    0,         1,         0,         0,         0,
0,        0   !
!     PMC800 =    0,         1,         0,         0,         0,
0,        0   !
!     PMC425 =    0,         1,         0,         0,         0,
0,        0   !
!     PMF187 =    0,         1,         0,         0,         0,
0,        0   !
!     PMF112 =    0,         1,         0,         0,         0,
0,        0   !
!     PMF081 =    0,         1,         0,         0,         0,
0,        0   !
!     PMF056 =    0,         1,         0,         0,         0,
0,        0   !
!     PMF030 =    0,         1,         0,         0,         0,
0,        0   !
!      EC056 =    0,         1,         0,         0,         0,
0,        0   !
!      EC030 =    0,         1,         0,         0,         0,
0,        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 =  10
  !

  Met. period to start output
  (NN1)                             Default: 1     ! NN1 =  10   !

  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 = 0.
       !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 0.
       !
       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     DIFFUSIVITY      ALPHA STAR      REACTIVITY    MESOPHYLL
      RESISTANCE     HENRY'S LAW COEFFICIENT
       NAME        (cm**2/s)                                              (s/cm)
       (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      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME              DIAMETER                  DEVIATION
                        (microns)                  (microns)
      -------      -------------------        ------------------
!          SO4 =           0.48,                      2.   !
!          NO3 =           0.48,                      2.   !
!       POC081 =         0.8125,                      0.   !
!       POC056 =         0.5625,                      0.   !
!       POC030 =            0.3,                      0.   !
!       PIC081 =         0.8125,                      0.   !
!       PIC056 =         0.5625,                      0.   !
!       PMC800 =             8.,                      0.   !
!       PMC425 =           4.25,                      0.   !
!       PMF187 =          1.875,                      0.   !
!       PMF112 =          1.125,                      0.   !
!       PMF081 =         0.8125,                      0.   !
!       PMF056 =         0.5625,                      0.   !
!       PMF030 =            0.3,                      0.   !
!        EC056 =         0.5625,                      0.   !
!        EC030 =            0.3,                      0.   !

!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 !
!         POC081 =         1.0E-04,            3.0E-05 !
!         POC056 =         1.0E-04,            3.0E-05 !
!         POC030 =         1.0E-04,            3.0E-05 !
!         PIC081 =         1.0E-04,            3.0E-05 !
!         PIC056 =         1.0E-04,            3.0E-05 !
!         PMC800 =         1.0E-04,            3.0E-05 !
!         PMC425 =         1.0E-04,            3.0E-05 !
!         PMF187 =         1.0E-04,            3.0E-05 !
!         PMF112 =         1.0E-04,            3.0E-05 !
!         PMF081 =         1.0E-04,            3.0E-05 !
!         PMF056 =         1.0E-04,            3.0E-05 !
!         PMF030 =         1.0E-04,            3.0E-05 !
!          EC056 =         1.0E-04,            3.0E-05 !
!          EC030 =         1.0E-04,            3.0E-05 !

!END!

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


INPUT GROUP: 11 -- Chemistry Parameters
---------------

     Ozone data input option (MOZ)     Default: 1            ! MOZ =  1   !
     (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 = 23.28, 26.79, 30.14, 36.73, 36.40, 34.65, 33.11, 32.68, 29.82,
     25.23, 26.15, 22.19 !

     Monthly ammonia concentrations
     (Used only if MCHEM = 1, or 3)
     (BCKNH3) in ppb                   Default: 12*10.
     !  BCKNH3 = 0.50, 0.50, 0.50, 0.50, 0.50, 0.50, 0.50, 0.50, 0.50, 0.50,
     0.50, 0.50 !

     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, 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 = 2,3,4,5)

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

        Roughness length (m) for modeling domain
        (Z0IN)                                  Default: 0.25   ! Z0IN = .25 !

        Leaf area index for modeling domain
        (XLAIIN)                                Default: 3.0    ! XLAIIN = 3.0
        !

        Elevation above sea level (m)
        (ELEVIN)                                Default: 0.0    ! ELEVIN = .0
        !

        Latitude (degrees) for met location
        (XLATIN)                                Default: -999.  ! XLATIN =
        -999.0 !
```

```
   Longitude (degrees) for met location
   (XLONIN)                        Default: -999.  ! XLONIN =
   -999.0 !

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

   Anemometer height (m) (Used only if METFM = 2,3)
   (ANEMHT)                        Default: 10.    ! ANEMHT =
   10.0 !

   Form of lateral turbulance data in PROFILE.DAT file
   (Used only if METFM = 4,5 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 over land and over water (m/s)
(SVMIN(12) and SWMIN(12))

                ----------  LAND  ----------       ---------  WATER
                ----------
   Stab Class :  A    B    C    D    E    F         A    B    C    D    E
   F
                ---  ---  ---  ---  ---  ---       ---  ---  ---  ---
```

```
                  ---  ---
     Default SVMIN : .50, .50, .50, .50, .50, .50,      .37, .37, .37, .37,
     .37, .37
     Default SWMIN : .20, .12, .08, .06, .03, .016,     .20, .12, .08, .06,
     .03, .016

           ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370, 0.370,
           0.370, 0.370, 0.370, 0.370!
           ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 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 = .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 = 5.0 !

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 = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

  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
       !

       Boundary Condition (BC) Puff control variables ------------------------

       Minimum height (m) to which BC puffs are mixed as they are emitted
       (MBCON=2 ONLY).  Actual height is reset to the current mixing height
       at the release point if greater than this minimum.
       (HTMINBC)                          Default:   500.     ! HTMINBC =
       500.0 !

       Search radius (km) about a receptor for sampling nearest BC puff.
       BC puffs are typically emitted with a spacing of one grid cell
       length, so the search radius should be greater than DGRIDKM.
       (RSAMPBC)                          Default:   10.      ! RSAMPBC =
       15.0 !

       Near-Surface depletion adjustment to concentration profile used when
       sampling BC puffs?
       (MDEPBC)                           Default:   1        ! MDEPBC =  0
       !
          0 = Concentration is NOT adjusted for depletion
          1 = Adjust Concentration for depletion

!END!


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


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

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

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  12  !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =   3  !
           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          Y       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 = FG11A !
   1 ! X = 1143.018, -637.276,   20.92,314.25,      1.22,  3.34,  312.0,
   .0,1.13E00, 2.27E-02, 4.326E01,
       0.0E00, 6.89E-03, 1.48E-01, 1.48E-01, 1.48E-01,  0.0E00,  0.0E00,
      5.86E-01, 5.86E-01, 1.52E-01, 1.52E-01, 1.52E-01, 1.52E-01, 1.52E-01,
      1.17E-02, 1.17E-02 !
   1 ! ZPLTFM  =       .0 !
   1 ! FMFAC  =      1.0 !   !END!
   2 ! SRCNAM = FG11B !
   2 ! X = 1143.025, -637.283,   20.92, 314.3,      1.22,  2.53,  317.6,
   .0,1.13E00, 2.27E-02, 4.326E01,
       0.0E00, 6.89E-03, 1.48E-01, 1.48E-01, 1.48E-01,  0.0E00,  0.0E00,
      5.86E-01, 5.86E-01, 1.52E-01, 1.52E-01, 1.52E-01, 1.52E-01, 1.52E-01,
      1.17E-02, 1.17E-02 !
   2 ! ZPLTFM  =       .0 !
   2 ! FMFAC  =      1.0 !   !END!
   3 ! SRCNAM = FG1MC !
   3 ! X = 1142.987, -637.323,    18.6, 314.3,       2.9, 14.85,  347.0,
   .0,6.43E00, 4.15E-01, 3.66E01,
       0.0E00, 3.24E-01, 6.63E00, 6.63E00, 6.63E00,  0.0E00,  0.0E00,
       5.4E00,  5.4E00, 7.41E00, 7.41E00, 7.41E00, 7.41E00, 7.41E00,
      5.84E-01, 5.84E-01 !
   3 ! ZPLTFM  =       .0 !
   3 ! FMFAC  =      1.0 !   !END!
   4 ! SRCNAM = FG16  !
   4 ! X = 1142.966, -637.347,   15.58, 314.3,       .97, 12.36,  363.7,   .0,
   0.0E00, 2.72E-02,  0.0E00,
       0.0E00, 2.72E-02, 5.53E-01, 5.53E-01, 5.53E-01,  0.0E00,  0.0E00,
      2.74E-01, 2.74E-01, 6.25E-01, 6.25E-01, 6.25E-01, 6.25E-01, 6.25E-01,
      4.94E-02, 4.94E-02 !
   4 ! ZPLTFM  =       .0 !
   4 ! FMFAC  =      1.0 !   !END!
   5 ! SRCNAM = FG21A !
```

```
   5 ! X = 1143.036, -637.299,   21.51, 314.3,      1.22,  2.46,  316.5,
   .0,2.62E00, 2.72E-02, 2.836E01,
       0.0E00, 6.83E-03, 1.48E-01, 1.48E-01, 1.48E-01,  0.0E00,  0.0E00,
      5.68E-01, 5.68E-01, 1.48E-01, 1.48E-01, 1.48E-01, 1.48E-01, 1.48E-01,
      1.14E-02, 1.14E-02 !
   5 ! ZPLTFM  =       .0 !
   5 ! FMFAC  =      1.0 !   !END!
   6 ! SRCNAM = FG21B !
   6 ! X = 1143.043, -637.307,   21.51, 314.3,      1.22,  2.66,  317.0,
   .0,2.62E00, 2.72E-02, 2.836E01,
       0.0E00, 6.83E-03, 1.48E-01, 1.48E-01, 1.48E-01,  0.0E00,  0.0E00,
      5.68E-01, 5.68E-01, 1.48E-01, 1.48E-01, 1.48E-01, 1.48E-01, 1.48E-01,
      1.14E-02, 1.14E-02 !
   6 ! ZPLTFM  =       .0 !
   6 ! FMFAC  =      1.0 !   !END!
   7 ! SRCNAM = FG2MC !
   7 ! X = 1142.996, -637.343,   19.91, 314.3,       3.2,  7.64,  347.0,
   .0,7.01E00, 2.18E-01,  9.6E00,
       0.0E00, 1.47E-01, 3.02E00, 3.02E00, 3.02E00,  0.0E00,  0.0E00,
      1.54E00, 1.54E00, 3.34E00, 3.34E00, 3.34E00, 3.34E00, 3.34E00,
      2.63E-01, 2.63E-01 !
   7 ! ZPLTFM  =       .0 !
   7 ! FMFAC  =      1.0 !   !END!
   8 ! SRCNAM = FG26 !
   8 ! X = 1142.976, -637.366,   15.58, 314.3,        .8, 12.36,  349.8,   .0,
   0.0E00, 7.43E-03,  0.0E00,
       0.0E00, 7.43E-03, 1.51E-01, 1.51E-01, 1.51E-01,  0.0E00,  0.0E00,
      7.5E-02, 7.5E-02, 1.71E-01, 1.71E-01, 1.71E-01, 1.71E-01, 1.71E-01,
      1.35E-02, 1.35E-02 !
   8 ! ZPLTFM  =       .0 !
   8 ! FMFAC  =      1.0 !   !END!
   9 ! SRCNAM = FG31 !
   9 ! X = 1143.057, -637.315,   20.95, 314.3,      1.22,  3.23,  314.8,
   .0,1.15E00, 3.44E-02, 4.458E01,
       0.0E00, 7.3E-03, 1.61E-01, 1.61E-01, 1.61E-01,  0.0E00,  0.0E00,
      5.94E-01, 5.94E-01, 1.56E-01, 1.56E-01, 1.56E-01, 1.56E-01, 1.56E-01,
      1.19E-02, 1.19E-02 !
   9 ! ZPLTFM  =       .0 !
   9 ! FMFAC  =      1.0 !   !END!
  10 ! SRCNAM = FG3MC !
  10 ! X = 1143.032, -637.345,   24.59, 314.3,      2.44,  6.75,  391.5,
  .0,7.58E00, 1.8E-01, 5.86E00,
       0.0E00, 1.32E-01, 2.72E00, 2.72E00, 2.72E00,  0.0E00,  0.0E00,
      2.41E00, 2.41E00, 3.02E00, 3.02E00, 3.02E00, 3.02E00, 3.02E00,
      2.38E-01, 2.38E-01 !
  10 ! ZPLTFM  =       .0 !
  10 ! FMFAC  =      1.0 !   !END!
  11 ! SRCNAM = FG18 !
  11 ! X = 1142.913, -637.139,   11.31, 314.3,      0.41, 29.25,  310.9,   .0,
  0.0E00, 0.0E00, 0.0E00,
       0.0E00, 2.89E-02, 2.89E-02, 2.89E-02, 0.0E00,  0.0E00,  0.0E00,
      0.0E00, 0.0E00, 0.0E00, 0.0E00, 0.0E00, 0.0E00, 0.0E00,
      0.0E00, 0.0E00 !
  11 ! ZPLTFM  =       .0 !
  11 ! FMFAC  =      1.0 !   !END!
  12 ! SRCNAM = FG28 !
  12 ! X = 1142.926, -637.170,   11.31, 314.3,      0.31, 42.04,  310.9,   .0,
  0.0E00, 0.0E00, 0.0E00,
       0.0E00, 2.82E-02, 2.82E-02, 2.82E-02, 0.0E00,  0.0E00,  0.0E00,
      0.0E00, 0.0E00, 0.0E00, 0.0E00, 0.0E00, 0.0E00, 0.0E00,
      0.0E00, 0.0E00 !
  12 ! ZPLTFM  =       .0 !
  12 ! 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.)
     ZPLTFM  is the platform height (m) for sources influenced by an isolated
             structure that has a significant open area between the surface
             and the bulk of the structure, such as an offshore oil platform.
             The Base Elevation is that of the surface (ground or ocean),
             and the Stack Height is the release height above the Base (not
             above the platform).  Building heights entered in Subgroup 13c
             must be those of the buildings on the platform, measured from
             the platform deck.  ZPLTFM is used only with MBDW=1 (ISC
             downwash method) for sources with building downwash.
             (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 height, width, length and X/Y offset (in meters)
           every 10 degrees.  LENGTH, XBADJ, and YBADJ are only needed for
           MBDW=2 (PRIME downwash option)
------
--------------------------------------------------------------------


--------

    a
     Building height, width, length, and X/Y offset from the source are
     treated
     as a separate input subgroup for each source and therefore must end with
     an input group terminator.  The X/Y offset is the position, relative to
     the
     stack, of the center of the upwind face of the projected building, with
     the
     x-axis pointing along the flow direction.

---------------
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 (km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                             a
 No.       Ordered list of X followed by list of Y, grouped by source
------     ------------------------------------------------------------


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


---------------
Subgroup (14d)
---------------
                                                     a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     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     Beg. X      Beg. Y      End. X    End. Y     Release    Base
Emission
 No.     Coordinate  Coordinate  Coordinate Coordinate  Height    Elevation
 Rates
            (km)        (km)        (km)       (km)       (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 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           Y         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 =  1315   !

!END!

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

                     X            Y          Ground        Height   b
Receptor        Coordinate   Coordinate    Elevation   Above Ground
  No.              (km)         (km)          (m)           (m)
--------        ----------   ----------    ---------   ------------
     1 ! X =     872.678,   -586.399,     255.000,       0.000!   !END!
```

