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DRAFT
for
Public Comment
December 2009

North Dakota State Implementation Plan for Regional Haze

A Plan for Implementing the Regional Haze Program Requirements of Section 308 of 40 CFR Part 51, Subpart P - Protection of Visibility

North Dakota Department of Health
Adopted: _____

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List of Acronyms

AIRS	Aerometric Information Retrieval System
AQS	EPA's Air Quality System
AVS	Antelope Valley Station
ASOFA	Advanced separated overfire air
BADL	Badlands National Park, SD
Bag	Baghouse
BART	Best Available Retrofit Technology
B_{ext}	Light extinction (typically measured in inverse megameters: 1/Mm or $Mm^{-1)}$
BHP	Brake Horsepower
BOWA	Boundary Waters Canoe Area Wilderness Area, MN
BRCA	Bryce Canyon National Park, UT
BRID	Bridger Wilderness, WY
Btu	British thermal unit
CAA	Clean Air Act (42 United States Code Sections 7401, et seq)
CABI	Cabinet Mountains Wilderness Area, MT
CALPUFF	Multi-layer, multi-species, non-steadystate, puff, long range transport dispersion modeling system
CAMx	Comprehensive Air Quality Model with extensions
CANY	Canyonlands National Park, UT
CEM	Continuous emissions monitor
CENRAP	Central Regional Air Planning Association
CFR	Code of Federal Regulations
CM	Coarse mass ($PM_{2.5}$ mass subtracted from PM_{10} mass)
CMAQ	Community Multiscale Air Quality model
CTIC	Conservation Technology Information Center
D	Distance in kilometers
DGC	Dakota Gasification Company
DOA	United States Department of Agriculture
DOI	United States Department of the Interior
Dv	deciview
Δdv	Change in deciviews
EC	Elemental carbon
EDMS	Emissions Data Management System
EGU	Electrical Generating Unit
EPA	United States Environmental Protection Agency
ESP	Electrostatic precipitator
FGD	Flue gas desulfurization
FLM	Federal Land Manager
FM	Fine mass ($PM_{2.5}$ mass)
FR	Federal Register
FS	United States Forest Service (DOA)
FWS	United States Fish and Wildlife Service (DOI)
GAMO	Gates of the Mountains Wilderness Area, MT
GCVTC	Grand Canyon Visibility Transport Commission
GPSP	Great Plains Synfuels Plant
GRSA	Great Sand Dunes Wilderness Area, CO

HEGL	Hercules - Glades Wilderness Area, MO
Hp	Horsepower
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPM	Integrated Planning Model
ISLE	Isle Royale National Park, MI
km	Kilometers
LADCO	Lake Michigan Air Directors Consortium
lb	Pounds
$lb/10^6$ Btu	Pounds per million British thermal units
LEC	Low Emission Combustion
LOST	Lostwood National Wildlife Refuge Wilderness Area, ND
ln	Natural logarithm
LNB	Low NO_x burner
LTPD	Long Tons Per Day
LTS	Long Term Strategy
LWA	Lostwood National Wildlife Refuge Wilderness Area, ND
MACT	Maximum Achievable Control Technology
MELA	Medicine Lake National Wildlife Refuge Wilderness Area, MT
MEVE	Mesa Verda National Park, CO
MI	Michigan
MING	Mingo Wilderness Area, MO
Mm	Megameters
MN	Minnesota
MOZI	Mount Zirkel Wilderness Area, CO
MPCA	Minnesota Pollution Control Agency
MT	Montana
MRPO	Midwest Regional Planning Organization
NAAQS	National Ambient Air Quality Standards
ND	North Dakota
NDAC	North Dakota Administrative Code (state rules)
NDCC	North Dakota Century Code (state laws)
NDDoH	North Dakota Department of Health
NEI	National Emissions Inventory
NESHAP	National Emission Standards for Hazardous Air Pollutants
NH_3	Ammonia
NO_3	Nitrate
NO_x	Oxides of nitrogen or nitrogen oxides
NOAB	North Absaroka Wilderness, WY
NPS	National Park Service (DOI)
NSPS	New Source Performance Standard
OC	Organic carbon
OFA	Overfire air
PM	Particulate matter
PMC	Coarse particulate matter, $PM_{10} – PM_{2.5}$
PM_{coarse}	Coarse particulate matter, $PM_{10} – PM_{2.5}$
PMF	Fine particulate matter, $PM_{2.5}$
PM_{fine}	Fine particulate matter, $PM_{2.5}$

$PM_{2.5}$	Fine particulate matter; particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers as measured by an EPA approved reference method
PM_{10}	Particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers as measured by an EPA approved reference method
POA	Primary Organic Aerosol
PSAT	Particulate Matter Source Apportionment Technology
PSD	Prevention of Significant Deterioration
Q	Emission rate in tons per year
RAVI	Reasonably Attributable Visibility Impairment
RPG	Reasonable Progress Goal
RHR	Regional Haze Rule/Regulation
ROMO	Rocky Mountain National Park, CO
SCR	Selective catalytic reduction
SENE	Seney National Wildlife Refuge Wilderness Area, MI
SD	South Dakota
SD	Spray dryer
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SMP	Smoke Management Plan
SNCR	Selective non-catalytic reduction
SO_2	Sulfur dioxide
SO_4	Sulfate
SO_x	Sulfur oxides
SRU	Sulfur recovery unit
THRO	Theodore Roosevelt National Park, ND
TRNP	Theodore Roosevelt National Park, ND
TPY	tons per year; also listed as tpy
TSD	Technical Support Document
TSS	WRAP Technical Support System
UCR	University of California at Riverside
ULBE	UL Bend National Wildlife Refuge Wilderness Area, MT
URP	Uniform rate of progress
USC	United States Code
VIEWS	Visibility Information Exchange Web System
VISTAS	Visibility Improvement State and Tribal Association of the Southeast
VOC	Volatile organic compounds
VOYA	Voyageurs National Park, MN
VR	Visual Range
WEMI	Weminuche Wilderness Area, CO
WICA	Wind Cave National Park, SD
WRAP	Western Regional Air Partnership
WS	Wet scrubber
YELL	Yellowstone National Park, MT & WY
ZION	Zion National Park, UT

i Submittal Letter

Ms. Carol Rushin
Acting Regional Administrator
United States Environmental Protection Agency Region 8
1595 Wynkoop Street
Denver Colorado 80202-1129

Re: North Dakota State Implementation Plan for Regional Haze

Dear Ms. Rushin:

The State of North Dakota is hereby submitting an amendment to the State Implementation Plan (SIP) to address the requirements for Regional Haze of Section 308 of 40 CFR Part 51, Requirements for Preparation, Adoption, and Submittal of Implementation Plans, Subpart P - Protection of Visibility. This SIP amendment was prepared by the North Dakota Department of Health, Air Quality Division.

We are enclosing two hard copies and three electronic copies of the SIP for your review.

Seven steam electric generating units in North Dakota have been identified as being subject to the BART requirements of 40 CFR 51.308(e). The installation of BART on these sources will result in a reduction of 98,618 tons per year of sulfur dioxide emissions and a reduction of 21,137 tons per year of nitrogen oxides emissions from the 2000-2004 average emissions. These reductions will significantly improve visibility in North Dakota's Class I areas as well as those in surrounding states.

With this submission, I am requesting the U. S. Environmental Protection Agency's approval of this SIP amendment and the BART for the seven Subject-to-BART Electrical Generating Units in North Dakota.

We would also call to your attention that visibility in the North Dakota Class I areas is severely adversely impacted by emissions from coal-fired electrical generating plants located north of the international border in southeastern Saskatchewan, Canada. These impacts and their sources are identified and discussed in Sections 6 and 8 of the SIP revision.

If you have any questions regarding this submittal, please feel free to contact Terry O'Clair, Division of Air Quality Director, North Dakota Department of Health, at 701-328-5178.

Sincerely,

John Hoeven
Governor

Enclosures
xc: L. David Glatt, Chief, Environmental Heath Section, Department of Health
Terry O'Clair, Director, Division of Air Quality, Department of Health

ii Executive Summary

This document comprises the State of North Dakota's State Implementation Plan (SIP) submittal to EPA to meet the requirements of Section 308 of the Regional Haze Regulation (40 CFR Part 51, Subpart P, Section 51.308). Adoption of the North Dakota State Implementation Plan For Regional Haze amends the Implementation Plan for the Control of Air Pollution for the State of North Dakota.

Section 1 describes the purpose of and legal authority of the SIP. Section 2 provides introductory and background information on the federal regional haze law and regulation, visibility impairment, a description of North Dakota's Class I areas and reasonable progress towards the 2064 visibility goals. Section 3 describes plan development and consultation with federal land managers, other states, the EPA, and stakeholders. Section 4 describes the North Dakota monitoring strategy and commitments for future monitoring. Section 5 describes baseline and natural visibility conditions for the North Dakota Class I areas and the uniform rate of progress for each Class I area. Section 6 describes the sources of visibility impairment at North Dakota=s Class I areas. Section 7 describes and provides the results of the Best Available Retrofit Technology (BART) process including the Air Pollution Control Permits to Construct issued to the seven power plant boilers subject to BART. Section 8 describes the CMAQ and CALPUFF modeling used in developing the SIP. Section 9 describes the process for determining the reasonable progress goals for North Dakota's Class I areas and what they are. Section 10 describes the long term strategy. Section 11 describes the commitments to future consultation, progress reports, periodic evaluations of SIP adequacy, and future SIP revisions. Section 12 summarizes the public participation and review process and the revisions made subsequent to the public hearing for the SIP. Appendices at the end of this document provide additional information on BART and reasonable progress modeling protocols, company BART analyses, Department BART determinations, the BART Air Pollution Control Permits to Construct, FLM and EPA comments during the 60-day FLM comment period, the public hearing record, Department responses to FLM, EPA, and public comments, consultation with the FLMs, EPA and other states, the legal opinions of the Attorney General, and the State BART rule.

The North Dakota BART determination process identified seven electrical generating units that are subject to the BART requirements. The installation of new control devices or modifications to existing control devices will reduce sulfur dioxide emission from point sources in the state by 98,618 tons per year and nitrogen oxides emissions by 21,139 tons per year. The BART reductions must be implemented no later than five years after EPA approves this SIP. The anticipated date of implementation is 2013. These reductions are expected to make a significant improvement in visibility in the affected Class I areas. Total sulfur dioxide emissions in North Dakota are expected to decline by 105,729 tons per year (60%) and nitrogen oxides emissions by 57,970 tons per year (25%) during this planning period.

The 2018 reasonable progress goals for the twenty percent worst days in the North Dakota Class I areas have been established at 16.9 deciviews for each unit of Theodore Roosevelt National Park (TRNP) and 18.9 deciviews at Lostwood Wilderness Area (LWA). The analyses conducted by the North Dakota Department of Health (NDDoH) and the Western Regional Air Partnership (WRAP) indicates there will be no degradation during the 20% best days.

1. Purpose / Legal Authority

The purpose of this submittal is to address the State Implementation Plan requirements for the State of North Dakota found in Paragraph 40 CFR 51.308, Regional Haze Program Requirements, of 40 CFR Part 51 Subpart P - Protection of Visibility.

The North Dakota Department of Health (the Department), the agency designated to administer and coordinate a statewide program of air pollution control, has general legal authority under North Dakota Century Code Sections 23-25-03 and 28-32-02 to adopt and enforce rules for visibility protection including regional haze visibility impairment.

The Department adopted rules in 1987 to implement Sections 40 CFR 51. 300 - 307 (NDAC Chapter 33-15-19 Visibility Protection, Effective date October 1, 1987) and in 2006 to implement Paragraph 40 CFR 51.308(e) (NDAC Chapter 33-15-25 Regional Haze Requirements, Effective Date January 1, 2007).

It is the legal opinion of the North Dakota Attorney General that the State Implementation Plan (SIP) is legal, valid and the Air Pollution Control Permits to Construct for the BART sources, as well as the Coyote Station, included within the SIP in Appendix D have the force and effect of law. A copy of the Attorney General opinion is contained in Appendix G.

2. Overview

2.1 Introduction

The Clean Air Act (CAA) defines the general concept of protecting visibility in each of the 156 Mandatory Class I Federal Areas across the nation as shown in Figure 2.1. Section 169A from the 1977 CAA set forth the following national visibility goal:

> "Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution."

The federal visibility regulations (40 CFR Part 51, Subpart P - Visibility Protection Section 51.300 - 309) detail a two-phased process to determine existing impairment in each of the Class I areas, how to remedy such impairment, and how to establish goals to restore visibility to "natural conditions" by the year 2064 in each of these areas. The federal regulations require states to prepare a SIP to: include a monitoring strategy, address existing impairment from major stationary facilities (Reasonably Attributable Visibility Impairment), prevent future impairment from proposed facilities, address Best Available Retrofit Technology (BART) for certain stationary sources, consider other major sources of visibility impairment, calculate baseline, current and natural visibility conditions, consult with the Federal Land Managers (FLMs) in the development or change to the SIP, develop a long-term strategy to address issues facing the state, set and achieve reasonable progress goals for each Class I area, and review the SIP every five years.

EPA promulgated regulations to implement the statute in December, 1980. Following litigation, a court settlement divided visibility protection into two phases.

Phase 1 of the visibility program, also known as Reasonably Attributable Visibility Impairment (RAVI), addresses impacts in Class I areas by establishing a process to evaluate source specific visibility impacts, or plume blight, from individual sources or small groups of sources. Part of that process relates to the evaluation of sources prior to construction through the Prevention of Significant Deterioration (PSD) permit program for major stationary sources. The plume blight part of the Phase 1 program also allows for the evaluation, and possible control, of reasonably attributable impairment from existing sources. North Dakota has developed, and EPA approved, a SIP for Phase 1 of the visibility program. The Phase 1 rule is NDAC 33-15-19, Visibility Protection.

Section 169B was added to the Clean Air Act Amendments of 1990 to address regional haze. Since regional haze does not respect state and tribal boundaries, the amendments authorized EPA to establish visibility transport regions as a way to combat regional haze.

Phase 2 of the visibility program addresses regional haze. This form of visibility impairment focuses on overall decreases in visual range, clarity, color, and ability to discern texture and details in Class I areas. The responsible air pollutants can be generated in the local vicinity or

transported by the wind often many hundreds or even thousands of miles from where they originated. For technical and legal reasons the second part of the visibility program was not implemented in regulation until 1999.

In July 1999, the EPA finalized the Regional Haze Rule (RHR) requiring States to adopt State Implementation Plans to address this aspect of visibility impairment in the Class I areas. The rule was amended in July, 2005. Under the current rules the Regional Haze SIP was to be submitted to the EPA by December 17, 2007.

The two key requirements of the regional haze program are:

1. Improve visibility for the most impaired days, and
2. Ensure no degradation in visibility for the least impaired days.

Though the national visibility goals are to be ultimately achieved by the year 2064, the SIP seeks to meet the two requirements stated above by 2018, the first planning period established by the federal rule.

Pursuant to the requirements of 51.308(a) and (b), the SIP is intended to meet the requirements of EPA=s Regional Haze rules that were adopted to comply with requirements set forth in Section 169B of the Clean Air Act. Elements of this SIP are to address:

- The core regional haze program requirements pursuant to 40 CFR 51.308(d),
- The Best Available Retrofit Technology (BART) requirements of 40 CFR 51.308(e),
- The requirements for comprehensive periodic revisions of regional haze SIPs of 40 CFR 51.308(f),
- The requirements for periodic reports describing progress towards the reasonable progress goals of 40 CFR 51.308(g),
- The requirement for determination of the adequacy of the existing implementation plan of 40 CFR 51.308(h), and
- The requirements for State and Federal Land Manager coordination of 40 CFR 51.308(i).

In addition, 40 CFR 51.308(c) of the original July 1999 regulation provided options for a regional planning process to allow states to develop a coordinated approach to regional haze. In March 1999, North Dakota became a member of the Western Regional Air Partnership (WRAP), the regional planning organization serving 13 western states, tribes and federal agencies. Section 51.308(c) was deleted on July 6, 2005 when the BART Guidelines were added to the regional haze rule.

