South Dakota
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DEPARTMENT of ENVIRONMENT and NATURAL RESOURCES
PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

September 18, 2009

Terry Graumann, Manager
Environmental Services
Otter Tail Power Company
PO Box 496
Fergus Falls, MN 56538-0496

Re: BART Modeling Protocol

Dear Mr. Graumann:

The South Dakota Department of Environment and Natural Resources (DENR) has been working with Otter Tail Power Company; the Environmental Protection Agency (EPA), Region 8; Fish and Wildlife Service; Forest Service; and National Park Service to determine if Otter Tail Power Company's Big Stone I facility near Big Stone City, South Dakota is reasonably anticipated to cause or contribute to any impairment of visibility at a federal Class I area in South Dakota or in a neighboring state. This evaluation is required since DENR determined that Big Stone I is a BART eligible source.

Otter Tail Power Company submitted an individual source analysis on March 19, 2008, which was not acceptable by all parties. The end result was the request for a BART modeling protocol that was approval by everyone and once that was achieved, Otter Tail Power Company would run the model using the approved protocol and submit the results to DENR. Otter Tail Power Company submitted a modeling protocol for Big Stone I dated June 2009 (see Attachment A). After several submittals and conference calls, Otter Tail Power Company committed to make the following changes to the protocol in an email dated August 31, 2009 (see Attachment B):

- Although Otter Tail Power Company attached the CALMET switches it would use, it committed to using the CALMET switches recommended and approved by EPA and Federal Land Managers (FLMs) dated August 20, 2009. However, to ensure the most up-to-date CALMET switches are used, DENR is requiring Otter Tail Power Company to use the CALMET switches identified in EPA's memorandum dated August 31, 2009, from Tyler J Fox, Group Leader, Air Quality Modeling Group, to EPA Regional Modeling Contacts. The date on the listing of CALMET switches is August 28, 2009. The memorandum may be viewed in Attachment C.

- Otter Tail Power Company committed to use the CALPUFF switches that Penny Shamblin, with Hunton and Williams, submitted to DENR by email on August 19, 2009. Although the document contains CALMET switches, only the CALPUFF switches (see Attachment D) in this email will be used by Otter Tail Power Company in the BART analysis. The CALMET switches mentioned above will be the ones used in the analysis.
- Otter Tail Power Company proposes to revise the June 2009 modeling protocol by using a 12 kilometer MM5 grid and a 4 kilometer CALMET grid rather than the 4 kilometer MM5 grid and 4 kilometer CALMET grid identified in the June 2009 modeling protocol. DENR reviewed other acceptable modeling protocols and is acceptable to this change.
- Although Otter Tail Power Company may run POSTUTIL option MNITRATE=2 for its own purposes, the modeling results DENR will accept for the BART analysis will be MNITRATE=1.

The CALPUFF switches Otter Tail Power Company is recommending contains five switches that are different then those recommended by EPA as defaults. The following identifies the variable, EPA's default, recommended default by Otter Tail Power Company, and DENR's response:

- "NSPEC" – Identifies the number of species modeled. The EPA default is 5 and Otter Tail Power Company is proposing 11, which follows the FLM guidance on particle speciation and size. DENR is agreeable to this change.
- "NSE" – Number of species emitted. The EPA default is 3 and Otter Tail Power Company is proposing 9.
- "MSPLIT" – Allows puffing. The EPA default is 0 (No) and Otter Tail Power Company is proposing 1 (Yes). Puff splitting in necessary due to the distance from Big Stone I to a federal Class I area. DENR is agreeable to this change.
- "MESHDN" – Grid receptor spacing. The EPA default is 1; however, Otter Tail Power Company is stating this is "Not Applicable". DENR is agreeable to this change.
- "BCKNH3" – Ammonia background. The EPA default is 10 parts per billion and Otter Tail Power Company is recommending 1 part per billion. During the June 3, 2009, conference call, EPA stated it was okay with this change. DENR is agreeable to this change.

It appears that Otter Tail Power Company has addressed all of DENR concerns and the concerns DENR received from EPA and the federal land managers. Therefore, DENR approves the modeling protocol as described above.

It is DENR's understanding that Otter Tail Power Company has already run the CALPUFF modeling using the modeling protocol DENR is approving today. Otter Tail Power Company determined that Big Stone I is reasonably anticipated to contribute to an impairment of visibility at the Boundary Waters and Voyageurs federal Class I areas in northern Minnesota and the Isle Royale federal Class I area in Michigan. The reasonably anticipated to contribute to an impairment is based on visibility impacts greater than 0.5 deciview based on the 98th percentile at the three federal Class I areas. DENR is requesting that Otter Tail Power Company submit a report describing this analysis, summarizing the results, and include the input and output files for all of the preprocessor, CALMET, CALPUFF, and postprocessor runs.

It is also DENR's understanding that Otter Tail Power Company is in the process of conducting a Case-by-Case BART analysis, which includes determining the visibility improvements expected at each of these Class I areas. In this evaluation, any modeling should follow the modeling protocol that DENR is approving today. Once Otter Tail Power Company has completed its analysis, a report outlining the steps and summarizing the results must be submitted and include all modeling inputs and outputs for all of the preprocessor, CALMET, CALPUFF, and postprocessor runs.

I want to thank everyone for their time and effort in developing an approvable BART modeling protocol for Big Stone I. If there are any questions, please contact me at 605-773-3151.

Sincerely,

Brian Gustafson, PE
Administrator
Air Quality Program

cc: Kevin Golden, EPA Region 8
Amy Platt, EPA Region 8
Tim Allen, Fish and Wildlife Service
John Notar, National Park Service

Modeling Protocol for a BART Assessment of the Big Stone I Coal-Fired Power Plant, Big Stone City, South Dakota

June 2009

Prepared For:

Big Stone I
Otter Tail Power Company,
Big Stone City, South Dakota

Prepared By:

TRC Environmental Corporation
650 Suffolk Street
Lowell, Massachusetts 01854
(978) 970-5600

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1. INTRODUCTION

TRC Environmental Corporation will be conducting a site-specific BART (Best Available Retrofit Technology) modeling assessment of the Big Stone I coal-fired power plant facility located near Milbank and Big Stone City in South Dakota to determine if any sources of this facility are subject to BART. The current document is a modeling protocol for this BART assessment, which is specific to the Big Stone I power plant facility. This document has been prepared to address comments in an EPA memo dated May 15, 2009 (Fox, 2009).

On July 6, 2005 the USEPA produced the Federal Register document, 40 CFR Part 51 in order to introduce new National Regional Haze Regulations for Best Available Retrofit Technology. The regional haze rule requires States to submit implementation plans (SIPs) to address regional haze visibility impairment in 156 Federally-protected parks and wilderness areas, commonly referred to as "Class 1 Areas". The final rule included a requirement for BART for certain large stationary sources that were put in place between 1962 and 1977. The regional haze rule uses the term "BART-eligible source" to describe those sources which have the potential to emit 250 tons or more of a visibility-impairing air pollutant, were put in place between August 7, 1962 and August 7 1977 and whose operations fall within one or more of 26 specifically listed source categories, of which Coal-Fired Power Plants are one.

BART review is required when the source emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility in any Class 1 area. In identifying a level of control of BART, States are required by section 169A(g) of the CAA to consider; (a) the costs of compliance, (b) the energy and non-air quality environmental impacts of compliance, (c) any existing pollution control technology in use at the source, (d) the remaining useful life of the source and (e) the degree of visibility improvement which may reasonably be anticipated from the use of BART.

The purpose of the modeling will be to assess the visibility impacts of sulfur dioxide (SO_2), particulate matter (PM) and nitrogen oxides (NO_x) emissions from the sources which are BART-eligible and compare their impacts to the 0.5 change in deciview threshold at all the federally mandatory Class I areas. Since there is no Class I areas within the 300 km radius usually applied, the South Dakota Department of Environment and Natural Resources requested that the Class I areas between 300 km and up to 625 km away from the Big Stone I facility sources be modeled. A total of eight Class I areas are located between these distances: two wilderness areas: Boundary Waters Canoe Area Wilderness and Rainbow Lake Wilderness, one National Wildlife Refuge (NWR): Lostwood and five National Parks: Voyageurs NP, Theodore Roosevelt NP, Badlands NP, Wind Cave NP and Isle Royale NP. However, Rainbow Lake Wilderness is one of two Class I areas where the visibility analysis is not required (http://www.dnr.state.wi.us/org/aw/air/modeling/psd.htm), so it will not be included in the modeling analysis. Although the MM5 datasets distributed by WRAP did not extend far enough in the East to include the Isle Royale NP or cover all of the Boundary Waters Class I area, the proposed new MM5 domains will include these areas.

The CALMET and CALPUFF non-steady-state models (Scire et al., 2000a,b) are recommended by the USEPA (*Federal Register*, 6 July 2005) to perform source-specific subject-to-BART screening. The CALPUFF system will therefore be used for this modeling analysis. The USEPA has promulgated the CALPUFF modeling system as a *Guideline Model* for Class I impact assessments and other long range transport applications or near field applications involving complex flows (USEPA, 2000), and the model is recommended by both the Federal Land Managers (FLM) Air Quality Workgroup (FLAG, 2000) and the Interagency Workgroup on Air Quality Modeling (IWAQM, 1998). The CALPUFF modeling system is also recommended in new proposed guidance by the FLMs (FLAG, 2008). A partially completed draft of proposed revisions to the IWAQM guidance dated May 27, 2009 has been released by EPA (EPA, 2009). The draft document does not contain a complete list of recommended switch settings but does contain some information on several model inputs which will be discussed in this protocol.

The Big Stone I BART modeling analysis will be performed with the EPA-approved Version 5.8 of the CALMET and CALPUFF models. Version 6.221 of CALPOST is proposed because it contains the FLM-approved implementation of Method 8 (FLAG, 2008), but in other respects is identical to the EPA-approved Version 5.6394.

CALMET is a diagnostic meteorological model that produces three-dimensional wind fields based on parameterized treatments of terrain effects such as slope flows and terrain blocking effects. Normally, meteorological observations are blended with gridded data from the NCAR-PSU Mesoscale Model, Version 5 (MM5). In this application MM5 data will be generated by TRC with a 4-km grid spacing for three years (2002, 2006 and 2007) to define the initial guess wind fields. A quantitative evaluation of the MM5 datasets will be conducted using the statistical measures outlined in EPA (2009) to demonstrate the 4-km datasets have equal (or better) technical merit than the 36-km MM5 datasets recommended by WRAP (2006) in their approach to BART modeling in this area. In addition, two configurations of CALMET will be tested quantitatively – one using CALMET at 4-km resolution using EPA (2009) switch settings and recommendations (except as described below) and in a second configuration using 2-km CALMET resolution with the traditional weighting factors given to the surface observations. The results of the meteorological model evaluations will be submitted to the SD DENR, FLMs and EPA for their review. The exceptions to the EPA (2009) configuration in the 4-km CALMET simulation includes the use of 4-km rather than 36-km MM5 data and the use of a fixed set of vertical layers in CALMET because it is not possible to set the layers exactly to the MM5 values as recommended by EPA because CALMET and MM5 use different vertical layer structures. The two CALMET configurations will allow an quantitative test of many of the conclusions in the EPA memo regarding grid resolution and model switch settings.

CALPUFF is a non-steady-state puff dispersion model. It accounts for spatial changes in the CALMET-produced meteorological fields, variability in surface conditions (elevation, surface roughness, vegetation type, etc.), chemical transformation, wet removal due to rain and snow, dry deposition, and terrain influences on plume interaction with the surface. CALPUFF contains a module to compute visibility effects, based on a humidity-dependent relationship between particulate matter concentrations and light extinction, as well as wet and dry acid deposition fluxes. The screening and refined meteorological and dispersion modeling simulations will be conducted for three years (2002, 2006 and 2007). SO_2, PM, and NO_x, emissions and their secondary products resulting from chemical conversions from the Big Stone I facility will be modeled at receptors in the Class I areas and their impacts on visibility evaluated. Visibility impacts will be estimated with the new FLM-recommended visibility algorithm and monthly average relative humidity adjustment factors (Method 8 in Version 6.221).

This protocol outlines the techniques and data sources that will be used in the BART analyses. In Section 2, a general description of the source configuration is provided. Descriptions of the site characteristics and data bases (meteorological, geophysical, and aerometric) are provided in Section 3. Section 4 includes an overview of the CALMET and CALPUFF models settings and parameters that will be used in the analysis.

2. SOURCE DESCRIPTION

The 450-megawatt Big Stone I facility is a coal-fired power plant situated close to Big Stone City and Milbank in Grant County, South Dakota, at the border of Minnesota State. A BART applicability analysis was completed for the facility to determine those sources subject to the BART controls. The BART-eligible sources include one stack approximately 152 meters high.

Table 2-1 shows the source parameters and emission rates for the source considered in this application. The highest 24-hour average actual emission rates of SO_2, NO_x and PM under normal conditions over the 2001-2003 period will be used for this analysis. As shown in Table 2-2, the filterable PM_{10} will be divided into a particle size distribution based on AP-42, Table 1.1-6 for baghouse controlled emissions because the facility currently uses a fabric filter for PM control. Approximately 57.6% of the filterable mass is in the fine ($PM_{2.5}$) size category, and 42.4% in the coarse (2.5 to 10 μm diameter) size range. Each of the particle size categories will be modeled as a separate PM species in CALPUFF. The filterable PM_{10} emission rate is reported by the facility at 10.48 g/s (83.2 lb/hr). Based on AP-42 Table 1.1-5, the total condensable PM_{10} would be approximately 0.01 lb/mmBtu based on approximately 0.4% sulfur coal or 7.07 g/sec (56.1 lb/hr) assuming an heat input of 5609 mmBtu/hr. This estimate is consistent with the stack test data (August, 2006) at Otter Tail Power's Hoot Lake Plant, Unit 2, (which burns PRB coal) where the ratio of the filterable/total PM_{10} ratio was 0.66, resulting in a 2/3 filterable and 1/3 condensable split to the total PM_{10}.[1]

Elemental Carbon (EC) emissions will be assumed to be 3.7% of the fine filterable fraction based on EPA (2002) and will be assigned to the smallest particle size category. The primary H_2SO_4 emissions are 0.454 g/s (3.604 lb/hr) based on annual emission inventories and Toxic Release Inventory reports. The remaining condensable emissions will be assigned to organic carbon and distributed equally into the two smallest particle size categories.

