AECOM Environment

Submitted to:
Montana-Dakota Utilities Co.
Bismarck, North Dakota

Submitted by:
AECOM
Westford, Massachusetts
60140139.0100
December 17, 2009

Updated BART CALPUFF Visibility Modeling Analysis for Montana-Dakota Utilities Heskett Station Unit 2

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Prepared By Mary M. Kaplan

Reviewed By Robert J. Paine

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1.0 Introduction

1.1 Background

The North Dakota Department of Health (NDDH) conducted CALPUFF modeling in 2005 for emission sources associated with all BART-eligible facilities in North Dakota. This study updates the CALPUFF modeling for one of these facilities, Heskett Unit 2, which is owned and operated by Montana-Dakota Utilities Co. (MDU). Heskett Unit 1, operational in 1954, has a capacity of 40 MW and is not BART-eligible since it was put into service before 1962. Unit 2, operational in 1963, has a capacity of 75 MW. Unit 2 was retrofitted to a fluidized-bed combustor in 1987, thus making it BART-eligible.

In 2006, MDU asked ENSR (now AECOM) to review the NDDH BART analysis for Heskett Unit 2 and to provide an analysis that considered updates to the November 2005 NDDH BART modeling protocol. The 2006 updates focused on the following three areas:

- US EPA had announced a court settlement regarding BART modeling that allowed each state to use the annual average background visibility instead of the best 20% days' background visibility for BART analyses. This development occurred because the actual BART rule (published in the Federal Register on July 6, 2005 at 70 Fed. Reg. 39104) stipulated that the annual average background visibility value should be used, while the preamble was inconsistent and mentioned that the 20% best days' background visibility should be used. As a result of the settlement, the NDDH adopted the annual average background visibility for the BART analysis.

- ENSR considered a more complete speciation of particulate emissions consistent with guidance provided by the National Park Service.

- ENSR adopted a 1-km CALPUFF grid spacing consistent with EPA guidance as provided in the CALPUFF FAQs regarding the resolution of terrain features with at least 5 grid elements. Support for use of 1-km grid spacing was provided to US EPA Region 8 and the Federal Land Managers in comments from AECOM dated August 12, 2009.

The results of the 2006 BART modeling analysis indicated that the 98th percentile daily regional haze impact of the peak baseline daily emissions from Heskett Unit 2 would not reach the NDDH-adopted contribution level of 0.5 delta-deciview. Therefore, Heskett Unit 2 was determined to be exempt from further BART review as NDDH confirmed in a May 8, 2007 letter to MDU.

The NDDH received EPA correspondence dated August 8, 2008 stating their concern in using a 1-km grid size and requesting a more robust discussion as to why the NDDH found the use of a 1-km grid size to be acceptable. Upon review of the EPA's comments, MDU requested AECOM develop responses to EPA's concerns. An AECOM response was filed with the NDDH on January 5, 2009.

On May 15, 2009, EPA issued a Clarification Memo on CALPUFF that challenged a BART exemption analysis for the Big Stone plant in South Dakota. The clarification recommended that the grid spacing to be used for CALMET/CALPUFF analyses should be no less than 4 km. MDU asked AECOM to update its January 5, 2009 document to take into account the issues raised in the EPA Clarification Memo. An updated AECOM response was provided to the NDDH on August 12, 2009 that included the rational for utilizing the 1-km grid size for Heskett Unit 2 in light of the May 15, 2009 EPA Clarification Memo. The

NDDH included the AECOM response as an attachment to the draft Regional Haze/BART SIP that was filed with the Federal Land Managers for review and comment in August 2009.

In a more recent Clarification Memo issued on August 31, 2009, EPA provided further guidance for running CALMET which was taken into account for recent modeling as described below.

In its recent review of the draft North Dakota Regional Haze Rule State Implementation Plan (SIP) (August 21, 2009), EPA Region 8 stated that any updates to the procedures stated in the November 2005 NDDH BART modeling protocol would need to adopt current CALPUFF modeling guidance, including the procedures discussed in the 2009 Clarification memos cited above.