Figure 2.1 - Map of United States Class I Areas

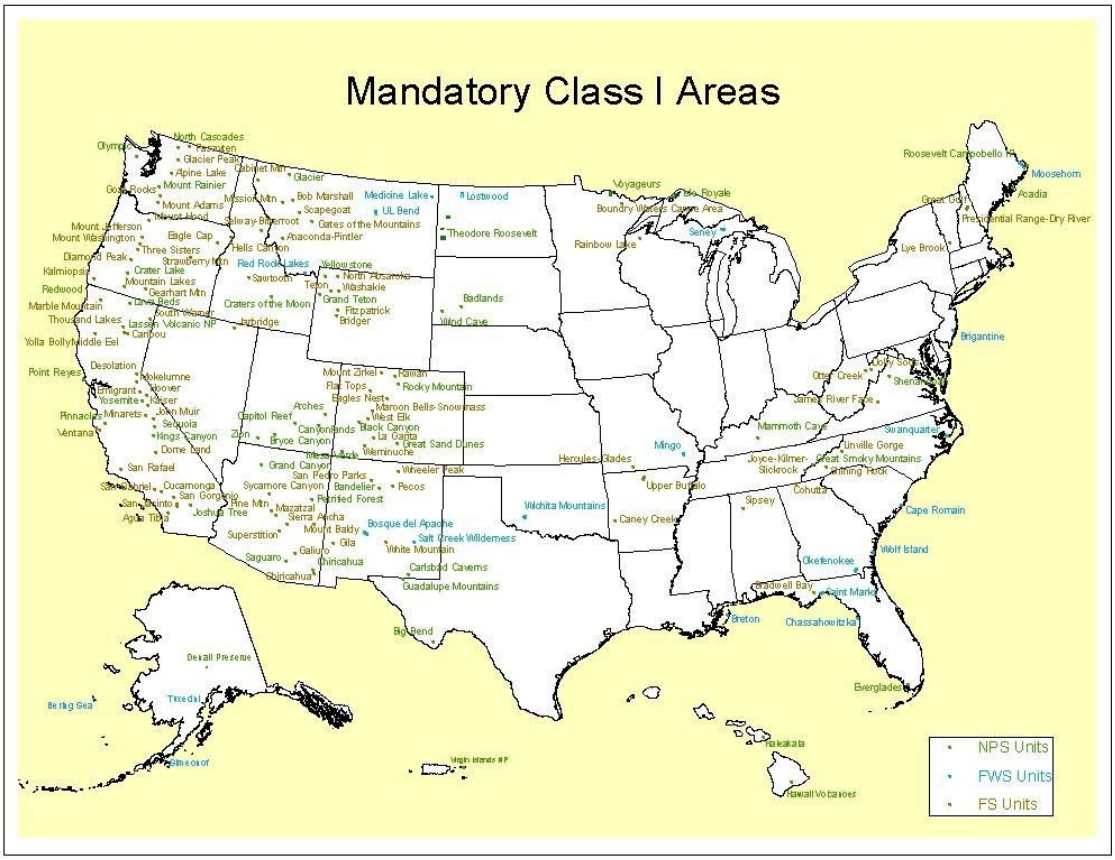
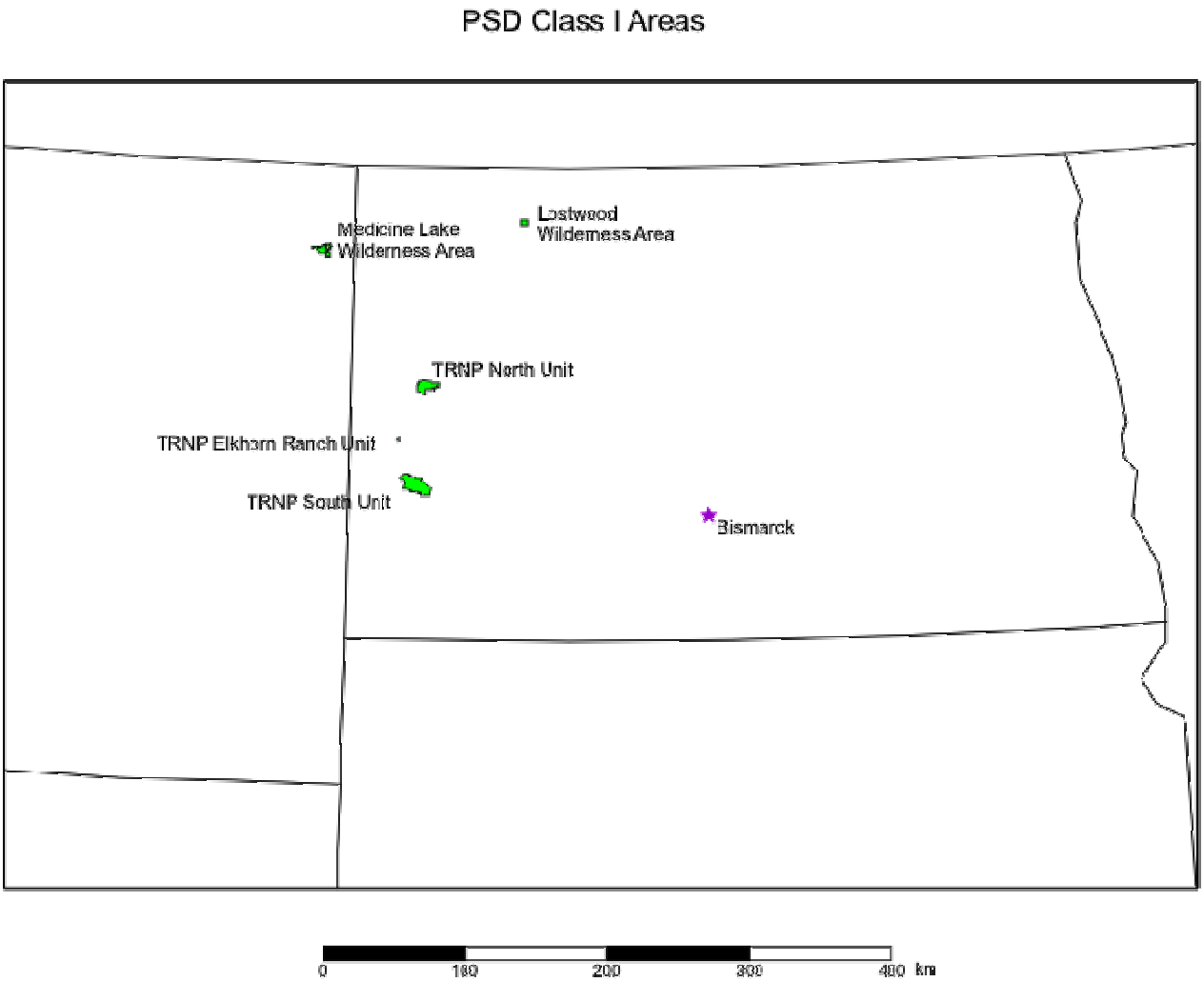


Figure 2.2 – Map of North Dakota Class I Areas



2.2 Visibility Impairment

Most visibility impairment occurs when pollution in the form of small particles scatters or absorbs light. Air pollutants come from a variety of natural and anthropogenic sources. Natural sources can include windblown dust and smoke from wildfires. Anthropogenic sources can include motor vehicles, electric utility and industrial fuel burning and manufacturing operations. More pollutants mean more absorption and scattering of light, which reduce the clarity and color of a scene. Some types of particles such as sulfates and nitrates, scatter more light, particularly during humid conditions. Other particles like elemental carbon from combustion processes are highly efficient at absorbing light. Commonly, the receptor is the human eye and the object may be a single viewing target or a scene.

In the 156 Class I areas across the country, visual range has been substantially reduced by air pollution. In eastern parks, average visual range has decreased from 90 miles to 15-25 miles. In the West, visual range has decreased from an average of 140 miles to 35-90 miles.

Some haze causing particles are directly emitted to the air. Others are formed when gases emitted to the air form particles as they are carried many miles from the source of the pollutants. Some haze-forming pollutants are also linked to human health problems and other environmental damage. Exposure to very small particles in the air has been linked with increased respiratory illness, decreased lung function, and premature death. In addition, particles such as nitrates and sulfates contribute to acid deposition potentially making lakes, rivers and streams unsuitable for some forms of aquatic life and impacting flora in the ecosystem. These same acid particles can also erode materials such as paint, buildings or other natural and man-made structures.

2.3 Description of North Dakota's Class I Areas

The Class I areas in North Dakota include: the Theodore Roosevelt National Park (TRNP) which consists of three separate, distinct units and the Lostwood National Wildlife Refuge Wilderness Area (LWA). The North Dakota Class I Areas are shown on Figure 2.1 and Figure 2.2.

Theodore Roosevelt National Park is located within Billings and McKenzie Counties in North Dakota. The colorful badlands and Little Missouri River of western North Dakota provide the scenic backdrop to the park which memorializes the 26th president for his enduring contributions to the conservation of our nation's resources. The park contains 70,447 acres divided among three separate units: South Unit, Elkhorn Ranch and North Unit and is managed by the National Park Service. The park is comprised of badlands, open prairie and hardwood draws that provide habitat for a wide variety of wildlife species including bison, prairie dogs, elk, deer, big horn sheep and other wildlife. The Little Missouri River passes through the three units of the park.

Lostwood National Wildlife Refuge Wilderness Area is located in Burke County in the northwestern part of the State. Created by an act of Congress in 1975, the wilderness covers an area of 5,577 acres. It is contained within Lostwood National Wildlife Refuge and is managed by the U.S. Fish and Wildlife Service. Lostwood National Wilderness Area is designated to preserve

a region well known for numerous lakes and mixed grass prairie. The wilderness ensures that the finest duck and waterfowl breeding region in North America remains wild and unimproved.

2.4 Class I Areas in Other States Impacted by North Dakota Sources

In accordance with 40 CFR 51.308, emissions sources within North Dakota have or may be reasonably expected to have impacts on the following Class I Areas: Boundary Waters Canoe Area Wilderness Area (BOWA) and Voyageurs National Park (VOYA) in Minnesota, Isle Royale National Park (ISLE) and Seney National Wildlife Refuge Wilderness Area (SENE) in Michigan, Medicine Lake National Wildlife Refuge Wilderness Area (MELA) and U. L. Bend National Wildlife Refuge Wilderness Area ((ULBE) in Montana, and Badlands National Park (BADL) and Wind Cave National Park (WICA) in South Dakota. As shown in Table 2.1 and Figure 2.1, sources in North Dakota have only a small impact on out-of-state Class I areas. For Class I areas that are more distant, the impact will be even smaller. Impacts from emission sources in North Dakota contribute 5 percent or more of the total 2002 extinction (Bext) in the above Class I areas except those in Michigan and BOWA. A 5 percent or larger contribution is considered a significant contribution.

Table 2.1
North Dakota
Species Contribution (%)
20% Worst Days
2000-2004

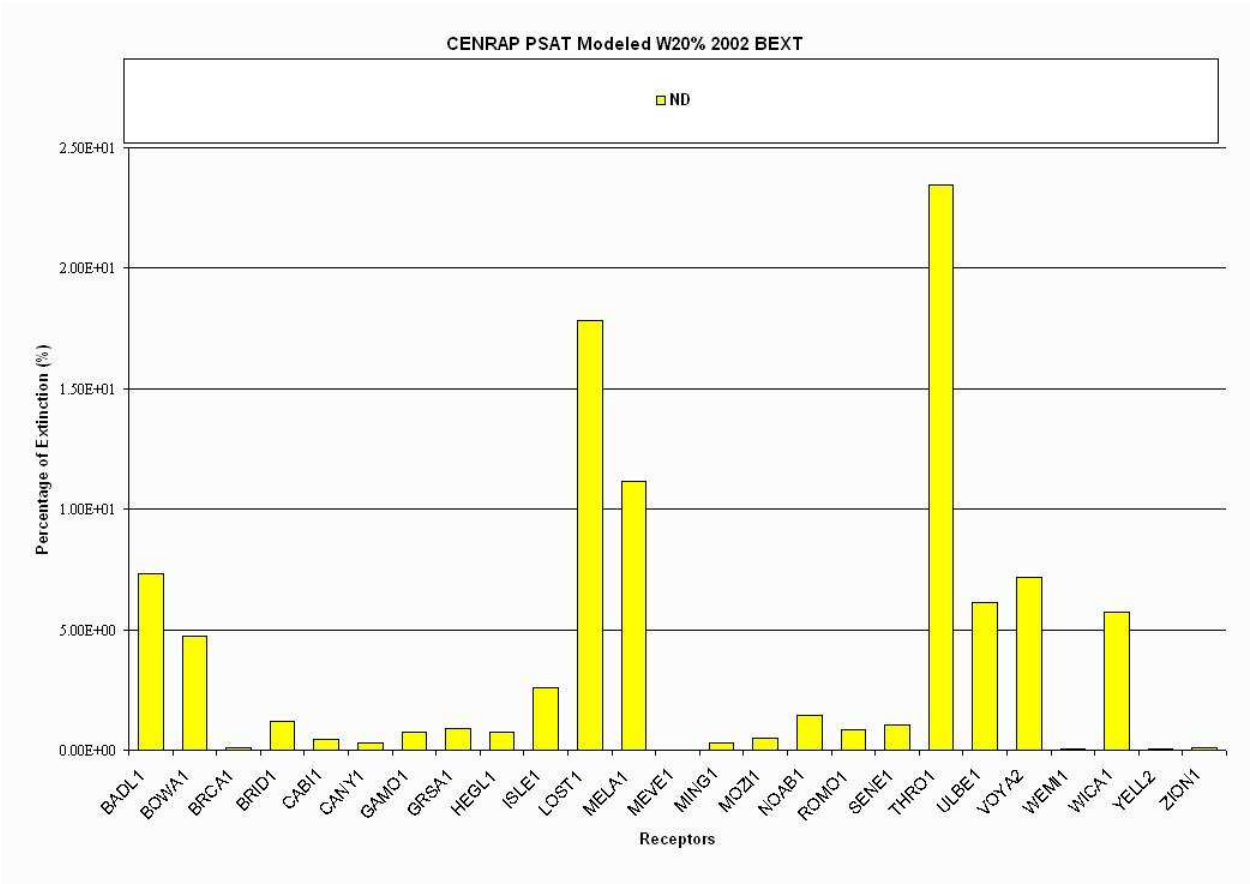
Class I Area	Sulfate	Nitrate	OC	EC	PMF	PMC	Sea Salt
TRNP	21	19	12	29	44	45	0
LWA	18	13	23	35	28	32	0
Badlands	8	10	2	4	3	3	0
Wind Cave	8	8	1	2	4	3	0
U.L. Bend	9	5	1	1	1	1	0
Medicine Lake	11	7	9	15	17	16	0
Gates of the Mountains	< 1	< 1	< 1	< 1	< 1	< 1	0
North Absaroka	1	1	< 1	< 1	< 1	< 1	0
Voyageurs	6	9	3*	6*	15*	22*	0
Boundary Waters*	3	10	2	4	10	7	0
Isle Royale*	2	4	1	2	6	6	0
Seney*	1	3	<1	<1	2	4	0

Based on WRAP's tracer analyses (SO_4 and NO_3) and weighted emissions potential (WEP) analyses unless otherwise noted.

*Based on CENRAP data.

From CENRAP's PSAT analysis, North Dakota's contribution to total extinction (20% worst days in base year 2002) at the nearby Class I areas is shown in Figure 2.3.

Figure 2.3



2.5 Programs to Address Visibility Impairment

North Dakota and EPA have many existing emission control programs/rules to improve and protect visibility in Class I areas.

North Dakota adopted and EPA approved a SIP for Phase 1 of the visibility program. This program addresses major source PSD permitting, source specific haze and plume blight aspects of visibility impairment. The Phase 1 rule is NDAC 33-15-19, Visibility Protection. It has an effective date of October 1, 1987.

North Dakota adopted NDAC 33-15-25, Regional Haze Requirements in 2006 with an effective date of January 1, 2007. This rule implements the BART provisions of the federal RHR.

North Dakota has several other emission control programs/rules that while not specifically written to address visibility impairment, do address visibility and work to improve and protect visibility in Class I areas. These include:

NDAC Chapter 33-15-02, Ambient Air Quality Standards, Section 33-15-02-03. Air quality guidelines. This rule states in part:

> "In keeping with the purpose of these ambient air quality standards, the quality should be such that:
>
> 4. Visibility will be protected.
>
> 7. Natural scenery will not be obscured."

NDAC Chapter 33-15-04, Open Burning Restrictions. Section 33-15-04-02. Permissible open burning. This rule states in part:

> "2. The following conditions apply to all types of permissible burning listed in subsection 1.
>
> h. Except in an emergency, burning may not be conducted is such proximity of any Class I area, as defined in chapter 33-15-15, that the ambient air of such area is adversely impacted.
>
> i. Except in an emergency, the visibility of any Class I area cannot be adversely impacted as defined in chapter 33-15-19."

NDAC Chapter 33-15-15, Prevention of Significant Deterioration of Air Quality, requires that a visibility analysis be prepared in accordance with chapter 33-15-19 as a part of the requirements for a PSD permit to construct.