```
  2 ! X =     873.438,   -586.319,     235.000,          0.000!   !END!
  3 ! X =     874.197,   -586.239,     236.000,          0.000!   !END!
  4 ! X =     874.957,   -586.158,     244.000,          0.000!   !END!
  5 ! X =     875.717,   -586.078,     243.000,          0.000!   !END!
  6 ! X =     876.476,   -585.998,     237.000,          0.000!   !END!
  7 ! X =     877.236,   -585.917,     213.000,          0.000!   !END!
  8 ! X =     877.996,   -585.837,     187.000,          0.000!   !END!
  9 ! X =     871.062,   -585.639,     244.000,          0.000!   !END!
 10 ! X =     871.822,   -585.559,     274.000,          0.000!   !END!
 11 ! X =     872.581,   -585.479,     250.000,          0.000!   !END!
 12 ! X =     873.341,   -585.399,     237.000,          0.000!   !END!
 13 ! X =       874.1,   -585.319,     214.000,          0.000!   !END!
 14 ! X =      874.86,   -585.239,     226.000,          0.000!   !END!
 15 ! X =      875.62,   -585.159,     183.000,          0.000!   !END!
 16 ! X =     876.379,   -585.078,     243.000,          0.000!   !END!
 17 ! X =     877.139,   -584.998,     213.000,          0.000!   !END!
 18 ! X =     877.898,   -584.917,     182.000,          0.000!   !END!
 19 ! X =     878.658,   -584.837,     179.000,          0.000!   !END!
 20 ! X =     879.417,   -584.756,     249.000,          0.000!   !END!
 21 ! X =     870.965,    -584.72,     244.000,          0.000!   !END!
 22 ! X =     871.725,    -584.64,     255.000,          0.000!   !END!
 23 ! X =     872.484,    -584.56,     253.000,          0.000!   !END!
 24 ! X =     873.244,    -584.48,     244.000,          0.000!   !END!
 25 ! X =     874.003,     -584.4,     244.000,          0.000!   !END!
 26 ! X =     874.763,    -584.32,     181.000,          0.000!   !END!
 27 ! X =     875.522,   -584.239,     220.000,          0.000!   !END!
 28 ! X =     876.282,   -584.159,     214.000,          0.000!   !END!
 29 ! X =     877.041,   -584.079,     243.000,          0.000!   !END!
 30 ! X =     877.801,   -583.998,     215.000,          0.000!   !END!
 31 ! X =      878.56,   -583.918,     239.000,          0.000!   !END!
 32 ! X =      879.32,   -583.837,     183.000,          0.000!   !END!
 33 ! X =     880.079,   -583.756,     210.000,          0.000!   !END!
 34 ! X =     880.839,   -583.676,     252.000,          0.000!   !END!
 35 ! X =     881.598,   -583.595,     262.000,          0.000!   !END!
 36 ! X =      868.59,    -584.04,     228.000,          0.000!   !END!
 37 ! X =      869.35,    -583.96,     219.000,          0.000!   !END!
 38 ! X =     870.109,    -583.88,     245.000,          0.000!   !END!
 39 ! X =     870.869,     -583.8,     231.000,          0.000!   !END!
 40 ! X =     871.628,    -583.72,     242.000,          0.000!   !END!
 41 ! X =     872.387,    -583.64,     208.000,          0.000!   !END!
 42 ! X =     873.147,    -583.56,     226.000,          0.000!   !END!
 43 ! X =     873.906,    -583.48,     244.000,          0.000!   !END!
 44 ! X =     874.666,     -583.4,     180.000,          0.000!   !END!
 45 ! X =     875.425,    -583.32,     244.000,          0.000!   !END!
 46 ! X =     876.185,    -583.24,     225.000,          0.000!   !END!
 47 ! X =     876.944,   -583.159,     244.000,          0.000!   !END!
 48 ! X =     877.703,   -583.079,     233.000,          0.000!   !END!
 49 ! X =     878.463,   -582.998,     177.000,          0.000!   !END!
 50 ! X =     879.222,   -582.918,     214.000,          0.000!   !END!
 51 ! X =     879.982,   -582.837,     255.000,          0.000!   !END!
 52 ! X =     880.741,   -582.756,     245.000,          0.000!   !END!
 53 ! X =       881.5,   -582.675,     274.000,          0.000!   !END!
 54 ! X =     868.494,    -583.12,     245.000,          0.000!   !END!
 55 ! X =     869.253,    -583.04,     244.000,          0.000!   !END!
 56 ! X =     870.013,   -582.961,     213.000,          0.000!   !END!
 57 ! X =     870.772,   -582.881,     192.000,          0.000!   !END!
 58 ! X =     871.531,   -582.801,     195.000,          0.000!   !END!
 59 ! X =     872.291,   -582.721,     244.000,          0.000!   !END!
 60 ! X =      873.05,   -582.641,     221.000,          0.000!   !END!
 61 ! X =     873.809,   -582.561,     244.000,          0.000!   !END!
 62 ! X =     874.569,   -582.481,     244.000,          0.000!   !END!
 63 ! X =     875.328,     -582.4,     259.000,          0.000!   !END!
 64 ! X =     876.087,    -582.32,     244.000,          0.000!   !END!
 65 ! X =     876.847,    -582.24,     244.000,          0.000!   !END!
 66 ! X =     877.606,   -582.159,     208.000,          0.000!   !END!
 67 ! X =     878.365,   -582.079,     230.000,          0.000!   !END!
 68 ! X =     879.125,   -581.998,     177.000,          0.000!   !END!
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 69 ! X =     879.884,   -581.918,     183.000,        0.000!   !END!
 70 ! X =     880.643,   -581.837,     191.000,        0.000!   !END!
 71 ! X =     881.402,   -581.756,     184.000,        0.000!   !END!
 72 ! X =     882.162,   -581.675,     242.000,        0.000!   !END!
 73 ! X =     868.397,   -582.201,     250.000,        0.000!   !END!
 74 ! X =     869.157,   -582.121,     213.000,        0.000!   !END!
 75 ! X =     869.916,   -582.041,     252.000,        0.000!   !END!
 76 ! X =     870.675,   -581.961,     254.000,        0.000!   !END!
 77 ! X =     871.435,   -581.881,     187.000,        0.000!   !END!
 78 ! X =     872.194,   -581.802,     226.000,        0.000!   !END!
 79 ! X =     872.953,   -581.721,     213.000,        0.000!   !END!
 80 ! X =     873.712,   -581.641,     214.000,        0.000!   !END!
 81 ! X =     874.472,   -581.561,     244.000,        0.000!   !END!
 82 ! X =     875.231,   -581.481,     253.000,        0.000!   !END!
 83 ! X =      875.99,   -581.401,     214.000,        0.000!   !END!
 84 ! X =     876.749,    -581.32,     185.000,        0.000!   !END!
 85 ! X =     877.509,    -581.24,     215.000,        0.000!   !END!
 86 ! X =     878.268,   -581.159,     241.000,        0.000!   !END!
 87 ! X =     879.027,   -581.079,     215.000,        0.000!   !END!
 88 ! X =     879.786,   -580.998,     182.000,        0.000!   !END!
 89 ! X =     881.305,   -580.837,     274.000,        0.000!   !END!
 90 ! X =     882.064,   -580.756,     264.000,        0.000!   !END!
 91 ! X =     867.542,   -581.361,     274.000,        0.000!   !END!
 92 ! X =     868.301,   -581.281,     274.000,        0.000!   !END!
 93 ! X =      869.06,   -581.201,     262.000,        0.000!   !END!
 94 ! X =     869.819,   -581.122,     276.000,        0.000!   !END!
 95 ! X =     870.579,   -581.042,     263.000,        0.000!   !END!
 96 ! X =     871.338,   -580.962,     206.000,        0.000!   !END!
 97 ! X =     872.097,   -580.882,     231.000,        0.000!   !END!
 98 ! X =     872.856,   -580.802,     249.000,        0.000!   !END!
 99 ! X =     873.615,   -580.722,     257.000,        0.000!   !END!
100 ! X =     874.374,   -580.642,     271.000,        0.000!   !END!
101 ! X =     875.134,   -580.562,     242.000,        0.000!   !END!
102 ! X =     875.893,   -580.481,     240.000,        0.000!   !END!
103 ! X =     876.652,   -580.401,     223.000,        0.000!   !END!
104 ! X =     877.411,   -580.321,     187.000,        0.000!   !END!
105 ! X =      878.17,    -580.24,     252.000,        0.000!   !END!
106 ! X =     878.929,    -580.16,     183.000,        0.000!   !END!
107 ! X =     879.688,   -580.079,     213.000,        0.000!   !END!
108 ! X =     867.445,   -580.441,     283.000,        0.000!   !END!
109 ! X =     868.204,   -580.362,     266.000,        0.000!   !END!
110 ! X =     868.964,   -580.282,     277.000,        0.000!   !END!
111 ! X =       872.0,   -579.963,     275.000,        0.000!   !END!
112 ! X =     872.759,   -579.883,     240.000,        0.000!   !END!
113 ! X =     873.518,   -579.803,     274.000,        0.000!   !END!
114 ! X =     874.277,   -579.722,     274.000,        0.000!   !END!
115 ! X =     875.036,   -579.642,     258.000,        0.000!   !END!
116 ! X =     875.796,   -579.562,     205.000,        0.000!   !END!
117 ! X =     876.555,   -579.482,     217.000,        0.000!   !END!
118 ! X =     877.314,   -579.401,     183.000,        0.000!   !END!
119 ! X =     871.903,   -579.043,     236.000,        0.000!   !END!
120 ! X =     872.662,   -578.963,     273.000,        0.000!   !END!
121 ! X =     873.421,   -578.883,     275.000,        0.000!   !END!
122 ! X =      874.18,   -578.803,     259.000,        0.000!   !END!
123 ! X =     874.939,   -578.723,     213.000,        0.000!   !END!
124 ! X =     875.698,   -578.643,     249.000,        0.000!   !END!
125 ! X =     876.457,   -578.562,     258.000,        0.000!   !END!
126 ! X =     877.216,   -578.482,     212.000,        0.000!   !END!
127 ! X =     877.975,   -578.401,     268.000,        0.000!   !END!
128 ! X =     872.565,   -578.044,     226.000,        0.000!   !END!
129 ! X =     873.324,   -577.964,     274.000,        0.000!   !END!
130 ! X =     874.083,   -577.884,     271.000,        0.000!   !END!
131 ! X =     874.842,   -577.804,     228.000,        0.000!   !END!
132 ! X =     875.601,   -577.723,     251.000,        0.000!   !END!
133 ! X =      876.36,   -577.643,     244.000,        0.000!   !END!
134 ! X =     877.119,   -577.563,     243.000,        0.000!   !END!
135 ! X =      871.71,   -577.205,     208.000,        0.000!   !END!
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   136 ! X =     872.468,   -577.125,     213.000,         0.000!   !END!
   137 ! X =     873.227,   -577.044,     252.000,         0.000!   !END!
   138 ! X =     873.986,   -576.964,     274.000,         0.000!   !END!
   139 ! X =     874.745,   -576.884,     274.000,         0.000!   !END!
   140 ! X =     875.504,   -576.804,     244.000,         0.000!   !END!
   141 ! X =     876.263,   -576.724,     215.000,         0.000!   !END!
   142 ! X =     877.021,   -576.643,     267.000,         0.000!   !END!
   143 ! X =      873.13,   -576.125,     247.000,         0.000!   !END!
   144 ! X =     873.889,   -576.045,     305.000,         0.000!   !END!
   145 ! X =     874.648,   -575.965,     267.000,         0.000!   !END!
   146 ! X =     875.406,   -575.885,     269.000,         0.000!   !END!
   147 ! X =     876.165,   -575.804,     271.000,         0.000!   !END!
   148 ! X =     873.792,   -575.126,     247.000,         0.000!   !END!
   149 ! X =    1174.116,   -429.607,    1154.000,         0.000!   !END!
   150 ! X =    1174.861,   -429.499,    1056.000,         0.000!   !END!
   151 ! X =    1175.607,   -429.391,     903.000,         0.000!   !END!
   152 ! X =    1176.352,   -429.283,     820.000,         0.000!   !END!
   153 ! X =    1177.097,   -429.175,     818.000,         0.000!   !END!
   154 ! X =    1173.239,     -428.8,    1278.000,         0.000!   !END!
   155 ! X =    1173.984,   -428.693,    1069.000,         0.000!   !END!
   156 ! X =    1174.729,   -428.585,     913.000,         0.000!   !END!
   157 ! X =    1175.475,   -428.477,     776.000,         0.000!   !END!
   158 ! X =     1176.22,   -428.369,     788.000,         0.000!   !END!
   159 ! X =    1176.965,   -428.262,     750.000,         0.000!   !END!
   160 ! X =    1172.362,   -427.994,    1327.000,         0.000!   !END!
   161 ! X =    1173.107,   -427.886,    1085.000,         0.000!   !END!
   162 ! X =    1173.852,   -427.779,     985.000,         0.000!   !END!
   163 ! X =    1174.597,   -427.671,     934.000,         0.000!   !END!
   164 ! X =    1175.342,   -427.563,     978.000,         0.000!   !END!
   165 ! X =    1176.087,   -427.456,     982.000,         0.000!   !END!
   166 ! X =    1176.833,   -427.348,     824.000,         0.000!   !END!
   167 ! X =    1169.995,   -427.402,    1317.000,         0.000!   !END!
   168 ! X =     1170.74,   -427.295,    1394.000,         0.000!   !END!
   169 ! X =    1171.485,   -427.188,    1487.000,         0.000!   !END!
   170 ! X =     1172.23,    -427.08,    1308.000,         0.000!   !END!
   171 ! X =    1172.975,   -426.973,    1237.000,         0.000!   !END!
   172 ! X =     1173.72,   -426.865,    1336.000,         0.000!   !END!
   173 ! X =    1174.465,   -426.757,    1290.000,         0.000!   !END!
   174 ! X =     1175.21,    -426.65,    1304.000,         0.000!   !END!
   175 ! X =    1175.955,   -426.542,    1111.000,         0.000!   !END!
   176 ! X =      1176.7,   -426.434,    1066.000,         0.000!   !END!
   177 ! X =    1169.863,   -426.488,    1189.000,         0.000!   !END!
   178 ! X =    1170.608,   -426.381,    1127.000,         0.000!   !END!
   179 ! X =    1171.353,   -426.274,    1299.000,         0.000!   !END!
   180 ! X =    1172.098,   -426.166,    1380.000,         0.000!   !END!
   181 ! X =    1172.843,   -426.059,    1553.000,         0.000!   !END!
   182 ! X =    1173.588,   -425.951,    1336.000,         0.000!   !END!
   183 ! X =    1174.333,   -425.844,    1219.000,         0.000!   !END!
   184 ! X =    1175.078,   -425.736,    1109.000,         0.000!   !END!
   185 ! X =    1175.823,   -425.628,    1133.000,         0.000!   !END!
   186 ! X =    1176.568,    -425.52,    1226.000,         0.000!   !END!
   187 ! X =    1168.986,   -425.682,    1280.000,         0.000!   !END!
   188 ! X =    1169.731,   -425.575,    1136.000,         0.000!   !END!
   189 ! X =    1170.476,   -425.467,     906.000,         0.000!   !END!
   190 ! X =    1171.221,    -425.36,     999.000,         0.000!   !END!
   191 ! X =    1171.966,   -425.253,    1170.000,         0.000!   !END!
   192 ! X =    1172.711,   -425.145,    1376.000,         0.000!   !END!
   193 ! X =    1173.456,   -425.037,    1318.000,         0.000!   !END!
   194 ! X =    1174.201,    -424.93,    1369.000,         0.000!   !END!
   195 ! X =    1174.946,   -424.822,    1152.000,         0.000!   !END!
   196 ! X =    1175.691,   -424.714,     924.000,         0.000!   !END!
   197 ! X =    1176.436,   -424.606,     882.000,         0.000!   !END!
   198 ! X =     1168.11,   -424.875,    1151.000,         0.000!   !END!
   199 ! X =    1168.855,   -424.768,    1116.000,         0.000!   !END!
   200 ! X =      1169.6,   -424.661,    1044.000,         0.000!   !END!
   201 ! X =    1170.345,   -424.553,     772.000,         0.000!   !END!
   202 ! X =     1171.09,   -424.446,     866.000,         0.000!   !END!
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   203 ! X =    1171.834,   -424.339,    1090.000,         0.000!   !END!
   204 ! X =    1173.324,   -424.124,    1020.000,         0.000!   !END!
   205 ! X =    1174.069,   -424.016,    1067.000,         0.000!   !END!
   206 ! X =    1167.979,   -423.961,    1224.000,         0.000!   !END!
   207 ! X =    1168.723,   -423.854,    1065.000,         0.000!   !END!
   208 ! X =    1169.468,   -423.747,     836.000,         0.000!   !END!
   209 ! X =    1170.213,    -423.64,     700.000,         0.000!   !END!
   210 ! X =    1170.958,   -423.532,     782.000,         0.000!   !END!
   211 ! X =    1171.703,   -423.425,     961.000,         0.000!   !END!
   212 ! X =    1173.937,   -423.102,     809.000,         0.000!   !END!
   213 ! X =    1174.681,   -422.995,     941.000,         0.000!   !END!
   214 ! X =    1167.847,   -423.047,     991.000,         0.000!   !END!
   215 ! X =    1168.592,    -422.94,     817.000,         0.000!   !END!
   216 ! X =    1169.337,   -422.833,     751.000,         0.000!   !END!
   217 ! X =    1170.081,   -422.726,     635.000,         0.000!   !END!
   218 ! X =    1170.826,   -422.619,     772.000,         0.000!   !END!
   219 ! X =    1171.571,   -422.511,     882.000,         0.000!   !END!
   220 ! X =     1168.46,   -422.026,     954.000,         0.000!   !END!
   221 ! X =    1169.205,   -421.919,     739.000,         0.000!   !END!
   222 ! X =     1169.95,   -421.812,     620.000,         0.000!   !END!
   223 ! X =    1170.694,   -421.705,     635.000,         0.000!   !END!
   224 ! X =    1171.439,   -421.597,     700.000,         0.000!   !END!
   225 ! X =    1172.183,    -421.49,     865.000,         0.000!   !END!
   226 ! X =    1168.329,   -421.113,     943.000,         0.000!   !END!
   227 ! X =    1169.074,   -421.005,     742.000,         0.000!   !END!
   228 ! X =    1169.818,   -420.898,     505.000,         0.000!   !END!
   229 ! X =    1170.563,   -420.791,     558.000,         0.000!   !END!
   230 ! X =    1171.307,   -420.684,     538.000,         0.000!   !END!
   231 ! X =    1172.052,   -420.576,     686.000,         0.000!   !END!
   232 ! X =    1168.197,   -420.199,     946.000,         0.000!   !END!
   233 ! X =    1168.942,   -420.092,     760.000,         0.000!   !END!
   234 ! X =    1169.686,   -419.984,     644.000,         0.000!   !END!
   235 ! X =    1170.431,   -419.877,     491.000,         0.000!   !END!
   236 ! X =    1171.175,    -419.77,     442.000,         0.000!   !END!
   237 ! X =     1171.92,   -419.662,     491.000,         0.000!   !END!
   238 ! X =    1168.066,   -419.285,     959.000,         0.000!   !END!
   239 ! X =     1168.81,   -419.178,     752.000,         0.000!   !END!
   240 ! X =    1169.555,   -419.071,     528.000,         0.000!   !END!
   241 ! X =    1170.299,   -418.963,     598.000,         0.000!   !END!
   242 ! X =    1171.043,   -418.856,     515.000,         0.000!   !END!
   243 ! X =    1171.788,   -418.749,     400.000,         0.000!   !END!
   244 ! X =    1172.532,   -418.641,     523.000,         0.000!   !END!
   245 ! X =    1167.935,   -418.371,     712.000,         0.000!   !END!
   246 ! X =    1170.167,    -418.05,     743.000,         0.000!   !END!
   247 ! X =    1170.912,   -417.942,     684.000,         0.000!   !END!
   248 ! X =    1171.656,   -417.835,     538.000,         0.000!   !END!
   249 ! X =      1172.4,   -417.727,     361.000,         0.000!   !END!
   250 ! X =    1201.214,   -417.246,     521.000,         0.000!   !END!
   251 ! X =    1204.191,   -416.805,     521.000,         0.000!   !END!
   252 ! X =    1189.038,   -417.173,     521.000,         0.000!   !END!
   253 ! X =    1190.527,   -416.954,     522.000,         0.000!   !END!
   254 ! X =    1192.015,   -416.736,     523.000,         0.000!   !END!
   255 ! X =    1193.503,   -416.517,     521.000,         0.000!   !END!
   256 ! X =    1194.991,   -416.298,     538.000,         0.000!   !END!
   257 ! X =     1196.48,   -416.079,     550.000,         0.000!   !END!
   258 ! X =    1197.968,   -415.859,     640.000,         0.000!   !END!
   259 ! X =    1199.456,   -415.639,     607.000,         0.000!   !END!
   260 ! X =    1200.944,   -415.419,     523.000,         0.000!   !END!
   261 ! X =    1202.432,   -415.199,     548.000,         0.000!   !END!
   262 ! X =     1203.92,   -414.978,     524.000,         0.000!   !END!
   263 ! X =    1205.408,   -414.757,     608.000,         0.000!   !END!
   264 ! X =    1208.384,   -414.315,     546.000,         0.000!   !END!
   265 ! X =    1209.871,   -414.093,     566.000,         0.000!   !END!
   266 ! X =    1211.359,   -413.871,     541.000,         0.000!   !END!
   267 ! X =    1212.847,   -413.649,     530.000,         0.000!   !END!
   268 ! X =     1181.33,   -416.432,     683.000,         0.000!   !END!
   269 ! X =    1182.818,   -416.216,     711.000,         0.000!   !END!
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270 ! X =    1184.306,   -415.998,     583.000,        0.000!   !END!
271 ! X =    1185.795,   -415.781,     599.000,        0.000!   !END!
272 ! X =    1187.283,   -415.564,     561.000,        0.000!   !END!
273 ! X =    1188.771,   -415.346,     582.000,        0.000!   !END!
274 ! X =    1190.259,   -415.128,     703.000,        0.000!   !END!
275 ! X =    1191.747,   -414.909,     707.000,        0.000!   !END!
276 ! X =    1193.235,    -414.69,     522.000,        0.000!   !END!
277 ! X =    1194.722,   -414.471,     760.000,        0.000!   !END!
278 ! X =     1196.21,   -414.252,     846.000,        0.000!   !END!
279 ! X =    1197.698,   -414.033,     952.000,        0.000!   !END!
280 ! X =    1199.186,   -413.813,     765.000,        0.000!   !END!
281 ! X =    1200.674,   -413.593,    1067.000,        0.000!   !END!
282 ! X =    1202.161,   -413.372,     915.000,        0.000!   !END!
283 ! X =    1203.649,   -413.152,     730.000,        0.000!   !END!
284 ! X =    1205.136,   -412.931,     822.000,        0.000!   !END!
285 ! X =    1206.624,    -412.71,     748.000,        0.000!   !END!
286 ! X =    1208.112,   -412.488,     544.000,        0.000!   !END!
287 ! X =    1209.599,   -412.267,     706.000,        0.000!   !END!
288 ! X =    1211.086,   -412.045,     627.000,        0.000!   !END!
289 ! X =    1212.574,   -411.822,     845.000,        0.000!   !END!
290 ! X =    1214.061,     -411.6,     772.000,        0.000!   !END!
291 ! X =    1215.549,   -411.377,     836.000,        0.000!   !END!
292 ! X =     1220.01,   -410.707,     665.000,        0.000!   !END!
293 ! X =    1175.112,   -415.469,     554.000,        0.000!   !END!
294 ! X =      1176.6,   -415.254,     760.000,        0.000!   !END!
295 ! X =    1178.088,   -415.038,     805.000,        0.000!   !END!
296 ! X =    1179.576,   -414.822,     703.000,        0.000!   !END!
297 ! X =    1181.064,   -414.605,     729.000,        0.000!   !END!
298 ! X =    1182.552,   -414.388,     699.000,        0.000!   !END!
299 ! X =     1184.04,   -414.171,    1109.000,        0.000!   !END!
300 ! X =    1185.528,   -413.954,    1001.000,        0.000!   !END!
301 ! X =    1187.015,   -413.737,     811.000,        0.000!   !END!
302 ! X =    1188.503,   -413.519,     522.000,        0.000!   !END!
303 ! X =    1189.991,   -413.301,     581.000,        0.000!   !END!
304 ! X =    1191.478,   -413.082,     629.000,        0.000!   !END!
305 ! X =    1192.966,   -412.864,     634.000,        0.000!   !END!
306 ! X =    1194.453,   -412.645,     582.000,        0.000!   !END!
307 ! X =    1195.941,   -412.425,     612.000,        0.000!   !END!
308 ! X =    1197.428,   -412.206,     944.000,        0.000!   !END!
309 ! X =    1198.916,   -411.986,    1281.000,        0.000!   !END!
310 ! X =    1200.403,   -411.766,    1427.000,        0.000!   !END!
311 ! X =    1201.891,   -411.546,    1221.000,        0.000!   !END!
312 ! X =    1203.378,   -411.325,    1030.000,        0.000!   !END!
313 ! X =    1204.865,   -411.105,     983.000,        0.000!   !END!
314 ! X =    1206.352,   -410.883,     894.000,        0.000!   !END!
315 ! X =     1207.84,   -410.662,     675.000,        0.000!   !END!
316 ! X =    1209.327,    -410.44,     950.000,        0.000!   !END!
317 ! X =    1210.814,   -410.219,     915.000,        0.000!   !END!
318 ! X =    1212.301,   -409.996,     732.000,        0.000!   !END!
319 ! X =    1213.788,   -409.774,     980.000,        0.000!   !END!
320 ! X =    1216.762,   -409.328,    1020.000,        0.000!   !END!
321 ! X =    1218.249,   -409.105,     886.000,        0.000!   !END!
322 ! X =    1219.736,   -408.881,     615.000,        0.000!   !END!
323 ! X =    1221.222,   -408.657,     680.000,        0.000!   !END!
324 ! X =    1176.335,   -413.427,     767.000,        0.000!   !END!
325 ! X =    1177.823,   -413.211,     919.000,        0.000!   !END!
326 ! X =    1179.311,   -412.994,     905.000,        0.000!   !END!
327 ! X =    1180.798,   -412.778,     911.000,        0.000!   !END!
328 ! X =    1182.286,   -412.561,     965.000,        0.000!   !END!
329 ! X =    1183.773,   -412.344,     837.000,        0.000!   !END!
330 ! X =    1185.261,   -412.127,    1055.000,        0.000!   !END!
331 ! X =    1186.748,    -411.91,     716.000,        0.000!   !END!
332 ! X =    1188.235,   -411.692,     825.000,        0.000!   !END!
333 ! X =    1189.723,   -411.474,     609.000,        0.000!   !END!
334 ! X =     1191.21,   -411.255,     814.000,        0.000!   !END!
335 ! X =    1192.697,   -411.037,    1006.000,        0.000!   !END!
336 ! X =    1194.184,   -410.818,    1036.000,        0.000!   !END!
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337 ! X =   1195.672,   -410.599,    732.000,        0.000!   !END!
338 ! X =   1197.159,   -410.379,    746.000,        0.000!   !END!
339 ! X =   1198.646,    -410.16,    929.000,        0.000!   !END!
340 ! X =   1200.133,    -409.94,   1008.000,        0.000!   !END!
341 ! X =    1201.62,    -409.72,   1288.000,        0.000!   !END!
342 ! X =   1203.107,   -409.499,   1266.000,        0.000!   !END!
343 ! X =   1204.594,   -409.278,   1218.000,        0.000!   !END!
344 ! X =   1206.081,   -409.057,    959.000,        0.000!   !END!
345 ! X =   1207.568,   -408.836,    681.000,        0.000!   !END!
346 ! X =   1209.054,   -408.614,    920.000,        0.000!   !END!
347 ! X =   1210.541,   -408.392,   1170.000,        0.000!   !END!
348 ! X =   1212.028,    -408.17,    956.000,        0.000!   !END!
349 ! X =   1213.514,   -407.948,    818.000,        0.000!   !END!
350 ! X =   1215.001,   -407.725,   1223.000,        0.000!   !END!
351 ! X =   1216.488,   -407.502,   1270.000,        0.000!   !END!
352 ! X =   1217.974,   -407.279,    872.000,        0.000!   !END!
353 ! X =   1219.461,   -407.055,    694.000,        0.000!   !END!
354 ! X =   1220.947,   -406.832,    963.000,        0.000!   !END!
355 ! X =   1222.434,   -406.608,    859.000,        0.000!   !END!
356 ! X =    1223.92,   -406.383,   1000.000,        0.000!   !END!
357 ! X =   1170.121,    -412.46,    365.000,        0.000!   !END!
358 ! X =   1171.608,   -412.245,    406.000,        0.000!   !END!
359 ! X =   1173.096,    -412.03,    600.000,        0.000!   !END!
360 ! X =   1174.583,   -411.815,    591.000,        0.000!   !END!
361 ! X =    1176.07,   -411.599,    644.000,        0.000!   !END!
362 ! X =   1177.558,   -411.383,   1036.000,        0.000!   !END!
363 ! X =   1179.045,   -411.167,   1309.000,        0.000!   !END!
364 ! X =   1180.532,   -410.951,   1262.000,        0.000!   !END!
365 ! X =   1182.019,   -410.734,   1261.000,        0.000!   !END!
366 ! X =   1183.506,   -410.517,   1072.000,        0.000!   !END!
367 ! X =   1184.994,     -410.3,   1199.000,        0.000!   !END!
368 ! X =   1186.481,   -410.083,   1097.000,        0.000!   !END!
369 ! X =   1187.968,   -409.865,    720.000,        0.000!   !END!
370 ! X =   1189.455,   -409.647,    640.000,        0.000!   !END!
371 ! X =   1190.942,   -409.429,    873.000,        0.000!   !END!
372 ! X =   1192.429,    -409.21,    852.000,        0.000!   !END!
373 ! X =   1193.915,   -408.991,    978.000,        0.000!   !END!
374 ! X =   1195.402,   -408.772,    809.000,        0.000!   !END!
375 ! X =   1196.889,   -408.553,    761.000,        0.000!   !END!
376 ! X =   1198.376,   -408.333,    987.000,        0.000!   !END!
377 ! X =   1199.863,   -408.113,    874.000,        0.000!   !END!
378 ! X =   1201.349,   -407.893,   1147.000,        0.000!   !END!
379 ! X =   1202.836,   -407.673,   1323.000,        0.000!   !END!
380 ! X =   1204.322,   -407.452,   1221.000,        0.000!   !END!
381 ! X =   1205.809,   -407.231,   1097.000,        0.000!   !END!
382 ! X =   1207.295,    -407.01,    800.000,        0.000!   !END!
383 ! X =   1208.782,   -406.788,    942.000,        0.000!   !END!
384 ! X =   1210.268,   -406.566,   1167.000,        0.000!   !END!
385 ! X =   1211.755,   -406.344,   1052.000,        0.000!   !END!
386 ! X =   1213.241,   -406.122,   1012.000,        0.000!   !END!
387 ! X =   1214.727,   -405.899,   1002.000,        0.000!   !END!
388 ! X =   1216.214,   -405.676,   1143.000,        0.000!   !END!
389 ! X =     1217.7,   -405.453,    998.000,        0.000!   !END!
390 ! X =   1219.186,    -405.23,    710.000,        0.000!   !END!
391 ! X =   1220.672,   -405.006,    998.000,        0.000!   !END!
392 ! X =   1222.158,   -404.782,    907.000,        0.000!   !END!
393 ! X =   1223.644,   -404.558,   1200.000,        0.000!   !END!
394 ! X =    1225.13,   -404.333,   1173.000,        0.000!   !END!
395 ! X =   1226.616,   -404.108,   1067.000,        0.000!   !END!
396 ! X =   1228.102,   -403.883,    896.000,        0.000!   !END!
397 ! X =   1229.588,   -403.658,    799.000,        0.000!   !END!
398 ! X =   1231.074,   -403.432,    683.000,        0.000!   !END!
399 ! X =   1169.857,   -410.632,    330.000,        0.000!   !END!
400 ! X =   1171.344,   -410.418,    523.000,        0.000!   !END!
401 ! X =   1172.831,   -410.203,    599.000,        0.000!   !END!
402 ! X =   1174.318,   -409.988,    769.000,        0.000!   !END!
403 ! X =   1175.805,   -409.772,    831.000,        0.000!   !END!
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404 ! X =    1177.292,   -409.556,     941.000,        0.000!   !END!
405 ! X =    1178.779,    -409.34,    1150.000,        0.000!   !END!
406 ! X =    1180.266,   -409.124,    1194.000,        0.000!   !END!
407 ! X =    1181.753,   -408.907,    1084.000,        0.000!   !END!
408 ! X =     1183.24,    -408.69,    1206.000,        0.000!   !END!
409 ! X =    1184.727,   -408.473,    1225.000,        0.000!   !END!
410 ! X =    1186.213,   -408.256,     987.000,        0.000!   !END!
411 ! X =      1187.7,   -408.038,    1063.000,        0.000!   !END!
412 ! X =    1189.187,    -407.82,     873.000,        0.000!   !END!
413 ! X =    1190.673,   -407.602,     921.000,        0.000!   !END!
414 ! X =     1192.16,   -407.384,    1233.000,        0.000!   !END!
415 ! X =    1193.646,   -407.165,    1006.000,        0.000!   !END!
416 ! X =    1195.133,   -406.946,    1024.000,        0.000!   !END!
417 ! X =    1196.619,   -406.726,     792.000,        0.000!   !END!
418 ! X =    1198.106,   -406.507,    1015.000,        0.000!   !END!
419 ! X =    1199.592,   -406.287,    1094.000,        0.000!   !END!