This EPA position was further discussed in a conference call held among EPA, the Federal Land Managers, NDDH, and MDU with AECOM on November 17, 2009. On November 25, 2009, MDU provided NDDH a modeling protocol document to guide an update to BART CALPUFF modeling for Heskett Unit 2, consistent with both current EPA CALPUFF modeling guidance and directives provided by EPA during the November 17, 2009 conference call. The November 25, 2009 protocol was approved by the NDDH on December 1, 2009.

On December 10, 2009, EPA Region 8 also approved the November 25, 2009 protocol with the condition that one CALPUFF setting, CDIV, should be adjusted to (0.01, 0.01) instead of (0,0). While the CALPUFF model developer has advised AECOM that the setting of 0.01 is obsolete and it should be revised to be 0, the adjustment was made to demonstrate its effect upon the modeling results. To that end, the modeling results section of this report has been updated to provide predicted visibility impacts for both versions of the CALPUFF CDIV setting.

For this updated modeling analysis, AECOM conducted CALPUFF modeling in accordance with the approved protocol to assess the visibility impact of Heskett Unit 2 emissions with four general areas of change to the modeling approach specified in the November 2005 NDDH BART modeling protocol, as described in the next section.

1.2 Elements of the Refined Analysis

The updates from the November 2005 NDDH BART modeling protocol that AECOM implemented in the updated BART modeling analyses for Heskett Unit 2 are summarized below.

- In the CALMET modeling, we adopted the recent EPA recommendations by increasing the grid size from 3 km to 4 km, and set other CALMET technical options to those stated in recent EPA Clarification Memos. We set the extent of the modeling domain to 50 km outside the area denoted by the modeled source and the boundaries of the PSD Class I areas.
- For national consistency with other BART analyses, we continued to use guidance from the National Park Service on the speciation of particulate matter emissions into several components that have different light scattering potential: coarse matter, inorganic fine matter, elemental carbon, sulfuric acid mist, and organic aerosol fine particulate.
- As a result of the EPA settlement regarding the definition of the natural visibility background and the NDDH position on this issue, we used the annual average background visibility as input to CALPOST for determining the change in visibility caused by emissions from Heskett Unit 2.

- We used CALMET and CALPUFF versions 5.8, with all technical options as noted in the 2009 EPA Clarification Memos, as well as applicable guidance from the March 16, 2006 EPA memo from Dennis Atkinson regarding the preferred CALPUFF dispersion option. In addition (and to be consistent with the CALPOST methods used by NDDH in their Regional Haze Rule SIP modeling), we used the recommended new IMPROVE equation application, also known as Method 8, in the approved version of CALPOST (Version 6.221) for processing the visibility impacts at the North Dakota Class I areas. We used inputs to CALPOST as provided in the proposed FLAG 2008 guidelines.

These modeling procedures were first used in a reassessment of the visibility impact of the peak daily baseline emissions for the modeling period of 2000-2002 (using NDDH's RUC data). The results of this modeling analysis clarify whether Heskett Unit 2 is subject to BART.

The BART analysis modeling procedures are discussed in more detail in Section 2 below. Results of the modeling for baseline emissions are provided in Section 3. References are provided in Section 4.

2.0 BART Analysis Updates

Updates to the modeling procedures described in Section 1.2 were made by AECOM in the updated CALMET/CALPUFF modeling for Heskett Unit 2. More details regarding this process are provided in this section.

2.1 Meteorological Processing with CALMET

One of the updates involved the use of a 4-km grid size instead of the 3-km grid size used by NDDH. The grid size adjustment is consistent with directives in the August 31, 2009 EPA Clarification Memo and comments made by EPA and the Federal Land Managers during the November 17, 2009 conference call. The digital terrain data that was used for this analysis consisted of 1-degree data (90-meter resolution). With this CALMET remodeling, the total grid domain was sized to provide a 50-km buffer around this specific source as well as the PSD Class I areas. Figure 2-1 shows the modeling domain.

Another update involved changing some of the CALMET switches from the values noted in the NDDH protocol (NDDH, 2005) to those provided in the EPA Clarification Memo released on August 31, 2009. This memorandum updates the draft Interagency Workgroup on Air Quality Modeling's (IWAQM) Phase 2 summary protocol (EPA, 2009). Table 2-1 shows the changes AECOM applied to the CALMET settings consistent with the August 31, 2009 EPA Clarification Memo.