NDAC Chapter 33-15-17. Restriction of Fugitive Emissions. Section 33-15-17-02 Restriction of fugitive particulate emissions. This rules states in part: "No person shall emit or cause to be

emitted into the ambient air from any source of fugitive emissions as specified in section 33-15-17-01 any particulate matter which:

5. Would have an adverse impact on visibility, as defined in chapter 33-15-19, on any federal class I area."

In addition to the above programs, the following emission control programs/rules, which do not specifically address visibility impairment, control the emission of pollutants that cause or contribute to visibility impairment:

NDAC Chapter 33-15-03	Restriction of Emission of Visible Air Contaminants
NDAC Chapter 33-15-05	Emissions of Particulate Matter Restricted
NDAC Chapter 33-15-06	Emissions of Sulfur Compounds Restricted
NDAC Chapter 33-15-07	Control of Organic Compounds Emissions
NDAC Chapter 33-15-08	Control of Air Pollution from Vehicles and Other Internal Combustion Engines
NDAC Chapter 33-15-12	Standards of Performance for New Stationary Sources
NDAC Chapter 33-15-14	Designated Air Contaminant Sources, Permit to Construct, Minor Source Permit to Operate, Title V Permit to Operate
NDAC Chapter 33-15-20	Control of Emissions from Oil and Gas Well Production Facilities
NDAC Chapter 33-15-21	Acid Rain Program
NDAC Chapter 33-15-22	Emissions Standards for Hazardous Air Pollutants for Source Categories

It should be noted that unless specifically stated in the text, all references to existing rules or emission control programs are intended only to provide information about various aspects of the program described and are neither being submitted to EPA for approval nor being incorporated into the SIP as Federally enforceable measures if they haven't previous been incorporated.

This SIP is North Dakota's comprehensive visibility plan which now contains both Phase 1 and Phase 2 visibility requirements. It addresses all aspects of North Dakota's visibility improvement program.

North Dakota is also setting emission limits as a part of this SIP for those sources subject to Best Available Retrofit Technology (BART) requirements of Phase 2 of the RHR which are described in detail in chapter 7 of this SIP.

This SIP documents those programs, rules, processes and controls deemed appropriate as measures to reduce regional haze and protect good visibility in North Dakota toward meeting the 2018 and 2064 goals established in the EPA RHR and CAA.

EPA has several existing emission control programs/rules which do not specifically address visibility impairment that will control the emission of pollutants that cause or contribute to visibility impairment which will impact North Dakota Class I areas. They include:

CAIR. CAIR will permanently cap emissions of SO_2 and NO_x from EGUs in the eastern United States by 2015. When fully implemented, CAIR as originally promulgated would have reduced SO_2 emissions from EGUs in these states by more than 70%, and NO_x emissions by more than 60%, from 2003 levels. CAIR has been remanded with a replacement rule likely to take 2 years to finalize. Any emission reductions from a CAIR replacement rule are unknown at this time. When winds are from an easterly direction, North Dakota Class I areas will see some benefit from the CAIR reductions.

NO_x SIP Call. Phase I of the NO_x SIP call applies to certain EGUs and large non-EGUs, including large industrial boilers and turbines, and cement kilns in the eastern United States. It is expected to reduce NO_x emissions by 90% to mitigate ozone transport. When winds are from an easterly direction, North Dakota Class I areas will see some benefit.

Heavy Duty Diesel (2007) Engine Standard (for on-road trucks and buses). The EPA set a PM emissions standard for new heavy-duty engines of 0.01 grams per brake-horsepower-hour(g/bhp-hr), to take full effect for diesel engines in the 2007 model year. This rule also includes standards for NO_x and non-methane hydrocarbons (NMHC) of 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. These NO_x and NMHC standards will be phased in together between 2007 and 2010, for diesel engines. Sulfur in diesel fuel must be lowered to enable modern pollution control technology to be effective on these trucks and buses. The EPA will require a 97 percent reduction in the sulfur content of highway diesel fuel from its current level of 500 parts per million (low sulfur diesel, or LSD) to 15 parts per million (ultra-low sulfur diesel, or ULSD).

Tier 2 Tailpipe (On-road vehicles). The EPA mobile source rules include the Tier 2 fleet averaging program, modeled after the California LEV II standards. Manufacturers can produce vehicles with emissions ranging from relatively dirty to zero emissions, but the mix of vehicles a manufacturer sells each year must have average NO_x emissions below a specified value. Tier 2 standards became effective in the 2005 model year.

Large Spark Ignition and Recreational Vehicle Rule. The EPA has adopted new standards for emissions of NO_x, hydrocarbons, and carbon monoxide from several groups of previously unregulated nonroad engines. Included in these are large industrial spark-ignition engines and recreational vehicles. Nonroad spark-ignition engines are those powered by gasoline, liquid propane gas, or compressed natural gas rated over 19 kilowatts (kW) (25 horsepower). These engines are used in commercial and industrial applications, including forklifts, electric generators, airport baggage transport vehicles, and a variety of farm and construction applications. Nonroad recreational vehicles include snowmobiles, off-highway motorcycles, and all-terrain-vehicles. These rules were initially effective in 2004 and will be fully phased-in by 2012.

Nonroad Diesel Rule. This rule sets standards that will reduce emissions by more than 90 percent from nonroad diesel equipment, and reduce sulfur levels by 99 percent from current levels in nonroad diesel fuel starting in 2007. This step will apply to most nonroad diesel fuel in 2010 and to fuel used in locomotives and marine vessels in 2012.

Industrial Boiler/Process Heater MACTs. The EPA issued final rules to substantially reduce emissions of toxic air pollutants from industrial, commercial and institutional boilers and process heaters. These rules reduce emissions of a number of toxic air pollutants, including hydrogen chloride, manganese, lead, arsenic and mercury by 2009. This rule also reduces emissions of SO_2 and PM in conjunction with the toxic air pollutant reductions. The applied Maximum Achievable Control Technology (MACT) control efficiencies were 4 percent for SO_2 and 40 percent for PM_{10} and $PM_{2.5}$. The EPA's industrial boiler MACT rules were vacated on June 8, 2007, however it is believed that by 2018 the USEPA will have re-promulgated a boiler MACT rule; however, the emission reductions may change from those of the vacated rule.

Combustion Turbine and Reciprocating Internal Combustion Engines MACTs. The EPA MACT regulations for Gas Turbines and stationary Reciprocating Internal Combustion will have NO_x co-benefit effects.

VOC 2-, 4-, 7-, and 10-year MACT Standards. Various point source MACTs and associated emission reductions have been implemented by EPA.

2.6 Reasonable Progress Toward the 2064 Visibility Goals

Section 51.308(d) contains the core requirements for the regional haze SIP. The requirements for reasonable progress goals (RPG) are found in 51.308(d)(1) which reads:

> "Reasonable progress goals. For each mandatory Class I Federal area located within the State, the State must establish goals (expressed in deciviews) that provide for reasonable progress towards achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most impaired days over the period of the implementation plan and ensure no degradation in visibility for the least impaired days over the same period."

The reasonable progress goals are interim goals that represent incremental visibility improvement over time for the most-impaired (20% worst) days and no degradation in visibility for the least-impaired (20% best) days. The first regional haze plan that States must submit to EPA needs to include RPGs for the year 2018, also known as the "2018 milestone year". The State has the flexibility in establishing different RPGs for each Class I area. In establishing the RPG, the State must consider four factors:

- the costs of compliance;
- the time necessary for compliance;
- the energy and non-air quality environmental impacts of compliance; and
- the remaining useful life of any potentially affected sources.

States must demonstrate how these factors were taken into consideration in selecting the RPG for each Class I area.

The North Dakota Department of Health has worked with the Western Regional Air Partnership (WRAP) and with the WRAP's ongoing modeling program as well as implemented our own modeling program to establish and refine RPGs for 2018 for the North Dakota Class I areas. This process is described in detail in sections 8 and 9.

The RPGs for each North Dakota Class I area established for 2018 are found in section 9. Required BART controls will be installed and become operational as expeditiously as practicable, but no later than five years after this SIP is approved by EPA. The controls are expected to be operational in 2013 - 2014.

The technical analyses described in this SIP demonstrate that emissions both inside and outside of North Dakota have an appreciable impact on the State's Class I areas. This includes emissions from neighboring states as well as international emissions from Canada, especially from the provinces of Alberta and Saskatchewan. Emission controls from many sources outside of North Dakota will not be fully defined during this round of the Regional Haze SIP process, necessitating consideration of outside controls and further interstate and possibly tribal consultation in the reasonable progress process to establish refined reasonable progress goals. The EPA, through the Department of State, will have to work with Canada and its provinces to reduce visibility impairing pollutants that impact North Dakota and other states' Class I areas. Until SIP controls including BART and other programs outside of North Dakota are defined, modeled and analyzed, North Dakota cannot fully determine progress toward the 2018 goal or the 2064 goal. North Dakota will make its best attempt at demonstrating progress toward the goals based on addressing sources within its control.

3. Plan Development and Consultation

The State is required by Section 51.308(d) (3) (i) of the EPA Regional Haze Rule to consult with other states to develop coordinated emission management strategies for Class I areas in those states North Dakota's emissions impact or those states whose emissions impact North Dakota's Class I areas and by Section 51.308(i) to consult with the federal land managers of the Class I areas in our state and the Class I areas in other states that emissions from North Dakota impact.

3.1 Consultation with Federal Land Managers

The North Dakota Department of Health consults with the FLMs as a part of the WRAP and as needed directly with the National Park Service and U.S. Fish and Wildlife Service in Denver, CO. They have reviewed and commented on North Dakota's BART modeling protocol and draft BART determinations submitted by the BART sources.

The National Park Service, the U.S. Fish and Wildlife Service, and the U.S. Forest Service (federal land manager of Boundary Waters Canoe Area Wilderness in Minnesota) were each furnished copies of this draft SIP for review and comment as part of the required 60 day FLM comment period (Section 51.308(i)(2)). Continuing consultation with the three FLM's in the future as required by 40 CFR 51,308(i)(4) is addressed in Section 11.1.1.

3.1.1 FLM Comments Provided During 60 Day Comment Period

A draft was provided to the FLMs in August 2009 for their 60-day consultation period. The FLM comments are included in Appendix J.

3.1.2 Response to FLM Comments

The Department's responses to the FLM's comments are included in Appendix J.

3.1.3 FLM Comments Provided on BART Portion of SIP in 2008

The Department had originally planned to submit the BART portion of the regional haze SIP separately from the Reasonable Progress portion of the SIP. The BART portion (which is now Section 7) was submitted to the FLMs in June of 2008 as part of the required 60-day FLM comment period.

Comments that were received from the FLMs in August of 2008 are attached in Appendix J.1.1 and discussed further in Section 7. They have been reviewed and considered by the Department and included as appropriate in Section 7 of this current SIP. The Department's responses to the FLM comments are attached in Appendix J.1.2.

3.2 Consultation with EPA Region 8

The North Dakota Department of Health has consulted with EPA as a part of the WRAP and as needed directly with Air Program staff of the EPA Region 8 office in Denver, CO in developing this SIP. EPA has reviewed and commented on the State BART modeling protocol, the BART Air Pollution Control Permit to Construct template and the draft BART determinations submitted by the BART sources.

In June of 2008, the Department submitted the BART portion of the SIP to EPA Region 8 at the same time it was submitted to the FLMs as discussed in Section 3.1.3. Comments were received from EPA and are attached as Appendix J.3.1. The Department's responses to the EPA comments are attached as Appendix J.3.2.

EPA was also provided a copy for comment of the draft SIP at the time it was provided to the FLMs as a part of the FLM 60 day comment period. The Department considered the EPA comments and made appropriate revisions to the SIP.

The Department also consulted with EPA Region 8 concerning Class I areas in Montana as they are preparing a federal implementation plan for Montana.

3.3 Consultation with Other States

The North Dakota Department of Health has consulted with our neighboring states of South Dakota and Montana through the WRAP and as needed individually. We also participated in monthly teleconferences from 2004 through 2008 with Minnesota and Michigan, the states containing the four northern Class I areas (Boundary Waters Canoe Wilderness Area and Voyageurs National Park in Minnesota, Isle Royale National Park and Seney National Wildlife Refuge Wilderness Area in Michigan), and other states in CENRAP and LADCO. We also individually consulted as needed with Minnesota, our neighbor directly to the east.

As a result of the consultations, Minnesota sent a memorandum dated September 19, 2007 to North Dakota and other states impacting Minnesota's Class I areas. Minnesota requested a response documenting these consultations have taken place to the satisfaction of North Dakota or detailing areas where additional consultation should occur. In those states Minnesota has identified as additional contribution states, they asked those states to respond with their agreement or disagreement with Minnesota's determination of contributing states and the additional control strategies that will be evaluated. Minnesota's memorandum and the NDDoH letter of response dated August 22, 2008 are attached in Appendix J.2.

These states were notified of the availability of the draft SIP at the time it was sent to the FLMs.

3.4 Regional Planning Consultation

The North Dakota Department of Health became a member of the Western Regional Air Partnership (WRAP) in March of 1999. WRAP is one of five regional planning organizations representing 13 western states, tribes in those states, federal agencies including EPA and FLMs, environmental organizations, industry, academics, and other stakeholders. Department staff has participated and continues to participate in many WRAP committees and workgroups including the Air Managers Committee, the Initiatives Oversight Committee, the Technical Oversight Committee, the Emissions Forum, the Stationary Sources Joint Forum, the Technical Analysis Forum, the Implementation Workgroup, and the BART Workgroup. Membership in the WRAP and participation in its many committees, forums and workgroups allows consultation with the many organizations WRAP represents.

3.5 Consultation with Tribes

The Department will notify the tribes in North Dakota of the public hearing and comment period on the draft RH SIP and provide them copies on CD. The Department also notified the WRAP Tribal Caucus Coordinator of its intent to draft a SIP to address regional haze and provided a list of contacts within the Department (see Appendix J.4).

3.6 Other Consultation

The Department has monthly teleconferences with the Subject-to-BART sources in North Dakota and has quarterly meetings with the Lignite Energy Council, an organization representing lignite coal mines and users within the State.

4. Monitoring Strategy and Other Implementation Plan Requirements

Part 40 CFR 51.305 and 51.308(d)(4) of the Federal Regional Haze Rule requires states to have a monitoring strategy in the SIP for addressing reasonably attributable visibility impairment (RAVI) and regional haze visibility impairment in the federal Class I areas within the State. The monitoring strategy required by 40 CFR 51.305 is discussed in Section 4.1. The monitoring strategy required by 40 CFR 51.308(d)(4) is summarized in Section 4.2 and is made a part of this RH SIP.

4.1 RAVI Monitoring Strategy in Current North Dakota Long Term Strategy

The RAVI monitoring strategy required by 40 CFR 51.305 was first included in the long term strategy section of North Dakota's first visibility protection SIP dated October 1, 1987 as Section 6.10. The visibility monitoring strategy was replaced on March 1, 1994 with Section 6.12. It was again replaced on January 1, 1996 with Section 6.13 of the SIP which is the present RAVI monitoring strategy. Section 6.13 is:

Air Quality Surveillance

> In April 1994, Section 6.12 of the SIP was submitted to EPA indicating visibility monitoring was not necessary due to a lack of visibility impairment and a database indicating stable conditions. In late 1994 and early 1995, there has been a resurgence of activity in the oil fields of Western North Dakota. The purpose of Section 6.13 is to withdraw Section 6.12 and identify current activities regarding visibility monitoring.
>
> An increase in oil drilling activities in 1995 has prompted the Park Service to revisit the idea of establishing visibility monitoring sites at the Class I areas in North Dakota. The Department has met with the Park Service to discuss arrangements for financing visibility monitoring. The Department has offered to use funds from an environmental trust that was established through deposits from penalties collected on several enforcement cases. Theodore Roosevelt National Park (TRNP) Service officials were receptive and have transmitted requests to their offices in Denver. Plans currently call for the Department and the Park Service to enter into a memorandum of understanding to proceed with establishing visibility monitoring at TRNP.

The Federal Land Managers installed IMPROVE monitors in Theodore Roosevelt National Park South Unit and Lostwood National Wildlife Refuge Wilderness Area in December of 1999.

The Department also worked with the National Park Service to install a webcam at the South Unit of TRNP using funds from the environmental trust as included in Section 6.13. The webcam became operational in August of 2002. It can be accessed on the internet at:

http://www.nature.nps.gov/air/WebCams/parks/throcam/throcam.cfm. In addition to the webcam picture, current conditions for ozone, sulfur dioxide, fine particulate matter ($PM_{2.5}$) and weather have been added and can be observed.

4.2 Regional Haze Visibility Impairment Monitoring Strategy and Other Implementation Plan Requirements

Section 51.308(d)(4) requires that the State must submit with the implementation plan a monitoring strategy for measuring, characterizing, and reporting of regional haze visibility impairment that is representative of all mandatory Class I Federal areas within the State. This monitoring strategy must be coordinated with the monitoring strategy required in section 51.305 for reasonably attributable visibility impairment. Compliance with this requirement may be met through participation in the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. The IMPROVE monitoring program is discussed in section 4.3.