Note that since all Class I areas are more than 50 km away from the facility, as recommended by the Federal Land Managers (FLMs) (US Fish and Wildlife, National Park Service and U.S. Forest Service), no downwash computations will be performed.

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[1] AP-42 Table 1.1-8 was not used to estimate the particulate matter size distribution for Big Stone I because the emission factors were derived for cyclones burning bituminous coal, not sub-bituminous coal which is burned at Big Stone I.

Table 2-1. Point Source Parameters and Emission Rates

Source	LCC[1] East (km)	LCC[1] North (km)	Stack Ht (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	SO_2 Emission Rate (g/s)	H_2SO_4 Emission Rate (g/s)	NO_x Emission Rate (g/s)	Filterable PM_{10} Emission Rate (g/s)	Condensable PM_{10} Emission Rate (g/s)
Main Stack	38.141	587.875	151.79	328.90	7.37	20.14	423.00	608.9	0.454	611.7	10.48	7.07

[1] Lambert Conformal Projection with an origin of 40.0N, 97.0W and standard parallels at 33N and 45N. Datum is NWS-84.

Table 2-2. PM_{10} Size Distribution[1]

Particle Size[2] (µm)	Cumulative Mass (PM) (%)	Cumulative Mass (PM_{10}) (%)
15	97	-
10	92	100
6	77	83.7
2.5	53	57.6
1.25	31	33.7
1.00	25	27.2
0.625	14	15.2

[1] From AP-42, Table 1.1-6, Cumulative particle size distribution and size-specific emission factors for dry bottom boilers burning pulverized bituminous and subbituminous coal.

[2] Expressed as aerodynamic equivalent diameter.

3. GEOPHYSICAL AND METEOROLOGICAL DATA

The South Dakota Department of Environment and Natural Resources requested that the eight Class I areas shown in Figure 3-1 be considered in the BART analysis. Rainbow Lake Wilderness is one of two Class I areas where the visibility analysis is not required so it is has been removed from the present analysis (see http://www.dnr.state.wi.us/org/aw/air/modeling/psd.htm). The MM5 dataset for this analysis will be extended to include the Isle Royale National Park as well as all of the Boundary Waters Class I area.

3.1 Terrain

The topography of the domain areas consists of terrain increasing toward the southwest from approximately 300 meters at the facility to 900 meters at Badlands NP and 1200 meters at Wind Cave NP, resulting in 900 meters (~3,000 feet) of terrain relief. The terrain relief also increases towards the northeast. The terrain gets mountainous on the west side of the facility near Badlands and Wind Cave National Parks.

The MM5 simulations will be conducted at 4-km grid spacing covering the modeling domain. CALMET will be run at the same 4-km resolution as MM5 using the EPA (2009) modeling options. A second simulation of CALMET using 4-km MM5 data as its initial guess field and 2-km CALMET grid spacing will be conducted and evaluated quantitatively. The results of the model performance at the two grid resolutions will be presented in a separate summary report.

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

One degree DEM data consists of an array of 1201 by 1201 elevations referenced on the geographic (latitude/longitude) coordinate system of the World Geodetic System 1972 Datum. Elevations are in meters relative to mean sea level, and the spacing of the elevations along each profile is 3 arc-seconds, which corresponds to a spacing of approximately 90 meters. For the North part of the east domain and north west domain covering the south side of Manitoba and Ontario, Canada, SRTM-3 data with also an approximate resolution of 90 meters will be used.

The USGS elevation records located within each grid cell in the computational domain are averaged to produce a mean elevation at each grid point. The CALPUFF computational domain is the same as the CALMET domain. The CALMET and CALPUFF domains extend at least 50 km beyond the Class I areas in order to provide an adequate buffer zone at the boundaries, and to allow the effects of flow curvature and possible small-scale recirculation to be evaluated.

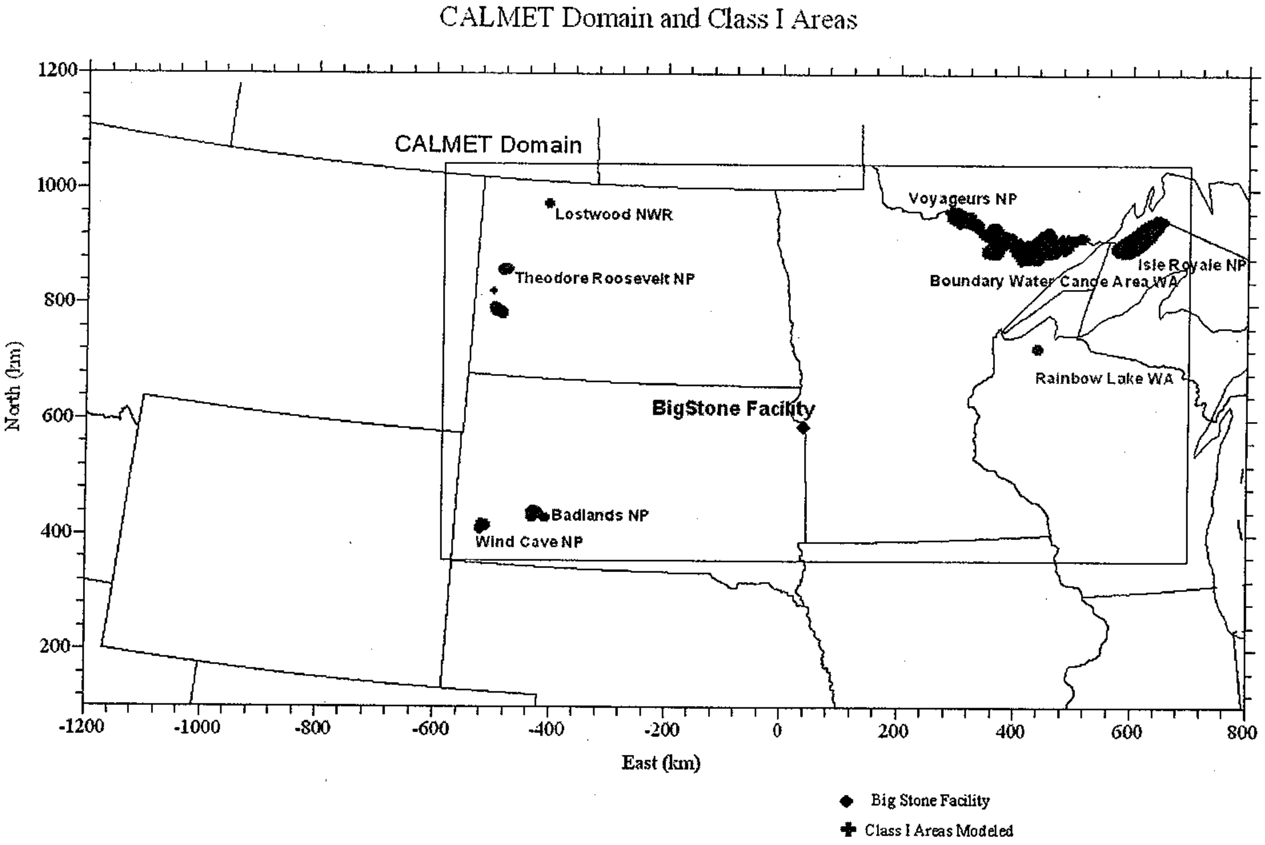

Figure 3-1. Proposed CALMET and CALPUFF modeling domain. The locations of the Class I areas are also shown.

3.2 Land Use

The Composite Theme Grid (CTG) land use data from the USGS, at a resolution of approximately 90m, will be processed to produce gridded fields of dominant land use categories for each grid cell. For the northern part of the domain covering Canada (south part of Manitoba and Ontario), 900 meters Global USGS land use data will also be incorporated using a mesh density for sampling of 2.

Land use data are first processed to produce fractional land use categories. The 37 USGS land use categories are then be mapped into 14 CALMET land use categories. Surface properties such as albedo, Bowen ratio, roughness length, and leaf area index are computed proportionally to the fractional land use. The USGS land use categories are described in Table 3-1. Table 3-2 displays the 14 CALMET land use categories and their associated geophysical parameters for summer conditions. Seasonal variations in surface properties will be considered as appropriate.

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

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

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

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

* Negative values indicate "irrigated" land use

3.3 Meteorological Data Base

The CALMET model has the ability to assimilate meteorological information from surface stations, precipitation stations and upper air stations. Specifically, CALMET uses surface observations of wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure, relative humidity, and precipitation type (e.g., snow, rain, etc.). These variables are routinely measured at the National Weather Service (NWS) surface stations and will be directly included on an hourly basis into CALMET. Upper air observations however are only available twice-daily at a few stations throughout the domain. The locations of the upper air stations in and around the region of interest is displayed in Figure 3-2.

As described in Section 4, CALMET will be run in two modes. The first mode is as described in Section 2.7 of the EPA (2009) draft report in IWAQM Phase 2 and with 4-km grid resolution. In this model the observed surface and upper air wind data are essentially not used because of the low weighting factors suggested by EPA. Because the EPA (2009) does not contain a complete list of recommended switch settings, additional clarification on EPA recommendations will be requested. In the second mode, the model will be run at higher resolution (2-km) and with more weight given to the observational data as has been the traditional mode of running CALMET in Class I analyses.

The surface and precipitation stations that will be included in the modeling are displayed in Figure 3-3. For 2002, there are 272 surface stations and 265 precipitation stations available with similar numbers in 2006 and 2007. As recommended in the WRAP Protocol (2006) observed cloud cover and ceiling height from the surface meteorological stations will be used instead of cloud cover computed from relative humidity from MM5 (ICLOUD = 0).

The three-dimensional gridded data from the prognostic numerical model MM5 with nested grids of 36-km, 12-km and 4-km grid spacing will be conducted by TRC. An existing 12-km MM5 dataset for 2006 will be used along with a new nested 4-km nest over the area of interest. Information about the existing MM5 model configuration is provided in Appendix B.

Table 3-3. Meteorological Data Sources and Parameters Available

Type of Dataset	Frequency	Source	Parameters available
Surface Observations	Hourly	NWS	Wind speed, wind direction, temperature, ceiling height, cloud cover, relative humidity, surface pressure, precipitation type
Precipitation Observations	Hourly	NWS	Precipitation rate
Modeled Profiles MM5 for 2002, 2006 and 2007	Hourly	TRC	Hourly, gridded fields of winds, temperature, pressure, and humidity and liquid water content on 4-km grid.

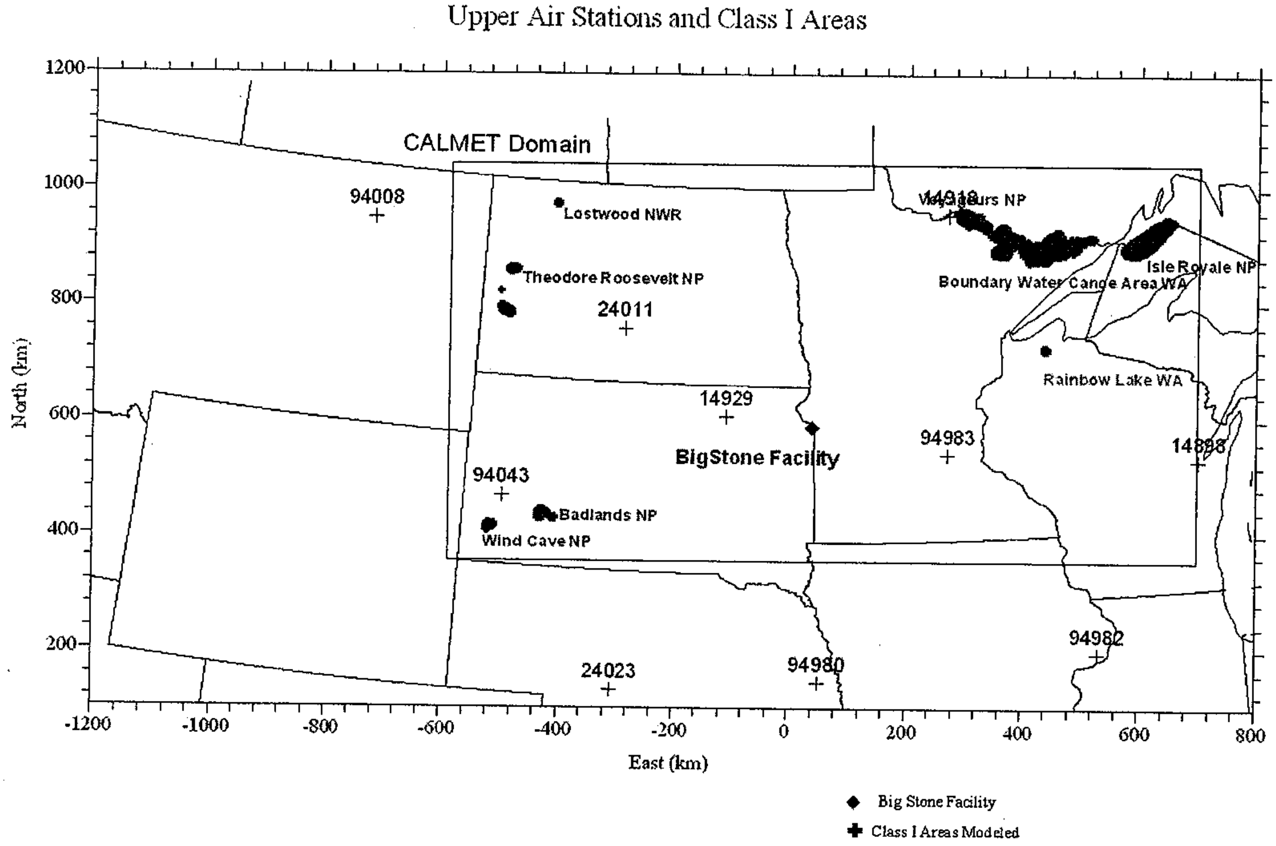

Figure 3-2. Plot of upper air stations available in the modeling domain.

