Iowa Department of Natural Resources
Air Quality Bureau

Variegated Protocol in Support of
Best Available Retrofit Technology Determinations

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1. INTRODUCTION

PURPOSE

The following documentation describes methods and procedures that will be employed by the Iowa Department of Natural Resources (IDNR) for completing analyses to determine if a source is subject to BART. Specifically addressed are the mechanisms designed to determine if a BART eligible source can reasonably be anticipated to cause or contribute to any visibility impairment in any Federally Mandated Class I area.

BACKGROUND

On June 15th 2005[1], the US EPA issued the "*Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations"*, an amendment to 40 CFR Part 51. The amendment, in conjunction with the Regional Haze rule and the Clean Air Act, defines BART eligible sources as: "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." Following identification, the Clean Air Act (169A) requires the State to determine whether any BART unit "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility in any [Class I] area."

The final rule established thresholds defining the terms "cause" and "contribute: a single source which imparts a change in visibility of 1.0 (or more) deciviews (dv) at any Class I area is considered a *cause* of visibility impairment; a single source *contributes* to visibility impairment at (or above) the 0.5 delta-deciview level. States are afforded the opportunity to enact more stringent de-minimus levels should they choose. While States are offered discretion regarding the technical tools utilized in determining a single sources' impact on visibility impairment, the Guidelines establish implementation of the CALPUFF air quality modeling system as the preferred method. However, the CALPUFF modeling system is shown to be inadequate at reasonably characterizing Iowa source contributions in nearby Class I areas. IDNR is thereby implementing a multivariate system which includes screening methods, CALPUFF model plant analyses, regional one-atmosphere photochemical grid modeling, and scale analyses.

OVERVIEW

The IDNR has devoted extensive personnel and computational resources toward implementation of the CALPUFF modeling system, in order to develop a scientifically sound modeling protocol for subject-to-BART determinations. After considerable study, IDNR has concluded that the CALPUFF modeling system fails to provide technically defensible results for applications unique to Iowa.

[1] Minor technical and typographical errors were corrected in a memo published June 24th 2005.

BART sources within Iowa's borders share an unusual geographical characteristic where the separation distance between a source and the border of its nearest neighboring Class I area consistently exceeds 390 kilometers (km). These same separation distances average approximately 525 km across Iowa's BART eligible sources. IDNR acknowledges CALPUFF has been adopted by EPA in the Guideline on Air Quality Models as the preferred model for assessing long range transport of pollutants and their impacts on Federal Class I areas. IDNR agrees that CALPUFF is well suited for a variety of single-source impact analyses, however, IDNR has not identified data or studies supporting the appropriateness of CALPUFF when applied in situations with minimum transport distances of ~400 km.

Through design and implementation CALPUFF is typically configured to conservatively over-predict ambient air concentrations. However, the levels of conservatism encountered by the IDNR are more appropriately described as model bias. As noted in the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 report:

> "...there are serious conceptual concerns with the use of puff dispersion for very long-range transport (300 km and beyond). As the puffs enlarge due to dispersion, it becomes problematic to characterize the transport by a single wind vector, as significant wind direction shear may well exist over the puff dimensions."

IDNR has implemented puff-splitting in an attempt to alleviate the errors, however, as noted in the draft CENRAP BART modeling protocol (Alpine Geophysics & ENVIRON, 2005):

> "Detailed guidance on when and how the puff-splitting algorithm should be used and actual verification studies demonstrating that the technique operates as intended are not discussed in the model documentation or presented in the science literature."

IDNR studies involving the use of puff-splitting do demonstrate that the option will reduce maximum impacts, however, actual reductions are minimal and serious abnormalities remain. For example, Figure 1 depicts maximum delta-deciview impacts as a function of distance. These results were generated using a theoretical source located in central Iowa with 2500 tons per year (tpy) emissions (each) of NOx and SO2, and 50 tpy of PM. Discrete receptors, with one degree separation, were defined around a ring of receptors. Ten independent simulations were performed, each employing puff splitting, with the only variable modified being the radius of the receptor ring. Beyond approximately 450 km, maximum impacts increase monotonically. Given the operational design and chemical mechanisms of the CALPUFF modeling system, such results are non-physical. As the majority of Iowa BART sources lie beyond 450 km from their nearest Class I area, application of CALPUFF will be limited to a model plant approach in which source-receptor distances remain below 450 km. Such a constraint avoids interpretation of CALPUFF results which are highly suspect of unacceptable overprediction.

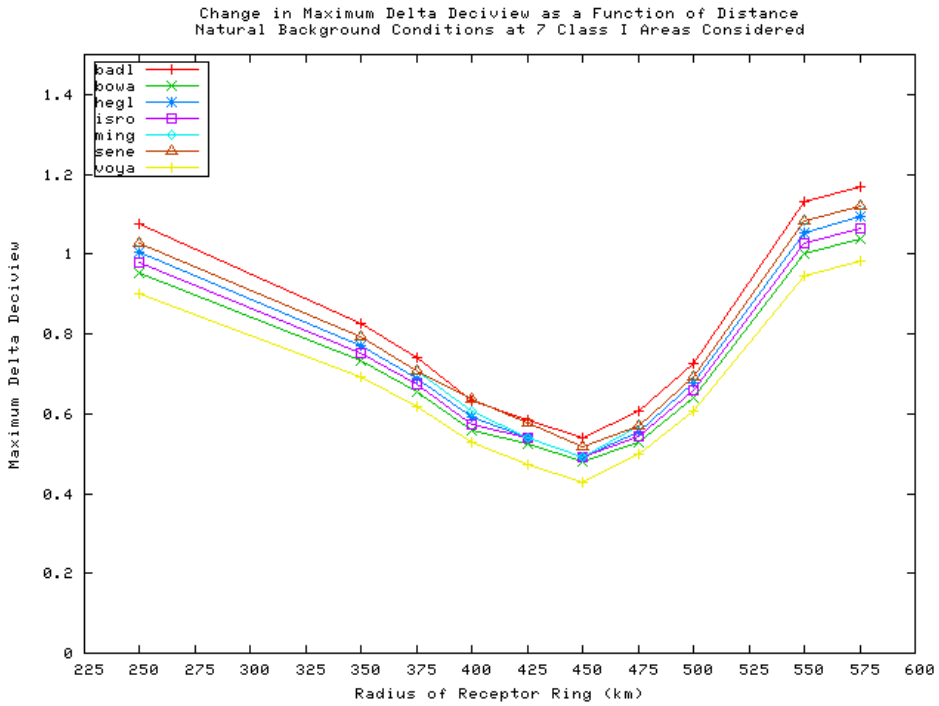

Figure 1. Maximum delta-deciview values as a function of distance. Generated using the Iowa DNR Model Plant configuration with 2500 tpy of SO2 and NOx emissions each, and 50 tpy of PM (modeled as PM2.5), for calendar year 2002. Results from seven Class I areas are depicted. Data were evaluated against annually averaged natural background conditions.