The state of North Dakota will depend on the Interagency Monitoring of PROtected Visual Environments (IMPROVE) monitoring program to collect and report aerosol monitoring data for long-term reasonable progress tracking as specified in the Regional Haze Rule (RHR). Because the RHR is a long-term tracking program with an implementation period nominally set for 60 years, the state expects that the IMPROVE program will provide data based on the following goals:

1. Maintain a stable configuration of the individual monitors and sampling sites, and stability in network operations for the purpose of continuity in tracking reasonable progress trends;
2. Assure sufficient data capture at each site of all visibility-impairing species;
3. Comply with EPA quality control and assurance requirements; and
4. Prepare and disseminate periodic reports on IMPROVE program operations.

The state of North Dakota is relying on the IMPROVE program to meet these monitoring operation and data collection goals, with the fundamental assumption that network data collection operations will not change, or if changed, will remain directly comparable to those operated by the IMPROVE program during the 2000-2004 RHR baseline period. Technical analyses and reasonable progress goals in this implementation plan for Regional Haze are based on data from these sites. As such, the State asks that the IMPROVE program identify potential issues affecting RHR implementation trends and/or notify the State before changes in the IMPROVE program affecting a RHR tracking site are made.

Further, the state of North Dakota notes that the human resources to operate these monitors are provided by Federal Land Management agencies. Beyond that in-kind contribution, resources for operation and sample analysis of a complete and representative monitoring network of these long-term reasonable progress tracking sites by the IMPROVE program are a collaborative responsibility of the EPA, states, tribes, and FLMs and the IMPROVE program steering committee. The state of North Dakota will collaborate with the EPA, FLMs, other states, tribes,

and the IMPROVE committee to assure adequate and representative data collection and reporting by the IMPROVE program. North Dakota will consult with the FLMs if IMPROVE monitoring budget changes will threaten Class I area monitoring within North Dakota, or in Class I areas affected by emissions from North Dakota.

Section 51.308(d)(4)(i) requires that the implementation plan must also provide for the following:

> (i) The establishment of any additional monitoring sites or equipment needed to assess whether reasonable progress goals to address regional haze for all mandatory Class I Federal areas within the State are being achieved.

The state of North Dakota depends on the following IMPROVE program-operated monitors listed in Table 4.1 for tracking RHR reasonable progress.

Table 4.1
IMPROVE Monitoring Sites in North Dakota

IMPROVE Monitoring Site	Class I Area	Sponsor	Start Date	Elevation MSL
LOST1	Lostwood National Wilderness Area	US Fish and Wildlife Service	12/1999	696 m 2283 ft
THRO1	Theodore Roosevelt National Park-South Unit, North Unit, Elkhorn Ranch Unit	National Park Service	12/1999	862 m 2828 ft

Note that the THRO1 IMPROVE monitor is located at the Painted Canyon Overlook in the South Unit of Theodore Roosevelt National Park. The THRO1 IMPROVE monitor also serves and is representative of haze conditions in the separate North Unit and the separate Elkhorn Ranch Unit of the Park.

The state of North Dakota will also operate additional non-IMPROVE monitors that may be used in the future evaluations of Class I area visibility. These may include $PM_{2.5}$ speciation or Federal Reference Methods, monitoring systems for SO_2, NO_x, ozone, continuous $PM_{2.5}$, continuous PM_{10}, and meteorological monitors for wind speed, wind direction, ambient temperature, ambient pressure, relative humidity, solar radiation, and precipitation. Monitors presently operating are listed in Table 4.2.

It should be noted that the two IMPROVE monitors located at the Theodore Roosevelt National Park South Unit and the Lostwood National Wilderness Area have complete data for the period 2000 through 2004 and are relied upon in this Regional Haze SIP to establish the baseline deciview conditions.

Table 4.2
Additional non-IMPROVE Monitors

Monitoring Site	Parameter	Sampling &Analysis Method	Operating Schedule
Lostwood National Wildlife Refuge AQS#: 38-013-0004 Co-located with the LOST1 IMPROVE site.	Sulfur Dioxide	Instrumental Pulsed Florescent	Continuous
	Nitrogen Dioxide	Instrumental Chemiluminescence	Continuous
	Ozone	Instrumental Ultra Violet	Continuous
	$PM_{2.5}$	$PM_{2.5}$ SCC W/No Correction TEOM Gravimetric 40^0 Celsius	Continuous
	PM_{10}	PM_{10} TEOM Gravimetric 50^0 Celsius	Continuous
	Wind Speed	Elec. or Mach Avg. Level 1	Continuous
	Wind Direction	Elec. or Mach Avg. Level 1	Continuous
	Ambient Temperature	Elec. or Mach Avg.	Continuous
	Delta Temperature	Elec. or Mach Avg.	Continuous
	Ambient Pressure	Barometric Pressure Transducer	Continuous
	Solar Radiation	Pyranometer	Continuous
	Relative Humidity	Hydgroscopic Plastic Film	Continuous
Theodore Roosevelt National Park North Unit AQS# 38-053-0002	Sulfur Dioxide	Instrumental Pulsed Florescent	Continuous
	Nitrogen Dioxide	Instrumental Chemiluminescence	Continuous
	Ozone	Instrumental Ultra Violet	Continuous
	$PM_{2.5}$	$PM_{2.5}$ SCC W/No Correction TEOM Gravimetric 40^0 Celsius	Continuous
	PM_{10}	PM_{10} TEOM Gravimetric 50^0 Celsius	Continuous
	Wind Speed	Elec. or Mach Avg. Level 1	Continuous
	Wind Direction	Elec. or Mach Avg. Level 1	Continuous
	Ambient Temperature	Elec. or Mach Avg.	Continuous
	Ambient Pressure	Barometric Pressure Transducer	Continuous
	Relative Humidity	Hydroscopic Plastic Film	Continuous
Theodore Roosevelt National Park South Unit Co-located with the THRO1 IMPROVE Site.	Sulfur Dioxide	Instrumental Pulsed Florescent	Continuous
	Ozone	Instrumental Ultra Violet	Continuous
	$PM_{2.5}$	$PM_{2.5}$ SCC W/ No Correction TEOM Gravimetric 50^0 Celsius	Continuous
	Wind Speed	Elec. or Mach Avg. Level 1	Continuous
	Wind Direction	Elec. or Mach Avg. Level 1	Continuous
	Ambient Temperature	Elec. or Mach Avg.	Continuous
	Relative Humidity	Hydroscopic Plastic Film	Continuous
	Solar Radiation	Pyranometer	Continuous
	Precipitation	Recording Weighting	Continuous

In addition, the National Park Service monitors dry deposition at the Theodore Roosevelt National Park South Unit monitoring site. The dry deposition is analyzed for SO_4, NO_3, HNO_3, NH_4, and SO_2 weekly.

Section 51.308(d)(4)(ii) requires that the implementation plan must also provide for the following:

> (ii) Procedures by which monitoring data and other information are used in determining the contribution of emissions from within the State to regional haze visibility impairment at mandatory Class I Federal areas both within and outside the State.

The state of North Dakota will use data reported by the IMPROVE program as part of the regional technical support analysis tools found at the Visibility Information Exchange Web System (VIEWS), as well as other analysis tools that are available from EPA, FLMs and other states and tribes. The state of North Dakota will participate in any ongoing regional analysis activities to collectively assess and verify the progress toward reasonable progress goals, also supporting interstate consultation as the RHR is implemented, and collaborate with EPA, states, tribes, and FLMs to ensure the continued operation of existing technical support analysis tools and systems developed by WRAP. If the WRAP systems disappear, North Dakota will develop or contract for other technical support analysis tools and systems as necessary.

The state of North Dakota may conduct additional analyses as needed.

Section 51.308(d)(4)(iv) requires that the implementation plan must also provide for the following:

> (iv) The implementation plan must provide for the reporting of all visibility monitoring data to the Administrator at least annually for each mandatory Class I Federal area in the State. To the extent possible, the State should report visibility monitoring data electronically.

The state of North Dakota will depend on the routine timely reporting of haze monitoring data by the IMPROVE program for the reasonable progress tracking sites to the EPA air quality data system and VIEWS. The state of North Dakota will collaborate with EPA, states, tribes, and FLMs to ensure the continued operation of existing WRAP technical support analysis tools and systems.

The additional non-IMPROVE monitoring is conducted and the data collected and reported in accordance with EPA guidance. It is reported through electronic data transfer techniques quarterly.

Section 51.308(d)(4)(v) requires that the implementation plan must also provide for the following:

(v) A statewide inventory of emissions of pollutants that are reasonably anticipated to cause or contribute to visibility impairment in any mandatory Class I Federal area. The inventory must include emissions for a baseline year, emissions for the most recent year for which data are available, and estimates of future projected emissions. The State must also include a commitment to update the inventory periodically.

The state of North Dakota has prepared a statewide inventory of emissions that can reasonably be expected to cause or contribute to visibility impairment in Federal Class I Areas. Section 6 of this plan summarizes the emissions by pollutant and source category.

The state of North Dakota commits to updating statewide emissions inventories periodically and submitting data to the EPA NEI system. The updates will be used for state tracking of emission changes, trends, and evaluation of whether reasonable progress goals are being achieved and other regional analyses. The inventories will be updated every one to three years on the same schedule as the every three-year reporting required by EPA's Consolidated Emissions Reporting Rule and the Air Emissions Reporting Requirements Rule. The Air Emissions Reporting Requirements Rule will completely replace the Consolidated Emissions Reporting Rule after the 2008 emission inventory data submittal which is due to June 1, 2010.

As a member of the WRAP, North Dakota will continue to use the WRAP-sponsored Emissions Data Management System (EDMS) and Fire Emissions Tracking System (FETS) to store and access emission inventory data for the region as long as they are maintained and available. If they are not available, North Dakota stores its data in house. North Dakota will continue to conduct its own modeling to simulate the air quality impacts of emissions for haze and other related air quality planning purposes. The state of North Dakota will collaborate with EPA, states, tribes and FLMs to ensure the continued operation of existing WRAP technical support analysis tools and systems.

Section 51.308(d)(4)(vi) requires that the implementation plan must also provide for the following:

(vi) Other elements, including reporting, recordkeeping, and other measures, necessary to assess and report on visibility.

The state of North Dakota will track data related to RHR haze plan implementation for sources for which the state has regulatory authority, and will depend on the IMPROVE program for monitoring data. To ensure the availability of data and analyses to report on visibility conditions and progress toward Class I area visibility goals, the state of North Dakota will collaborate with EPA, states, tribes and FLMs to ensure the continued operation of the IMPROVE program and the existing WRAP-sponsored technical support analysis tools and systems for emissions inventory data.

4.3 Overview of the IMPROVE Monitoring Network

In the mid-1980's, the Interagency Monitoring of PROtected Visual Environments (IMPROVE) program was established to measure visibility impairment in mandatory Class I Federal areas throughout the United States. The monitoring sites are operated and maintained through a formal cooperative relationship between the EPA, National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management, NOAA and U.S. Forest Service. In 1991, several additional organizations joined the effort: National Association of Clean Air Agencies, Western States Air Resources Council (WESTAR), Mid-Atlantic Regional Air Management Association (MARAMA) and Northeast States for Coordinated Air Use Management (NESCAUM).

The objectives of the IMPROVE program include establishing the current visibility and aerosol conditions in mandatory Class I Federal areas; identifying the chemical species and emission sources responsible for existing human-made visibility impairment; documenting long-term trends for assessing progress towards the national visibility goals; and supporting the requirements of the Regional Haze Rule by providing regional haze monitoring representing all visibility-protected Federal Class I areas where practical. Figure 4.1 shows the IMPROVE site at Lostwood National Wilderness Area, and Figure 4.2 shows the four separate modules used for sampling the different pollutant species.

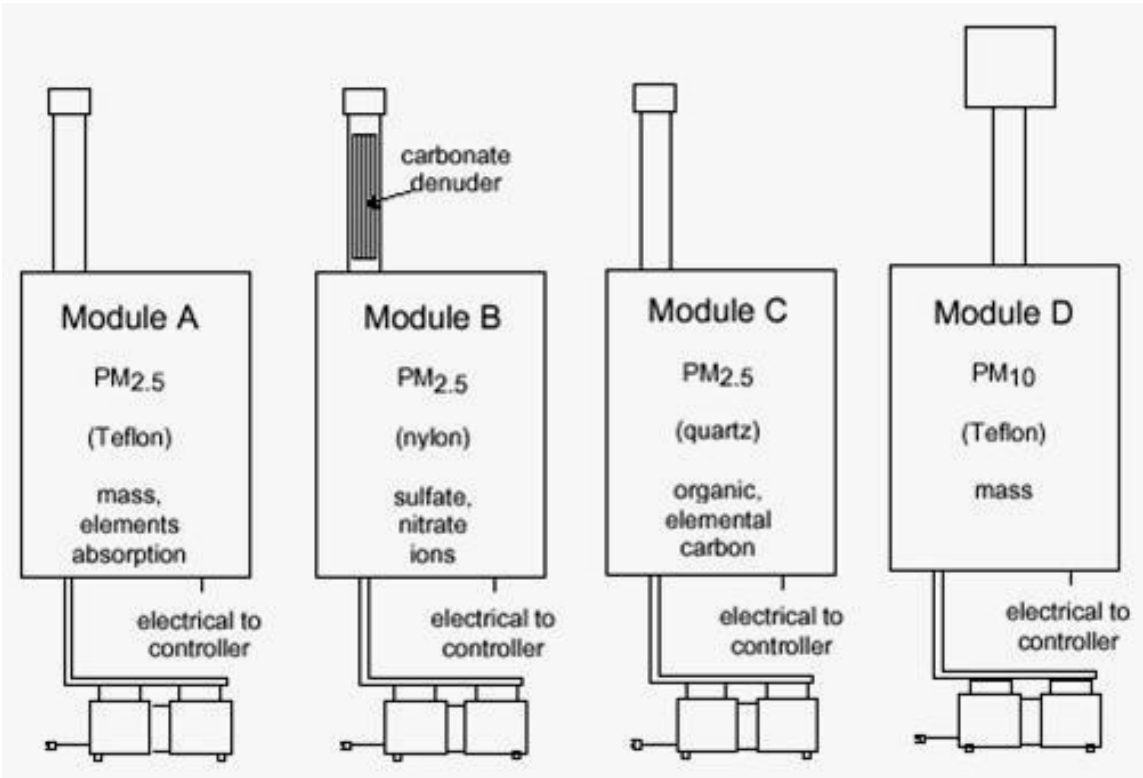
Figure 4.1
Pictures of the IMPROVE Monitoring Site at
Lostwood National Wilderness Area

Exterior

Interior

The IMPROVE sampler consists of four separate modules for measuring regional haze

Figure 4.2
IMPROVE Sampler Module



The data collected at the IMPROVE monitoring sites are used by land managers, industry planners, scientists, public interest groups and air quality regulators to better understand and protect the visual air quality resource in Class I areas. Most importantly, the IMPROVE Program scientifically documents the visual air quality of the wilderness areas and national parks.

The IMPROVE program has developed methods for estimating light extinction from speciated aerosol and relative humidity data. The three most common metrics used to describe visibility impairment are:

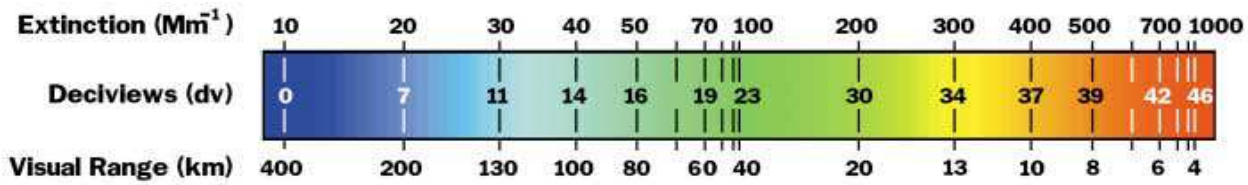
Extinction (b_{ext}) – Extinction is a measure of the fraction of light lost per unit length along a sight path due to scattering and absorption by gases and particles, expressed in inverse Megameters (Mm^{-1}). This metric is useful for representing the contribution of each aerosol species to visibility impairment and can be practically thought of as the units of light lost in a million meter distance.

Visual Range (VR) – Visual range is the greatest distance a large black object can be seen on the horizon, expressed in kilometers (km) or miles (mi).

Deciview (dv) – This is the metric used for tracking regional haze in the RHR. The deciview index was designed to be linear with respect to human perception of visibility. A one deciview change is approximately equivalent to a 10% change in extinction, whether visibility is good or poor. A one deciview change in visibility is generally considered to be the minimum change the average person can detect with the naked eye. See Section 5.1 for additional information.

For reference, Figure 4.3 compares b_{ext} in Mm^{-1}, deciviews (dv) which are unitless, and visual range in kilometers (km).

Figure 4.3
Comparison of Extinction (Mm^{-1}), Deciview (dv), and Visual Range (km)



The IMPROVE network estimates light extinction based upon the measured mass of various contributing aerosol species. EPA's 2003 guidance for calculating light extinction is based on the original protocol defined by the IMPROVE program in 1988. For further information, see: http://vista.cira.colostate.edu/improve/Publications/GuidanceDocs/guidancedocs.htm.

