INTERNATIONAL PAPER

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Augusta, GA 30906
706-798-5711

April 28, 2006

Mr. Peter Courtney
Environmental Protection Division
Georgia Department of Natural Resources
4244 International Parkway, Suite 120
Atlanta, GA 30354

Subject: BART Modeling Protocol for the International Paper Augusta, GA Pulp and Paper Mill

Dear Mr. Courtney:

Please find attached for your review the International Paper (IP) Augusta Mill's Protocol for the Application of the CALPUFF Model in Support of the Best Available Retrofit Technology (BART) Regulation – 40 CFR 51.300 and Appendix Y. This protocol was prepared at the request of the Georgia Environmental Protection Division (EPD) in order to document the modeling procedures that will be used to perform CALPUFF dispersion modeling in support of the EPA BART regulation. IP is proposing to perform modeling analyses to determine whether air emissions from potentially BART eligible emission units at the IP Augusta Pulp and Paper mill cause or contribute to regional haze in any Class I area within 300 kilometers of the mill as defined by 40 CFR 51, Appendix Y.

It is our understanding that you will provide us with any comments on this protocol by June 15, 2006. If our modeling analysis shows that the Augusta Mill is not exempt from performing a BART control technology analysis, we will move forward with the BART evaluation for submittal later this year.

We would like to point out that the protocol does contain some alternative modeling methodologies in Section 7.0 of the protocol. IP provided detailed comments on the draft VISTAS protocol in October 2005 and these alternative methodologies were addressed. However, IP never received a response from VISTAS on our comments, thus, we are including these alternatives in this proposal for your consideration. These alternatives are technically sound and provide a more realistic assessment of our mill's impact at Class I areas.

If you have any questions or comments regarding the attached protocol, please contact me at (706) 796-5363 or Mr. Randy Taylor of URS Corporation at (919) 461-1520.

Sincerely,

Jeremy Pearson
Environmental Performance Manager

Enclosure

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

International Paper

Augusta, Georgia

Prepared by:

URS

URS Corporation
1600 Perimeter Park Drive, Suite 400
Morrisville, North Carolina 27560

April 2006

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

International Paper
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Morrisville, North Carolina 27560

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1.0 Introduction

International Paper (IP) has retained URS Corporation (URS) to prepare this *Protocol for the Application of the CALPUFF Model in Support of the Best Available Retrofit Technology (BART) Regulation – 40 CFR 51.300 and Appendix Y*. This protocol was prepared at the request of the Georgia Department of Natural Resources, Environmental Protection Division (Georgia DNR) in order to document the modeling procedures that will be used to perform CALPUFF dispersion modeling in support of the EPA BART regulation. IP is proposing to perform modeling analyses to determine whether air emissions from potentially BART eligible emission units at the IP Augusta, Georgia pulp and paper mill cause or contribute to regional haze in any Class I area within 300 kilometers of the mill as defined by 40 CFR 51, Appendix Y. The following provides a regulatory background of the BART regulation and a summary of the modeling procedures detailed in this protocol.

The Clean Air Act established goals for visibility in many national parks and wilderness areas. Through the 1977 amendments to the Clean Air Act, Congress set a national goal for visibility as "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution." The Amendments required EPA to issue regulations to assure "reasonable progress" toward meeting the national goal.

In 1980, EPA promulgated regulations to address the visibility issues that are "reasonably attributable" to a single source or small group of sources. In 1988, the States, Federal Land Managers (e.g., National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management), and EPA began monitoring of fine particle concentrations and visibility in 30 national parks and wilderness areas across the country.

The Clean Air Act Amendments of 1990 required EPA to take regulatory action on regional haze and they proposed the Regional Haze Regulations in July 1997 in conjunction with issuing new national ambient air quality standards for fine particulate matter.

On July 1, 1999, EPA promulgated the final Regional Haze Regulation. The final Regional Haze Regulation calls for state and federal agencies to work together to improve visibility in 156 national parks and wilderness areas in the United States by developing and implementing long-term air quality protection plans to reduce the pollution that causes visibility impairment in these protected areas.

The Regional Haze regulation provides States flexibility in determining reasonable progress goals for protected areas by conducting certain analyses to ensure that they consider the possibility of setting an ambitious reasonable progress goal, one that is aimed at reaching natural background conditions by the year 2064. The regulation requires States to establish goals for each affected area to (1) improve visibility on the haziest days, and (2) ensure no degradation occurs on the clearest days over the period of each implementation plan.

The Regional Haze regulation also requires States to develop long-term strategies including enforceable measures designed to meet reasonable progress goals. The first long-term strategy will cover 10 to 15 years, with reassessment and revision of those goals and strategies in 2018 and every 10 years thereafter. State's strategies will address their contribution to visibility problems in Class I areas both within and outside the State.

One of the principal elements of the visibility protection provisions of the Clean Air Act addresses installation of best available retrofit technology (BART) for certain existing sources. "BART-eligible" sources are those sources built between 1962 and 1977 that have the potential to emit more than 250 tons per year of one or more visibility-impairing compounds including sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), and volatile organic compounds (VOCs), and that fall within 26 industrial source categories (including Kraft pulp and paper manufacturing).

Soon after the Regional Haze Regulation was finalized, several parties filed petitions to challenge the rule with the U.S. Court of Appeals for the D.C. Circuit. In April 2004, EPA Administrator Mike Leavitt signed a proposed amendment to the 1999 Regional Haze Regulation. The proposed rule satisfied the terms of a May 2002 ruling by the U.S. Court of Appeals for the D.C. Circuit, which vacated parts of the BART provisions of the 1999 Regional Haze Regulation (*American Corn Growers et. al. v. EPA*, 291 F. 3d 1 (D.C. cir. 2002).

The rule requires states to consider the visibility impacts of an individual facility when determining whether they have to install controls, and what those controls would be. The final BART implementation and guidance rule (40 CFR Part 51, Appendix Y) was published on July 6, 2005 and it allows for a BART evaluation for any BART-eligible source that "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area.

Pursuant to the rule, States have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling demonstrating that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. Regional Planning Organizations (RPOs), such as the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) have prepared guidance for performing the dispersion modeling analyses. According to 40 CFR Part 51, Appendix Y, a BART-eligible source is considered to "contribute" to visibility impairment in a Class I area if the modeled 98^{th} percentile change in deciviews (dv) is equal to or greater than the "contribution threshold." Any BART-eligible source determined to cause or contribute to visibility impairment in any Class I area is subject to a BART evaluation.

The *Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART)*, December 22, *2005*, was prepared by the VISTAS RPO to provide some common protocol guidance for performing conservative BART exemption and determination modeling evaluations as allowed by the regulation.

It should be noted that the final BART rule defines a "contribution threshold" of 0.5 dv as the value where a modeled BART eligible source may "contribute" to visibility impairment and the threshold to determine whether a single source "causes" visibility impairment is set at a 1.0 dv change from natural conditions (background visual range) over a 24-hour averaging period in the final BART rule (70 FR 39118). An approximate 1.0 deciview change was defined by Pitchford and Malm (1992) as a "just noticeable change" to the observer when the background visual range equals the line of sight of the observer. According to L. Willard Richards in "Use of the Deciview Haze Index as an Indicator for Regional Haze" if a shorter line of sight distance than the background visual range (natural conditions) is used in performing the calculations then a higher extinction value, or deciview, is needed to cause a "just noticeable change." In other words, when the line of sight is less than the background visual range, then it would require a higher deciview value in order to be a "just noticeable change." However, this protocol uses a conservative modeling approach as defined by the VISTAS protocol by comparing the extinction changes from a single source at Class I area receptors only (not along the line of sight) to the background visual range (natural conditions) in order to compare to the 0.5 deciview change threshold. We are also proposing in this protocol to use the refined line-of-sight modeling approach if needed in order to better determine the actual impact that a single source would have on natural visibility conditions in a Class I area (Section 7.0).

1.1 Objective of Protocol

The VISTAS States have accepted EPA's guidance to use the CALPUFF modeling system to comply with the BART modeling requirements of the regional haze rule. This protocol is intended to satisfy the BART requirement that a BART-eligible source must submit a site-specific modeling protocol to the State for review and approval prior to performing CALPUFF modeling. Many of the methods and procedures recommended in the VISTAS common modeling protocol will be followed for modeling and the results will be presented in the standard recommended format.

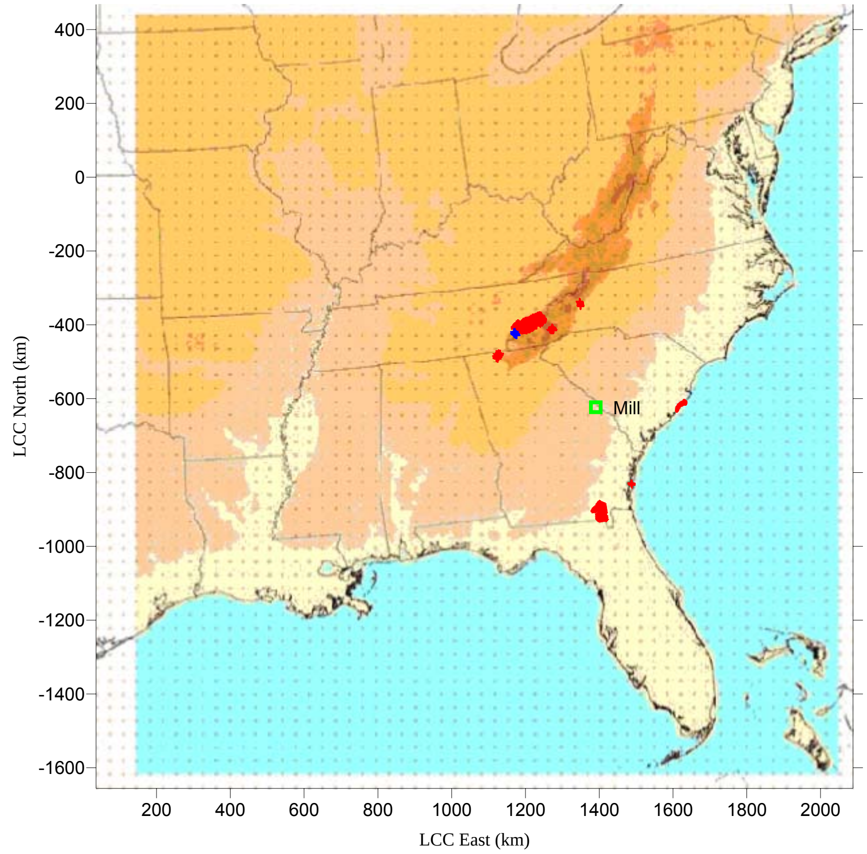
IP is also proposing to conduct more refined CALPUFF modeling to better quantify the estimated impact of the mill's potentially BART-eligible units on regional haze as necessary. The refined modeling procedures, including examples, and the justification for these procedures are presented in this protocol. IP Augusta requests that Georgia DNR carefully evaluate and approve these modeling procedures or provide detailed comments to IP regarding why these procedures are not acceptable. IP Augusta and our environmental consultant, URS Corporation are willing to discuss these procedures in greater detail with the Georgia DNR and supply additional material demonstrating why these modeling procedures are appropriate for calculating changes in regional haze from individual point sources.

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

1) Air Quality modeling to determine whether a potentially BART-eligible source is exempt from a BART control technology evaluation.
2) Air Quality modeling of emissions from all BART-eligible sources that are required to perform a BART control technology evaluation for the purpose of determining the relative benefits of potential alternative control options as it pertains to reducing regional haze in Class I areas.

1.2 Facility Location and Relevant Class I Areas

The International Paper Augusta, Georgia pulp and paper mill is located at 4278 Mike Padgett Highway near Augusta, Georgia. The Universal Transverse Mercator (UTM) coordinates, in kilometers (km), for the mill are Zone 17, 411.300 East and 3688.200 North. The approximate Lambert Conformal Conic (LCC) coordinates are 1390.566 km East and -623.286 km North. There are eight (8) Class I areas within 300 kilometers of the Augusta Mill: Cape Romain, Okefenokee and Wolf Island National Wildlife Refuge Areas, Shining Rock, Linville Gorge, Joyce Kilmer/Slickrock and Cohutta Wilderness Areas and the Great Smoky Mountains National Park. Figure 1-1 displays the location of the mill and the eight Class I areas. Cape Romain is located approximately 219 kilometers east of the mill, Wolf Island is located approximately 226 kilometers southeast of the mill, Okefenokee is located 254 kilometers south of the mill, Shining Rock is located 236 km northwest of the mill, Great Smoky Mountains is located 268 kilometers northwest of the mill, Linville Gorge is located 275 kilometers north of the mill, Joyce Kilmer/Slickrock is located 289 kilometers northwest of the mill and Cohutta is located 294 kilometers northwest of the mill.



URS	**URS Corporation – North Carolina** *1600 Perimeter Park Drive Suite 400* *Morrisville, North Carolina 27560* *Telephone (919) 461-1100 Fax (919) 461-1415*		International Paper – Augusta **Facility Location Relative to Class I Areas**	FILE NO. 31825278
	SCALE:	DRAWN BY: SCL	DATE:	FIG. NO. 1-1
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1.3 Source Impact Evaluation Criteria

To assess whether the IP Augusta Mill is exempt from performing a BART control technology evaluation, a two-tiered modeling approach is being proposed. For the initial exemption modeling, the CALPUFF model will be used with 12-km grid CALMET data in a screening mode. If the initial modeling results show haze impacts less than the recommended visibility threshold value of 0.5 dv, no further modeling would be necessary. If the initial 12-km grid modeling results show haze impacts greater than the recommended visibility threshold of 0.5 dv, then a finer resolution 4-km CALMET meteorological grid will be used in the CALPUFF modeling. If the finer resolution modeling results show haze impacts less than the visibility threshold on 0.5 dv, then no further modeling would be necessary. All modeling results will be presented in detail in a report that will be submitted to Georgia DNR for review and approval.

If the initial 12-km grid model greatly exceeds the recommended threshold or finer grid modeling results exceed the recommended threshold then BART determination CALPUFF modeling will be conducted using finer resolution CALMET data. It is expected that Georgia DNR will accept EPA guidance that the threshold value to establish that a source contributes to visibility impairment is 0.5 deciview.

Since the EPA BART guidance rule specifically states that modeling results should be based on the 98^{th} percentile value, we are proposing that the 98^{th} percentile be applied to all CALPUFF modeling results. Thus, for the 12-km initial modeling exemption analysis, the 24-hour 98^{th} percentile value across all receptors in the Class I area will be compared to the threshold value of 0.5 dv. If the 24-hour 98^{th} percentile value is below 0.5 dv, then IP Augusta will be exempt from performing a BART evaluation. If the 24-hour 98^{th} percentile value is greater than 0.5 dv, then IP may choose to perform finer grid modeling for exemption purposes or use the alternative modeling approaches described in Section 7 of this protocol.

URS will use the 12-km modeling results to focus finer grid modeling for exemption purposes on only those Class I areas where impacts greater than 0.5 dv are projected in the 12-km modeling.

For finer grid (4 km or less) analyses, the 98^{th} percentile value for the 24-hour average will also be used.

1.4 General Overview of the CALPUFF Modeling System

The CALPUFF modeling system consists of four main processors: CALMET, CALPUFF, POSTUTIL and CALPOST. CALMET is the meteorological model that generates hourly three-dimensional meteorological fields of variables such as wind and temperature. CALPUFF simulates the transport, dispersion, and transformation of compounds emitted from a source and calculates hourly concentration values for visibility impairing compounds at each receptor located in the modeling domain. POSTUTIL can perform many post processing tasks on the CALPUFF output data file. CALPOST calculates time-averaged concentration values from the CALPUFF predictions and performs regional haze calculations like those described in the Section 6.1 of this protocol.

2.0 BART Source Descriptions

The IP Augusta Mill is located near Augusta, Georgia, along the Savannah River. The primary activities at Augusta Mill are pulp production (Standard Industrial Classification [SIC] code 2611) and paperboard production (SIC code 2631). The Mill began operations in 1960. Primary operations at the mill include multiple fuel-fired boilers, chemical recovery operations, wood pulping and bleaching operations, papermaking, and additional operations and equipment necessary to support these operations. The facility currently employs over 750 people, and produces a nominal 750,000 tons per year of coated bleached board used for greeting cards, pharmaceutical and foodservice packaging, and cigarette packaging.

2.1 Unit Specific Source Data

The emission estimates used in the CALPUFF model are intended to reflect steady-state operating conditions during periods of high capacity utilization. Consistent with the VISTAS common protocol, modeled emissions will not include periods of start-up, shutdown, and malfunction. The modeling will be based on the 24-hour average actual emission rate from the highest emitting day during the most recent 3-year period. The following hierarchy for developing the emission estimates will be used for the IP Augusta mill:

- Continuous Emissions Monitoring (CEM) data;
- Facility emissions tests;
- Emission factors;
- Permit limits; or
- Potential to emit.

The Augusta Mill will develop emission estimates based on source testing and accepted emission factors used for routine annual emissions reporting. In general, the following emission rates will be used:

- Short-term (24-hours) allowable emission rates (e.g., emission rates calculated using the maximum rated capacity of the unit);

- Federally enforceable short-term limits (24-hours); or

- Peak 24-hour actual emission rates (or calculated emission rates) from the most recent 3-years of operation that account for “high capacity utilization” during normal operating conditions and fuel/material flexibility allowed under the existing air permit. In situations where a unit is allowed to use more than one fuel, the fuel resulting in the highest emission rates will be used for the modeling as long as it represents a realistic fuel firing scenario.

Short-term emission rates (24-hours) for SO_2, NO_x, H_2SO_4 mist, and PM_{10} (including condensable and filterable direct PM_{10}) will be modeled since visibility changes are calculated for a 24-hour averaging period. All BART-eligible emission units at the mill that emit these compounds will be modeled together in the CALPUFF model.

Listed below is a brief description of all the BART-eligible emission units at the mill:

- No. 2 Power Boiler (PB2A): This boiler fires pulverized coal, No. 6 fuel oil, natural gas, and used oil. The No. 2 Power Boiler also serves as a backup control device for the non-condensable gas (NCG) system. The No. 2 Power Boiler nominal throughput is 532 MMBtu/hr when firing pulverized coal, 600 MMBtu/hr when firing No. 6 fuel oil, and 677 MMBtu/hr when firing natural gas. The unit is controlled by an electrostatic precipitator.
- Riley Auxiliary Boiler (RLYA): The Riley Auxiliary Boiler is permitted to operate only when one of the primary boilers or recovery boilers is offline. This package boiler fires No. 2 fuel oil or natural gas. The Riley Boiler nominal throughput is 220 MMBtu/hr when firing either No. 2 fuel oil or natural gas.
- No. 2 Recovery Boiler (RB2A): This direct contact evaporator (DCE) recovery boiler fires black liquor solids, with No. 6 fuel oil or natural gas as auxiliary fuels. The No. 2 Recovery Boiler nominal throughput is 2.0 million pounds of black liquor solids per day, 460 MMBtu/hr when firing No. 6 fuel oil, and 100 MMBtu/hr of natural gas. The unit is controlled by an electrostatic precipitator.
- No. 2 Smelt Dissolving Tank (ST2A): This smelt dissolving tank receives smelt from the No. 2 Recovery Boiler. This unit is controlled by a wet scrubber.
- No. 2 Paper Machine (PM2A): This paper machine is equipped with 28 infrared (IR) heaters (1.1 MMBtu/hr each) and 2 aircap heaters (rated at 3.4 and 8.0 MMBtu/hr) that are natural gas fired.
- No. 1 Slaker/Causticizer (CAU1): The No. 1 Slaker/Causticizer has a maximum throughput of 13 tons CaO per hour. The slaker vent duct is equipped with a liquid spray nozzle, but this is not considered a formal air pollution control device.

The following BART-eligible units do not emit SO_2, NO_x, H_2SO_4 mist, or PM_{10} and will not be modeled.

- No. 2 Brownstock Washer
- No. 2 Screens

Tables 2-1 and 2-2 provide detailed stack parameter information for the modeled BART-eligible emission units at the mill.

2.2 Tabulated Source Data

TABLE 2-1
BART ELIGIBLE EMISSION UNITS - POINT SOURCE PARAMETERS
INTERNATIONAL PAPER, AUGUSTA, GEORGIA
URS PROJECT NO. 31825278

Model ID	Source Description	UTM Easting (m)	UTM Northing (m)	LCC Easting (km)	LCC Northing (km)	Base Elevation (m)	Stack Height (m)	Temperature (°K)	Exit Velocity (m/s)	Stack Diameter (m)
PB2A	No. 2 Power Boiler	411316.00	3688176.25	1390.566	-623.286	50.5	60.96	518.7	20.6	2.74
RB2A	No. 2 Recovery Boiler	411375.41	3688129.25	1390.566	-623.286	50.5	60.96	430.93	21.8	2.44
ST2A	No. 2 Smelt Dissolving Tank	411313.84	3688110.25	1390.566	-623.286	50.5	39.40	336.7	17.8	1.05
RLYA	Riley Boiler	411268.39	3688148.25	1390.566	-623.286	50.5	36.58	TBD	TBD	TBD
CAU1	No. 1 Slaker/Causticizer	411373.9	3688026.5	1390.566	-623.286	50.5	11.58	TBD	TBD	TBD

TBD – These parameters to be determined and included in the BART exemption modeling.

TABLE 2-2
BART ELIGIBLE EMISSION UNITS - VOLUME SOURCE PARAMETERS
INTERNATIONAL PAPER, AUGUSTA, GEORGIA
URS PROJECT NO. 31825278

Model ID	Source Description	UTM Easting (m)	UTM Northing (m)	LCC Easting (km)	LCC Northing (km)	Base Elevation (m)	Release Height (m)	Horizontal Dimension (m)	Vertical Dimension (m)
PM2A	No. 2 Paper Machine	411142.09	3688250.00	1390.566	-623.286	50.5	19.5	14.84	9.08

3.0 Geophysical and Meteorological Data

URS will use the geophysical and meteorological data developed by VISTAS for initial 12-km and 4-km BART exemption modeling. The development of this information is discussed in detail in the VISTAS common protocol.

In the event that source-specific fine-scale (<4-km grid) modeling is needed, a revised protocol would be submitted to the Georgia DNR for review and comment. Since the scope of this modeling cannot be determined, the exact configuration of any refined modeling domain also cannot be determined. Since domain placement and grid size selection cannot be determined until either 12-km or 4-km grid modeling has been completed, a detailed discussion cannot be presented at this time describing a more refined modeling domain and the interactions of terrain, land use, MM5 data, observational data, monitoring data and other parameters. In the event a more refined modeling domain is developed, a revised protocol will be prepared and submitted to the Georgia DNR for review and comment using the following outline to discuss the use of geophysical and meteorological data.

- 3.1 Modeling Domain and Terrain
- 3.2 Land Use
- 3.3 Meteorological Data Base
  - 3.3.1 MM5 Simulations
  - 3.3.2 Measurements and Observations
- 3.4 Air Quality Data Base
  - 3.4.1 Ozone Concentrations-Measured
  - 3.4.2 Ammonia Concentrations – Measured
  - 3.4.3 Concentration of Other Pollutants – Measured
- 3.5 Natural Conditions at Class I Areas

4.0 CALPUFF Modeling Methodology

Initial CALPUFF modeling will be performed using a screening level approach in order to efficiently and conservatively determine whether the Augusta Mill can be exempted from a BART evaluation. The screening method described in this section will help identify specific Class I areas that might be most affected by emissions from BART eligible emission units located at the Augusta Mill. It will also supply useful information on whether performing a more time consuming and refined "source-specific" analysis would be beneficial. Should source-specific modeling become necessary, this information will assist URS in tailoring the modeling domain to focus on the areas of greatest concerns.

CALPUFF modeling will be performed using a standard set of default meteorological, air quality and dispersion conditions that have been developed by VISTAS for a 12- and 4-km gridded CALMET domain. These data were developed to be consistent with recommendations developed by the Interagency Workgroup on Air Quality Modeling (IWAQM, 1998) and FLAG (2000).

As mentioned earlier, the results from the CALPUFF screening analysis has a high degree of conservatism (i.e., systematic tendency to over-predict visibility impacts) as compared to a source-specific methodology. Therefore, predicted impacts on visibility impairment will be overstated by using these screening modeling methodologies.

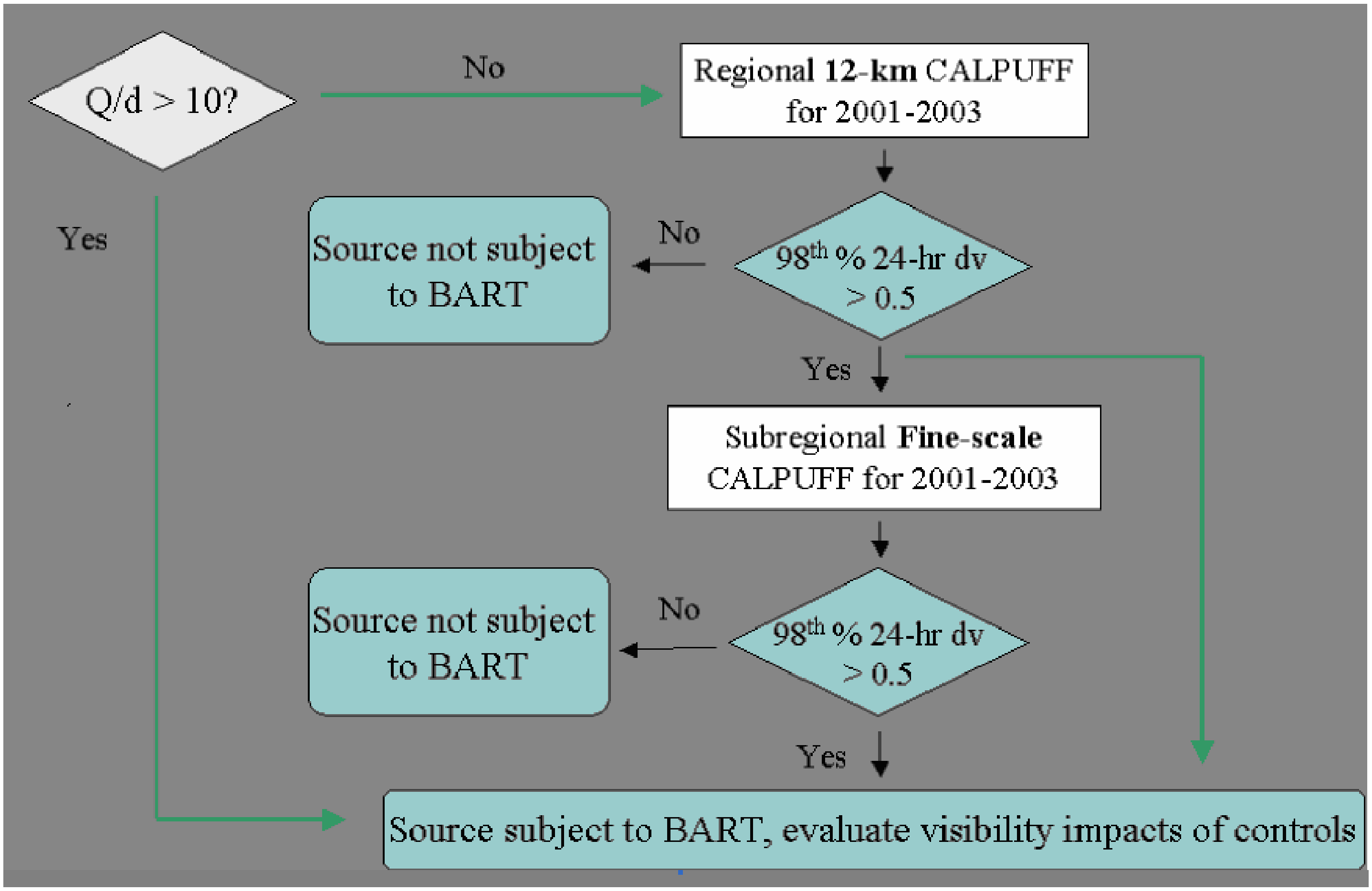
4.1 Methodology

The screening level methodology will use the CALPUFF model with three years of meteorological data with the standard compliment of model algorithms invoked and will use the most conservative of all the conditions likely to be examined for the source in question. For example, there are many factors that influence the contribution of a source beyond just the distance to the Class I area. The frequency of winds transporting the compounds toward the Class I area may often be important to include for a reliable screening analysis. Also, a more distant Class I area downwind in the predominant wind direction from a source may receive a higher visibility impact than a closer Class I area that is infrequently downwind of the source. Further, there may be correlations between winds from certain directions and meteorological conditions conducive for higher visibility impacts. Such effects and relationships will be addressed in the screening approach.

If initial screening level 12-km CALPUFF modeling is too conservative, a less conservative modeling approach (finer grid) can and will be performed by URS using a standard set of 4-km gridded CALMET data developed by VISTAS. URS will use the 98th percentile impacts when using the 12- and 4-km data as recommended under 40 CFR 51, Appendix Y. We may also develop even more refined gridded data (< 4 km) depending on the results from standard 4-km grid modeling. All modeling will be based on using a 98th percentile value when comparing to thresholds. As discussed in Section 3.0 a detailed site-specific protocol would need to be developed and approved before proceeding with this step.

The regional haze impacts at each Class I area will be calculated from the daily visibility values for each receptor by determining the change in deciviews compared against natural visibility conditions. EPA's "Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule," EPA-454/B03-005 (September 2003) lists recommended natural visibility conditions. To determine whether IP may reasonably be anticipated to cause or contribute to visibility impairment at a nearby Class I area, the impacts predicted by CALPUFF will be compared against the pertinent natural visibility background and the threshold that has been selected. URS is also proposing refinements to the natural visibility background values as discussed in Section 7.

Figure 4-1 presents the BART modeling process flow chart that will be followed.



URS	**URS Corporation – North Carolina** *1600 Perimeter Park Drive Suite 400* *Morrisville, North Carolina 27560* *Telephone (919) 461-1100 Fax (919) 461-1415*			**International Paper – Augusta** **BART Modeling Flow Chart**	FILE NO. 31825278
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4.2 CALMET Model Configuration and Application

Sections 4.3.2 and 4.4.2 within the VISTAS common protocol discuss in detail the model configurations used to generate the common CALMET meteorological files for modeling BART eligible sources. The configuration is reported to follow the IWAQM recommendations (EPA, 1998, Appendix A), except as noted in the protocol. For CALPUFF screening and initial fine grid assessments, there is no need to compile CALMET inputs, run the CALMET model or evaluate the outputs.