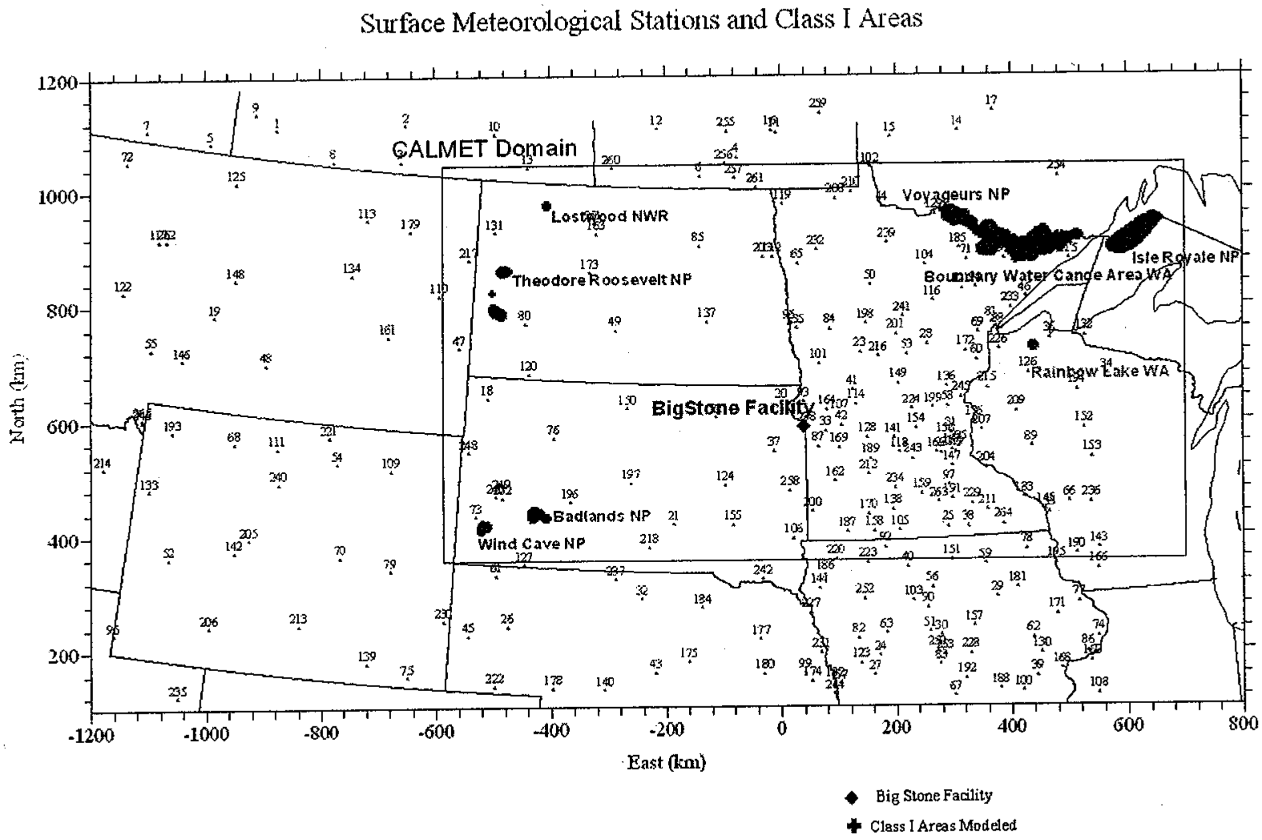

Figure 3-3. Plot of surface stations available in the modeling domain.

3.4 Air Quality Monitoring Data

CALPUFF will use hourly ozone concentration measurements in the chemical transformation rates (SO_2 to SO_4, NO_x to HNO_3/NO_3). The ambient ozone measurements are used in determining SO_2 loss rates due to chemical transformation to sulfate and in determining NO_x loss rates to nitrate. Ambient ozone hourly concentrations from EPA AIRS and CASTNet networks for 2002, 2006 and 2007 will be processed into OZONE.DAT files and used as ozone background in CALPUFF. An 80 parts per billion (ppb) concentration will be used as backup when hourly ozone concentrations are missing, which given the number of ozone stations is unlikely to be used.

A constant background ammonia concentration of 1 parts per billion (ppb) as recommended by the FLMs and EPA will be used in the CALPUFF runs. The output of CALPUFF will be postprocessed with POSTUTIL using the MNITRATE=1 switch. This eliminates the potential for double counting of ammonia by overlapping puffs from the modeled Big Stone source.

A second postprocessing simulation will be conducted using full ammonia limiting calculations based on data from background monthly average sulfate, total nitrate and total ammonia data from the 2002 CMAQ model using the POSTUTIL option MNITRATE=2. This second option accounts for both overlapping puffs from the modeled source as well as spatial and monthly variability of ammonia and background sulfate and nitrate from sources not included in the CALPUFF simulations. The results from both sets of simulations will be presented.

4. AIR QUALITY MODELING OPTIONS

4.1 Modeling Domain

CALMET and CALPUFF use terrain-following coordinates. In order to cover a large enough area for the refined analysis covering all seven Class I areas within a single domain, and including a buffer of at least 50 km around each Class I area, the domain dimensions of 1300 km x 700 km will be used. For a 4-km grid spacing, this amounts to 325 x 175 grid cells. In the vertical, the CALMET domain will be designed to match the MM5 model parameters up to the 4000 meters above the ground to the extent possible. Because MM5 uses a sigma coordinate system in the vertical and CALMET uses a fixed terrain following system, it is not possible to match the layers in the two models exactly as indicated should be done in the EPA (2009) guidance. However, the vertical grid spacing at the location of the source will be used in determining the CALMET vertical layer structure. Approximately 25 vertical levels will be used to match the number of MM5 layers below 4000 meters.

CALMET and CALPUFF will be run for three years, 2002, 2006 and 2007. A network of discrete receptors derived from the list of receptors developed by the National Park Service (NPS) are located within the boundaries of the seven Class I areas modeled: Boundary Water Canoe Area Wilderness, Voyageur National Park, Badlands National Park, Wind Cave National Park, Lostwood National Wildlife Refuge, Theodore Roosevelt National Park and Isle Royale National Park.

4.2 Meteorological Modeling Options

4-km Simulation. EPA-approved Version 5.8 Level 070623 of CALMET will be run using the recommendations described in Section 2.7 of EPA (2009), except as noted above regarding vertical layer structure. This includes using the regulatory set of options, including Maul-Carson convective mixing height over land only (IMIXH= - 1), OCD delta-T method for overwater fluxes (ICOARE=0), and no convective heat flux threshold overland (THRESHL= 0 W/m^3). These values of IMIXH, ICOARE and THRESHL, differ from the settings in the CALMET input files provided for sources located in South Dakota state on the WRAP Regional Modeling Center web page http://pah.cert.ucr.edu/aqm/308/bart.shtml. , but follow regulatory guidance set by EPA. In addition, NOOBS will be set to 0 and the MM5 data will be used as the initial guess field. Diagnostic adjustments will be turned off in the 4-km simulation and small values (i.e., 0.001 km) will be used for the RMAX1, RMAX2, R1 and R2 parameters, effectively minimizing the use of the surface and upper air wind observations. The EPA document references additional CALMET parameters in Appendix A of the document, but that section is missing from the draft EPA report. Some additional guidance from EPA may be necessary on the switch settings that will conform to EPA recommendations.

Initial Guess Field

MM5 data will be used to define the initial guess field for the CALMET simulations (IPROG=14). For all three years hourly MM5 data with a grid spacing of 4 km will be used in the modeling. The CALMET horizontal grid specifications will be set to match those of the MM5 grid.

2-km Simulation. As a test of the performance of the EPA (2009) recommended model switch setting, a simulation of CALMET at higher grid resolution (2-km grid spacing) will be conducted using the traditional model options including diagnostic adjustments for terrain effects, more weight to surface observations with the typical 2:1 ratio of RMAX1/R1 and RMAX2/R2. The switch settings will be similar to those used previously except because these new runs will have higher resolution MM5 data available (4-km vs 36-km resolution), smaller RMAX1, RMAX2, R1 and R2 parameters will be developed to allow the higher resolution data to be retained. In the previous simulations, RMAX1=100 km and RMAX2=200 km were used with the 36-km MM5 data. Values between ½ to ¼ of these values will be evaluated in the 2-km simulation to strike a balance between smooth transitions from the observations to the MM5 data without completely eliminating the influence of the observations. It is proposed that NOOBS=1 be used in the 2-km simulations. As with the 4-km CALMET run, precipitation rates will be determined based on precipitation station measurements. Also, as with the 4-km runs, cloud amount and ceiling height will be derived from the surface station measurements. Overwater air-sea temperature difference will be derived from the MM5 data (ITWPROG=2) and prognostic temperature data will determined based on the 3-D temperature fields from the high resolution MM5 output. The performance of the CALMET simulations will be compared to that from the 4-km runs and presented to the regulatory agencies.

Step 1 Field: Terrain Effects

In developing the Step 1 wind field, CALMET adjusts the initial guess field to terrain effects, including slope flows and blocking effects. Slope flows are a function of the local slope and altitude of the nearest crest. The crest is defined as the highest peak within a radius TERRAD around each grid point. A value of TERRAD of 10 km will be used in the CALMET simulations as it is recommended by the WRAP Protocol (2006) and in agreement with an analysis of the scale of the terrain. The Step 1 field produces a flow field consistent with the fine-scale CALMET terrain resolution (2 km).

Step 2 Field: Objective Analysis

In Step 2, observations are incorporated into the Step 1 wind field to produce a final wind field. Each observation site influences the final wind field within a radius of influence (parameters RMAX1 at the surface and RMAX2 aloft). Observations and Step 1 wind fields are weighted by means of parameters R1 at the surface and R2 aloft: at a distance R1 from an observation site, the Step 1 wind field and the surface observations are weighted equally. As noted above, RMAX1/R1 and RMAX2/R2 will retain 2:1 ration, although the values of RMAX1 and RMAX2 will be reduced to25-50% of the values used when 36-km MM5 was used. This more typical use of a 2:1 ratio with R1 *smaller* than RMAX1 is a deviation from the WRAP CALMET setting where R1 was set to 100 km and RMAX1 to 50km. The WRAP setting with RMAX1 being larger than R1 inevitably creates bull-eye effects around each meteorological stations at the surface and thus should be avoided. Also vertical extrapolation for the surface meteorological stations will be activated (IEXTRP=-4), which is a deviation from the WRAP protocol but in agreement with the EPA BART guidance. This setting will insure that the surface observations, vertically extrapolated within the boundary layer, are blended with the MM5-based Step 1 field aloft.

4.3 Dispersion Modeling Options

CALPUFF simulations will be conducted generally following the WRAP Protocol 2006 guidance, but with the EPA-approved Version 5.8 Level 070623 rather than Version 6 of the model. List of options to be used includes:

- Gaussian near-field vertical distribution
- Partial plume path adjustment method for terrain
- Transitional plume rise will be modeled
- Partial plume penetration of elevated inversion option will be activated
- Stack tip downwash will be used
- MESOPUFF II scheme will be used for the chemical transformation
- Pasquill-Gifford (PG) dispersion coefficients (rural areas) and McElroy-Pooler coefficients (urban areas) will be used to compute dispersion coefficients. The probability density function (PDF) for convective conditions will not be used because this is available only with the turbulence-based dispersion option.)
- Transition of σ_y to time-dependent (Heffter) growth rates will be set to 550 meters
- The switch for using Heffter equation for sigma z will not be activated
- PG sigma-y, z adjustment for roughness will not be selected
- Puff splitting (MSPLIT=1) will be activated
- Wet deposition, dry deposition will be applied
- The minimum turbulence velocities sigma-v for each stability class will be set to 0.5 m/s over land and 0.37 m/s over water.

The CALPUFF computational grid will be the same as the meteorological grid. The modeling domain include a buffer zone of 50 km around the source area and beyond the borders of the Class I areas. This minimizes edge effects and allows pollutants involved in flow reversals to be brought back into the Class I areas. Note that the CALMET modeling domain from previous studies will be extended to include the Isle Royale National Park

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

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

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

Deposition and chemical transformation effects will be modeled using the default dry deposition model, the scavenging coefficient wet removal module, and the default chemical transformation mechanism.

A total of five chemically active species will be modeled with CALPUFF for this analysis: SO_2, SO_4, NO_x, HNO_3 and NO_3.. The chemical mechanism computes transformation rates of SO_2 to SO_4 and NO_x to NO_3/HNO_3. Hourly measured ozone concentrations will be provided in an external file for use with the chemical transformation module. These ozone concentrations, along with radiation intensity, are used as surrogates for the OH concentration during the day when the gas phase free radical chemistry is active.