In December 2005, the IMPROVE Steering Committee voted to adopt a revised algorithm for use by IMPROVE as an alternative to the original approach.

The choice between use of the default or the revised equation for calculating the visibility metrics for each Class I area is made by the state in which the Class I area is located. North Dakota has chosen to use the revised equation. The revised algorithm for estimating light extinction is calculated as recommended for use by the IMPROVE steering committee using the following equations:

$b_{ext} \approx 2.2\times f_s(RH)\times$[Small Amm. Sulfate] + $4.8\times f_L(RH)\times$[Large Amm. Sulfate]
+$2.4\times f_s(RH)\times$ [Small Amm. Nitrate] + $5.1\times f_L(RH)\times$ [Large Amm. Nitrate]
+2.8× [Small Particulate Organic Matter] + 6.1× [Large Particulate Organic Matter]
+10× [Elemental Carbon]
+1× [Fine Soil]
+$1.7\times f_{ss}(RH)\times$ [Sea Salt]
+0.6× [Coarse Mass]
+0.33× [NO_2 (ppb)]
+Rayleigh Scattering (Site Specific)

Where:
b_{ext} = light extinction in units of inverse megameters (Mm^{-1}),
$f_S(RH)$ = function of relative humidity for small size fraction,
$f_L(RH)$ = function of relative humidity for large size fraction,
$f_{SS}(RH)$ = function of relative humidity for sea salt, and
all species concentrations are provided in $\mu g/m^3$.

The revised algorithm splits ammonium sulfate ($(NH_4)_2SO_4$), ammonium nitrate (NH_4NO_3) and total particulate organic matter (POM =1.8 × organic carbon) concentrations into small and large size fractions. The equations for ammonium sulfate are:

[Large $(NH_4)_2SO_4$] = [Total $(NH_4)_2SO_4$]^2 ÷ 20, for [Total $(NH_4)_2SO_4$] < 20 $\mu g/m^3$
[Large $(NH_4)_2SO_4$] = [Total $(NH_4)_2SO_4$], for [Total $(NH_4)_2SO_4$] ≥ 20$\mu g/m^3$

[Small $(NH_4)_2SO_4$] = [Total $(NH_4)_2SO_4$] – [Large $(NH_4)_2SO_4$]

Similar equations are used to apportion total ammonium nitrate and total particulate organic matter concentrations into small and large size fractions.

Light extinction is converted to deciview using the following relationship:

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

Where:
dv = deciview,
b_{ext} = light extinction in units of inverse megameters (Mm^{-1}).

5. Baseline and Natural Visibility Conditions and Uniform Rate of Progress for North Dakota Class I Areas

5.1 The Deciview

The Clean Air Act (Section 169A(a)(1)) states "Congress hereby declares as a national goal the prevention of any future, and remedying of any existing impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution." In order to achieve this goal, all man-made pollution must be eliminated such that natural conditions (visibility) are restored. Natural conditions include naturally occurring phenomena that reduce visibility as measured in terms of light extinction, visual range, contrast, or coloration (40 CFR 51.301). The State is required to develop a SIP that contains measures that make reasonable progress toward the national goal of no man-made visibility impairment.

The primary metric for assessing baseline conditions, natural conditions and the rate of progress is the deciview. A deciview is a haze index derived from calculated light extinction, such that uniform changes in haziness correspond to uniform incremental changes in perception across the entire range of conditions, from pristine to highly impaired. The deciview index is calculated based on the following equation:

Deciview haze index = $10 \ln (b_{ext}/10\ Mm^{-1})$

Where: b_{ext} = the atmospheric light extinction coefficient expressed in inverse megameters (Mm^{-1})

The deciview scale is zero for pristine conditions and increases as visibility degrades. Each one deciview change represents a perceptible or small just-noticeable change in visual air quality or haziness to the average person under most circumstances when viewing scenes in Class I areas regardless of background visibility conditions. This is approximately a 10% change in the light extinction (Mm^{-1}) reading.

In order to determine the rate of progress of visibility improvement, the baseline conditions and natural conditions must be determined for each Class I area. The baseline visibility conditions are calculated from IMPROVE data for the years 2000-2004. Natural visibility conditions are determined by estimating the natural concentrations of visibility impairing pollutants that existed prior to man's influence. These concentrations are then used to calculate light extinction and the deciview metric.

5.2 Baseline Visibility Conditions

The Class I Federal Areas in North Dakota are the North Unit, South Unit and Elkhorn Ranch Unit of Theodore Roosevelt National Park and the Lostwood Wilderness Area. Although IMPROVE monitoring data is not available for the North Unit and Elkhorn Ranch Units of

TRNP, the Department considers monitoring data from the South Unit to be representative of conditions of the other two units. Since the monitoring is representative we only refer to the TRNP although there are three distinct separate areas.

Baseline visibility is the average of the IMPROVE monitoring data for 2000 through 2004. Baseline visibility is calculated for both the 20 percent best and 20 percent worst days. The monitoring data from the IMPROVE sites as plotted by WRAP and displayed on their TSS website are shown in Figures 5.1 - 5.4.

Figure 5.1

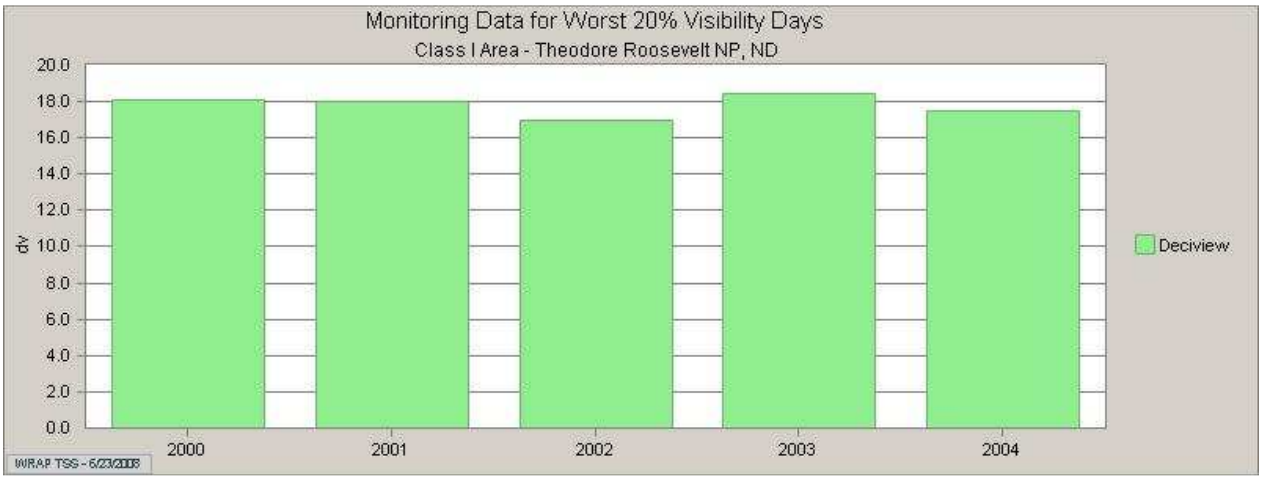


Figure 5.2

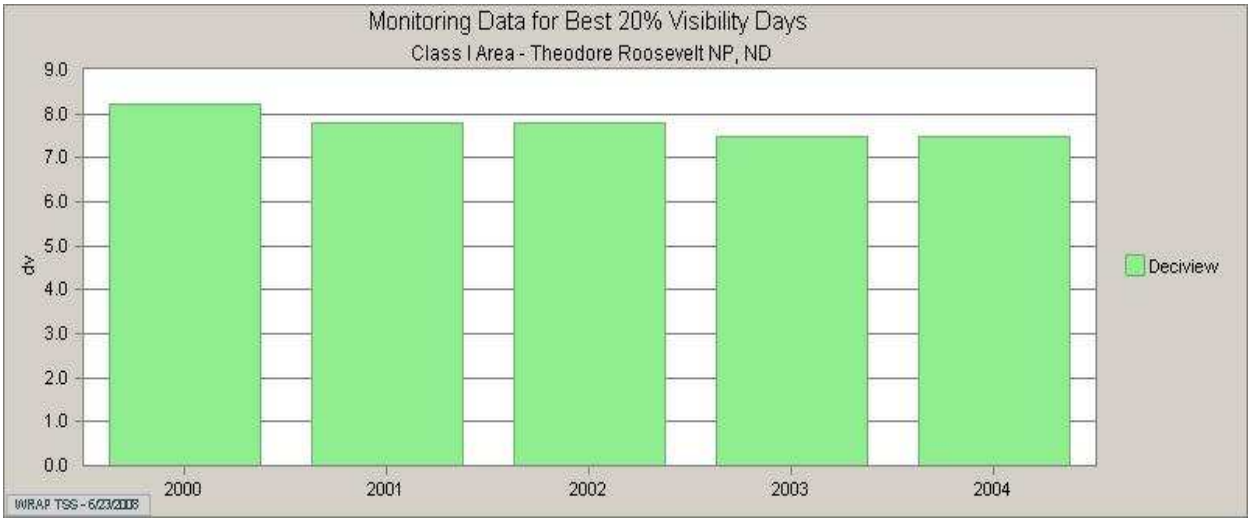


Figure 5.3

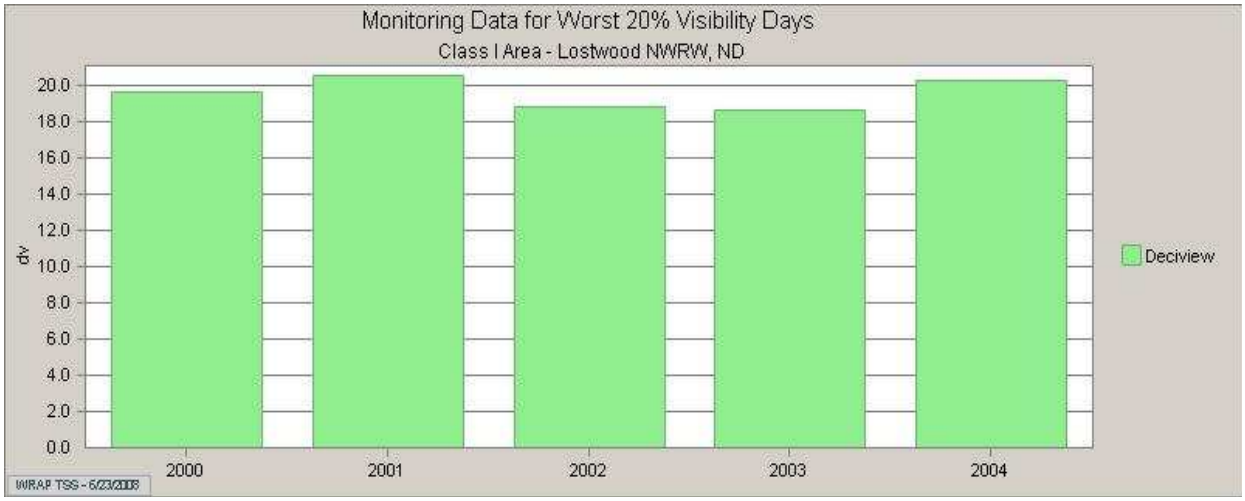
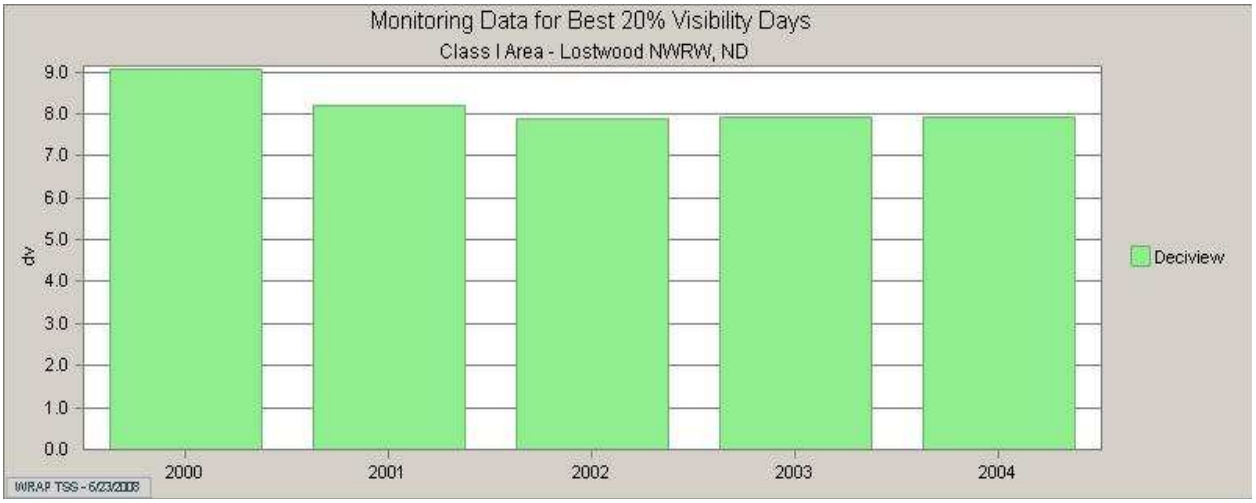


Figure 5.4



Based on the IMPROVE data, the baseline visibility conditions in the North Dakota Class I areas are shown in Table 5.1.

Table 5.1
Baseline Visibility (Deciviews)

Year	TRNP		LWA	
	20% Best Days	**20% Worst Days**	**20% Best Days**	**20% Worst Days**
2000	8.2	18.1	9.1	19.7
2001	7.8	18.0	8.2	20.6
2002	7.8	17.0	7.9	18.8
2003	7.5	18.4	7.9	18.6
2004	7.5	17.5	7.9	20.2
Baseline (avg.)	7.8	17.8	8.2	19.6

Note: Figures 5.1-5.4 and Table 5.1 are based on the revised IMPROVE Algorithm. The source of the figures and data is the WRAP TSS website.

5.3 Natural Visibility Conditions

EPA has prepared "Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Program" (EPA-454/B-03-005, Sept. 2003) to aid states in estimating natural visibility conditions. Natural visibility conditions represent the long-term degree of visibility that is estimated to exist in a given Class I area in the absence of man-made impairment. Natural visibility conditions are not constant, but vary with changing natural processes such as fire, windblown dust, volcanic activity and biogenic emissions. EPA has developed a default approach which will satisfy the requirements for the initial SIP which addresses regional haze. The default approach defines two separate regions of the United States (1) The East, which consists of all states east of the Mississippi River, and up to one tier of states west of the Mississippi; and (2) the West, including the regions of the Mountain and Pacific time zones. States that are near the boundary between East and West are free to choose which set of natural visibility values are more appropriate and adopt those values. North Dakota is considered to be in the West Region; however, it is one of those states that are on the boundary of East and West. Appendix B of EPA guidance document provides the default natural extinction values (deciviews) for both the best and worst days. The values for the North Dakota Class I areas are shown in Table 5.2.

Table 5.2
EPA Default Natural Visibility Conditions (Deciviews)

Area	Best Days	Worst Days
TRNP	2.19	7.31
LWA	2.21	7.33

These natural visibility condition values were calculated based on an IMPROVE algorithm which has since been modified. The new IMPROVE equation accounts for the effect of particle size distribution on light extinction efficiency of sulfate, nitrate and organic carbon. The mass multiplier for organic carbon is increased from 1.4 to 1.8. New terms were added to the equation to account for light extinction by sea salt and light absorption by gaseous nitrogen dioxide. Site specific values are used for Rayleigh scattering to account for variations in elevation and temperature. Separate relative humidity enhancement factors are used for small and large size distributions of ammonium sulfate, ammonium nitrate and sea salt.

The WRAP calculated the natural background visibility conditions consistent with EPA's guidance using the revised IMPROVE equation. The results of that calculation are shown in Table 5.3.

Table 5.3
WRAP Calculated Natural Visibility Conditions (Deciviews)

Area	Best Days	Worst Days
TRNP	3.0	7.8
LWA	2.9	8.0

The values in Table 5.3 have been established as the natural background values for North Dakota and are used to establish the uniform rate of progress. The improvement necessary to achieve natural conditions is shown in Table 5.4.