The model-ready meteorological data sets have been developed by VISTAS for one large 36 (12)-km regional domain and five smaller sub-regional domains. The Augusta Mill is located in sub-regional domain number 4 depicted in the VISTAS common protocol. Figure 4-2 displays the configuration of the regional domain and the potential location of a smaller CALPUFF modeling domain.

4.3 CALPUFF Model Configuration and Application

4.3.1 Model Codes

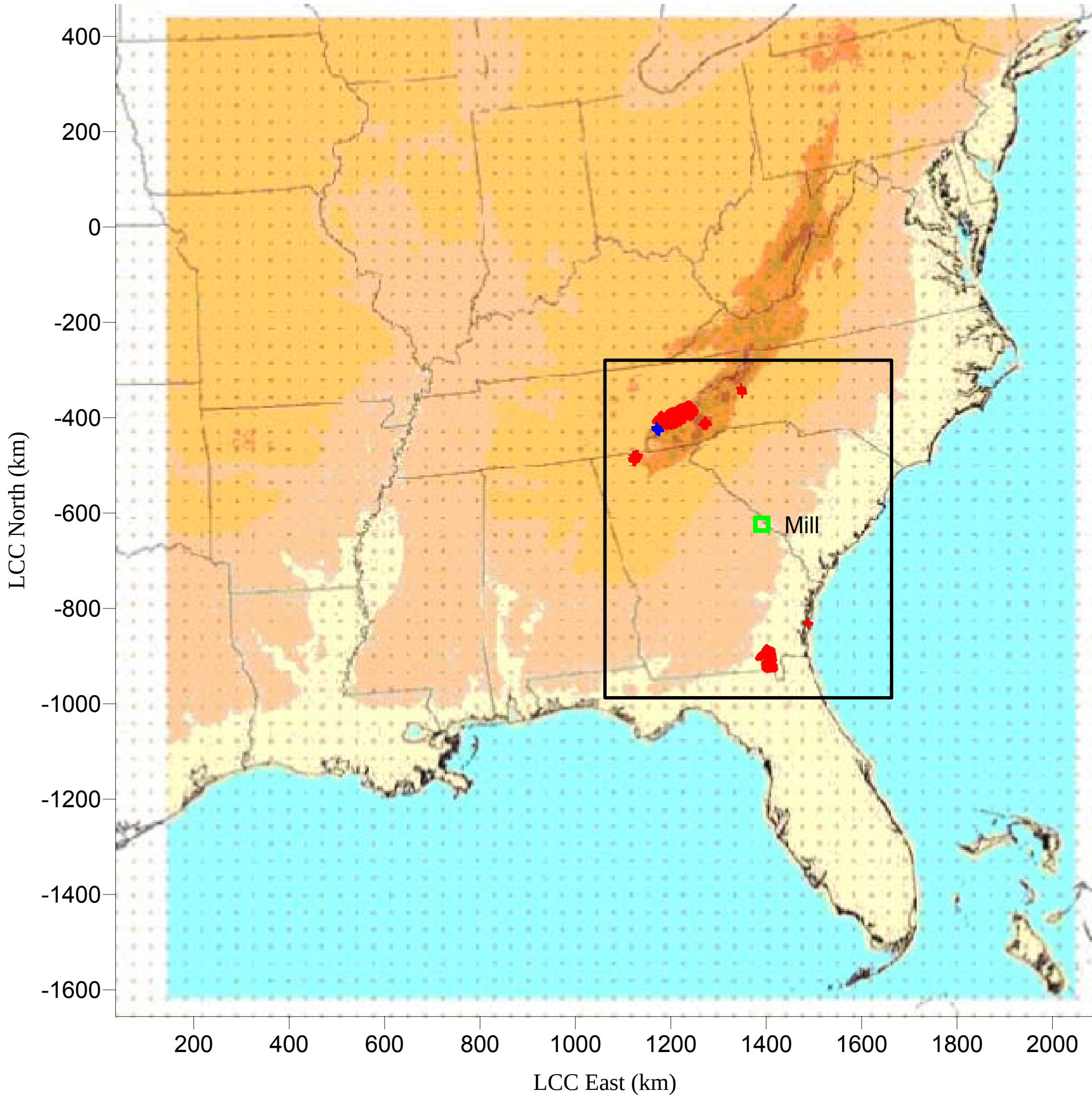
URS will use the newly released VISTAS version of the CALPUFF modeling system. This version contains enhancements funded by the Minerals Management Service (MMS) and VISTAS. This version includes CALMET, CALPUFF, CALPOST, CALSUM, POSTUTIL, and CALVIEW, and will be obtained from the CALPUFF website.

It should be noted that this model is not the EPA guideline codes but rather updated versions containing science improvements and bug fixes. (The guideline CALPUFF code is ver 5.7, level 030402). This substitution results from EPA phasing out the legacy Pasquill-Gifford (P-G) dispersion parameters with the introduction of AERMOD as a new guideline model.

CALPUFF can employ the AERMOD turbulence-based dispersion coefficients and probability density function (pdf) dispersion methods scheme instead of P-G. The appropriate model codes will be obtained and used. The sequence of model processors for all modeling is CALPUFF, POSTUTIL and finally CALPOST. CALMET and associated preprocessors are not discussed since VISTAS performed these model runs.

4.3.2 Domain Definition

The meteorological modeling data sets cover three contiguous years (2001, 2002, and 2003) and were resolved to a 12 and 4 km horizontal resolution grid using MM5 data. Details of the modeling domains and the meteorological databases for 2001, 2002, and 2003 are discussed in detail in the VISTAS common protocol.



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International Paper – Augusta

VISTAS CALMET DOMAINS with Proposed CALPUFF Sub-domain

FILE NO. 31825278

FIG. NO. 4-2

Receptor Network and Class I Receptors. Discrete receptor coordinate data for the eight Federal Class I areas within 300 km of the source were developed using the National Park Service (NPS) Convert Class I Areas (NCC) computer program. The receptor elevations provided by the NPS will be used for modeling. All receptors for each Class I area will be included in single CALPUFF simulations. Appendix D contains a listing of the Lambert Conformal coordinates for each Class I area with the associated receptor heights.

4.3.3 Model Set-Up

The modeling will use a CALPUFF computational domain that includes all applicable Class I areas within 300 km of the source and will include a 50-kilometer buffer around applicable Class I areas and the mill. The size and location of the potential 12- and 4-km CALPUFF computational domains are shown in Figure 4-2. The CALPUFF computational domains will initially include all eight Class I areas.

As depicted in Figure 4-2, the CALPUFF modeling domains are a subset of the larger regional CALMET meteorological domain. A smaller CALPUFF domain is being used to reduce the CALPUFF run times. It is expected that the CALPUFF 12-km sub domain will be approximately 324 kilometers in the east/west direction and 432 kilometers in the north/south direction. Using a 12-km grid spacing from the CALMET files, this would relate to 27 x 36 grid squares. It is expected that any potential CALPUFF 4-km sub domain will be the same size with more grid cells unless one dominant Class I area is identified. Should this occur then a smaller sub-domain may be developed which only includes the critical Class I area. Appendix A contains a summary of the input options, which will be selected when performing CALPUFF modeling.

4.3.4 Emissions Input Development

Stack Parameters. Point source stack parameters required for modeling BART-eligible units include: height of the stack opening from ground, inside diameter, exit velocity, exit gas temperature, elevation of ground, and location coordinates of the stack. Volume sources will also be evaluated.

Stack Emission Rates. Emission rates for the CALPUFF modeling analyses will be developed following EPA's BART guidance. Source terms in the initial modeling will be based on periods of high capacity utilization associated with normal operating conditions. If more accurate short-term data become available that reflects the 24-hour average actual emission rate with normal operations from the highest emitting day of the meteorological period it will be used for the modeling. Periods of start-up, shutdown or malfunctions will not be included in the modeling.

The compounds that will be included in the model include SO_2, NO_x, H_2SO_4 mist, and PM_{10} (including condensable and filterable direct PM_{10}). Compounds with emissions that are less than the de minimis levels (40 tons per year for SO_2 and NO_x and 15 tons per year for PM_{10}) will be excluded from the modeling.

In cases where a unit may burn more than one fuel, the fuel resulting in the highest short-term emission rates will be used for the modeling, as long as a reasonable scenario is represented.

Emissions Speciation. Defining an applicable PM speciation profile for the highest 24-hour average actual emissions will prove particularly challenging. However, we understand that reliable estimates are necessary given the widely varying effects of different types of particulate matter on visibility. For example, the extinction coefficient ranges in value from 0.3 to 0.6 m2/g for coarse particles, to 1.0 to 1.25 m2/g for fine inorganic particulate matter, to 1.5 to 4.0 m2/g for sulfate and nitrate precursors, to 1.8 to 4.7 m2/g for organic aerosols, and up to 8-12 m2/g for elemental carbon (Tombach and McDonald). Thus, generalized, conservative, or arbitrary assignments of particulate emissions to different pollutant categories can have a considerable influence on modeled visibility impacts attributable to a single facility.

Currently, data are quite limited on appropriate speciation of organic/inorganic and filterable/condensable emissions by source category. While speciation profiles are available for gas-and oil-fired combustion turbines and coal combustion processes, detailed profiles for the full range of BART-eligible units is lacking. In practice, except in cases where facilities operate continuous emission monitors on all affected equipment, there is likely to be limited information of regarding actual emissions on the requisite time resolution (24-hour average), much less speciation profiles for PM species.

For this reason, all PM_{10} emissions will be initially modeled in the form of elemental carbon, which has the highest PM extinction efficiency. Should the PM_{10} component become a critical factor in the visibility assessment then PM emissions may be speciated to include fine particulate matter (PMF), coarse particulate matter (PMC), soot or elemental carbon (EC), organic aerosols (SOA), and sulfate (SO_4). The effort to develop this detailed information will not be done unless necessary to better refine the modeling for the IP Augusta Mill.

URS will evaluate the relative contribution of all visibility impairing compounds including SO_4 and NO_3. Should these components by themselves prevent the facility from being exempted then no additional exemption modeling will be conducted at the screening level.

If BART determination modeling is required, a more detailed investigation into PM speciation may be required. The only PM speciation for initial screening modeling will be for H_2SO_4 emissions. Since H_2SO_4 emissions will be modeled as SO_4, this contribution to total PM will be subtracted from the PM_{10} emission rates for modeling runs.

Condensable Emissions. Condensable emissions will be considered primary fine particulate matter. For the screening assessment all condensable mass will be assigned to the < 0.48 μm category. We may also conduct a literature search to provide evidence that a different value, based on emissions testing or other reliable information is more appropriate. Using this single category maintains conservatism in the analysis where there may be uncertainty regarding the exact size of condensable PM mass. If source-specific size categories are not available, then AP-42 factors may be used for emission units where AP-42 factors are available. For emission units where AP-42 factors are not available, assumptions for partitioning will be resolved with the reviewing agencies during the review process.

Size Classification of Primary PM Emissions. Initially and as a conservative modeling assumption all PM will be modeled in the 0.48 micron category. Should a more detailed analysis be needed then URS will segregate emissions by size category. URS understands that using information from AP-42 or other reference documents that the PM size classification frequently only applies to the "filterable" PM mass. Furthermore, when modeling PM size classes, an appropriate "mass mean diameter" will be used that is within the specified particle size range. URS understands that the use of a mass mean diameter equal to the top of the range is inappropriate since it will overestimate PM deposition and possibly underestimate PM concentrations and visibility impacts.

4.3.5 Additional CALPUFF Input Information and Settings

This section discusses the procedures and input assumptions that we will follow in applying the CALPUFF model for BART exemption and determination modeling.

CALPUFF Model Options. The model options, parameter settings, and 'switches' for exercising CALPUFF for BART modeling are discussed below. Appendix A contains tables that list the default and proposed screening configurations for the BART modeling. The default configurations are from the IWAQM Phase 2 Report (EPA, 1998).

Visibility Modeling Domain. The CALPUFF domain will be configured to include the source and all Class I areas within 300 km. An additional 50 km buffer zone will be established in each cardinal direction from the source and Class I area.

Building Downwash. Building and structure information will be included for point sources subject to plume downwash.

Puff Dispersion. The EPA (1998) guidance for plume dispersion modeling will be followed therefore Pasquill-Gifford curves will be used for modeling since turbulence-based dispersion coefficients and probability density function (pdf) dispersion methods have not been approved for long-range transport modeling using CALPUFF.

Puff Representation. The default integrated puff sampling methodology will be used in CALPUFF.

Puff Splitting. There is no quantitative evidence that the horizontal and vertical puff-splitting algorithms in CALPUFF yield improved accuracy and precision in model estimates of inert or linearly reactive compounds although conceptually the methods are appealing because they mimic lateral and vertical wind speed and direction shears. Therefore puff splitting will not be invoked.

Chemical Mechanism. The MESOPUFF II module will be used for BART modeling. For the aqueous phase conversion of SO_2 to sulfate (important when the plume interacts with clouds and fog), the IWAQM defaults will be used, i.e., nighttime SO_2 loss rate (RNITE1) is assumed to be 0.2 percent per hour. The nighttime NOx loss rate (RNITE2) and HNO3 formation rate (RNITE3) are both set to 2.0 percent per hour.

Species Modeled. Species to be modeled in CALPUFF include SO_2, SO_4, NO_x, NO_3 and particulate matter. Initially all PM will be modeled in the < 0.48 µm size category. We will evaluate the relative contribution of all visibility impairing compounds including SO_4 and NO_3. If necessary, a more detailed investigation into PM speciation and size distribution may be performed.

Should initial delta dv estimates exceed the contribution threshold by a small amount, then absent more detailed speciation and size distribution data, PM will be modeled in five (5) size categories:

= < 0.625 µm,
> 0.625-1.0 µm,
> 1.0-1.25 µm,
> 2.5-6.0 µm, and
> 6-10 µm aerodynamic diameters.

Particulate matter emissions by size category will be combined wherever possible into the appropriate species for the visibility analysis. These species include (a) elemental carbon (EC), (b) fine PM or “soil” (< 2.5 µm in diameter), (c) coarse PM (between 2.5-10 µm in diameter) and (d) organics, referred to as secondary organic aerosols in the CALPOST postprocessor. If source-specific emissions factors are not available, AP-42 factors will be used to estimate the PM speciation for those source sectors for which AP-42 emissions factors have been developed. Otherwise assumptions will need to be proposed by IP and approved by the state, EPA and FLM.

Background Ozone Concentrations. Ozone concentration data for 2001-2003 from ambient AIRS/CASNET/Georgia DNR monitors located within the particular domain being modeled will be used to develop background estimates. Only non-urban ozone stations will be used in the OZONE.DAT file. Monthly average ozone background values will be computed from daytime average ozone concentrations (6 am to 6 pm average).

Background Ammonia Concentrations. A constant (0.5 ppb) value will be used for ammonia. For each applicable Class I area, CMAQ NH_3 data will be used in POSTUTIL to repartition HNO_3 and NO_3.

Other Background Concentrations. Concentrations of SO_4 and TNO_3 (HNO_3 + NO_3) from CMAQ 2001-2003 will be used for modeling.

5.0 POSTUTIL PROCESSING

POSTUTIL Parameters. User-selected options, parameter settings, and ‘switches’ for exercising POSTUTIL are presented in Appendix B. This appendix contains tables that list the proposed screening and default configurations for the BART modeling. The ammonia-limiting method (ALM) in CALPUFF (Escoffier-Czaja and Scire, 2002, 2005) repartitions nitric acid and nitrate on a receptor-by-receptor and hour-by-hour basis to account for the models systematic over-prediction due to overlapping puffs. URS will set the parameter MNIRATE=1 in POSTUTIL to implement this approximate correction in its simplest form. URS will use ammonia from CMAQ to define NH3 for each Class I area. URS will choose ammonia from either the CMAQ grid cell where the IMPROVE monitor is located or the grid cell of the centroid of the Class I area (the later in the case that the IMPROVE monitor is located outside the Class I area or there is no IMPROVE monitor.)

6.0 CALPOST PROCESSING

CALPOST Parameters. Appendix C summarizes the CALPOST post-processor options, parameters, and switches. Tables are presented containing the proposed and default configurations for the BART modeling. While all receptors will be included in a single CALPUFF simulation, URS will calculate the visibility impacts in CALPOST for each Class I area separately using the NDRECP parameter. It specifies the receptor range to be processed in CALPOST. Given the importance of the CALPOST processor to the entire BART visibility estimation a brief overview of how CALPOST calculates visibility impacts is presented in the following section.

6.1 Visibility Assessment

The recommended procedure for quantifying visibility impacts is described in detail in the VISTAS common protocol. The key point is that the light extinction coefficient (bext) can be calculated from the IMPROVE Equation as:

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

The monthly site-specific f(RH) values will be obtained for each mandatory Federal Class I Area from Table A-3 in the EPA (2003) guidance document. Then, the haze index (HI), in deciviews, will be calculated in terms of the extinction coefficient via:

$$HI = 10 \ln (b_{ext}/10)$$

The change in visibility (measured in terms of 'delta-deciviews') will then be compared against background conditions. The delta-deciview, .dv, value will be calculated from the Augusta Mill's contribution to extinction, b_{source}, and background extinction, $b_{background}$, as follows:

$$dv = 10 \ln (\{b_{background} + b_{source}\} / b_{background})$$

If the dv value is greater than the 0.5 dv threshold, then IP could contribute to visibility impairment and may be 'subject to BART' controls. If not, IP will be BART-exempt.

Visibility Impacts from BART-Eligible Sources

Visibility Impact Method. CALPOST will be run initially using Method 6 (MVISBK=6) for calculating extinction. That is, monthly f(RH) adjustment factors will be applied directly to the background and modeled sulfate and nitrate concentrations, as recommended in the BART guidelines. Note that the RHMAX parameter (the maximum relative humidity factor used in the particle growth equation) is not used when Method 6 is selected. Similarly, the relative humidity adjustment factor (f(RH)) curves in CALPOST (e.g., IWAQM growth curve and the 1996 IMPROVE curve) are not used when MVISBK is equal to 6.

Monthly average Class I area-specific relative humidity values will be employed in the extinction analysis (EPA, 2003, Table A-3). Species to be considered include SO_4, NO_3, EC, SOA (i.e., condensable organic emissions), soil, and coarse PM. With Method 6, background extinction coefficients are computed from EPA (2003) monthly estimates of concentrations of ammonium sulfate (BKSO4), ammonium nitrate (BKNO3), coarse particulates (BKPMC), organic carbon (BKOC), soil (BKSOIL), and elemental carbon (BKEC). Values for these coefficients are listed in CALPOST input group 2 contained in Appendix C. In screening analyses, the extinction due to Rayleigh scattering (i.e., the scattering of light by natural particles much smaller than the wavelength of the light) will be set to 10 Mm^{-1} (BEXTRAY = 10.0) for all modeled Class I areas.

Natural Background Light Extinction. The Appendix Y BART guidance recommends that visibility impacts should be evaluated against 'natural' background conditions. EPA (2003) describes the calculation of the annual average background extinction (in 1/Mm) for a Class I area using the area's annual f(RH) and average natural concentrations based on the area's geographic location. Annual average background extinction values (in 1/Mm) are converted to annual average Haze Index (HI) values (in deciview or dv). The average HI value is for the 20% best visibility days (B_{est} Days (dv)) is estimated from 10th percentile of the annual average HI value for a Class I area assuming a normal distribution. Thus, no average natural concentrations are provided for determining extinction for the 20% best visibility days. EPA maintains that the above definition of natural visibility baseline as the 20% best visibility days is likely to be reasonably conservative and consistent with the Regional Haze Rule goal of natural conditions.

There are major technical issues with this approach: (a) the same concentrations assumed at all Class I areas in the East or West, (b) the same concentrations assumed to occur every month of the year, and (c) fine sea salt and associated water is not included. Also, in the calculation of 20% best visibility days, the same frequency distribution is assumed for every Class I area in the East or in the West. In other words, 'one size fits all' (Tombach, 2004). But this really is not the case.

The background extinction computation with Method 6 in CALPOST involves user-supplied monthly concentrations of SO_4, NO_3, PM coarse, organic carbon, soil, and elemental carbon species. In practice, concentrations for only 2 species, SO_4 ([BKSO4]) and soil ([BKSOIL]), are supplied in the CALPOST input file to represent hygroscopic and non-hygroscopic portions of background extinction, respectively. Furthermore, the species concentrations are held constant over the annual cycle (i.e., no daily, monthly, or seasonal variation). Finally, the EPA natural background default values are defined separately for the eastern and western U.S. result in natural background extinction values that vary spatially and temporally only in response to the spatial distribution and monthly variation of climatologically-representative relative humidity values (EPA, 2003, Table A-3). Thus, the default definition of natural conditions does not take into account meteorologically caused visibility impairment.

For CALPUFF analyses, these EPA (2003) default procedures for calculation of light extinction will be used for current and natural background conditions.

To determine background extinction for the BART analysis with CALPOST, average natural concentrations that represent average natural background visibility for the best 20% days need to be determined. URS will use the approach recommended in the most current version of the VISTAS protocol.

Impact Threshold. The EPA BART guidance recommends that the threshold value for defining whether a source "contributes" to visibility impairment is 0.5 dv change from natural conditions.

BART determinations are based upon the 98th percentile of the predicted 24-hour average deciview change obtained from the CALPOST postprocessor. When 98^{th} percentile modeling is conducted the highest modeled delta deciview value for each modeling day for each modeled receptor will be determined. The value is then compared to the 0.5 dv contribution threshold value. If the value exceeds the "contribution" threshold of 0.5 dv the source will be subject to a BART evaluation. If the value is less than the "contribution" threshold 0.5 dv, the source is exempted from the BART requirements.

To conserve computational and analysis resources, the CALPUFF modeling will be performed sequentially for calendar years 2001, 2002, and 2003. URS understands that evaluation of all three years will be required to exclude a BART eligible source from the BART requirements.

Since the current regulatory version of CALPOST does not generate 98th percentile results, URS will use a modified version of CALPOST that generates a file with a full distribution of daily delta-deciview values for each receptor should source-specific modeling be performed. The Colorado Department of Public Health and Environment (CDPHE, 2005) has developed a FORTRAN processor to generate 98^{th} percentile results and it is available upon request.

7.0 ALTERNATIVE MODELING METHODOLOGY

Over the years the accepted practice for modeling a single point source for regional haze was to use the CALPUFF model and follow guidance developed by the Federal Land Manager. These FLM modeling procedures have always included many highly conservative modeling assumptions. One of these assumptions is that the delta dv value at a single "worst-case" receptor location within the Class I area is the value used to compare to the just-noticeable-change haze threshold of 1.0 dv or a 10 percent change in extinction.

URS researched the formulation of the deciview metric and discovered that it is based on a line of sight (LOS) concept. Appendix G contains a technical paper on the development and application of the dv. The LOS concept is not new and was originally discussed by the VISTAS technical consultant in the initial draft of the VISTAS Modeling Protocol dated January 31, 2005 under section 4.1.4 (Additional Technical Considerations). The draft protocol actually gave an example of how an analysis could be conducted using CALPUFF by averaging predicted change in dv along a LOS.

The following paragraphs have been extracted from the Initial Draft VISTA Modeling Protocol regarding the LOS modeling approach when using CALPUFF to estimate regional haze impacts from a single source.

Statement 1 from Initial VISTAS Draft Protocol:

"A more difficult issue to address is that CALPOST calculates the extinction coefficient at each receptor point. That value represents extinction in the vicinity of that point, but does not necessarily represent the impact of the source on extinction over any sight path, particularly

over the longer sight paths that are likely under natural conditions. The human perception of visibility takes place over sight paths, not at points.

For example, consider a 40-km sight path that represents the visual range and includes 10 CALPUFF receptor points on a 4 km grid. If there is a 10% change in extinction (a 1 dv change) at two receptors and no change at the others, the actual change in haziness over the sight path is 2% (or 0.2 dv). If, as the EPA asserts in its BART proposal, a 0.5 dv change is barely perceptible, then this change in haziness would be wholly imperceptible even though two receptor points exceed the 0.5 dv threshold!

Thus, if the scale of the plume is small compared to the visual range under natural conditions, which is likely to be the case at all but the longest transport distances (and will be especially true for the small plumes very close to the source), the change in extinction at any receptor point is not representative of the effect of the source on the ability to see through the haze. Rather, in such cases, a sight path must be selected and the average change in extinction over that sight path calculated."

Statement 2 from Initial VISTAS Draft Protocol:

"… Also, when the plume is narrow, the aerosol concentrations across it may vary considerably from one CALPUFF receptor to the next, and the concentration field is unlikely to be uniform over the distance one can see (the visual range), especially if the background is assumed to be at default natural conditions. Therefore the light extinction impact of the source will vary depending on the sight path. In such situations, this variability of the aerosol from one CALPUFF receptor to the next should be taken into account by averaging the CALPOST-calculated light extinction over all receptors along each of the sight paths of interest within a Class I area."

After our further review of the formulation of the deciview metric, URS agrees that this approach should be applicable for BART exclusion and determination analyses and URS proposes to use the LOS approach for BART modeling if initial predicted values suggest this approach would provide a more accurate representation and comparison to the 0.5 contribution threshold value.

After reviewing many ground level plume footprint plots from CALPUFF for a point source near a Class I area it was verified that a plume is not widely dispersed under "worst-case" meteorological conditions (see Appendix H). Therefore using one "worst-case" receptor location to determine if a "just noticeable change" in regional haze is occurring does not properly represent a facility's impact on the change in deciview based on the formulation of the deciview metric.

It should be noted that the deciview is properly applied for ambient monitoring studies or one atmosphere modeling that include a homogeneous mix of visibility impairing compounds resulting from a wide variety of emission sources over a large geographical region thereby causing relatively small changes in deciviews over the length of the visual range.

Therefore in order to properly apply the 0.5 deciview threshold for BART modeling, URS is proposing to conduct (if needed) additional regional haze modeling based on averaging the predicted change in deciviews along a line of receptors extending from a worst-case receptor location within the Class I area extending to a distance equal to the visual range for that day.

It should be noted, as a preliminary modeling step for either screening level or refined level modeling, URS will still conduct the standard "worst-case" receptor modeling and present results in a standard format. However if initial modeling indicates that a 0.5 deciview threshold is exceeded by a factor of 2 or less then the more refined LOS modeling approach will be used for screening and refined level CALPUFF modeling. These modeling steps have been discussed in this protocol An example of how the modeling approach will work is presented below assuming that a visual range approach is acceptable.

Maximum hourly emissions of SO_2, NO_x, filterable and condensable PM_{10} will be input to the CALPUFF model. Results from the initial VISTAS modeling will be used to determine the "worst-case" LOS receptor locations within the Class I area. CALPUFF will be used to determine the highest delta dv receptor location along the front and back edges of the Class I area. The worst-case receptor location along the front and back edges will be considered the starting points for the LOS analysis. It will be assumed that observers look into the Class I area and the LOS ends at the visual range for the 24-hour time period being investigated.

Once the worst-case receptors have been identified, several other analyses will be conducted. The initial maximum modeling results for each time period will be evaluated to determine if any of the predicted "worst-case" extinctions occurred during periods of fog, rain or other naturally occurring haze. Should any of these conditions actually occur then a new 24-hour natural background value will be determined using the Method 7 modeling approach as discussed in a previous draft of the VISTAS protocol. The CALPOST model currently has the ability to address this issue using Method 7 for a 24-hour time period.

For the 24-hour averaging period the top 50 delta dv values will be studied with respect to the default monthly f(RH) values to determine whether using actual relative humidity data and the EPA f(RH) curve for the time period results in a higher f(RH) value. This type of analysis was discussed in the December 2005 draft VISTAS protocol. If a higher f(RH) value is determined then the CALPOST program will be run using the actual relative humidity and associated EPA f(RH) value to determine a new initial maximum delta dv value. To limit the number of times CALPOST is executed, only periods with higher EPA f(RH) values will be recalculated to determine the final worst-case receptor locations.

Two additional CALPUFF analyses will be conducted in order to produce a final 24-hour LOS visibility impairment estimate. A string of LOS receptors will be developed that extend backwards towards the Augusta Mill and another set of receptors that extends downwind along the same line-of-sight (forward). The backward facing analysis will begin at a receptor location directly downstream but on the opposite boundary from the "worst-case" receptor located nearest the Augusta Mill. The LOS will extend through the Class I area and over the worst-case receptor on the front side of the Class I area and end at the actual visual range for the time period under investigation. The forward facing LOS will begin at the nearest worst-case receptor on the front side of the Class I area (nearest the Augusta Mill) and look through the Class I area and extend downwind ending at the applicable visual range. The length of each string of receptors will vary depending on the actual visual range for the 24-hour time period under study and each string will end at the most sensitive receptor location required by the deciview metric. A total of 50 evenly spaced receptors will be placed along each string. This limit is dictated by CALPOST printed output information. The time specific natural background visual range can be provided from CALPOST and will be based on using actual EPA adjusted f(RH) data.