Six additional PM_{10} species will be modeled corresponding to the midpoint of each particle size bin shown in Table 2-2. The fine, coarse, elemental carbon and organic carbon species will be constructed in postprocessing steps using the POSTUTIL program from these six PM species according to the appropriate size weights for size bin as discussed in Section 2.

4.4 Visibility Calculations

Calculations of the impact of the simulated plume particulate matter component concentrations on light extinction will be carried out with the CALPOST postprocessor following the new proposed FLAG (2008) guidance. The procedure deviates from the WRAP protocol (2006). The original IMPROVE/EPA equation (1) described below was recommended to determine the change in light extinction due to changes in component concentrations. Using the notations of CALPOST:

$$B_{ext} = 3f(RH)[(NH_4)2SO_4] + 3f(RH)[NH_4NO_3] + 4[OC] + 1[Soil] + 0.6[Coarse\ Mass] + 10[EC] + b_{ray} \quad (1)$$

The concentrations, in square brackets, are in $\mu g/m^3$ and b_{ext} is in units of Mm^{-1}.

But a revised new IMPROVE algorithm to compute the extinction (1/Mm) has been developed by the IMPROVE steering committee for estimating light extinction from particulate matter as described in equation (2) below. This algorithm provides a better correspondence between the measured visibility and that calculated from particulate matter component concentrations (Tombach, 2006):

$$
\begin{aligned}
b_{ext} = {} & 2.2 f_S(RH) \bullet [\mathit{small\ sulfate}] + 4.8 f_L(RH) \bullet [\mathit{large\ sulfate}] \\
& + 2.4 f_S(RH) \bullet [\mathit{small\ nitrate}] + 5.1 f_L(RH) \bullet [\mathit{large\ nitrate}] \\
& + 2.8 \bullet [\mathit{small\ organics}] + 6.1 \bullet [\mathit{large\ organics}] \\
& + 10 \bullet [\mathit{elemental\ carbon}] \\
& + 1 \bullet [\mathit{fine\ soil}] \\
& + 1.7 f_{SS}(RH) \bullet [\mathit{sea\ salt}] \\
& + 0.6 \bullet [\mathit{coarse\ matter}] \\
& + \mathit{Rayleigh\ scattering}\ (\mathit{site-specific}) \\
& + 0.17 \bullet [NO_2]
\end{aligned} \tag{2}
$$

All of the brackets [] denote concentrations in $\mu g/m^3$.

In CALPOST, the new IMPROVE algorithm as proposed by FLAG (2008) is implemented as CALPOST Method 8. The implementation of this method in CALPOST is described in more details in Appendix A. The proposed FLAG (2008) methodology is included in CALPOST V6.221 Level 080724, which has been reviewed and approved by the FLMs. This version of CALPOST is publicly available on the TRC's CALPUFF website (http://www.src.com/calpuff/calpuff1.htm) and will be used for this analysis.

The Rayleigh scattering term (b_{ray}) will be site-specific and computed as a function of the elevation as shown in Table 4-1, following FLAG(2008) guidance. Note that organic carbon (OC), which consists of condensable particulates and elemental carbon (EC) for soot particulates will be modeled along with fine and coarse particulate matter as described in Section 2.

To represent background natural conditions, monthly background concentrations must be entered into the CALPOST input control file for all aerosols defining the background. The WRAP Protocol (2006) recommendations are to use as natural conditions background, all three types of EPA default Natural Conditions: Best 20% Days, Annual Average and Worst 20% Days. In "Guidance for Estimating Visibility Conditions Under the Regional Haze Rule" (EPA2003), these three default values are defined only by their extinction coefficient in Mm^{-1}. For CALPOST Method 8, explicit background concentrations are required to allow the computation of the small and large sulfate particulates, nitrate particulates and organic carbon. So, in this analysis, the annual averaged background conditions will be used to define the natural background for each of the six Class I areas, following FLAG(2008). The concentrations used as background for each of the six Class I areas are summarized in Table 4-2. These concentrations will be used to compute a natural background light extinction following the revised IMPROVE formulae described above, for each of the Class I areas.

Tables 4-3, 4-4, and 4-5, provide the monthly f(RH) values for each of the 6 Class I areas, that are used to compute extinction coefficients for hygroscopic species, respectively for small

Table 4-1. Rayleigh Scattering Term (Mm^{-1}) for each Class I area as a Function of Elevation

Class I Area	Highest Elevation in feet (meters)	Rayleigh Scattering Term (Mm^{-1})
Boundary Water Canoe Area Wilderness	1998.0 (609)	11
Voyageurs NP	1335.3 (407)	12
Badlands NP	3031.5 (924)	11
Wind Cave NP	4796.6 (1462)	10
Lostwood NWR	2427.8 (740)	11
Theodore Roosevelt NP	2900.3 (884)	11

Source: FLAG (2008)

Table 4-2. Annual Averaged Conditions Levels of Aerosol Components ($\mu g/m^3$) to Define Natural Background (FLAG 2008 – Method 8 values per Class I Area)

Class I Area	SO_4	NO_3	OC	EC	Soil	Coarse Mass
Boundary Water Canoe Area Wilderness	0.23	0.10	1.71	0.02	0.31	2.53
Voyageurs NP	0.23	0.10	1.75	0.02	0.26	2.73
Badlands NP	0.12	0.10	0.60	0.02	0.50	3.00
Wind Cave NP	0.12	0.10	0.60	0.02	0.49	2.98
Lostwood NWR	0.12	0.10	0.60	0.02	0.50	3.00
Theodore Roosevelt NP	0.12	0.10	0.60	0.02	0.50	3.00
Isle Royale NP	0.23	0.10	1.55	0.02	0.24	2.89

Source: FLAG (2008)

Table 4-3. Monthly Site-Specific RH adjustment factors f(RH) values for hygroscopic species – Small ammonium sulfate and ammonium nitrate particles. Method 8 (FLAG (2008))

Class I area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Boundary Water Canoe Area Wilderness	3.23	2.81	2.93	2.63	2.89	3.22	3.44	3.71	3.83	3.08	3.49	3.49
Voyageurs NP	3.16	2.77	2.82	2.59	2.65	3.28	3.25	3.48	3.66	3.02	3.37	3.32
Badlands NP	2.94	2.96	3.01	2.87	3.1	2.91	2.64	2.59	2.56	2.58	3.11	2.98
Wind Cave NP	2.81	2.81	2.86	2.82	3.06	2.81	2.5	2.46	2.44	2.52	2.97	2.83
Lostwood NWR	3.21	3.15	3.36	2.6	2.54	2.86	2.89	2.6	2.53	2.72	3.6	3.52
Theodore Roosevelt NP	3.17	3.11	3.22	2.71	2.74	2.85	2.73	2.49	2.48	2.66	3.42	3.37

Source: FLAG (2008)

Table 4-4. Monthly Site-Specific RH adjustment factors f(RH) values for hygroscopic species – Large ammonium sulfate and ammonium nitrate particles – Method 8 (FLAG(2008))

Class I area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Boundary Water Canoe Area Wilderness	2.5	2.25	2.28	2.09	2.2	2.43	2.57	2.71	2.78	2.38	2.64	2.64
Voyageurs NP	2.46	2.22	2.22	2.07	2.09	2.46	2.46	2.59	2.7	2.35	2.58	2.55
Badlands NP	2.31	2.31	2.31	2.21	2.34	2.25	2.08	2.05	2.02	2.05	2.38	2.33
Wind Cave NP	2.23	2.22	2.22	2.18	2.32	2.18	2	1.97	1.95	2	2.3	2.24
Lostwood NWR	2.51	2.45	2.54	2.06	2.03	2.221	2.23	2.05	2.02	2.13	2.69	2.67
Theodore Roosevelt NP	2.47	2.42	2.45	2.12	2.14	2.21	2.14	1.99	1.99	2.1	2.58	2.57

Source: FLAG (2008)

Table 4-5. Monthly Site-Specific RH adjustment factors f(RH) values for hygroscopic species – Sea salt particles - Method 8 (FLAG(2008))

Class I area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Boundary Water Canoe Area Wilderness	3.73	3.35	3.29	2.91	3.0	3.44	3.68	3.88	3.98	3.45	3.89	3.91
Voyageurs NP	3.69	3.31	3.2	2.9	2.89	3.46	3.55	3.71	3.87	3.42	3.83	3.8
Badlands NP	3.37	3.33	3.27	3.05	3.25	3.15	2.89	2.81	2.74	2.82	3.41	3.38
Wind Cave NP	3.25	3.2	3.13	3.01	3.22	3.06	2.75	2.68	2.63	2.75	3.28	3.24
Lostwood NWR	3.77	3.66	3.67	2.86	2.79	3.07	3.11	2.82	2.8	2.99	3.93	3.95
Theodore Roosevelt NP	3.67	3.56	3.51	2.93	2.97	3.09	2.96	2.72	2.72	2.93	3.75	3.78

Source: FLAG (2008)

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The revised visibility algorithm developed for the IMPROVE Steering Committee (IMPROVE 2005) as recommended by FLAG (2008) has been implemented in CALPOST. It differs from the previous IMPROVE algorithm as used in Methods 2 and 6 in six areas:

- Extinction efficiencies of sulfates, nitrates, and organics vary with concentration, as there are distinct efficiencies for "small" and "large" particles and the ratio of small-to-large particle fraction decreases as the concentration increases. Furthermore, the extinction efficiency for sulfates no longer equals that for nitrates.
- A separate hygroscopic humidity enhancement factor curve is prescribed for "small" and "large" particles, $f_S(RH)$ and $f_L(RH)$. These curves apply to sulfates and nitrates.
- Light extinction due to scattering by sea salt (with its own hygroscopic humidity enhancement factor $f_{SS}(RH)$) is included.
- Light absorption by NO_2 gas is included in the extinction.
- Background particulate organic matter concentration is taken to be 1.8 times measured organic carbon concentrations.
- Rayleigh scattering extinction varies with site elevation and mean temperature.

Items 5 and 6 remain direct inputs to CALPOST, and require no structural changes to the postprocessor. The user must confirm that appropriate values are provided.

Item 4, the introduction of light extinction due to NO_2 gas absorption, has been added to CALPOST as a discrete component independent of the visibility method chosen. New control file inputs associated with NO_2 are:

```
    Modeled species to be included in computing the light extinction
    Include NO2 absorption?    (LVNO2) -- Default: F    ! LVNO2   = T  !
            With Visibility Method 8 -- Default: T

    Source of NO2 (when LVNO2=T) may be from CALPUFF NO2 concentrations
    and from a fraction of CALPUFF NOx concentrations.  Specify the
    fraction of NOx that is treated as NO2.
                          (FNO2NOX) -- Default: 1.0 ! FNO2NOX = 0.75 !

   Extinction Efficiency (1/Mm per ug/m**3)
   ----------------------------------------
             NO2 GAS          (EENO2) -- Default: .17 ! EENO2   = .17 !
```

Items 1 through 3 are implemented as visibility method 8 in CALPOST, along with the specific choice of the new f(RH) curves. Selection of the revised IMPROVE algorithm requires the following new control file selections:

```
Particle growth curve f(RH) for hygroscopic species
                              (MFRH) -- Default: 2   ! MFRH   = 4  !
     1 =  IWAQM (1998) f(RH) curve (originally used with MVISBK=1)
     2 =  FLAG (2000) f(RH) tabulation
     3 =  EPA (2003) f(RH) tabulation
     4 =  IMPROVE (2006) f(RH) tabulations for sea salt, and for
          small and large SULFATE and NITRATE particles;
          Used with Visibility Method 8 (MVISBK = 8)

Method used for background light extinction
                             (MVISBK) -- Default: 2   ! MVISBK =  8  !
     1 =  Supply single light extinction and hygroscopic fraction
     2 =  Compute extinction from speciated PM measurements (A)
     3 =  Compute extinction from speciated PM measurements (B)
     4 =  Read hourly transmissometer background extinction measurements
     5 =  Read hourly nephelometer background extinction measurements
     6 =  Compute extinction from speciated PM measurements
     7 =  Use observed weather or prognostic weather information for
          background extinction during weather events; otherwise, Method 2
     8 =  Compute extinction from speciated PM measurements using the
          IMPROVE (2006) variable extinction efficiency formulation
          (MFRH must be set to 4)
          - Split between small and large particle concentrations of
            SULFATES, NITRATES, and ORGANICS is a function of concentration
            and different extinction efficiencies are used for each
          - Source-induced change in visibility includes the increase in
            extinction of the background aerosol due to the change in the
            extinction efficiency that now depends on total concentration.
          - Fsmall(RH) and Flarge(RH) adjustments for small and large
            particles are applied to observed and modeled sulfate and
            nitrate concentrations
          - Fsalt(RH) adjustment for sea salt is applied to background
            sea salt concentrations
          - F(RH) factors are capped at F(RHMAX)
          - RH for Fsmall(RH), Flarge(RH), and Fsalt(RH) may be
            obtained from hourly data as in Method 2 or from the FLAG
            monthly RH adjustment factor used for Method 6 where EPA
            F(RH) tabulation is used to infer RH, or monthly Fsmall,
            Flarge, and Fsalt RH adjustment factors can be directly
            entered. Furthermore, a monthly RH factor may be applied
            to either hourly concentrations or daily concentrations
            to obtain the 24-hourextinction.

            These choices are made using the M8_MODE selection.
```

```
Additional inputs used for MVISBK = 8:
----------------------------------
 Extinction coefficients for hygroscopic species (modeled and
 background) may be computed using hourly RH values and hourly
 modeled concentrations, or using monthly RH values inferred from
 the RHFAC adjustment factors and either hourly or daily modeled
 concentrations, or using monthly RHFSML, RHFLRG, and RHFSEA
 adjustment factors and either hourly or daily modeled
 concentrations.

  (M8_MODE) -- Default: 5      ! M8_MODE=  5   !
               FLAG (2008)

      1 = Use hourly RH values from VISB.DAT file with hourly
          modeled and monthly background concentrations.
      2 = Use monthly RH from monthly RHFAC and EPA (2003) f(RH)
          tabulation with hourly modeled and monthly background
          concentrations.
          (VISB.DAT file is NOT needed).
      3 = Use monthly RH from monthly RHFAC with EPA (2003) f(RH)
          tabulation with daily modeled and monthly background
          concentrations.
          (VISB.DAT file is NOT needed).
      4 = Use monthly RHFSML, RHFLRG, and RHFSEA with hourly
          modeled and monthly background concentrations.
          (VISB.DAT file is NOT needed).
      5 = Use monthly RHFSML, RHFLRG, and RHFSEA with daily modeled
          and monthly background concentrations.
          (VISB.DAT file is NOT needed).
```