Table 5.4
Improvement Necessary To Achieve Natural Conditions
(Deciviews)

Area	Baseline Best Days	Natural Best Days	Improvement Required	Baseline Worst Days	Natural Worst Days	Improvement Required
TRNP	7.8	3.0	4.8	17.8	7.8	10.0
LWA	8.2	2.9	5.3	19.6	8.0	11.6

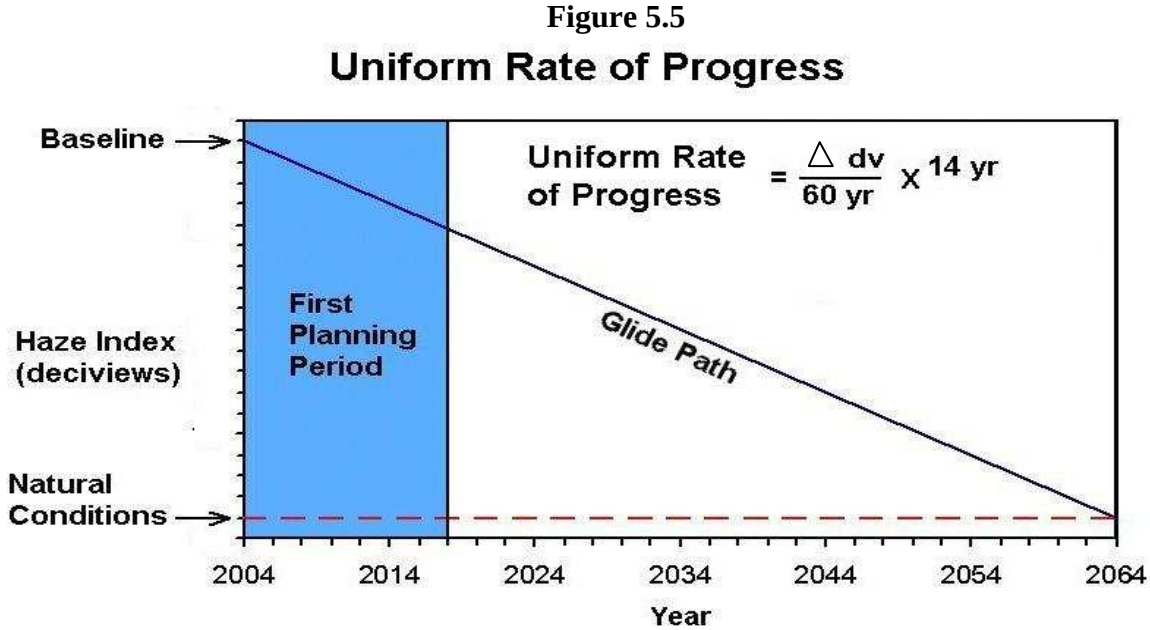
5.4 Uniform Rate of Progress

The uniform rate of progress to achieve natural conditions in any Class I Federal area is calculated as the difference between baseline condition for the 20% worst days and natural condition for the 20% worst days divided by 60 years (2004-2064). Mathematically it is determined by the following equation:

URP = [Baseline Condition - Natural Condition]) 60 yrs dv/yr

By multiplying the uniform rate of progress by 14 years in the first planning period (10 years thereafter), the progress needed by 2018 to be on the path to achieving natural conditions can be calculated as shown in Figure 5.5.

Figure 5.5



Δ dv = Baseline conditions minus natural conditions

Based on the above data, the uniform rate of progress is calculated as follows:

Theodore Roosevelt National Park

URP = (17.8 – 7.8)(14/60) dv
URP = 2.3 dv

Lostwood Wilderness Area

URP = (19.6 – 8.0)(14/60) dv
URP = 2.7 dv

The uniform rate of progress for the Theodore Roosevelt National Park and Lostwood Wilderness Area for the first planning period is shown graphically in Figures 5.5 and 5.6. For the best days, the State must ensure that no degradation occurs over the same planning period.

Figure 5.6

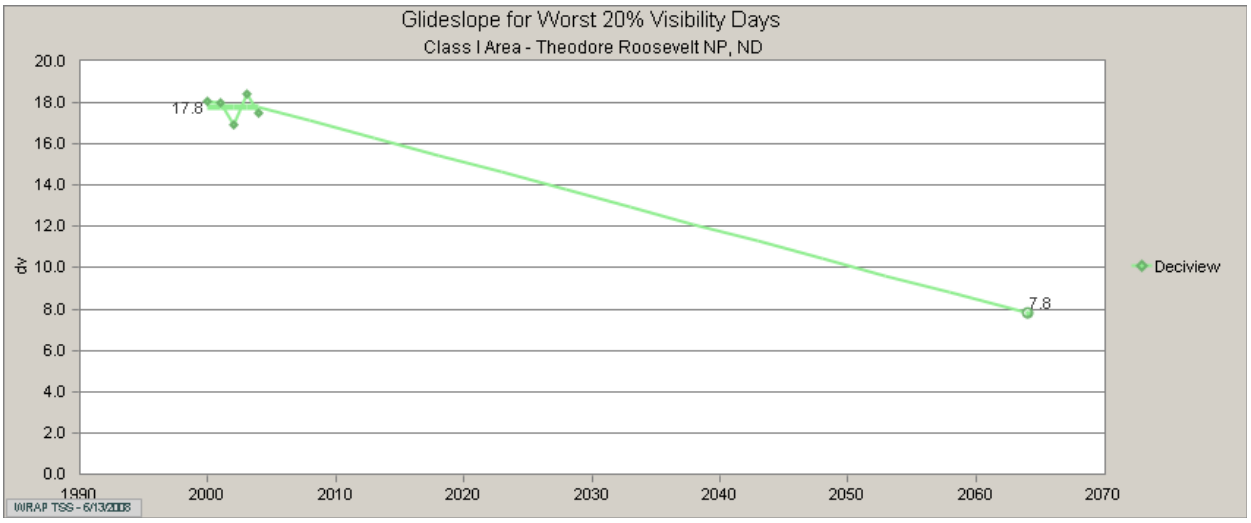
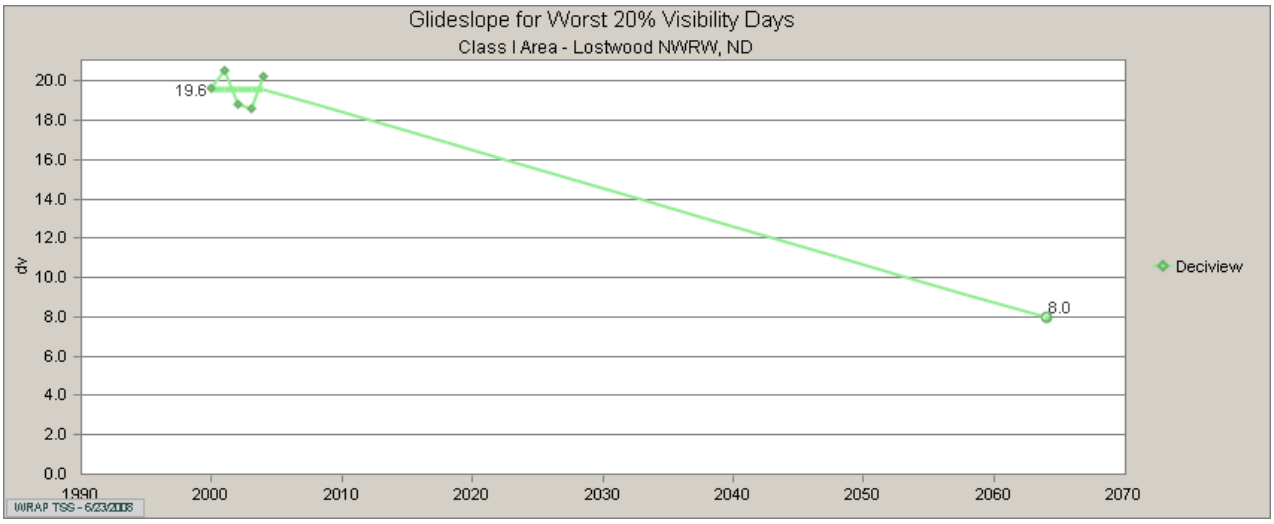


Figure 5.7


Glideslope for Worst 20% Visibility Days
Class I Area - Lostwood NWRW, ND
dv
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
19.6
8.0
1990
2000
2010
2020
2030
2040
2050
2060
2070
Deciview
WRAP TSS - 6/23/2008

6. Sources of Visibility Impairment in North Dakota Class I Areas

6.1 Introduction

40 CFR 51.308(d)(4)(v) requires a statewide inventory of emissions of pollutants that are reasonably anticipated to cause or contribute to visibility impairment in any mandatory Class I Federal Area be included in the SIP. Emissions within North Dakota are both naturally occurring and man-made. Naturally occurring emissions include wildfires, windblown dust and others. In North Dakota, the primary sources of anthropogenic emissions include electric utility steam generating units (EGUs), energy production and processing sources, agricultural production and processing sources, prescribed burning and fugitive dust sources. The North Dakota inventory includes emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), fine particulate matter (PMF), coarse particulate matter (PMC), organic carbon (OC), volatile organic compounds (VOC), elemental carbon (EC) and ammonia (NH_3).

6.2 Emissions in North Dakota

The most recent complete inventory of all emission categories is from 2002. The point source data was compiled by the State while the rest of the inventory was prepared by the WRAP and its contractors with input from the state (Case Plan 02d – see Section 9 for a discussion of this case plan). A summary of the inventory is shown in Table 6.1. The WRAP Oil and Gas inventory for sulfur dioxide was adjusted to include sulfur dioxide emissions from flaring and lease use of sour gas at well sites (WRAP did not include flaring and lease use emissions). The adjustment was based on hydrogen sulfide data for the combusted gas, which is compiled by the Health Department, and the amount of gas flared or used onsite which is compiled by the North Dakota Oil and Gas Division.

Table 6.1
North Dakota 2002 Emissions Inventory (tons)

	Point	All Fire	Biogenic	Area	Area O&G	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	Wind Blown Dust	Total
SO_2	157,069	540	0	5,557	4,958	812	7,246	3	26	0	176,211
NO_x	87,438	1,774	44,569	10,833	4,631	24,746	55,502	3	40	0	229,536
OC	262	3,657	0	1,466	0	231	1,034	201	1,989	0	8,840
EC	29	510	0	262	0	272	3,625	15	135	0	4,847
PMF	2,002	821	0	1,617	0	0	0	3,086	36,354	17,639	61,519
PMC	565	503	0	199	0	141	0	28,711	172,066	158,752	360,936
NH_3	518	812	0	118,398	0	732	33	0	0	0	120,493
VOC	2,086	3,849	233,561	60,455	7,740	12,814	13,515	0	0	0	334,020
CO	11,944	60,735	67,769	21,933	36	211,842	95,869	0	0	0	470,129
Total	261,912	73,200	345,898	220,719	17,365	251,590	176,825	32,020	210,610	176,391	1,766,529

A complete emissions inventory is not available for a more recent year. However, more recent data for point source emissions are available for 2007. Those data are shown in Table 6.2.

Table 6.2
North Dakota Point Source Emissions Inventory 2007

	SO_2	NO_x	OC	EC	PMF	PMC	NH_3	VOC	CO
Point Sources	147,998	82,185	526	31	655	2,749	6,446	4,579	15,897

WRAP has developed a future inventory for North Dakota for the year 2018. The PRP18b emissions inventory for North Dakota is shown in Table 6.3. Again, sulfur dioxide emissions for the Area Oil and Gas inventory were increased by the Department to include emissions from flaring and lease use of sour gas. The PRP18b emissions inventory also included the proposed Gascoyne 500 coal-fired power plant. The Permit to Construct application for this facility has been withdrawn. The sulfur dioxide and nitrogen oxides emissions for this plant were removed from the inventory by the Department. The Department does not expect any additional coal-fired power plants to be constructed in North Dakota before 2018.

The Department does not agree with WRAP's estimate of nitrogen oxides emissions from the Area Oil and Gas industry for 2018. WRAP has predicted that 2018 NO_x emissions would be 4.5 times greater than 2002 emissions. The Department discussed this estimate with the Oil and Gas Division of the North Dakota Industrial Commission. It was the opinion of the Oil and Gas Division that most of the Bakken formation development will be over by 2018 and drilling rig activities are expected to settle back to the same ratio as production (i.e., 2-2.5 times the 2002 levels). Based on discussions with the Oil and Gas Division, it is believed that an increase of 2 – 2.5 times the 2002 emission rate is appropriate for 2018. In subsequent discussions with WRAP, representatives of WRAP admitted that 2018 estimates of NO_x emissions related to oil and gas activity in North Dakota may have been overstated. The inventory in Table 6.3 represents a 2.5 times increase for Area Oil and Gas sources.

The Department also disagrees with WRAP's estimate of PMF and PMC emissions for 2018. As explained in Section 9.5.2, agricultural conservation tillage practices, which reduce emissions, are expected to increase by 2018. Since agricultural activities and farm land are the major sources of fugitive and windblown PMF and PMC emissions, it is expected these emissions will decrease. Even though a decrease is expected, the emissions of PMF and PMC shown in Table 6.3 were not adjusted by the Department.

In future Regional Haze SIP reviews, the Department will use the most current, refined emissions inventories available.

Table 6.3
North Dakota 2018 Emission Inventory (tons)

	Point	All Fire	Biogenic	Area	Area O&G	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	Wind Blown Dust	Total
SO_2	59,560	337	0	5,995	4,200	81	276	3	30	0	70,482
NO_x	62,383	1,073	44,569	12,456	11,577	4,906	34,557	3	41	0	171,566
OC	248	2,647	0	1,387	0	151	457	193	2,041	0	7,126
EC	32	449	0	267	0	48	1,363	14	139	0	2,312
PMF	2,086	404	0	1,647	0	0	0	2,956	37,999	17,639	62,731
PMC	2,349	460	0	216	0	111	0	27,478	184,063	158,752	373,429
NH_3	462	379	0	118,493	0	739	47		0	0	120,120
VOC	2,418	2,346	233,561	69,597	17,968	3,487	8,357	0	0	0	337,735
CO	17,477	41,604	67,769	21,474	172	90,152	102,471	0	0	0	341,118
Total	147,015	49,699	345,898	231,532	33,917	99,675	147,528	30,648	224,314	176,391	1,486,618

The change in emissions during the planning period (2002-2018) is shown in Table 6.4.

Table 6.4
North Dakota Emission Inventory Planning Period Change

	2002 (TPY)	**2018 (TPY)**	**Change (TPY)**	**Change (%)**
SO_2	176,211	70,482	-105,729	-60.0
NO_x	229,536	171,566	-57,970	-25.3
OC	8,840	7,126	-1,714	-19.4
EC	4,847	2,312	-2,535	-52.3
PMF	61,519	62,731	1,212	2.0
PMC	360,936	373,429	12,493	3.5
NH_3	120,493	120,120	-373	-0.3
VOC	334,020	337,735	3,715	1.1
CO	470,129	341,118	-129,011	-27.4

6.3 Emissions from Other States and Canadian Provinces

The visibility in the Class I areas in North Dakota is influenced by emissions from surrounding states, Canada and sources outside WRAP's modeling domain. The three contiguous states to North Dakota are Montana, South Dakota and Minnesota. The 2002 emissions from the respective states are shown in Table 6.5.

Table 6.5
Nearby States 2002 Emissions (tons)

	Montana[a]	South Dakota[a]	Minnesota[b]	North[a] Dakota
SO_2	51,923	22,725	160,000	176,211
NO_x	243,142	146,822	485,000	229,536
OC	48,088	9,166		8,840
EC	11,873	4,703		4,847
PMF	77,239	82,414	169,000	61,519
PMC	621,276	615,354	610,000	360,936
NH_3	66,229	120,406	179,000	120,493
VOC	1,181,318	518,981	366,000	334,020
CO	1,639,949	509,702		470,129

[a]Source - WRAP TSS (Case Plan 02d)
[b]Source - Minnesota Draft Haze SIP

North Dakota's contribution to visibility impairment in TRNP and LWA is generally small (see Table 6.6). Sulfates and nitrates, as discussed further in Section 8, are the primary pollutants of concern in these Class I areas. In-state sources contribute 21 percent or less of sulfate or nitrate during the 20 percent worst baseline days at TRNP or LWA. It should be noted in Table 6.6 the sulfate and nitrate values are based on WRAP regional modeling using the CAM_x – PSAT source apportionment total, while the analyses of weighted emissions potential for organic carbon (OC), elemental carbon (EC), and particulate matter (PM) are based on emissions and residence time, not modeling.

Table 6.6
ND Sources Extinction Contribution
2000-2004
20% Worst Days

Class I Area	Pollutant Species	Extinction (Mm^{-1})	Species Contribution To Total Extinction (%)	ND Sources Contribution To Species Extinction (%) [a]
TRNP	Sulfate	17.53	35	21
	Nitrate	13.74	27	19
	OC	10.82	21	12
	EC	2.75	5	29
	PMF	0.9	2	44
	PMC	4.82	10	45
	Sea Salt	0.07	0	0
LWA	Sulfate	21.4	34	18
	Nitrate	22.94	36	13
	OC	11.05	18	23
	EC	2.84	5	35
	PMF	0.62	1	28
	PMC	3.93	6	32
	Sea Salt	0.26	0	0

[a] North Dakota contribution for sulfate and nitrate based on WRAP's tracer analysis and OC, EC, PMF, PMC and Sea Salt contribution based on WRAP's weighted emissions potential analysis.

In general, sources within Canada and sources outside WRAP's modeling domain are bigger contributors to regional haze in TRNP and LWA than North Dakota sources.