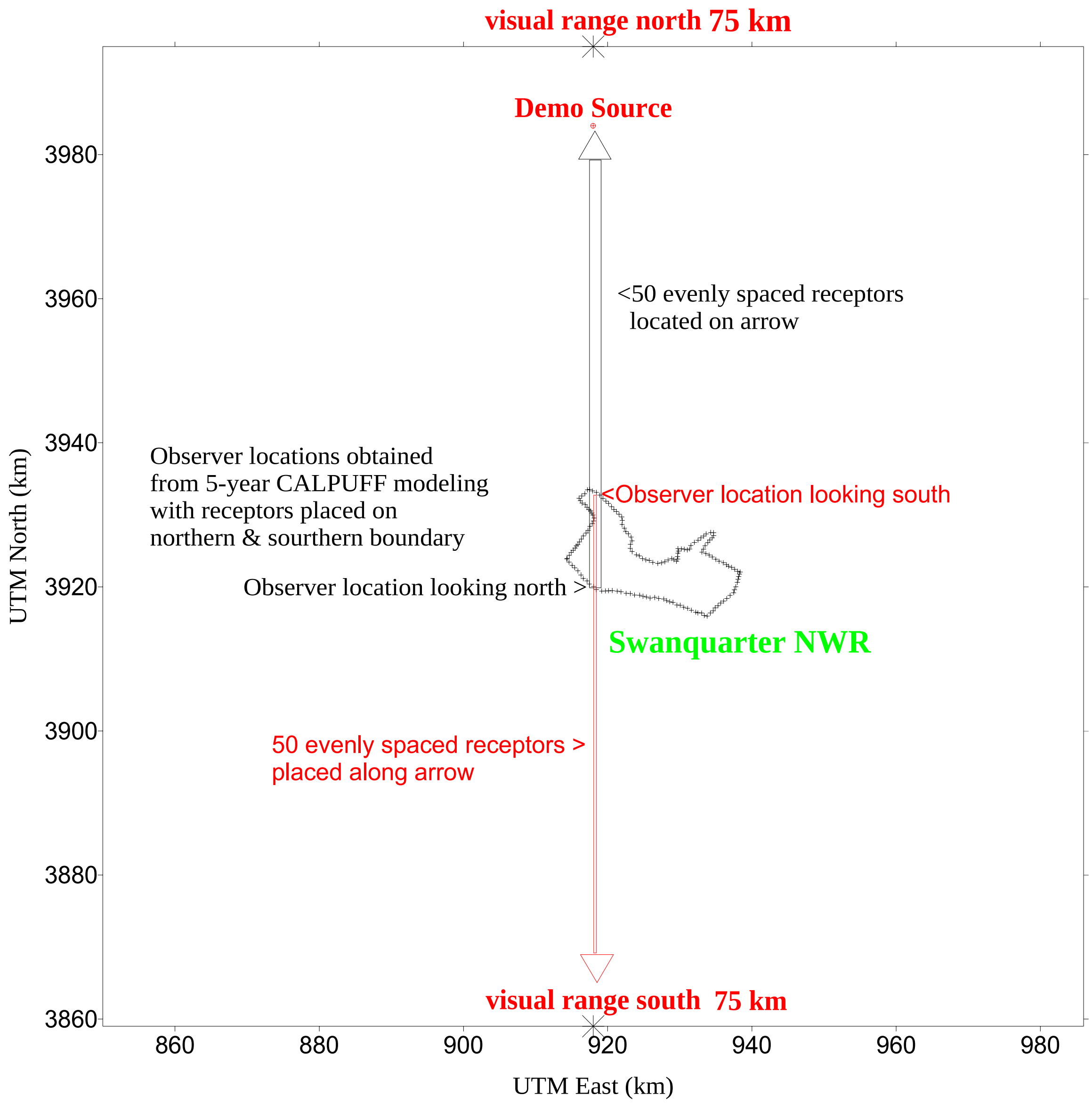
The following formula will be used to convert background extinction from CALPUFF to a visual range:

$$VR = 3912/b_{ext(NC)}$$

VR = visual range (km)
$b_{ext(NC)}$ = background extinction for natural conditions (Mm^{-1})

Figure 7-1 is an illustration of how the modeling would be conducted using the LOS modeling approach for two receptor strings. A 75-km LOS was assumed for illustration.

Tabulated results from the analysis would be prepared and presented in the simple format presented in Table 7-1. This example assumes a 170-kilometer visual range is applicable for both time periods. The actual table would include 50 receptors.



URS	**URS Corporation – North Carolina** ***1600 Perimeter Park Drive Suite 400*** ***Morrisville, North Carolina 27560*** ***Telephone (919) 461-1100 Fax (919) 461-1415***		**International Paper – Augusta** **Example of LOS Modeling Approach**	FILE NO. 31825278
	SCALE: AS SHOWN	DRAWN BY: **SCL** CHECKED BY:	DATE: SCL DATE:	FIG. NO. 7-1

Table 7-1: Example of LOS Modeling Results

FORWARD LOOKING LOS

24-Hour Period Distance (km)	Delta Deciview
0	1.647
10	1.524
20	1.246
30	0.911
40	0.631
50	0.475
60	0.39
70	0.328
80	0.279
90	0.244
100	0.217
110	0.194
120	0.174
130	0.156
140	0.137
150	0.12
160	0.102
170	0.085
Average	0.492222

BACKWARD LOOKING LOS

24-Hour Period Distance (km)	Delta Deciview
0	1.246
10	1.524
20	1.647
30	2.003
40	1.466
50	0.872
60	0.036
70	0.007
80	0.001
90	0
100	0
110	0
120	0
130	0
140	0
150	0
160	0
170	0
Average	0.489

The adjustment for Rayleigh scattering originally recommended by VISTAS for sources located near sea level will be incorporated for all modeling. Also, since the facility is located near the coast, a sea salt adjustment for natural conditions will be applied should initial modeling results without this assumption slightly exceed ambient threshold limits. The procedures outlined in a 2003 Air & Waste Management Association technical paper titled, Regional Haze Assessments with CALPUFF: Application of Refined Procedures will be used for this refinement in the modeling approach. Initial modeling will be conducted using the standard IMPROVE coefficients. Again, should initial modeling results only slightly exceed ambient thresholds then the Georgia DNR will be contacted to gain approval for using the EPRI coefficients.

8.0 REPORTING

8.1 Presentation of Modeling Results

The CALPOST processing computes the daily maximum change in deciviews. For evaluating compliance with the VISTAS screening threshold, the highest change in extinction value will be compared to the threshold value (e.g., 0.5 dv). At a minimum, tabular presentation of the following results will be provided:

> Number of days at all receptors within each Class I area with impacts > 0.5 dv; and
> Number of Class I areas with impacts > 0.5 dv.

For evaluating compliance using all grid modeling results from exemption and determination modeling the 98^{th} percentile of the predicted 24-hour averaged deciview impact deduced from the CALPOST postprocessor will be compared to the threshold value (e.g., 0.5 dv). At a minimum, tabular presentation of the following results will be provided:

> Number of days at all receptors within each Class I area with impacts > 0.5 dv; and
> Number of Class I areas with impacts > 0.5 dv.

A variety of other tabular and graphical summaries may also be developed.

8.2 Reporting of CALPUFF Modeling Results

The report accompanying the CALPUFF modeling will provide a clear description of the modeling procedures followed and the results of the analysis. Any departures from the approved modeling protocol will be discussed and justified. The report will also include a discussion of the uncertainty in the modeling results and the likelihood that the modeling process was effective in its determination. Any needs for source-specific or alternative modeling will be identified.

Accompanying the modeling report will be an electronic archive (CDs, DVDs, or removable USB2/IEEE 1394 hard drives as appropriate) that includes the full set of CALPUFF inputs and model output fields as well as any pre- or post-processor codes used to generate the results. The VISTAS 12/4-km regional CALPUFF-ready meteorological fields will not be included in the archive. The modeling data archive will be sufficiently complete as to allow an independent modeler to fully corroborate the CALPUFF screening results.

9.0 REFERENCES

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APPENDIX A - CALPUFF Configuration

The tables below identify the recommended CALPUFF configurations for VISTAS BART modeling. Also identified are the default recommendations from the IWAQM Phase 2 Report (EPA, 1998).

Input Groups in the CALPUFF Control File.

Input Group	Description	Applicable to BART Modeling
0	Input and output file names	Yes
1	General run control parameters	Yes
2	Technical options	Yes
3	Species list	Yes
4	Grid control parameters	Yes
5	Output options	Yes
6	Sub grid scale complex terrain inputs	No
7	Dry deposition parameters for gases	Yes
8	Dry deposition parameters for particles	Yes
9	Miscellaneous dry deposition for parameters	Yes
10	Wet deposition parameters	Yes
11	Chemistry parameters	Yes
12	Diffusion and computational parameters	Yes
13	Point source parameters	Yes
14	Area source parameters	No
15	Line source parameters	No
16	Volume source parameters	Yes
17	Discrete receptor information	Yes

CALPUFF Model Input Group 1: General Run Control Parameters

Parameter	Default	IP	Comments
METRUN	0	0	All model periods in met file(s) will be run
IBYR	-	2001	Starting year
IBMO	-	1	Starting month
IBDY	-	1	Starting day
IBHR	-	1	Starting hour
XBTZ	-	5	Base time zone (6 = CST)
IRLG	-	8760	Length of run
NSPEC	5	6	Number of MESOPUFF I I chemical species
NSE	3	4	Number of chemical species to be emitted
ITEST	2	2	Program is executed after SETUP phase
MRESTART	0	0	Do not read or write a restart file during run
NRESPD	0	0	File written only at last period
METFM	1	1	CALMET binary file (CALMET.MET)
AVET	60	60	Averaging time in minutes
PGTIME	60	60	PG Averaging time in minutes

CALPUFF Model Input Group 2: Technical Options

Parameter	Default	IP	Comments
MGAUSS	1	1	Gaussian distribution used in near field
MCTADJ	3	3	Partial plume path terrain adjustment
MCTSG	0	0	Sub-grid-scale complex terrain not modeled
MSLUG	0	0	Near-field puffs not modeled as elongated
MTRANS	1	1	Transitional plume rise modeled
MTIP	1	1	Stack tip downwash used
MSHEAR	0	0	(0, 1) Vertical wind shear (not modeled, modeled)
MSPLIT	0	0	Puffs are not split
MCHEM	1	1	MESOPUFF I I chemical parameterization Scheme
MAQCHEM	0	0	Aqueous phase transformation not modeled
MWET	1	1	Wet removal modeled
MDRY	1	1	Dry deposition modeled
MDISP	3	2	Dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological calculated variables

CALPUFF Model Input Group 2: Technical Options

MTURBVW	3	3	Use both σv and σw from PROFILE.DAT to compute σy and σz (n/a)
MDISP2	3	2	Dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological calculated variables
MROUGH	0	0	PG σy and σz not adjusted for roughness
MPARTL	1	1	No partial plume penetration of elevated inversion
MTINV	0	0	Strength of temperature inversion computed from default gradients
MPDF	0	1	PDF not used for dispersion under convective conditions
MSGTIBL	0	0	Sub-grid TIBL module not used for shoreline
MBCON	0	0	Boundary concentration conditions not modeled
MFOG	0	0	Do not configure for FOG model output
MREG	1	0	NO checks are made

CALPUFF Model Input Group 3: Species List-Chemistry Options.

CSPEC	Modeled[1]	Emitted[2]	Dry Deposition[3]	Output Group Number
SO_2	1	1	1	0
SO_4^{-2}	1	1	2	0
NOx	1	1	1	0
HNO_3	1	0	1	0
NO_3 -	1	0	2	0
NH_3	1	0	1	0
PMC	1	1	2	0
PMF	1	1	2	0
EC	1	1	2	0
SOA	1	1	2	0

Notes: 1 0=no, 1=yes
2 0=no, 1=yes
3 0=none; 1=computed-gas; 2=computed-particle; 3=user-specified

CALPUFF Model Input Group 4: Map Projection and Grid Control Parameters.

Parameter	Default	IP	Comments
PMAP	UTM	LCC	Map Projection
NX	-	160	Number of X grid cells in meteorological grid
NY	-	172	Number of Y grid cells in meteorological grid
NZ	-	10	Number of vertical layers in meteorological Grid
DGRIDKM	-	12	Grid spacing (km)
ZFACE	-	0, 20 40, 80, 160, 320, 640, 1200, 2000, 3000, 4000	Cell face heights in meteorological grid (m)
XORIGKM	-	137.973	Reference X coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
YORIGKM	-	-1625.974	Reference Y coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
IUTMZN	-	17	UTM zone of coordinates
IBCOMP	-		X index of lower left corner of the computational grid
JBCOMP	-		Y index of lower left corner of the computational grids
IECOMP	-		X index of the upper right corner of the computational grid
JECOMP	-		Y index of the upper right corner of the computational grid
LSAMP	T	F	Sampling grid is not used
IBSAMP	-	0	X index of lower left corner of the sampling Grid
JBSAMP	-	0	Y index of lower left corner of the sampling Grid
IESAMP	-	0	X index of upper right corner of the sampling grid
JESAMP	-	0	Y index of upper right corner of the sampling grid
MESHDN	1	1	Nesting factor of the sampling grid

CALPUFF Model Input Group 5: Output Options.

Parameter	Default	IP	Comments
ICON	1	1	Output file CONC.DAT containing concentrations is created
IDRY	1	1	Output file DFLX.DAT containing dry fluxes is Created
IWET	1	1	Output file WFLX.DAT containing wet fluxes is created
IVIS	1	1	Output file containing relative humidity data is created
LCOMPRS	T	T	Perform data compression in output file
IMFLX	0	0	Do not calculate mass fluxes across specific boundaries
IMBAL	0	0	Mass balances for each species not reported hourly
ICPRT	0	1	Print concentration fields to the output list file
IDPRT	0	0	Do not print dry flux fields to the output list file
IWPRT	0	0	Do not print wet flux fields to the output list file
ICFRQ	1	1	Concentration fields are printed to output list file every hr
IDFRQ	1	1	Dry flux fields are printed to output list file every 1 hour
IWFRQ	1	1	Wet flux fields are printed to output list file every 1 hour
IPRTU	1	3	Units for line printer output are in g/m3 for concentration and g/m2/s for deposition
IMESG	2	2	Messages tracking the progress of run written to screen
LDEBUG	F	F	Logical value for debug output
IPFDEB	1	1	First puff to track
NPFDEB	1	1	Number of puffs to track
NN1	1	1	Meteorological period to start output
NN2	10	10	Meteorological period to end output

CALPUFF Model Input Group 6: Sub-Grid Scale Complex Terrain Inputs.

Parameter	Default	IP	Comments
NHILL	0	0	Number of terrain features
NCTREC	0	0	Number of special complex terrain receptors
MHILL	-	2	Input terrain and receptor data for CTSG hills input in CTDM format
XHILL2M	1	1	Conversion factor for changing horizontal dimensions to meters
ZHILL2M	1	1	Conversion factor for changing vertical dimensions to meters
XCTDMKM	-	0.0 E+00	X origin of CTDM system relative to CALPUFF coordinate system (km)
YCTDMKM	-	0.0 E+00	Y origin of CTDM system relative to CALPUFF coordinate system (km)

CALPUFF Model Input Group 7: Dry Deposition Parameters for Gases.

Species	Default	IP	Comments
SO_2	0.1509	0.1509	Diffusivity
	1000.	1000.	Alpha star
	8.0	8.0	Reactivity
	0.0	0.0	Mesophyll resistance
	0.04	0.04	Henry's Law coefficient
NO_x	0.1656	0.1656	Diffusivity
	1.0	1.0	Alpha star
	8.0	8.0	Reactivity
	5.0	5.0	Mesophyll resistance
	3.5	3.5	Henry's Law coefficient
HNO_3	0.1628	0.1628	Diffusivity
	1.0	1.0	Alpha star
	18.0	18.0	Reactivity
	0.0	0.0	Mesophyll resistance
	8.0E-8	8.0E-8	Henry's Law coefficient
	0.000359	0.000359	Henry's Law coefficient

CALPUFF Model Input Group 8: Dry Deposition Parameters for Particles.

Species	Default	IP	Comments
SO_4	0.48	0.48	Geometric mass mean diameter of $SO4^{-2}$ [μm]
NO_3	2.0	0.48	Geometric mass mean diameter of $NO3^{-}$ [μm]
PMC	2.0	0.48	Geometric mass mean diameter of PMC [μm]
PMF	2.0	0.48	Geometric mass mean diameter of PMF [μm]
EC	2.0	0.48	Geometric mass mean diameter of EC [μm]
SOA	0.48	0.48	Geometric mass mean diameter of SOA [μm]

(Geometric Standard Deviation for all species assumed to be 2.0 μm).

CALPUFF Model Input Group 9: Miscellaneous Dry Deposition Parameters.

Parameter	Default	IP	Comments
RCUTR	30	30	Reference cuticle resistance (s/cm)
RGR	10	10	Reference ground resistance (s/cm)
REACTR	8	8	Reference pollutant reactivity
NINT	9	9	Number of particle size intervals for effective particle deposition velocity
IVEG	1	1	Vegetation in non-irrigated areas is active and unstressed

CALPUFF Model Input Group 10: Wet Deposition Parameters.

	Default	IP	Comments
SO_2	3.21E-05	3.21E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
SO_4	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
HNO_3	6.0E-05	6.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
NO_3	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
NH_3	8.0E-05	8.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
PMC	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [$^{s-1}$]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
PMF	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [$^{s-1}$]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
EC	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [$^{s-1}$]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
OC	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [$^{s-1}$]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]

CALPUFF Model Input Group 11: Chemistry Parameters.

Parameter	Default	IP	Comments
MOZ	1	1	Read ozone background concentrations from ozone.dat file (measured values).
BCKO3	12*80	12*40	Background ozone concentration (ppb)
BCKNH3	12*10	12*0.5	Background ammonia concentration (ppb)
RNITE1	0.2	0.2	Nighttime NO_2 loss rate in percent/hour
RNITE2	2	2	Nighttime NOX loss rate in percent/hour
RNITE3	2	2	Nighttime HNO_3 loss rate in percent/hour
MH202	1	1	Background H2O2 concentrations (Aqueous phase transformations not modeled)
BCKH202	1	1	Background monthly H2O2 concentrations (Aqueous phase transformations not modeled)
BCKPMF	1.	1.	Fine particulate concentration for SOA Option (micrograms per cubic meter)
OFRAC	.2	.2	Organic fraction of fine particulate for SOA Option
VCNX	50.	50.	VOC/NOx ratio for SOA Option

CALPUFF Model Input Group 12: Dispersion/Computational Parameters.

Parameter	Default	IP	Comments
SYDEP	550	550	Horizontal size of a puff in meters beyond which the time dependant dispersion equation of Heffter (1965) is used
MHFTSZ	0	0	Do not use Heffter formulas for sigma z
JSUP	5	5	Stability class used to determine dispersion rates for puffs above boundary layer
CONK1	0.01	0.01	Vertical dispersion constant for stable Conditions
CONK2	0.1	0.1	Vertical dispersion constant for neutral/stable conditions

Parameter	Default	IP	Comments
TBD	0.5	0.5	Use ISC transition point for determining the transition point between the Schulman-Scire to Huber-Snyder Building Downwash scheme
IURB1	10	10	Lower range of land use categories for which urban dispersion is assumed
IURB2	19	19	Upper range of land use categories for which urban dispersion is assumed
ILANDUIN	20	*	Land use category for modeling domain
XLAIIN	3.0	*	Leaf area index for modeling domain
ZOIN	-0.25	*	Roughness length in meters for modeling domain
ELEVIN	0.0	*	Elevation above sea level
XLATIN	-999	-	North latitude of station in degrees
XLONIN	-999	-	South latitude of station in degrees
ANEMHT	10	10	Anemometer height in meters
ISIGMAV	1	1	Sigma-v is read for lateral turbulence data
IMIXCTDM	0	0	Predicted mixing heights are used
XMXLEN	1	1	Maximum length of emitted slug in meteorological grid units
XSAMLEN	1	10	Maximum travel distance of slug or puff in meteorological grid units during one sampling unit
MXNEW	99	60	Maximum number of puffs or slugs released from one source during one time step
MXSAM	99	60	Maximum number of sampling steps during one time step for a puff or slug
NCOUNT	2	2	Number of iterations used when computing the transport wind for a sampling step that includes transitional plume rise

Parameter	Default	IP	Comments
SYMIN	1	1	Minimum sigma y in meters for a new puff or slug
SZMIN	1	1	Minimum sigma z in meters for a new puff or slug
SVMIN	.50	.50	Minimum lateral turbulence velocities (m/s)
SWMIN	0.20, 0.12, 0.08, 0.06, 0.03, 0.016	0.20, 0.12, 0.08, 0.06, 0.03, 0.016	Minimum vertical turbulence velocities (m/s)
WSCALM	0.5	0.5	Minimum non-calm wind speeds (m/s)
XMAXZI	3000.	3000.	Maximum mixing height (m)
XMINZI	50.	20.	Minimum mixing height (m)
SL2PF	10.	10.	Maximum Sy/puff length
PLXO	0.07, 0.07, 0.10, 0.15, 0.35, 0.55	0.07, 0.07, 0.10, 0.15, 0.35, 0.55	Wind speed power-law exponents
WSCAT	1.54, 3.09, 5.14, 8.23, 10.80	1.54, 3.09, 5.14, 8.23, 10.80	Upper bounds 1st 5 wind speed classes
PGGO	0.020, 0.035	0.020, 0.035	Potential temp gradients PG E & F (deg/km)
CDIV	0.01	0.01	Divergence criterion for dw/dz (1/s)
PPC	0.5, 0.5, 0.5, 0.5, 0.35, 0.35	0.5, 0.5, 0.5, 0.5, 0.35, 0.35	Plume path coefficients (only if MCTADJ=3)
NSPLIT	3	3	Number of puffs when puffs split
IRESPLIT	-	1900	Hour(s) when puff is eligible to split
ZISPLIT	100	100	Previous hour's minimum mixing height, m
ROLDMAX	0.25	0.25	Previous Max mixing height/current mixing height ratio, must be less than this value to allow puff to split
NSPLITH	5	5	Number of puffs resulting from a split
SYSPLITH	1.0	1.0	Minimum sigma-y of puff before it may split

Parameter	Default	IP	Comments
SHSPLITH	2.0	2.0	Minimum puff elongation rate from wind shear before puff may split
CNSPLITH	1.0E-07	1.0E-07	Minimum species concentration before a puff may split
EPSSLUG	1.0E-04	1.0E-04	Criterion for SLUG sampling
EPSAREA	1.0E-06	1.0E-06	Criterion for area source integration
DSRISE	1.0	1.0	Trajectory step length for numerical rise algorithm
Note: Values indicated by an asterisk (*) were allowed to vary spatially across the domain and were obtained from CALMET			

CALPUFF Model Input Group 13: Point Source Parameters.

Parameter	Default	IP	Comments
NPT1	-	5	Number of point sources with constant stack parameters or variable emission rate scale factors
IPTU	1	3	Units for point source emission rates are g/s
NSPT1	0	0	Number of source-species combinations with variable emissions scaling factors
NPT2	-	0	Number of point sources with variable emission parameters provided in external file

CALPUFF Model Input Group 14: Area Source Parameters.

Parameter	Default	IP	Comments
NAR1		Varies by scenario	Number of polygon area sources
IARU	1	1	Units for area source emission rates are g/m2/s
NSAR1	0	-	Number of source species combinations with variable emissions scaling factors
NAR2	-	-	Number of buoyant polygon area sources with variable location and emission parameters

CALPUFF Model Input Group 15: Line Source Parameters.

Parameter	Default	IP	Comments
NLN2	-	-	Number of buoyant line sources with variable location and emission parameters
NLINES	-	-	Number of buoyant line sources
ILNU	1	-	Units for line source emission rates is g/s
NSLN1	0	-	Number of source-species combinations with variable emissions scaling factors
MXNSEG	7	-	Maximum number of segments used to model each line
NLRISE	6	-	Number of distance at which transitional rise is computed
XL	-	-	Average line source length (m)
HBL	-	-	Average height of line source height (m)
WBL	-	-	Average building width (m)
WML	-	-	Average line source width (m)
DXL	-	-	Average separation between buildings (m)
FPRIMEL	-	-	Average buoyancy parameter (m4/s3)

CALPUFF Model Input Group 16: Volume Source Parameters.

Parameter	Default	IP	Comments
NVL1	-	1	Number of volume sources
IVLU	1	-	Units for volume source emission rates is grams per second
NSVL1	0	-	Number of source-species combinations with variable emissions scaling factors
IGRDVL	-	-	Gridded volume source data is not used
VEFFHT	-	-	Effective height of emissions (m)
VSIGYI	-	-	Initial sigma y value (m)
VSIGZI	-	-	Initial sigma z value (m)

Table B-18. CALPUFF Model Input Group 17: Discrete Receptor Information.

Parameter	Default	IP	Comments
NREC	-	1927	Number of non-gridded receptors

APPENDIX B - POSTUTIL Screening Configuration

The tables below identify the recommended POSTUTIL processor screening configurations for BART modeling.

Input Groups in the POSTUTIL Processor Control File.

Sub Group	Description	Applicable to BART Modeling
0a	Input and output file names	Yes
1	NMET – Number of CALMET data files (365)	Yes
2	NFILES – Number of CALMET data files (1)	Yes

POSTUTIL Processor Input Group 1: General Run Control Parameters

Parameter	DEFAULT	IP	Comments
ISYR	--	2001	Starting year
ISMO	--	1	Starting month
ISDY	--	1	Starting day
ISHR	--	0	Starting hour
NPER	--	8760	Number of periods to process
NSPECINP	--	6	Number of CALPUFF species to process
NSPECOUT	--	6	Number of species to output
NSPECCMP	--	0	Number of species to derive
MDUPLCT	--	1	Stop run if duplicate name
NSCALED	--	0	Number of CALPUFF files to ‘scale’
MNITRATE	--	1	Recompute the HNO_3/NO_3 partition for CALPUFF modeled concentrations? 1 = yes for all sources combined
BCKNH3	10.	CMAQ.	Default NH_3 concentration (ppb) for HNO_3/NO_3 partitioning

POSTUTIL Processor Input Group 2: Species Processing Information

Parameter	DEFAULT	IP	Comments
ASPECI	--	SO_2, SO_4, NO_x, HNO_3, NO_3, PM_{10}	Species to post-process
ASPECO	--	SO_2, SO_4, NO_x, HNO_3, NO_3, PM_{10}	Species to output
CSPECCMP	--	CSPECCMP = N SO_2 = 0.0 SO_4 = 0.291667 NO = 0.466667 NO_2 = 0.304348 HNO_3 = 0.222222 NO_3 = 0.451613 PM_{10} = 0.0	Nitrogen species to be computed by scaling and summing one or more of the processed input species using the scaling factors for each of the NSPECINP input species
CSPECCMP	--	CSPECCMP = S SO_2 = 0.50 SO_4 = 0.333333 NO = 0.0 NO_2 = 0.0 HNO_3 = 0.0 NO_3 = 0.0 PM_{10} = 0.0	Sulfur species to be computed by scaling and summing one or more of the processed input species using the scaling factors for each of the NSPECINP input species
MODDAT	--	A (Default=1.0) SO_2 = 1.1 SO_4 = 1.5 HNO3 = 0.8 NO_3 = 0.1 B (Default=0.0) SO_2 = 0.0 SO_4 = 0.0 HNO_3 = 0.0 NO_3 = 0.0	Each species in NSCALED CALPUFF data files may be scaled before processing (e.g., to change the emission rate for all sources modeled in the run that produced a data file). For each scaled species the scaling factors are A and B where x' = Ax + B.

APPENDIX C – CALPOST Screening Configuration

The tables below identify the recommended CALPOST processor screening configurations for BART modeling.

Input Groups in the CALPOST Processor Control File.

Group	Description	Applicable to BART Modeling
0	Input and output file names	Yes
1	General Run Control Parameters	Yes
2	Visibility Parameters	Yes
3	Output Options	Yes

CALPOST Processor Input Group 1: General Run Control Parameters

Parameter	DEFAULT	IP	Comments
ISYR	--	2001	Starting year
ISMO	--	1	Starting month
ISDY	--	1	Starting day
ISHR	--	0	Starting hour
NPER	--	8760	Number of periods to process
NREP	1	1	Process every hour of data? Yes = 1
ASPEC	--	VISIB	Process species for visibility
ILAYER	1	1	Layer/deposition code; 1 for CALPUFF concentrations
A	0.0	0.0	Scaling factor, slope
B	0.0	0.0	Scaling factor, intercept
LBACK	F	F	Add hourly background concentrations or fluxes?
LG	F	F	Process gridded receptors?
LD	F	T	Process discrete receptors?
LCT	F	F	Process complex terrain receptors?
LDRING	F	F	Report receptor ring results?
NDRECP	-1	-1	Select all discrete receptors
IBGRID	-1	-1	X index of LL corner of receptor grid
JBGRID	-1	-1	Y index of LL corner of receptor grid
IEGRID	-1	-1	X index of UR corner of receptor grid
JEGRID	-1	-1	X index of UR corner of receptor grid
NGONOFF	0	0	Number of gridded receptor rows
NGXRECP	1	0	Exclude specific gridded receptors, Yes = 0

CALPOST Processor Input Group 2: Species Processing Information

Parameter	DEFAULT	IP	Comments
RHMAX	98	95	Maximum RH (%) used in particle growth curve
LVSO4	T	T	Compute light extinction for sulfate?
LVNO3	T	T	Compute light extinction for nitrate?
LVOC	T	F	Compute light extinction for organic carbon?
LVMPC	T	F	Compute light extinction for coarse particles?
LVMPF	T	T	Compute light extinction for fine particles?
LVEC	T	F	Compute light extinction for elemental carbon?
LVBK	T	T	Include background in extinction calculation?
SPECPMC	PMC	PMC	Coarse particulate species
SPECPMF	PMF	PM10	Fine particulate species
EEPMC	0.6	0.6	Extinction efficiency for coarse particulates
EEPMF	1.0	1.0	Extinction efficiency for fine particulates
EEPMCBK	0.6	0.6	Extinction efficiency for coarse part. background
EESO4	3.0	3.0	Extinction efficiency for ammonium sulfate
EENO3	3.0	3.0	Extinction efficiency for ammonium nitrate
EEOC	4.0	4.0	Extinction efficiency for organic carbon
EESOIL	1.0	1.0	Extinction efficiency for soil
EEEC	10.0	10.0	Extinction efficiency for elemental carbon
MVISBK	2	6	Method 6 for background light extinction: Compute extinction from speciated PM measurements. FLAG RH adjustment factor applied to observed & modeled sulfate and nitrate
BEXTBTBK	--	10	Background extinction for MVISBK=1 (1/Mm)
RHFRAC	--	10	Percentage of particles affected by RH
RHFAC	12*value	Depends on Class I Area	Extinction coefficients for modeled and background hygroscopic species computed using EPA (2003) monthly RH adjustment factors
BKSEC	0.02	0.02	Background elem. carbon extinct. coeff – east
BKSO4	0.23	0.23	Background sulfate extinction coeff – east
BKNO3	0.10	0.10	Background nitrate extinction coeff – east
BKPMC	3.00	3.00	Background coarse part. extinction coeff – east
BKSOC	1.40	1.40	Background organic carbon extinct. coeff – east
BKSSOIL	0.50	0.50	Background soil extinction coeff – east
BKSEC	0.02	0.02	Background elem. carbon extinct. coeff – east
BEXTRAY	10.0	10.0	Extinction due to Rayleigh scattering (1/Mm)

CALPOST Processor Input Group 3: Output Options

Parameter	DEFAULT	IP	Comments
LDOC	F	F	Print documentation image?
IPRTU	1	3	Print output units ($\mu g/m^3$) for concentrations and ($\mu g/m^2/sec$) for deposition
L1HR	T	F	Report 1 hr averaging times
L3HR	T	F	Report 3 hr averaging times
L24HR	T	T	Report 24 hr averaging times
LRUNL	T	F	Report run-length (annual) averaging times
LT50	T	F	Top 50 table
LTOPN	F	F	Top ‘N’ table
NTOP	4	4	Number of ‘Top-N’ values at each receptor
ITOP	1,2,3,4	1,2,3,4	Ranks of ‘Top-N’ values at each receptor
LEXCD	F	F	Threshold exceedances counts
THRESH1	-1.0	-1.0	Averaging time threshold for 1 hr averages
THRESH3	-1.0	-1.0	Averaging time threshold for 3 hr averages
THRESH24	-1.0	-1.0	Averaging time threshold for 24 hr averages
THRESHN	-1.0	-1.0	Averaging time threshold for NAVG-hr averages
NDAY	0	0	Accumulation period, days
NCOUNT	1	1	Number of exceedances allowed
LECHO	F	F	Echo option
LTIME	F	F	Time series option
LPLT	F	F	Plot file option
LGRD	F	F	Use grid format instead of DATA format
LDEBUG	F	F	Output information for debugging?