Table 2-1 Comparison of CALMET Settings Used in NDDH 2005 Protocol and in Updated Modeling

Variable	Description	NDDH 2005 Values	Updated Values
DGRIDM	Grid spacing (km)	3	4
XORIGKM	Southwest grid cell X coordinate	-380	-175
YORIGKM	Southwest grid cell Y coordinate	140	268
NX	No. of X grid cells	213	79
NY	No. of Y grid cells	153	77
NZ	No. vertical layers	12	10
ZFACE	Cell face heights (m)	0.,20.,50.,90.,140.,200., 270.,370.,500.,1000., 1700.,2500.,4200.	0.,20.,40.,80.,160.,320., 640.,1200.,2000.,3000., 4000.
BIAS	Layer-dependent biases modifying the weights of surface and upper air stations (BIAS(NZ))	-1.0, -0.9, -0.7, -0.4, 0.0, 0.3, 0.7, 1.0, 1.0, 1.0, 1.0, 1.0	0,0,0,0,0,0,0,0,0,0
TERRAD	Radius of influence of terrain features (km)	10	15
R1	Distance from a surface observation station at which the wind observation and the first guess field are equally weighted (km)	10	50
R2	Distance from an upper-air observation station at which the wind observation and the first guess field are equally weighted (km)	10	100
ZUPWND	Bottom and top of layer through which the domain scale winds are computed (m)	1., 2500.	1., 1000.
MNMDAV	Max. search distance (in grid cells) for spatial averaging of mixing ht. and temperature	7	1
ILEVZI	Layer of winds used in upwind averaging of mixing heights	3	1
ZIMAX	Maximum over land mixing height (m)	4000	3000
ZIMAXW	Maximum over water mixing height (m)	4000	3000

* Values for years 2000, 2001, 2002

2.2 CALPUFF Modeling Options

As with the CALMET modeling, AECOM changed some of the switches in CALPUFF from the values noted in the November 2005 NDDH BART modeling protocol to those provided in the Dennis Atkinson Dispersion Coefficient memorandum released on March 16, 2006. At that time, Mr. Atkinson was the Model Clearinghouse Director of the EPA Office of Air Quality Planning and Standards (OAQPS). In 2006, he released a memo detailing the settings to be used in CALPUFF modeling. AECOM followed Mr. Atkinson's recommendations with the exception of the CDIV value, which has been updated by the model developer (TRC) to be 0.0. Table 2-2 shows the changes AECOM made to the CALPUFF settings, consistent with Mr. Atkinson's EPA directives.

Table 2-2 Comparison of CALPUFF Settings Used in NDDH 2005 Protocol and in Updated Modeling

Variable	Description	NDDH 2005 Values	Updated Values
NSPEC	Number of chemical species	7	9
NSE	Number of chemical species emitted	4	7
MSPLIT	Allow puff splitting (1=yes)	1	0
MDISP	Method used to compute dispersion coefficients	2	3
MPDF	PDF used for dispersion under convective conditions (1=yes)	1	0
NX	No. of X grid cells	213	79
NY	No. of Y grid cells	153	77
NZ	No. vertical layers	12	10
DGRIDM	Grid spacing (km)	3	4
ZFACE	Cell face heights (m)	0.,20.,50.,90.,140.,200., 270.,370.,500.,1000.,1700., 2500.,4200.	0.,20.,40.,80.,160.,320., 640.,1200., 2000.,3000., 4000.
XORIGKM	Southwest grid cell X coordinate	-380	-175
YORIGKM	Southwest grid cell Y coordinate	140	268
IBCOMP	Southwest X-index of computational grid	20	1
JBCOMP	Southwest Y-index of computational grid	6	1
IECOMP	Northeast X-index of computational grid	213	79
JECOMP	Northeast Y-index of computational grid	153	77