420 ! X =    1201.079,   -406.067,     996.000,        0.000!   !END!
421 ! X =    1202.565,   -405.846,    1148.000,        0.000!   !END!
422 ! X =    1204.051,   -405.626,    1368.000,        0.000!   !END!
423 ! X =    1205.537,   -405.405,    1052.000,        0.000!   !END!
424 ! X =    1207.023,   -405.184,     958.000,        0.000!   !END!
425 ! X =     1208.51,   -404.962,     988.000,        0.000!   !END!
426 ! X =    1209.996,    -404.74,    1019.000,        0.000!   !END!
427 ! X =    1211.482,   -404.518,    1344.000,        0.000!   !END!
428 ! X =    1212.968,   -404.296,    1246.000,        0.000!   !END!
429 ! X =    1214.454,   -404.073,    1377.000,        0.000!   !END!
430 ! X =     1215.94,    -403.85,    1135.000,        0.000!   !END!
431 ! X =    1217.426,   -403.627,    1196.000,        0.000!   !END!
432 ! X =    1218.911,   -403.404,     851.000,        0.000!   !END!
433 ! X =    1220.397,    -403.18,     883.000,        0.000!   !END!
434 ! X =    1221.883,   -402.956,    1060.000,        0.000!   !END!
435 ! X =    1223.369,   -402.732,    1207.000,        0.000!   !END!
436 ! X =    1224.854,   -402.507,    1245.000,        0.000!   !END!
437 ! X =     1226.34,   -402.283,    1045.000,        0.000!   !END!
438 ! X =    1227.826,   -402.058,    1068.000,        0.000!   !END!
439 ! X =    1229.311,   -401.832,     870.000,        0.000!   !END!
440 ! X =    1230.797,   -401.607,     782.000,        0.000!   !END!
441 ! X =    1241.194,    -400.02,    1326.000,        0.000!   !END!
442 ! X =    1169.593,   -408.805,     453.000,        0.000!   !END!
443 ! X =     1171.08,    -408.59,     439.000,        0.000!   !END!
444 ! X =    1172.567,   -408.376,     582.000,        0.000!   !END!
445 ! X =    1174.054,    -408.16,     664.000,        0.000!   !END!
446 ! X =     1175.54,   -407.945,     770.000,        0.000!   !END!
447 ! X =    1177.027,   -407.729,     853.000,        0.000!   !END!
448 ! X =    1178.514,   -407.513,     810.000,        0.000!   !END!
449 ! X =      1180.0,   -407.297,     979.000,        0.000!   !END!
450 ! X =    1181.487,    -407.08,     809.000,        0.000!   !END!
451 ! X =    1182.973,   -406.864,     818.000,        0.000!   !END!
452 ! X =     1184.46,   -406.646,    1027.000,        0.000!   !END!
453 ! X =    1185.946,   -406.429,    1372.000,        0.000!   !END!
454 ! X =    1187.432,   -406.211,    1203.000,        0.000!   !END!
455 ! X =    1188.919,   -405.994,     975.000,        0.000!   !END!
456 ! X =    1190.405,   -405.775,    1077.000,        0.000!   !END!
457 ! X =    1191.891,   -405.557,    1343.000,        0.000!   !END!
458 ! X =    1193.377,   -405.338,    1463.000,        0.000!   !END!
459 ! X =    1194.864,   -405.119,    1193.000,        0.000!   !END!
460 ! X =     1196.35,     -404.9,     932.000,        0.000!   !END!
461 ! X =    1197.836,    -404.68,    1059.000,        0.000!   !END!
462 ! X =    1199.322,   -404.461,    1144.000,        0.000!   !END!
463 ! X =    1200.808,    -404.24,    1231.000,        0.000!   !END!
464 ! X =    1202.294,    -404.02,    1197.000,        0.000!   !END!
465 ! X =     1203.78,   -403.799,    1220.000,        0.000!   !END!
466 ! X =    1205.266,   -403.579,    1342.000,        0.000!   !END!
467 ! X =    1206.751,   -403.357,    1350.000,        0.000!   !END!
468 ! X =    1208.237,   -403.136,    1251.000,        0.000!   !END!
469 ! X =    1209.723,   -402.914,    1467.000,        0.000!   !END!
470 ! X =    1211.209,   -402.692,    1407.000,        0.000!   !END!
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471 ! X =   1212.694,    -402.47,   1671.000,        0.000!   !END!
472 ! X =    1214.18,   -402.247,   1369.000,        0.000!   !END!
473 ! X =   1215.666,   -402.025,   1412.000,        0.000!   !END!
474 ! X =   1217.151,   -401.801,   1279.000,        0.000!   !END!
475 ! X =   1218.637,   -401.578,    863.000,        0.000!   !END!
476 ! X =   1220.122,   -401.354,    823.000,        0.000!   !END!
477 ! X =   1221.608,   -401.131,   1103.000,        0.000!   !END!
478 ! X =   1223.093,   -400.906,   1432.000,        0.000!   !END!
479 ! X =   1224.578,   -400.682,   1448.000,        0.000!   !END!
480 ! X =   1226.064,   -400.457,   1352.000,        0.000!   !END!
481 ! X =   1227.549,   -400.232,   1094.000,        0.000!   !END!
482 ! X =   1229.034,   -400.007,    802.000,        0.000!   !END!
483 ! X =   1230.519,   -399.781,    756.000,        0.000!   !END!
484 ! X =    1239.43,   -398.422,   1213.000,        0.000!   !END!
485 ! X =   1240.915,   -398.195,   1312.000,        0.000!   !END!
486 ! X =    1169.33,   -406.978,    365.000,        0.000!   !END!
487 ! X =   1170.816,   -406.763,    393.000,        0.000!   !END!
488 ! X =   1172.303,   -406.548,    455.000,        0.000!   !END!
489 ! X =   1173.789,   -406.333,    590.000,        0.000!   !END!
490 ! X =   1175.275,   -406.118,    775.000,        0.000!   !END!
491 ! X =   1176.762,   -405.902,    690.000,        0.000!   !END!
492 ! X =   1178.248,   -405.686,    697.000,        0.000!   !END!
493 ! X =   1179.734,    -405.47,    678.000,        0.000!   !END!
494 ! X =    1181.22,   -405.253,    607.000,        0.000!   !END!
495 ! X =   1182.707,   -405.037,    824.000,        0.000!   !END!
496 ! X =   1184.193,    -404.82,    802.000,        0.000!   !END!
497 ! X =   1185.679,   -404.602,   1033.000,        0.000!   !END!
498 ! X =   1187.165,   -404.385,   1241.000,        0.000!   !END!
499 ! X =   1188.651,   -404.167,   1297.000,        0.000!   !END!
500 ! X =   1190.137,   -403.949,   1503.000,        0.000!   !END!
501 ! X =   1191.623,    -403.73,   1477.000,        0.000!   !END!
502 ! X =   1193.108,   -403.512,   1533.000,        0.000!   !END!
503 ! X =   1194.594,   -403.293,   1242.000,        0.000!   !END!
504 ! X =    1196.08,   -403.073,   1270.000,        0.000!   !END!
505 ! X =   1197.566,   -402.854,   1198.000,        0.000!   !END!
506 ! X =   1199.052,   -402.634,   1372.000,        0.000!   !END!
507 ! X =   1200.537,   -402.414,   1394.000,        0.000!   !END!
508 ! X =   1202.023,   -402.194,   1187.000,        0.000!   !END!
509 ! X =   1203.508,   -401.973,   1517.000,        0.000!   !END!
510 ! X =   1204.994,   -401.752,   1490.000,        0.000!   !END!
511 ! X =   1206.479,   -401.531,   1518.000,        0.000!   !END!
512 ! X =   1207.965,    -401.31,   1632.000,        0.000!   !END!
513 ! X =    1209.45,   -401.088,   1692.000,        0.000!   !END!
514 ! X =   1210.936,   -400.866,   1888.000,        0.000!   !END!
515 ! X =   1212.421,   -400.644,   1951.000,        0.000!   !END!
516 ! X =   1213.906,   -400.422,   1603.000,        0.000!   !END!
517 ! X =   1215.392,   -400.199,   1543.000,        0.000!   !END!
518 ! X =   1216.877,   -399.976,   1292.000,        0.000!   !END!
519 ! X =   1218.362,   -399.752,   1067.000,        0.000!   !END!
520 ! X =   1219.847,   -399.529,    928.000,        0.000!   !END!
521 ! X =   1221.332,   -399.305,   1190.000,        0.000!   !END!
522 ! X =   1222.817,   -399.081,   1415.000,        0.000!   !END!
523 ! X =   1224.302,   -398.856,   1066.000,        0.000!   !END!
524 ! X =   1225.787,   -398.632,    899.000,        0.000!   !END!
525 ! X =   1227.272,   -398.407,    714.000,        0.000!   !END!
526 ! X =   1228.757,   -398.182,    703.000,        0.000!   !END!
527 ! X =   1237.666,   -396.825,   1097.000,        0.000!   !END!
528 ! X =    1239.15,   -396.597,   1224.000,        0.000!   !END!
529 ! X =   1240.635,    -396.37,   1526.000,        0.000!   !END!
530 ! X =   1242.119,   -396.142,   1566.000,        0.000!   !END!
531 ! X =   1243.604,   -395.914,   1311.000,        0.000!   !END!
532 ! X =   1245.088,   -395.686,   1283.000,        0.000!   !END!
533 ! X =   1246.573,   -395.458,   1482.000,        0.000!   !END!
534 ! X =   1169.066,    -405.15,    290.000,        0.000!   !END!
535 ! X =   1170.552,   -404.936,    389.000,        0.000!   !END!
536 ! X =   1172.038,   -404.721,    506.000,        0.000!   !END!
537 ! X =   1173.524,   -404.506,    644.000,        0.000!   !END!
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538 ! X =     1175.01,   -404.291,     578.000,        0.000!   !END!
539 ! X =    1176.496,   -404.075,     539.000,        0.000!   !END!
540 ! X =    1177.982,   -403.859,     634.000,        0.000!   !END!
541 ! X =    1179.468,   -403.643,     662.000,        0.000!   !END!
542 ! X =    1180.954,   -403.427,     567.000,        0.000!   !END!
543 ! X =     1182.44,    -403.21,     579.000,        0.000!   !END!
544 ! X =    1183.926,   -402.993,     660.000,        0.000!   !END!
545 ! X =    1185.411,   -402.776,     878.000,        0.000!   !END!
546 ! X =    1186.897,   -402.558,     907.000,        0.000!   !END!
547 ! X =    1188.383,    -402.34,     955.000,        0.000!   !END!
548 ! X =    1189.868,   -402.122,    1048.000,        0.000!   !END!
549 ! X =    1191.354,   -401.904,    1056.000,        0.000!   !END!
550 ! X =    1192.839,   -401.685,    1333.000,        0.000!   !END!
551 ! X =    1194.325,   -401.466,    1223.000,        0.000!   !END!
552 ! X =     1195.81,   -401.247,    1411.000,        0.000!   !END!
553 ! X =    1197.296,   -401.028,    1106.000,        0.000!   !END!
554 ! X =    1198.781,   -400.808,    1347.000,        0.000!   !END!
555 ! X =    1200.267,   -400.588,    1222.000,        0.000!   !END!
556 ! X =    1201.752,   -400.368,    1524.000,        0.000!   !END!
557 ! X =    1203.237,   -400.147,    1386.000,        0.000!   !END!
558 ! X =    1204.722,   -399.926,    1198.000,        0.000!   !END!
559 ! X =    1206.207,   -399.705,    1242.000,        0.000!   !END!
560 ! X =    1207.693,   -399.484,    1415.000,        0.000!   !END!
561 ! X =    1209.178,   -399.262,    1358.000,        0.000!   !END!
562 ! X =    1210.663,    -399.04,    1355.000,        0.000!   !END!
563 ! X =    1212.148,   -398.818,    1403.000,        0.000!   !END!
564 ! X =    1213.633,   -398.596,    1712.000,        0.000!   !END!
565 ! X =    1215.118,   -398.373,    1431.000,        0.000!   !END!
566 ! X =    1216.603,    -398.15,    1422.000,        0.000!   !END!
567 ! X =    1218.087,   -397.927,    1236.000,        0.000!   !END!
568 ! X =    1219.572,   -397.703,    1228.000,        0.000!   !END!
569 ! X =    1221.057,   -397.479,    1492.000,        0.000!   !END!
570 ! X =    1222.542,   -397.255,    1372.000,        0.000!   !END!
571 ! X =    1224.026,   -397.031,    1181.000,        0.000!   !END!
572 ! X =    1225.511,   -396.806,     792.000,        0.000!   !END!
573 ! X =    1226.996,   -396.581,     939.000,        0.000!   !END!
574 ! X =     1228.48,   -396.356,     737.000,        0.000!   !END!
575 ! X =    1229.965,   -396.131,    1213.000,        0.000!   !END!
576 ! X =    1231.449,   -395.905,    1173.000,        0.000!   !END!
577 ! X =    1235.902,   -395.226,    1111.000,        0.000!   !END!
578 ! X =    1237.387,     -395.0,    1138.000,        0.000!   !END!
579 ! X =    1238.871,   -394.773,    1362.000,        0.000!   !END!
580 ! X =    1240.355,   -394.545,    1709.000,        0.000!   !END!
581 ! X =    1241.839,   -394.318,    1585.000,        0.000!   !END!
582 ! X =    1243.323,    -394.09,    1298.000,        0.000!   !END!
583 ! X =    1244.808,   -393.862,    1224.000,        0.000!   !END!
584 ! X =    1246.292,   -393.633,    1150.000,        0.000!   !END!
585 ! X =    1247.776,   -393.404,    1348.000,        0.000!   !END!
586 ! X =    1171.774,   -402.894,     383.000,        0.000!   !END!
587 ! X =     1173.26,   -402.679,     482.000,        0.000!   !END!
588 ! X =    1174.745,   -402.464,     533.000,        0.000!   !END!
589 ! X =    1176.231,   -402.248,     559.000,        0.000!   !END!
590 ! X =    1177.717,   -402.032,     598.000,        0.000!   !END!
591 ! X =    1179.202,   -401.816,     532.000,        0.000!   !END!
592 ! X =    1180.688,     -401.6,     525.000,        0.000!   !END!
593 ! X =    1182.173,   -401.383,     533.000,        0.000!   !END!
594 ! X =    1183.659,   -401.166,     543.000,        0.000!   !END!
595 ! X =    1185.144,   -400.949,     562.000,        0.000!   !END!
596 ! X =    1186.629,   -400.731,     602.000,        0.000!   !END!
597 ! X =    1188.115,   -400.514,     736.000,        0.000!   !END!
598 ! X =      1189.6,   -400.296,     817.000,        0.000!   !END!
599 ! X =    1191.085,   -400.077,     809.000,        0.000!   !END!
600 ! X =     1192.57,   -399.859,     920.000,        0.000!   !END!
601 ! X =    1194.056,    -399.64,    1017.000,        0.000!   !END!
602 ! X =    1195.541,   -399.421,    1006.000,        0.000!   !END!
603 ! X =    1197.026,   -399.201,     956.000,        0.000!   !END!
604 ! X =    1198.511,   -398.982,    1137.000,        0.000!   !END!
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605 ! X =    1199.996,   -398.762,     982.000,          0.000!   !END!
606 ! X =    1201.481,   -398.541,    1187.000,          0.000!   !END!
607 ! X =    1202.966,   -398.321,    1365.000,          0.000!   !END!
608 ! X =    1204.451,     -398.1,    1245.000,          0.000!   !END!
609 ! X =    1205.935,   -397.879,    1074.000,          0.000!   !END!
610 ! X =     1207.42,   -397.658,    1365.000,          0.000!   !END!
611 ! X =    1208.905,   -397.436,    1401.000,          0.000!   !END!
612 ! X =     1210.39,   -397.214,    1080.000,          0.000!   !END!
613 ! X =    1211.874,   -396.992,    1260.000,          0.000!   !END!
614 ! X =    1213.359,    -396.77,    1660.000,          0.000!   !END!
615 ! X =    1214.844,   -396.547,    1703.000,          0.000!   !END!
616 ! X =    1216.328,   -396.324,    1525.000,          0.000!   !END!
617 ! X =    1217.813,   -396.101,    1299.000,          0.000!   !END!
618 ! X =    1219.297,   -395.878,    1389.000,          0.000!   !END!
619 ! X =    1220.782,   -395.654,    1084.000,          0.000!   !END!
620 ! X =    1222.266,    -395.43,    1048.000,          0.000!   !END!
621 ! X =     1223.75,   -395.206,    1002.000,          0.000!   !END!
622 ! X =    1225.235,   -394.981,    1374.000,          0.000!   !END!
623 ! X =    1226.719,   -394.756,     910.000,          0.000!   !END!
624 ! X =    1228.203,   -394.531,    1109.000,          0.000!   !END!
625 ! X =    1229.687,   -394.306,    1002.000,          0.000!   !END!
626 ! X =    1231.171,    -394.08,    1469.000,          0.000!   !END!
627 ! X =    1232.656,   -393.854,    1136.000,          0.000!   !END!
628 ! X =     1234.14,   -393.628,    1324.000,          0.000!   !END!
629 ! X =    1235.624,   -393.401,     912.000,          0.000!   !END!
630 ! X =    1237.108,   -393.175,    1427.000,          0.000!   !END!
631 ! X =    1238.592,   -392.948,    1487.000,          0.000!   !END!
632 ! X =    1240.075,    -392.72,    1681.000,          0.000!   !END!
633 ! X =    1241.559,   -392.493,    1310.000,          0.000!   !END!
634 ! X =    1243.043,   -392.265,    1080.000,          0.000!   !END!
635 ! X =    1244.527,   -392.037,    1029.000,          0.000!   !END!
636 ! X =    1246.011,   -391.808,     989.000,          0.000!   !END!
637 ! X =    1247.494,    -391.58,    1038.000,          0.000!   !END!
638 ! X =    1248.978,   -391.351,    1337.000,          0.000!   !END!
639 ! X =    1172.995,   -400.852,     368.000,          0.000!   !END!
640 ! X =    1174.481,   -400.637,     411.000,          0.000!   !END!
641 ! X =    1175.966,   -400.421,     485.000,          0.000!   !END!
642 ! X =    1177.451,   -400.205,     480.000,          0.000!   !END!
643 ! X =    1178.936,   -399.989,     569.000,          0.000!   !END!
644 ! X =    1180.421,   -399.773,     610.000,          0.000!   !END!
645 ! X =    1181.907,   -399.556,     585.000,          0.000!   !END!
646 ! X =    1183.392,   -399.339,     596.000,          0.000!   !END!
647 ! X =    1184.877,   -399.122,     591.000,          0.000!   !END!
648 ! X =    1186.362,   -398.905,     681.000,          0.000!   !END!
649 ! X =    1187.847,   -398.687,     787.000,          0.000!   !END!
650 ! X =    1189.332,   -398.469,     528.000,          0.000!   !END!
651 ! X =    1190.817,   -398.251,     700.000,          0.000!   !END!
652 ! X =    1192.302,   -398.032,     615.000,          0.000!   !END!
653 ! X =    1193.786,   -397.813,     905.000,          0.000!   !END!
654 ! X =    1195.271,   -397.594,     836.000,          0.000!   !END!
655 ! X =    1196.756,   -397.375,     827.000,          0.000!   !END!
656 ! X =    1198.241,   -397.155,     768.000,          0.000!   !END!
657 ! X =    1199.725,   -396.935,     983.000,          0.000!   !END!
658 ! X =     1201.21,   -396.715,    1281.000,          0.000!   !END!
659 ! X =    1202.694,   -396.495,    1378.000,          0.000!   !END!
660 ! X =    1204.179,   -396.274,    1371.000,          0.000!   !END!
661 ! X =    1205.663,   -396.053,    1135.000,          0.000!   !END!
662 ! X =    1207.148,   -395.832,     884.000,          0.000!   !END!
663 ! X =    1208.632,    -395.61,     907.000,          0.000!   !END!
664 ! X =    1210.117,   -395.389,    1249.000,          0.000!   !END!
665 ! X =    1211.601,   -395.167,    1528.000,          0.000!   !END!
666 ! X =    1213.085,   -394.944,    1552.000,          0.000!   !END!
667 ! X =     1214.57,   -394.722,    1473.000,          0.000!   !END!
668 ! X =    1216.054,   -394.499,    1677.000,          0.000!   !END!
669 ! X =    1217.538,   -394.276,    1553.000,          0.000!   !END!
670 ! X =    1219.022,   -394.052,    1572.000,          0.000!   !END!
671 ! X =    1220.506,   -393.828,    1526.000,          0.000!   !END!
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672 ! X =    1221.99,  -393.604,  1261.000,      0.000!   !END!
673 ! X =   1223.474,   -393.38,  1217.000,      0.000!   !END!
674 ! X =   1224.958,  -393.156,  1247.000,      0.000!   !END!
675 ! X =   1226.442,  -392.931,   947.000,      0.000!   !END!
676 ! X =   1227.926,  -392.706,  1163.000,      0.000!   !END!
677 ! X =    1229.41,   -392.48,  1434.000,      0.000!   !END!
678 ! X =   1230.894,  -392.255,  1373.000,      0.000!   !END!
679 ! X =   1232.378,  -392.029,  1170.000,      0.000!   !END!
680 ! X =   1233.861,  -391.803,  1293.000,      0.000!   !END!
681 ! X =   1235.345,  -391.576,  1077.000,      0.000!   !END!
682 ! X =   1236.829,   -391.35,   953.000,      0.000!   !END!
683 ! X =   1238.312,  -391.123,  1202.000,      0.000!   !END!
684 ! X =   1239.796,  -390.895,  1602.000,      0.000!   !END!
685 ! X =   1241.279,  -390.668,  1433.000,      0.000!   !END!
686 ! X =   1242.763,   -390.44,  1106.000,      0.000!   !END!
687 ! X =   1244.246,  -390.212,   966.000,      0.000!   !END!
688 ! X =    1245.73,  -389.984,  1077.000,      0.000!   !END!
689 ! X =   1247.213,  -389.755,   884.000,      0.000!   !END!
690 ! X =   1248.696,  -389.526,  1096.000,      0.000!   !END!
691 ! X =   1174.216,   -398.81,   459.000,      0.000!   !END!
692 ! X =   1175.701,  -398.594,   516.000,      0.000!   !END!
693 ! X =   1177.185,  -398.378,   579.000,      0.000!   !END!
694 ! X =    1178.67,  -398.162,   576.000,      0.000!   !END!
695 ! X =   1180.155,  -397.946,   656.000,      0.000!   !END!
696 ! X =    1181.64,  -397.729,   718.000,      0.000!   !END!
697 ! X =   1183.125,  -397.513,   760.000,      0.000!   !END!
698 ! X =   1184.609,  -397.295,   994.000,      0.000!   !END!
699 ! X =   1187.579,   -396.86,   782.000,      0.000!   !END!
700 ! X =   1189.063,  -396.642,   618.000,      0.000!   !END!
701 ! X =   1190.548,  -396.424,   489.000,      0.000!   !END!
702 ! X =   1192.033,  -396.206,   549.000,      0.000!   !END!
703 ! X =   1193.517,  -395.987,   598.000,      0.000!   !END!
704 ! X =   1195.001,  -395.768,   577.000,      0.000!   !END!
705 ! X =   1196.486,  -395.549,   809.000,      0.000!   !END!
706 ! X =    1197.97,  -395.329,   899.000,      0.000!   !END!
707 ! X =   1199.455,  -395.109,  1006.000,      0.000!   !END!
708 ! X =   1200.939,  -394.889,  1262.000,      0.000!   !END!
709 ! X =   1202.423,  -394.669,   988.000,      0.000!   !END!
710 ! X =   1203.907,  -394.448,  1120.000,      0.000!   !END!
711 ! X =   1205.392,  -394.227,  1054.000,      0.000!   !END!
712 ! X =   1206.876,  -394.006,   860.000,      0.000!   !END!
713 ! X =    1208.36,  -393.784,  1013.000,      0.000!   !END!
714 ! X =   1209.844,  -393.563,  1203.000,      0.000!   !END!
715 ! X =   1211.328,  -393.341,  1212.000,      0.000!   !END!
716 ! X =   1212.812,  -393.118,  1380.000,      0.000!   !END!
717 ! X =   1214.296,  -392.896,  1300.000,      0.000!   !END!
718 ! X =    1215.78,  -392.673,  1206.000,      0.000!   !END!
719 ! X =   1217.263,   -392.45,  1581.000,      0.000!   !END!
720 ! X =   1218.747,  -392.227,  1457.000,      0.000!   !END!
721 ! X =   1220.231,  -392.003,  1699.000,      0.000!   !END!
722 ! X =   1221.715,  -391.779,  1543.000,      0.000!   !END!
723 ! X =   1223.198,  -391.555,  1640.000,      0.000!   !END!
724 ! X =   1224.682,   -391.33,  1476.000,      0.000!   !END!
725 ! X =   1226.166,  -391.106,  1036.000,      0.000!   !END!
726 ! X =   1227.649,  -390.881,  1315.000,      0.000!   !END!
727 ! X =   1229.133,  -390.655,  1504.000,      0.000!   !END!
728 ! X =   1230.616,   -390.43,  1469.000,      0.000!   !END!
729 ! X =     1232.1,  -390.204,  1242.000,      0.000!   !END!
730 ! X =   1233.583,  -389.978,  1453.000,      0.000!   !END!
731 ! X =   1235.066,  -389.751,  1414.000,      0.000!   !END!
732 ! X =    1236.55,  -389.525,  1012.000,      0.000!   !END!
733 ! X =   1238.033,  -389.298,  1127.000,      0.000!   !END!
734 ! X =   1239.516,  -389.071,  1352.000,      0.000!   !END!
735 ! X =   1240.999,  -388.843,  1189.000,      0.000!   !END!
736 ! X =   1242.482,  -388.615,  1257.000,      0.000!   !END!
737 ! X =   1243.965,  -388.387,  1048.000,      0.000!   !END!
738 ! X =   1245.449,  -388.159,   856.000,      0.000!   !END!
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739 ! X =    1246.932,   -387.931,     825.000,         0.000!   !END!
740 ! X =    1248.415,   -387.702,    1060.000,         0.000!   !END!
741 ! X =    1249.897,   -387.473,    1125.000,         0.000!   !END!
742 ! X =    1175.435,   -396.767,     429.000,         0.000!   !END!
743 ! X =     1176.92,   -396.551,     537.000,         0.000!   !END!
744 ! X =    1178.404,   -396.335,     459.000,         0.000!   !END!
745 ! X =    1179.889,   -396.119,     575.000,         0.000!   !END!
746 ! X =    1181.373,   -395.903,     564.000,         0.000!   !END!
747 ! X =    1182.858,   -395.686,     646.000,         0.000!   !END!
748 ! X =    1188.795,   -394.816,     609.000,         0.000!   !END!
749 ! X =    1190.279,   -394.598,     535.000,         0.000!   !END!
750 ! X =    1191.764,   -394.379,     489.000,         0.000!   !END!
751 ! X =    1193.248,   -394.161,     408.000,         0.000!   !END!
752 ! X =    1194.732,   -393.942,     669.000,         0.000!   !END!
753 ! X =    1196.216,   -393.722,     675.000,         0.000!   !END!
754 ! X =      1197.7,   -393.503,     789.000,         0.000!   !END!
755 ! X =    1199.184,   -393.283,     834.000,         0.000!   !END!
756 ! X =    1200.668,   -393.063,     852.000,         0.000!   !END!
757 ! X =    1202.152,   -392.843,     817.000,         0.000!   !END!
758 ! X =    1203.636,   -392.622,     823.000,         0.000!   !END!
759 ! X =     1205.12,   -392.401,     750.000,         0.000!   !END!
760 ! X =    1206.603,    -392.18,     930.000,         0.000!   !END!
761 ! X =    1208.087,   -391.959,    1127.000,         0.000!   !END!
762 ! X =    1209.571,   -391.737,     726.000,         0.000!   !END!
763 ! X =    1211.054,   -391.515,    1065.000,         0.000!   !END!
764 ! X =    1212.538,   -391.293,    1323.000,         0.000!   !END!
765 ! X =    1214.022,    -391.07,    1448.000,         0.000!   !END!
766 ! X =    1215.505,   -390.847,    1548.000,         0.000!   !END!
767 ! X =    1216.989,   -390.624,    1772.000,         0.000!   !END!
768 ! X =    1218.472,   -390.401,    1416.000,         0.000!   !END!
769 ! X =    1219.956,   -390.177,    1198.000,         0.000!   !END!
770 ! X =    1221.439,   -389.954,    1225.000,         0.000!   !END!
771 ! X =    1222.922,   -389.729,    1580.000,         0.000!   !END!
772 ! X =    1224.406,   -389.505,    1529.000,         0.000!   !END!
773 ! X =    1225.889,    -389.28,    1165.000,         0.000!   !END!
774 ! X =    1227.372,   -389.055,    1418.000,         0.000!   !END!
775 ! X =    1228.855,    -388.83,    1635.000,         0.000!   !END!
776 ! X =    1230.338,   -388.605,    1459.000,         0.000!   !END!
777 ! X =    1231.822,   -388.379,    1310.000,         0.000!   !END!
778 ! X =    1233.305,   -388.153,    1441.000,         0.000!   !END!
779 ! X =    1234.788,   -387.926,    1391.000,         0.000!   !END!
780 ! X =    1236.271,     -387.7,    1337.000,         0.000!   !END!
781 ! X =    1237.754,   -387.473,    1455.000,         0.000!   !END!
782 ! X =    1239.236,   -387.246,    1336.000,         0.000!   !END!
783 ! X =    1240.719,   -387.018,    1223.000,         0.000!   !END!
784 ! X =    1242.202,   -386.791,    1226.000,         0.000!   !END!
785 ! X =    1243.685,   -386.563,     979.000,         0.000!   !END!
786 ! X =    1245.168,   -386.335,    1079.000,         0.000!   !END!
787 ! X =     1246.65,   -386.106,    1104.000,         0.000!   !END!
788 ! X =    1248.133,   -385.877,     858.000,         0.000!   !END!
789 ! X =    1249.615,   -385.648,    1030.000,         0.000!   !END!
790 ! X =    1178.138,   -394.509,     475.000,         0.000!   !END!
791 ! X =    1179.623,   -394.292,     440.000,         0.000!   !END!
792 ! X =    1181.107,   -394.076,     640.000,         0.000!   !END!
793 ! X =    1191.495,   -392.553,     369.000,         0.000!   !END!
794 ! X =    1192.978,   -392.334,     478.000,         0.000!   !END!
795 ! X =    1194.462,   -392.115,     570.000,         0.000!   !END!
796 ! X =    1195.946,   -391.896,     552.000,         0.000!   !END!
797 ! X =     1197.43,   -391.677,     843.000,         0.000!   !END!
798 ! X =    1198.913,   -391.457,     604.000,         0.000!   !END!
799 ! X =    1200.397,   -391.237,     605.000,         0.000!   !END!
800 ! X =    1201.881,   -391.017,     652.000,         0.000!   !END!
801 ! X =    1203.364,   -390.796,     770.000,         0.000!   !END!
802 ! X =    1204.848,   -390.575,     834.000,         0.000!   !END!
803 ! X =    1206.331,   -390.354,     725.000,         0.000!   !END!
804 ! X =    1207.814,   -390.133,     608.000,         0.000!   !END!
805 ! X =    1209.298,   -389.911,     656.000,         0.000!   !END!
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806 ! X =    1210.781,   -389.689,    1126.000,        0.000!   !END!
807 ! X =    1212.264,   -389.467,    1115.000,        0.000!   !END!
808 ! X =    1213.748,   -389.245,    1387.000,        0.000!   !END!
809 ! X =    1215.231,   -389.022,    1569.000,        0.000!   !END!
810 ! X =    1216.714,   -388.799,    1595.000,        0.000!   !END!
811 ! X =    1218.197,   -388.576,    1195.000,        0.000!   !END!
812 ! X =     1219.68,   -388.352,     961.000,        0.000!   !END!
813 ! X =    1221.163,   -388.128,    1084.000,        0.000!   !END!
814 ! X =    1222.646,   -387.904,    1324.000,        0.000!   !END!
815 ! X =    1224.129,    -387.68,    1732.000,        0.000!   !END!
816 ! X =    1225.612,   -387.455,    1720.000,        0.000!   !END!
817 ! X =    1227.095,    -387.23,    1512.000,        0.000!   !END!
818 ! X =    1228.578,   -387.005,    1680.000,        0.000!   !END!
819 ! X =    1230.061,    -386.78,    1528.000,        0.000!   !END!
820 ! X =    1231.544,   -386.554,    1452.000,        0.000!   !END!
821 ! X =    1233.026,   -386.328,    1535.000,        0.000!   !END!
822 ! X =    1234.509,   -386.102,    1401.000,        0.000!   !END!
823 ! X =    1235.992,   -385.875,    1483.000,        0.000!   !END!
824 ! X =    1237.474,   -385.648,    1605.000,        0.000!   !END!
825 ! X =    1238.957,   -385.421,    1574.000,        0.000!   !END!
826 ! X =    1240.439,   -385.194,    1577.000,        0.000!   !END!
827 ! X =    1241.922,   -384.966,    1326.000,        0.000!   !END!
828 ! X =    1243.404,   -384.738,    1393.000,        0.000!   !END!
829 ! X =    1244.887,    -384.51,    1134.000,        0.000!   !END!
830 ! X =    1246.369,   -384.282,     971.000,        0.000!   !END!
831 ! X =    1247.851,   -384.053,     945.000,        0.000!   !END!
832 ! X =    1249.333,   -383.824,    1058.000,        0.000!   !END!
833 ! X =    1192.709,   -390.508,     492.000,        0.000!   !END!
834 ! X =    1194.193,   -390.289,     640.000,        0.000!   !END!
835 ! X =    1195.676,    -390.07,     587.000,        0.000!   !END!
836 ! X =    1197.159,   -389.851,     517.000,        0.000!   !END!
837 ! X =    1198.643,   -389.631,     876.000,        0.000!   !END!
838 ! X =    1200.126,   -389.411,     983.000,        0.000!   !END!
839 ! X =    1201.609,   -389.191,     850.000,        0.000!   !END!
840 ! X =    1203.092,    -388.97,     776.000,        0.000!   !END!
841 ! X =    1204.576,   -388.749,     518.000,        0.000!   !END!
842 ! X =    1206.059,   -388.528,     555.000,        0.000!   !END!
843 ! X =    1207.542,   -388.307,     487.000,        0.000!   !END!
844 ! X =    1209.025,   -388.085,     626.000,        0.000!   !END!
845 ! X =    1210.508,   -387.864,     794.000,        0.000!   !END!
846 ! X =    1211.991,   -387.641,     824.000,        0.000!   !END!
847 ! X =    1213.474,   -387.419,    1004.000,        0.000!   !END!
848 ! X =    1214.957,   -387.196,    1101.000,        0.000!   !END!
849 ! X =    1216.439,   -386.973,    1435.000,        0.000!   !END!