APPENDIX D – Class I Receptors in Lambert Conformal Coordinates

Wolf Island Class I Area		
Lambert Conformal X (km)	**Lambert Conformal Y (km)**	**Height (m)**
1488.68964	-835.19	1
1489.47214	-835.06	1
1488.52987	-834.28	1
1487.42808	-832.58	3
1488.21034	-832.44	2
1488.99259	-832.31	1
1489.77483	-832.17	1
1486.48621	-831.8	1
1487.2684	-831.67	1
1488.05058	-831.53	1
1488.83275	-831.39	1
1489.6149	-831.26	1
1486.32662	-830.89	1
1487.10873	-830.75	1
1487.89082	-830.61	1
1488.67291	-830.48	1
1489.45498	-830.34	1
1485.38499	-830.11	1
1486.16703	-829.97	1
1486.94905	-829.83	1
1487.73107	-829.7	1
1488.51307	-829.56	1
1489.29505	-829.42	1
1485.22549	-829.19	1
1486.00745	-829.05	1
1486.78939	-828.92	1
1487.57132	-828.78	1
1488.35323	-828.65	1
1489.13513	-828.51	1
1485.84787	-828.14	1

Cape Romain Class I Area		
Lambert Conformal X (km)	**Lambert Conformal Y (km)**	**Height (m)**
1609.918	-633.619	0
1610.682	-633.471	1
1610.506	-632.561	1
1611.27	-632.414	1
1611.094	-631.504	1
1611.858	-631.356	1
1610.154	-630.742	1
1610.918	-630.594	1
1611.682	-630.446	1
1612.446	-630.298	1
1610.742	-629.684	1
1611.506	-629.537	1
1612.27	-629.389	1
1610.566	-628.775	0
1611.33	-628.627	1
1612.093	-628.479	1
1612.857	-628.331	1
1610.39	-627.865	1
1611.154	-627.717	1
1610.214	-626.955	1
1610.978	-626.807	1
1611.741	-626.66	1
1610.802	-625.898	1
1611.565	-625.75	1
1610.626	-624.988	1
1611.389	-624.84	2
1612.152	-624.693	1
1615.968	-623.952	0
1611.213	-623.931	1
1611.976	-623.783	1
1616.554	-622.895	0
1611.037	-623.021	1
1611.8	-622.873	1
1612.387	-621.816	1
1613.149	-621.668	1
1617.727	-620.779	0
1612.973	-620.758	1
1613.736	-620.61	1
1621.949	-618.069	0
1622.712	-617.92	1
1623.474	-617.772	1

Cape Romain Class I Area		
Lambert Conformal X (km)	**Lambert Conformal Y (km)**	**Height (m)**
1614.146	-618.643	1
1623.297	-616.862	1
1624.059	-616.713	1
1624.822	-616.564	1
1625.584	-616.415	1
1633.208	-614.921	1
1633.97	-614.771	0
1614.732	-617.586	1
1621.594	-616.25	0
1622.357	-616.102	1
1623.119	-615.953	1
1623.882	-615.804	1
1624.644	-615.655	1
1625.406	-615.506	1
1626.169	-615.357	1
1626.931	-615.208	1
1627.693	-615.059	1
1628.456	-614.909	2
1629.218	-614.76	2
1629.98	-614.611	1
1630.742	-614.461	2
1631.505	-614.311	1
1633.791	-613.862	0
1615.318	-616.528	1
1616.08	-616.38	1
1616.843	-616.232	1
1620.655	-615.49	0
1621.417	-615.341	1
1622.179	-615.192	1
1622.942	-615.044	1
1623.704	-614.895	1
1624.466	-614.746	1
1625.229	-614.597	1
1628.278	-614	1
1629.04	-613.851	1
1632.088	-613.253	1
1634.375	-612.803	0
1619.715	-614.729	0
1620.477	-614.581	1
1621.24	-614.432	1
1622.002	-614.283	1

Cape Romain Class I Area		
Lambert Conformal X (km)	**Lambert Conformal Y (km)**	**Height (m)**
1622.764	-614.134	1
1623.526	-613.986	1
1624.289	-613.837	1
1625.051	-613.688	1
1625.813	-613.539	1
1626.575	-613.389	1
1627.337	-613.24	1
1629.624	-612.792	1
1630.386	-612.643	1
1631.148	-612.493	1
1631.91	-612.344	1
1634.196	-611.894	0
1618.776	-613.968	1
1619.538	-613.82	1
1620.3	-613.671	1
1621.062	-613.523	1
1621.824	-613.374	1
1622.587	-613.225	1
1623.349	-613.076	1
1624.111	-612.927	1
1624.873	-612.778	1
1625.635	-612.629	1
1626.397	-612.48	1
1627.159	-612.331	1
1627.921	-612.182	1
1628.683	-612.033	1
1629.445	-611.883	1
1630.207	-611.734	1
1630.969	-611.584	1
1634.017	-610.985	0
1620.123	-612.762	1
1620.885	-612.613	1
1621.647	-612.465	1
1622.409	-612.316	1
1623.171	-612.167	1
1623.933	-612.018	1
1624.695	-611.869	1
1625.457	-611.72	1
1626.219	-611.571	1
1626.981	-611.422	1
1627.743	-611.273	1

Cape Romain Class I Area		
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1628.505	-611.123	1
1633.077	-610.226	0
1633.839	-610.076	1
1634.6	-609.927	1
1621.47	-611.555	1
1622.232	-611.407	1
1622.994	-611.258	1
1623.756	-611.109	1
1624.517	-610.96	1
1625.279	-610.811	1
1626.041	-610.662	1
1626.803	-610.513	1
1627.565	-610.364	1
1628.327	-610.214	1
1629.089	-610.065	1
1629.851	-609.916	1
1630.613	-609.766	1
1634.422	-609.018	0
1624.34	-610.051	1
1625.102	-609.902	1
1625.863	-609.753	1
1626.625	-609.604	1
1627.387	-609.455	1
1628.149	-609.305	1
1628.911	-609.156	1
1629.672	-609.007	1
1630.434	-608.857	1
1634.243	-608.109	0
1628.732	-608.247	1
1629.494	-608.098	1
1630.256	-607.948	1
1631.017	-607.799	1
1629.316	-607.189	1
1630.077	-607.039	1
1630.839	-606.89	1
1631.601	-606.74	1
1629.899	-606.13	1
1630.66	-605.981	1
1631.422	-605.831	1
1629.721	-605.221	1
1630.482	-605.072	1

Great Smokey Mountains								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1201.214	-417.246	521	1197.428	-412.206	944	1183.507	-410.517	1072
1204.191	-416.805	521	1198.916	-411.986	1281	1184.994	-410.3	1199
1189.038	-417.173	521	1200.403	-411.766	1427	1186.481	-410.083	1097
1190.527	-416.954	522	1201.891	-411.546	1221	1187.968	-409.865	720
1192.015	-416.736	523	1203.378	-411.325	1030	1189.455	-409.647	640
1193.503	-416.517	521	1204.865	-411.105	983	1190.942	-409.429	873
1194.992	-416.298	538	1206.352	-410.883	894	1192.429	-409.21	852
1196.48	-416.079	550	1207.84	-410.662	675	1193.915	-408.991	978
1197.968	-415.859	640	1209.327	-410.44	950	1195.402	-408.772	809
1199.456	-415.639	607	1210.814	-410.219	915	1196.889	-408.553	761
1200.944	-415.419	523	1212.301	-409.996	732	1198.376	-408.333	987
1202.432	-415.199	548	1213.788	-409.774	980	1199.863	-408.113	874
1203.92	-414.978	524	1216.762	-409.328	1020	1201.349	-407.893	1147
1205.408	-414.757	608	1218.249	-409.105	886	1202.836	-407.673	1323
1208.384	-414.315	546	1219.736	-408.881	615	1204.322	-407.452	1221
1209.871	-414.093	566	1221.222	-408.657	680	1205.809	-407.231	1097
1211.359	-413.871	541	1176.335	-413.427	767	1207.296	-407.01	800
1212.847	-413.649	530	1177.823	-413.211	919	1208.782	-406.788	942
1181.33	-416.432	683	1179.311	-412.995	905	1210.268	-406.566	1167
1182.818	-416.216	711	1180.798	-412.778	911	1211.755	-406.344	1052
1184.307	-415.999	583	1182.286	-412.561	965	1213.241	-406.122	1012
1185.795	-415.781	599	1183.773	-412.344	837	1214.728	-405.899	1002
1187.283	-415.564	561	1185.261	-412.127	1055	1216.214	-405.676	1143
1188.771	-415.346	582	1186.748	-411.91	716	1217.7	-405.453	998
1190.259	-415.128	703	1188.235	-411.692	825	1219.186	-405.23	710
1191.747	-414.909	707	1189.723	-411.474	609	1220.672	-405.006	998
1193.235	-414.69	522	1191.21	-411.256	814	1222.158	-404.782	907
1194.723	-414.471	760	1192.697	-411.037	1006	1223.644	-404.558	1200
1196.21	-414.252	846	1194.184	-410.818	1036	1225.131	-404.333	1173
1197.698	-414.033	952	1195.672	-410.599	732	1226.616	-404.108	1067
1199.186	-413.813	765	1197.159	-410.379	746	1228.102	-403.883	896
1200.674	-413.593	1067	1198.646	-410.16	929	1229.588	-403.658	799
1202.161	-413.372	915	1200.133	-409.94	1008	1231.074	-403.432	683
1203.649	-413.152	730	1201.62	-409.72	1288	1169.857	-410.632	330
1205.137	-412.931	822	1203.107	-409.499	1266	1171.344	-410.418	523
1206.624	-412.71	748	1204.594	-409.278	1218	1172.831	-410.203	599
1208.112	-412.488	544	1206.081	-409.057	959	1174.318	-409.988	769
1209.599	-412.267	706	1207.568	-408.836	681	1175.805	-409.772	831
1211.087	-412.045	627	1209.054	-408.614	920	1177.292	-409.556	941
1212.574	-411.822	845	1210.541	-408.392	1170	1178.779	-409.34	1150
1214.061	-411.6	772	1212.028	-408.17	956	1180.266	-409.124	1194
1215.549	-411.377	836	1213.515	-407.948	818	1181.753	-408.907	1084
1220.01	-410.707	665	1215.001	-407.725	1223	1183.24	-408.69	1206
1175.112	-415.469	554	1216.488	-407.502	1270	1184.727	-408.473	1225
1176.6	-415.254	760	1217.974	-407.279	872	1186.213	-408.256	987
1178.088	-415.038	805	1219.461	-407.055	694	1187.7	-408.038	1063
1179.576	-414.822	703	1220.947	-406.832	963	1189.187	-407.82	873
1181.064	-414.605	729	1222.434	-406.608	859	1190.673	-407.602	921
1182.552	-414.388	699	1223.92	-406.383	1000	1192.16	-407.384	1233
1184.04	-414.171	1109	1170.121	-412.46	365	1193.646	-407.165	1006
1185.528	-413.954	1001	1171.608	-412.245	406	1195.133	-406.946	1024
1187.015	-413.737	811	1173.096	-412.03	600	1196.619	-406.726	792
1188.503	-413.519	522	1174.583	-411.815	591	1198.106	-406.507	1015
1189.991	-413.301	581	1176.07	-411.599	644	1199.592	-406.287	1094
1191.478	-413.082	629	1177.558	-411.383	1036	1201.079	-406.067	996
1192.966	-412.864	634	1179.045	-411.167	1309	1202.565	-405.846	1148
1194.453	-412.645	582	1180.532	-410.951	1262	1204.051	-405.626	1368
1195.941	-412.426	612	1182.019	-410.734	1261	1205.537	-405.405	1052

Great Smokey Mountains								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1207.024	-405.184	958	1229.034	-400.007	802	1177.982	-403.859	634
1208.51	-404.962	988	1230.519	-399.781	756	1179.468	-403.643	662
1209.996	-404.74	1019	1239.43	-398.422	1213	1180.954	-403.427	567
1211.482	-404.518	1344	1240.915	-398.195	1312	1182.44	-403.21	579
1212.968	-404.296	1246	1169.33	-406.978	365	1183.926	-402.993	660
1214.454	-404.073	1377	1170.816	-406.763	393	1185.411	-402.776	878
1215.94	-403.85	1135	1172.303	-406.548	455	1186.897	-402.558	907
1217.426	-403.627	1196	1173.789	-406.333	590	1188.383	-402.34	955
1218.911	-403.404	851	1175.275	-406.118	775	1189.868	-402.122	1048
1220.397	-403.18	883	1176.762	-405.902	690	1191.354	-401.904	1056
1221.883	-402.956	1060	1178.248	-405.686	697	1192.84	-401.685	1333
1223.369	-402.732	1207	1179.734	-405.47	678	1194.325	-401.466	1223
1224.854	-402.508	1245	1181.22	-405.253	607	1195.81	-401.247	1411
1226.34	-402.283	1045	1182.707	-405.037	824	1197.296	-401.028	1106
1227.826	-402.058	1068	1184.193	-404.82	802	1198.781	-400.808	1347
1229.311	-401.832	870	1185.679	-404.602	1033	1200.267	-400.588	1222
1230.797	-401.607	782	1187.165	-404.385	1241	1201.752	-400.368	1524
1241.194	-400.02	1326	1188.651	-404.167	1297	1203.237	-400.147	1386
1169.593	-408.805	453	1190.137	-403.949	1503	1204.722	-399.926	1198
1171.08	-408.59	439	1191.623	-403.73	1477	1206.208	-399.705	1242
1172.567	-408.376	582	1193.109	-403.512	1533	1207.693	-399.484	1415
1174.054	-408.16	664	1194.594	-403.293	1242	1209.178	-399.262	1358
1175.54	-407.945	770	1196.08	-403.073	1270	1210.663	-399.04	1355
1177.027	-407.729	853	1197.566	-402.854	1198	1212.148	-398.818	1403
1178.514	-407.513	810	1199.052	-402.634	1372	1213.633	-398.596	1712
1180	-407.297	979	1200.537	-402.414	1394	1215.118	-398.373	1431
1181.487	-407.08	809	1202.023	-402.194	1187	1216.603	-398.15	1422
1182.973	-406.864	818	1203.508	-401.973	1517	1218.087	-397.927	1236
1184.46	-406.646	1027	1204.994	-401.752	1490	1219.572	-397.703	1228
1185.946	-406.429	1372	1206.48	-401.531	1518	1221.057	-397.479	1492
1187.432	-406.211	1203	1207.965	-401.31	1632	1222.542	-397.255	1372
1188.919	-405.994	975	1209.45	-401.088	1692	1224.026	-397.031	1181
1190.405	-405.775	1077	1210.936	-400.866	1888	1225.511	-396.806	792
1191.891	-405.557	1343	1212.421	-400.644	1951	1226.996	-396.581	939
1193.378	-405.338	1463	1213.906	-400.422	1603	1228.48	-396.356	737
1194.864	-405.119	1193	1215.392	-400.199	1543	1229.965	-396.131	1213
1196.35	-404.9	932	1216.877	-399.976	1292	1231.449	-395.905	1173
1197.836	-404.68	1059	1218.362	-399.752	1067	1235.902	-395.226	1111
1199.322	-404.461	1144	1219.847	-399.529	928	1237.387	-395	1138
1200.808	-404.24	1231	1221.332	-399.305	1190	1238.871	-394.773	1362
1202.294	-404.02	1197	1222.817	-399.081	1415	1240.355	-394.545	1709
1203.78	-403.799	1220	1224.302	-398.856	1066	1241.839	-394.318	1585
1205.266	-403.579	1342	1225.787	-398.632	899	1243.324	-394.09	1298
1206.752	-403.357	1350	1227.272	-398.407	714	1244.808	-393.862	1224
1208.237	-403.136	1251	1228.757	-398.182	703	1246.292	-393.633	1150
1209.723	-402.914	1467	1237.666	-396.825	1097	1247.776	-393.404	1348
1211.209	-402.692	1407	1239.15	-396.598	1224	1171.774	-402.894	383
1212.694	-402.47	1671	1240.635	-396.37	1526	1173.26	-402.679	482
1214.18	-402.247	1369	1242.119	-396.142	1566	1174.746	-402.464	533
1215.666	-402.025	1412	1243.604	-395.915	1311	1176.231	-402.248	559
1217.151	-401.802	1279	1245.088	-395.686	1283	1177.717	-402.032	598
1218.637	-401.578	863	1246.573	-395.458	1482	1179.202	-401.816	532
1220.122	-401.355	823	1169.066	-405.151	290	1180.688	-401.6	525
1221.608	-401.131	1103	1170.552	-404.936	389	1182.173	-401.383	533
1223.093	-400.906	1432	1172.038	-404.721	506	1183.659	-401.166	543
1224.578	-400.682	1448	1173.524	-404.506	644	1185.144	-400.949	562
1226.064	-400.457	1352	1175.01	-404.291	578	1186.63	-400.731	602
1227.549	-400.232	1094	1176.496	-404.075	539	1188.115	-400.514	736

Great Smokey Mountains								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1189.6	-400.296	817	1198.241	-397.155	768	1209.844	-393.563	1203
1191.085	-400.077	809	1199.725	-396.935	983	1211.328	-393.341	1212
1192.571	-399.859	920	1201.21	-396.715	1281	1212.812	-393.118	1380
1194.056	-399.64	1017	1202.695	-396.495	1378	1214.296	-392.896	1300
1195.541	-399.421	1006	1204.179	-396.274	1371	1215.78	-392.673	1206
1197.026	-399.201	956	1205.664	-396.053	1135	1217.263	-392.45	1581
1198.511	-398.982	1137	1207.148	-395.832	884	1218.747	-392.227	1457
1199.996	-398.762	982	1208.632	-395.61	907	1220.231	-392.003	1699
1201.481	-398.541	1187	1210.117	-395.389	1249	1221.715	-391.779	1543
1202.966	-398.321	1365	1211.601	-395.167	1528	1223.198	-391.555	1640
1204.451	-398.1	1245	1213.085	-394.944	1552	1224.682	-391.33	1476
1205.936	-397.879	1074	1214.57	-394.722	1473	1226.166	-391.106	1036
1207.42	-397.658	1365	1216.054	-394.499	1677	1227.649	-390.881	1315
1208.905	-397.436	1401	1217.538	-394.276	1553	1229.133	-390.655	1504
1210.39	-397.214	1080	1219.022	-394.052	1572	1230.616	-390.43	1469
1211.874	-396.992	1260	1220.506	-393.828	1526	1232.1	-390.204	1242
1213.359	-396.77	1660	1221.99	-393.604	1261	1233.583	-389.978	1453
1214.844	-396.547	1703	1223.474	-393.38	1217	1235.066	-389.751	1414
1216.328	-396.324	1525	1224.958	-393.156	1247	1236.55	-389.525	1012
1217.813	-396.101	1299	1226.442	-392.931	947	1238.033	-389.298	1127
1219.297	-395.878	1389	1227.926	-392.706	1163	1239.516	-389.071	1352
1220.782	-395.654	1084	1229.41	-392.48	1434	1240.999	-388.843	1189
1222.266	-395.43	1048	1230.894	-392.255	1373	1242.482	-388.615	1257
1223.75	-395.206	1002	1232.378	-392.029	1170	1243.966	-388.387	1048
1225.235	-394.981	1374	1233.861	-391.803	1293	1245.449	-388.159	856
1226.719	-394.756	910	1235.345	-391.576	1077	1246.932	-387.931	825
1228.203	-394.531	1109	1236.829	-391.35	953	1248.415	-387.702	1060
1229.687	-394.306	1002	1238.312	-391.123	1202	1249.898	-387.473	1125
1231.172	-394.08	1469	1239.796	-390.895	1602	1175.435	-396.767	429
1232.656	-393.854	1136	1241.279	-390.668	1433	1176.92	-396.551	537
1234.14	-393.628	1324	1242.763	-390.44	1106	1178.404	-396.335	459
1235.624	-393.401	912	1244.246	-390.212	966	1179.889	-396.119	575
1237.108	-393.175	1427	1245.73	-389.984	1077	1181.373	-395.903	564
1238.592	-392.948	1487	1247.213	-389.755	884	1182.858	-395.686	646
1240.076	-392.72	1681	1248.696	-389.526	1096	1188.795	-394.816	609
1241.559	-392.493	1310	1174.216	-398.81	459	1190.279	-394.598	535
1243.043	-392.265	1080	1175.701	-398.594	516	1191.764	-394.379	489
1244.527	-392.037	1029	1177.186	-398.378	579	1193.248	-394.161	408
1246.011	-391.808	989	1178.67	-398.162	576	1194.732	-393.942	669
1247.494	-391.58	1038	1180.155	-397.946	656	1196.216	-393.722	675
1248.978	-391.351	1337	1181.64	-397.729	718	1197.7	-393.503	789
1172.995	-400.852	368	1183.125	-397.513	760	1199.184	-393.283	834
1174.481	-400.637	411	1184.61	-397.295	994	1200.668	-393.063	852
1175.966	-400.421	485	1187.579	-396.86	782	1202.152	-392.843	817
1177.451	-400.205	480	1189.064	-396.642	618	1203.636	-392.622	823
1178.936	-399.989	569	1190.548	-396.424	489	1205.12	-392.401	750
1180.422	-399.773	610	1192.033	-396.206	549	1206.603	-392.18	930
1181.907	-399.556	585	1193.517	-395.987	598	1208.087	-391.959	1127
1183.392	-399.339	596	1195.002	-395.768	577	1209.571	-391.737	726
1184.877	-399.122	591	1196.486	-395.549	809	1211.055	-391.515	1065
1186.362	-398.905	681	1197.97	-395.329	899	1212.538	-391.293	1323
1187.847	-398.687	787	1199.455	-395.109	1006	1214.022	-391.07	1448
1189.332	-398.469	528	1200.939	-394.889	1262	1215.505	-390.847	1548
1190.817	-398.251	700	1202.423	-394.669	988	1216.989	-390.624	1772
1192.302	-398.032	615	1203.907	-394.448	1120	1218.472	-390.401	1416
1193.786	-397.813	905	1205.392	-394.227	1054	1219.956	-390.177	1198
1195.271	-397.594	836	1206.876	-394.006	860	1221.439	-389.954	1225
1196.756	-397.375	827	1208.36	-393.785	1013	1222.922	-389.729	1580

Great Smokey Mountains								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1224.406	-389.505	1529	1246.369	-384.282	971	1222.094	-384.254	877
1225.889	-389.28	1165	1247.851	-384.053	945	1223.577	-384.029	892
1227.372	-389.055	1418	1249.333	-383.824	1058	1225.059	-383.805	910
1228.855	-388.83	1635	1192.709	-390.508	492	1226.541	-383.58	1134
1230.339	-388.605	1459	1194.193	-390.289	640	1228.023	-383.355	1358
1231.822	-388.379	1310	1195.676	-390.07	587	1229.506	-383.13	1512
1233.305	-388.153	1441	1197.159	-389.851	517	1230.988	-382.904	1674
1234.788	-387.926	1391	1198.643	-389.631	876	1232.47	-382.678	1806
1236.271	-387.7	1337	1200.126	-389.411	983	1233.952	-382.452	1678
1237.754	-387.473	1455	1201.609	-389.191	850	1235.434	-382.225	1725
1239.236	-387.246	1336	1203.092	-388.97	776	1236.916	-381.999	1256
1240.719	-387.018	1223	1204.576	-388.749	518	1238.397	-381.772	1160
1242.202	-386.791	1226	1206.059	-388.528	555	1239.879	-381.544	1382
1243.685	-386.563	979	1207.542	-388.307	487	1241.361	-381.317	1289
1245.168	-386.335	1079	1209.025	-388.085	626	1242.843	-381.089	1584
1246.65	-386.106	1104	1210.508	-387.864	794	1244.325	-380.861	1317
1248.133	-385.877	858	1211.991	-387.641	824	1245.806	-380.633	1170
1249.616	-385.648	1030	1213.474	-387.419	1004	1211.444	-383.99	548
1178.139	-394.509	475	1214.957	-387.196	1101	1212.926	-383.768	730
1179.623	-394.292	440	1216.439	-386.973	1435	1214.408	-383.545	699
1181.107	-394.076	640	1217.922	-386.75	1039	1215.89	-383.323	749
1191.495	-392.553	369	1219.405	-386.527	765	1217.372	-383.099	624
1192.979	-392.334	478	1220.888	-386.303	961	1218.854	-382.876	608
1194.462	-392.115	570	1222.37	-386.079	963	1220.336	-382.652	530
1195.946	-391.896	552	1223.853	-385.855	1391	1221.818	-382.428	797
1197.43	-391.677	843	1225.336	-385.63	1485	1223.3	-382.204	1103
1198.913	-391.457	604	1226.818	-385.405	1332	1224.782	-381.98	1110
1200.397	-391.237	605	1228.301	-385.18	1520	1226.264	-381.755	1130
1201.881	-391.017	652	1229.783	-384.955	1705	1227.746	-381.53	1499
1203.364	-390.796	770	1231.266	-384.729	1572	1229.228	-381.305	1742
1204.848	-390.575	834	1232.748	-384.503	1802	1230.71	-381.079	1769
1206.331	-390.354	725	1234.23	-384.277	1371	1232.191	-380.853	1639
1207.814	-390.133	608	1235.713	-384.05	1674	1233.673	-380.627	1342
1209.298	-389.911	656	1237.195	-383.823	1676	1235.155	-380.401	1247
1210.781	-389.689	1126	1238.677	-383.596	1586	1236.636	-380.174	1168
1212.265	-389.467	1115	1240.159	-383.369	1727	1238.118	-379.947	1012
1213.748	-389.245	1387	1241.641	-383.142	1516	1239.599	-379.72	959
1215.231	-389.022	1569	1243.124	-382.914	1359	1241.081	-379.492	1366
1216.714	-388.799	1595	1244.606	-382.686	1097	1242.562	-379.265	1348
1218.197	-388.576	1195	1246.088	-382.457	1022	1244.044	-379.037	1526
1219.68	-388.352	961	1247.57	-382.229	1016	1245.525	-378.808	1042
1221.163	-388.128	1084	1249.051	-382	732	1214.134	-381.72	488
1222.646	-387.904	1324	1198.372	-387.805	652	1215.616	-381.497	515
1224.129	-387.68	1732	1199.855	-387.585	1164	1217.097	-381.274	491
1225.612	-387.455	1720	1201.338	-387.365	1129	1218.579	-381.051	550
1227.095	-387.23	1512	1202.821	-387.144	1070	1220.061	-380.827	579
1228.578	-387.005	1680	1204.304	-386.924	942	1221.543	-380.603	781
1230.061	-386.78	1528	1205.786	-386.703	668	1223.024	-380.379	900
1231.544	-386.554	1452	1207.269	-386.481	425	1224.506	-380.155	1059
1233.026	-386.328	1535	1208.752	-386.26	532	1225.987	-379.93	1123
1234.509	-386.102	1401	1210.235	-386.038	696	1227.469	-379.705	1307
1235.992	-385.875	1483	1211.717	-385.816	673	1228.95	-379.48	1166
1237.474	-385.648	1605	1213.2	-385.594	775	1230.432	-379.254	1302
1238.957	-385.421	1574	1214.682	-385.371	1061	1231.913	-379.028	1672
1240.439	-385.194	1577	1216.165	-385.148	939	1233.394	-378.802	1533
1241.922	-384.966	1326	1217.647	-384.925	817	1234.876	-378.576	1429
1243.404	-384.738	1393	1219.13	-384.701	763	1236.357	-378.349	1457
1244.887	-384.51	1134	1220.612	-384.478	616	1237.838	-378.122	1391

Great Smokey Mountains								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1239.319	-377.895	937						
1240.8	-377.668	1015						
1242.282	-377.44	1056						
1243.763	-377.212	1071						
1245.244	-376.984	1060						
1218.304	-379.225	427						
1219.785	-379.002	480						
1221.267	-378.778	488						
1222.748	-378.554	624						
1224.229	-378.33	761						
1225.71	-378.105	732						
1227.191	-377.88	881						
1228.673	-377.655	821						
1230.154	-377.429	1000						
1231.635	-377.204	1094						
1233.116	-376.978	1208						
1234.597	-376.751	860						
1236.078	-376.525	857						
1237.558	-376.298	1391						
1239.039	-376.071	1265						
1240.52	-375.843	1067						
1242.001	-375.616	921						
1243.482	-375.388	611						
1226.914	-376.055	608						
1229.876	-375.604	699						
1231.356	-375.379	785						
1232.837	-375.153	892						
1234.318	-374.927	622						
1235.798	-374.7	762						
1237.279	-374.473	1130						
1238.759	-374.246	1458						
1240.24	-374.019	1097						
1241.72	-373.791	823						
1243.201	-373.563	603						
1232.558	-373.328	534						
1234.039	-373.102	545						
1235.519	-372.875	582						
1236.999	-372.649	735						
1238.479	-372.422	885						
1239.96	-372.195	873						
1239.319	-377.895	937						