Variable	Description	NDDH 2005 Values	Updated Values
Dry Part. Dep.	Chemical parameters of particulate deposition species	Model defaults for which mean diameter = 6.25 m and standard deviation = 0.0 m for PMC	Model defaults for all but PMC for which mean diameter = 6.0 m and standard deviation = 2.0 m
XMAXZI	Maximum mixing height	4000	3000
IRESPLIT	Hours when puff is eligible for vertical split	Hours 0-4 and 19-23	Hour 17
ROLDMAX	Vertical puff split allowed only when the ratio of last hour's mixing height to max. mixing height experienced by the puff is smaller than this value	0.33	0.25
MDISP2	Backup method used to compute dispersion coefficients	1	3
MREG	Test options specified to see if they conform to regulatory values (1=yes)	0	1
CSPEC	Species modeled	SO2,SO4,NOX,HNO3,NO3, PMC,PMF	SO2,SO4,NOX,HNO3, NO3, EC,PMC,PMF,SOA
CDIV	Divergence criterion for dw/dz across puff used to initiate adjustment for horizontal convergence (1/s)	0.01, 0.01	0,0

Note that CDIV was set to (0,0) because the CALPUFF model developer, Joe Scire, indicated in a December 22, 2006 e-mail to Robert Paine of AECOM (see below) that this setting is appropriate. However, EPA Region 8 has stated its preference that a CDIV of (0.01, 0.01) be used because that setting was specified in the March 16, 2006 EPA memo from Dennis Atkinson. To resolve this issue, we have conducted the modeling both ways and present two sets of results in Section 3 of this report.

From: Scire, Joseph [mailto:JScire@TRCSOLUTIONS.com]
Sent: Friday, December 22, 2006 9:11 AM
To: Paine, Bob
Subject: RE: CDIV question

Bob,

The default values for CDIV has been 0.0, 0.0 going back at least six years (i.e., 2000). We may have tested other values earlier than this, but using zero for the CDIV has been the default for quite a while.

The use of the smaller value gives better protection again mass accumulation within convergence zones by compensating with increased sigma z to account for vertical movement of the air.
Joe

Joseph S. Scire, CCM
TRC
Vice President, Atmospheric Studies Group,
Wannalancit Mills, 650 Suffolk Street, Suite 200,
Lowell, Massachusetts 01854

tel: (978) 656-3627
cell: (978) 697-0830
fax: (978) 453-1995

email: jscire@trcsolutions.com
or jscire@alum.mit.edu

2.3 Characterization of Baseline Emissions

The National Park Service has issued guidance on how to speciate particulate matter emissions into different constituents that have different light scattering EPA potential: coarse matter, inorganic fine matter, elemental carbon, sulfuric acid mist, and organic aerosol fine particulate. The guidance is located at http://www.vistas-sesarm.org/BART/calpuff.asp on the VISTAS regional planning organization web site. While NDDH did not include this guidance in its BART screening protocol, AECOM believes it should be included in this updated analysis.

Engineers from MDU have reviewed the speciation profiles and selected the data for a dry bottom PC with FGD and ESP controls spreadsheet as the most representative of the emissions from Heskett Unit 2. A series of Method 8 stack tests conducted August 24 – 26, 2000 found an average H_2SO_4 rate of 9.0 lb/hr (2.9 ppm) at full load. The resulting emissions that were used in the CALPUFF regional haze modeling are listed in Table 2-3 (these values have not changed from the ENSR 2006 BART modeling). To simplify the modeling, the coarse and fine inorganic matter were combined as fine matter, which has a slightly higher visibility extinction efficiency than coarse matter.

Table 2-3 Heskett Unit 2 emissions data for updated BART modeling

Component	Emission Rate (lb/hr)
SO_2	1475.5
NO_2	302.8
Coarse matter (PMC)	8.2
Inorganic fine matter (PMF)	6.3
Elemental carbon (EC)	0.2
H_2SO_4	9.0
Organic aerosols (SOA)	2.0

2.4 Natural Background Determination

Following the settlement of a court case involving how to determine natural background visibility for BART analyses, EPA determined that each state can select either the annual average or 20% best days' background. NDDH has adopted the annual average background visibility approach. The concentrations to be used in the CALPOST input for the particulate species that contribute to visibility impairment are listed in Table 2-4. In the post-processing, the various elements of the Theodore Roosevelt National Park were considered as a single Class I area, departing from the treatment in the November 2005 NDDH BART modeling protocol. The bases for this change are reflected in EPA's comments 23, 39 and 53 pertaining to the August 21, 2009 draft NDDH Regional Haze SIP and comments provided by EPA and the Federal Land Managers during the November 17, 2009 conference call.