850 ! X =    1217.922,    -386.75,    1039.000,        0.000!   !END!
851 ! X =    1219.405,   -386.527,     765.000,        0.000!   !END!
852 ! X =    1220.888,   -386.303,     961.000,        0.000!   !END!
853 ! X =     1222.37,   -386.079,     963.000,        0.000!   !END!
854 ! X =    1223.853,   -385.855,    1391.000,        0.000!   !END!
855 ! X =    1225.336,    -385.63,    1485.000,        0.000!   !END!
856 ! X =    1226.818,   -385.405,    1332.000,        0.000!   !END!
857 ! X =    1228.301,    -385.18,    1520.000,        0.000!   !END!
858 ! X =    1229.783,   -384.955,    1705.000,        0.000!   !END!
859 ! X =    1231.266,   -384.729,    1572.000,        0.000!   !END!
860 ! X =    1232.748,   -384.503,    1802.000,        0.000!   !END!
861 ! X =     1234.23,   -384.277,    1371.000,        0.000!   !END!
862 ! X =    1235.713,    -384.05,    1674.000,        0.000!   !END!
863 ! X =    1237.195,   -383.823,    1676.000,        0.000!   !END!
864 ! X =    1238.677,   -383.596,    1586.000,        0.000!   !END!
865 ! X =    1240.159,   -383.369,    1727.000,        0.000!   !END!
866 ! X =    1241.641,   -383.142,    1516.000,        0.000!   !END!
867 ! X =    1243.123,   -382.914,    1359.000,        0.000!   !END!
868 ! X =    1244.606,   -382.686,    1097.000,        0.000!   !END!
869 ! X =    1246.088,   -382.457,    1022.000,        0.000!   !END!
870 ! X =    1247.569,   -382.228,    1016.000,        0.000!   !END!
871 ! X =    1249.051,     -382.0,     732.000,        0.000!   !END!
872 ! X =    1198.372,   -387.805,     652.000,        0.000!   !END!
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873 ! X =   1199.855,   -387.585,   1164.000,        0.000!   !END!
874 ! X =   1201.338,   -387.365,   1129.000,        0.000!   !END!
875 ! X =   1202.821,   -387.144,   1070.000,        0.000!   !END!
876 ! X =   1204.304,   -386.924,    942.000,        0.000!   !END!
877 ! X =   1205.786,   -386.703,    668.000,        0.000!   !END!
878 ! X =   1207.269,   -386.481,    425.000,        0.000!   !END!
879 ! X =   1208.752,    -386.26,    532.000,        0.000!   !END!
880 ! X =   1210.235,   -386.038,    696.000,        0.000!   !END!
881 ! X =   1211.717,   -385.816,    673.000,        0.000!   !END!
882 ! X =     1213.2,   -385.593,    775.000,        0.000!   !END!
883 ! X =   1214.682,   -385.371,   1061.000,        0.000!   !END!
884 ! X =   1216.165,   -385.148,    939.000,        0.000!   !END!
885 ! X =   1217.647,   -384.925,    817.000,        0.000!   !END!
886 ! X =    1219.13,   -384.701,    763.000,        0.000!   !END!
887 ! X =   1220.612,   -384.478,    616.000,        0.000!   !END!
888 ! X =   1222.094,   -384.254,    877.000,        0.000!   !END!
889 ! X =   1223.577,   -384.029,    892.000,        0.000!   !END!
890 ! X =   1225.059,   -383.805,    910.000,        0.000!   !END!
891 ! X =   1226.541,    -383.58,   1134.000,        0.000!   !END!
892 ! X =   1228.023,   -383.355,   1358.000,        0.000!   !END!
893 ! X =   1229.505,    -383.13,   1512.000,        0.000!   !END!
894 ! X =   1230.988,   -382.904,   1674.000,        0.000!   !END!
895 ! X =    1232.47,   -382.678,   1806.000,        0.000!   !END!
896 ! X =   1233.952,   -382.452,   1678.000,        0.000!   !END!
897 ! X =   1235.434,   -382.225,   1725.000,        0.000!   !END!
898 ! X =   1236.916,   -381.999,   1256.000,        0.000!   !END!
899 ! X =   1238.397,   -381.772,   1160.000,        0.000!   !END!
900 ! X =   1239.879,   -381.544,   1382.000,        0.000!   !END!
901 ! X =   1241.361,   -381.317,   1289.000,        0.000!   !END!
902 ! X =   1242.843,   -381.089,   1584.000,        0.000!   !END!
903 ! X =   1244.325,   -380.861,   1317.000,        0.000!   !END!
904 ! X =   1245.806,   -380.633,   1170.000,        0.000!   !END!
905 ! X =   1211.444,    -383.99,    548.000,        0.000!   !END!
906 ! X =   1212.926,   -383.768,    730.000,        0.000!   !END!
907 ! X =   1214.408,   -383.545,    699.000,        0.000!   !END!
908 ! X =    1215.89,   -383.323,    749.000,        0.000!   !END!
909 ! X =   1217.372,   -383.099,    624.000,        0.000!   !END!
910 ! X =   1218.854,   -382.876,    608.000,        0.000!   !END!
911 ! X =   1220.336,   -382.652,    530.000,        0.000!   !END!
912 ! X =   1221.818,   -382.428,    797.000,        0.000!   !END!
913 ! X =     1223.3,   -382.204,   1103.000,        0.000!   !END!
914 ! X =   1224.782,    -381.98,   1110.000,        0.000!   !END!
915 ! X =   1226.264,   -381.755,   1130.000,        0.000!   !END!
916 ! X =   1227.746,    -381.53,   1499.000,        0.000!   !END!
917 ! X =   1229.228,   -381.305,   1742.000,        0.000!   !END!
918 ! X =    1230.71,   -381.079,   1769.000,        0.000!   !END!
919 ! X =   1232.191,   -380.853,   1639.000,        0.000!   !END!
920 ! X =   1233.673,   -380.627,   1342.000,        0.000!   !END!
921 ! X =   1235.155,   -380.401,   1247.000,        0.000!   !END!
922 ! X =   1236.636,   -380.174,   1168.000,        0.000!   !END!
923 ! X =   1238.118,   -379.947,   1012.000,        0.000!   !END!
924 ! X =   1239.599,    -379.72,    959.000,        0.000!   !END!
925 ! X =   1241.081,   -379.492,   1366.000,        0.000!   !END!
926 ! X =   1242.562,   -379.265,   1348.000,        0.000!   !END!
927 ! X =   1244.044,   -379.037,   1526.000,        0.000!   !END!
928 ! X =   1245.525,   -378.808,   1042.000,        0.000!   !END!
929 ! X =   1214.134,    -381.72,    488.000,        0.000!   !END!
930 ! X =   1215.616,   -381.497,    515.000,        0.000!   !END!
931 ! X =   1217.097,   -381.274,    491.000,        0.000!   !END!
932 ! X =   1218.579,   -381.051,    550.000,        0.000!   !END!
933 ! X =   1220.061,   -380.827,    579.000,        0.000!   !END!
934 ! X =   1221.542,   -380.603,    781.000,        0.000!   !END!
935 ! X =   1223.024,   -380.379,    900.000,        0.000!   !END!
936 ! X =   1224.506,   -380.155,   1059.000,        0.000!   !END!
937 ! X =   1225.987,    -379.93,   1123.000,        0.000!   !END!
938 ! X =   1227.469,   -379.705,   1307.000,        0.000!   !END!
939 ! X =    1228.95,    -379.48,   1166.000,        0.000!   !END!
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 940 ! X =    1230.432,   -379.254,    1302.000,         0.000!   !END!
 941 ! X =    1231.913,   -379.028,    1672.000,         0.000!   !END!
 942 ! X =    1233.394,   -378.802,    1533.000,         0.000!   !END!
 943 ! X =    1234.876,   -378.576,    1429.000,         0.000!   !END!
 944 ! X =    1236.357,   -378.349,    1457.000,         0.000!   !END!
 945 ! X =    1237.838,   -378.122,    1391.000,         0.000!   !END!
 946 ! X =    1239.319,   -377.895,     937.000,         0.000!   !END!
 947 ! X =      1240.8,   -377.668,    1015.000,         0.000!   !END!
 948 ! X =    1242.281,    -377.44,    1056.000,         0.000!   !END!
 949 ! X =    1243.763,   -377.212,    1071.000,         0.000!   !END!
 950 ! X =    1245.244,   -376.984,    1060.000,         0.000!   !END!
 951 ! X =    1218.304,   -379.225,     427.000,         0.000!   !END!
 952 ! X =    1219.785,   -379.002,     480.000,         0.000!   !END!
 953 ! X =    1221.266,   -378.778,     488.000,         0.000!   !END!
 954 ! X =    1222.748,   -378.554,     624.000,         0.000!   !END!
 955 ! X =    1224.229,    -378.33,     761.000,         0.000!   !END!
 956 ! X =     1225.71,   -378.105,     732.000,         0.000!   !END!
 957 ! X =    1227.191,    -377.88,     881.000,         0.000!   !END!
 958 ! X =    1228.673,   -377.655,     821.000,         0.000!   !END!
 959 ! X =    1230.154,   -377.429,    1000.000,         0.000!   !END!
 960 ! X =    1231.635,   -377.204,    1094.000,         0.000!   !END!
 961 ! X =    1233.116,   -376.978,    1208.000,         0.000!   !END!
 962 ! X =    1234.597,   -376.751,     860.000,         0.000!   !END!
 963 ! X =    1236.078,   -376.525,     857.000,         0.000!   !END!
 964 ! X =    1237.558,   -376.298,    1391.000,         0.000!   !END!
 965 ! X =    1239.039,   -376.071,    1265.000,         0.000!   !END!
 966 ! X =     1240.52,   -375.843,    1067.000,         0.000!   !END!
 967 ! X =    1242.001,   -375.616,     921.000,         0.000!   !END!
 968 ! X =    1243.482,   -375.388,     611.000,         0.000!   !END!
 969 ! X =    1226.914,   -376.055,     608.000,         0.000!   !END!
 970 ! X =    1229.876,   -375.604,     699.000,         0.000!   !END!
 971 ! X =    1231.356,   -375.379,     785.000,         0.000!   !END!
 972 ! X =    1232.837,   -375.153,     892.000,         0.000!   !END!
 973 ! X =    1234.318,   -374.927,     622.000,         0.000!   !END!
 974 ! X =    1235.798,     -374.7,     762.000,         0.000!   !END!
 975 ! X =    1237.279,   -374.473,    1130.000,         0.000!   !END!
 976 ! X =    1238.759,   -374.246,    1458.000,         0.000!   !END!
 977 ! X =     1240.24,   -374.019,    1097.000,         0.000!   !END!
 978 ! X =     1241.72,   -373.791,     823.000,         0.000!   !END!
 979 ! X =    1243.201,   -373.563,     603.000,         0.000!   !END!
 980 ! X =    1232.558,   -373.328,     534.000,         0.000!   !END!
 981 ! X =    1234.039,   -373.102,     545.000,         0.000!   !END!
 982 ! X =    1235.519,   -372.875,     582.000,         0.000!   !END!
 983 ! X =    1236.999,   -372.649,     735.000,         0.000!   !END!
 984 ! X =    1238.479,   -372.422,     885.000,         0.000!   !END!
 985 ! X =    1239.959,   -372.194,     873.000,         0.000!   !END!
 986 ! X =    1124.359,    -493.51,     903.000,         0.000!   !END!
 987 ! X =     1125.11,   -493.407,     958.000,         0.000!   !END!
 988 ! X =    1125.861,   -493.304,    1057.000,         0.000!   !END!
 989 ! X =    1123.482,   -492.698,     969.000,         0.000!   !END!
 990 ! X =    1124.233,   -492.595,     846.000,         0.000!   !END!
 991 ! X =    1124.984,   -492.492,     853.000,         0.000!   !END!
 992 ! X =    1125.735,   -492.389,     873.000,         0.000!   !END!
 993 ! X =    1121.103,   -492.091,    1070.000,         0.000!   !END!
 994 ! X =    1121.855,   -491.988,    1189.000,         0.000!   !END!
 995 ! X =    1122.606,   -491.886,    1015.000,         0.000!   !END!
 996 ! X =    1123.357,   -491.783,     893.000,         0.000!   !END!
 997 ! X =    1124.108,    -491.68,     763.000,         0.000!   !END!
 998 ! X =    1124.859,   -491.576,     732.000,         0.000!   !END!
 999 ! X =     1125.61,   -491.473,     805.000,         0.000!   !END!
1000 ! X =    1126.361,    -491.37,     962.000,         0.000!   !END!
1001 ! X =    1120.227,   -491.279,     934.000,         0.000!   !END!
1002 ! X =    1120.978,   -491.176,     926.000,         0.000!   !END!
1003 ! X =    1121.729,   -491.073,    1023.000,         0.000!   !END!
1004 ! X =     1122.48,    -490.97,     950.000,         0.000!   !END!
1005 ! X =    1123.231,   -490.867,     823.000,         0.000!   !END!
1006 ! X =    1123.982,   -490.764,     762.000,         0.000!   !END!
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  1007 ! X =    1124.733,   -490.661,     775.000,        0.000!   !END!
  1008 ! X =    1125.484,   -490.558,     764.000,        0.000!   !END!
  1009 ! X =    1126.235,   -490.455,     908.000,        0.000!   !END!
  1010 ! X =    1120.102,   -490.363,     918.000,        0.000!   !END!
  1011 ! X =    1120.853,   -490.261,     822.000,        0.000!   !END!
  1012 ! X =    1121.604,   -490.158,     876.000,        0.000!   !END!
  1013 ! X =    1122.355,   -490.055,     918.000,        0.000!   !END!
  1014 ! X =    1123.105,   -489.952,     673.000,        0.000!   !END!
  1015 ! X =    1123.856,   -489.849,     671.000,        0.000!   !END!
  1016 ! X =    1124.607,   -489.746,     785.000,        0.000!   !END!
  1017 ! X =    1125.358,   -489.643,     937.000,        0.000!   !END!
  1018 ! X =    1126.109,    -489.54,     883.000,        0.000!   !END!
  1019 ! X =     1126.86,   -489.436,     967.000,        0.000!   !END!
  1020 ! X =    1119.977,   -489.448,     785.000,        0.000!   !END!
  1021 ! X =    1120.728,   -489.345,     821.000,        0.000!   !END!
  1022 ! X =    1121.478,   -489.243,     846.000,        0.000!   !END!
  1023 ! X =    1122.229,    -489.14,     766.000,        0.000!   !END!
  1024 ! X =     1122.98,   -489.037,     610.000,        0.000!   !END!
  1025 ! X =    1123.731,   -488.934,     793.000,        0.000!   !END!
  1026 ! X =    1124.481,   -488.831,     959.000,        0.000!   !END!
  1027 ! X =    1125.232,   -488.728,     928.000,        0.000!   !END!
  1028 ! X =    1125.983,   -488.624,    1090.000,        0.000!   !END!
  1029 ! X =    1126.734,   -488.521,    1154.000,        0.000!   !END!
  1030 ! X =    1127.484,   -488.418,    1002.000,        0.000!   !END!
  1031 ! X =    1128.235,   -488.314,     893.000,        0.000!   !END!
  1032 ! X =    1120.602,    -488.43,     610.000,        0.000!   !END!
  1033 ! X =    1121.353,   -488.327,     706.000,        0.000!   !END!
  1034 ! X =    1122.104,   -488.224,     581.000,        0.000!   !END!
  1035 ! X =    1122.854,   -488.122,     628.000,        0.000!   !END!
  1036 ! X =    1123.605,   -488.019,     673.000,        0.000!   !END!
  1037 ! X =    1124.356,   -487.915,     878.000,        0.000!   !END!
  1038 ! X =    1125.106,   -487.812,    1099.000,        0.000!   !END!
  1039 ! X =    1125.857,   -487.709,    1175.000,        0.000!   !END!
  1040 ! X =    1126.608,   -487.606,    1139.000,        0.000!   !END!
  1041 ! X =    1127.358,   -487.502,    1097.000,        0.000!   !END!
  1042 ! X =    1128.109,   -487.399,     862.000,        0.000!   !END!
  1043 ! X =    1120.477,   -487.515,     606.000,        0.000!   !END!
  1044 ! X =    1121.228,   -487.412,     557.000,        0.000!   !END!
  1045 ! X =    1121.978,   -487.309,     598.000,        0.000!   !END!
  1046 ! X =    1122.729,   -487.206,     646.000,        0.000!   !END!
  1047 ! X =    1123.479,   -487.103,     777.000,        0.000!   !END!
  1048 ! X =     1124.23,     -487.0,     939.000,        0.000!   !END!
  1049 ! X =    1124.981,   -486.897,    1000.000,        0.000!   !END!
  1050 ! X =    1125.731,   -486.794,    1134.000,        0.000!   !END!
  1051 ! X =    1126.482,   -486.691,    1042.000,        0.000!   !END!
  1052 ! X =    1127.232,   -486.587,    1096.000,        0.000!   !END!
  1053 ! X =    1127.983,   -486.484,     905.000,        0.000!   !END!
  1054 ! X =    1128.733,    -486.38,     796.000,        0.000!   !END!
  1055 ! X =    1120.352,     -486.6,     498.000,        0.000!   !END!
  1056 ! X =    1121.102,   -486.497,     532.000,        0.000!   !END!
  1057 ! X =    1121.853,   -486.394,     579.000,        0.000!   !END!
  1058 ! X =    1122.603,   -486.291,     620.000,        0.000!   !END!
  1059 ! X =    1123.354,   -486.188,     753.000,        0.000!   !END!
  1060 ! X =    1124.104,   -486.085,     971.000,        0.000!   !END!
  1061 ! X =    1124.855,   -485.982,     995.000,        0.000!   !END!
  1062 ! X =    1125.605,   -485.879,    1063.000,        0.000!   !END!
  1063 ! X =    1126.356,   -485.775,     912.000,        0.000!   !END!
  1064 ! X =    1127.106,   -485.672,    1072.000,        0.000!   !END!
  1065 ! X =    1127.857,   -485.569,     970.000,        0.000!   !END!
  1066 ! X =    1128.607,   -485.465,     828.000,        0.000!   !END!
  1067 ! X =    1120.226,   -485.684,     460.000,        0.000!   !END!
  1068 ! X =    1120.977,   -485.582,     567.000,        0.000!   !END!
  1069 ! X =    1121.727,   -485.479,     524.000,        0.000!   !END!
  1070 ! X =    1122.478,   -485.376,     596.000,        0.000!   !END!
  1071 ! X =    1123.228,   -485.273,     661.000,        0.000!   !END!
  1072 ! X =    1123.979,    -485.17,     732.000,        0.000!   !END!
  1073 ! X =    1124.729,   -485.067,     963.000,        0.000!   !END!
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1074 ! X =   1125.479,   -484.964,    957.000,        0.000!   !END!
1075 ! X =    1126.23,    -484.86,    924.000,        0.000!   !END!
1076 ! X =    1126.98,   -484.757,   1039.000,        0.000!   !END!
1077 ! X =   1127.731,   -484.654,    867.000,        0.000!   !END!
1078 ! X =   1128.481,    -484.55,    846.000,        0.000!   !END!
1079 ! X =   1129.231,   -484.447,    715.000,        0.000!   !END!
1080 ! X =   1129.982,   -484.343,    734.000,        0.000!   !END!
1081 ! X =   1130.732,   -484.239,    761.000,        0.000!   !END!
1082 ! X =   1131.482,   -484.136,    798.000,        0.000!   !END!
1083 ! X =     1118.6,   -484.974,    476.000,        0.000!   !END!
1084 ! X =   1119.351,   -484.872,    488.000,        0.000!   !END!
1085 ! X =   1120.101,   -484.769,    446.000,        0.000!   !END!
1086 ! X =   1120.852,   -484.666,    443.000,        0.000!   !END!
1087 ! X =   1121.602,   -484.563,    549.000,        0.000!   !END!
1088 ! X =   1122.352,   -484.461,    526.000,        0.000!   !END!
1089 ! X =   1123.103,   -484.358,    596.000,        0.000!   !END!
1090 ! X =   1123.853,   -484.255,    733.000,        0.000!   !END!
1091 ! X =   1124.603,   -484.152,    905.000,        0.000!   !END!
1092 ! X =   1125.354,   -484.048,    867.000,        0.000!   !END!
1093 ! X =   1126.104,   -483.945,    781.000,        0.000!   !END!
1094 ! X =   1126.854,   -483.842,    900.000,        0.000!   !END!
1095 ! X =   1127.604,   -483.738,    808.000,        0.000!   !END!
1096 ! X =   1128.355,   -483.635,    638.000,        0.000!   !END!
1097 ! X =   1129.105,   -483.532,    774.000,        0.000!   !END!
1098 ! X =   1129.855,   -483.428,    881.000,        0.000!   !END!
1099 ! X =   1130.606,   -483.324,    769.000,        0.000!   !END!
1100 ! X =   1118.475,   -484.059,    487.000,        0.000!   !END!
1101 ! X =   1119.226,   -483.956,    396.000,        0.000!   !END!
1102 ! X =   1119.976,   -483.854,    426.000,        0.000!   !END!
1103 ! X =   1120.726,   -483.751,    458.000,        0.000!   !END!
1104 ! X =   1121.476,   -483.648,    475.000,        0.000!   !END!
1105 ! X =   1122.227,   -483.545,    514.000,        0.000!   !END!
1106 ! X =   1122.977,   -483.442,    546.000,        0.000!   !END!
1107 ! X =   1123.727,   -483.339,    623.000,        0.000!   !END!
1108 ! X =   1124.477,   -483.236,    833.000,        0.000!   !END!
1109 ! X =   1125.228,   -483.133,    909.000,        0.000!   !END!
1110 ! X =   1125.978,    -483.03,    655.000,        0.000!   !END!
1111 ! X =   1126.728,   -482.927,    841.000,        0.000!   !END!
1112 ! X =   1127.478,   -482.823,    717.000,        0.000!   !END!
1113 ! X =   1128.229,    -482.72,    579.000,        0.000!   !END!
1114 ! X =   1128.979,   -482.616,    680.000,        0.000!   !END!
1115 ! X =   1129.729,   -482.513,    838.000,        0.000!   !END!
1116 ! X =   1130.479,   -482.409,    810.000,        0.000!   !END!
1117 ! X =   1122.851,   -482.527,    578.000,        0.000!   !END!
1118 ! X =   1123.602,   -482.424,    640.000,        0.000!   !END!
1119 ! X =   1124.352,   -482.321,    605.000,        0.000!   !END!
1120 ! X =   1125.102,   -482.218,    722.000,        0.000!   !END!
1121 ! X =   1125.852,   -482.115,    654.000,        0.000!   !END!
1122 ! X =   1126.602,   -482.012,    858.000,        0.000!   !END!
1123 ! X =   1127.352,   -481.908,    695.000,        0.000!   !END!
1124 ! X =   1128.102,   -481.805,    552.000,        0.000!   !END!
1125 ! X =   1128.852,   -481.701,    646.000,        0.000!   !END!
1126 ! X =   1129.603,   -481.598,    848.000,        0.000!   !END!
1127 ! X =   1130.353,   -481.494,    870.000,        0.000!   !END!
1128 ! X =   1131.103,    -481.39,    732.000,        0.000!   !END!
1129 ! X =   1122.726,   -481.612,    549.000,        0.000!   !END!
1130 ! X =   1123.476,   -481.509,    522.000,        0.000!   !END!
1131 ! X =   1124.226,   -481.406,    518.000,        0.000!   !END!
1132 ! X =   1124.976,   -481.303,    566.000,        0.000!   !END!
1133 ! X =   1125.726,     -481.2,    582.000,        0.000!   !END!
1134 ! X =   1126.476,   -481.096,    709.000,        0.000!   !END!
1135 ! X =   1127.226,   -480.993,    619.000,        0.000!   !END!
1136 ! X =   1127.976,    -480.89,    598.000,        0.000!   !END!
1137 ! X =   1128.726,   -480.786,    732.000,        0.000!   !END!
1138 ! X =   1129.476,   -480.683,    896.000,        0.000!   !END!
1139 ! X =   1130.226,   -480.579,    949.000,        0.000!   !END!
1140 ! X =   1130.976,   -480.475,    760.000,        0.000!   !END!
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1141 ! X =   1131.726,   -480.372,    644.000,      0.000!   !END!
1142 ! X =     1122.6,   -480.697,    579.000,      0.000!   !END!
1143 ! X =    1123.35,   -480.594,    511.000,      0.000!   !END!
1144 ! X =     1124.1,   -480.491,    513.000,      0.000!   !END!
1145 ! X =    1124.85,   -480.388,    549.000,      0.000!   !END!
1146 ! X =     1125.6,   -480.285,    579.000,      0.000!   !END!
1147 ! X =    1126.35,   -480.181,    594.000,      0.000!   !END!
1148 ! X =     1127.1,   -480.078,    536.000,      0.000!   !END!
1149 ! X =    1127.85,   -479.975,    598.000,      0.000!   !END!
1150 ! X =     1128.6,   -479.871,    670.000,      0.000!   !END!
1151 ! X =    1129.35,   -479.768,    815.000,      0.000!   !END!
1152 ! X =     1130.1,   -479.664,    975.000,      0.000!   !END!
1153 ! X =    1130.85,    -479.56,    839.000,      0.000!   !END!
1154 ! X =     1131.6,   -479.457,    696.000,      0.000!   !END!
1155 ! X =   1123.224,   -479.679,    457.000,      0.000!   !END!
1156 ! X =   1123.974,   -479.576,    457.000,      0.000!   !END!
1157 ! X =   1124.724,   -479.473,    429.000,      0.000!   !END!
1158 ! X =   1125.474,   -479.369,    487.000,      0.000!   !END!
1159 ! X =   1126.224,   -479.266,    502.000,      0.000!   !END!
1160 ! X =   1126.974,   -479.163,    582.000,      0.000!   !END!
1161 ! X =   1127.724,    -479.06,    587.000,      0.000!   !END!
1162 ! X =   1128.474,   -478.956,    760.000,      0.000!   !END!
1163 ! X =   1129.223,   -478.853,    914.000,      0.000!   !END!
1164 ! X =   1129.973,   -478.749,   1039.000,      0.000!   !END!
1165 ! X =   1130.723,   -478.645,    917.000,      0.000!   !END!
1166 ! X =   1131.473,   -478.542,    903.000,      0.000!   !END!
1167 ! X =   1132.223,   -478.438,    654.000,      0.000!   !END!
1168 ! X =   1122.349,   -478.867,    456.000,      0.000!   !END!
1169 ! X =   1123.099,   -478.764,    495.000,      0.000!   !END!
1170 ! X =   1123.849,   -478.661,    400.000,      0.000!   !END!
1171 ! X =   1124.598,   -478.558,    519.000,      0.000!   !END!
1172 ! X =   1125.348,   -478.454,    630.000,      0.000!   !END!
1173 ! X =   1126.098,   -478.351,    582.000,      0.000!   !END!
1174 ! X =   1126.848,   -478.248,    611.000,      0.000!   !END!
1175 ! X =   1127.598,   -478.144,    769.000,      0.000!   !END!
1176 ! X =   1128.347,   -478.041,    610.000,      0.000!   !END!
1177 ! X =   1129.097,   -477.938,    701.000,      0.000!   !END!
1178 ! X =   1129.847,   -477.834,    915.000,      0.000!   !END!
1179 ! X =   1130.597,    -477.73,    890.000,      0.000!   !END!
1180 ! X =   1131.346,   -477.627,    762.000,      0.000!   !END!
1181 ! X =   1132.096,   -477.523,    616.000,      0.000!   !END!
1182 ! X =   1119.974,    -478.26,    310.000,      0.000!   !END!
1183 ! X =   1120.724,   -478.157,    408.000,      0.000!   !END!
1184 ! X =   1121.474,   -478.054,    449.000,      0.000!   !END!
1185 ! X =   1122.223,   -477.951,    476.000,      0.000!   !END!
1186 ! X =   1122.973,   -477.848,    449.000,      0.000!   !END!
1187 ! X =   1123.723,   -477.745,    468.000,      0.000!   !END!
1188 ! X =   1124.473,   -477.642,    482.000,      0.000!   !END!
1189 ! X =   1125.222,   -477.539,    615.000,      0.000!   !END!
1190 ! X =   1125.972,   -477.436,    647.000,      0.000!   !END!
1191 ! X =   1126.722,   -477.333,    614.000,      0.000!   !END!
1192 ! X =   1127.471,   -477.229,    747.000,      0.000!   !END!
1193 ! X =   1128.221,   -477.126,    942.000,      0.000!   !END!
1194 ! X =   1128.971,   -477.022,    893.000,      0.000!   !END!
1195 ! X =    1129.72,   -476.919,    955.000,      0.000!   !END!
1196 ! X =    1130.47,   -476.815,    874.000,      0.000!   !END!
1197 ! X =    1131.22,   -476.712,    662.000,      0.000!   !END!
1198 ! X =   1131.969,   -476.608,    636.000,      0.000!   !END!
1199 ! X =   1132.719,   -476.504,    544.000,      0.000!   !END!
1200 ! X =   1126.596,   -476.418,    717.000,      0.000!   !END!
1201 ! X =   1127.345,   -476.314,    750.000,      0.000!   !END!
1202 ! X =   1128.095,   -476.211,    982.000,      0.000!   !END!
1203 ! X =   1128.844,   -476.107,   1141.000,      0.000!   !END!
1204 ! X =   1126.469,   -475.503,    847.000,      0.000!   !END!
1205 ! X =   1127.219,   -475.399,   1013.000,      0.000!   !END!
1206 ! X =    1273.44,   -416.507,   1629.000,      0.000!   !END!
1207 ! X =   1274.184,    -416.39,   1586.000,      0.000!   !END!
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1208 ! X =    1274.928,   -416.274,    1370.000,         0.000!   !END!
1209 ! X =    1275.672,   -416.157,    1274.000,         0.000!   !END!
1210 ! X =    1276.416,    -416.04,    1181.000,         0.000!   !END!
1211 ! X =    1268.832,   -416.294,    1183.000,         0.000!   !END!
1212 ! X =    1269.576,   -416.178,    1416.000,         0.000!   !END!
1213 ! X =    1270.321,   -416.062,    1541.000,         0.000!   !END!
1214 ! X =    1271.065,   -415.945,    1677.000,         0.000!   !END!
1215 ! X =    1271.809,   -415.828,    1640.000,         0.000!   !END!
1216 ! X =    1272.553,   -415.712,    1770.000,         0.000!   !END!
1217 ! X =    1273.297,   -415.595,    1679.000,         0.000!   !END!
1218 ! X =    1274.041,   -415.478,    1585.000,         0.000!   !END!
1219 ! X =    1274.785,   -415.361,    1529.000,         0.000!   !END!
1220 ! X =    1275.529,   -415.244,    1309.000,         0.000!   !END!
1221 ! X =    1276.273,   -415.127,    1128.000,         0.000!   !END!
1222 ! X =    1267.946,   -415.498,    1097.000,         0.000!   !END!
1223 ! X =     1268.69,   -415.382,    1217.000,         0.000!   !END!
1224 ! X =    1269.434,   -415.266,    1536.000,         0.000!   !END!
1225 ! X =    1270.178,   -415.149,    1463.000,         0.000!   !END!
1226 ! X =    1270.922,   -415.033,    1436.000,         0.000!   !END!
1227 ! X =    1271.666,   -414.916,    1629.000,         0.000!   !END!
1228 ! X =     1272.41,     -414.8,    1771.000,         0.000!   !END!
1229 ! X =    1273.154,   -414.683,    1622.000,         0.000!   !END!
1230 ! X =    1273.898,   -414.566,    1425.000,         0.000!   !END!
1231 ! X =    1274.641,   -414.449,    1312.000,         0.000!   !END!
1232 ! X =    1275.385,   -414.332,    1362.000,         0.000!   !END!
1233 ! X =    1276.129,   -414.215,    1067.000,         0.000!   !END!
1234 ! X =    1276.873,   -414.098,    1162.000,         0.000!   !END!
1235 ! X =    1277.617,   -413.981,    1399.000,         0.000!   !END!
1236 ! X =    1267.059,   -414.702,    1029.000,         0.000!   !END!
1237 ! X =    1267.803,   -414.586,    1227.000,         0.000!   !END!
1238 ! X =    1268.547,    -414.47,    1505.000,         0.000!   !END!
1239 ! X =    1269.291,   -414.354,    1347.000,         0.000!   !END!
1240 ! X =    1270.035,   -414.237,    1317.000,         0.000!   !END!
1241 ! X =    1270.779,   -414.121,    1536.000,         0.000!   !END!
1242 ! X =    1271.523,   -414.004,    1675.000,         0.000!   !END!
1243 ! X =    1272.267,   -413.887,    1729.000,         0.000!   !END!
1244 ! X =     1273.01,   -413.771,    1523.000,         0.000!   !END!
1245 ! X =    1273.754,   -413.654,    1544.000,         0.000!   !END!
1246 ! X =    1274.498,   -413.537,    1429.000,         0.000!   !END!
1247 ! X =    1275.242,    -413.42,    1315.000,         0.000!   !END!
1248 ! X =    1275.986,   -413.303,    1068.000,         0.000!   !END!
1249 ! X =     1276.73,   -413.186,    1066.000,         0.000!   !END!
1250 ! X =    1277.473,   -413.069,    1352.000,         0.000!   !END!
1251 ! X =    1266.173,   -413.906,    1024.000,         0.000!   !END!
1252 ! X =    1266.917,    -413.79,    1296.000,         0.000!   !END!
1253 ! X =    1267.661,   -413.674,    1404.000,         0.000!   !END!
1254 ! X =    1268.404,   -413.558,    1373.000,         0.000!   !END!
1255 ! X =    1269.148,   -413.441,    1198.000,         0.000!   !END!
1256 ! X =    1269.892,   -413.325,    1198.000,         0.000!   !END!
1257 ! X =    1270.636,   -413.208,    1419.000,         0.000!   !END!
1258 ! X =     1271.38,   -413.092,    1571.000,         0.000!   !END!
1259 ! X =    1272.124,   -412.975,    1741.000,         0.000!   !END!
1260 ! X =    1272.867,   -412.859,    1717.000,         0.000!   !END!
1261 ! X =    1273.611,   -412.742,    1616.000,         0.000!   !END!
1262 ! X =    1274.355,   -412.625,    1569.000,         0.000!   !END!
1263 ! X =    1275.099,   -412.508,    1422.000,         0.000!   !END!
1264 ! X =    1275.842,   -412.391,    1161.000,         0.000!   !END!
1265 ! X =    1265.287,    -413.11,     968.000,         0.000!   !END!
1266 ! X =     1266.03,   -412.994,    1198.000,         0.000!   !END!
1267 ! X =    1266.774,   -412.878,    1362.000,         0.000!   !END!
1268 ! X =    1267.518,   -412.762,    1470.000,         0.000!   !END!
1269 ! X =    1268.262,   -412.645,    1248.000,         0.000!   !END!
1270 ! X =    1269.006,   -412.529,    1058.000,         0.000!   !END!
1271 ! X =    1269.749,   -412.413,    1170.000,         0.000!   !END!
1272 ! X =    1270.493,   -412.296,    1415.000,         0.000!   !END!
1273 ! X =    1271.237,    -412.18,    1689.000,         0.000!   !END!
1274 ! X =     1271.98,   -412.063,    1547.000,         0.000!   !END!
```