2. METHODOLOGIES

VARIEGATED ASSESSMENT

As an alternative to sole reliance upon the CALPUFF modeling system, the Iowa DNR is utilizing a multivariate approach in the subject-to-BART determination process. Simple screening procedures will be conducted using Q/d methodology. Comparison of emission rates against thresholds established through CALPUFF model plant analyses will also occur. A third phase of the multiform approach will include a variety of assessments utilizing the CAMx regional scale one-atmosphere model. Determination of which sources are found to be subject to BART will follow careful consideration of the results from each methodology. Details regarding the implementation of each stage are provided in the following sections.

Q/D

A Q/d (emissions divided by distance) screening approach will determine those small sources which are probable candidates for exclusion from BART review. Distance, specified in km, will be defined as the distance between the location of the BART source and the nearest National Park Service 1 km receptor. The National Park Service Class I area 1 km resolution receptor grids serve as an accurate proxy to GIS derived border data, and accommodate calculation of Q/d through spreadsheets.

Q/d evaluation assumes a multiplicative factor in the denominator. Standard procedures used in the past, such as the '"Screening Threshold" Method for PSD Modeling, North Carolina Air Quality Section', have typically used a constant of 20. The IDNR will utilize 20d, as well as a more conservative constant of 10. The value of Q will be calculated by summing the annual potential NOx and SO2 emissions, in tons per year.

The Q/d values for each method (10d and 20d) will be compared against a cutoff factor of 1. Two factors of conservatism are included in this approach. First, potential, rather than actual emissions are incorporated. Second, the more conservative 10d values are also consulted. The subject to BART determination will be made utilizing the 10d values, in concert with 20d results, and consultation of results from the studies listed below. However, facilities with both Q/d values less than one will not likely be considered subject to BART.

CALPUFF MODEL PLANT ANALYSES

The CALPUFF modeling system is being employed through implementation of a 'model plant' assessment to screen sources which are not reasonably anticipated to cause or contribute to visibility impairment at nearby Class I areas. The model plant analysis implements the CALPUFF modeling system utilizing methods which closely mirror the configuration detailed in the Iowa DNR draft CALPUFF modeling protocol submitted to EPA on August 19th, 2005. Additionally, these analyses follow the model plant

processing outlined in the technical support documentation referenced in the BART preamble (EPA, 2005b). A review of the configuration is provided below.

Version Control

Based upon verbal comments received from EPA Region VII, the IDNR will implement beta versions of the CALMET/CALPUFF processors. The beta version modifications primarily include bug fixes, and are thus suited for regulatory use.

Domain

Meteorological processing will be computed upon a Lambert Conic Conformal (LCC) projection consisting of 171 by 165 horizontal grid cells with 12 km resolution. In order to reduce the computational burden and minimize potential boundary artifacts, the CALPUFF domain consists of a subset of the CALMET domain. Specifically, 9 grid cells (108 km) are eliminated along each boundary. Figure 2 depicts the horizontal attributes of the CALMET and CALPUFF modeling domains. The CALMET/CALPUFF domains are depicted with reference to the 36 km Regional Planning Organizations (RPO) meteorological modeling domain.

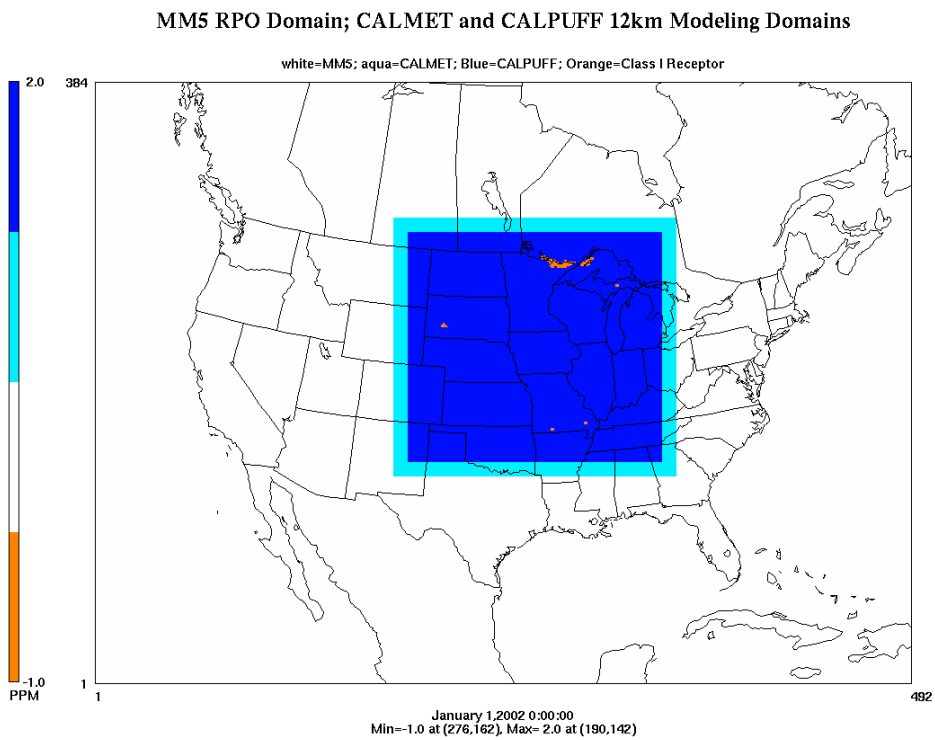

Figure 2. The dark blue area depicts the horizontal attributes of the CALPUFF modeling domain. Boundary cells modeled within CALMET and excluded in CALPUFF are indicated in aqua. The outer domain represents the RPO 36 km MM5 domain. Grid cells which contain a National Park Service 1 km Class I area receptor are indicated in orange.

Meteorological Data

The meteorological data incorporated within the model plant analyses originates with three annual MM5 mesoscale meteorological simulations, covering the years 2002-2004. The 2002 MM5 data was generated by the IDNR, while years 2003 and 2004 were supplied by Kirk Baker with the Lake Mike Michigan Air Directors Consortium (LADCo). Within CALMET, 36 km MM5 data is interpreted to the 12 km CALMET grid, as the first-guess field. Kinematic and slope flow effects were modeled, in combination with the "No-Obs" approach. With the exception of the No-Obs approach, the majority of the remaining CALMET options were assigned values commensurate with the recommendations of the IWAQM Phase 2 report. Notable exceptions include the use of the MM5 gridded cloud fields, as well as a unique vertical structure which includes 13 layer interfaces and a (PBL) ceiling of 3448 meters.