The last of these selections, M8_MODE, provides options for how concentrations are averaged, and how the relative humidity enhancement factors for hygroscopic species are determined. M8_MODE has a default value of 5, which is consistent with the new FLAG (2008) guidance

1. MM5 Domain Configuration (36-km, 12-km Resolution)

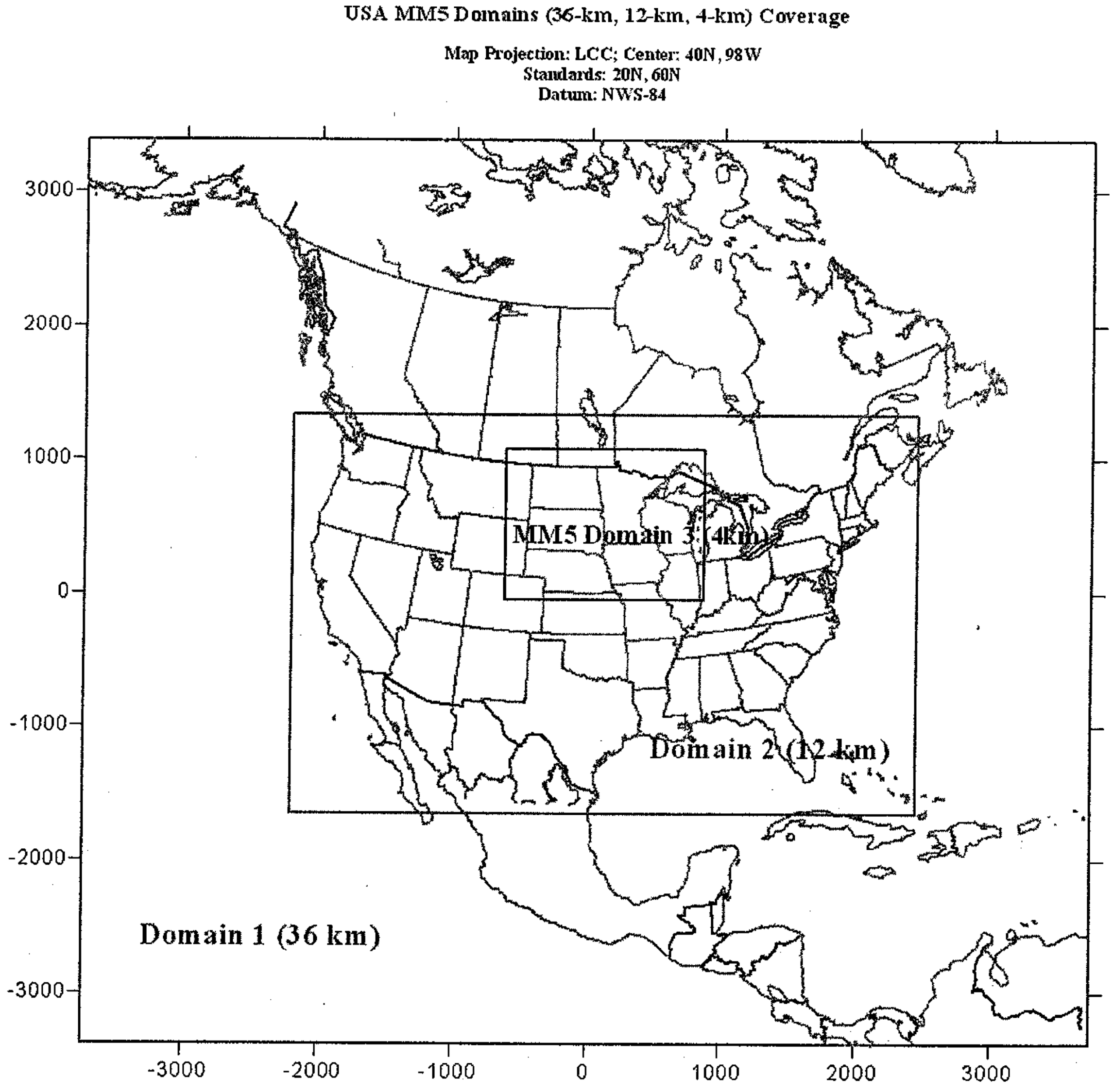
MM5 simulations have been run for 1996 for North America for two domains: a coarse Domain 1 (36-km resolution), and a nested Domain 2 (12-km resolution). The Lambert Conical Conformal (LCC) mapping projection is used in modeling. The center of the coordinate system is located at the center of Domain 1 at 40°N and 98°W. Two standard latitudes of LCC are set to 20°N and 60°N. The coarse domain (Domain 1) covers an area of 7488 km in the west-east (X) direction by 6768 km in the south-north (Y) direction with grid spacing of 36 km (Table B-1).

An additional nest at 4 km grid spacing will be developed to cover the modeling area of interest for the Big Stone BART modeling. One way nesting will be used as in the other nests. Figure B-1 shows the two initial modeling domains and the new 4-km inner nest (Domain 3).

There are forty-one sigma levels in the vertical direction from the surface up to 100 hPa (Table B-2). The first sigma level is about 11 m above the ground, very close to the anemometer height at operational weather stations. The vertical spatial resolution varies from the surface to the model top. About twenty levels are below 1500 m above the ground for better resolving the atmospheric boundary layer in the model.

Table B-1 Domain Configuration and Parameterizations for 2006 MM5 Simulations. The Lambert Conical Conformal (LCC) map projection is used in the MM5 modeling.

Settings	Domain 1	Domain 2
Grid number	209 x 189	388 x 250
Grid size (km)	36	12
Nesting	NA	One-way
Sigma levels	41	41
Moisture	Reisner 2	Reisner 2
Cumulus	Kain-Fritsch 2	Kain-Fritsch 2
Boundary layer	ETA	ETA
Radiation	RRTM	RRTM
Soil model	NOAH LSM	NOAH LSM
FDDA	3D and Surface Analysis	3D and Surface Analysis
Run Length	2.5 days	2.5 days
Spin-up time	12 hours	12 hours
Terrain and land-use data	USGS 10-minute (~19 km)	USGS 5-minute (~9 km)



MM5 Domains:
D1: X: -3744 - 3744 km, Y: -3384 - 3384 km; dxy= 36 km; 209 x 189 i1= 1,j1= 1
D2: X: -2196 - 2448 km, Y: -1656 - 1332 km; dxy= 12 km; 388 x 250 i1= 44,j1= 49
D3: X: -612 - 864 km, Y: -48 - 1080 km; dxy= 4 km; 370 x 283 i1=133,j1=135

Figure B-2. Map showing the MM5 Domain 1 (36-km) and Domain 2 (12-km) and the new Domain 3 (4-km).

Table B-2. Sigma Levels used in the North American MM5 Simulations for 2006.

Level	Sigma	Half Sigma	Ref. Pressure (mb)	Height (m)
surface	1.0000	-	1010.0	0.0
1	0.9970	0.9985	1008.6	10.9
2	0.9936	0.9953	1005.7	34.1
3	0.9898	0.9917	1002.4	60.3
4	0.9856	0.9877	998.8	89.6
5	0.9808	0.9832	994.7	122.5
6	0.9754	0.9781	990.1	160.0
7	0.9694	0.9724	984.9	202.1
8	0.9626	0.9660	979.1	249.6
9	0.9549	0.9588	972.5	303.7
10	0.9463	0.9506	965.0	364.8
11	0.9367	0.9415	956.8	433.5
12	0.9258	0.9313	947.4	511.5
13	0.9136	0.9197	936.9	600.1
14	0.8999	0.9068	925.1	700.4
15	0.8845	0.8922	911.9	814.4
16	0.8672	0.8759	897.0	944.1
17	0.8477	0.8575	880.3	1092.1
18	0.8258	0.8368	861.4	1261.5
19	0.8012	0.8135	840.3	1455.3
20	0.7736	0.7874	816.5	1677.7
21	0.7425	0.7581	789.8	1934.1
22	0.7076	0.7251	759.8	2230.9
23	0.6683	0.6880	726.0	2576.1
24	0.6242	0.6463	688.1	2980.0
25	0.5746	0.5994	645.5	3455.7
26	0.5188	0.5467	597.5	4021.9
27	0.4688	0.4938	549.4	4628.0
28	0.4284	0.4486	508.2	5180.4
29	0.3879	0.4082	471.4	5705.6
30	0.3474	0.3677	434.6	6265.0
31	0.3065	0.3270	397.5	6866.0
32	0.2620	0.2843	358.7	7545.5
33	0.2175	0.2398	318.2	8317.4
34	0.1675	0.1925	275.2	9224.7
35	0.1175	0.1425	229.7	10311.2
36	0.0783	0.0979	189.1	11426.7
37	0.0588	0.0686	162.4	12261.6
38	0.0392	0.0490	144.6	12875.1
39	0.0196	0.0294	126.8	13547.3
40	0.0000	0.0098	108.9	14290.2

2. Model Parameterizations and Schemes

The MM5 model was run in the non-hydrostatic mode using the upper radiative boundary condition. MM5 physical schemes and parameterizations are listed in Table B-1. The Reisner graupel scheme was used for the explicit moisture parameterization. It predicts all five water contents in the atmosphere. This scheme includes additional equation to predict graupel. It is an expansive scheme compared with simple ice scheme, but it is affordable with the improved computer power at TRC. The cumulus scheme used in MM5 is the Kain-Fritsch 2 scheme (Kain, 2002). This scheme includes shallow convection. For planetary boundary layer (PBL) scheme, the Mellor-Yamada scheme used in the ETA model (Janjic, 1990, 194) was used in this MM5 modeling. This scheme was implemented in the NCEP MRF model. It is efficient and suitable for high-resolution PBL. The Rapid Radiative Transfer Model was used for the radiation scheme in both Domains (Malwer et al., 1997). This scheme is a highly accurate and efficient method developed by AER Inc. Multiple-layer soil temperatures were computed using the NOAH land surface model (National Centers for Environmental Prediction, Oregon State University, Air Force, and Hydrologic Research Laboratory). Additional geographical data, such as soil types, vegetation fraction, and annual deep soil temperatures are needed for the land surface model; and these data were obtained from NCAR.

One way nesting is used in the MM5 simulation, meaning that the mother domain is not affected by its child-domain. Such nesting allows adding new domains later without re-running all the other domains.

Analysis Four Dimensional Data Assimilation (FDDA) was applied to both Domain 1 and Domain 2, but it will not be applied to the Domain 3. Typically the effect of assimilated data is passed into high resolution domains such as the 4-km domain through the lower resolution nests, rather than directly in the high resolution domain.

3. Initial Data and Simulation

MM5 is initialized using the 1° x 1° Final Analysis (FNL) data from NCEP at NCAR. It is an improvement of the original 2.5-degree by 2.5-degree data set. The FNL data were archived at NCAR with temporal resolution of six hours at the surface and 26 standard pressure levels under 10 hPa: 1000, 975, 950, 925, 900, 850, 800, 750, 700, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200, 150, 100, 70, 50, 30, 20, and 10 hPa. The data set includes two-dimensional variables of snow cover, sea surface temperature (SST), sea level pressure, and three-dimensional variables of temperature, geopotential height, U and V components, and relative humidity.

The SST spatial resolution of 1° x 1° in FNL data is too coarse in the coastal area. To improve SST in MM5, a better SST data set, the daily 4-km MODIS SSTs, is ingested into the simulation. The MODIS (MODerate Resolution Imaging Spectroradiometer) SSTs are derived from the sensors onboard the NASA Terra and Aqua platforms. The MODIS SSTs include from both the sensors of mid-infrared (IR) and thermal IR channels. The product used in the simulation is the MODIS Global Level 3 Mapped mid-IR SSTs.

MM5 is run for 2.5-day periods with 12 hours for spin-up time. The initial FNL data are model output and already in the dynamically-consistent state. The spin-up time of 12 hours is enough to allow MM5 reach dynamical balance in its domains. The 2.5-day simulation length can reduce the divergence between forecasts and analyses. MM5 output covers the period from 2005123112 to 2007010111, so that any conversion between local and UTC times can be properly processed. There are 183 2.5-day simulations in total for the annual period.

Gustafson, Brian

From: TGraumann@otpco.com
Sent: Monday, August 31, 2009 12:40 PM
To: Gustafson, Brian
Cc: pshamblin@hunton.com
Subject: Big Stone Plant - Proposed BART Modeling Protocol - 8.31.2009

Brian,

Otter Tail Power Company has considered the questions and concerns expressed by the participants on the July 22, 2009 conference call regarding the Big Stone I BART modeling protocol, and EPA Region 8's July 30th summary of that call.