Cohutta								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1124.359	-493.51	903	1121.228	-487.412	557	1119.976	-483.854	426
1125.11	-493.407	958	1121.978	-487.309	598	1120.726	-483.751	458
1125.861	-493.304	1057	1122.729	-487.206	646	1121.477	-483.648	475
1123.482	-492.698	969	1123.48	-487.103	777	1122.227	-483.545	514
1124.233	-492.595	846	1124.23	-487	939	1122.977	-483.442	546
1124.984	-492.492	853	1124.981	-486.897	1000	1123.727	-483.339	623
1125.735	-492.389	873	1125.731	-486.794	1134	1124.478	-483.236	833
1121.104	-492.091	1070	1126.482	-486.691	1042	1125.228	-483.133	909
1121.855	-491.989	1189	1127.232	-486.587	1096	1125.978	-483.03	655
1122.606	-491.886	1015	1127.983	-486.484	905	1126.728	-482.927	841
1123.357	-491.783	893	1128.733	-486.38	796	1127.478	-482.823	717
1124.108	-491.68	763	1120.352	-486.6	498	1128.229	-482.72	579
1124.859	-491.576	732	1121.102	-486.497	532	1128.979	-482.616	680
1125.61	-491.473	805	1121.853	-486.394	579	1129.729	-482.513	838
1126.361	-491.37	962	1122.603	-486.291	620	1130.479	-482.409	810
1120.227	-491.279	934	1123.354	-486.188	753	1122.851	-482.527	578
1120.978	-491.176	926	1124.104	-486.085	971	1123.602	-482.424	640
1121.729	-491.073	1023	1124.855	-485.982	995	1124.352	-482.321	605
1122.48	-490.97	950	1125.605	-485.879	1063	1125.102	-482.218	722
1123.231	-490.867	823	1126.356	-485.775	912	1125.852	-482.115	654
1123.982	-490.764	762	1127.106	-485.672	1072	1126.602	-482.012	858
1124.733	-490.661	775	1127.857	-485.569	970	1127.352	-481.908	695
1125.484	-490.558	764	1128.607	-485.465	828	1128.102	-481.805	552
1126.235	-490.455	908	1120.227	-485.684	460	1128.852	-481.701	646
1120.102	-490.363	918	1120.977	-485.582	567	1129.603	-481.598	848
1120.853	-490.261	822	1121.727	-485.479	524	1130.353	-481.494	870
1121.604	-490.158	876	1122.478	-485.376	596	1131.103	-481.39	732
1122.355	-490.055	918	1123.228	-485.273	661	1122.726	-481.612	549
1123.106	-489.952	673	1123.979	-485.17	732	1123.476	-481.509	522
1123.856	-489.849	671	1124.729	-485.067	963	1124.226	-481.406	518
1124.607	-489.746	785	1125.48	-484.964	957	1124.976	-481.303	566
1125.358	-489.643	937	1126.23	-484.86	924	1125.726	-481.2	582
1126.109	-489.54	883	1126.98	-484.757	1039	1126.476	-481.096	709
1126.86	-489.436	967	1127.731	-484.654	867	1127.226	-480.993	619
1119.977	-489.448	785	1128.481	-484.55	846	1127.976	-480.89	598
1120.728	-489.345	821	1129.231	-484.447	715	1128.726	-480.786	732
1121.478	-489.243	846	1129.982	-484.343	734	1129.476	-480.683	896
1122.229	-489.14	766	1130.732	-484.239	761	1130.226	-480.579	949
1122.98	-489.037	610	1131.482	-484.136	798	1130.976	-480.475	760
1123.731	-488.934	793	1118.6	-484.974	476	1131.726	-480.372	644
1124.482	-488.831	959	1119.351	-484.872	488	1122.6	-480.697	579
1125.232	-488.728	928	1120.101	-484.769	446	1123.35	-480.594	511
1125.983	-488.624	1090	1120.852	-484.666	443	1124.1	-480.491	513
1126.734	-488.521	1154	1121.602	-484.563	549	1124.85	-480.388	549
1127.484	-488.418	1002	1122.352	-484.461	526	1125.6	-480.285	579
1128.235	-488.314	893	1123.103	-484.358	596	1126.35	-480.181	594
1120.602	-488.43	610	1123.853	-484.255	733	1127.1	-480.078	536
1121.353	-488.327	706	1124.603	-484.152	905	1127.85	-479.975	598
1122.104	-488.224	581	1125.354	-484.048	867	1128.6	-479.871	670
1122.854	-488.122	628	1126.104	-483.945	781	1129.35	-479.768	815
1123.605	-488.019	673	1126.854	-483.842	900	1130.1	-479.664	975
1124.356	-487.915	878	1127.605	-483.738	808	1130.85	-479.56	839
1125.106	-487.812	1099	1128.355	-483.635	638	1131.6	-479.457	696
1125.857	-487.709	1175	1129.105	-483.532	774	1123.225	-479.679	457
1126.608	-487.606	1139	1129.855	-483.428	881	1123.974	-479.576	457
1127.358	-487.503	1097	1130.606	-483.324	769	1124.724	-479.473	429
1128.109	-487.399	862	1118.475	-484.059	487	1125.474	-479.369	487
1120.477	-487.515	606	1119.226	-483.956	396	1126.224	-479.266	502

Cohutta								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1126.974	-479.163	582						
1127.724	-479.06	587						
1128.474	-478.956	760						
1129.223	-478.853	914						
1129.973	-478.749	1039						
1130.723	-478.645	917						
1131.473	-478.542	903						
1132.223	-478.438	654						
1122.349	-478.867	456						
1123.099	-478.764	495						
1123.849	-478.661	400						
1124.598	-478.558	519						
1125.348	-478.454	630						
1126.098	-478.351	582						
1126.848	-478.248	611						
1127.598	-478.144	769						
1128.347	-478.041	610						
1129.097	-477.938	701						
1129.847	-477.834	915						
1130.597	-477.73	890						
1131.346	-477.627	762						
1132.096	-477.523	616						
1119.974	-478.26	310						
1120.724	-478.157	408						
1121.474	-478.054	449						
1122.223	-477.951	476						
1122.973	-477.849	449						
1123.723	-477.746	468						
1124.473	-477.642	482						
1125.222	-477.539	615						
1125.972	-477.436	647						
1126.722	-477.333	614						
1127.471	-477.229	747						
1128.221	-477.126	942						
1128.971	-477.023	893						
1129.72	-476.919	955						
1130.47	-476.815	874						
1131.22	-476.712	662						
1131.969	-476.608	636						
1132.719	-476.504	544						
1126.596	-476.418	717						
1127.345	-476.314	750						
1128.095	-476.211	982						
1128.844	-476.107	1141						
1126.469	-475.503	847						
1127.219	-475.399	1013						

Shining Rock								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1273.44	-416.507	1629	1275.842	-412.391	1161			
1274.184	-416.39	1586	1265.287	-413.11	968			
1274.928	-416.274	1370	1266.03	-412.994	1198			
1275.672	-416.157	1274	1266.774	-412.878	1362			
1276.416	-416.04	1181	1267.518	-412.762	1470			
1268.832	-416.294	1183	1268.262	-412.646	1248			
1269.576	-416.178	1416	1269.006	-412.529	1058			
1270.321	-416.062	1541	1269.749	-412.413	1170			
1271.065	-415.945	1677	1270.493	-412.296	1415			
1271.809	-415.828	1640	1271.237	-412.18	1689			
1272.553	-415.712	1770	1271.981	-412.063	1547			
1273.297	-415.595	1679	1272.724	-411.946	1550			
1274.041	-415.478	1585	1273.468	-411.83	1437			
1274.785	-415.361	1529	1274.212	-411.713	1508			
1275.529	-415.245	1309	1274.955	-411.596	1300			
1276.273	-415.128	1128	1275.699	-411.479	1176			
1267.946	-415.498	1097	1268.863	-411.617	1012			
1268.69	-415.382	1217	1269.607	-411.501	1285			
1269.434	-415.266	1536	1270.35	-411.384	1366			
1270.178	-415.149	1463	1271.094	-411.268	1566			
1270.922	-415.033	1436	1271.837	-411.151	1451			
1271.666	-414.916	1629	1272.581	-411.034	1359			
1272.41	-414.8	1771	1273.325	-410.918	1273			
1273.154	-414.683	1622	1274.068	-410.801	1274			
1273.898	-414.566	1425	1274.812	-410.684	1280			
1274.642	-414.449	1312	1275.555	-410.567	1155			
1275.385	-414.332	1362	1270.207	-410.472	1179			
1276.129	-414.215	1067	1270.951	-410.355	1348			
1276.873	-414.098	1162	1271.694	-410.239	1488			
1277.617	-413.981	1399	1270.808	-409.443	1442			
1267.059	-414.702	1029	1271.551	-409.327	1565			
1267.803	-414.586	1227	1272.295	-409.21	1505			
1268.547	-414.47	1505	1273.038	-409.093	1409			
1269.291	-414.354	1347	1273.782	-408.977	1380			
1270.035	-414.237	1317	1274.525	-408.86	1303			
1270.779	-414.121	1536	1275.269	-408.743	1104			
1271.523	-414.004	1675	1269.922	-408.648	1500			
1272.267	-413.887	1729	1271.408	-408.415	1678			
1273.011	-413.771	1523	1272.152	-408.298	1707			
1273.754	-413.654	1544	1272.895	-408.181	1515			
1274.498	-413.537	1429	1273.638	-408.065	1321			
1275.242	-413.42	1315	1274.382	-407.948	1219			
1275.986	-413.303	1068	1271.265	-407.503	1394			
1276.73	-413.186	1066	1272.009	-407.386	1522			
1277.474	-413.069	1352	1272.752	-407.269	1411			
1266.173	-413.906	1024	1273.495	-407.152	1234			
1266.917	-413.79	1296	1271.122	-406.59	1189			
1267.661	-413.674	1404	1271.865	-406.474	1343			
1268.404	-413.558	1373	1272.609	-406.357	1265			
1269.148	-413.441	1198	1270.979	-405.678	1045			
1269.892	-413.325	1198	1271.722	-405.562	1235			
1270.636	-413.208	1419	1272.465	-405.445	1066			
1271.38	-413.092	1571						
1272.124	-412.975	1741						
1272.867	-412.859	1717						
1273.611	-412.742	1616						
1274.355	-412.625	1569						
1275.099	-412.508	1422						

Joyce Kilmer Slickrock								
Lambert Conformal X (km)	**Lambert Conformal Y (km)**	**Height (m)**	**Lambert Conformal X (km)**	**Lambert Conformal Y (km)**	**Height (m)**	**Lambert Conformal X (km)**	**Lambert Conformal Y (km)**	**Height (m)**
1174.116	-429.607	1154	1168.724	-423.854	1065			
1174.861	-429.499	1056	1169.468	-423.747	836			
1175.607	-429.391	903	1170.213	-423.64	700			
1176.352	-429.283	820	1170.958	-423.532	782			
1177.097	-429.175	818	1171.703	-423.425	961			
1173.239	-428.8	1278	1173.937	-423.102	809			
1173.984	-428.693	1069	1174.682	-422.995	941			
1174.729	-428.585	913	1167.847	-423.047	991			
1175.475	-428.477	776	1168.592	-422.94	817			
1176.22	-428.369	788	1169.337	-422.833	751			
1176.965	-428.262	750	1170.081	-422.726	635			
1172.362	-427.994	1327	1170.826	-422.619	772			
1173.107	-427.887	1085	1171.571	-422.511	882			
1173.852	-427.779	985	1168.461	-422.026	954			
1174.597	-427.671	934	1169.205	-421.919	739			
1175.342	-427.563	978	1169.95	-421.812	620			
1176.088	-427.456	982	1170.694	-421.705	635			
1176.833	-427.348	824	1171.439	-421.597	700			
1169.995	-427.402	1317	1172.184	-421.49	865			
1170.74	-427.295	1394	1168.329	-421.113	943			
1171.485	-427.188	1487	1169.074	-421.005	742			
1172.23	-427.08	1308	1169.818	-420.898	505			
1172.975	-426.973	1237	1170.563	-420.791	558			
1173.72	-426.865	1336	1171.307	-420.684	538			
1174.465	-426.757	1290	1172.052	-420.576	686			
1175.21	-426.65	1304	1168.198	-420.199	946			
1175.955	-426.542	1111	1168.942	-420.092	760			
1176.7	-426.434	1066	1169.686	-419.984	644			
1169.863	-426.489	1189	1170.431	-419.877	491			
1170.608	-426.381	1127	1171.175	-419.77	442			
1171.353	-426.274	1299	1171.92	-419.662	491			
1172.098	-426.166	1380	1168.066	-419.285	959			
1172.843	-426.059	1553	1168.81	-419.178	752			
1173.588	-425.951	1336	1169.555	-419.071	528			
1174.333	-425.844	1219	1170.299	-418.963	598			
1175.078	-425.736	1109	1171.043	-418.856	515			
1175.823	-425.628	1133	1171.788	-418.749	400			
1176.568	-425.52	1226	1172.532	-418.641	523			
1168.987	-425.682	1280	1167.935	-418.371	712			
1169.731	-425.575	1136	1170.167	-418.05	743			
1170.476	-425.467	906	1170.912	-417.942	684			
1171.221	-425.36	999	1171.656	-417.835	538			
1171.966	-425.253	1170	1172.4	-417.727	361			
1172.711	-425.145	1376						
1173.456	-425.037	1318						
1174.201	-424.93	1369						
1174.946	-424.822	1152						
1175.691	-424.714	924						
1176.436	-424.607	882						
1168.11	-424.875	1151						
1168.855	-424.768	1116						
1169.6	-424.661	1044						
1170.345	-424.554	772						
1171.09	-424.446	866						
1171.834	-424.339	1090						
1173.324	-424.124	1020						
1174.069	-424.016	1067						
1167.979	-423.961	1224						

Linville Gorge								
Lambert Conformal X (km)	**Lambert Conformal Y (km)**	**Height (m)**	**Lambert Conformal X (km)**	**Lambert Conformal Y (km)**	**Height (m)**	**Lambert Conformal X (km)**	**Lambert Conformal Y (km)**	**Height (m)**
1349.498	-350.859	468	1346.472	-337.331	924			
1350.236	-350.735	457	1347.209	-337.207	901			
1349.345	-349.949	478	1347.946	-337.084	1114			
1350.083	-349.825	576	1348.683	-336.96	1219			
1347.717	-349.286	550	1345.583	-336.544	946			
1348.455	-349.162	472	1346.32	-336.421	983			
1349.193	-349.039	721	1347.056	-336.297	1142			
1349.931	-348.915	759	1346.167	-335.511	1063			
1350.669	-348.791	600						
1351.406	-348.667	517						
1347.564	-348.376	641						
1348.302	-348.252	439						
1349.04	-348.129	607						
1349.778	-348.005	881						
1350.516	-347.881	758						
1347.412	-347.466	920						
1348.15	-347.342	665						
1348.887	-347.219	458						
1349.625	-347.095	585						
1350.363	-346.971	870						
1347.997	-346.432	826						
1348.735	-346.308	518						
1349.473	-346.185	525						
1350.21	-346.061	695						
1350.948	-345.937	892						
1347.845	-345.522	874						
1348.582	-345.398	581						
1349.32	-345.275	573						
1350.057	-345.151	664						
1348.43	-344.488	728						
1349.167	-344.364	694						
1349.905	-344.241	914						
1348.277	-343.578	756						
1349.015	-343.454	631						
1349.752	-343.331	944						
1348.125	-342.668	826						
1348.862	-342.544	624						
1349.599	-342.42	965						
1347.972	-341.758	732						
1348.709	-341.634	685						
1349.446	-341.51	889						
1347.819	-340.848	890						
1348.557	-340.724	697						
1349.294	-340.6	827						
1346.93	-340.061	1096						
1347.667	-339.938	749						
1348.404	-339.814	816						
1349.141	-339.69	1106						
1346.777	-339.151	1055						
1347.514	-339.027	762						
1348.251	-338.904	909						
1348.988	-338.78	1092						
1345.888	-338.364	941						
1346.625	-338.241	813						
1347.362	-338.117	953						
1348.099	-337.994	1097						
1348.835	-337.87	1083						
1345.735	-337.454	923						

Okefenokee								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1401.401	-877.287	36.0	1404.777	-888.047	36.0	1388.045	-894.538	36.0
1399.829	-877.544	36.0	1403.202	-888.305	36.0	1399.375	-894.585	36.0
1403.275	-878.866	27.0	1401.627	-888.562	36.0	1386.469	-894.792	36.0
1401.701	-879.123	27.0	1400.052	-888.819	36.0	1417.01	-893.581	36.0
1400.128	-879.38	30.0	1398.477	-889.075	36.0	1397.799	-894.842	36.0
1398.555	-879.637	36.0	1416.101	-888.073	36.0	1415.434	-893.841	36.0
1396.982	-879.893	36.0	1396.902	-889.332	36.0	1413.858	-894.1	37.0
1405.148	-880.444	36.0	1414.527	-888.332	36.0	1384.894	-895.046	36.0
1403.575	-880.702	37.0	1412.952	-888.591	36.0	1396.223	-895.098	36.0
1402.002	-880.959	36.0	1395.327	-889.588	33.0	1412.282	-894.359	36.0
1400.428	-881.216	36.0	1411.377	-888.85	38.0	1410.706	-894.618	36.0
1398.855	-881.473	36.0	1409.802	-889.109	29.0	1394.647	-895.354	36.0
1397.281	-881.729	36.0	1393.752	-889.843	32.0	1409.131	-894.877	36.0
1408.596	-881.764	36.0	1408.227	-889.368	36.0	1393.071	-895.61	36.0
1407.023	-882.023	36.0	1392.177	-890.099	36.0	1407.555	-895.135	36.0
1405.449	-882.281	36.0	1406.652	-889.626	36.0	1405.978	-895.393	36.0
1403.875	-882.538	27.0	1405.077	-889.883	37.0	1391.495	-895.865	36.0
1402.302	-882.796	27.0	1390.602	-890.354	38.0	1404.402	-895.651	36.0
1400.728	-883.053	30.0	1403.502	-890.141	37.0	1389.918	-896.12	36.0
1399.154	-883.309	27.0	1401.927	-890.398	37.0	1402.826	-895.908	36.0
1397.58	-883.566	31.0	1400.352	-890.655	36.0	1401.25	-896.165	36.0
1396.006	-883.822	36.0	1398.776	-890.912	36.0	1388.342	-896.375	36.0
1412.045	-883.083	36.0	1416.404	-889.909	36.0	1399.674	-896.422	37.0
1410.472	-883.342	36.0	1397.201	-891.168	36.0	1386.766	-896.629	36.0
1394.432	-884.078	36.0	1414.829	-890.168	36.0	1417.313	-895.417	36.0
1408.898	-883.601	36.0	1413.254	-890.428	36.0	1398.098	-896.679	36.0
1407.324	-883.859	36.0	1395.626	-891.424	36.0	1415.737	-895.677	36.0
1405.75	-884.117	36.0	1411.679	-890.687	38.0	1385.19	-896.884	36.0
1404.176	-884.374	36.0	1410.103	-890.945	37.0	1414.16	-895.937	36.0
1402.602	-884.632	36.0	1394.051	-891.68	38.0	1396.521	-896.935	36.0
1401.028	-884.889	36.0	1408.528	-891.204	36.0	1412.584	-896.196	36.0
1399.453	-885.146	36.0	1392.475	-891.936	36.0	1411.008	-896.455	36.0
1397.879	-885.402	36.0	1406.953	-891.462	36.0	1383.613	-897.137	36.0
1415.496	-884.401	27.0	1405.378	-891.72	38.0	1394.945	-897.191	36.0
1413.922	-884.66	30.0	1390.9	-892.191	38.0	1409.432	-896.713	36.0
1396.305	-885.658	31.0	1403.802	-891.978	37.0	1393.368	-897.447	36.0
1412.347	-884.919	32.0	1389.324	-892.446	37.0	1407.855	-896.972	36.0
1394.731	-885.914	27.0	1402.227	-892.235	36.0	1406.279	-897.23	36.0
1410.773	-885.178	27.0	1400.651	-892.492	36.0	1391.792	-897.702	36.0
1409.199	-885.437	36.0	1387.749	-892.701	36.0	1404.703	-897.488	36.0
1393.156	-886.17	36.0	1399.076	-892.749	36.0	1390.216	-897.957	36.0
1407.625	-885.695	36.0	1416.707	-891.745	36.0	1403.126	-897.745	36.0
1406.051	-885.953	36.0	1397.5	-893.005	36.0	1388.639	-898.212	36.0
1404.476	-886.211	36.0	1415.131	-892.005	36.0	1401.55	-898.002	36.0
1402.902	-886.468	36.0	1413.556	-892.264	36.0	1399.973	-898.259	36.0
1401.327	-886.725	36.0	1395.924	-893.261	37.0	1387.062	-898.467	36.0
1399.753	-886.982	36.0	1411.981	-892.523	38.0	1417.615	-897.254	36.0
1398.178	-887.239	36.0	1410.405	-892.782	38.0	1398.396	-898.516	36.0
1415.798	-886.237	37.0	1394.349	-893.517	38.0	1416.039	-897.514	36.0
1414.224	-886.496	36.0	1408.829	-893.04	36.0	1385.486	-898.721	36.0
1396.604	-887.495	27.0	1392.773	-893.773	36.0	1414.463	-897.773	36.0
1412.65	-886.755	27.0	1407.254	-893.299	36.0	1396.82	-898.772	36.0
1395.029	-887.751	27.0	1405.678	-893.557	36.0	1412.886	-898.033	36.0
1411.075	-887.014	27.0	1391.197	-894.028	36.0	1383.909	-898.975	36.0
1409.501	-887.273	30.0	1404.102	-893.814	36.0	1395.243	-899.028	36.0
1393.454	-888.007	34.0	1389.621	-894.283	36.0	1411.309	-898.291	36.0
1407.926	-887.531	36.0	1402.526	-894.072	36.0	1409.733	-898.55	36.0
1406.351	-887.789	36.0	1400.951	-894.329	36.0	1393.666	-899.284	36.0

Okefenokee								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1382.332	-899.228	36.0	1387.952	-903.979	36.0	1400.19	-909.539	36.0
1408.156	-898.809	36.0	1418.524	-902.764	36.0	1419.433	-908.274	36.0
1406.579	-899.067	36.0	1399.293	-904.027	36.0	1417.854	-908.534	36.0
1392.09	-899.539	36.0	1386.374	-904.233	36.0	1398.611	-909.796	36.0
1405.003	-899.325	36.0	1416.947	-903.024	37.0	1416.276	-908.794	36.0
1390.513	-899.795	36.0	1397.715	-904.284	32.0	1414.697	-909.053	36.0
1403.426	-899.582	36.0	1415.369	-903.283	27.0	1397.032	-910.052	36.0
1388.936	-900.049	36.0	1413.792	-903.543	36.0	1413.119	-909.313	36.0
1401.849	-899.839	36.0	1384.796	-904.487	37.0	1411.54	-909.572	36.0
1400.272	-900.096	36.0	1412.214	-903.802	37.0	1409.962	-909.831	36.0
1387.359	-900.304	36.0	1410.636	-904.061	36.0	1408.383	-910.089	34.0
1417.918	-899.09	36.0	1383.219	-904.741	36.0	1406.804	-910.347	30.0
1398.695	-900.353	36.0	1409.059	-904.319	36.0	1405.225	-910.605	33.0
1416.342	-899.35	36.0	1407.481	-904.577	36.0	1403.646	-910.863	33.0
1385.782	-900.558	36.0	1381.641	-904.995	36.0	1402.067	-911.12	33.0
1414.765	-899.61	36.0	1405.903	-904.835	36.0	1400.488	-911.377	31.0
1397.118	-900.609	36.0	1404.326	-905.093	36.0	1419.736	-910.111	31.0
1413.188	-899.869	36.0	1380.063	-905.248	36.0	1418.157	-910.371	36.0
1384.205	-900.812	36.0	1389.826	-905.562	36.0	1398.909	-911.634	36.0
1395.541	-900.865	36.0	1402.748	-905.351	36.0	1416.578	-910.631	36.0
1411.611	-900.128	37.0	1401.17	-905.608	36.0	1414.999	-910.891	36.0
1410.034	-900.387	37.0	1388.248	-905.817	36.0	1397.33	-911.89	36.0
1393.964	-901.121	36.0	1399.592	-905.865	36.0	1413.42	-911.15	36.0
1382.628	-901.066	36.0	1418.827	-904.6	36.0	1395.751	-912.146	36.0
1408.457	-900.645	36.0	1386.67	-906.071	36.0	1411.842	-911.409	36.0
1406.88	-900.904	36.0	1417.249	-904.86	34.0	1410.262	-911.668	36.0
1392.387	-901.377	36.0	1398.014	-906.121	29.0	1394.172	-912.402	36.0
1381.051	-901.319	36.0	1415.671	-905.12	30.0	1408.683	-911.926	36.0
1405.303	-901.161	36.0	1414.094	-905.38	36.0	1407.104	-912.184	36.0
1390.81	-901.632	36.0	1385.092	-906.325	36.0	1392.593	-912.657	36.0
1403.726	-901.419	36.0	1412.516	-905.639	36.0	1405.525	-912.442	36.0
1389.233	-901.887	36.0	1410.938	-905.898	36.0	1403.946	-912.7	36.0
1402.149	-901.676	36.0	1383.514	-906.579	36.0	1402.367	-912.957	36.0
1400.571	-901.933	36.0	1409.36	-906.156	36.0	1400.787	-913.214	36.0
1387.655	-902.141	37.0	1407.782	-906.415	36.0	1399.208	-913.471	32.0
1418.221	-900.927	36.0	1381.936	-906.833	36.0	1416.881	-912.468	33.0
1398.994	-902.19	37.0	1406.204	-906.673	36.0	1415.301	-912.728	35.0
1416.644	-901.187	36.0	1380.358	-907.086	36.0	1397.629	-913.728	35.0
1386.078	-902.396	36.0	1404.625	-906.93	36.0	1413.722	-912.987	33.0
1415.067	-901.446	36.0	1390.123	-907.399	36.0	1396.049	-913.984	31.0
1397.417	-902.446	36.0	1403.047	-907.188	36.0	1412.143	-913.246	30.0
1413.49	-901.706	36.0	1401.469	-907.445	36.0	1410.563	-913.505	31.0
1384.501	-902.65	36.0	1388.545	-907.654	36.0	1394.47	-914.24	36.0
1395.839	-902.703	36.0	1399.891	-907.702	36.0	1408.984	-913.764	36.0
1411.913	-901.965	36.0	1419.13	-906.437	36.0	1392.89	-914.495	37.0
1410.335	-902.224	36.0	1417.552	-906.697	32.0	1407.405	-914.022	36.0
1394.262	-902.958	36.0	1398.312	-907.958	30.0	1405.825	-914.28	36.0
1382.923	-902.904	36.0	1415.974	-906.957	33.0	1404.246	-914.538	36.0
1408.758	-902.482	37.0	1414.396	-907.216	33.0	1402.666	-914.795	36.0
1392.684	-903.214	36.0	1396.734	-908.215	30.0	1401.086	-915.052	36.0
1407.181	-902.74	37.0	1412.817	-907.476	36.0	1399.507	-915.309	36.0
1381.346	-903.157	36.0	1411.239	-907.735	36.0	1417.183	-914.305	36.0
1405.603	-902.998	36.0	1409.661	-907.993	36.0	1415.603	-914.565	36.0
1404.026	-903.256	36.0	1408.082	-908.252	36.0	1397.927	-915.565	36.0
1379.768	-903.41	36.0	1406.504	-908.51	36.0	1414.024	-914.824	36.0
1389.529	-903.724	36.0	1404.925	-908.768	36.0	1396.347	-915.822	36.0
1402.448	-903.513	36.0	1403.347	-909.025	36.0	1412.444	-915.084	36.0
1400.871	-903.77	36.0	1401.768	-909.282	36.0	1410.864	-915.343	32.0

Okefenokee								
Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)	Lambert Conformal X (km)	Lambert Conformal Y (km)	Height (m)
1394.767	-916.078	36.0	1198.241	-397.155	36.0	1420.881	-926.907	37.0
1409.285	-915.601	36.0	1199.725	-396.935	36.0	1419.299	-927.168	36.0
1393.187	-916.333	36.0	1201.21	-396.715	36.0	1400.015	-928.432	36.0
1407.705	-915.859	33.0	1202.695	-396.495	36.0	1417.717	-927.428	36.0
1406.125	-916.117	31.0	1204.179	-396.274	36.0	1416.135	-927.688	36.0
1404.545	-916.375	32.0	1205.664	-396.053	36.0	1398.433	-928.688	36.0
1402.965	-916.633	36.0	1207.148	-395.832	36.0	1414.553	-927.947	36.0
1401.385	-916.89	36.0	1208.632	-395.61	36.0	1396.851	-928.945	36.0
1399.805	-917.147	36.0	1210.117	-395.389	36.0	1412.971	-928.206	36.0
1417.485	-916.142	36.0	1211.601	-395.167	36.0	1411.389	-928.465	36.0
1415.905	-916.402	36.0	1213.085	-394.944	36.0	1395.268	-929.201	36.0
1398.225	-917.403	36.0	1214.57	-394.722	36.0	1409.807	-928.724	36.0
1414.325	-916.662	36.0	1216.054	-394.499	36.0	1408.225	-928.983	36.0
1396.645	-917.66	36.0	1217.538	-394.276	36.0	1406.643	-929.241	37.0
1412.745	-916.921	36.0	1219.022	-394.052	36.0	1405.06	-929.498	37.0
1411.165	-917.18	36.0	1220.506	-393.828	36.0	1403.478	-929.756	37.0
1395.065	-917.916	36.0	1221.99	-393.604	36.0	1401.896	-930.013	37.0
1409.585	-917.439	36.0	1223.474	-393.38	36.0	1421.184	-928.745	37.0
1393.485	-918.171	36.0	1224.958	-393.156	36.0	1419.602	-929.005	37.0
1408.005	-917.697	36.0	1226.442	-392.931	36.0	1400.313	-930.27	37.0
1406.425	-917.955	36.0	1227.926	-392.706	36.0	1418.02	-929.266	37.0
1391.904	-918.427	36.0	1229.41	-392.48	36.0	1416.437	-929.525	37.0
1404.845	-918.213	36.0	1230.894	-392.255	36.0	1398.731	-930.527	37.0
1403.264	-918.47	36.0	1232.378	-392.029	36.0	1414.855	-929.785	37.0
1401.684	-918.728	36.0	1233.861	-391.803	36.0	1397.148	-930.783	37.0
1420.948	-917.459	33.0	1235.345	-391.576	36.0	1413.272	-930.044	37.0
1419.368	-917.72	29.0	1236.829	-391.35	41.0	1411.69	-930.303	37.0
1400.104	-918.985	36.0	1238.312	-391.123	37.0	1410.108	-930.562	37.0
1417.788	-917.98	36.0	1239.796	-390.895	36.0	1408.525	-930.821	37.0
1398.523	-919.241	36.0	1241.279	-390.668	36.0	1406.942	-931.079	37.0
1416.207	-918.24	36.0	1242.763	-390.44	36.0	1405.36	-931.337	37.0
1414.627	-918.499	36.0	1244.246	-390.212	36.0	1403.777	-931.594	37.0
1396.943	-919.497	36.0	1245.73	-389.984	36.0	1402.194	-931.852	37.0
1413.047	-918.759	36.0	1247.213	-389.755	36.0	1419.904	-930.843	37.0
1411.466	-919.018	36.0	1248.696	-389.526	36.0	1400.612	-932.109	37.0
1395.362	-919.754	36.0	1174.216	-398.81	36.0	1418.322	-931.103	37.0
1409.886	-919.276	36.0	1175.701	-398.594	36.0			
1393.782	-920.009	36.0	1177.186	-398.378	36.0			
1408.305	-919.535	36.0	1178.67	-398.162	36.0			
1406.725	-919.793	36.0	1180.155	-397.946	36.0			
1405.144	-920.051	36.0	1181.64	-397.729	36.0			
1403.564	-920.308	36.0	1183.125	-397.513	36.0			
1401.983	-920.565	36.0	1184.61	-397.295	36.0			
1419.67	-919.557	36.0	1187.579	-396.86	36.0			
1400.402	-920.822	37.0	1189.064	-396.642	36.0			
1418.09	-919.817	35.0	1190.548	-396.424	36.0			
1398.822	-921.079	30.0	1192.033	-396.206	36.0			
1416.509	-920.077	36.0	1193.517	-395.987	36.0			
1414.929	-920.337	36.0	1195.002	-395.768	36.0			
1397.241	-921.336	36.0	1196.486	-395.549	36.0			
1413.348	-920.596	36.0	1197.97	-395.329	36.0			
1411.767	-920.855	36.0	1199.455	-395.109	36.0			
1395.66	-921.592	36.0	1200.939	-394.889	36.0			
1410.187	-921.114	36.0	1202.423	-394.669	36.0			
1394.079	-921.847	36.0	1203.907	-394.448	36.0			
1408.606	-921.372	36.0	1205.392	-394.227	36.0			
1407.025	-921.631	36.0	1206.876	-394.006	36.0			
1392.498	-922.103	36.0	1208.36	-393.785	37.0			