Configuration

Configuration of CALPUFF within the framework of the model plant analyses closely mirrors the settings followed in the draft IDNR CALPUFF modeling protocol. In general, modeling options follow the IWAQM Phase 2 recommendations. Notable exceptions include the following:

- Puff splitting was enabled for years 2002 and 2004. Puff splitting was excluded from the 2003 simulation, as run times approached day per day (real-time) requirements at the mid-point of the simulation (*e.g.* the 2003 annual CALPUFF simulation was estimated to require 160 days to complete).
- Three species were emitted, NOx, SO2, and primary particulate matter. All primary particulate matter is assumed to be PM2.5. This assumption is prescribed through assignment of geometric mass mean diameter and geometric standard deviation as 0.48 and 2.0 microns, respectively.
- Model plant stack parameters mirrored the values provided in the *Calpuff Analysis in support of the June 2005 Changes to the Regional Haze Rule* (EPA 2005b). Specifically, the following Industrial Boiler stack parameters were defined: stack height of 55 meters, stack diameter of 2.6 meters, exit velocity of 11.4 m/s, and an exit temperature of 414 K. Stack location was defined near the center of the State of Iowa with a base elevation of 333.5 meters. The industrial boiler was selected as Iowa EGU sources are anticipated to satisfy the BART requirements through participation in the CAIR cap and trade program for NOx and SO2.
- Background ozone values were set to 40 ppb. A conservative background concentration of 3 ppb was assigned for NH3.
- Discrete receptors were defined in concentric rings with varying radii. One degree separation yielded 360 receptors per simulation, with visibility impacts evaluated at each receptor regardless of whether or not it is located in a Class I area.

Numerous iterations of CALPUFF have been conducted through the model plant configuration, evaluating the impacts of receptor distances, emission rates, meteorology, and model configuration. The model plant evaluation also included implementation of

POSTUTIL, with MNITRATE=1 and a background value of NH3 consistent with CALPUFF, at 3 ppb.

As mentioned, the model plant analysis evaluates the visibility impacts as if each receptor were located within a Class I area. Specifically, IDNR assumes that each receptor may be located in one of seven nearby Class I areas:

- Badlands, South Dakota
- Isle Royal & Seney, Michigan
- Voyageurs & Boundary Waters Canoe Area, Minnesota
- Mingo & Hercules-Glades, Missouri

Initial evaluation involves natural background as based upon annually averaged conditions. Of the seven Class I areas listed above, all sites (except the Badlands) utilize Eastern site data. Western site concentrations are assigned only to the Badlands. The annually averaged natural background concentration data are listed in Table 1.

Table 1. Natural background concentrations (ug/m3) for Eastern and Western U.S. Class I Sites. Data define annually averaged natural background conditions. Source: EPA's Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program.

	Eastern	**Western**
$(NH_4)_2SO_4$	0.23	0.12
NH_4NO_3	0.10	0.10
OC	1.40	0.47
EC	0.02	0.02
SOIL	0.50	0.50
CM	3.00	3.00

At the request of EPA Region VII, the 20% best natural background conditions will also be examined. While results based upon the 20% best natural background conditions will be provided, annual average natural background conditions will also be considered in the determination process. These methods are consistent with the proposed Settlement Agreement referenced in 71 FR 25838 which will provide further clarification regarding selection of natural background criteria.

Standard CALPOST configuration requires that natural background conditions be represented as speciated concentration data. No such data exists for the 20 percent best natural background conditions, these conditions are described only through Class I area specific deciview values. Thus, the deciview values must be converted into speciated concentrations. Procedures described in the 2005 draft North Dakota protocol were followed to scale the annual concentration data to the 20 percent best natural background conditions. An example of the scaling methods follows.

The IMPROVE equation (Eq. 2.1) is coupled with the following Class I area specific data: the annually averaged natural background concentrations; the annually averaged f(RH) value; and the deciview value representing the 20% best natural background visibility conditions. For example, visibility degradation at Boundary Waters Canoe Area

(BOWA) for the 20% best natural background conditions is described as 3.53 dv (EPA, 2003). This value is converted to an extinction coefficient, via Eq. 2.2, yielding 14.23 Mm^{-1}. Incorporating the annually averaged f(RH) value (2.93[2]) and natural background concentrations from Table 1, Eq. 2.3 is solved for the BOWA specific scaling factor: [X]. The scaling factor (in this example, 0.385) is then applied equally to the speciated annually averaged natural background concentrations to arrive at 20 percent best conditions. The results for this example, as well as the remaining 6 Class I areas, are provided in Table 2.

$$B_{ext} = 3 \cdot f(RH) \cdot \left[(NH_4)_2 SO_4\right] + 3 \cdot f(RH) \cdot \left[NH_4 NO_3\right] + 4 \cdot [OC] + 10 \cdot [EC] + 1 \cdot [SOIL] + 0.6 \cdot [CM] + B_{Rayleigh} \quad \text{(Eq. 2.1)}$$

$$B_{ext} = 10 \cdot e^{(dv/10)} \quad \text{(Eq. 2.2)}$$

$$14.23 = 3 \cdot 2.93 \cdot [0.12] \cdot [X] + 3 \cdot 2.93 \cdot \left[0.10\right] \cdot [X] + 4 \cdot [1.40] \cdot [X] + 10 \cdot [0.02] \cdot [X] + 1 \cdot [0.5] \cdot [X] + 0.6 \cdot [3.0] \cdot [X] + 10 \quad \text{(Eq. 2.3)}$$

Table 2. Site specific data associated with calculation of the natural background conditions on the 20 percent best days.

			20% Best Natural Background						
				Scaled Concentrations (ug/m3)					
Site	**f(RH)**	**Scaling Factor [X]**	**Deciviews (B_{ext})** [a]	**SO_4**	**NO_3**	**OC**	**EC**	**SOIL**	**CM**
BADL	2.55	0.402	2.18 (12.44)	0.048	0.040	0.189	0.008	0.201	1.207
BOWA	2.93	0.385	3.53 (14.23)	0.088	0.038	0.538	0.008	0.192	1.154
HEGL	3.13	0.386	3.59 (14.32)	0.089	0.039	0.540	0.008	0.193	1.157
ISRO	2.90	0.387	3.54 (14.25)	0.089	0.039	0.542	0.008	0.194	1.162
MING	3.14	0.385	3.59 (14.32)	0.089	0.039	0.540	0.008	0.193	1.156
SENE	3.30	0.392	3.69 (14.46)	0.090	0.039	0.549	0.008	0.196	1.177
VOYA	2.71	0.377	3.41 (14.06)	0.087	0.038	0.527	0.008	0.188	1.130

[a]Deciview values are listed first. The values in parenthesis are the corresponding B_{ext}, calculated using Eq. 2.2.

Results

For each model plant simulation, the CALPOST processor requires 14 iterations: seven Class I areas times two natural background scenarios. Results for each Class I area assessment were tabulated and ranked individually. Both maximum and 98th percentile values will be considered when determining the levels at which emissions may cause

[2] The f(RH) values at the centroid of the Class I area were employed.

(delta deciview value greater than or equal to 1.0) or contribute (delta deciview value greater than or equal to 0.5) to visibility impairment

IDNR has found that any BART eligible unit which emits less than 3000 tpy of combined NOx and SO2 will likely be exempted from a subject to BART determination. This conclusion is based on a number of sensitivity analyses conducted using the model plant approach. As puff splitting was enabled in the majority of simulations, and run times averaged approximately 30 hours per year, the decision was made to concentrate on a single ring of receptors. Unless specifically noted, the following results depict impacts recorded on discrete receptors 425 km from the model plant stack. Referencing Figure 1, 425 km does not represent the minimum point of the curve, and thus provides another degree of conservatism. Receptor separation remained one degree.