Table 2-4 Annual Average Natural Levels of Aerosol Components (μg/m³)

Component	Lostwood Wilderness(1)	Theodore Roosevelt NP(1)
Ammonium sulfate	0.12	0.12
Ammonium nitrate	0.10	0.10
Organic carbon mass	0.60	0.60
Elemental carbon	0.02	0.02
Soil	0.50	0.50
Coarse mass	3.00	3.00

(1) From "Federal Land Managers' Air Quality Related Values Workgroup" (FLAG, 2008), Appendix V-1, Table V.1-2.

2.5 Light Extinction and Haze Impact Calculations

The FLAG 2008 document (dated June 26, 2008) provides guidance on the recommended new IMPROVE equation application. CALPOST Version 6.221 defines this application as Method 8, Mode 5. The assessment of visibility impacts at the Class I areas will use CALPOST Method 8.

The CALPOST postprocessor will be used for the calculation of the impact of the modeled source's primary and secondary particulate matter concentrations on light extinction. In the new IMPROVE equation, the total sulfate, nitrate, and organic carbon compound concentrations are each split into two fractions, representing small and large size distributions of those components. New terms, such as sea salt (important for coastal locations), absorption by NO_2 (only used where NO_2 data are available), and site-specific Rayleigh scattering have been added to the equation. The new IMPROVE equation for calculating light extinction is shown below.

$$
\begin{aligned}
b_{ext} = \; & 2.2 \times f_S(RH) \times [\text{Small Sulfate}] + 4.8 \times f_L(RH) \times [\text{Large Sulfate}] \\
& + 2.4 \times f_S(RH) \times [\text{Small Nitrate}] + 5.1 \times f_L(RH) \times [\text{Large Nitrate}] \\
& + 2.8 \times [\text{Small Organic Mass}] + 6.1 \times [\text{Large Organic Mass}] \\
& + 10 \times [\text{Elemental Carbon}] \\
& + 1 \times [\text{Fine Soil}] \\
& + 0.6 \times [\text{Coarse Mass}] \\
& + 1.7 \times f_{SS}(RH) \times [\text{Sea Salt}] \\
& + \text{Rayleigh Scattering (Site Specific)} \\
& + 0.33 \times [NO_2 \text{ (ppb)}] \quad \{\text{or as: } 0.1755 \times [NO_2 \; (\mu g/m^3)]\}
\end{aligned}
$$

Where:

[ ] indicates concentrations in $\mu g/m^3$

$f_S(RH)$ = Relative humidity adjustment factor for small sulfate and nitrate

$f_L(RH)$ = Relative humidity adjustment factor for large sulfate and nitrate

$f_{SS}(RH)$ = Relative humidity adjustment factor for sea salt

For Total Sulfate $< 20 \; \mu g/m^3$:

$$[\text{Large Sulfate}] = ([\text{Total Sulfate}] / 20 \; \mu g/m^3) \times [\text{Total Sulfate}]$$

For Total Sulfate $\geq 20 \; \mu g/m^3$:

$$[\text{Large Sulfate}] = [\text{Total Sulfate}]$$

And:

$$[\text{Small Sulfate}] = [\text{Total Sulfate}] - [\text{Large Sulfate}]$$

To calculate large and small nitrate and organic mass, substitute ({Large, Small, Total} {Nitrate, Organic Mass}) for Sulfate.