APPENDIX E – EPA Natural Background Values

Appendix B
Default Natural b_{ext}, *dv*, and 10[th] and 90[th] Percentile *dv* Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [a]	Worst Days (dv) [a]
Acadia NP	ME	44.35	-68.24	21.40	7.61	3.77	11.45
Agua Tibia Wilderness	CA	33.42	-116.99	15.86	4.61	2.05	7.17
Alpine Lake Wilderness	WA	47.55	-121.16	16.99	5.30	2.74	7.86
Anaconda-Pintler Wilderness	MT	45.95	-113.5	16.03	4.72	2.16	7.28
Arches NP	UT	38.73	-109.58	15.58	4.43	1.87	6.99
Badlands NP	SD	43.81	-102.36	16.06	4.74	2.18	7.30
Bandelier NM	NM	35.79	-106.34	15.62	4.46	1.90	7.02
Bering Sea	AK	60.46	-172.75				
Big Bend NP	TX	29.33	-103.31	15.46	4.37	1.81	6.93
Black Canyon of the Gunnison NM	CO	38.57	-107.75	15.68	4.50	1.94	7.06
Bob Marshall Wilderness	MT	47.68	-113.23	16.17	4.80	2.24	7.36
Bosque del Apache	NM	33.79	-106.85	15.54	4.41	1.85	6.97
Boundary Waters Canoe Area	MN	48.06	-91.43	20.89	7.37	3.53	11.21
Breton	LA	29.87	-88.82	21.57	7.69	3.85	11.53
Bridger Wilderness	WY	42.99	-109.49	15.71	4.52	1.96	7.08
Brigantine	NJ	39.49	-74.39	21.05	7.44	3.60	11.28
Bryce Canyon NP	UT	37.57	-112.17	15.58	4.43	1.87	6.99
Cabinet Mountains Wilderness	MT	48.18	-115.68	16.27	4.87	2.31	7.43
Caney Creek Wilderness	AR	34.41	-94.08	21.14	7.49	3.65	11.33
Canyonlands NP	UT	38.23	-109.91	15.60	4.45	1.89	7.01
Cape Romain	SC	32.99	-79.49	21.22	7.52	3.68	11.36
Capitol Reef NP	UT	38.06	-111.15	15.63	4.47	1.91	7.03
Caribou Wilderness	CA	40.49	-121.21	16.05	4.73	2.17	7.29
Carlsbad Caverns NP	NM	32.12	-104.59	15.61	4.46	1.90	7.02
Chassahowitzka	FL	28.69	-82.66	21.46	7.63	3.79	11.47
Chiricahua NM	AZ	32.01	-109.34	15.47	4.36	1.80	6.92
Chiricahua Wilderness	AZ	31.86	-109.28	15.45	4.35	1.79	6.91
Cohutta Wilderness	GA	34.93	-84.57	21.39	7.60	3.76	11.44
Crater Lake NP	OR	42.92	-122.13	16.74	5.15	2.59	7.71
Craters of the Moon NM	ID	43.39	-113.54	15.80	4.57	2.01	7.13
Cucamonga Wilderness	CA	34.24	-117.59	15.85	4.61	2.05	7.17
Denali Preserve NP	AK	63.31	-151.19	16.27	4.86	2.30	7.42
Desolation Wilderness	CA	38.9	-120.17	15.80	4.57	2.01	7.13
Diamond Peak Wilderness	OR	43.53	-122.1	16.84	5.21	2.65	7.77
Dolly Sods Wilderness	WV	39	-79.37	21.13	7.48	3.64	11.32
Dome Land Wilderness	CA	35.84	-118.23	15.70	4.51	1.95	7.07
Eagle Cap Wilderness	OR	45.22	-117.37	16.12	4.78	2.22	7.34

Appendix B
Default Natural b_{ext}, dv, and 10th and 90th Percentile
dv Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [a]	Worst Days (dv) [a]
Eagles Nest Wilderness	CO	39.67	-106.29	15.72	4.52	1.96	7.08
Emigrant Wilderness	CA	38.18	-119.77	15.81	4.58	2.02	7.14
Everglades NP	FL	25.35	-80.98	20.77	7.31	3.47	11.15
Fitzpatrick Wilderness	WY	43.24	-109.6	15.73	4.53	1.97	7.09
Flat Tops Wilderness	CO	39.95	-107.3	15.70	4.51	1.95	7.07
Galiuro Wilderness	AZ	32.6	-110.39	15.40	4.32	1.76	6.88
Gates of the Mountains Wilderness	MT	46.86	-111.82	15.93	4.66	2.10	7.22
Gearhart Mountain Wilderness	OR	42.51	-120.86	16.33	4.90	2.34	7.46
Gila Wilderness	NM	33.21	-108.47	15.51	4.39	1.83	6.95
Glacier NP	MT	48.64	-113.84	16.48	5.00	2.44	7.56
Glacier Peak Wilderness	WA	48.21	-121	16.88	5.24	2.68	7.80
Goat Rocks Wilderness	WA	46.52	-121.47	16.93	5.26	2.70	7.82
Grand Canyon NP	AZ	36.3	-112.79	15.51	4.39	1.83	6.95
Grand Teton NP	WY	43.82	-110.71	15.74	4.53	1.97	7.09
Great Gulf Wilderness	NH	44.3	-71.28	21.10	7.47	3.63	11.31
Great Sand Dunes NM	CO	37.77	-105.57	15.74	4.54	1.98	7.10
Great Smoky Mountains NP	TN	35.6	-83.52	21.39	7.60	3.76	11.44
Guadalupe Mountains NP	TX	31.91	-104.85	15.64	4.47	1.91	7.03
Haleakala NP	HI	20.71	-156.16	16.02	4.71	2.15	7.27
Hawaii Volcanoes NP	HI	19.41	-155.34	16.33	4.91	2.35	7.47
Hells Canyon Wilderness	OR	45.54	-116.59	16.09	4.76	2.20	7.32
Hercules-Glades Wilderness	MO	36.68	-92.9	21.03	7.43	3.59	11.27
Hoover Wilderness	CA	38.11	-119.37	15.78	4.56	2.00	7.12
Isle Royale NP	MI	48.01	-88.83	20.91	7.38	3.54	11.22
James River Face Wilderness	VA	37.59	-79.44	20.96	7.40	3.56	11.24
Jarbidge Wilderness	NV	41.77	-115.35	15.75	4.54	1.98	7.10
John Muir Wilderness	CA	36.97	-118.88	15.80	4.58	2.02	7.14
Joshua Tree NM	CA	33.92	-115.88	15.72	4.52	1.96	7.08
Joyce-Kilmer-Slickrock Wilderness	TN	35.44	-83.99	21.40	7.61	3.77	11.45
Kaiser Wilderness	CA	37.28	-119.17	15.80	4.57	2.01	7.13
Kalmiopsis Wilderness	OR	42.26	-123.92	16.74	5.15	2.59	7.71
Kings Canyon NP	CA	36.92	-118.61	15.79	4.57	2.01	7.13
La Garita Wilderness	CO	37.95	-106.83	15.69	4.50	1.94	7.06
Lassen Volcanic NP	CA	40.49	-121.41	16.08	4.75	2.19	7.31
Lava Beds NM	CA	41.76	-121.52	16.37	4.93	2.37	7.49
Linville Gorge Wilderness	NC	35.88	-81.9	21.36	7.59	3.75	11.43
Lostwood	ND	48.59	-102.46	16.11	4.77	2.21	7.33

Appendix B
Default Natural b_{ext}, dv, and 10th and 90th Percentile dv Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [a]	Worst Days (dv) [a]
Lye Brook Wilderness	VT	43.13	-73.02	20.99	7.41	3.57	11.25
Mammoth Cave NP	KY	37.2	-86.15	21.58	7.69	3.85	11.53
Marble Mountain Wilderness	CA	41.51	-123.21	16.65	5.10	2.54	7.66
Maroon Bells-Snowmass Wilderness	CO	39.1	-107.02	15.70	4.51	1.95	7.07
Mazatzal Wilderness	AZ	34.13	-111.56	15.44	4.35	1.79	6.91
Medicine Lake	MT	48.49	-104.35	16.07	4.74	2.18	7.30
Mesa Verde NP	CO	37.25	-108.45	15.73	4.53	1.97	7.09
Minarets Wilderness	CA	37.74	-119.19	15.78	4.56	2.00	7.12
Mingo	MO	37	-90.19	21.03	7.43	3.59	11.27
Mission Mountains Wilderness	MT	47.48	-113.87	16.21	4.83	2.27	7.39
Mokelumne Wilderness	CA	38.57	-120.06	15.80	4.58	2.02	7.14
Moosehorn	ME	45.09	-67.29	21.22	7.52	3.68	11.36
Mount Adams Wilderness	WA	46.2	-121.49	16.86	5.22	2.66	7.78
Mount Baldy Wilderness	AZ	33.95	-109.54	15.51	4.39	1.83	6.95
Mount Hood Wilderness	OR	45.37	-121.73	16.83	5.21	2.65	7.77
Mount Jefferson Wilderness	OR	44.61	-121.84	16.91	5.25	2.69	7.81
Mount Rainier NP	WA	46.86	-121.72	17.05	5.34	2.78	7.90
Mount Washington Wilderness	OR	44.3	-121.88	17.03	5.33	2.77	7.89
Mount Zirkel Wilderness	CO	40.75	-106.68	15.71	4.52	1.96	7.08
Mountain Lakes Wilderness	OR	42.33	-122.11	16.50	5.01	2.45	7.57
North Absaroka Wilderness	WY	44.74	-109.8	15.74	4.53	1.97	7.09
North Cascades NP	WA	48.83	-121.35	16.86	5.22	2.66	7.78
Okefenokee	GA	30.82	-82.33	21.41	7.61	3.77	11.45
Olympic NP	WA	47.77	-123.74	17.02	5.32	2.76	7.88
Otter Creek Wilderness	WV	38.99	-79.65	21.14	7.49	3.65	11.33
Pasayten Wilderness	WA	48.89	-120.44	16.84	5.21	2.65	7.77
Pecos Wilderness	NM	35.9	-105.62	15.65	4.48	1.92	7.04
Petrified Forest NP	AZ	34.99	-109.79	15.54	4.41	1.85	6.97
Pine Mountain Wilderness	AZ	34.31	-111.8	15.47	4.36	1.80	6.92
Pinnacles NM	CA	36.48	-121.19	16.12	4.78	2.22	7.34
Point Reyes NS	CA	38.06	-122.9	16.20	4.83	2.27	7.39
Presidential Range-Dry River Wilderness	NH	44.2	-71.34	21.15	7.49	3.65	11.33
Rainbow Lake Wilderness	WI	46.42	-91.31	20.99	7.42	3.58	11.26
Rawah Wilderness	CO	40.69	-105.95	15.72	4.52	1.96	7.08
Red Rock Lakes	MT	44.64	-111.78	15.81	4.58	2.02	7.14
Redwood NP	CA	41.44	-124.03	16.90	5.25	2.69	7.81
Rocky Mountain NP	CO	40.35	-105.7	15.67	4.49	1.93	7.05

Appendix B
Default Natural b_{ext}, dv, and 10[th] and 90[th] Percentile dv Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [14]	Worst Days (dv) [14]
Roosevelt Campobello International Park	ME	44.85	-66.94	21.22	7.52	3.68	11.36
Saguaro NM	AZ	32.17	-110.61	15.35	4.28	1.72	6.84
Salt Creek	NM	33.6	-104.41	15.58	4.43	1.87	6.99
San Gabriel Wilderness	CA	34.27	-117.94	15.88	4.61	2.05	7.17
San Gorgonio Wilderness	CA	34.12	-116.84	15.74	4.54	1.98	7.10
San Jacinto Wilderness	CA	33.75	-116.64	15.78	4.56	2.00	7.12
San Pedro Parks Wilderness	NM	36.11	-106.81	15.63	4.47	1.91	7.03
San Rafael Wilderness	CA	34.76	-119.81	16.03	4.72	2.16	7.28
Sawtooth Wilderness	ID	43.99	-115.06	15.82	4.59	2.03	7.15
Scapegoat Wilderness	MT	47.16	-112.74	16.05	4.73	2.17	7.29
Selway-Bitterroot Wilderness	ID	46.12	-114.88	16.09	4.76	2.20	7.32
Seney	MI	46.25	-86.09	21.23	7.53	3.69	11.37
Sequoia NP	CA	36.51	-118.56	15.79	4.57	2.01	7.13
Shenandoah NP	VA	38.47	-78.49	20.98	7.41	3.57	11.25
Shining Rock Wilderness	NC	35.38	-82.85	21.40	7.61	3.77	11.45
Sierra Ancha Wilderness	AZ	33.85	-110.9	15.46	4.36	1.80	6.92
Simeonof	AK	54.91	-159.28	17.21	5.43	2.87	7.99
Sipsey Wilderness	AL	34.32	-87.44	21.28	7.55	3.71	11.39
South Warner Wilderness	CA	41.31	-120.2	16.09	4.76	2.20	7.32
St. Marks	FL	30.11	-84.15	21.54	7.67	3.83	11.51
Strawberry Mountain Wilderness	OR	44.29	-118.74	16.37	4.93	2.37	7.49
Superstition Wilderness	AZ	33.5	-111.27	15.40	4.32	1.76	6.88
Swanquarter	NC	35.39	-76.39	20.91	7.38	3.54	11.22
Sycamore Canyon Wilderness	AZ	35.01	-112.09	15.53	4.40	1.84	6.96
Teton Wilderness	WY	44.04	-110.17	15.74	4.53	1.97	7.09
Theodore Roosevelt NP	ND	46.96	-103.46	16.08	4.75	2.19	7.31
Thousand Lakes Wilderness	CA	40.7	-121.58	16.10	4.76	2.20	7.32
Three Sisters Wilderness	OR	44.04	-121.91	17.01	5.31	2.75	7.87
Tuxedni	AK	60.14	-152.61	16.58	5.06	2.50	7.62
UL Bend	MT	47.54	-107.89	15.87	4.62	2.06	7.18
Upper Buffalo Wilderness	AR	36.17	-92.41	21.04	7.44	3.60	11.28
Ventana Wilderness	CA	36.21	-121.6	16.09	4.76	2.20	7.32
Virgin Islands NP (b)	VI	18.35	-64.74				
Voyageurs NP	MN	48.47	-92.8	20.64	7.25	3.41	11.09
Washakie Wilderness	WY	44.1	-109.57	15.73	4.53	1.97	7.09
Weminuche Wilderness	CO	37.61	-107.25	15.68	4.50	1.94	7.06
West Elk Wilderness	CO	38.75	-107.21	15.71	4.51	1.95	7.07

Appendix B
Default Natural b_{ext}, *dv*, and 10[th] and 90[th] Percentile *dv* Values at All Mandatory Federal Class I Areas

Mandatory Federal Class I Area	State	Lat.	Lon.	bext (Mm-1)	Ann. Avg. (dv)	Best Days (dv) [a]	Worst Days (dv) [a]
Wheeler Peak Wilderness	NM	36.57	-105.4	15.70	4.51	1.95	7.07
White Mountain Wilderness	NM	33.48	-105.85	15.56	4.42	1.86	6.98
Wichita Mountains	OK	34.75	-98.65	20.60	7.23	3.39	11.07
Wind Cave NP	SD	43.58	-103.47	15.97	4.68	2.12	7.24
Wolf Island	GA	31.33	-81.3	21.33	7.58	3.74	11.42
Yellowstone NP	WY	44.63	-110.51	15.77	4.56	2.00	7.12
Yolla Bolly Middle Eel Wilderness	CA	40.09	-122.96	16.25	4.85	2.29	7.41
Yosemite NP	CA	37.85	-119.54	15.81	4.58	2.02	7.14
Zion NP	UT	37.32	-113.04	15.56	4.42	1.86	6.98

(a) Values for the best and worst days are estimated from a statistical approach described in Section 2.6 of this document.
(b) *f(RH)* values for Virgin Islands National Park were not calculated because of the limited RH data available. As such no estimates for Natural Visibility Conditions are presented at this time.

APPENDIX F – EPA Monthly F(RH) Values

Table A-3 Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Centroid of the Area (Supplemental Information)

Class I Area	Site Name	Map ID	Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Acadia	Acadia	1	ACAD1	ME	44.37	68.26	3.3	2.9	2.8	3.4	3.1	3.0	3.4	3.8	4.0	3.8	3.6	3.5
Agua Tibia	Agua Tibia	100	AGTI1	CA	33.41	116.93	2.4	2.4	2.4	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.1	2.2
Alpine Lakes	Snoqualmie Pass	80	SNPA1	WA	47.42	121.42	4.3	3.8	3.5	3.9	2.9	3.2	2.9	3.1	3.3	3.9	4.5	4.5
Anaconda - Pintler	Sula	71	SULA1	MT	45.98	113.42	3.3	2.9	2.5	2.4	2.4	2.3	2.0	1.9	2.1	2.5	3.2	3.3
Ansel Adams	Kaiser	110	KAIS1	CA	37.65	119.20	3.0	2.7	2.4	2.1	1.9	1.7	1.6	1.6	1.6	1.8	2.3	2.7
Arches	Canyonlands	50	CANY1	UT	38.64	109.58	2.6	2.3	1.8	1.6	1.6	1.3	1.4	1.5	1.6	1.6	2.0	2.3
Badlands	Badlands	59	BADL1	SD	43.74	101.94	2.6	2.7	2.6	2.4	2.8	2.7	2.5	2.4	2.2	2.3	2.7	2.7
Bandelier	Bandelier	33	BAND1	NM	35.78	106.27	2.2	2.1	1.8	1.8	1.6	1.4	1.7	2.1	1.9	1.7	2.0	2.2
Bering Sea (a)					60.45	172.79												
Big Bend	Big Bend	31	BIBE1	TX	29.31	103.19	2.0	1.9	1.6	1.5	1.6	1.6	1.7	2.0	2.1	1.9	1.8	1.9
Black Canyon of the Gunnison	Weminuche	65	WEMI1	CO	38.58	107.70	2.4	2.2	1.9	1.9	1.9	1.6	1.7	1.9	2.0	1.8	2.1	2.3
Bob Marshall	Monture	73	MONT1	MT	47.75	113.38	3.6	3.1	2.8	2.6	2.7	2.7	2.3	2.2	2.6	2.9	3.5	3.6
Bosque del Apache	Bosque del Apache	38	BOAP1	NM	33.79	106.83	2.1	1.9	1.6	1.4	1.4	1.3	1.8	2.0	1.9	1.6	1.8	2.2
Boundary Waters Canoe Area	Boundary Waters	23	BOWA1	MN	47.95	91.50	3.0	2.6	2.7	2.4	2.3	2.9	3.1	3.4	3.5	2.8	3.2	3.2
Breton	Breton	20	BRET1	LA	29.73	88.88	3.7	3.5	3.7	3.6	3.8	4.0	4.3	4.3	4.2	3.7	3.7	3.7
Bridger	Bridger	65	BRID1	WY	42.98	109.76	2.5	2.4	2.3	2.2	2.1	1.8	1.5	1.5	1.7	2.0	2.4	2.4
Brigantine	Brigantine	5	BRIG1	NJ	39.46	74.45	2.8	2.6	2.7	2.6	3.0	3.2	3.4	3.7	3.6	3.3	2.9	2.8
Bryce Canyon	Bryce Canyon	49	BRCA1	UT	37.62	112.17	2.6	2.4	1.9	1.6	1.5	1.3	1.3	1.5	1.5	1.6	2.0	2.4
Cabinet Mountains	Cabinet Mountains	75	CABI1	MT	48.21	115.71	3.8	3.3	2.9	2.6	2.7	2.7	2.3	2.2	2.6	3.0	3.7	3.9
Caney Creek	Caney Creek	28	CACR1	AR	34.41	94.08	3.4	3.1	2.9	3.0	3.6	3.6	3.4	3.4	3.6	3.5	3.4	3.5
Canyonlands	Canyonlands	50	CANY1	UT	38.46	109.82	2.6	2.3	1.7	1.6	1.6	1.2	1.3	1.6	1.8	1.8	2.0	2.3
Cape Romain	Cape Romain	15	ROMA1	SC	32.94	79.66	3.3	3.0	2.9	2.8	3.2	3.7	3.6	4.1	4.0	3.7	3.4	3.2
Capitol Reef	Capitol Reef	52	CAPI1	UT	38.36	111.05	2.7	2.4	2.0	1.7	1.6	1.4	1.4	1.6	1.6	1.7	2.1	2.5
Caribou	Lassen Volcanic	90	LAVO1	CA	40.50	121.18	3.7	3.1	2.8	2.5	2.4	2.2	2.1	2.1	2.2	2.4	3.0	3.4
Carlsbad Caverns	Guadalupe Mountains	32	GUMO1	TX	32.14	104.48	2.1	2.0	1.6	1.5	1.6	1.8	1.8	2.1	2.2	1.8	1.9	2.1
Chassahowitzka	Chassahowitzka	18	CHAS1	FL	28.75	82.55	3.8	3.5	3.4	3.2	3.3	3.9	3.9	4.2	4.1	3.9	3.7	3.9
Chiricahua NM	Chiricahua	39	CHIR1	AZ	32.01	109.39	2.0	2.0	1.6	1.3	1.3	1.1	1.8	2.1	1.8	1.5	1.6	2.2
Chiricahua W	Chiricahua	39	CHIR1	AZ	31.84	109.27	2.0	1.9	1.8	1.2	1.3	1.1	1.8	2.1	1.8	1.5	1.6	2.2
Cohutta	Cohutta	12	COHU1	GA	34.92	84.58	3.3	3.1	3.0	2.8	3.4	3.8	4.0	4.2	4.2	3.8	3.4	3.5
Crater Lake	Crater Lake	86	CRLA1	OR	42.90	122.13	4.6	3.9	3.7	3.4	3.2	3.0	2.8	2.9	3.1	3.6	4.6	4.6
Craters of the Moon	Craters of the Moon	69	CRMO1	ID	43.47	113.55	3.1	2.7	2.3	2.0	2.0	1.8	1.4	1.4	1.6	2.0	2.8	3.0
Cucamonga	San Gabriel	93	SAGA1	CA	34.25	117.57	2.5	2.4	2.4	2.2	2.1	2.1	2.1	2.2	2.2	2.2	2.1	2.2
Denali	Denali	102	DENA1	AK	63.72	148.97	2.5	2.3	2.1	1.9	1.9	2.2	2.6	3.0	2.8	2.9	3.0	3.1
Desolation	Bliss	96	BLIS1	CA	38.98	120.12	3.2	2.8	2.4	2.0	1.8	1.6	1.5	1.6	1.7	1.9	2.4	3.0
Diamond Peak	Crater Lake	86	CRLA1	OR	43.53	122.10	4.5	4.0	3.6	3.7	3.2	3.1	2.9	2.9	3.1	3.7	4.6	4.6
Dolly Sods	Dolly Sods	8	DOSO1	WV	39.11	79.43	3.0	2.8	2.8	2.6	3.1	3.4	3.5	3.9	3.9	3.3	3.0	3.1

Table A-3 Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Centroid of the Area (Supplemental Information)

Class I Area	Site Name	Map ID	Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Dome Land	Dome Land	109	DOME1	CA	35.70	118.19	2.5	2.3	2.2	1.9	1.8	1.8	1.8	1.8	1.8	1.9	2.0	2.2
Eagle Cap	Starkey	76	STAR1	OR	45.10	117.29	3.8	3.2	2.5	2.1	2.0	1.9	1.6	1.6	1.6	2.3	3.4	4.0
Eagles Nest	White River	56	WHRI1	CO	39.69	106.25	2.2	2.2	2.0	2.0	2.1	1.9	1.8	2.0	2.0	1.9	2.1	2.1
Emigrant	Yosemite	96	YOSE1	CA	38.20	119.75	3.2	2.8	2.5	2.1	1.9	1.7	1.5	1.5	1.6	1.9	2.4	2.9
Everglades	Everglades	19	EVER1	FL	25.39	80.68	2.7	2.6	2.6	2.4	2.4	2.7	2.6	2.9	3.0	2.8	2.6	2.7
Fitzpatrick	Bridger	65	BRID1	WY	43.27	109.57	2.5	2.3	2.2	2.1	2.1	1.8	1.5	1.5	1.7	2.0	2.4	2.4
Flat Tops	White River	56	WHRI1	CO	39.97	107.25	2.3	2.2	2.0	2.0	2.0	1.8	1.7	1.9	1.9	1.8	2.2	2.2
Galiuro	Chiricahua	39	CHIR1	AZ	32.56	110.32	2.0	1.8	1.5	1.2	1.2	1.1	1.5	1.8	1.8	1.5	1.6	2.1
Gates of the Mountains	Gates of the Mountains	74	GAMO1	MT	46.87	111.81	2.9	2.6	2.4	2.3	2.3	2.3	2.0	1.9	2.1	2.4	2.8	2.8
Gearhart Mountain	Crater Lake	86	CRLA1	OR	42.49	120.85	4.0	3.4	3.1	2.8	2.7	2.5	2.3	2.3	2.4	2.8	3.7	3.8
Gila	Gila Cliffs	42	GICL1	NM	33.22	108.25	2.1	1.9	1.6	1.3	1.4	1.2	2.1	2.0	1.8	1.6	1.8	2.2
Glacier	Glacier	72	GLAC1	MT	48.51	114.00	4.0	3.5	3.2	3.1	3.2	3.4	2.8	2.6	3.2	3.5	3.8	3.9
Glacier Peak	North Cascades	81	NOCA1	WA	48.21	121.04	4.2	3.7	3.4	3.8	2.9	3.2	2.9	3.1	3.3	3.9	4.4	4.4
Goat Rocks	White Pass	79	WHPA1	WA	46.54	121.48	4.3	3.8	3.4	4.2	2.8	3.4	3.0	3.2	3.1	3.8	4.4	4.6
Grand Canyon	Grand Canyon, Hance	48	GRCA2	AZ	35.97	111.98	2.4	2.3	1.9	1.5	1.4	1.2	1.4	1.7	1.6	1.6	1.9	2.3
Grand Teton	Yellowstone	68	YELL2	WY	43.68	110.73	2.6	2.4	2.2	2.1	2.1	1.8	1.5	1.5	1.7	2.0	2.4	2.6
Great Gulf	Great Gulf	4	GRGU1	NH	44.31	71.22	2.8	2.6	2.6	2.8	2.9	3.2	3.5	3.8	4.0	3.4	3.1	2.9
Great Sand Dunes	Great Sand Dunes	53	GRSA1	CO	37.73	105.52	2.4	2.3	2.0	1.9	1.9	1.8	1.9	2.3	2.2	1.9	2.4	2.4
Great Smoky Mountains	Great Smoky Mountains	10	GRSM1	TN	35.63	83.94	3.3	3.0	2.9	2.7	3.2	3.9	3.8	4.0	4.2	3.8	3.3	3.4
Guadalupe Mountains	Guadalupe Mountains	32	GUMO1	TX	31.83	104.80	2.0	2.0	1.6	1.5	1.6	1.5	1.9	2.2	2.2	1.8	1.9	2.2
Haleakala	Haleakala	106	HALE1	HI	20.81	156.28	2.7	2.6	2.6	2.5	2.4	2.3	2.5	2.4	2.4	2.5	2.8	2.7
Hawaii Volcanoes	Hawaii Volcanoes	107	HAVO1	HI	19.43	155.27	3.2	2.9	3.0	3.0	3.0	2.9	3.1	3.2	3.2	3.2	3.7	3.2
Hells Canyon	Hells Canyon	77	HECA1	OR	45.34	116.57	3.7	3.1	2.5	2.2	2.1	2.0	1.6	1.6	1.8	2.4	3.5	3.9
Hercules - Glade	Hercules - Glade	28	HEGL1	MO	36.69	92.90	3.2	2.9	2.7	2.7	3.3	3.3	3.3	3.3	3.4	3.1	3.1	3.3
Hoover	Hoover	97	HOOV1	CA	38.14	119.45	3.1	2.8	2.5	2.1	1.9	1.6	1.5	1.5	1.6	1.8	2.3	2.8
Isle Royale	Isle Royale	25	ISLE1	MI	47.99	88.83	3.1	2.5	2.7	2.4	2.2	2.6	3.0	3.2	3.8	2.7	3.3	3.3
James River Face	James River Face	7	JARI1	VA	37.62	79.48	2.8	2.6	2.7	2.4	3.0	3.3	3.4	3.7	3.6	3.2	2.8	3.0
Jarbidge	Jarbidge	68	JARB1	NV	41.89	115.43	3.0	2.6	2.1	2.1	2.2	2.2	1.6	1.4	1.4	1.6	2.4	2.8
John Muir	Kaiser	110	KAIS1	CA	37.39	118.84	2.9	2.6	2.4	2.1	1.9	1.7	1.7	1.7	1.7	1.9	2.2	2.6
Joshua Tree	Joshua Tree	101	JOSH1	CA	34.03	116.18	2.4	2.3	2.2	2.0	2.0	1.9	2.0	2.0	2.0	2.0	1.9	2.0
Joyce Kilmer - Slickrock	Great Smoky Mountains	10	GRSM1	TN	35.43	84.00	3.3	3.1	2.9	2.7	3.3	3.8	4.0	4.2	4.2	3.8	3.3	3.5
Kaiser	Kaiser	110	KAIS1	CA	37.28	119.18	3.0	2.7	2.5	2.1	1.9	1.7	1.6	1.7	1.7	1.9	2.3	2.7
Kalmiopsis	Kalmiopsis	89	KALM1	OR	42.27	123.93	4.5	3.9	3.8	3.5	3.6	3.3	3.2	3.2	3.3	3.6	4.4	4.3
Kings Canyon	Sequoia	98	SEQU1	CA	36.82	118.76	2.8	2.6	2.4	2.1	1.9	1.8	1.7	1.7	1.8	1.9	2.3	2.5
La Garita	Weminuche	55	WEMI1	CO	37.96	106.81	2.3	2.2	1.9	1.8	1.8	1.6	1.7	2.1	2.0	1.8	2.2	2.3
Lassen Volcanic	Lassen Volcanic	90	LAVO1	CA	40.54	121.57	3.8	3.2	2.9	2.5	2.4	2.2	2.1	2.1	2.2	2.4	3.1	3.5