Figures 3 through 5 depict results from twelve model plant analyses. Each of the twelve individual plots contains a bar chart displaying the number of days in which a delta deciview value greater than or equal to 0.5 was produced (labeled on the left hand y-axis). At the 98th percentile, 7 days with delta-deciview values exceeding 0.5 are permitted. This is depicted in the images by the solid red line (to remain within the 98th percentile the bar charts must remain at or below this line). The maximum delta deciview values are also reported (labeled on the right hand y-axis and indicated using a character similar to the asterisk). The solid blue line denotes the 0.5 delta-deciview level. Within each plot, results for each of the seven Class I areas are provided.

The twelve individual plots in Figures 3-5 are positioned in a four-panel configuration. The four panels are arranged according to the following: the upper left plot depicts results from the model plant using emissions of 2500 tpy of SO2, 2500 tpy of NOx, and 50 tpy of PM2.5 and results compared against annually averaged natural background conditions. The upper right figure uses the same emission scenario, however, results are compared against the 20 percent best natural background conditions. The bottom two plots follow a similar pattern, however, emissions differ as the lower plots utilize the model plant configured with 1500 tpy of SO2 and NOx each, and 50 tpy of PM2.5. The plots in Figure 3 are confined to calendar year 2002, with Figures 4 and 5 relating data from years 2003 and 2004, respectively.

The results presented in Figures 3 through 5 illustrate that the model plant, with 5000 tpy of NOx & SO2 combined (and 50 tpy of PM2.5), does not yield any delta deciview values greater than 0.5 at the 98th percentile (the count of delta deciviews greater than 0.5 does not exceed 7 days in any one year) as compared against annually averaged natural background conditions. The situation changes dramatically when compared against the 20 percent best natural background conditions. Alternatively, at 3000 tpy SO2/NOx, the 98th percentile is never exceeded, regardless of the natural background scenario. Additionally, at 3000 tpy SO2/NOx maximum impacts for years 2002 and 2003, as compared against annually averaged natural background conditions, do not exceed 0.5. Year 2004 does produce higher impacts. As mentioned, the impacts do not exceed the 98th percentile.

In summary, the IDNR has found that Iowa BART sources with NOx+SO2 emissions less than 3000 tpy will likely be exempt from a subject to BART determination. However, the exclusion of a source based solely upon model plant analysis will not likely occur. Further review, for example through implementation of alternative modeling efforts, will be conducted prior to final determinations.

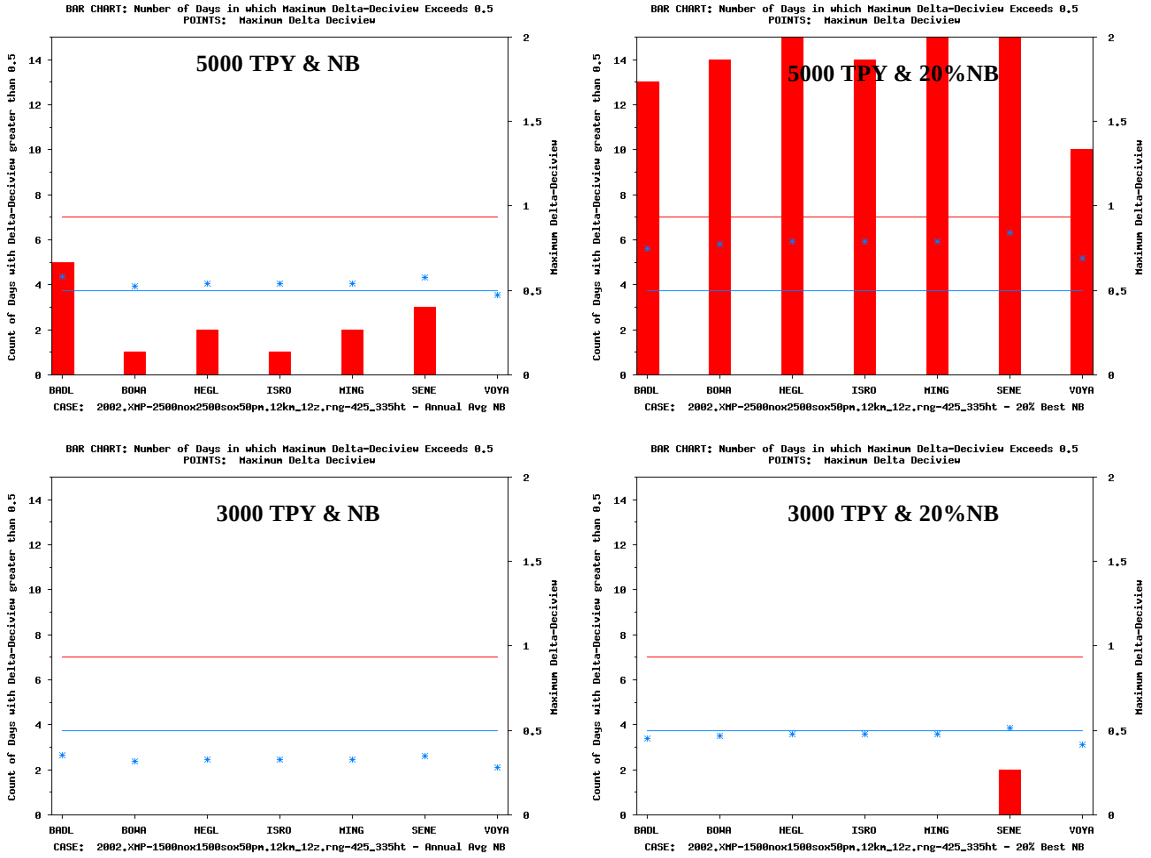

Figure 3. Delta deciview impacts from four Iowa Model Plant configurations: results for year 2002 from the model plant with combined SO2 and NOX emissions of 5000 and 3000 tpy, as compared against annually averaged natural background (NB) conditions and 20% best natural background conditions.