```
  1275 ! X =    1272.724,   -411.946,    1550.000,        0.000!   !END!
  1276 ! X =    1273.468,    -411.83,    1437.000,        0.000!   !END!
  1277 ! X =    1274.212,   -411.713,    1508.000,        0.000!   !END!
  1278 ! X =    1274.955,   -411.596,    1300.000,        0.000!   !END!
  1279 ! X =    1275.699,   -411.479,    1176.000,        0.000!   !END!
  1280 ! X =    1268.863,   -411.617,    1012.000,        0.000!   !END!
  1281 ! X =    1269.606,   -411.501,    1285.000,        0.000!   !END!
  1282 ! X =     1270.35,   -411.384,    1366.000,        0.000!   !END!
  1283 ! X =    1271.094,   -411.268,    1566.000,        0.000!   !END!
  1284 ! X =    1271.837,   -411.151,    1451.000,        0.000!   !END!
  1285 ! X =    1272.581,   -411.034,    1359.000,        0.000!   !END!
  1286 ! X =    1273.325,   -410.918,    1273.000,        0.000!   !END!
  1287 ! X =    1274.068,   -410.801,    1274.000,        0.000!   !END!
  1288 ! X =    1274.812,   -410.684,    1280.000,        0.000!   !END!
  1289 ! X =    1275.555,   -410.567,    1155.000,        0.000!   !END!
  1290 ! X =    1270.207,   -410.472,    1179.000,        0.000!   !END!
  1291 ! X =    1270.951,   -410.355,    1348.000,        0.000!   !END!
  1292 ! X =    1271.694,   -410.239,    1488.000,        0.000!   !END!
  1293 ! X =    1270.808,   -409.443,    1442.000,        0.000!   !END!
  1294 ! X =    1271.551,   -409.327,    1565.000,        0.000!   !END!
  1295 ! X =    1272.295,    -409.21,    1505.000,        0.000!   !END!
  1296 ! X =    1273.038,   -409.093,    1409.000,        0.000!   !END!
  1297 ! X =    1273.782,   -408.977,    1380.000,        0.000!   !END!
  1298 ! X =    1274.525,    -408.86,    1303.000,        0.000!   !END!
  1299 ! X =    1275.268,   -408.743,    1104.000,        0.000!   !END!
  1300 ! X =    1269.921,   -408.648,    1500.000,        0.000!   !END!
  1301 ! X =    1271.408,   -408.415,    1678.000,        0.000!   !END!
  1302 ! X =    1272.152,   -408.298,    1707.000,        0.000!   !END!
  1303 ! X =    1272.895,   -408.181,    1515.000,        0.000!   !END!
  1304 ! X =    1273.638,   -408.065,    1321.000,        0.000!   !END!
  1305 ! X =    1274.382,   -407.948,    1219.000,        0.000!   !END!
  1306 ! X =    1271.265,   -407.502,    1394.000,        0.000!   !END!
  1307 ! X =    1272.008,   -407.386,    1522.000,        0.000!   !END!
  1308 ! X =    1272.752,   -407.269,    1411.000,        0.000!   !END!
  1309 ! X =    1273.495,   -407.152,    1234.000,        0.000!   !END!
  1310 ! X =    1271.122,    -406.59,    1189.000,        0.000!   !END!
  1311 ! X =    1271.865,   -406.474,    1343.000,        0.000!   !END!
  1312 ! X =    1272.609,   -406.357,    1265.000,        0.000!   !END!
  1313 ! X =    1270.979,   -405.678,    1045.000,        0.000!   !END!
  1314 ! X =    1271.722,   -405.562,    1235.000,        0.000!   !END!
  1315 ! X =    1272.465,   -405.445,    1066.000,        0.000!   !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.