In an effort to move the process along on a schedule that will enable the Department of Environment and Natural Resources to complete its Regional Haze State Implementation Plan in a timely manner, Otter Tail offers the following revisions to its "Modeling Protocol for a BART Assessment of the Big Stone I Coal-Fired Power Plant, Big Stone City, South Dakota June 2009", which Penny Shamblin submitted to you electronically on July 1, 2009 (copy attached).

During the July 22, 2009 call, EPA and the Federal Land Managers requested that Big Stone provide a detailed justification for using our proposed 4 km MM5 grid and a 4 km CALMET grid. While it is our opinion that our proposal could be justified, we are concerned that the demonstration could evolve into a research project that would not be satisfactorily resolved with all parties in a timeframe necessary to complete the modeling. Consequently, Otter Tail proposes to use a 12 km MM5 grid and a 4 km CALMET grid rather than the 4 km MM5 grid and the 4 km CALMET grid. Our proposal is consistent with those modeling proposals adopted by Wyoming, North Dakota, VISTAS and WRAP. The 2-km simulation as described in section 4.2 page 4-2 will be eliminated from the Big Stone modeling protocol. Consistent with Section 3.4 page 3-10, we may however perform additional supplemental modeling using full ammonia limiting calculations using the POSTUTIL option MNITRATE=2. The results from both the approved modeling protocol and the supplemental modeling simulations will be presented.

The proposed CALMET and CALPUFF switch settings are attached. Otter Tail has accepted the EPA-FLM Recommended CALMET Input File Values dated August 20, 2009. The proposed CALPUFF Inputs are those that we had initially proposed to you on August 19, 2009.

We look forward to moving forward with the modeling on an expedited schedule. Thank you for your review and approval of these revisions.

Regards,

Terry

Terry Graumann

Terry Graumann
Manager, Environmental Services
Otter Tail Power Company
P.O. Box 496
215 S. Cascade
Fergus Falls, MN 56538-0496
Telephone: 218-739-8407 Fax: 218-739-8629
E-Mail: tgraumann@otpco.com

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

AUG 31 2009

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Clarification on EPA-FLM Recommended Settings for CALMET

TO: Regional Modeling Contacts

FROM: Tyler J Fox, Group Leader
Air Quality Modeling Group, C439-01

The purpose of this memorandum is to update the draft recommendations for CALMET settings that were provided previously with the draft *Reassessment of the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report: Revisions to Phase 2 Recommendations* (EPA, 2009).

On May 15, 2009, the EPA Model Clearinghouse issued a memorandum addressing a number of issues related to the operation of the CALMET diagnostic meteorological model in regulatory modeling applications for long-range transport (LRT). Additionally, a draft version of revisions to the existing IWAQM Phase 2 guidance was released on May 27, 2009 to provide technical context for the Clearinghouse memorandum. This draft document outlined a series of recommendations for CALMET settings that were intended to facilitate the direct "pass-through" of prognostic meteorological data to the CALPUFF modeling system using the same horizontal and vertical grid structure of the parent prognostic data set. This purpose is consistent with one of our overarching goals expressed at the 8th Conference on Air Quality Modeling promoting the use of prognostic meteorological model products in regulatory dispersion modeling applications.

Due to the time sensitive nature of the Clearinghouse memorandum, it was not possible to complete extensive testing of the recommended CALMET operational settings prior to release of the memorandum and draft IWAQM reassessment report. Subsequent testing of the CALMET model with the proposed settings against mesoscale tracer databases indicates that CALMET/CALPUFF performance using the draft recommendations deteriorates somewhat in comparison to other MM5/CALMET horizontal grid configurations that were tested. Specifically, testing against the Cross-Appalachian Tracer Experiment (CAPTEX) mesoscale tracer study dataset showed that when MM5 and CALMET were run on the same horizontal grid resolution, performance was poorer than other MM5/CALMET grid configurations tested. While the performance deterioration was not drastic, it was significant. These results have caused us to reconsider our interim guidance because it is inconsistent with our desire to promote the use of both the best meteorological products and prognostic data in general. The use of

CALMET as a vehicle to "pass-through" MM5 or other numerical weather prediction (NWP) model data is no longer considered viable.

The EPA has dedicated considerable time and resources to the evaluation of the use of NWP data in conjunction with the CALMET/CALPUFF modeling system. As discussed in the draft IWAQM reassessment report, there are technical limitations to the applicability of diagnostic wind field models that together with advances in NWP model technology and resolution make the fuller use of NWP model data an attractive alternative. The draft IWAQM reassessment document also discusses EPA's intention to transition to the full use of NWP model data rather than continue reliance upon wind fields from DWMs for LRT applications. Therefore, rather than continue to dedicate time and resources to evaluating configurations for CALMET that would facilitate a direct "pass-through" of NWP data, EPA will focus its efforts toward expediting the testing and review of its MM5/WRF-to-CALPUFF software prototype discussed at the 9th Conference on Air Quality Modeling in anticipation of an early 2010 release.

In the interim, a revised series of recommendations for CALMET settings were agreed upon during a recent meeting with modelers from EPA and the Federal Land Manager (FLM) community. Therefore, as discussed during the EPA modelers' conference call on August 19th, the EPA Model Clearinghouse is providing all of the Regional Modeling Contacts with the attached revised list of recommended switch settings for CALMET. These recommendations are based in large part upon the understanding we have developed from the numerous tracer evaluations we have conducted in addition to the collective experience of the National Park Service, Forest Service, and US Fish and Wildlife from the BART process. In general the recommendations are based upon values from the VISTAS BART modeling protocol with limited modifications based on our internal testing.

As attached, these updated recommendations supersede the recommendations from the draft IWAQM reassessment report. While the draft IWAQM recommendations intended to configure CALMET to facilitate a direct "pass-through" of MM5 data are no longer considered viable, our position regarding grid resolution presented in the May 15, 2009, Model Clearinghouse memorandum have not changed. In particular, we wish to call to your attention that in most circumstances it is considered inappropriate to consider CALMET horizontal grid resolutions of less than four (4) kilometers, consistent with our discussion in the May 15, 2009 Model Clearinghouse memorandum. It is anticipated that the FLMs will likewise require adherence to these recommendations for modeling conducted pursuant to the Class I AQRV requirements of the PSD program. In those cases, it is important to remember that the FLMs have the affirmative responsibility for AQRV related studies, and usually take the lead in negotiating the protocol for model settings (per Section 6.2.3 of the *Guideline on Air Quality Models*, Appendix W to 40 CFR Part 51).

REFERENCES

USEPA, 2009: Reassessment of the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report: Revisions to Phase 2 Recommendations (Draft). EPA- EPA-454/B-09-XXX, Research Triangle Park, NC, 56 pp.

cc: Richard Wayland
Bill Harnett
Raj Rao
Dan Deroeck
Roger Brode
Bret Anderson
John Vimont
Tim Allen
John Notar
Rick Graw

EPA-FLM Recommended CALMET Input File Values

August 28, 2009

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
0 - Input and output file names	a	GEODAT	Input filename of geophysical data	GEO.DAT	User defined
		SRFDAT	Input filename of hourly meteorological data	SURF.DAT	User defined
		CLDDAT	Input filename of gridded cloud data	CLOUD.DAT	
		PRCDAT	Input filename of hourly precipitation data	PRECIP.DAT	User defined
		WTDAT	Input filename of gridded fields of terrain weighting factors	WT.DAT	
		METLST	Output filename of list file	CALMET.LST	User defined
		METDAT	Output filename of generated gridded met fields	CALMET.DAT	User defined
		PACDAT	Output filename of generated gridded met files (MESEOPUFF II)	PACOUT.DAT	
		LCFILES	Convert names to upper or lower case	User defined	T
		NUSTA	Number of upper air stations	User defined	User defined (>0)
		NOWSTA	Number of over water met stations	User defined	User defined
		NM3D	Number of MM4/MM5/3D.DAT files	User defined	User defined (>0)
		NIGF	Number of coarse grid CALMET fields as initial guess fields	User defined	0
	b	UPDAT	Input filenames of upper air data	UPn.DAT (n=1,2,3...)	User defined
	c	SEADAT	Input filename of over water stations	SEAn.DAT (n=1,2,3,..)	User defined
	d	M3DDAT	Input filename of MM4/MM5/3D.DAT	MM50n.DAT	User defined
	e	IGFDAT	Input filename of IGF-CALMET files	IGFn.DAT (n=1,2,3...)	
	f	DIADAT	Input filename of preprocessed sfc/UA data	DIAG.DAT	
		PRGDAT	Input filename of prognostic gridded wind fields	PROG.DAT	
		TSTPRT	Output filename of intermediate winds, and misc...etc	TEST.PRT	

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		TSTOUT	Output filename of final wind fields	TEST.OUT	
		TSTKIN	Output filename of wind fields after kinematic winds	TEST.KIN	
		TSTFRD	Output filename of winds after Froude Number effects	TEST.FRD	
		TSTSLP	Output filename winds after slope effects	TEST.SLP	
		DCSTGD	Output filename of distance land internal variables	DCST.GRD	
1 - General run and control parameters		IBYR	Beginning year	User defined	User defined
		IBMO	Beginning month	User defined	User defined
		IBDY	Beginning day	User defined	User defined
		IBHR	Beginning hour	User defined	User defined
		IBTZ	Base time zone	User defined	User defined
		IRLG	Length of run (hours)	User defined	User defined
		IRTYPE	Output type to create	1	1
		LCALGRD	Require fields for CALGRID	T	T
		ITEST	Flag to stop run after setup phase	2	2
		MREG	Conformity to regulatory values	User defined	1
2 - Map projection and grid control parameters		PMAP	Map projection	UTM	LCC
		FEAST	False Easting at projection origin (km)	0.0	0.0
		FNORTH	False northing at projection origin (km)	0.0	0.0
		IUTMZN	UTM zone	User defined	-999
		UTMHEM	Hemisphere of UTM projection	N	N
		RLAT0	Latitude of projection origin (decimal degrees - N)	User defined	User defined
		RLON0	Longitude of projection origin (decimal degrees - W)	User defined	User defined
		XLAT1	Matching latitude for projection (decimal degrees - N)	User defined	User defined

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		XLAT2	Matching latitude of projection (decimal degrees - N)	User defined	User defined
		Datum	Datum-region of output coordinates	WGS-84	User defined
		NX	Number of east to west or X grid cells	User defined	User defined
		NY	Number of north to south or Y grid cells	User defined	User defined
		DGRIDKM	Grid spacing in kilometers (km)	User defined	User defined (≥4km)
		XORIGKM	Southwest corner of grid cell (1,1), X-coordinate (km)	User defined	User defined
		YORIGKM	Southwest corner of grid cell (1,1), Y-coordinate (km)	User defined	User defined
		NZ	Number of vertical layers	User defined	10
		ZFACE	Cell face heights in arbitrary vertical grid (ZFACE (NZ+1)) (m)	User defined	0,20,40,80,160,320,640,1200,2000,3000,4000
3 - Output options		LSAVE	Save met fields in unformatted file	T	T
		IFORMO	Type of unformatted output file	1	1
		LPRINT	Print met fields	F	F
		IPRINF	Print interval in hours	1	1
		IUVOUT	Layers of U, V wind components to print (IUVOUT (NZ))	NZ*0	10*0
		IWOUT	Levels of W wind component to print (IWOUT (NZ))	NZ*0	10*0
		ITOUT	Levels of 3-D temps to print (ITOUT (NZ))	NZ*0	10*0
		STABILITY	Print PGT Stability	0	0
		USTAR	Print friction velocity	0	0
		MONIN	Print Monin-Obukhov	0	0
		MIXHT	Print mixing height	0	0
		WSTAR	Print convective velocity scale	0	0
		PRECIP	Print precipitation rate	0	0

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		SENSHEAT	Print sensible heat flux	0	0
		CONVZI	Print convective mixing height (Zic)	0	0
		LDB	Print met data and internal variables)	F	F
		NN1	Test and debug print options: first time step	1	1
		NN2	Test and debug print options: last time step	1	1
		LDBCST	Test and debug print options: distance to land internal variables	F	F
		IOUTD	Test and debug print options: control variables for writing winds	0	0
		NZPRN2	Test and debug print options: number of levels starting at sfc	1	0
		IPR0	Test and debug print options: interpolated winds	0	0
		IPR1	Test and debug print options: terrain adjusted surface wind	0	0
		IPR2	Test and debug print options: smoothed wind and diverge fields	0	0
		IPR3	Test and debug print options: final wind speed and direction	0	0
		IPR4	Test and debug print options: final divergence	0	0
		IPR5	Test and debug print options: winds after Kinematic effects	0	0
		IPR6	Test and debug print options: winds after Froude No. adjustment	0	0
		IPR7	Test and debug print options: winds after slope flow	0	0
		IPR8	Test and debug print options: final winds	0	0
4 - Meteorological data options		NOOBS	No observation mode	0	0
		NSSTA	Number of surface stations	User defined	User defined (>0)
		NPSTA	Number of precipitation stations	User defined	User defined (>0)
		ICLOUD	Gridded cloud fields	0	0
		IFORMS	Surface met data file format	2	2
		IFORMP	Precipitation data file format	2	2