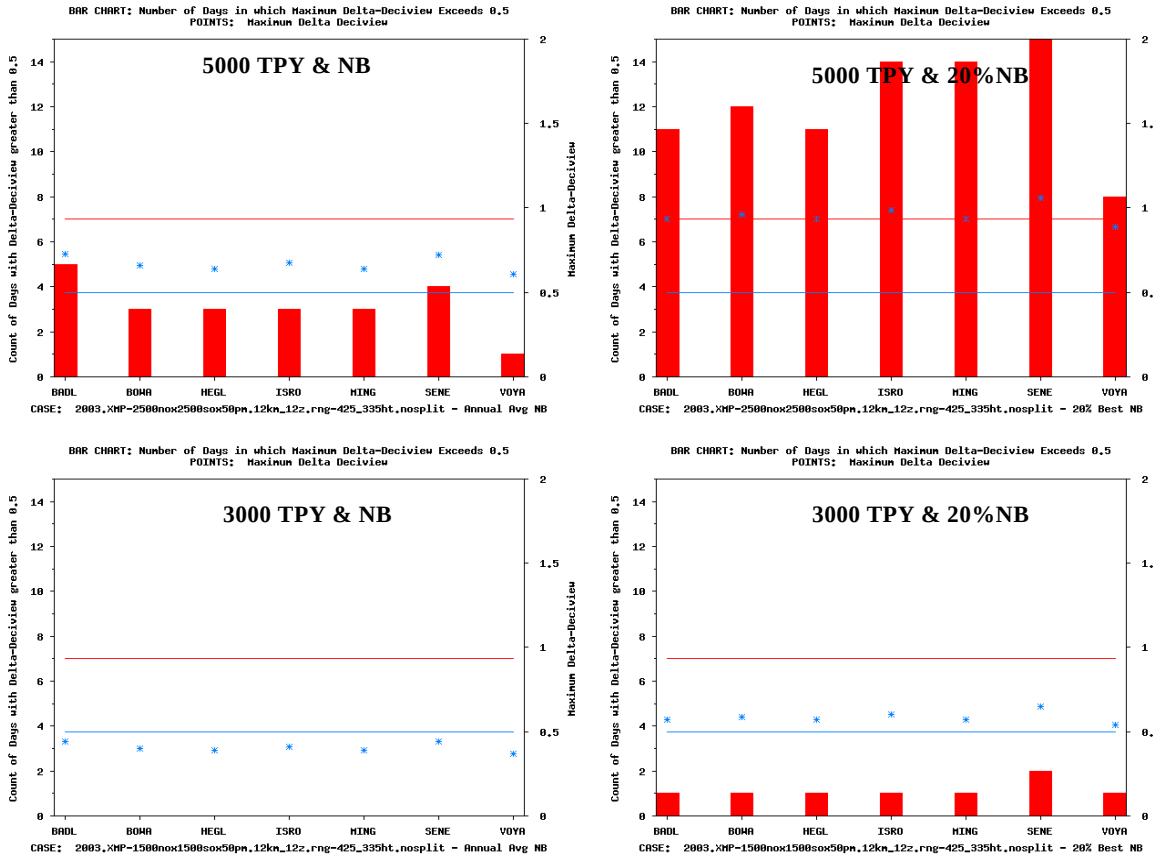

Figure 4. Delta deciview impacts from four Iowa Model Plant configurations: results for year 2003 from the model plant with combined SO2 and NOX emissions of 5000 and 3000 tpy, as compared against annually averaged natural background (NB) conditions and 20% best natural background conditions. Puff splitting was not enabled for this year, due to computational restraints described previously.

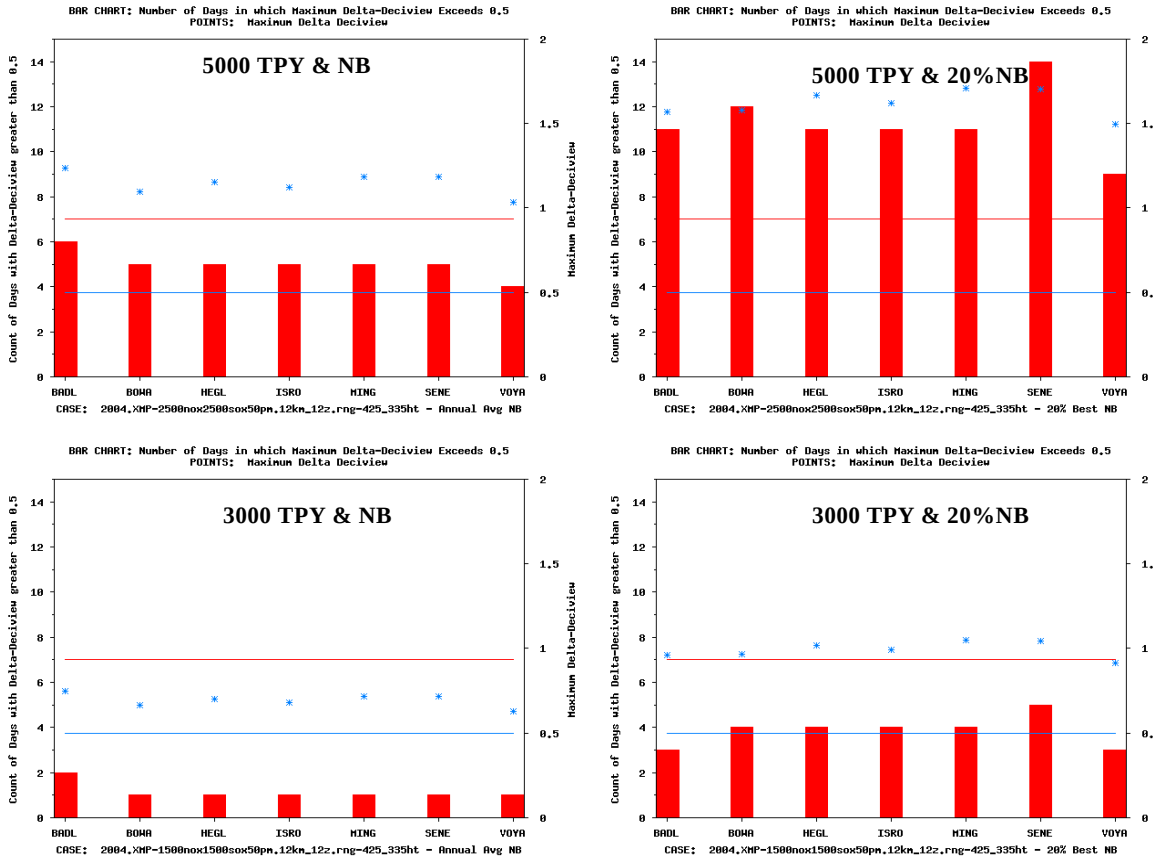

Figure 5. Delta deciview impacts from four Iowa Model Plant configurations: results for year 2004 from the model plant with combined SO2 and NOX emissions of 5000 and 3000 tpy, as compared against annually averaged natural background (NB) conditions and 20% best natural background conditions.

3. ALTERNATIVE MODELING

CONFIGURATION

The IDNR utilized the CAMx v4.20 modeling system in the framework for determining which sources cause or contribute to visibility impairment at nearby Class I areas. A number of annual simulations, utilizing calendar year 2002, with the focus upon modeling cumulative impacts, are planned. Figure 6 depicts the horizontal structure of modeling domains. As several CAMx simulations were conducted, the 36 km (LADCO 4_RPO) domain has been employed. Refinement of critical runs will occur through implementation of a 12 km grid as necessary, also pictured in Figure 6.