Table A-3 Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Centroid of the Area (Supplemental Information)

Class I Area	Site Name	Map ID	Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Lava Beds	Lava Beds	87	LABE1	CA	41.71	121.34	4.0	3.4	3.1	2.7	2.6	2.4	2.3	2.3	2.4	2.7	3.5	3.8
Linville Gorge	Linville Gorge	13	LIGO1	NC	35.89	81.89	3.3	3.0	3.0	2.7	3.3	3.9	4.1	4.5	4.4	3.7	3.2	3.4
Lostwood	Lostwood	62	LOST1	ND	48.60	102.46	3.0	2.9	2.9	2.3	2.3	2.6	2.7	2.4	2.3	2.4	3.2	3.2
Lye Brook	Lye Brook	3	LYBR1	VT	43.15	73.12	2.7	2.8	2.8	2.6	2.8	3.0	3.3	3.6	3.7	3.3	2.9	2.8
Mammoth Cave	Mammoth Cave	9	MACA1	KY	37.22	86.07	3.4	3.1	2.9	2.6	3.2	3.5	3.7	3.9	3.9	3.4	3.2	3.5
Marble Mountain	Trinity	104	TRIN1	CA	41.52	123.21	4.4	3.8	3.7	3.3	3.4	3.2	3.2	3.2	3.2	3.4	4.1	4.2
Maroon Bells - Snowmass	White River	56	WHRI1	CO	39.15	106.82	2.2	2.1	2.0	2.0	2.1	1.7	1.9	2.2	2.1	1.8	2.1	2.1
Mazatzal	Ike's Backbone	46	IKBA1	AZ	33.92	111.43	2.1	1.9	1.7	1.3	1.3	1.1	1.5	1.7	1.6	1.6	1.7	2.1
Medicine Lake	Medicine Lake	63	MELA1	MT	48.50	104.29	3.0	2.9	2.9	2.3	2.2	2.5	2.5	2.2	2.2	2.4	3.2	3.2
Mesa Verde	Mesa Verde	54	MEVE1	CO	37.20	108.49	2.5	2.3	1.9	1.5	1.5	1.3	1.6	2.0	1.9	1.7	2.1	2.3
Mingo	Mingo	26	MING1	MO	36.98	90.20	3.3	3.0	2.8	2.6	3.0	3.2	3.3	3.6	3.6	3.1	3.1	3.3
Mission Mountains	Monture	73	MONT1	MT	47.40	113.65	3.6	3.1	2.7	2.5	2.6	2.6	2.3	2.2	2.5	2.9	3.6	3.6
Mokelumne	Bliss	95	BLIS1	CA	38.68	120.03	3.2	2.8	2.4	2.0	1.9	1.6	1.5	1.6	1.7	1.9	2.4	2.8
Moosehorn	Moosehorn	2	MOOS1	ME	45.12	67.26	3.0	2.7	2.7	3.0	3.0	3.1	3.4	3.8	3.9	3.5	3.2	3.2
Mount Adams	White Pass	79	WHPA1	WA	46.19	121.50	4.3	3.8	3.4	4.4	2.9	3.5	3.1	3.3	3.1	3.9	4.5	4.6
Mount Baldy	Mount Baldy	43	BALD1	AZ	34.12	109.57	2.2	2.0	1.7	1.4	1.3	1.2	1.6	1.9	1.7	1.6	1.8	2.2
Mount Hood	Mount Hood	85	MOHO1	OR	45.38	121.69	4.3	3.8	3.5	3.9	3.0	3.2	2.9	3.0	3.1	3.9	4.5	4.6
Mount Jefferson	Three Sisters	84	THSI1	OR	44.55	121.83	4.4	3.9	3.6	3.7	3.1	3.1	2.9	2.9	3.0	3.8	4.6	4.5
Mount Rainier	Mount Rainier	78	MORA1	WA	46.76	122.12	4.4	4.0	3.6	4.7	3.1	3.7	3.3	3.5	3.4	4.1	4.7	4.7
Mount Washington	Three Sisters	84	THSI1	OR	44.30	121.87	4.4	3.9	3.6	3.7	3.1	3.1	3.0	2.9	3.0	3.8	4.6	4.6
Mount Zirkel	Mount Zirkel	58	MOZI1	CO	40.55	106.70	2.2	2.2	2.0	2.1	2.2	1.9	1.7	1.9	2.0	1.9	2.1	2.1
Mountain Lakes	Crater Lake	86	CRLA1	OR	42.34	122.11	4.3	3.6	3.3	3.0	2.9	2.6	2.5	2.5	2.6	3.1	4.1	4.3
North Absaroka	North Absaroka	67	NOAB1	WY	44.77	109.78	2.4	2.3	2.2	2.2	2.1	1.9	1.7	1.6	1.8	2.0	2.4	2.4
North Cascades	North Cascades	81	NOCA1	WA	48.54	121.44	4.1	3.7	3.4	3.7	2.9	3.2	2.9	3.2	3.5	3.9	4.4	4.4
Okefenokee	Okefenokee	16	OKEF1	GA	30.74	82.13	3.5	3.2	3.1	3.0	3.6	3.7	3.7	4.1	4.0	3.8	3.5	3.6
Olympic	Olympic	83	OLYM1	WA	47.32	123.35	4.5	4.1	3.8	4.1	3.2	3.5	3.1	3.5	3.7	4.4	4.8	4.8
Otter Creek	Dolly Sods	8	DOSO1	WV	39.00	79.65	3.0	2.8	2.8	2.8	3.2	3.5	3.7	4.1	4.0	3.3	3.0	3.1
Pasayten	Pasayten	82	PASA1	WA	48.85	120.52	4.2	3.7	3.4	3.7	2.9	3.2	2.9	3.2	3.3	3.9	4.4	4.5
Pecos	Wheeler Peak	35	WHPE1	NM	35.93	105.64	2.3	2.1	1.8	1.7	1.7	1.5	1.8	2.1	2.0	1.7	2.0	2.2
Petrified Forest	Petrified Forest	41	PEFO1	AZ	35.08	109.77	2.4	2.2	1.7	1.4	1.3	1.2	1.5	1.8	1.7	1.6	1.9	2.3
Pine Mountain	Ike's Backbone	46	IKBA1	AZ	34.31	111.80	2.2	2.0	1.7	1.4	1.3	1.1	1.4	1.8	1.6	1.5	1.7	2.1
Pinnacles	Pinnacles	92	PINN1	CA	36.49	121.16	3.2	2.8	2.6	2.4	2.3	2.0	2.0	2.1	2.1	2.3	2.5	2.9
Point Reyes	Point Reyes	91	PORE1	CA	38.12	122.90	3.6	3.3	3.1	2.7	2.6	2.3	2.5	2.6	2.6	2.7	2.9	3.3
Presidential Range - Dry River	Great Gulf	4	GRGU1	NH	44.21	71.35	2.8	2.6	2.6	2.8	3.0	3.4	3.7	4.0	4.3	3.5	3.1	3.0
Rawah	Mount Zirkel	58	MOZI1	CO	40.70	105.94	2.1	2.1	2.0	2.1	2.3	2.0	1.8	2.0	2.0	1.9	2.1	2.0
Red Rock Lakes	Yellowstone	66	YELL2	WY	44.67	111.70	2.7	2.5	2.3	2.1	2.1	1.9	1.7	1.6	1.8	2.1	2.6	2.7

Table A-3 Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Centroid of the Area (Supplemental Information)

Class I Area	Site Name	Map ID	Site Code	St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Redwood	Redwood	88	REDW1	CA	41.56	124.08	4.4	3.9	4.6	3.9	4.5	4.7	4.9	4.7	4.3	3.7	3.8	3.4
Rocky Mountain	Rocky Mountain	57	ROMO1	CO	40.28	105.55	1.7	1.9	1.9	2.1	2.3	2.0	1.8	2.0	1.9	1.8	1.8	1.7
Roosevelt Campobello	Moosehorn	2	MOOS1	ME	44.88	66.95	3.0	2.7	2.7	3.0	3.0	3.1	3.4	3.8	3.9	3.5	3.3	3.2
Saguaro	Saguaro	40	SAGU1	AZ	32.25	110.73	1.8	1.6	1.4	1.1	1.1	1.1	1.4	1.8	1.6	1.4	1.8	2.1
Saint Marks	Saint Marks	17	SAMA1	FL	30.12	84.08	3.7	3.4	3.4	3.4	3.5	4.0	4.1	4.4	4.2	3.8	3.7	3.8
Salt Creek	Salt Creek	36	SACR1	NM	33.61	104.37	2.1	1.9	1.5	1.5	1.7	1.6	1.8	2.0	2.1	1.8	1.8	2.1
San Gabriel	San Gabriel	93	SAGA1	CA	34.27	117.94	2.6	2.5	2.4	2.2	2.2	2.1	2.2	2.2	2.2	2.3	2.1	2.2
San Gorgonio	San Gorgonio	99	SAGO1	CA	34.18	116.90	2.7	2.8	2.6	2.3	2.2	1.9	1.8	1.9	1.9	1.9	1.9	2.2
San Jacinto	San Gorgonio	99	SAGO1	CA	33.75	116.65	2.5	2.4	2.4	2.2	2.1	2.0	2.1	2.1	2.1	2.1	2.0	2.1
San Pedro Parks	San Pedro Parks	34	SAPE1	NM	36.11	106.81	2.3	2.1	1.8	1.6	1.6	1.4	1.7	2.0	1.9	1.7	2.1	2.2
San Rafael	San Rafael	94	RAFA1	CA	34.78	119.83	2.8	2.7	2.7	2.4	2.3	2.3	2.5	2.5	2.4	2.6	2.3	2.6
Sawtooth	Sawtooth	70	SAWT1	ID	44.18	114.93	3.3	2.9	2.3	2.0	2.0	1.8	1.4	1.4	1.5	2.0	2.9	3.3
Scapegoat	Monture	73	MONT1	MT	47.17	112.73	3.2	2.8	2.6	2.4	2.5	2.4	2.1	2.0	2.3	2.6	3.1	3.1
Selway - Bitterroot	Sula	71	SULA1	MT	45.86	114.00	3.5	3.0	2.6	2.3	2.4	2.3	1.9	1.9	2.1	2.6	3.3	3.5
Seney	Seney	22	SENE1	MI	46.26	86.03	3.3	2.8	2.9	2.7	2.6	3.1	3.6	4.0	4.1	3.4	3.6	3.5
Sequoia	Sequoia	98	SEQU1	CA	36.50	118.82	2.5	2.4	2.4	2.2	1.9	1.8	1.7	1.6	1.8	1.9	2.3	2.3
Shenandoah	Shenandoah	6	SHEN1	VA	38.52	78.44	3.1	2.8	2.8	2.5	3.1	3.4	3.5	3.9	3.9	3.2	3.0	3.1
Shining Rock	Shining Rock	11	SHRO1	NC	35.39	82.78	3.3	3.0	2.9	2.7	3.4	3.9	4.1	4.5	4.4	3.8	3.3	3.4
Sierra Ancha	Sierra Ancha	45	SIAN1	AZ	33.82	110.88	2.1	2.0	1.7	1.3	1.3	1.1	1.5	1.8	1.6	1.5	1.7	2.1
Simeonof	Simeonof	105	SIME1	AK	54.92	159.28	4.3	4.1	3.6	3.9	3.9	4.3	5.0	5.2	4.5	3.8	4.0	4.3
Sipsey	Sipsey	21	SIPS1	AL	34.34	87.34	3.4	3.1	2.9	2.8	3.3	3.7	3.9	3.9	3.9	3.6	3.3	3.4
South Warner	Lava Beds	87	LABE1	CA	41.33	120.20	3.6	3.1	2.7	2.4	2.3	2.1	1.9	1.9	2.0	2.3	3.1	3.4
Strawberry Mountain	Starkey	76	STAR1	OR	44.30	118.73	3.9	3.3	2.8	2.9	2.3	2.4	2.0	2.0	1.9	2.6	3.7	4.1
Superstition	Tonto	44	TONT1	AZ	33.63	111.10	2.1	1.9	1.6	1.3	1.3	1.1	1.5	1.7	1.6	1.5	1.7	2.1
Swanquarter	Swanquarter	14	SWAN1	NC	35.31	76.28	2.9	2.7	2.6	2.5	2.9	3.2	3.4	3.5	3.4	3.1	2.8	2.9
Sycamore Canyon	Sycamore Canyon	47	SYCA1	AZ	34.03	116.18	2.4	2.3	2.2	2.0	2.0	1.9	2.0	2.0	2.0	2.0	1.9	2.0
Teton	Yellowstone	66	YELL2	WY	44.09	110.18	2.5	2.4	2.2	2.1	2.1	1.9	1.6	1.5	1.7	2.0	2.4	2.5
Theodore Roosevelt	Theodore Roosevelt	61	THRO1	ND	47.30	104.00	2.9	2.8	2.8	2.3	2.3	2.5	2.4	2.2	2.2	2.3	3.0	3.0
Thousand Lakes	Lassen Volcanic	90	LAVO1	CA	40.70	121.58	3.8	3.2	2.9	2.5	2.4	2.2	2.1	2.1	2.2	2.4	3.1	3.5
Three Sisters	Three Sisters	84	THSI1	OR	44.29	122.04	4.5	4.0	3.6	3.7	3.1	3.1	3.0	2.9	3.0	3.8	4.6	4.6
Tuxedni	Tuxedni	103	TUXE1	AK	60.16	152.60	3.5	3.3	2.9	2.7	2.7	2.9	3.6	4.0	3.9	3.5	3.5	3.7
UL Bend	UL Bend	64	ULBE1	MT	47.55	107.87	2.7	2.5	2.5	2.3	2.2	2.2	2.0	1.8	1.9	2.2	2.7	2.7
Upper Buffalo	Upper Buffalo	27	UPBU1	AR	35.83	93.21	3.3	3.0	2.7	2.8	3.4	3.4	3.4	3.4	3.6	3.3	3.2	3.3
Ventana	Pinnacles	92	PINN1	CA	36.22	121.59	3.2	2.9	2.8	2.4	2.3	2.1	2.2	2.3	2.2	2.4	2.5	2.9
Virgin Islands (b)	Virgin Islands	106	VIIS1	VI	18.33	64.79												
Voyageurs	Voyageurs	24	VOYA2	MN	48.59	93.17	2.8	2.4	2.4	2.3	2.3	3.1	2.7	3.0	3.2	2.6	2.9	2.8

Table A-3 Monthly Site-Specific f(RH) Values for Each Mandatory Federal Class I Area, Based on the Centroid of the Area (Supplemental Information)

Class I Area	Site Name	Map ID	Code	Site St	LAT	LONG	Jan f(RH)	Feb f(RH)	Mar f(RH)	Apr f(RH)	May f(RH)	Jun f(RH)	Jul f(RH)	Aug f(RH)	Sep f(RH)	Oct f(RH)	Nov f(RH)	Dec f(RH)
Washakie	North Absoraka	67	NOAB1	WY	43.95	109.59	2.5	2.3	2.2	2.1	2.1	1.8	1.6	1.5	1.8	2.0	2.4	2.5
Weminuche	Weminuche	55	WEMI1	CO	37.65	107.60	2.4	2.2	1.9	1.7	1.7	1.5	1.6	2.0	1.9	1.7	2.1	2.3
West Elk	White River	56	WHRI1	CO	38.69	107.19	2.3	2.2	1.9	1.9	1.9	1.7	1.8	2.1	2.0	1.8	2.1	2.2
Wheeler Peak	Wheeler Peak	35	WHPE1	NM	36.57	105.42	2.3	2.2	1.9	1.8	1.8	1.8	1.8	2.2	2.1	1.8	2.2	2.3
White Mountain	White Mountain	37	WHIT1	NM	33.49	105.83	2.1	1.9	1.6	1.5	1.5	1.4	1.8	2.0	2.0	1.7	1.8	2.1
Wichita Mountains	Wichita Mountains	30	WIMO1	OK	34.74	98.59	2.7	2.8	2.4	2.4	3.0	2.7	2.3	2.5	2.9	2.8	2.7	2.8
Wind Cave	Wind Cave	60	WICA1	SD	43.55	103.48	2.6	2.6	2.5	2.6	2.7	2.6	2.3	2.3	2.2	2.2	2.6	2.6
Wolf Island	Okefenokee	18	OKEF1	GA	31.31	81.30	3.4	3.1	3.1	3.0	3.3	3.7	3.7	4.1	4.0	3.7	3.5	3.5
Yellowstone	Yellowstone	66	YELL2	WY	44.55	110.40	2.5	2.4	2.3	2.2	2.2	1.9	1.7	1.6	1.8	2.1	2.5	2.5
Yolla Bolly - Middle Eel	Trinity	104	TRIN1	CA	40.11	122.96	4.0	3.4	3.1	2.8	2.7	2.5	2.4	2.5	2.6	2.7	3.3	3.6
Yosemite	Yosemite	96	YOSE1	CA	37.71	119.70	3.3	3.0	2.8	2.3	2.1	1.8	1.5	1.5	1.5	1.8	2.4	2.8
Zion	Zion	51	ZION1	UT	37.26	113.01	2.7	2.4	2.0	1.6	1.5	1.3	1.2	1.4	1.4	1.6	2.0	2.4

a: No particulate matter sampling or visibility monitoring is conducted in the Bering Sea Wilderness.

b: *f(RH)* values for Virgin Islands National Park were not calculated because of the limited RH data available.

APPENDIX G – Paper Describing the Deciview Metric

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Use of the Deciview Haze Index as an Indicator for Regional Haze

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ABSTRACT

The U.S. Environmental Protection Agency (EPA) Notice of Proposed Rulemaking (NPR) for regional haze uses the deciview haze index (dv) as the indicator for visibility impairment and proposes a change of 1 dv as "a small but noticeable change in haziness under most circumstances." All previous visibility rules have specified human perception as the indicator for visibility impairment. This article examines the technical basis cited in the NPR for this new indicator for visibility impairment and for the perception threshold of approximately 1 dv. Derivations based on the assumptions and approximations cited in the NPR show that the deciview haze index does not have the correct functional form to relate changes in haze within federal Class I areas to the visual perception of those changes. The just-noticeable change in light extinction is, in most cases, inversely proportional to the sight path length instead of proportional to the light-extinction coefficient. These derivations also indicate that a 1-dv change in haziness is typically too small to be perceived in most Class I areas.

INTRODUCTION

The deciview haze index (dv) was introduced by Pitchford and Malm[1] for use in presenting data for the light-extinction coefficient (b_{ext}) of ambient air. (Technical terms are defined in a glossary at the end of this article.) For example, their paper contains a map of the United States with isopleths indicating the average visibility conditions. Pitchford and Malm[1] indicated that the deciview haze index is the preferred metric for such presentations because it is more linearly related to the human perception of regional haze than other metrics that have commonly been used, such as the visual range (VR) or b_{ext}. The deciview haze index has been widely accepted, with the result that the majority of publications on the relation between air quality and visibility use the deciview haze index to present light-extinction data.

IMPLICATIONS

EPA has proposed a regional haze rule that uses a new indicator for visibility impairment. The technical basis for this new indicator was developed for faint scenic elements that are almost obscured by haze, and this technical basis can be used to show that the indicator does not have the correct functional form to relate changes in haze within federal Class I areas to the visual perception of those changes.

The importance of the deciview haze index as an indicator for visibility impairment was increased by the regional haze regulations published in a Notice of Proposed Rulemaking (NPR) by the U.S. Environmental Protection Agency (EPA) on July 31, 1997.[2] If this rule were to be promulgated as proposed, it would be the first rule to specify an indicator different from human perception for determining the existence of visibility impairment. The NPR proposes using the deciview haze index as a metric for determining reasonable progress toward the national goal in Section 169(a) of the Clean Air Act, which calls for "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas, which impairment results from manmade air pollution."

The proposed rule would require that haze in Class I areas be monitored, that the average haze level during the 20% of the days that have the highest $PM_{2.5}$ concentrations decrease by 1 dv every 10 or 15 years, and that the average haze level during the 20% of the days that have the lowest $PM_{2.5}$ concentrations not increase by more than 0.1 dv. Three-year running averages would be used to determine compliance. It is proposed that once the visibility conditions are within 1.0 dv of natural conditions, the visibility State Implementation Plan would be considered a type of maintenance plan. The NPR states, "The EPA proposes a one-deciview increment above natural conditions to be perceived as sufficiently near to natural conditions for those sensitive scenes that are thought to exist in all mandatory Class I federal areas."

The use of the deciview haze index in the NPR is compatible with the EPA Office of Air Quality Planning and Standards (OAQPS) Staff Paper on the National Ambient Air Quality Standards for Particulate Matter,[3] which states, "Under many circumstances, a change of one deciview represents a change perceptible to the average person."

One effect of the NPR is to propose giving the deciview haze index regulatory status as an indicator for visibility impairment. Another effect is to propose establishing a perception threshold with the statement, "A one deciview change in haziness is a small but noticeable change in haziness under most circumstances when viewing scenes in mandatory Class I Federal areas."

Because proposals in the NPR would give regulatory status to the deciview haze index as an indicator for regional haze, it is appropriate at this time to review its derivation and examine some of its properties. The purpose of this review is to increase the understanding of atmospheric optics and visual perception thresholds related to regional haze. The NPR cites only Pitchford and Malm[1] as the technical basis for using the deciview haze index as an indicator for visibility impairment, and for using a 1-dv change in haziness as the level corresponding to a significant change in the indicator. The citations considered in this article are restricted to those cited by the NPR or by Pitchford and Malm.[1] Mathematical derivations appear in the appendix, while the approach used in these derivations and the resulting conclusions are presented in the following text.

DERIVATION OF THE DECIVIEW HAZE INDEX

Pitchford and Malm[1] based the derivation of the deciview haze index on the three assumptions described below. This review accepts these assumptions without modification and does not attempt to examine results that could be obtained from other assumptions or to evaluate the relative merits of these assumptions compared to other assumptions that could be made. Thus, the scope of this article is narrowly directed toward examining the technical basis presented in the NPR.

The assumptions used by Pitchford and Malm[1] are:

(1) Contrast is a good indicator of visibility. The apparent contrast of an element of a scene can be used to estimate whether the element can be perceived and, when it can be perceived, the apparent contrast can also be used to evaluate the visual quality of its appearance.

(2) The magnitude of the change in apparent contrast of a distant terrain feature against the horizon sky required for a change to be just noticeable is proportional to the apparent contrast of the terrain feature.

(3) The apparent contrast of a distant terrain feature against the horizon sky is given by eq 6 in the appendix.

The first and third assumptions are widely used and accepted. The third assumption is valid if the horizon sky radiance has the same value at each end of the sight path. It could be regarded as a restriction; that is, that the derivation of the deciview haze index applies only to the apparent contrast of terrain features viewed against the horizon sky. The second assumption is the one most easily questioned, as indicated in the appendix.

The initial steps of the derivation of Pitchford and Malm[1] are presented in Section A.1 of the appendix and are accepted without modification. They derive an equation for Δb_{extJNC}, which is the change in the light-extinction coefficient corresponding to a just-noticeable change (JNC) in the contrast of an element in a scene. Since Pitchford and Malm[1] state that their paper develops the theory previously presented by Pitchford et al.,[4] Section A.2 presents additional equations from this prior work. Section A.3 presents a simple extension of the equations of Pitchford and Malm. An equation derived by Pitchford and Malm can be rearranged to obtain

$$\Delta b_{extJNC} = (1/r)\ \ln(1\text{-}L) \qquad (1)$$

where r is the length of the sight path and L is a constant whose value depends on the spatial frequency of elements in a scene but does not depend on the values of b_{ext} or r. Pitchford and Malm[1] state that this equation "indicates that the change in extinction coefficient corresponding to a JNC in a scenic element is inversely proportional to the distance to the element. The most sensitive scenic element is the one at the greatest distance that is still visible at the lower extinction coefficient value, but just disappears at the higher extinction coefficient. In other words, the most sensitive distance for a scenic element is near the visual range."

FUNCTIONAL FORM

The 1/r functional form in eq 1 is not new. This relation and the curves in Figure 1 were derived by Pitchford et al.[4] as described in Section A.2 of the appendix. The percent changes in b_{ext} shown in this figure can be approximately converted into changes in the deciview haze index by dividing the percent changes by a factor of 10. The curve for L = 0.24 gives a threshold change of approximately 1 dv for sight paths with a length equal to the visual range (VR), so this curve gives the best correspondence with the assumptions used in the NPR. The curves in Figure 1 show that when the length of the sight path is a small fraction of the visual range, b_{ext} must change by several tens of percent (several deciview units) for the change to be perceptible. For example, more than a 40% change (more than a 4-dv change) in regional haze is required for the change to be perceptible in sight paths shorter than 20% of the visual range.

The full derivation of the deciview haze index by Pitchford and Malm is not reproduced in the appendix. Their first step beyond the equations presented in the

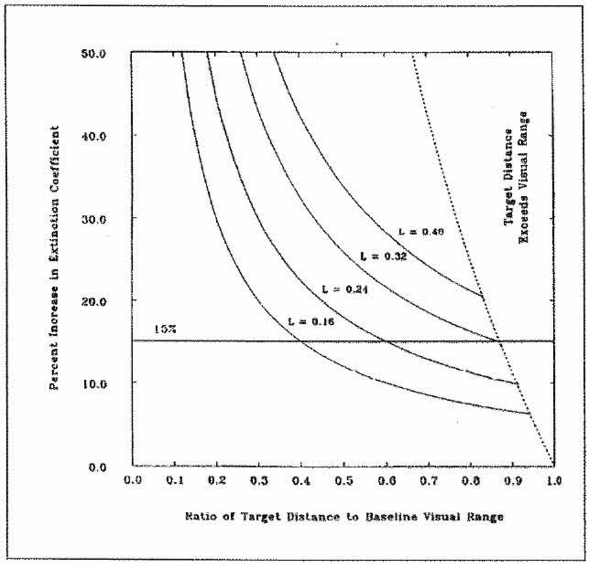

Figure 1. Figure 1 from Pitchford et al.[4] The curves were calculated from eq 12 using a liminal contrast of 5% ($-\ln\varepsilon = 3.0$). The line labeled L = 0.24 best corresponds with the analyses in the NPR. This line indicates that a 10% increase in b_{ext} (i.e., a 1-dv change) corresponds to a JNC in haze when the length of the sight path is equal to the VR. For points below and to the left of this line, the change in b_{ext} "is too small for a noticeable visibility change to occur." Points to the right of the dotted line are beyond the VR. Points above the L = 0.24 line and to the left of the dotted line correspond to noticeable changes in visibility. The horizontal line at a 15% increase was proposed by Pitchford et al.[4] as the basis for a regulatory strategy.

appendix is to restrict the derivation to the special case in which the sight path length *r* is equal to the visual range *VR*. Pitchford and Malm[1] state that their derivation applies to a scenic element at the most sensitive distance, that is, an element "at the greatest distance that is still visible at the lower extinction coefficient value, but just disappears at the higher extinction coefficient." This restriction in the derivation of the deciview haze index was ignored by EPA in the OAQPS Staff Paper[3] and the NPR.

PERCEPTION THRESHOLD

Pitchford and Malm[1] do not endorse a specific change in dv to be used as a visual perception threshold. They do conclude a discussion by saying, "It seems reasonable to presume that a fractional change in extinction coefficient between about 5 and 20% would produce a JNC in a scene." These percentage changes in light extinction correspond to changes of 0.5 and 2.0 dv, respectively. Malm and the authors of the NPR are vigorous in saying that a 1-dv change is not a perception threshold. However, the quotations from the NPR cited above and the above statement by Pitchford and Malm would make it difficult in any future regulatory process to use a threshold for the perception of changes in regional haze outside the range of a 0.5 to 2-dv change.

Because of the NPR's endorsement of a 1-dv change as a noticeable change under most circumstances, a derivation is presented in Section A.3 of the value of the constant *L* in eq 1 that causes both eq 1 and a 1-dv change in haze to give the same value for Δb_{extJNC} when *r* is equal to *VR*. This value of *L* causes eq 1 to give results in agreement with those calculated from a 1-dv change under conditions where the derivation of the deciview haze index is applicable. The value of *L* depends on the liminal (threshold) contrast assumed in the calculation of VR. Conservative analyses sometimes assume that a terrain feature must have a contrast of 5% against the horizon sky to be perceptible, but it is more commonly assumed that features with a 2% contrast can be perceived. These two assumptions lead to different values of VR, hence different values of *r* at which the two calculation methods should give the same value for Δb_{extJNC}. The derivation in Section A.3 shows that if a liminal contrast of 2% is used, eq 1 becomes

$$\Delta b_{extJNC} = 0.41/r \qquad (2)$$

and if a liminal contrast of 5% is used, eq 1 becomes

$$\Delta b_{extJNC} = 0.32/r \qquad (3)$$

Eqs 2 and 3 apply to sight paths of any length less than or equal to the visual range, and give the values for Δb_{extJNC} equal to those calculated from a 1-dv change when the length of the sight path is equal to the visual range. Thus, a Δb_{extJNC} calculated from these equations is more generally applicable than the value recommended in the NPR, and it equals the NPR value in the special case where the NPR value is applicable. Because of their general applicability, it is recommended that EPA give consideration to using either eqs 2 or 3 in the regional haze regulations for Class I areas instead of the deciview haze index.

PROTECTION OF VIEWS OUTSIDE CLASS I AREAS

The deciview haze index was designed to apply to the most sensitive sight paths, that is, sight paths to the farthest features that are perceptible. The use of the deciview haze index as the indicator for regional haze in the NPR instead of eqs 2 or 3 has the effect of protecting integral vistas, which are views that extend beyond the boundaries of Class I areas. Current visibility impairment regulations apply to sight paths within Class I areas, so use of the deciview haze index in the NPR increases the scope of visibility regulations.