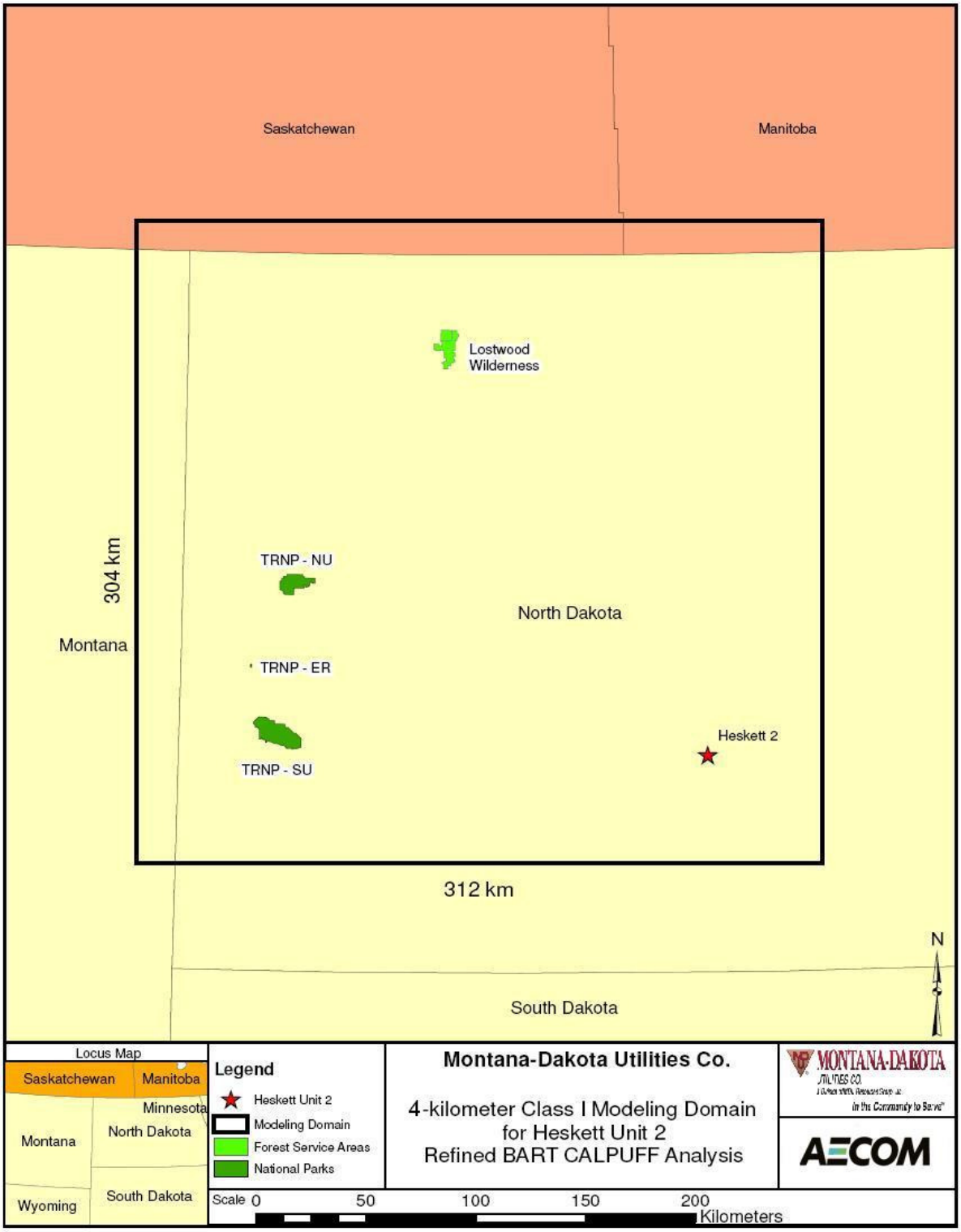
The FLAG 2008 document provides inputs to the new IMPROVE equation for the annual average natural conditions. Inputs to the CALPOST Method 8 calculations for each Class I area are listed in Table 2-5.