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		IFORMC	Cloud data format	2	2
5 - Wind field options and parameters		IWFCOD	Wind model options	1	1
		IFRADJ	Compute Froude number adjustment effects	1	1
		IKINE	Compute Kinematic effects	0	0
		IOBR	Use O'Brien procedures for adjust vertical velocity	0	0
		ISLOPE	Compute slope effects	1	1
		IEXTRP	Extrapolate sfc wind obs to upper levels	-4	-4
		ICALM	Extrapolate sfc winds even if calm	0	0
		BIAS	Surface/upper weighting factors (BIAS (NZ))	NZ*0	10*0
		RMIN2	Minimum distance for extrapolation of winds	4	-1
		IPROG	Use prognostic model winds as input to diagnostic wind model	0	14
		ISTEPPG	Timestep (hours) of prognostic model data	1	1
		IGFMET	Use coarse CALMET fields as initial guess	0	0
		LVARY	Use varying radius of influence	F	F
		RMAX1	Maximum radius of influence in surface layer (km)	User defined	100
		RAMX2	Maximum radius of influence over land aloft (km)	User defined	200
		RMAX3	Maximum radius of influence over water (km)	User defined	200
		RMIN	Minimum radius of influence in wind field interpolation (km)	0.1	0.1
		TERRAD	Radius of influence of terrain features (km)	User defined	15
		R1	Relative weight at surface of 1st guess fields and obs (km)	User defined	50
		R2	Relative weight aloft of 1st guess fields and obs (km)	User defined	100
		RPROG	Weighting factors of prognostic wind field data (km)	User defined	0
		DIVLIM	Maximum acceptable divergence	5.0E-06	5.0E-06

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		NITER	Maximum number of iterations in divergence minimum	50	50
		NSMTH	Number of passes in smoothing (NSMITH (NZ))	2, (nxnz-1)*4	2, 9*4
		NINTR2	Maximum number of stations for interpolation (NINTR2(NZ))	99	10*99
		CRITFN	Critical Froude Number	1	1
		ALPHA	Empirical factor controlling influence of kinematic effects	0.1	0.1
		FEXTR2	Multiplicative scaling factor for extrap of sfc obs to upper layers (FEXTRS(NX))	NZ*0.0	10*0
		NBAR	Number of barriers to interpolation of wind fields	0	0
		KBAR	Level (1 to NZ) up to which barriers apply	NZ	10
		XBBAR (NBAR>0)	X coordinate of beginning of each barrier (km)	User defined	0
		YBBAR (NBAR>0)	Y coordinate of beginning of each barrier (km)	User defined	0
		XEBAR (NBAR>0)	X coordinate of ending of each barrier (km)	User defined	0
		YEBAR (NBAR>0)	Y coordinate of ending of each barrier (km)	User defined	0
		IDIOPT1	Compute surface temperature	0	0
		ISURFT [b]	Sfc met station to use for sfc temp	User defined	User defined
		IDIOPT2	Domain-averaged temp lapse rate	0	0
		IUPT (IDIOPT2=0) [b]	UA station to use for the domain-scale lapse rate	User defined	User defined
		ZUPT (IDIOPT2=0)	Depth through which domain-scale lapse rate is computed (m)	200	200
		IDIOPT3	Domain-averaged wind component	0	0
		IUPWIND (IDIOPT3=0)	UA station to use for domain-scale winds	-1	-1
		ZUPWIND (IDIOPT3=0)	Bottom and top of layer thru which domain winds computed (m)	1., 1000	1., 1000
		IDIOPT4	Read observed surface wind components	0	0
		IDIOPT5	Read observed upper wind components	0	0

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		LLBREZE	Use lake breeze module	F	F
		NBOX	Number of lake breeze regions	User defined	0
		XG1	X grid line 1 defining the region of interest	User defined	0
		XG2	X grid line 2 defining the region of interest	User defined	0
		YG1	Y grid line 1 defining the region of interest	User defined	0
		YG2	Y grid line 2 defining the region of interest	User defined	0
		XBCST	X point defining the coastline (km)	User defined	0
		YBCST	Y point defining the coastline (km)	User defined	0
		XECST	X point defining the coastline (km)	User defined	0
		YECST	Y point defining the coastline (km)	User defined	0
		NLB	Number of stations in the region (sfc + upper air)	User defined	0
		METBXID	Station ID's in the region (METBXID (NLB))	User defined	0
6 - Mixing height, temperature and precipitation parameters		CONSTB	Mix ht constant: neutral, mechanical equation	1.41	1.41
		CONSTE	Mix ht constant: convective equation	0.15	0.15
		CONSTN	Mix ht constant: stable equation	2400	2400
		CONSTW	Mix ht equation: over water	0.16	0.16
		FCORIOL	Absolute value of Coriolis parameter	1.0E-04	1.0E-04
		IAVEZI	Spatial averaging of Mix ht: conduct spatial averaging	1	1
		MNMDAV	Spatial averaging of Mix ht: Max search radius (# of grid cells)	1	1
		HAFANG	Spatial avg'n of Mix ht: 0.5-angle of upwind cone for avg (deg)	30	30
		ILEVZI	Spatial averaging of Mix ht: Layer of winds used in upwind	1	1
		IMIXH	Zic Mix Ht Options: Method to compute Mix ht	1	-1

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		THRESHL	Zic Mix Ht Options: Threshold buoyancy flux reqrd to sustain over land (W/m3)	0.05	0.0
		THRESHW	Zic Mix Ht Options: Threshold buoyancy flux reqrd sustain over water (W/m3)	0.05	0.05
		ITWPROG	Zic Mix Ht Options: Overwater lapse rates used in Zic growth	0	0
		ILUOC3D	Zic Mix Ht Options: Land use category in 3D.DAT	16	16
		DPTMIN	Min potential Temp lapse rate in stable layer above Zic (deg-K/m)	0.001	0.001
		DZZI	Depth of computing capping lapse rate (m)	200	200
		ZIMIN	Minimum over land mixing height (m)	50	50
		ZIMAX	Maximum over land mixing height (m)	3000	3000
		ZIMINW	Minimum over water mixing height (m)	50	50
		ZIMAXW	Maximum over water mixing height (m)	3000	3000
		ICOARE	Over water surface fluxes methods and parameters	10	0
		DSELF	Coastal/shallow water length scale (km)	0	0
		IWARM	COARE warm layer computation	0	0
		ICOOL	COARE cool skin layer computation	0	0
		ITPROG	3D temp from obs or from prognostic data	0	0
		IRAD	Temp interpolation type	1	1
		TRADKM	Radius of influence of temp interpolation (km)	500	500
		NUMTS	Max number of stations to include in interpolation	5	5
		IAVET	Conduct spatial averaging of temp	1	1
		TGDEFB	Default temp gradient below mix ht over water (deg-K/m)	-0.0098	-0.0098
		TGDEFA	Default temp gradient above mix ht over water (deg-K/m)	-0.0045	-0.0045

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		JWAT1	Beginning land use categories for temp interpolation over water	User defined - 999	55
		JWAT2	Ending land use categories for temp interpolation over water	User defined - 999	55
		NFLAGP	Method of precipitation interpolation	2	2
		SIGMAP	Radius of influence for precipitation (km)	100	100
		CUTP	Minimum precipitation rate cutoff (mm/hr)	0.01	.01
7 -Surface meteorological station parameters		CSNAM	Station name	User defined	User defined
		IDSSTA	Station identification number	User defined	User defined
		XSSTA	X-coordinate (km)	User defined	User defined
		YSSTA	Y-coordinate (km)	User defined	User defined
		XSTZ	Time zone	User defined	User defined
		ZANEM	Anemometer height (m)	User defined	User defined
8- Upper air meteorolo-gcal station parameters		CUNAM	Station name	User defined	
		IDUSTA	Station identification number	User defined	
		XUSTA	X-coordinate (km)	User defined	
		YUSTA	Y-coordinate (km)	User defined	
		UUTZ	Time zone	User defined	
9 - Precipitation station parameters		CPNAM	Station name	User defined	User defined
		IDPSTA	Station identification number	User defined	User defined
		XPSTA	X-coordinate (km)	User defined	User defined
		YPSTA	Y-coordinate (km)	User defined	User defined

CALMET Inputs

Variable	Description	EPA Default	WRAP Values	IWAQM 09	Big Stone	Notes
GEO.DAT	Name of Geophysical data file	GEO.DAT	GEO.DAT		GEO.DAT	WRAP
SURF.DAT	Name of Surface data file	SURF.DAT	SURF.DAT		SURF.DAT	WRAP
PRECIP.DAT	Name of Precipitation data file	PRECIP.DAT	PRECIP.DAT		PRECIP.DAT	WRAP
NUSTA	Number of upper air data sites	User Defined	0		0	WRAP
UPN.DAT	Names of NUSTA upper air data files	UPN.DAT	NA		NA	WRAP
IBYR	Beginning year	User Defines	User Defines		User Defines	Based on 12 Km MM5 data availability
IBMO	Beginning month	User Defines	User Defines		User Defines	
IBDY	Beginning day	User Defines	User Defines		User Defines	
IBHR	Beginning hour	User Defines	User Defines		User Defines	
IBTZ	Base time zone	User Defines	User Defines		User Defines	
IRLG	Number of hours to simulate	User Defines	User Defines		User Defines	
IRTYPE	Output file type to create (must be 1 for CALPUFF)	1	1		1	WRAP
LCALGRD	Are w-components and temperature needed?	T	T		T	WRAP
NX	Number of east-west grid cells	User Defines	Table 3-1		313	Domain specific based on MM5 grid spacing resolution
NY	Number of north-south grid cells	User Defines	Table 3-1		181	Domain specific based on MM5 grid spacing resolution
DGRIDKM	Grid spacing	User Defines	4		4	WRAP
XORIGKM	Southwest grid cell X coordinate	User Defines	Table 3-1		-506	Domain specific based on MM5 data
YORIGKM	Southwest grid cell Y coordinate	User Defines	Table 3-1		298	Domain specific based on MM5 data
XLATO	Southwest grid cell latitude	User Defines	Table 3-1		User Defines	Domain specific based on MM5 data
YLONO	Southwest grid cell longitude	User Defines	Table 3-1		User Defines	Domain specific based on MM5 data
IUTMZN	UTM Zone	User Defines	NA		NA	WRAP
LLCONF	When using Lambert Conformal map coordinates, rotate winds from true north to map north?	F	F		F	WRAP
XLAT1	Latitude of 1st standard parallel	30	33		33	WRAP
XLAT2	Latitude of 2nd standard parallel	60	45		45	WRAP
RLON0	Longitude used if LLCONF = T	90	97		97	WRAP
RLAT0	Latitude used if LLCONF = T	40	40		40	WRAP
NZ	Number of vertical Layers	User Defines	11	~24	~24	IWAQM 09
ZFACE	Vertical cell face heights (NZ+1 values)	User Defines	0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, and 5000		0, 20, 46, 72, 104, 136, 178, 220, 272, 326, 394, 460, 548, 636, 746, 860, 1002, 1152, 1336, 1534, 1774, 2040, 2358, 2720, 3154, 3656	IWAQM, based on MM5 levels
LSAVE	Save met. Data fields in an unformatted file?	T	T		T	WRAP
IFORMO	Format of unformatted file (1 for CALPUFF)	1	1		1	WRAP
NSSTA	Number of stations in SURF.DAT file	User Defines	Domain dependent, see Figure 3-1 for locations		2002 - 204 2006 - 250 2007 - 250	Domain specific
NPSTA	Number of stations in PRECIP.DAT	User Defines	Domain dependent, see Figure 3-1 for locations		2002 - 263 2006 - 267 2007 - 267	Domain specific
ICLOUD	Is cloud data to be input as gridded fields? 0=No)	0	0		0	WRAP
IFORMS	Format of surface data (2 = formatted)	2	2		2	WRAP
IFORMP	Format of precipitation data (2= formatted)	2	2		2	WRAP
IFORMC	Format of cloud data (2= formatted)	2	2		2	WRAP
IWFCOD	Generate winds by diagnostic wind module? (1 = Yes)	1	1	1	1	WRAP
IFRADJ	Adjust winds using Froude number effects? (1= Yes)	1	1	0	1	WRAP, VISTAS, Montaha, North Dakota
IKINE	Adjust winds using Kinematic effects? (1 = Yes)	0	0	0	0	WRAP
IOBR	Use O'Brien procedure for vertical winds? (0 = No)	0	0	0	0	WRAP