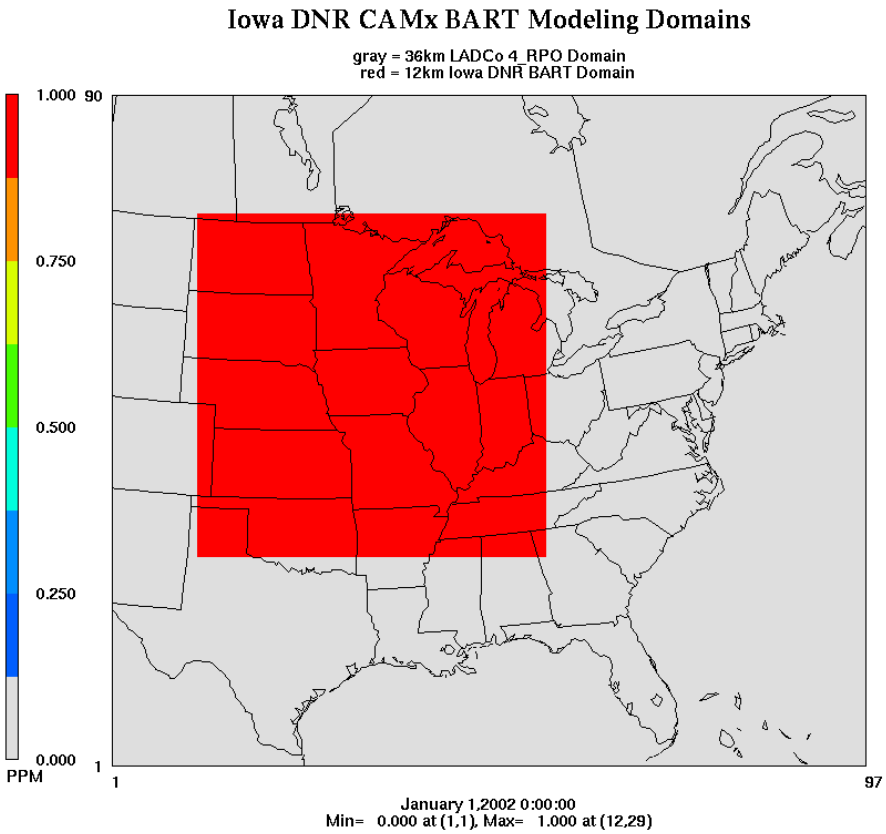

Figure 6. Depiction of the 36 and 12 km modeling domains to be employed within the CAMx framework for BART modeling.

The meteorological data driving the CAMx system is derived from the IDNR 2002 MM5v363 36/12km simulation. An independent performance evaluation of the dataset has been completed by Baker *et. al.* (2004), Baker (2005a), Kemball-Cook *et. al.* (2005), and Johnson (2004). Reviewers found the dataset well suited to air quality modeling applications. Consequently, the 36 km meteorological dataset is in wide use within the regional modeling community, including use by LADCO, CENRAP, and various member states. The 12km dataset is also in use by LADCO, IDNR, and the Five-States

Modeling Study Project. Through the results detailed in the referenced reviews, as well as the propensity of the dataset in current studies, IDNR concludes that the meteorological model performance is suitable for use in alternative modeling approaches to BART.

Our application of the CAMx modeling system corresponds with the LADCo 2002 BaseJ emissions inventory. The inventory is the product of a multi-year iterative improvement process, and includes the latest available Iowa point source inventory, in conjunction with numerous point, area, on-road, and off-road updates (Janssen, 2005). A performance evaluation conducted by Kirk Baker (2005b) reveals simulation performance commensurate with the current works of other RPOs. In reference to the BART determination, where underprediction may falsely exempt a potential BART source, most species, when biased, were positively biased. Organic carbon species were the exception, showing predominantly underpredictions.

Based upon CAMx model performance, in conjunction with study of the emissions inventory and meteorological datasets driving the photochemical grid model, the CAMx v4.20-BaseJ configuration is viewed to be an appropriate platform for alternative modeling approaches to BART.

MODELING SCENARIOS

The initial suite of cumulative CAMx model simulations consists of four independent studies. The first scenario (completed) included reproduction of the LADCO BaseJ simulation and a sensitivity run in which all Iowa BART source emissions (EGU and non-EGU) were zeroed out (emissions were zeroed out on a facility wide basis for any plant containing a BART unit). Analysis yielded impacts greater than 0.5 delta-deciviews upon nearby Class I areas. For example, BOWA experienced maximum delta deciview values of up to 3.5, with delta deciviews exceeding 0.5 on approximately 40 days[3]. Thus IDNR can clearly conclude, that in the absence of CAIR, potential Iowa BART sources would not be eligible for cumulative exclusion from BART.

The second study utilizes a modified elevated point source file in which all non-EGU elevated source emissions are eliminated, on a facility wide basis. While BART unit emissions do not reflect 24-hour averaged maximums in this scenario, a level of compensation is reached through inclusion of sources facility wide (*i.e.*, emissions from all emission units are included, not just those that are BART eligible).

The third scenario is similar to the study above. A more conservative approach to the zeroing of facility wide emissions is implemented, as all low point sources, in addition to elevated point sources, are zeroed out.

The fourth sensitivity is the examination of 12 km results. The third scenario will be re-run with 12 km meteorology in combination with flexi-nested emissions. Preliminary results from a previous study indicate 12 km modeling does yield higher speciated

[3] The evaluation was computed using annually averaged natural background conditions. Migrating to the 20% best conditions would needlessly exacerbate the obvious impacts.

component concentrations, while maintaining a spatial distribution very similar to the 36 km simulation. Given the similarity in 12 vs. 36 km results, in combinations with increased computational restraints, only a limited number of scenarios will be reproduced at 12 km.

EVALUATION

Results from the CAMx simulations will be evaluated through implementation of software developed by the IDNR. The standard IMPROVE equation (Eq. 2.1) will be utilized to convert 24-hour averaged speciated modeled concentration data to extinction coefficients. Equation 3.1 lists the species involved in the summation of total extinction, with Eqs. 3.2 - 3.8 relaying the method used to convert concentration data to B_{ext}.

$$b_{tot} = b_{SO4} + b_{NO3} + b_{OC} + b_{EC} + b_{soil} + b_{coarse} + b_{ray} \qquad \text{(Eq. 3.1)}$$

$$b_{SO4} = 3\,[(NH_4)_2SO_4]f(rh) \qquad \text{(Eq. 3.2)}$$
$$b_{NO3} = 3\,[NH_4NO_3]f(rh) \qquad \text{(Eq. 3.3)}$$
$$b_{OC} = 4\,[OMC] \qquad \text{(Eq. 3.4)}$$
$$b_{EC} = 10\,[EC] \qquad \text{(Eq. 3.5)}$$
$$b_{soil} = 1\,[Soil] \qquad \text{(Eq. 3.6)}$$
$$b_{coarse} = 0.6\,[Coarse\ Mass] \qquad \text{(Eq. 3.7)}$$
$$b_{ray} = 10\ Mm^{-1} \qquad \text{(Eq. 3.8)}$$

The mapping of CAMx to IMPROVE species is revealed in Eqs. 3.9 - 3.14. CAMx SO4 and NO3 concentrations are ionic; to remain consistent with the IMPROVE methods, these species are assumed to be completely neutralized by ammonium (NH4).

$$[(NH_4)_2SO_4] = 1.375 \times PSO4 \qquad \text{(Eq. 3. 9)}$$
$$[NH_4NO_3] = 1.290 \times PNO3 \qquad \text{(Eq. 3.10)}$$
$$[OC] = POA + SOA1 + SOA2 + SOA3 + SOA4 + SOA5 \qquad \text{(Eq. 3.11)}$$
$$[EC] = PEC \qquad \text{(Eq. 3.12)}$$
$$[Soil] = FPRM + FCRS \qquad \text{(Eq. 3.13)}$$
$$[Coarse\ Mass] = CPRM + CCRS \qquad \text{(Eq. 3.14)}$$