If the indicator for regional haze had the functional form of eqs 2 or 3, the protections of the regional haze rules would apply to sight paths within each Class I area. The application of these equations requires determining the longest sight path in each Class I area. In some areas, the longest sight paths are at high elevations, where the air is typically clearer than at lower elevations. In a Class I area where long sight paths are available only at high elevations, it would be appropriate to use data for haze at those elevations in visibility analyses.

Work is now in progress to estimate the length of the longest sight path available in each Class I area, and to compare these lengths with the VR calculated from the average light-extinction coefficient on the 20% of days that are most impaired and the 20% of days that are least impaired each year. Figure 2 shows preliminary results for 35 Class I areas that are national parks. The length of the longest line that could be drawn within each park and the length of the longest sight path were estimated from the maps in National Park Service brochures. The VR data were calculated by Sisler from IMPROVE monitoring data.[5] The dotted lines in Figure 2 compare the lengths of the longest lines in the parks with VR, and the solid lines compare the estimated lengths of the longest sight paths within the parks with VR.

These data show that for average conditions during the 20% of the days that are least impaired, the longest sight paths within all 35 parks were shorter than the VR, and in many cases, the longest sight paths were substantially shorter than the VR. For average conditions during the 20% of days that were most impaired, the longest lines that could be drawn in the Class I areas were shorter than the VR in more than half the parks. It was also estimated for the hazy conditions that the longest sight path was shorter than the VR in more than 80% of the parks, and the longest sight path was less than half the VR in about half of the parks. These data show it is the exception, rather than the rule, for a sight path with a length equal to the VR to be available anywhere within a national park.

APPLICATION TO A WESTERN CLASS I AREA

A 1-yr intensive visibility study was recently completed for the Mt. Zirkel Wilderness Area (MZWA) in north-central Colorado.[6] The purpose of the Mt. Zirkel Visibility Study (MZVS) was to determine the effects of local and regional sources on visibility impairment in the MZWA. The database from this study is complete enough to support an analysis of the issues raised in this article, and results for a wavelength of 550 nm are presented in Table 1. The longest sight path length within the MZWA is 35 km (22 mi), and it is assumed that the monitoring data from a site at the southern boundary of the MZWA are applicable to this sight path.

Eq 2 was derived during the MZVS (see Appendix B.6 and Section 6.8.3 in reference 6) and gives a value of 11.7 Mm^{-1} for the Δb_{extJNC} for the longest sight path within the MZWA. The Δb_{extJNC} from eq 2 is nearly 10 times larger

Table 1. Data for the longest sight path in the MZWA.

Parameter	20% Least Impaired Days	20% Most Impaired Days
b_{sp} (Light scattering by particles)	2.5 Mm^{-1}	14 Mm^{-1}
b_{ap} (Light absorption by particles)[a]	0.6 Mm^{-1}	2.6 Mm^{-1}
b_{sg} (Rayleigh scattering)	8.4 Mm^{-1}	8.4 Mm^{-1}
b_{ext}	11.5 Mm^{-1}	25 Mm^{-1}
VR (from eq 11)	340 km^{-1}	156 km^{-1}
r/VR	0.10	0.22
Δb_{extJNC} (from eq 2)	11.7 Mm^{-1}	11.7 Mm^{-1}
Δb_{ext} for a 1-dv change	1.2 Mm^{-1}	2.6 Mm^{-1}
Increase in non-Rayleigh light extinction required for a change in b_{ext} to be perceptible in the MZWA	380%	71%
Decrease in non-Rayleigh light extinction for 1-dv change		16%
Δb_{ext} for a 0.1-dv change	0.12 Mm^{-1}	

[a]Approximate upper limit.

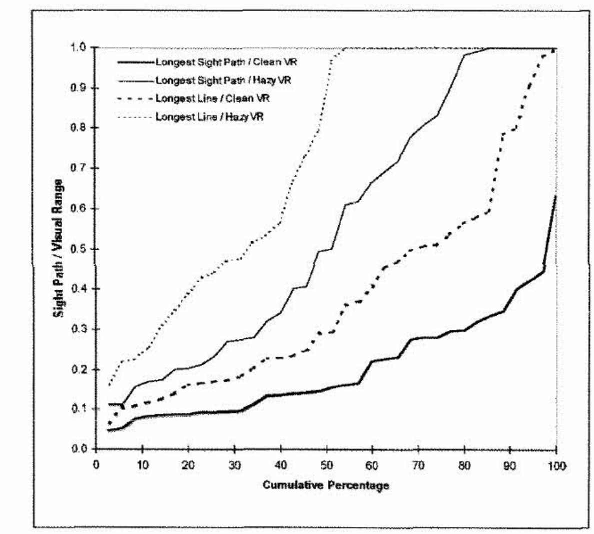

Figure 2. Comparison of the lengths of the longest lines that can be drawn within 35 national parks and the estimated lengths of the longest sight paths within these parks with the VR. The VRs were calculated from the average light-extinction coefficient for both the 20% of days that are the least impaired (clean) and the 20% of days that are the most impaired (hazy). A point on a line indicates the percentage of the parks that have a ratio equal to or smaller than the value at that point. Most ratios are less than 1.0, so sight paths are typically shorter than the VR, and some are much shorter than the VR.

than the change in b_{ext} corresponding to a 1-dv change in haze on the 20% of the days that were least impaired and about 4.5 times larger on the 20% of the days that were most impaired. As stated above, this calculation is based on the assumptions used by Pitchford and Malm,[1] including the assumption that the JNC in contrast corresponds to the contrast change resulting from a 1-dv change in regional haze in a sight path with a length equal to VR. With one exception, these assumptions are completely consistent with the assumptions used as the technical basis for the NPR. The single exception is that the calculations in Table 1 do not assume that sight paths equal in length to the VR were available within the MZWA.

One requirement proposed in the NPR is that the average deciview haze index not increase by more than 0.1 dv on the 20% of days that are least impaired. Such a requirement could be used to deny a permit (or require compensating emissions reductions before granting a permit) for a proposed project that is estimated to increase haze on the 20% least impaired days in the MZWA by an amount approximately 100 times smaller than the amount that would, according to the analyses of Pitchford et al.,[4] cause a perceptible change in haze. This requirement would also trigger the need for emissions reductions in the event that either natural variability in haze or regional growth caused a 0.1-dv increase in haze to be measured on the 20% least impaired days. The NPR does not provide the technical basis for limiting changes in haze to a value 100 times smaller than a visually perceptible change.

As a side issue, the VR of 340 km in Table 1 is unearthly. This value was calculated from the standard equation (eq 11 in the appendix). However, for the very clean conditions in the MZWA, the assumption that the atmosphere is uniform over a sight path of this length is incorrect.[7] An initially horizontal sight path of this length would end at an elevation of 9.1 km (29,700 ft) above the observer's elevation, which is well above the altitudes typically affected by regional haze. There are no peaks on Earth with an elevation that great, so the assumption of the presence of a dark terrain feature at the visual range cannot be satisfied.

COMMENTS

As mentioned above, this review was narrowly restricted to analyses based on the same assumptions as used by Pitchford and Malm.[1] Those assumptions were not amplified or modified, nor were they compared with other possible assumptions. The most significant findings of this review are:

(1) The derivation of the deciview haze index was based on a special case that is not typically encountered by visitors in federal Class I areas. Typical scenes within Class I areas do not include scenic elements "at the greatest distance that is still visible at the lower extinction coefficient value, but just disappears at the higher extinction coefficient."

(2) The deciview haze index does not have the correct functional form to serve as an indicator for visibility impairment within federal Class I areas for cases typically encountered by visitors.

(3) In most circumstances in Class I areas, a 1-dv change in regional haze on the 20% least impaired days is smaller than a perceptible change. This article presents an example in which a 1-dv change is nearly 10 times smaller than the perceptible change (derived from the assumptions in the NPR).

(4) The requirement that the average value of the deciview haze index increase by no more than 0.1 dv on the 20% least impaired days sets a standard that can be 100 times smaller than a perceptible change in regional haze.

The difference between these findings and the information in the NPR occurs primarily because the derivation of the deciview haze index is based on a special case—a sight path length equal to the VR—while the general case of sight paths of any length is addressed in this review.

RECOMMENDATIONS

It is recommended that the technical basis for the NPR be extended and broadened so that it is more robust. It would be desirable for the additional analyses to consider more than the contrast of faint ridges against the horizon sky. Most visitors to Class I areas are also interested in the clarity of views of features on cliffs, mountainsides, and views in valleys. Simple calculation methods exist for relating the clarity of such views to light extinction,[8] and they have the potential to provide a sound technical basis for rule-making.

The recommended approach for additional analyses resembles the approach used when setting air quality standards to protect human health. Neither visibility nor human health are closely linked to air quality. It is not possible to predict the health of an individual or the visual quality of a scene from air quality information alone. In both cases, a wide range of effects can be observed at a given level of air quality. However, relationships can be established and used as the technical basis for the level of the indicator selected for the standards. For visibility impairment, these relationships can be established experimentally or by calculations. The State of Colorado used an experimental determination of the level of a visibility indicator. Photographs showing various levels of haze were judged by panels to be acceptable or not acceptable, and the standard was set at a level of light extinction that corresponded to the change in the consensus.[9] The IMPROVE Monitoring Program has a large library of photographs and air quality data that could be used in this manner.

A theoretical relationship between the appearance of elements in a scene and light extinction can be constructed by (1) selecting views in Class I areas that are representative of sensitive views; (2) determining the properties of elements in the view that affect the appearance of these elements, such as their orientation and reflectance; and (3) calculating apparent contrasts and contrast transmittances for these scenic elements for a range of sun angles, different cloud covers, different ratios of scattering to absorption, and so forth. Scatter plots and other statistical relations between the calculated apparent contrasts or contrast transmittance and the light-extinction coefficient can be used, in comparison with best estimates of perception thresholds, to set standards. Calculations similar to those recommended here have recently been performed for the MZVS[6] and for the Dallas-Fort Worth Winter Haze Project.[10]

Because of the limitations of the assumptions cited in the NPR and used in this article, the derivations herein do not provide an indication of whether more complete and appropriate technical analyses would support more or less stringent regional haze regulations than those in the NPR.

APPENDIX

This appendix presents the mathematical derivations that underlie the discussions in the body of the paper. The derivations in Section A.1 are taken from Pitchford and Malm,[1] those in Section A.2 are taken from the earlier paper by Pitchford et al.,[4] and Section A.3 presents an extension of those derivations.

A.1. Derivation of Pitchford and Malm

The deciview haze index (dv) was introduced by Pitchford and Malm[1] and is defined by the relation

$$dv = 10\ \ln_e(b_{ext}/10\ \text{Mm}^{-1}) \tag{4}$$

The value of b_{ext} for green light and particle-free air at 1.8-km elevation is approximately 10 Mm^{-1}. Therefore, *dv* has a value of zero for particle-free air under these conditions and increases by approximately one unit for each 10% increase in b_{ext}.

The second assumption listed in the body of the article is most easily questioned: for a change in contrast to be noticeable, the magnitude of the change is proportional to the apparent contrast (*C*).

$$\Delta C_{JNC} = L\ C \tag{5}$$

where *L* is a constant that depends on the spatial frequency but not the contrast. Neither Pitchford et al.[4] nor Pitchford and Malm[1] explicitly say so, but it is believed this equation is intended to be applicable for either positive or negative values of ΔC_{JNC} for either positive or negative contrasts. Carlson and Cohen[11] have shown that eq 5 is not generally valid but that it may provide a reasonable approximation in viewing environments such as a view of a terrain feature against the horizon sky.

The third assumption is that the apparent contrast of a terrain feature at a distance *r* viewed against the sky is equal to

$$C = C_o \exp(-r\ b_{ext}) \tag{6}$$

where C_o is the initial contrast of the terrain feature and b_{ext} is the average light-extinction coefficient for the sight path. This equation is valid for a terrain feature viewed against the horizon sky provided the sky radiance is the same at each end of the sight path. This third assumption could be regarded as a restriction; that is, the derivation of the deciview haze index applies only to terrain features viewed against the sky in the absence of variable clouds or other nonstandard conditions.

If b_{ext} is decreased to become $b_{ext} - \Delta b_{ext}$, the apparent contrast will become $C - \Delta C$. If these values are substituted into eq 6 and then eq 6 as written above is subtracted, the result is

$$\Delta C = C_o \exp(-r\ b_{ext})\ [1 - \exp(r\ \Delta b_{ext})] = C\ [1 - \exp(r\ \Delta b_{ext})] \tag{7}$$

The algebraic signs in this derivation have been selected to agree with Pitchford and Malm.[1] The conventions in eq 7 are that both Δb_{ext} and ΔC are positive numbers and C_o is negative. These choices of algebraic signs are appropriate for a decrease in b_{ext} in a view of a dark terrain feature against the sky. The change in Δb_{extJNC} that will make this contrast change equal to ΔC_{JNC} can be calculated by combining eqs 5 and 7

$$\Delta C_{JNC} = L\ C = C\ [1 - \exp(r\ \Delta b_{extJNC})] \tag{8}$$

or

$$1 - L = \exp(r\ \Delta b_{extJNC}) \tag{9}$$

Eq 9 is eq 4 in Pitchford and Malm[1] and, except for an arbitrary choice of algebraic signs, eq 7 is eq 4 in Pitchford et al.[4] Eq 1 in the text of this article is a rearrangement of eq 9.

The remainder of the derivation of the deciview haze index by Pitchford and Malm is not reproduced here. Their next step is to restrict the derivation to the special case in which the sight path length *r* is equal to the visual range *VR* when deriving their eq 6 from their eq 4. Pitchford and Malm[1] clearly state that their derivation applies to a scenic element at the most sensitive distance, that is, an element "at the greatest distance that is still visible at the lower extinction coefficient value, but just disappears at the higher extinction coefficient."

A.2. Interpretation by Pitchford et al.

The derivation of the deciview haze index by Pitchford and Malm[1] closely follows a derivation in an earlier article by Pitchford et al.[4] that foreshadows the general structure of the regional haze regulations in the NPR. In this earlier article, a percent change in b_{ext} was recommended as a metric for progress toward the national goal of no manmade visibility impairment. Pitchford et al.[4] take the derivation one step further by introducing the parameter X, which is the ratio of the sight path length r to the visual range VR

$$X = r/VR \tag{10}$$

and making use of the Koschmieder relation for the visual range

$$-\ln\varepsilon = VR\ b_{ext} \tag{11}$$

where ε is the liminal (threshold) contrast. For example, if the liminal contrast is 2%, $-ln\varepsilon$ is equal to 3.91. Pitchford et al.[4] obtain the relation

$$\Delta b_{extJNC}/b_{ext} = [\ln(1 - L)]/(X \ln\varepsilon) \tag{12}$$

In their derivation, the symbol K was used for $-ln\varepsilon$ and $-Y$ was used for $\Delta b_{extJNC}/b_{ext}$. All factors except X in the right-hand side of eq 12 are constants, so this equation shows in simple terms the dependence of Δb_{extJNC} on the ratio of the sight path length to the visual range. Eq 12 was used by Pitchford et al.[4] to calculate their Figure 1, which is reproduced as Figure 1 in this article.

A.3. Extension of the Derivation of Pitchford and Malm

Rearrangement of eq 9 gives

$$\Delta b_{extJNC} = (1/r) \ln(1 - L) \tag{13}$$

The following derivation determines the value of the constant, ln(1 - L) in eq 13, required for the value of Δb_{extJNC} calculated for the case of a sight path length equal to the VR to be the same as the Δb_{ext} that would cause a change of 1 dv. To change the deciview haze index by one unit, it is necessary to change b_{ext} by a factor of exp(0.1) = 1.10517. Thus, the value of Δb_{extJNC} that results in a 1-dv change is 0.10517 b_{ext}. When r is equal to VR, eq 13 becomes

$$\Delta b_{extJNC} = (1/VR) \ln (1 - L) = 0.10517\ b_{ext} \tag{14}$$

Use of eq 11 gives the result that

$$\ln (1 - L) = 0.10517 (-\ln\varepsilon) \tag{15}$$

Eqs 13 and 15 are evaluated for liminal contrasts of 2% ($-\ln\varepsilon$ = 3.9) and 5% ($-\ln\varepsilon$ = 3.0) to obtain eqs 2 and 3, respectively.

GLOSSARY

Apparent: A modifier to indicate values measured at the location of the observer, that is, as the value appears to the observer.

b_{ext}: Symbol for the light-extinction coefficient.

Class I area: Certain large national parks and wilderness areas afforded visibility protection by the Clean Air Act.

Contrast: The difference between the radiance of an element of a scene and its viewing background divided by the radiance of the background. If a terrain feature viewed against the horizon sky has a contrast of -10%, the radiance of the terrain feature is 10% less than the radiance of the background sky.

Deciview haze index: A logarithmically scaled measure of the light-extinction coefficient similar to the decibel scale for sound (see eq 4 and the accompanying discussion).

dv: The abbreviation for the units of the deciview haze index.

Haze: A suspension in the atmosphere of minute particles that are not individually seen but nevertheless reduce visibility.

Indicator: An air quality parameter used as a surrogate for an effect of air quality. Air quality regulations specify upper limits and other constraints on the allowable levels of indicators.

Integral vista: A view outside the boundary of a Class I area that is important to the visual experience within the Class I area. Except for a few integral vistas designated by states, integral vistas are not protected by existing visibility regulations.

Light-extinction coefficient: The rate with respect to distance at which a collimated beam of light is attenuated by light scattering and light absorption. The value of the light-extinction coefficient for green light and particle-free air at 1.8-km elevation is approximately 1% per kilometer, which can be written as 0.01 km^{-1} or 10 Mm^{-1}.

Liminal: The threshold value for perception.

$PM_{2.5}$: Concentration of ambient particulate matter with an aerodynamic diameter less than 2.5 μm, referred to as fine particles.

Spatial frequency: A measure of the angles subtended by variations in contrast in a scene at the location of the observer. Spatial frequencies can be measured in cycles per degree.

Visual range (VR): In many applications, and in this article, the VR is defined by and calculated from eq 11 and is based on measurements of the light-extinction coefficient at the sampler inlet(s). If a case existed in which the atmosphere and its illumination were uniform over the VR and beyond and the atmospheric composition were the same as at the sampler inlet(s), the VR would be the greatest distance a dark target could be perceived against the horizon sky.

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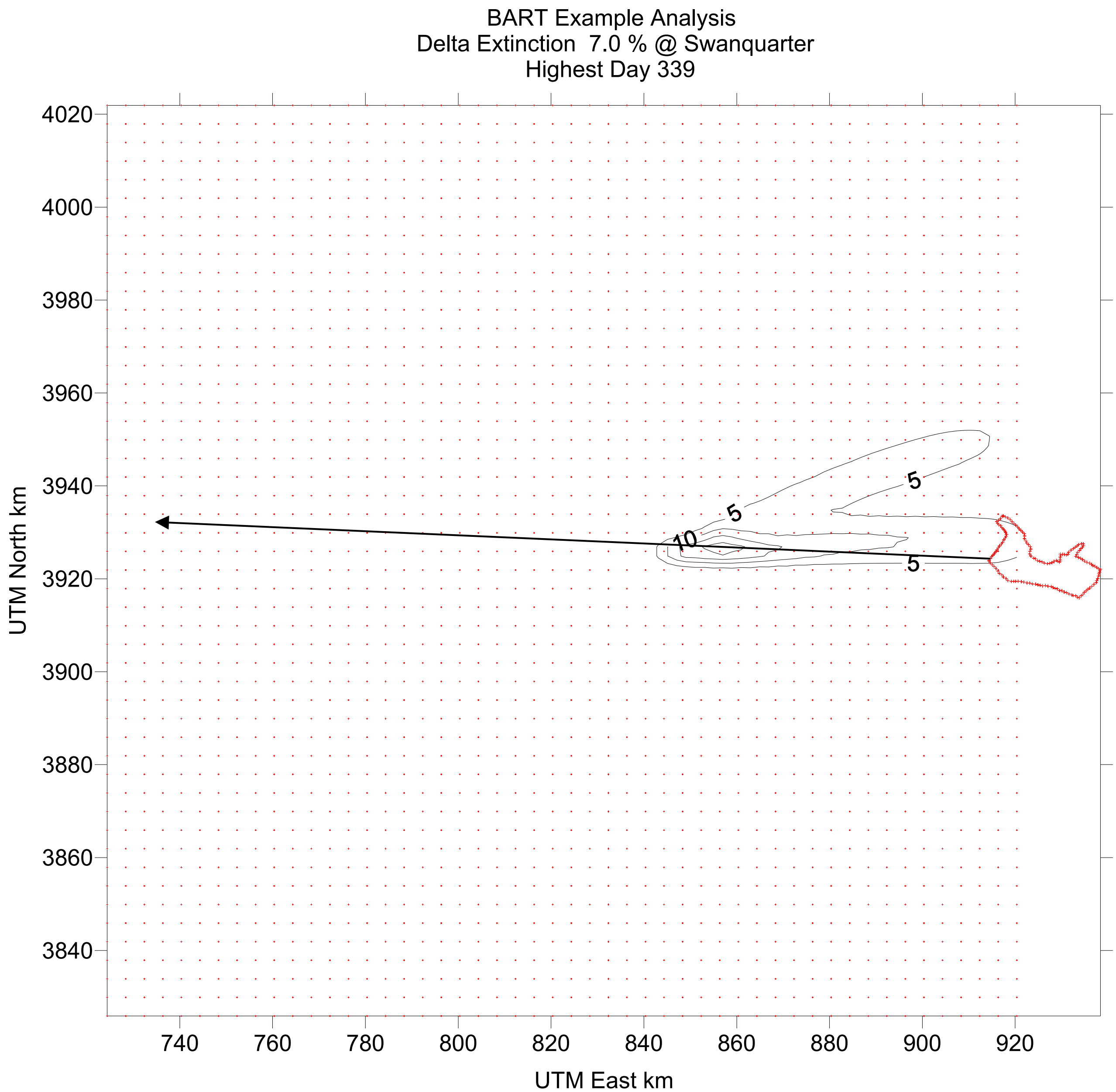
About the Author

L. Willard Richards is one of the founders of Sonoma Technology, Inc. and is now Vice President Emeritus. He received his B.S. in chemistry from the California Institute of Technology and a Ph.D. in physical chemistry from Harvard University.

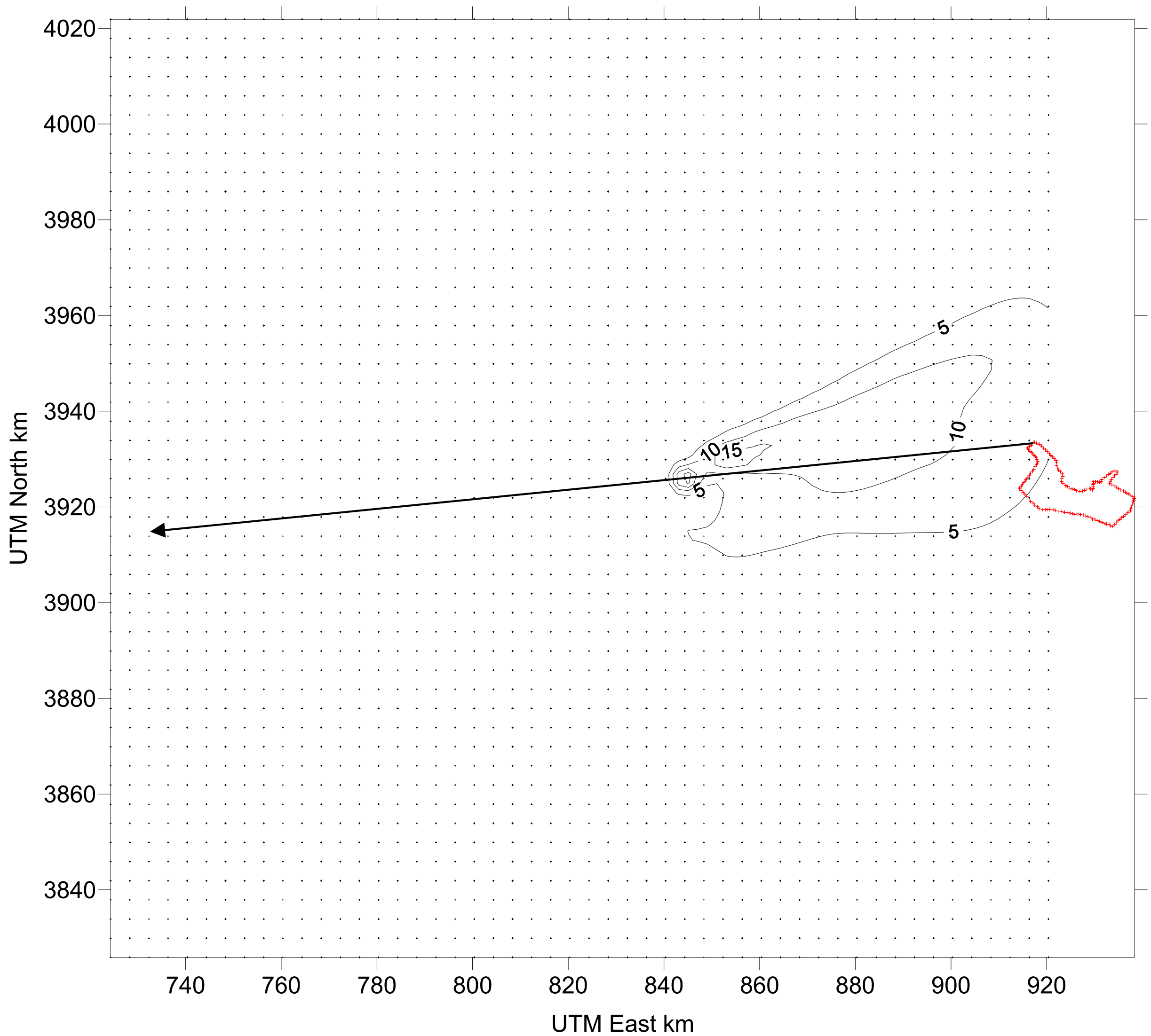
APPENDIX H – CALPUFF Plots Showing Plume Distribution



Refine CALPUFF with 4km Grid for 1989
Source Located 75 km East of Class I Area
Emission Rate (tons/yr)
SO_2 = 2000
NO_x = 1000
SO_4 = 200
PM10 = 500

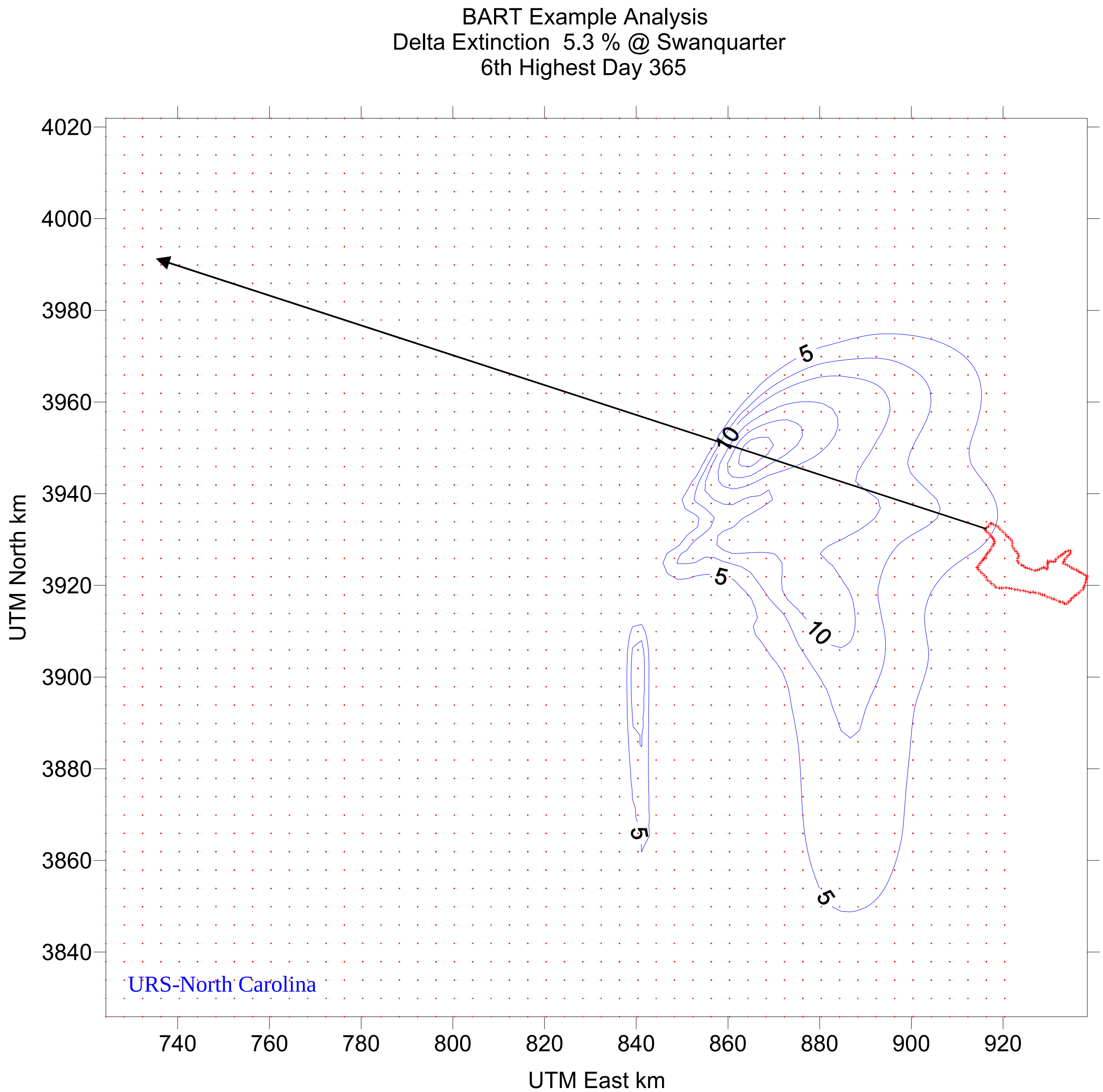
Arrow is Potential Worst Case Line-of-Sight

BART Example Analysis
Delta Extinction 6.5 % @ Swanquarter
4th Highest Day 18



Refine CALPUFF with 4km Grid for 1989
Source Located 75 km East of Class I Area
Emission Rate (tons/yr)
SO_2 = 2000
NO_x = 1000
SO_4 = 200
PM10 = 500

Arrow is Potential Worst Case Line-of-Sight



Refine CALPUFF with 4km Grid for 1989
Source Located 75 km East of Class I Area
Emission Rate (tons/yr)
SO_2 = 2000
NO_x = 1000
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