SAMPLE POSTUTIL INPUT FILE

OCFRBGAUT01.INP
12-KM SCREENING ANALYSIS YEAR 2001

```
OC FAIRBURN GEORGIA
BART APPLICABILITY ANALYSIS 2001
SIPSEY/JOYCE KILMER/GREAT SMOKEY MOUNTAINS/COHUTTA/SHINING ROCK
---------------- Run title (3 lines) ------------------------------------------

                    POSTUTIL MODEL CONTROL FILE
                    ---------------------------

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

INPUT GROUP: 0 -- Input and Output File Names
--------------

-------------
Subgroup (0a)
-------------

Output Files
------------

 File            Default File Name
 ----            -----------------
 List File       POSTUTIL.LST       ! UTLLST =T:\BART\OCFRBGA\12KM\OCFRBGAUT01.LST
!
 Data File       MODEL.DAT          ! UTLDAT =T:\BART\OCFRBGA\12KM\OCFRBGAUT01.CON
!


Input Files
-----------

 A time-varying file of "background" concentrations can be included
 when the ammonia-limiting method (ALM) for setting the HNO3/NO3
 concentration partition is accomplished in 1 step.  This option
 is selected by setting MNITRATE=3 in Input Group 1.
 Species required in the "background" concentration file are:
 SO4, NO3, HNO3 and TNH3 (total NH3 = NH3gaseous + NH3particulate).

 File            Default File Name
 ----            -----------------
 BCKG File       BCKGALM.DAT         * BCKGALM =BCKGALM.DAT     *


 A number of CALPUFF data files may be processed in this application.
 The files may represent individual CALPUFF simulations that were made
 for a specific set of species and/or sources.  Specify the total number
 of CALPUFF runs you wish to combine, and provide the filename for each
 in subgroup 0b.

     Number of CALPUFF data files (NFILES)
                                     Default: 1       ! NFILES  = 1   !


 Meteorological data files are needed for the HNO3/NO3 partition option.
 Three types of meteorological data files can be used:
       METFM= 0 - CALMET.DAT
       METFM= 1 - 1-D file with RH, Temp and Rhoair timeseries
       METFM= 2 - 2-D files with either Rh, Temp or Rhoair in each
                  (3 2_D files are needed)
      The default is to use CALMET.DAT files.

                                     Default: 0       ! METFM   = 0   !
```

```
 Multiple meteorological data files may be used in sequence to span the
 processing period.  Specify the number of time-period files (NMET) that
 you need to use, and provide a filename for each in subgroup 0b.
 - NMET is 0 if no meteorological files are provided
 - NMET is 1 if METFM=1 (multiple file feature is not available)
 - NMET is 1 or more if METFM=0 or 2 (multiple CALMET files or 2DMET files)

     Number of meteorological data file time-periods (NMET)
                                 Default: 0       ! NMET    = 0   !



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

     Convert filenames to lower case?  Default: T     ! LCFILES = T !
         T = lower case
         F = UPPER CASE

!END!

-----------------------------------------------------------
 NOTE: file/path names can be up to 70 characters in length
-----------------------------------------------------------

-------------
Subgroup (0b)
-------------

NMET CALMET Data Files (METFM=0):

Input File      Default File Name
----------      -----------------
   1            MET.DAT            * UTLMET =CALMET.DAT   *


NMET 1-D Data Files (METFM=1):

Input File      Default File Name
----------      -----------------
   1            MET_1D.DAT         * MET1D   = MET_1D.DAT * *END*


NMET 2-D Data Files of Each Type (METFM=2):

Input File      Default File Name
----------      -----------------
   1            RHUMD.DAT          * M2DRHU  = RELHUM.DAT * *END*
   1            TEMP.DAT           * M2DTMP  = TEMP.DAT   * *END*
   1            RHOAIR.DAT         * M2DRHO  = RHOAIR.DAT * *END*


NFILES CALPUFF Data Files:

Input File      Default File Name
----------      -----------------
   1            CALPUFF.DAT        ! MODDAT =T:\BART\OCFRBGA\12KM\OCFRBGA01.con !
!END!


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

```
Note:  provide NMET lines of the form   * UTLMET = name * *END*

                                   or   * MET1D  = name * *END*

                                   or   * M2DRHU = name * *END*
                                (and)   * M2DTMP = name * *END*
                                (and)   * M2DRHO = name * *END*

       and NFILES lines of the form     * MODDAT = name * *END*

       where the * should be replaced with an exclamation point,
       the special delimiter character.


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

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

     Starting date:    Year  (ISYR) --    No default   ! ISYR  =  2001 !
                       Month (ISMO) --    No default   ! ISMO  = 1   !
                       Day   (ISDY) --    No default   ! ISDY  = 1   !
                       Hour  (ISHR) --    No default   ! ISHR  = 1   !

     Number of periods to process
                                (NPER) -- No default   ! NPER  = 8760  !

     Number of species to process from CALPUFF runs
                            (NSPECINP) -- No default   ! NSPECINP = 19 !

     Number of species to write to output file
                            (NSPECOUT) -- No default   ! NSPECOUT = 9 !

     Number of species to compute from those modeled
     (must be no greater than NSPECOUT)
                            (NSPECCMP) -- No default   ! NSPECCMP = 4 !


 When multiple files are used, a species name may appear in more than
 one file.  Data for this species will be summed (appropriate if the
 CALPUFF runs use different source groups).  If this summing is not
 appropriate, remove duplicate species from the file(s).

     Stop run if duplicate species names
     are found? (MDUPLCT)           Default: 0       ! MDUPLCT  =  0  !
        0 = no  (i.e., duplicate species are summed)
        1 = yes (i.e., run is halted)

 Data for each species in a CALPUFF data file may also be scaled as
 they are read.  This can be done to alter the emission rate of all
 sources that were modeled in a particular CALPUFF application.
 The scaling factor for each species is entered in Subgroup (2d), for
 each file for which scaling is requested.

     Number of CALPUFF data files that will be scaled
     (must be no greater than NFILES)
     (NSCALED)                      Default: 0       ! NSCALED = 0 !


 Ammonia-Limiting Method Option to recompute the HNO3/NO3 concentration
 partition prior to performing other actions is controlled by MNITRATE.
 This option will NOT alter any deposition fluxes contained in the CALPUFF
 file(s).  Three partition selections are provided.  The first two are
```

```
typically used in sequence (POSTUTIL is run more than once).  The first
selection (MNITRATE=1) computes the partition for the TOTAL (all sources)
concentration fields (SO4, NO3, HNO3; NH3), and the second (MNITRATE=2)
uses this partition (from the previous application of POSTUTIL) to
compute the partition for individual source groups.  The third selection
(MNITRATE=3) can be used instead in a single POSTUTIL application if a
file of background concentrations is provided (BCKGALM in Input Group 0).

Required information for MNITRATE=1 includes:
         species NO3, HNO3, and SO4
         NH3 concentration(s)
         met. data file for RH and T

Required information for MNITRATE=2 includes:
         species NO3 and HNO3 for a source group
         species NO3ALL and HNO3ALL for all source groups, properly
         partitioned

Required information for MNITRATE=3 includes:
         species NO3, HNO3, and SO4 for a source group
         species NO3, HNO3, SO4 and TNH3 from the background BCKGALM file
         If TNH3 is not in the background BCKGALM file, monthly TNH3
         concentrations are used (BCKTNH3)
         TNH3= total NH3 = NH3gaseous+NH3particulate

    Recompute the HNO3/NO3 partition for concentrations?
    (MNITRATE)                     Default: 0       ! MNITRATE  =  0  !
       0 = no
       1 = yes, for all sources combined
       2 = yes, for a source group
       3 = yes, ALM application in one step


SOURCE OF AMMONIA:

Ammonia may be available as a modeled species in the CALPUFF files,
and it may or may not be appropriate to use it for repartitioning NO3/HNO3
(in option MNITRATE=1 or MNITRATE=3).  Its use is contolled by NH3TYP.
When NH3 is listed as a processed species in Subgroup (2a), as one of
the NSPECINP ASPECI entries, and the right option is chosen for NH3TYP,
the NH3 modeled values from the CALPUFF concentration files will be used
in the chemical equilibrium calculation.

NH3TYP also controls when monthly background ammonia values are used.  Both
gaseous (NH3) and total (TNH3=NH3gaseous+NH3particulate) ammonia can be provided
monthly as BCKNH3/BCKTNH3.

    What is the input source of Ammonia?
    (NH3TYP)                       No Default       ! NH3TYP = 0  !
       0 = No background will be used.
           ONLY NH3 or TNH3 from the concentration
           files listed in Subgroup (2a&2b) as
           a processed species will be used.
           (Cannot be used with MNITRATE=3)

       1 = NH3 Monthly averaged background (BCKNH3)
           listed below will be added to NH3 from
           concentration files listed in Subgroup (2a)

       2 = NH3 from background concentration file BCKGALM
           will be added to NH3 from concentration files
           listed in Subgroup (2a&2b)
           (ONLY possible for MNITRATE=3)
```

```
        3 = NH3 Monthly averaged background (BCKNH3)
            listed below will be used alone.