The influence of sources outside of North Dakota on TRNP and LWA for the 2000-2004 period can be seen in Figures 6.1-6.16 and Table 6.7. These figures and data were obtained from the WRAP TSS website. Figures 6.3, 6.4, 6.9 and 6.10 are based on WRAP's tracer analysis study which is considered a more rigorous analysis than the weighted emissions potential analysis (Figures 6.5 – 6.8 and 6.11 – 6.16). The Department does not agree with the WRAP's estimate of nitrogen oxides emissions from the oil and gas source category for 2018 (see Section 6.2). The Department believes WRAP has overestimated the 2018 nitrogen oxides emissions. Therefore, Figures 6.4 and 6.12 overestimate the percentage of oil and gas nitrogen oxides contribution for 2018.

Figure 6.1

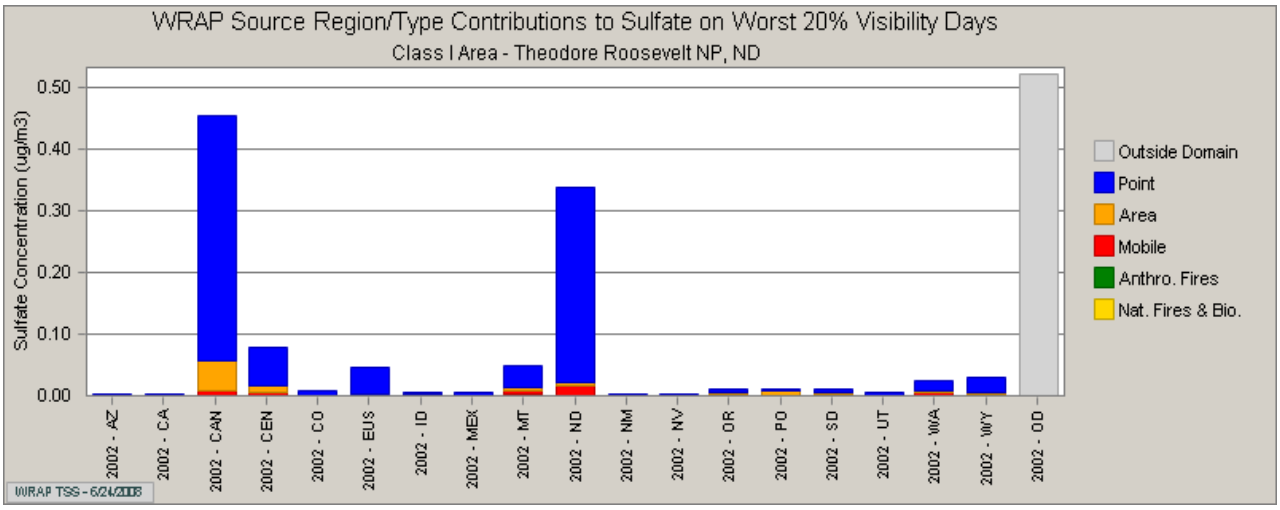