Table 2-5 New IMPROVE Equation CALPOST Inputs

Component	Lostwood Wilderness(1)	Theodore Roosevelt NP(1)
Sea salt concentration ($\mu g/m^3$)	0.03	0.01
Raleigh scattering (Mm^{-1})	11	11
Monthly f_L (RH)	2.51, 2.45, 2.54, 2.06, 2.03, 2.21, 2.23, 2.05, 2.02, 2.13, 2.69, 2.67	2.47, 2.42, 2.45, 2.12, 2.14, 2.21, 2.14, 1.99, 1.99, 2.10, 2.58, 2.57
Monthly f_S (RH)	3.21, 3.15, 3.36, 2.60, 2.54, 2.86, 2.89, 2.60, 2.53, 2.72, 3.60, 3.52	3.17, 3.11, 3.22, 2.71, 2.74, 2.85, 2.73, 2.49, 2.48, 2.66, 3.42, 3.37
Monthly f_{SS} (RH)	3.77, 3.66, 3.67, 2.86, 2.79, 3.07, 3.11, 2.82, 2.80, 2.99, 3.93, 3.95	3.67, 3.56, 3.51, 2.93, 2.97, 3.09, 2.96, 2.72, 2.72, 2.93, 3.75, 3.78

(1) From "Federal Land Managers' Air Quality Related Values Workgroup" (FLAG, 2008), Appendix V-1, Tables V.1-2 to V.1-5.

Figure 2-1 Modeling domain for 4 kilometer grid



3.0 Updated BART Analysis Results and Conclusions

The results of the updated BART modeling for Heskett Unit 2 are provided in Table 3-1 with the use of CDIV = (0,0) and in Table 3-2 with the use of CDIV = (0.01, 0.01). The two sets of results are nearly the same, and they indicate that for the three years modeled all 98th percentile daily predictions of the change in visibility are below 0.5 deciview.

Table 3-1 Results of Updated BART Modeling with CDIV = (0, 0)

Class I Area	Met Year 2000				Met Year 2001				Met Year 2002				00-02 Peak
	Days above		MAX dv	8th Highest	Days above		MAX dv	8th Highest	Days above		MAX dv	8th Highest	8th Highest
	0.5 dv Δ B_{ext}	1.0 dv Δ B_{ext}	Δ B_{ext}	Δ dv	0.5 dv Δ B_{ext}	1.0 dv Δ B_{ext}	Δ B_{ext}	Δ dv	0.5 dv Δ B_{ext}	1.0 dv Δ B_{ext}	Δ B_{ext}	Δ dv	Δ dv
Lostwood W	1	0	0.69	0.19	0	0	0.38	0.23	0	0	0.31	0.11	0.23
T. Roosevelt NP	2	0	0.75	0.27	3	0	0.98	0.27	1	0	0.54	0.27	0.27

Table 3-2 Results of Updated BART Modeling with CDIV = (0.01, 0.01)

Class I Area	Met Year 2000				Met Year 2001				Met Year 2002				00-02 Peak
	Days above		MAX dv	8th Highest	Days above		MAX dv	8th Highest	Days above		MAX dv	8th Highest	8th Highest
	0.5 dv Δ B_{ext}	1.0 dv Δ B_{ext}	Δ B_{ext}	Δ dv	0.5 dv Δ B_{ext}	1.0 dv Δ B_{ext}	Δ B_{ext}	Δ dv	0.5 dv Δ B_{ext}	1.0 dv Δ B_{ext}	Δ B_{ext}	Δ dv	Δ dv
Lostwood W	1	0	0.82	0.20	0	0	0.40	0.23	0	0	0.32	0.11	0.23
T. Roosevelt NP	3	0	0.75	0.26	3	1	1.10	0.27	1	0	0.55	0.28	0.28

Based upon the predicted change in visibility in the two North Dakota Class I areas associated with the modeled peak daily baseline emissions reported above in either Table 3-1 or 3-2, Heskett Unit 2 is not subject to BART.

4.0 References

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Environmental Protection Agency (EPA), Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts, EPA-454/R-98-019, page 14, December, 1998

Federal Land Managers' Air Quality Related Values Workgroup (FLAG). Phase I Report Revised Draft, June 2008.

North Dakota Department of Health. November 2005. Protocol for BART-Related Visibility Impairment Modeling Analyses in North Dakota (Final). North Dakota Department of Health, Division of Air Quality,1200 Missouri Avenue, Bismarck, ND