Delta deciviews will be calculated using two methods. First, Eq. 3.15 (in combination with Eqs. 3.1 - 3.14) will be implemented in comparison of a given scenario run with the basecase simulation. As these results are not indicative of natural background conditions, (however, they do provide a more realistic perspective regarding the actual visibility impairment caused by a BART facility), a second method will be pursued.

$$\Delta dv = 10 \cdot \ln\left(\frac{b_{basecase}}{10}\right) - 10 \cdot \ln\left(\frac{b_{scenario}}{10}\right) \qquad \text{(Eq. 3.15)}$$

The second method requires that the change in the speciated (24-hour averaged) concentrations between the basecase and scenario runs be calculated. These speciated

differences will be used to calculate the B_{ext} associated with the source(s), as specified in Eqs. 3.16 - 23. The natural background total B_{ext} will then be calculated (as in Eq. 3.1) using the speciated natural background concentrations from Table 1 and Class I area specific f(rh) values. Through Equation 3.23, a delta deciview value will then be calculated. These methods will be repeated in the computation of impacts against the 20 percent best natural background conditions.

$$b_{source} = b_{SO4} + b_{NO3} + b_{OC} + b_{EC} + b_{soil} + b_{coarse} \quad \text{(Eq. 3.16)}$$

$$b_{SO4_{source}} = 3 \cdot f(rh) \cdot 1.375 \cdot \left([SO_4]_{background} - [SO_4]_{scenario}\right) \quad \text{(Eq. 3.17)}$$

$$b_{NO3_{source}} = 3 \cdot f(rh) \cdot 1.290 \cdot \left([NO_3]_{background} - [NO_3]_{scenario}\right) \quad \text{(Eq. 3.18)}$$

$$b_{OMC_{source}} = 4 \cdot \left([OMC]_{background} - [OMC]_{scenario}\right) \quad \text{(Eq. 3.19)}$$

$$b_{EC_{source}} = 10 \cdot \left([EC]_{background} - [EC]_{scenario}\right) \quad \text{(Eq. 3.20)}$$

$$b_{SOIL_{source}} = 1 \cdot \left([SOIL]_{background} - [SOIL]_{scenario}\right) \quad \text{(Eq. 3.21)}$$

$$b_{CM_{source}} = 0.6 \cdot \left([CM]_{background} - [CM]_{scenario}\right) \quad \text{(Eq. 3.22)}$$

$$\Delta dv = 10 \cdot \ln\left(\frac{b_{source} + b_{natural}}{b_{natural}}\right) \quad \text{(Eq. 3.23)}$$

The above methods will be applied to all CAMx grid cells containing any portion of one of the seven Class I areas previously mentioned. In summary, the procedures are designed to remain consistent with EPA's BART modeling guidance (EPA, 2005a) and the Federal Land Managers Air Quality Related Values Workgroup report (FLAG, 2000).

Finding no maximum delta-deciview values greater than 0.5 (from any of the three methods) will likely lead to state-wide exemption of the BART sources involved in the given scenario. Should initial cumulative modeling quantify delta-deciview impacts exceeding 0.5 deciviews, evaluation refinement will occur. These methods will include examination of all available data through a composite matrix. For each BART eligible source, information regarding Q/d analyses, CALPUFF model plant evaluation, and CAMx results will be assembled and utilized in a weight-of evidence approach in the final subject-to-BART determination. If a unit is not clearly identifiable as either subject or exempt from the BART determination process, further review through case-by-case CALPUFF modeling procedures, refinement in CAMx modeling (such as emission inventory adjustment), or alternative (EPA approvable) techniques, may be utilized.

4. PM, VOCS, AND NH3

OVERVIEW

The BART Guidelines list the following species as visibility-impairing: SO2, NOx, particulate matter, volatile organic compounds (VOCs), and ammonia (NH3). Visibility impairment attributable to SO2 and NOx emissions are explicitly addressed in all the above methods. However, visibility-impacts attributable to particulate matter, VOCs, or NH3 are not directly quantifiable in all the above methods. The following discussion addresses this deficiency.

PM

While CAIR satisfies BART for SO2 and NOx, particulate matter emissions must still be addressed for electrical generating units. Returning to the CALPUFF model plant analysis, a simulation in which 10,000 tpy of PM (conservatively modeled as PM2.5) shows no impact upon nearby Class I areas at the 98th percentile (Figure 7). Maximum impacts above 0.5 dv are observed, but occur primarily when the 20 percent best natural background conditions are considered. Tempering the results against observed Iowa EGU PM emissions, actual (facility wide) emissions[4] from Iowa's largest PM source (an EGU) totaled 3758 tpy, approximately 62% less than the levels applied in the model plant. Based upon these results we conclude that EGU PM emissions from Iowa BART sources will not cause or contribute to visibility impairment at any nearby Class I areas. Additionally, as PM emissions from non-EGU BART eligible sources remain below those of the EGU's, the aforementioned conclusion is also applicable to Iowa's non-EGU BART eligible units.

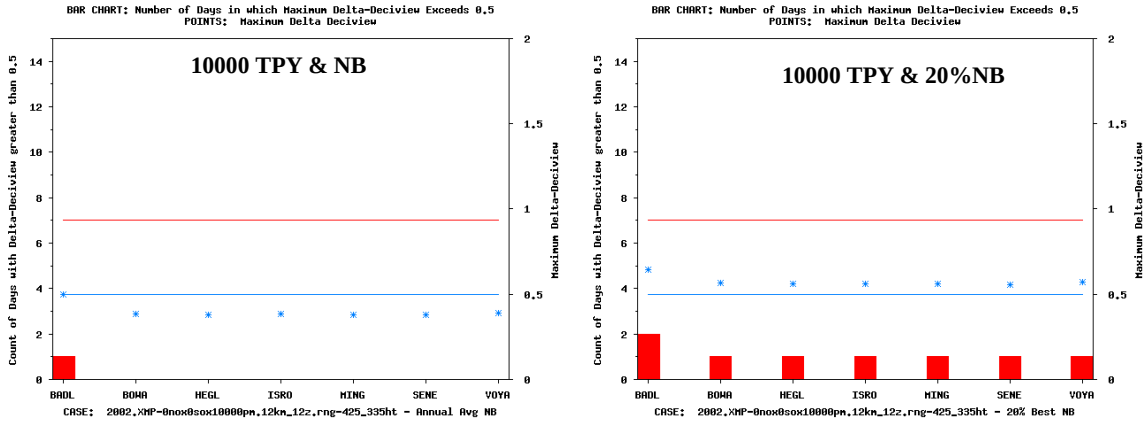

Figure 7. Delta deciview impacts from two Iowa Model Plant configurations: results for year 2002 from the model plant with emissions of: 0 tpy SO2, 0 tpy NOX and 10,000 tpy PM2.5, as compared against annually averaged natural background (NB) conditions and 20% best natural background conditions.

[4] Emissions inventory data from 2004 was consulted.