        4 = NH3 from background concentration file BCKGALM
            will be used alone
            (ONLY possible for MNITRATE=3)
```

OPTION	NH3 or TNH3 CONC	BCKNH3 or BCKTNH3	TNH3/BCKGALM or BCKTNH3
0	X	0	0
1	X	X	0
2	X	0	X
3	0	X	0
4	0	0	X

```
     Default monthly (12 values) background ammonia concentration (ppb)
     used for HNO3/NO3 partition (need to choose one or the other):

      Gaseous NH3 (BCKNH3)            Default: -999
      ! BCKNH3 = 12*0.5  !

      Total TNH3  (BCKTNH3)           Default: -999
      * BCKTNH3 = 1., 1., 1., 1.1, 1.4, 1.3, 1.3, 1.2, 4*1. *

     If a single value is entered, this is used for all 12 months.
     Month 1 is JANUARY, Month 12 is DECEMBER.

!END!
-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Species Processing Information
--------------

-------------
Subgroup (2a)
-------------

  The following NSPECINP species will be processed:

! ASPECI =           SO2 !         !END!
! ASPECI =           SO4 !         !END!
! ASPECI =           NOX !         !END!
! ASPECI =          HNO3 !         !END!
! ASPECI =           NO3 !         !END!
! ASPECI =        POC081 !         !END!
! ASPECI =        POC056 !         !END!
! ASPECI =        POC030 !         !END!
! ASPECI =        PIC081 !         !END!
! ASPECI =        PIC056 !         !END!
! ASPECI =        PMC800 !         !END!
! ASPECI =        PMC425 !         !END!
! ASPECI =        PMF187 !         !END!
! ASPECI =        PMF112 !         !END!
! ASPECI =        PMF081 !         !END!
! ASPECI =        PMF056 !         !END!
! ASPECI =        PMF030 !         !END!
```

```
! ASPECI =          EC056 !         !END!
! ASPECI =          EC030 !         !END!


-------------
Subgroup (2b)
-------------

  The following NSPECOUT species will be written:

! ASPECO =            SO2 !         !END!
! ASPECO =            SO4 !         !END!
! ASPECO =            NOX !         !END!
! ASPECO =           HNO3 !         !END!
! ASPECO =            NO3 !         !END!
! ASPECO =             EC !         !END!
! ASPECO =           SOIL !         !END!
! ASPECO =            SOA !         !END!
! ASPECO =            PMC !         !END!


-------------
Subgroup (2c)
-------------

  The following NSPECCMP species will be computed by scaling and summing
  one or more of the processed input species.  Identify the name(s) of
  the computed species and provide the scaling factors for each of the
  NSPECINP input species (NSPECCMP groups of NSPECINP+1 lines each):

! CSPECCMP  =       EC  !
!    EC056  =   1.0000  !
!    EC030  =   1.0000  !
!END!

! CSPECCMP  =     SOIL  !
!   PMF187  =   1.0000  !
!   PMF112  =   1.0000  !
!   PMF081  =   1.0000  !
!   PMF056  =   1.0000  !
!   PMF030  =   1.0000  !
!   PIC081  =   1.0000  !
!   PIC056  =   1.0000  !
!END!

! CSPECCMP  =      SOA  !
!   POC081  =   1.0000  !
!   POC056  =   1.0000  !
!   POC030  =   1.0000  !
!END!

! CSPECCMP  =      PMC  !
!   PMC800  =   1.0000  !
!   PMC425  =   1.0000  !
!END!

-------------
Subgroup (2d)
-------------

  Each species in NSCALED CALPUFF data files may be scaled before being
  processed (e.g., to change the emission rate for all sources modeled
  in the run that produced a data file).  For each file, identify the
```

file name and then provide the name(s) of the scaled species and the corresponding scaling factors (A,B where x' = Ax+B).

```
             A(Default=1.0)      B(Default=0.0)
             --------------      --------------
```

SAMPLE CALPOST INPUT FILE

OCFBGAVANCO01.INP
12-KM SCREENING ANALYSIS YEAR 2001
COHUTTA ANNUAL AVERAGE NATURAL BACKGROUND

```
OC FAIRBURN GEORGIA
BART APPLICABILITY ANALYSIS - 2001
COHUTTA VISTAS ANNUAL AVERAGE NATURAL BACKGROUND
---------------- Run title (3 lines) ------------------------------------------

                    CALPOST MODEL CONTROL FILE
                    --------------------------

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

INPUT GROUP: 0 -- Input and Output File Names
--------------

Input Files
-----------

File                      Default File Name
----                      -----------------
Conc/Dep Flux File        MODEL.DAT          ! MODDAT
=T:\BART\OCFRBGA\12KM\OCFRBGAUT01.con   !
Relative Humidity File    VISB.DAT           * VISDAT =   *
Background Data File      BACK.DAT           * BACKDAT =   *
Transmissometer or        VSRN.DAT           * VSRDAT =   *
Nephelometer Data File     or
DATSAV Weather Data File   or
Prognostic Weather  File

Output Files
------------

File                      Default File Name
----                      -----------------
List File                 CALPOST.LST        ! PSTLST
=T:\BART\OCFRBGA\12KM\OCFRBGAVANCO01.lst   !

Pathname for Timeseries Files   (blank)      * TSPATH =   *
(activate with exclamation points only if
providing NON-BLANK character string)

Pathname for Plot Files   (blank)            * PLPATH =   *
(activate with exclamation points only if
 providing NON-BLANK character string)

User Character String (U) to augment default filenames
(activate with exclamation points only if
 providing NON-BLANK character string)

Timeseries          TSERIES_ASPEC_ttHR_CONC_TSUNAM.DAT
Peak Value          PEAKVAL_ASPEC_ttHR_CONC_TSUNAM.DAT

                                             * TSUNAM =   *

Top Nth Rank Plot   RANK(ALL)_ASPEC_ttHR_CONC_TUNAM.DAT
                or  RANK(ii)_ASPEC_ttHR_CONC_TUNAM.GRD

                                             * TUNAM =   *

Exceedance Plot       EXCEED_ASPEC_ttHR_CONC_XUNAM.DAT
                 or  EXCEED_ASPEC_ttHR_CONC_XUNAM.GRD

                                             * XUNAM =   *

Echo Plot
```

```
(Specific Days)
           yyyy_Mmm_Ddd_hh00(UTCszzzz)_L00_ASPEC_ttHR_CONC.DAT
     or    yyyy_Mmm_Ddd_hh00(UTCszzzz)_L00_ASPEC_ttHR_CONC.GRD


Visibility Plot      DAILY_VISIB_VUNAM.DAT   * VUNAM =   *
(Daily Peak Summary)


Auxiliary Output Files
----------------------

File                      Default File Name
----                      -----------------
Visibility Change         DELVIS.DAT         * DVISDAT =   *


--------------------------------------------------------------------------------
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 132 characters in length
NOTE: (2) Filenames for ALL PLOT and TIMESERIES FILES are constructed
          using a template that includes a pathname, user-supplied
          character(s), and context-specific strings, where
             ASPEC = Species Name
              CONC = CONC Or WFLX Or DFLX Or TFLX
                tt = Averaging Period (e.g. 03)
                ii = Rank (e.g. 02)
                hh = Hour(ending) in LST
             szzzz = Base time zone shift from UTC (EST is -0500)
              yyyy = Year(LST)
                mm = Month(LST)
                dd = day of month (LST)
          are determined internally based on selections made below.
          If a path or user-supplied character(s) are supplied, each
          must contain at least 1 non-blank character.

!END!
--------------------------------------------------------------------------------

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

     Option to run all periods found
     in the met. file(s)  (METRUN)        Default: 0   ! METRUN =   1  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in CALPUFF data file(s)

     Starting date:    Year  (ISYR) --    No default   ! ISYR  =  2001   !
     (used only if     Month (ISMO) --    No default   ! ISMO  =  0   !
      METRUN = 0)      Day   (ISDY) --    No default   ! ISDY  =  0   !
                       Hour  (ISHR) --    No default   ! ISHR  =  0   !

     Number of hours to process (NHRS) -- No default   ! NHRS  =  8760  !

     Process every hour of data?(NREP) -- Default: 1   ! NREP  =  1  !
      (1 = every hour processed,
       2 = every 2nd hour processed,
       5 = every 5th hour processed, etc.)
```

```
Species & Concentration/Deposition Information
----------------------------------------------

      Species to process (ASPEC)       -- No default   ! ASPEC = VISIB  !
      (ASPEC = VISIB for visibility processing)

      Layer/deposition code (ILAYER)   -- Default: 1   ! ILAYER =  1  !
        '1'  for CALPUFF concentrations,
        '-1' for dry deposition fluxes,
        '-2' for wet deposition fluxes,
        '-3' for wet+dry deposition fluxes.

      Scaling factors of the form:     -- Defaults:    ! A =  0.0    !
            X(new) = X(old) * A + B         A = 0.0    ! B =  0.0    !
        (NOT applied if A = B = 0.0)        B = 0.0

      Add Hourly Background Concentrations/Fluxes?
                              (LBACK)  -- Default: F   ! LBACK =  F !

Source information
------------------

  Option to process source contributions:
         0 =  Process only total reported contributions
         1 =  Sum all individual source contributions and process
         2 =  Run in TRACEBACK mode to identify source
              contributions at a SINGLE receptor
                             (MSOURCE) -- Default: 0   ! MSOURCE =  0  !

Receptor information
--------------------

  Gridded receptors processed?    (LG) -- Default: F   ! LG  = F  !
  Discrete receptors processed?   (LD) -- Default: F   ! LD  = T  !
  CTSG Complex terrain receptors processed?
                                 (LCT) -- Default: F   ! LCT = F  !

--Report results by DISCRETE receptor RING?
  (only used when LD = T)     (LDRING) -- Default: F   ! LDRING = F  !

--Select range of DISCRETE receptors (only used when LD = T):

  Select ALL DISCRETE receptors by setting NDRECP flag to -1;
                               OR
  Select SPECIFIC DISCRETE receptors by entering a flag (0,1) for each
     0 = discrete receptor not processed
     1 = discrete receptor processed
  using repeated value notation to select blocks of receptors:
     23*1, 15*0, 12*1
  Flag for all receptors after the last one assigned is set to 0
  (NDRECP) -- Default: -1
 ! NDRECP = 148*0, 101*0, 736*0, 220*1, 110*0 !


--Select range of GRIDDED receptors (only used when LG = T):

       X index of LL corner (IBGRID) -- Default: -1     ! IBGRID = -1  !
           (-1 OR 1 <= IBGRID <= NX)

       Y index of LL corner (JBGRID) -- Default: -1     ! JBGRID = -1  !
           (-1 OR 1 <= JBGRID <= NY)

       X index of UR corner (IEGRID) -- Default: -1     ! IEGRID = -1  !
```

```
            (-1 OR 1 <= IEGRID <= NX)

        Y index of UR corner (JEGRID) -- Default: -1     ! JEGRID = -1  !
            (-1 OR 1 <= JEGRID <= NY)

   Note: Entire grid is processed if IBGRID=JBGRID=IEGRID=JEGRID=-1


--Specific gridded receptors can also be excluded from CALPOST
  processing by filling a processing grid array with 0s and 1s.  If the
  processing flag for receptor index (i,j) is 1 (ON), that receptor
  will be processed if it lies within the range delineated by IBGRID,
  JBGRID,IEGRID,JEGRID and if LG=T. If it is 0 (OFF), it will not be
  processed in the run.  By default, all array values are set to 1 (ON).

  Number of gridded receptor rows provided in Subgroup (1a) to
  identify specific gridded receptors to process
                             (NGONOFF) -- Default: 0      ! NGONOFF =  0  !

!END!


--------------
Subgroup (1a) -- Specific gridded receptors included/excluded
--------------

    Specific gridded receptors are excluded from CALPOST processing
    by filling a processing grid array with 0s and 1s.  A total of
    NGONOFF lines are read here.  Each line corresponds to one 'row'
    in the sampling grid, starting with the NORTHERNMOST row that
    contains receptors that you wish to exclude, and finishing with
    row 1 to the SOUTH (no intervening rows may be skipped).  Within
    a row, each receptor position is assigned either a 0 or 1,
    starting with the westernmost receptor.
       0 = gridded receptor not processed
       1 = gridded receptor processed

    Repeated value notation may be used to select blocks of receptors:
       23*1, 15*0, 12*1

    Because all values are initially set to 1, any receptors north of
    the first row entered, or east of the last value provided in a row,
    remain ON.

    (NGXRECP) -- Default: 1


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

INPUT GROUP: 2 -- Visibility Parameters (ASPEC = VISIB)
--------------

    Identify the Base Time Zone for the CALPUFF simulation
                                (BTZONE) -- No default   ! BTZONE = 5.0 !

    Particle growth curve f(RH) for hygroscopic species
                                  (MFRH) -- Default: 2   ! MFRH   =  3  !

         1 =  IWAQM (1998) f(RH) curve (originally used with MVISBK=1)
         2 =  FLAG (2000) f(RH) tabulation
         3 =  EPA (2003) f(RH) tabulation

    Maximum relative humidity (%) used in particle growth curve
```

```
                          (RHMAX) -- Default: 98  ! RHMAX  = 98.0 !

    Modeled species to be included in computing the light extinction
     Include SULFATE?          (LVSO4) -- Default: T   ! LVSO4  = T  !
     Include NITRATE?          (LVNO3) -- Default: T   ! LVNO3  = T  !
     Include ORGANIC CARBON?   (LVOC)  -- Default: T   ! LVOC   = T  !
     Include COARSE PARTICLES? (LVPMC) -- Default: T   ! LVPMC  = T  !
     Include FINE PARTICLES?   (LVPMF) -- Default: T   ! LVPMF  = T  !
     Include ELEMENTAL CARBON? (LVEC)  -- Default: T   ! LVEC   = T  !

    And, when ranking for TOP-N, TOP-50, and Exceedance tables,
     Include BACKGROUND?       (LVBK)  -- Default: T   ! LVBK   = T  !

    Species name used for particulates in MODEL.DAT file
                   COARSE    (SPECPMC) -- Default: PMC ! SPECPMC = PMC !
                   FINE      (SPECPMF) -- Default: PMF ! SPECPMF = SOIL !

Extinction Efficiency (1/Mm per ug/m**3)
----------------------------------------
    MODELED particulate species:
               PM  COARSE      (EEPMC) -- Default: 0.6 ! EEPMC  = 0.6 !
               PM  FINE        (EEPMF) -- Default: 1.0 ! EEPMF  = 1.0 !
    BACKGROUND particulate species:
               PM  COARSE    (EEPMCBK) -- Default: 0.6 ! EEPMCBK = 0.6 !
    Other species:
              AMMONIUM SULFATE (EESO4) -- Default: 3.0 ! EESO4  = 3.0 !
              AMMONIUM NITRATE (EENO3) -- Default: 3.0 ! EENO3  = 3.0 !
              ORGANIC CARBON   (EEOC)  -- Default: 4.0 ! EEOC   = 4.0 !
              SOIL             (EESOIL)-- Default: 1.0 ! EESOIL = 1.0 !
              ELEMENTAL CARBON (EEEC)  -- Default: 10. ! EEEC   = 10.0 !

Background Extinction Computation
---------------------------------

    Method used for the 24h-average of percent change of light extinction:
    Hourly ratio of source light extinction / background light extinction
    is averaged?               (LAVER) -- Default: F   ! LAVER = F  !


    Method used for background light extinction
                              (MVISBK) -- Default: 2   ! MVISBK =  6  !

         1 =  Supply single light extinction and hygroscopic fraction
              - Hourly F(RH) adjustment applied to hygroscopic background
                and modeled sulfate and nitrate
         2 =  Compute extinction from speciated PM measurements (A)
              - Hourly F(RH) adjustment applied to observed and modeled sulfate
                and nitrate
              - F(RH) factor is capped at F(RHMAX)
         3 =  Compute extinction from speciated PM measurements (B)
              - Hourly F(RH) adjustment applied to observed and modeled sulfate
                and nitrate
              - Receptor-hour excluded if RH>RHMAX
              - Receptor-day excluded if fewer than 6 valid receptor-hours
         4 =  Read hourly transmissometer background extinction measurements
              - Hourly F(RH) adjustment applied to modeled sulfate and nitrate
              - Hour excluded if measurement invalid (missing, interference,
                or large RH)
              - Receptor-hour excluded if RH>RHMAX
              - Receptor-day excluded if fewer than 6 valid receptor-hours
         5 =  Read hourly nephelometer background extinction measurements
              - Rayleigh extinction value (BEXTRAY) added to measurement
              - Hourly F(RH) adjustment applied to modeled sulfate and nitrate
```

```
          - Hour excluded if measurement invalid (missing, interference,
            or large RH)
          - Receptor-hour excluded if RH>RHMAX
          - Receptor-day excluded if fewer than 6 valid receptor-hours
     6 =  Compute extinction from speciated PM measurements
          - FLAG monthly RH adjustment factor applied to observed and
            modeled sulfate and nitrate
     7 =  Use observed weather or prognostic weather information for
          background extinction during weather events; otherwise, use Method 2
          - Hourly F(RH) adjustment applied to modeled sulfate and nitrate
          - F(RH) factor is capped at F(RHMAX)
          - During observed weather events, compute Bext from visual range
            if using an observed weather data file, or
          - During prognostic weather events, use Bext from the prognostic
            weather file
          - Use Method 2 for hours without a weather event

Additional inputs used for MVISBK = 1:
--------------------------------------
 Background light extinction (1/Mm)
                          (BEXTBK) -- No default   ! BEXTBK = 0.0 !
 Percentage of particles affected by relative humidity
                          (RHFRAC) -- No default   ! RHFRAC = 0.0 !

Additional inputs used for MVISBK = 6:
--------------------------------------
 Extinction coefficients for hygroscopic species (modeled and
 background) are computed using a monthly RH adjustment factor
 in place of an hourly RH factor (VISB.DAT file is NOT needed).
 Enter the 12 monthly factors here (RHFAC).  Month 1 is January.

 (RHFAC)  -- No default     ! RHFAC = 3.3, 3.1, 3.0, 2.8,
                                      3.4, 3.8, 4.0, 4.2,
                                      4.2, 3.8, 3.4, 3.5 !

Additional inputs used for MVISBK = 7:
--------------------------------------
 The weather data file (DATSAV abbreviated space-delimited) that
 is identified as VSRN.DAT may contain data for more than one
 station.  Identify the stations that are needed in the order in
 which they will be used to obtain valid weather and visual range.
 The first station that contains valid data for an hour will be
 used.  Enter up to MXWSTA (set in PARAMS file) integer station IDs
 of up to 6 digits each as variable IDWSTA, and enter the corresponding
 time zone for each, as variable TZONE (= UTC-LST).

 A prognostic weather data file with Bext for weather events may be used
 in place of the observed weather file.  Identify this as the VSRN.DAT
 file and use a station ID of IDWSTA = 999999, and TZONE = 0.

 NOTE:  TZONE identifies the time zone used in the dataset.  The
        DATSAV abbreviated space-delimited data usually are prepared
        with UTC time rather than local time, so TZONE is typically
        set to zero.

 (IDWSTA)   -- No default
! IDWSTA = 999999 !
 (TZONE)    -- No default
! TZONE  = 0.0 !

Additional inputs used for MVISBK = 2,3,6,7:
--------------------------------------------
 Background extinction coefficients are computed from monthly
```

```
     CONCENTRATIONS of ammonium sulfate (BKSO4), ammonium nitrate (BKNO3),
     coarse particulates (BKPMC), organic carbon (BKOC), soil (BKSOIL), and
     elemental carbon (BKEC).  Month 1 is January.
     (ug/m**3)

     (BKSO4)  -- No default     ! BKSO4 = 0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00 !
     (BKNO3)  -- No default     ! BKNO3 = 0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00 !
     (BKPMC)  -- No default     ! BKPMC = 0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00 !
     (BKOC)   -- No default     ! BKOC  = 0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00 !
     (BKSOIL) -- No default     ! BKSOIL= 11.38, 11.38, 11.38, 11.38,
                                          11.38, 11.38, 11.38, 11.38,
                                          11.38, 11.38, 11.38, 11.38 !
     (BKEC)   -- No default     ! BKEC  = 0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00,
                                          0.00, 0.00, 0.00, 0.00 !

    Additional inputs used for MVISBK = 2,3,5,6,7:
    ----------------------------------------------
     Extinction due to Rayleigh scattering is added (1/Mm)
                        (BEXTRAY) -- Default: 10.0 ! BEXTRAY = 10.0 !

!END!
-------------------------------------------------------------------------------

INPUT GROUP: 3 -- Output options
--------------

Documentation
-------------

    Documentation records contained in the header of the
    CALPUFF output file may be written to the list file.
    Print documentation image?
                                 (LDOC) -- Default: F   !  LDOC = F !

Output Units
------------
    Units for All 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

    Visibility: extinction expressed in 1/Mega-meters (IPRTU is ignored)


Averaging time(s) reported
--------------------------

    1-hr averages           (L1HR) -- Default: T   !   L1HR = F  !

    3-hr averages           (L3HR) -- Default: T   !   L3HR = F  !
```

```
    24-hr averages         (L24HR) -- Default: T   !  L24HR = T  !

    Run-length averages    (LRUNL) -- Default: T   !  LRUNL = F  !

    User-specified averaging time in hours - results for
    an averaging time of NAVG hours are reported for
    NAVG greater than 0:
                            (NAVG) -- Default: 0   !   NAVG =  0  !


Types of tabulations reported
------------------------------

   1) Visibility: daily visibility tabulations are always reported
                  for the selected receptors when ASPEC = VISIB.
                  In addition, any of the other tabulations listed
                  below may be chosen to characterize the light
                  extinction coefficients.
                  [List file or Plot/Analysis File]


   2) Top 50 table for each averaging time selected
      [List file only]
                            (LT50) -- Default: T   !   LT50 = F  !

   3) Top 'N' table for each averaging time selected
      [List file or Plot file]
                           (LTOPN) -- Default: F   !  LTOPN = T  !