Variable	Description	EPA Default	WRAP Values	IWAQM 09	Big Stone	Notes
ISLOPE	Compute slope flows? (1 = Yes)	1	1	0	1	WRAP, VISTAS, Montana, North Dakota
IEXTRP	Extrapolate surface winds to upper layers? (-4 = use similarity theory and ignore layer 1 of upper air station data)	-4	1	1	-4	VISTAS, Montana
ICALM	Extrapolate surface calms to upper layers? (0 = No)	0	0	0	0	WRAP
BIAS	Surface/upper-air weighting factors (NZ values)	NZ*0	NZ*0		NZ*0	WRAP
IPROG	Using prognostic or MM-FDDA data? (0 = No)	0	14	14	14	WRAP
LVARY	Use varying radius to develop surface winds?	F	F		F	WRAP
RMAX1	Max surface over-land extrapolation radius (km)	User Defines	50	0.001	25	Domain specific based on MM5 grid spacing resolution
RMAX2	Max aloft over-land extrapolations radius (km)	User Defines	100	0.001	50	Domain specific based on MM5 grid spacing resolution
RMAX3	Maximum over-water extrapolation radius (km)	User Defines	100	0.001	100	WRAP
RMIN	Minimum extrapolation radius (km)	0.1	0.1		0.1	WRAP
RMIN2	Distance (km) around an upper air site where vertical extrapolation is excluded (Set to – 1 if IEXTRP = ±4)	4	4		NA	Not relevant if not using upper air stations
TERRAD	Radius of influence of terrain features (km)	User Defines	10		10	WRAP
R1	Relative weight at surface of Step 1 field and obs	User Defines	100	0.001	12.5	R1 half of RMAX1 consistent with Montana
R2	Relative weight aloft of Step 1 field and obs	User Defines	200	0.001	25	R2 half of RMAX2 consistent with Montana
DIVLIM	Maximum acceptable divergence	5.00E-06	5.00E-06		5.00E-06	WRAP
NITER	Max number of passes in divergence minimization	50	50		50	WRAP
NSMTH	Number of passes in smoothing (NZ values)	2,4*(NZ-1)	2,4*(NZ-1)		2,4*(NZ-1)	WRAP
NINTR2	Max number of stations for interpolations (NA values)	99	99		99	WRAP
CRITFN	Critical Froude number	1	1		1	WRAP
ALPHA	Empirical factor triggering kinematic effects	0.1	0.1		0.1	WRAP
IDIOPT1	Compute temperatures from observations (0 = True)	0	0		0	WRAP
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	User Defines	1		211	most representative
IDIOPT2	Compute domain-average lapse rates? (0 = True)	0	0		0	WRAP
IUPT	Station for lapse rates (between 1 and NUSTA)	User Defines	1		NA	Not relevant if not using upper air stations
ZUPT	Depth of domain-average lapse rate (m)	200	200		200	WRAP
IDIOPT3	Compute internally initial guess winds? (0 = True)	0	0		0	WRAP
IUPWND	Upper air station for domain winds (-1 = 1/r**2 interpolation of all stations)	-1	-1		-1	WRAP
ZUPWND	Bottom and top of layer for 1st guess winds (m)	1., 1000.	1., 1000.		1., 1000.	WRAP
IDIOPT4	Read surface winds from SURF.DAT? (0 = True)	0	0		0	WRAP
IDIOPT5	Read aloft winds from UPn.DAT? (0 = True)	0	0		0	WRAP
CONSTB	Neutral mixing height B constant	1.41	1.41		1.41	WRAP
CONSTE	Convective mixing height E constant	0.15	0.15		0.15	WRAP
CONSTN	Stable mixing height N constant	2400	2400		2400	WRAP
CONSTW	Over-water mixing height W constant	0.16	0.16		0.16	WRAP
FCORIOL	Absolute value of Carioles parameter	1.00E-04	1.00E-04		1.00E-04	WRAP
IAVEZI	Spatial averaging of mixing heights? (1 = True)	1	1		1	WRAP
MNMDAV	Max averaging radius (number of grid cells)	1	1		1	WRAP
HAFANG	Half-angle for looking upwind (degrees)	30	30		30	WRAP
ILEVZI	Layer to use in upwind averaging (between 1 and NZ)	1	1		1	WRAP
DPTMIN	Minimum capping potential temperature lapse rate	0.001	0.001		0.001	WRAP
DZZI	Depth for computing capping lapse rate (m)	200	200		200	WRAP
ZIMIN	Minimum over-land mixing height (m)	50	50		50	WRAP

Variable	Description	EPA Default	WRAP Values	IWAQM 09	Big Stone	Notes
ZIMAX	Maximum over-land mixing height (m)	3000	4500		4500	WRAP
ZIMINW	Minimum over-water mixing height (m)	50	50		50	
ZIMAXW	Maximum over-water mixing height (m)	3000	4500		4500	WRAP
IRAD	Form of temperature interpolation (1 = 1/r)	1	1		1	WRAP
TRADKM	Radius of temperature interpolation (km)	500	500		500	WRAP
NUMTS	Max number of stations in temperature interpolations	5	5		5	WRAP
IAVET	Conduct spatial averaging of temperature? (1 = True)	1	0		0	WRAP
TGDEFB	Default over-water mixed layer lapse rate (K/m)	-0.0098	-0.0098		-0.0098	WRAP
TGDEFA	Default over-water capping lapse rate (K/m)	-0.0045	-0.0045		-0.0045	WRAP
JWAT1	Beginning landuse type defining	999	51		51	WRAP
JWAT2	Ending landuse type defining water	999	55		55	WRAP
NFLAGP	Method for precipitation interpolation (2= 1/r**2)	2	2		2	WRAP
SIGMAP	Precip radius for interpolations (km)	100	100		100	WRAP
CUTP	Minimum cut off precip rate (mm/hr)	0.01	0.01		0.01	WRAP
SSn	NSSTA input records for surface stations	User Defines	Figure 3-1		2002 - 204 2006 - 250 2007 - 250	Specific to meteorology year modeled
Usn	NUSTA input records for upper-air stations	User Defines	NA		NA	WRAP
PSn	NPSTA input records for precipitations stations	User Defines	Figure 3-1		2002 - 263 2006 - 267 2007 - 267	Specific to meteorology year modeled
NOOBS		0	1	0	1	WRAP
ITWPROG	Option for overwater lapse rates used in convective mixing height growth	0			2	Addresses lack of bouy data over water
ITPROG	3D temperature from observations or from prognostic data?	0			2	Maximizes use of MM5 data

CALPUFF Inputs

Variable	Description	EPA Default	WRAP Values	IWAQM 09	Big Stone	Notes
METDAT	CALMET input data filename	CALMET.DAT	CALMET.DAT		CALMET.DAT	WRAP
PUFLST	Filename for general output from CALPUFF	CALPUFF.LST	CALPUFF.LST		CALPUFF.LST	WRAP
CONDAT	Filename for output concentration data	CONC.DAT	CONC.DAT		CONC.DAT	WRAP
DFDAT	Filename for output dry deposition fluxes	DFLX.DAT	DFLX.DAT		DFLX.DAT	WRAP
WFDAT	Filename for output wet deposition fluxes	WFLX.DAT	WFLX.DAT		WFLX.DAT	WRAP
VISDAT	Filename for output relative humidities (for visibility)	VISB.DAT	VISB.DAT		VISB.DAT	WRAP
METRUN	Do we run all periods (1) or a subset (0)?	0	0		0	WRAP
IBYR	Beginning year	User Defined	User Defined		User Defined	Based on 12 km MM5 data availability
IBMO	Beginning month	User Defined	User Defined		User Defined	
IBDY	Beginning day	User Defined	User Defined		User Defined	
IBHR	Beginning hour	User Defined	User Defined		User Defined	
IRLG	Length of runs (hours)	User Defined	User Defined		User Defined	
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5	5-9		11	Following FLM guidance on particle speciation and size to address comments
NSE	Number of species emitted	3	2-9		9	WRAP
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	0	2 or 3		2 or 3	WRAP
METFM	Format of input meteorology (1 = CALMET)	1	1		1	WRAP
AVET	Averaging time lateral dispersion parameters (minutes)	60	60		60	WRAP
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1	1		1	WRAP
MCTADJ	Terrain adjustments to plume path (3 = Plume	3	3		3	WRAP
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	0	0		0	WRAP
MSLUG	Near-field puff treatment (0 = No slugs)	0	0		0	WRAP
MTRANS	Model transitional plume rise? (1 = Yes)	1	1		1	WRAP
MTIP	Treat stack tip downwash? (1 = Yes)	1	1		1	WRAP
MSHEAR	Treat vertical wind shear? (0 = No)	0	0		0	WRAP
MSPLIT	Allow puffs to split? (0 = No)	0	0		1	EPA Region 8 recommendation; necessary due to distance from source to Class I areas
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1	1		1	WRAP
MWET	Model wet deposition? (1 = Yes)	1	1		1	WRAP
MDRY	Model dry deposition? (1 = Yes)	1	1		1	WRAP

Variable	Description	EPA Default	WRAP Values	IWAQM 09	Big Stone	Notes
MDISP	Method for dispersion coefficients (3 = PG & M	3	3		3	WRAP
MTURBVW	Turbulence characterization? (Only if MDISP =	3	3		3	WRAP
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3	3		3	WRAP
MROUGH	Adjust PG for surface roughness? (0 = No)	0	0		0	WRAP
MPARTL	Model partial plume penetration? (0 = No)	1	1		1	WRAP
MTINV	Elevated inversion strength (0 = compute from	0	0		0	WRAP
MPDF	Use PDF for convective dispersion? (0 = No)	0	0		0	WRAP
MSGTIBL	Use TIBL module? (0 = No) allows treatment c	0	0		0	WRAP
MREG	Regulatory default checks? (1 = Yes)	1	1		1	WRAP
CSPECn	Names of species modeled (for MESOPUFF II, must be SO2, SO4, NOx, HN03, NO3)	User Defined	5		11	
Species Names	Species that will be modeled	User Defined	SO2, SO4, NOX, NO3, HNO3, PM25 (depends on emissions data provide by States)		SO2, SO4, NOX, NO3, HNO3, PM800, PM425, PM187, PM112, PM081, PM056	Following FLM guidance on particle speciation and size to address comments
Specie Groups	Grouping of species, if any.	User Defined			NA	No grouping
NX	Number of east-west grids of input meteorolog	User Defined	Table 3-1		313	Domain specific
NY	Number of north-south grids of input meteorolo	User Defined	Table 3-1		181	Domain specific
NZ	Number of vertical layers of input meteorology	User Defined	11	24	24	IWAQM 09
DGRIDKM	Meteorology grid spacing (km)	User Defined	4		4	WRAP
ZFACE	Vertical cell face heights of input meteorology	User Defined	Table 3-2		User Defined	Domain specific
XORIGKM	Southwest corner (east-west) of input meteoro	User Defined	Table 3-1		User Defined	Domain specific
YORIGIM	Southwest corner (north-south) of input meteo	User Defined	Table 3-1		User Defined	Domain specific
IUTMZN	UTM zone	User Defined	NA		User Defined	Domain specific
XLAT	Latitude of center of meteorology domain	User Defined	Table 3-1		User Defined	Domain specific
XLONG	Longitude of center of meteorology domain	User Defined	Table 3-1		User Defined	Domain specific
XBTZ	Base time zone of input meteorology	User Defined	MST		User Defined	Domain specific
IBCOMP	Southwest of Xindex of computational domain	User Defined	Table 3-1		User Defined	Domain specific
JBCOMP	Southwest of Y-index of computational domain	User Defined	Table 3-1		User Defined	Domain specific
IECOMP	Northeast of Xindex of computational domain	User Defined	Table 3-1		User Defined	Domain specific
JECOMP	Northeast of Y- index of computational domain	User Defined	Table 3-1		User Defined	Domain specific
LSAMP	Use gridded receptors (T -= Yes)	F	F		F	WRAP
IBSAMP	Southwest of Xindex of receptor grid	User Defined	NA		User Defined	Domain specific
JBSAMP	Southwest of Y-index of receptor grid	User Defined	NA		User Defined	Domain specific
IESAMP	Northeast of Xindex of receptor grid	User Defined	NA		User Defined	Domain specific
JESAMP	Northeast of Y-index of receptor grid	User Defined	NA		User Defined	Domain specific
MESHDN	Gridded receptor spacing = DGRIDKM/MESHI	1	NA		NA	WRAP
ICON	Output concentrations? (1 = Yes)	1	1		1	WRAP
IDRY	Output dry deposition flux? (1 = Yes)	1	1		1	WRAP
IWET	Output wet deposition flux? (1 = Yes)	1	1		1	WRAP
IVIS	Output RH for visibility calculations (1 = Yes)	1	1		1	WRAP
LCOMPRS	Use compression option in output? (T = Yes)	T	T		T	WRAP
ICPRT	Print concentrations? (0 = No)	0	0		0	WRAP
IDPRT	Print dry deposition fluxes (0 = No)	0	0		0	WRAP
IWPRT	Print wet deposition fluxes (0 = No)	0	0		0	WRAP
ICFRQ	Concentration print interval (1 = hourly)	1	1		1	WRAP
IDFRQ	Dry deposition flux print interval (1 = hourly)	1	1		1	WRAP
IWFRQ	Wet deposition flux print interval (1 = hourly)	1	1		1	WRAP
IPRTU	Print output units (1 = g/m**3; g/m**2/s)	1	1		1	WRAP
IMESG	Status messages to screen? (1 = Yes)	1	1		1	WRAP
Output Specie	Where to output various species	User Defined	Default		Default	WRAP
LDEBUG	Turn on debug tracking? (F = No)	F	F		F	WRAP
Dry Gas Dep	Chemical parameters of gaseous deposition s	User Defined	Default		Default	WRAP
Dry Part. Dep	Chemical parameters of particulate deposition	User Defined	Default		Default	WRAP
RCUTR	Reference cuticle resistance (s/cm)	30	30		30	WRAP
RGR	Reference ground resistance (s/cm)	10	10		10	WRAP
REACTR	Reference reactivity	8	8		8	WRAP
NINT	Number of particle-size intervals	9	9		9	WRAP
IVEG	Vegetative state (1 = active and unstressed)	1	1		1	WRAP
Wet Dep	Wet deposition parameters	User Defined	TBD		Default	Default
MOZ	Ozone background? (1 = read from ozone.dat)	1	1		1	WRAP
BCKO3	Ozone default (ppb) (Use only for missing data	80	80		80	WRAP
BCKNH3	Ammonia background (ppb)	10	1		1	WRAP
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2	0.2		0.2	WRAP
RNITE2	Nighttime NOx loss rate (%/hr)	2	2		2	WRAP
RNITE3	Nighttime HNO3 loss rate (%/hr)	2	2		2	WRAP
SYTDEP	Horizontal size (m) to switch to time dependen	550	550		550	WRAP
MHFTSZ	Use Heffter for vertical dispersion? (0 = No)	0	0		0	WRAP
JSUP	PG Stability class above mixed layer	5	5		5	WRAP
CONK1	Stable dispersion constant (Eq. 2.7-3)	0.01	0.01		0.01	WRAP
CONK2	Neutral dispersion constant (Eq. 2.7-4)	0.1	0.1		0.1	WRAP
TBD	Transition for downwash algorithms (0.5 = ISC	0.5	0.5		0.5	WRAP
IURB1	Beginning urban landuse type	10	10		10	WRAP
IURB2	Ending urban landuse type	19	19		19	WRAP