VOCs AND NH3

Citing 70 FR 39160 (the BART Guidelines):

> "[States] should use [their] best judgment in deciding whether VOC or ammonia emissions from a source are likely to have an impact on visibility in an area. Certain types of VOC emissions, for example, are more likely to form secondary organic aerosols than others. Similarly, controlling ammonia emissions in some areas may not have a significant impact on visibility. You need not provide a formal showing of an individual decision that a source of VOC or ammonia emissions is not subject to BART review. Because air quality modeling may not be feasible for individual sources of VOC or ammonia, you should also exercise your judgment in assessing the degree of visibility impacts due to emissions of VOC and emissions of ammonia or ammonia compounds. You should fully document the basis for judging that a VOC or ammonia source merits BART review, including your assessment of the source's contribution to visibility impairment."

Accordingly, the IDNR proposes that quantitative analyses of emissions inventory data provides sufficient evidence to conclude that Iowa point source NH3 or VOC emissions do not cause or contribute to any visibility impairment in any Class I area. A simple scale analysis demonstrates that point source emissions of ammonia are insignificant in comparison to other ammonia source types. Iowa point source NH3 emissions totaled 3,366 tpy in 2002. Area source emissions were approximately seventy-seven times higher, at 259,640 tpy (Figure 8). Similarly, VOC emissions from Iowa BART sources comprised only 4% of the total (anthropogenic plus biogenic) 2002 VOC inventory (Figure 9). Therefore, point source ammonia and VOC emissions will not be evaluated for visibility impacts.

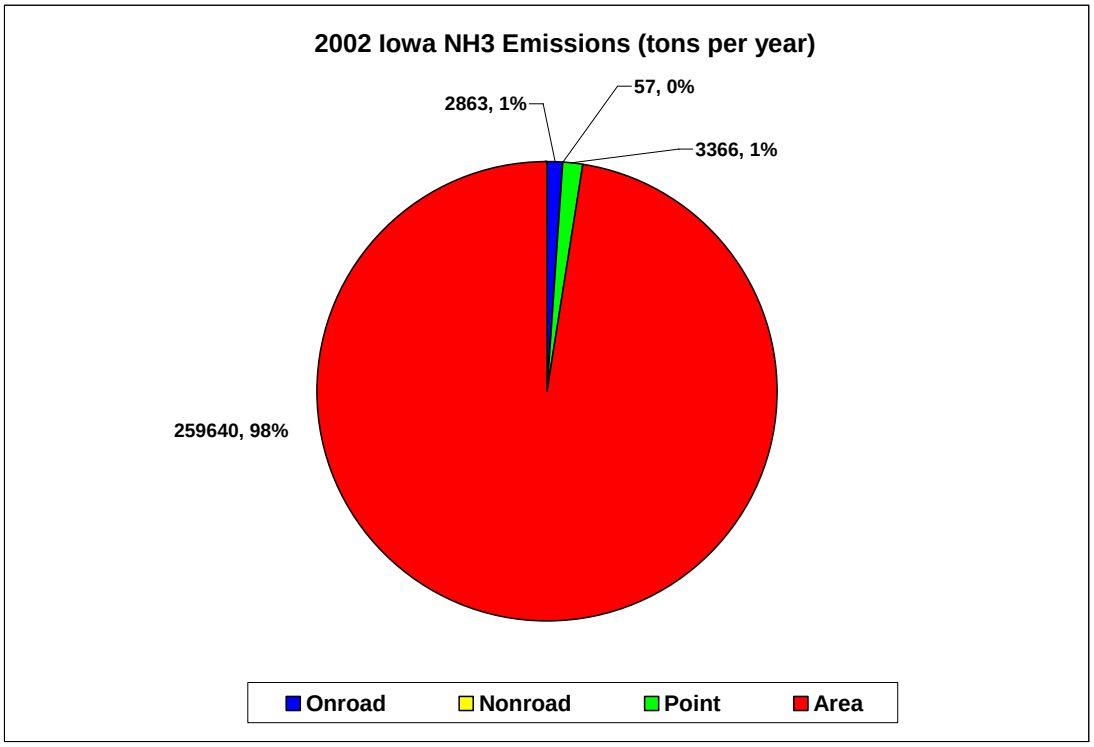

Figure 8. Distribution of the 2002 Iowa ammonia emission inventory by source category.

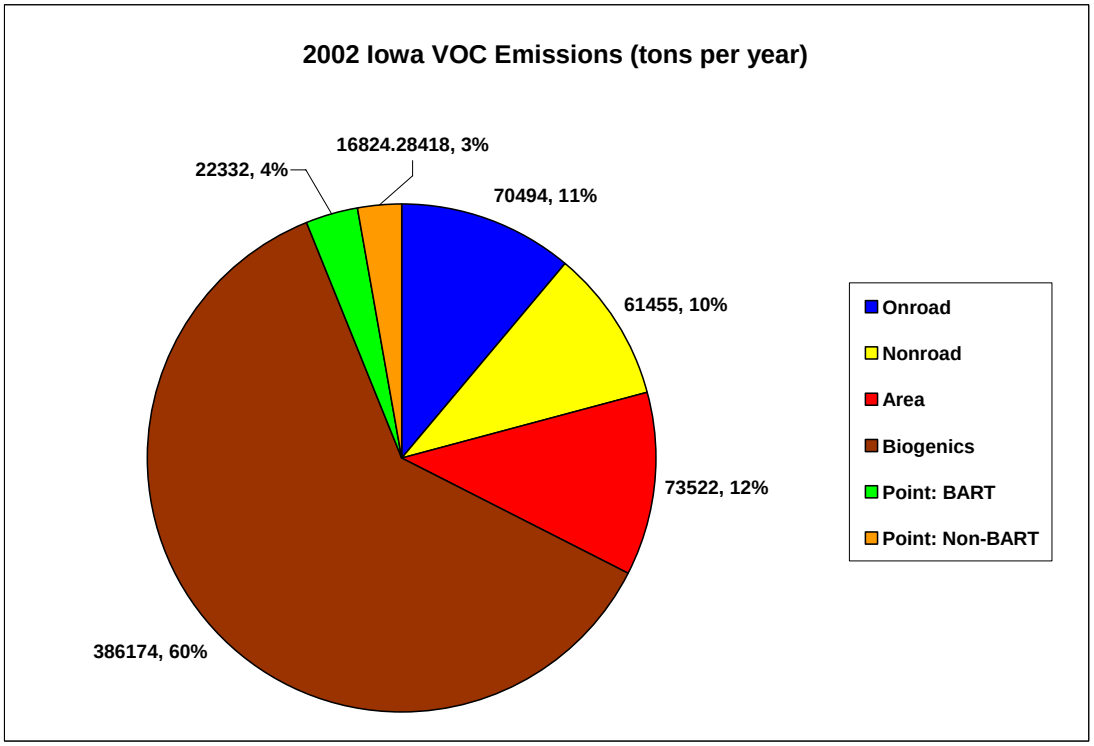

Figure 9. Distribution of the 2002 Iowa VOC emission inventory by source category.

5. SUMMARY

As described above, the subject to BART determinations will occur through a multi-faceted assessment. No single tool is currently available which is capable of accurately assessing single source impacts over transport distances in the 500 km range. Implementation of the Q/d, CALPUFF, and CAMx tools provides the State of Iowa with an array of analyses which can be cross referenced in derivation of sound BART determinations.

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