        -- Number of 'Top-N' values at each receptor
           selected (NTOP must be <= 4)
                            (NTOP) -- Default: 4   ! NTOP =  1   !

        -- Specific ranks of 'Top-N' values reported
           (NTOP values must be entered)
                   (ITOP(4) array) -- Default:     ! ITOP =  1   !
                                      1,2,3,4


   4) Threshold exceedance counts for each receptor and each averaging
      time selected
      [List file or Plot file]
                           (LEXCD) -- Default: F   !  LEXCD = F  !

        -- Identify the threshold for each averaging time by assigning a
           non-negative value (output units).

                                   -- Default: -1.0
           Threshold for  1-hr averages   (THRESH1) !  THRESH1 = -1.0  !
           Threshold for  3-hr averages   (THRESH3) !  THRESH3 = -1.0  !
           Threshold for 24-hr averages  (THRESH24) ! THRESH24 = -1.0  !
           Threshold for NAVG-hr averages (THRESHN) !  THRESHN = -1.0  !


        -- Counts for the shortest averaging period selected can be
           tallied daily, and receptors that experience more than NCOUNT
           counts over any NDAY period will be reported.  This type of
           exceedance violation output is triggered only if NDAY > 0.

           Accumulation period(Days)
                            (NDAY) -- Default: 0   !    NDAY =  0  !
           Number of exceedances allowed
```

```
                    (NCOUNT) -- Default: 1   !  NCOUNT =  1  !


   5) Selected day table(s)

      Echo Option -- Many records are written each averaging period
      selected and output is grouped by day
      [List file or Plot file]
                           (LECHO) -- Default: F   !  LECHO = F  !

      Timeseries Option -- Averages at all selected receptors for
      each selected averaging period are written to timeseries files.
      Each file contains one averaging period, and all receptors are
      written to a single record each averaging time.
      [TSERIES_ASPEC_ttHR_CONC_TSUNAM.DAT files]
                           (LTIME) -- Default: F   !  LTIME = F  !

      Peak Value Option -- Averages at all selected receptors for
      each selected averaging period are screened and the peak value
      each period is written to timeseries files.
      Each file contains one averaging period.
      [PEAKVAL_ASPEC_ttHR_CONC_TSUNAM.DAT files]
                           (LPEAK) -- Default: F   !  LPEAK = F  !

        -- Days selected for output
                      (IECHO(366)) -- Default: 366*0
           ! IECHO  = 366*0  !
           (366 values must be entered)

Plot output options
-------------------

     Plot files can be created for the Top-N, Exceedance, and Echo
     tables selected above.  Two formats for these files are available,
     DATA and GRID.  In the DATA format, results at all receptors are
     listed along with the receptor location [x,y,val1,val2,...].
     In the GRID format, results at only gridded receptors are written,
     using a compact representation.  The gridded values are written in
     rows (x varies), starting with the most southern row of the grid.
     The GRID format is given the .GRD extension, and includes headers
     compatible with the SURFER(R) plotting software.

     A plotting and analysis file can also be created for the daily
     peak visibility summary output, in DATA format only.

     Generate Plot file output in addition to writing tables
     to List file?
                                 (LPLT) -- Default: F   ! LPLT  = F !

     Use GRID format rather than DATA format,
     when available?
                                 (LGRD) -- Default: F   ! LGRD  = F !


Auxiliary Output Files (for subsequent analyses)
------------------------------------------------

      Visibility

      A separate output file may be requested that contains the change
      in visibility at each selected receptor when ASPEC = VISIB.  This
      file can be processed to construct visibility measures that are
      not available in CALPOST.
```

```
      Output file with the visibility change at each receptor?
                                 (MDVIS) -- Default: 0   ! MDVIS  =  1  !

           0 =  Do Not create file
           1 =  Create file of DAILY (24 hour) Delta-Deciview
           2 =  Create file of DAILY (24 hour) Extinction Change (%)
           3 =  Create file of HOURLY Delta-Deciview
           4 =  Create file of HOURLY Extinction Change (%)


Additional Debug Output
-----------------------

   Output selected information to List file
    for debugging?
                                (LDEBUG) -- Default: F  ! LDEBUG  = F !

   Output hourly extinction information to REPORT.HRV?
    (Visibility Method 7)
                               (LVEXTHR) -- Default: F  ! LVEXTHR = F !

!END!
```

APPENDIX C

COMPARATIVE ANALYSIS FOR EXPLICIT CALPUFF MODELING

Sample model processing files provided by the VISTAS Technical Contractor demonstrate modeling of a single point source using CALPUFF, POSTUTIL, and CALPOST to assess visibility change.[20] The sample approach simulates actual emissions of each of three gaseous pollutants (SO_2, SO_4, and NO_X) and unit emissions (e.g., 1 g/s) of each of six generic particle categories distinguished and designated by size: PM800, PM425, PM187, PM112, PM081, and PM056, to represent PM_{6-10}, $PM_{2.5-6}$, $PM_{1.25-2.5}$, $PM_{1-1.25}$, $PM_{0.625-1}$, and $PM_{0.5-0.625}$, respectively. Because unit emission rates were modeled from the single point source in the sample approach, actual emission rates were used in the POSTUTIL postprocessing step to combine PM types and sizes into light scattering groups by scaling the modeled concentrations up or down by the multiplicative factor of the actual emission rate of each PM size category, which includes multiple types of PM (e.g., coarse filterable PM, fine filterable PM, organic condensable PM, inorganic condensable PM, and elemental carbon). The output concentration file from POSTUTIL was then input to CALPOST to calculate visibility change attributable to emissions from the point source in the sample analysis.

The preceding approach is reasonable for modeling a single point source; however, for facilities with multiple emission point sources, the preceding approach is not appropriate. Specifically, for sources with multiple emission points that have different exhaust characteristics (e.g., stack height, diameter, velocity, and temperature) and/or different emissions profiles of speciated PM, the use of unit emission rates is not appropriate since the CALPUFF output concentrations at particular receptors will not distinguish which source(s) contribute to the PM concentrations. Therefore, the POSTUTIL source profile technique cannot be applied. One alternative to this approach for sources with multiple emission points is to model each emission point individually in multiple CALPUFF runs using unit emission rates, then run POSTUTIL to assign the PM concentrations at each receptor for each modeled emission point to each species, finally running the CALSUM postprocessing utility to combine the impacts of all sources. This approach, though conceptually appropriate, is undesirable due to substantial additional computer runtime required to model and post-process each emission point individually.

As a computationally efficient alternative to the preceding approaches, the BART Applicability Analysis for OC's Fairburn facility was conducted by explicitly modeling in CALPUFF the actual emission rate of each of 14 particle species defined as described in Table C-1. The nomenclature used in Table C-1 is analogous to that used to describe the emissions from OC's BART-eligible emission units in Section 2 of this report. While some differences within the PM subcategories is noted between this comparative analysis and those identified in Section 2, the principles behind the comparative analysis remain unchanged.

[20] http://www.src.com/verio/download/sample_files.htm#EXAMPLE_BART

TABLE C-1. EXPLICIT MODELING OF PM TYPES AND SIZE CATEGORIES

Modeled PM Category	Components
PMC800 PMC425	Filterable coarse particles divided between two size categories (PM_{6-10}, $PM_{2.5-6}$)
PMF187 PMF112 PMF081 PMF056	Filterable fine particles divided among four size categories ($PM_{1.25-2.5}$, $PM_{1-1.25}$, $PM_{0.625-1}$, $PM_{0.5-0.625}$)
POC081 POC056	Primary condensable organic emissions divided between two size categories ($PM_{0.625-1}$ and $PM_{0.5-0.625}$)
PIC081 PIC056	Primary condensable inorganic emissions divided between two size categories ($PM_{0.625-1}$ and $PM_{0.5-0.625}$)
EC187 EC112 EC081 EC056	Primary elemental carbon emissions divided among four size categories ($PM_{1.25-2.5}$, $PM_{1-1.25}$, $PM_{0.625-1}$, $PM_{0.5-0.625}$)

So that explicit modeling of the 14 particle species and sizes could be conducted equivalently to the unit emissions approach, identical model processing options for each PM size category were enabled as summarized in Table C-2.

TABLE C-2. REPRESENTATION OF EXPLICITLY MODELED PM SIZE CATEGORIES IN CALPUFF

Model Species	Computed Deposition Mode	Geometric Mass Mean Diameter (microns)	Geometric Standard Deviation (microns)*	Precipitation Scavenging Coefficient Liquid (s^{-1})	Precipitation Scavenging Coefficient Frozen (s^{-1})
PMC800	Particle	8.0	0	1.0×10^{-4}	3.0×10^{-5}
PMC425	Particle	4.25	0	1.0×10^{-4}	3.0×10^{-5}
PMF187 EC187	Particle	1.87	0	1.0×10^{-4}	3.0×10^{-5}
PMF112 EC112	Particle	1.12	0	1.0×10^{-4}	3.0×10^{-5}
PMF081 EC081 POC081 PIC081	Particle	0.81	0	1.0×10^{-4}	3.0×10^{-5}
PMF056 EC056 POC056 PIC056	Particle	0.56	0	1.0×10^{-4}	3.0×10^{-5}

* Zero geometric standard deviation indicates that CALPUFF utilizes the deposition velocity associated with the geometric mass mean diameter.

To post-process the CALPUFF output concentrations that result from explicitly modeled multiple emission points, POSTUTIL was used only to group modeled PM into light extinction groups. Unit scaling factors were used in POSTUTIL and there was no adjustment to the explicitly modeled emission rate. Table C-3 summarizes the POSTUTIL grouping of modeled PM species into light extinction groups, and the light extinction coefficient subsequently used in CALPOST to compute light extinction due to the multiple emission points at the source.

TABLE C-3. ASSIGNMENT OF MODELED PM SPECIES TO LIGHT EXTINCTION GROUPS

Modeled Components	CALPOST Light Extinction Group	Extinction Coefficient (m^2/g)
PMC800 PMC425	PMC	0.6
PMF187 PMF112 PMF081 PMF056 PIC081 PIC056	SOIL	1
POC081 POC056	SOA	4
EC187 EC112 EC081 EC056	EC	10

Implementation of the explicit modeling approach required minor changes to the parameter declaration file and re-compilation of the CALPUFF model executable file. Note that this approach does not require changes to the FORTRAN model code, only the parameter declaration limits. Explicit modeling of the 14 PM types and sizes plus the SO_2, SO_4, NO_X, HNO_3, and NO_3 species results in a total of 19 modeled species, which is within the default parameter limit of 20 species modeled (MXSPEC). However, the parameter for particle species deposited (MXPDEP) was increased from 9 to 20 to accommodate the greater number (16, including SO_4 and NO_3) of particle species simulated in the model.

This modified approach follows conceptually the steps outlined in the revised *VISTAS BART Modeling Protocol* as evidenced between comparisons between the two methods. Results using the explicit method for multiple emission points and the sample method using a single point source with PM speciation (PMF, PMC, SOA, EC) applied during the POSTUTIL step provides equivalent results. The following example model input and output files of a comparative analysis are presented to illustrate this approach. The comparative analysis was performed using emissions from a representative example BART-eligible facility located in South Carolina using the screening approach for the data year 2002 to compute visibility impacts at the Cape Romain NWR Class I area using the annual average natural background conditions.

To demonstrate the equivalent performance of both models, the following four example point sources listed in Table C-4 were modeled.

TABLE C-4. COMPARATIVE ANALYSIS EMISSIONS SOURCES

	Emission Rates (g/s)			
Modeled PM Category	**Source 1**	**Source 2**	**Source 3**	**Source 4**
PMC800	1.20×10^{-3}	1.20×10^{-1}	4.10×10^{-2}	4.10×10^{-2}
PMC425	2.50×10^{-2}	3.70×10^{-1}	2.60×10^{-1}	2.60×10^{-1}
PMF187	1.30×10^{-1}	3.40×10^{-1}	6.60×10^{-1}	6.60×10^{-1}
PMF112	7.00×10^{-2}	1.60×10^{-1}	3.30×10^{-1}	3.30×10^{-1}
PMF081	2.80×10^{-1}	3.10×10^{-1}	5.90×10^{-1}	5.90×10^{-1}
PMF056	6.20×10^{-1}	5.60×10^{-1}	1.40	1.40
POC081	1.80×10^{-3}	8.40×10^{-1}	5.60×10^{-2}	5.60×10^{-2}
POC056	1.80×10^{-3}	8.40×10^{-1}	5.60×10^{-2}	5.60×10^{-2}
PIC081	3.60×10^{-2}	7.70	2.50×10^{-1}	2.50×10^{-1}
PIC056	3.60×10^{-2}	7.70	2.50×10^{-1}	2.50×10^{-1}
EC187	--	--	--	--
EC112	--	--	--	--
EC081	--	--	--	--
EC056	--	--	--	--

The emissions rates listed in Table C-4 for all sources were modeled explicitly using Trinity's modified CALPUFF executable. Using the VISTAS Sample approach, unit PM emission rates were modeled for each individual source in a separate CALPUFF run and the scaling factors listed in Table C-5 were applied in POSTUTIL. Note that as described in Table C-3, emission rates for PMF and PIC are combined in this approach.

TABLE C-5. VISTAS SAMPLE ANALYSIS POSTUITL SCALING FACTORS

	Emission Rates (g/s)			
Modeled PM Category	**Source 1**	**Source 2**	**Source 3**	**Source 4**
CSPECCMP = EC				
PM187	0.00000	0.00000	0.00000	0.00000
PM112	0.00000	0.00000	0.00000	0.00000
PM081	0.00000	0.00000	0.00000	0.00000
PM056	0.00000	0.00000	0.00000	0.00000
CSPECCMP = SOIL				
PM187	0.13000	0.34000	0.66000	0.66000
PM112	0.07000	0.16000	0.33000	0.33000
PM081	0.31600	8.01000	0.84000	0.84000
PM056	0.65600	8.26000	1.65000	1.65000
CSPECCMP = SOA				
PM081	0.00180	0.84000	0.05600	0.05600
PM056	0.00180	0.84000	0.05600	0.05600
CSPECCMP = PMC				
PM800	0.00120	0.12000	0.04100	0.04100
PM425	0.02500	0.37000	0.26000	0.26000

VISTAS SAMPLE ANALYSES

1. MS-DOS BATCH RUN FILE **RUNCPUFF1.BAT**
   This MS-DOS batch file sequentially runs the following analyses to simulate unit PM emissions from four sources independently, apply the actual emission rates using POSTUTIL, combine the files using the CALSUM utility to add the concentrations at each receptor due to each source, then finally run CALPOST to calculate the visibility impact.

2. CALPUFF INPUT FILE SOURCE “A” **VISTAS02A.INP**
3. CALPUFF INPUT FILE SOURCE “B” **VISTAS02B.INP**
4. CALPUFF INPUT FILE SOURCE “C” **VISTAS02C.INP**
5. CALPUFF INPUT FILE SOURCE “D” **VISTAS02D.INP**
   These CALPUFF input files were used to run the model for each source individually, with all PM emission rates modeled as 1.0 g/s. A total of 11 species are modeled. The standard CALPUFFL.EXE CALPUFF executable file obtained from the VISTAS Technical Contractor was used to perform the analysis. The output of the CALPUFF runs “VISTAS02*x*.CON” are the concentration files that are input to POSTUTIL in the next step.

6. POSTUTIL INPUT FILE SOURCE “A” **VISTASUT02A.INP**
7. POSTUTIL INPUT FILE SOURCE “B” **VISTASUT02B.INP**
8. POSTUTIL INPUT FILE SOURCE “C” **VISTASUT02C.INP**
9. POSTUTIL INPUT FILE SOURCE “D” **VISTASUT02D.INP**
   The POSTUTIL input files were used to scale the PM concentrations modeled in CALPUFF by the actual emission rates of each PM species. The sum of PM species factors applied in POSTUTIL equals the total PM emission rate for the source (less contribution from primary sulfate emissions), and the speciated factors represent those tabulated for each source in Section 2 of this report. Note that scaling of “SOIL” concentrations include contributions from emissions quantified as PIC and PMF as illustrated in Table C-3. A total of 9 species are output from POSTUTIL, including the computed species (EC, SOIL, SOA, PMC) integrated over the size categories in addition to the explicitly modeled species (SO2, SO4, NOX, HNO3, NO3). The output of the POSTUTIL runs “VISTASUT02*x*.CON” are the grouped and scaled concentration files input to CALSUM in the next step.

10. CALSUM INPUT FILE **VISTASSUM02.INP**
    This CALSUM input file, after being copied into the appropriate file name “CALSUM.INP” for compatibility with the CALSUM.exe runstream, adds the scaled concentrations of the 9 output species from POSTUTIL for each receptor and averaging period. The output of CALSUM in “VISTASUT02.CON”, which is subsequently passed to CALPOST.

11. CALPOST INPUT FILE **VISTASVANCR02.INP**
    This CALPOST file calculates the visibility impacts due to concentrations reported in “VISTASUT02.CON” for the receptors representing Cape Romain using the annual average natural background conditions. The results of the analysis are written to the file “VISTASVANCR02.LST”.

TRINITY'S EXPLICIT ANALYSES

1. MS-DOS BATCH RUN FILE **RUNCPUFF2.BAT**
   This MS-DOS batch file sequentially runs the following analyses to simulate actual emissions from four sources modeled in one CALPUFF run, combine the speciated PM size groups into output species using POSTUTIL, then finally run CALPOST to calculate the visibility impact.

2. CALPUFF INPUT FILE ALL SOURCES **EXPLICIT02.INP**
   This CALPUFF input file was used to run the model for all sources using actual PM emission rates speciated for type (e.g., PIC, PMF) and size distribution. A total of 19 species are modeled, including speciated size categories of all PM. The sum of PM species emission rates equals the total PM emission rate for the source (less contribution from primary sulfate emissions), and the speciated factors represent those tabulated for each source in Section 2 of this report. The output of the CALPUFF runs "EXPLICIT02.CON" is the concentration files that are input to POSTUTIL in the next step.

3. POSTUTIL INPUT FILE ALL SOURCES **EXPLICITUT02.INP**
   The POSTUTIL input file was used only to combine, not scale, the PM concentrations modeled in CALPUFF. A total of 9 species are output from POSTUTIL, including the computed species (EC, SOIL, SOA, PMC) integrated over the size categories in addition to the explicitly modeled species (SO2, SO4, NOX, HNO3, NO3). The output of the POSTUTIL runs "EXPLICITUT02.CON" are the grouped concentration files input to CALSUM in the next step.

4. CALPOST INPUT FILE **EXPLICITVANCR02.INP**
   This CALPOST file calculates the visibility impacts due to concentrations reported in "EXPLICITUT02.CON" for the receptors representing Cape Romain using the annual average natural background conditions. The results of the analysis are written to the file "EXPLICITVANCR02.LST".

COMPARATIVE ANALYSIS OUTPUT FILES

The output files from the VISTAS Sample and Trinity's explicit analyses follow and indicate equivalent results. The primary benefit of this approach is time savings from running CALPUFF and subsequent postprocessors once (albeit for a greater number of sources) than one time for each source. Table C-6 compares computer runtime for these methods on Pentium-4 class desktop computers. The differences in computer processing runtime are appreciable when integrated over numerous runs for facilities with multiple emissions sources.

TABLE C-6. COMPARISON OF COMPUTER RUNTIME USING SAMPLE AND EXPLICIT APPROACHES

Processing Step	VISTAS Sample Analysis Runtime (minutes)	Trinity's Explicit Analysis Runtime (minutes)
CALPUFF	170	105
POSTUTIL	2	< 1
CALSUM	< 1	--
CALPOST	< 1	< 1
Total Time	**2 hours, 54 minutes**	**1 hour, 47 minutes**

The computer modeling executable, input, and output files for the comparative analysis are provided for review on the electronic media included with this BART Applicability Analysis report. Each analysis is contained within a separate folder (i.e., "VISTAS" and "EXPLICIT", respectively) that includes the CALPUFF model executable file. The "PARAMS.PUF" parameter declaration file is also included to demonstrate how Trinity modified the parameters to accommodate the explicit modeling approach as described in this appendix.

APPENDIX D

ELECTRONIC MEDIA DATA FILE INDEX

Electronic media enclosed with this report contain the input and output files from all CALPUFF, POSUTIL, and CALPOST processing for the screening analyses, as well as the comparative analyses presented in Appendix C. Each analysis is contained within its own appropriately name compressed file, which includes model executable files and batch files to manage the runstream. A consistent file naming convention is used throughout, with the following general structure. All filenames contain the OCFRBGA root to denote OC – Fairburn, Georgia. Note that screening meteorological data files are not provided due to file size. Note also that path names in input files will need to be modified to represent the user's directory structure when replicating these analyses.

CALPUFF Runstream Files

OCFRBGA*yy*.*fff*
yy = **01**, **02**, and **03** denotes data analysis years 2001, 2002, and 2003, respectively
fff = **inp** denotes input files
fff = **lst** denotes CALPUFF output summary files
fff = **con** denotes CALPUFF output concentration files

Ozone Data Files

OZONE20*yy*DOM4.*dat*
yy = **01**, **02**, and **03** denotes data analysis years 2001, 2002, and 2003, respectively

Screening Analyses POSTUTIL Processing Files

OCFRBGAUT*yy*.*fff*
yy = **01**, **02**, and **03** denotes data analysis years 2001, 2002, and 2003, respectively
fff = **inp** denotes input files
fff = **lst** denotes POSTUTIL output summary files
fff = **con** denotes POSTUTIL output concentration files

CALPOST Runstream Files

OCFRBGAVAN*aayy*.*fff*
yy = **01**, **02**, and **03** denotes data analysis years 2001, 2002, and 2003, respectively
fff = **inp** denotes input files
fff = **lst** denotes CALPOST output summary files

aa denotes the Class I areas considered in the analyses:
- CO = Cohutta Wilderness Area
- GS = Great Smoky Mountains National Park
- JK = Joyce Kilmer-Slickrock Wilderness Area
- SR = Shining Rock Wilderness Area
- SI = Sipsey Wilderness Area