Figure 6.2

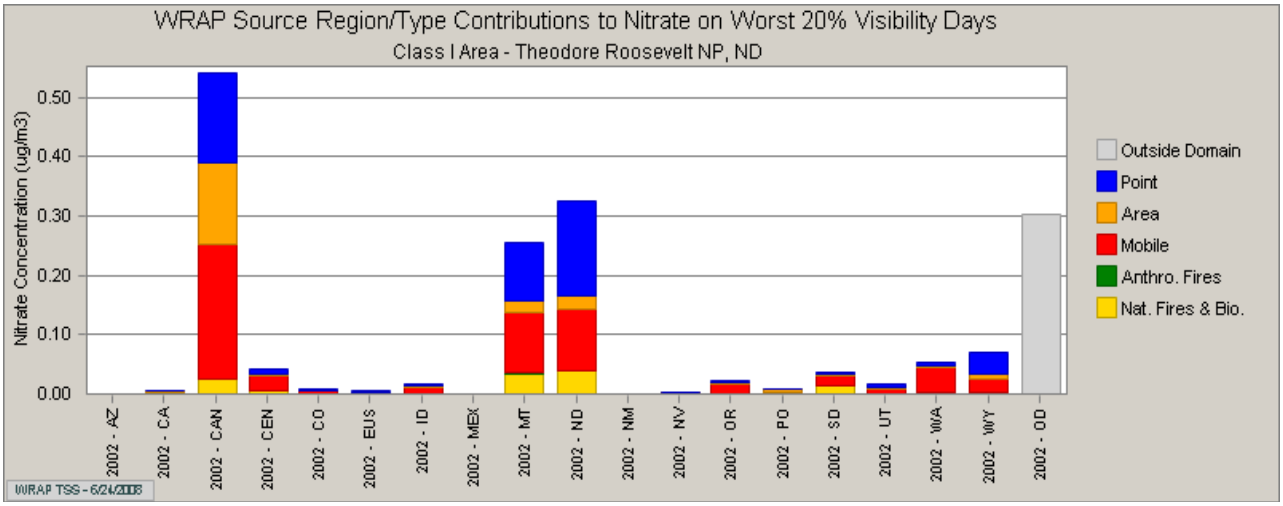


Figure 6.3

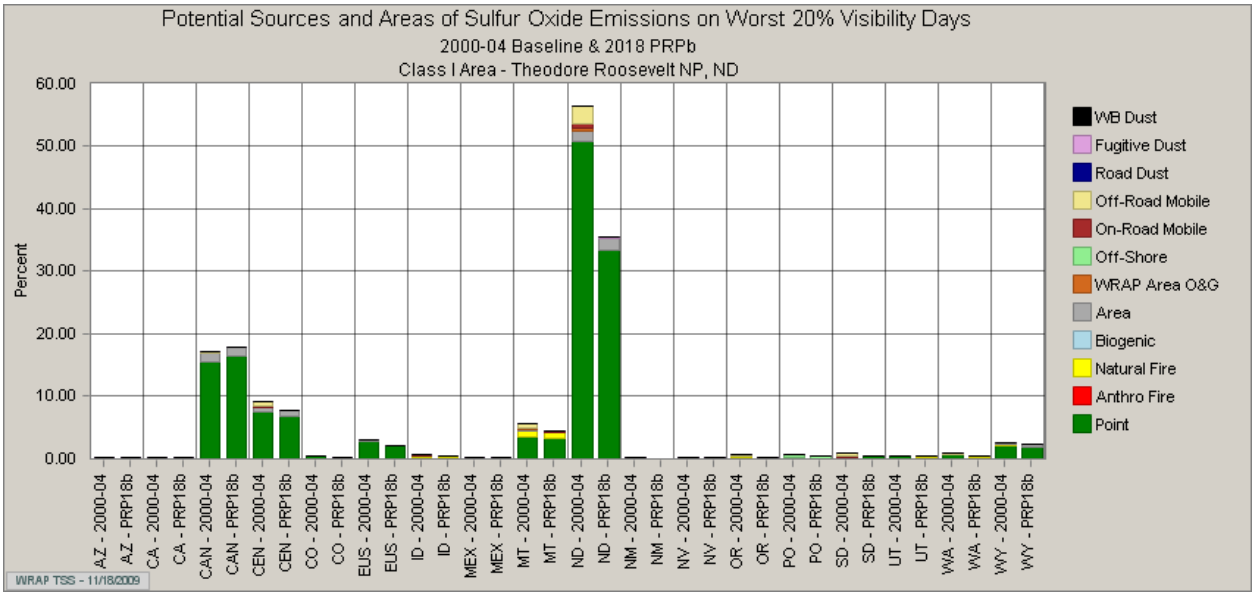


Figure 6.4

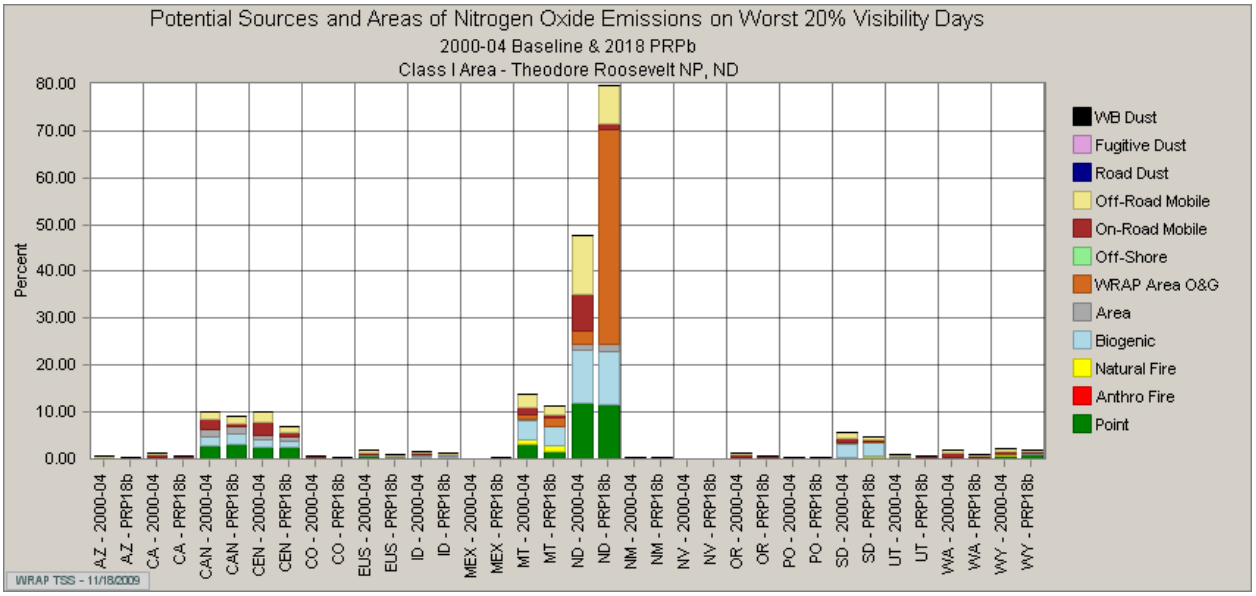


Figure 6.5

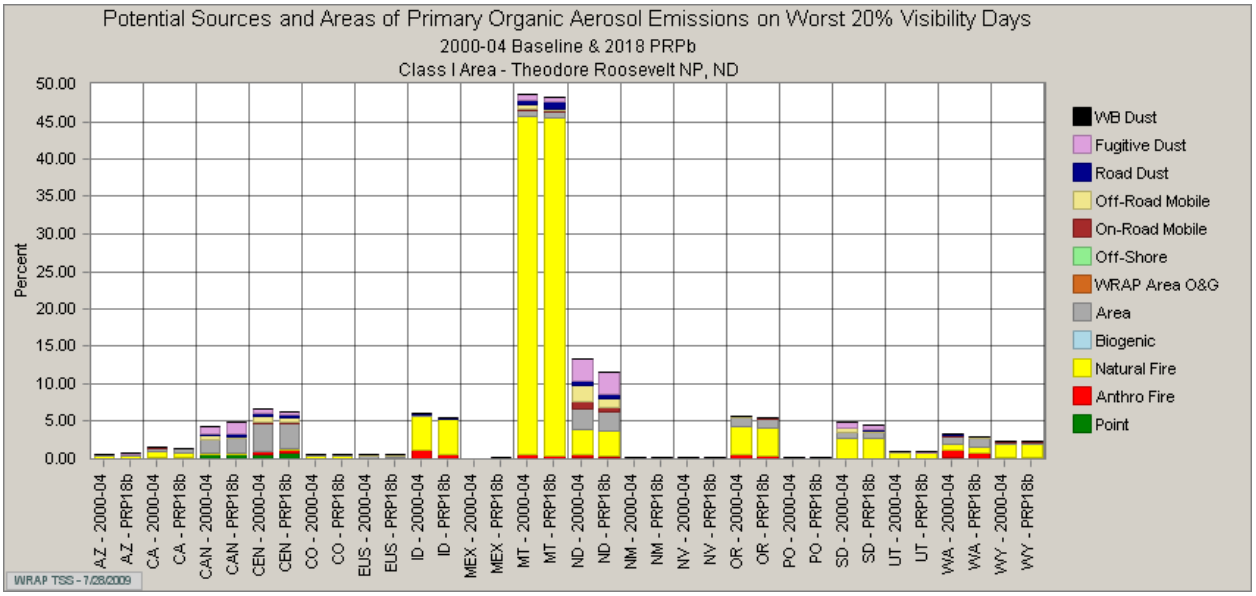


Figure 6.6

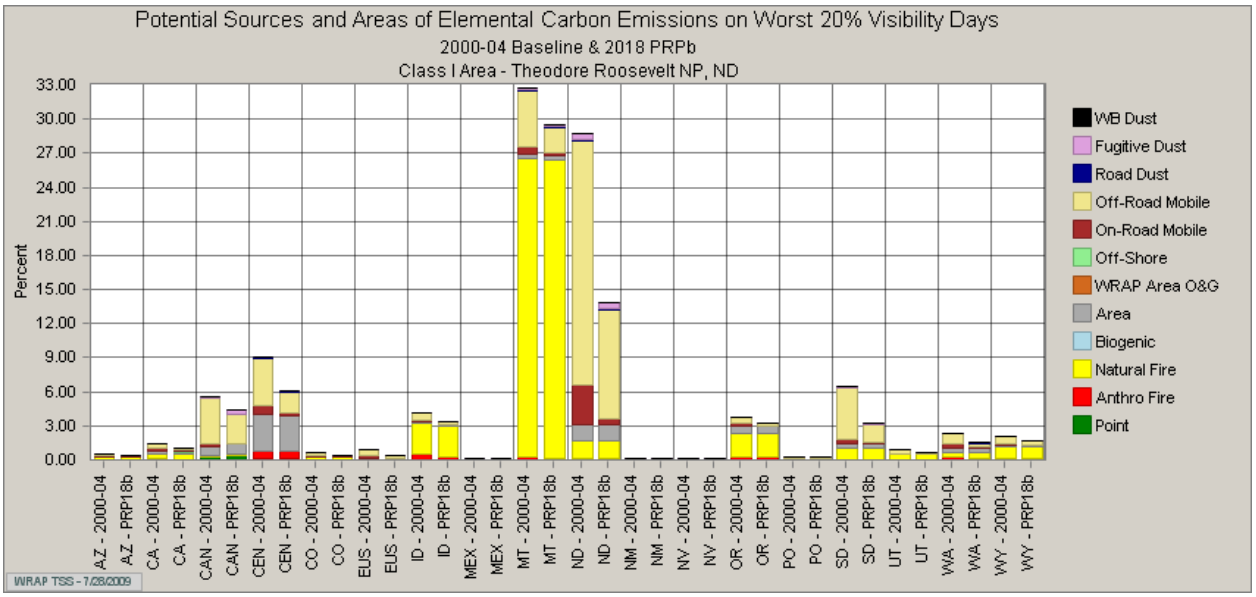


Figure 6.7

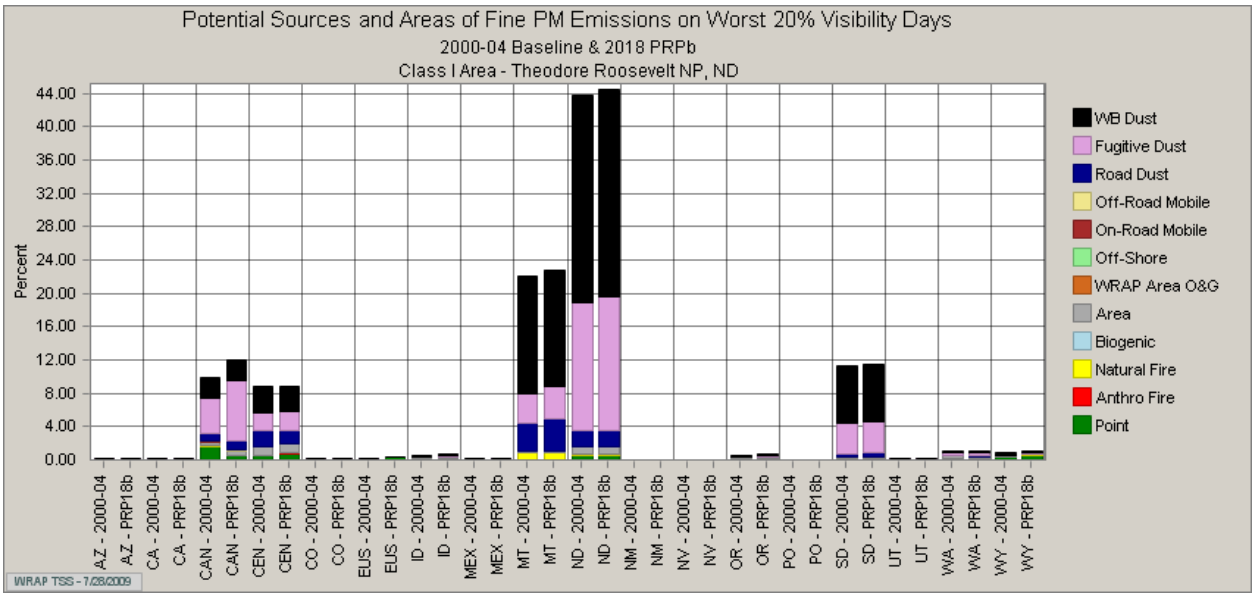


Figure 6.8

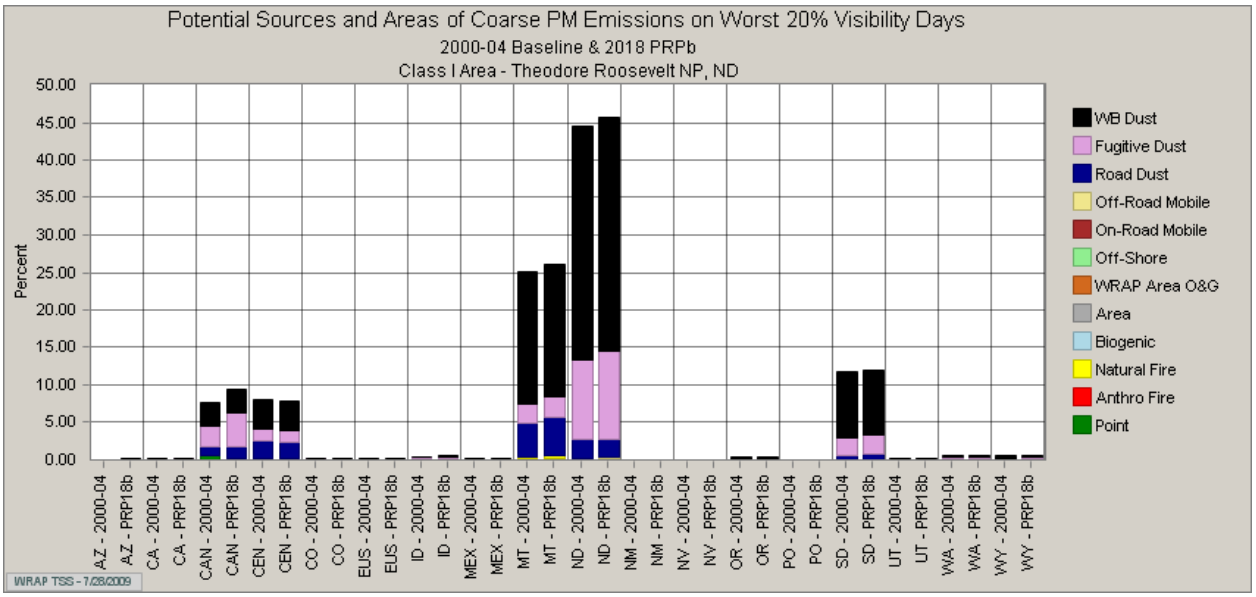
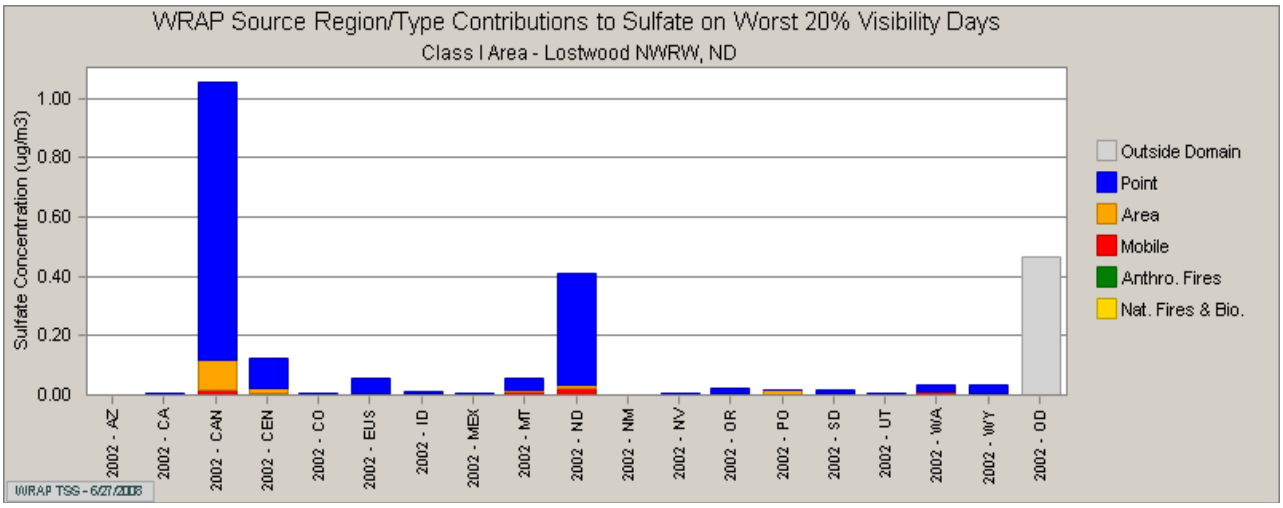


Figure 6.9



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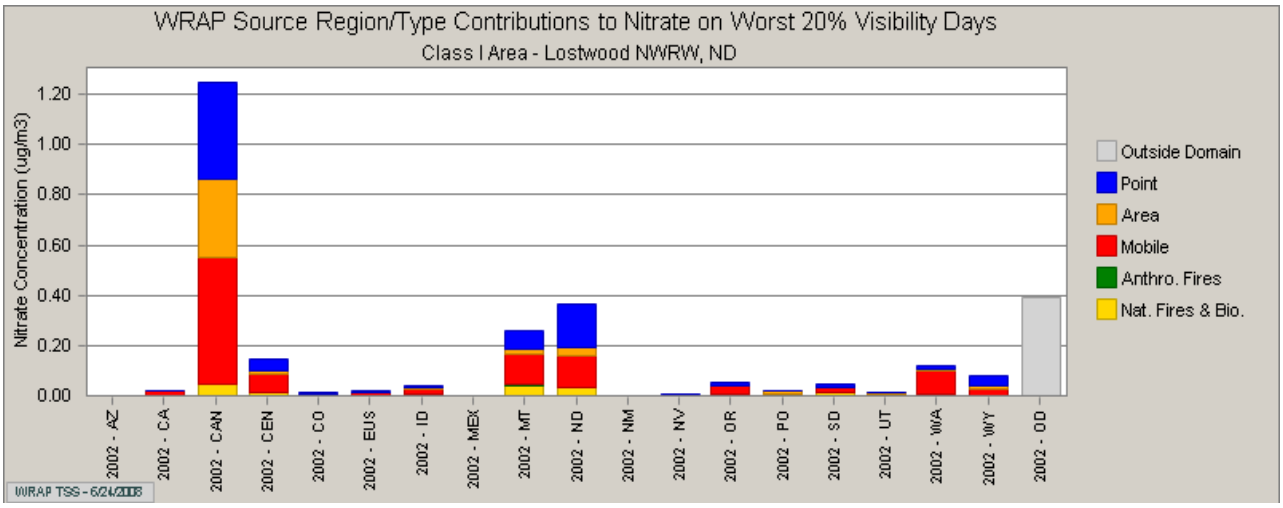


Figure 6.11

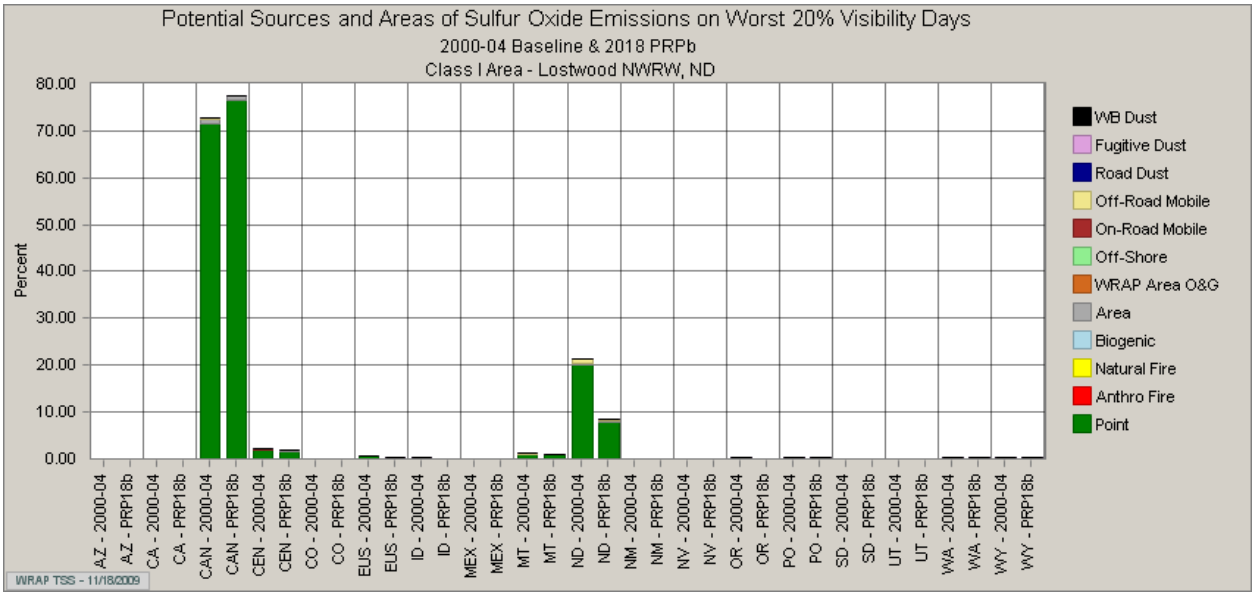


Figure 6.12

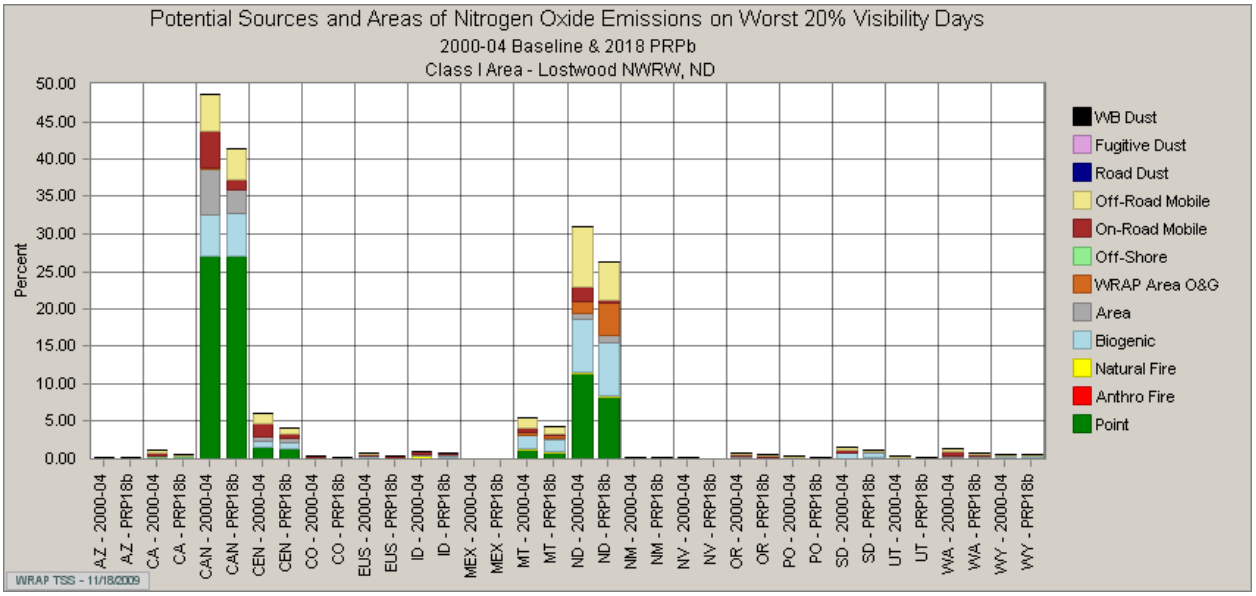


Figure 6.13

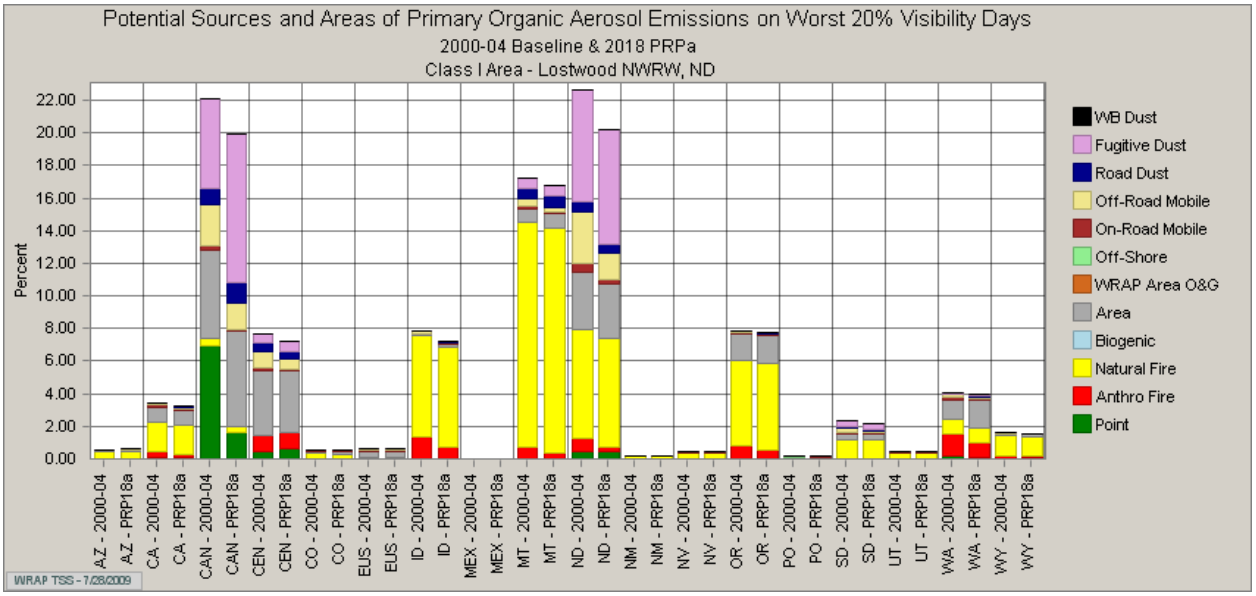


Figure 6.14

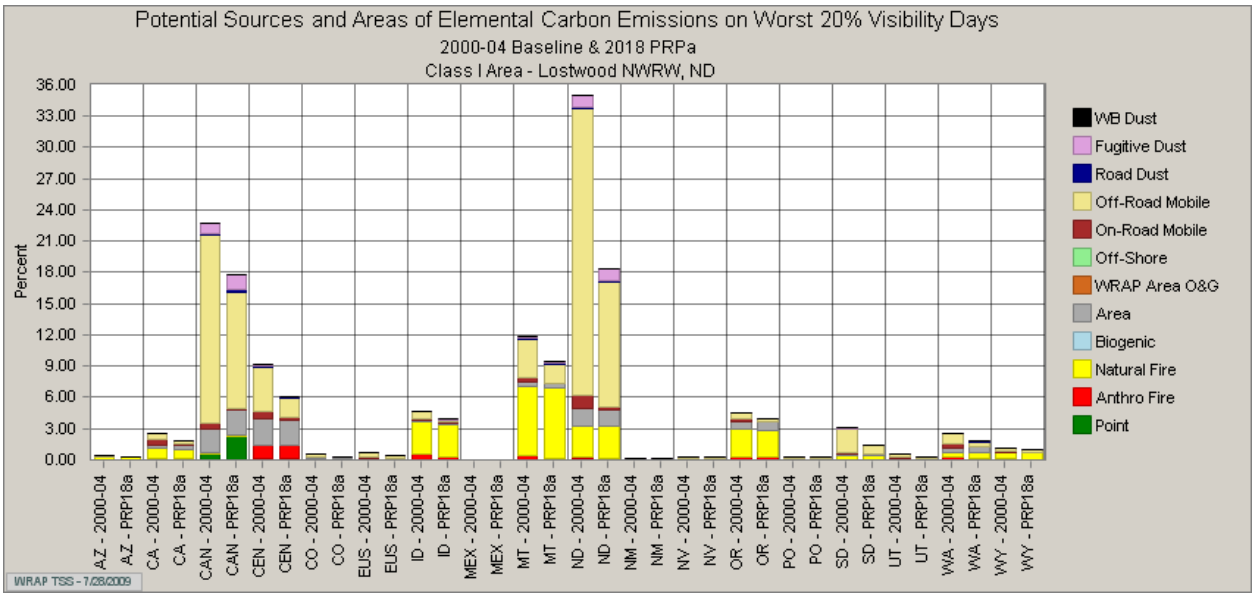


Figure 6.15

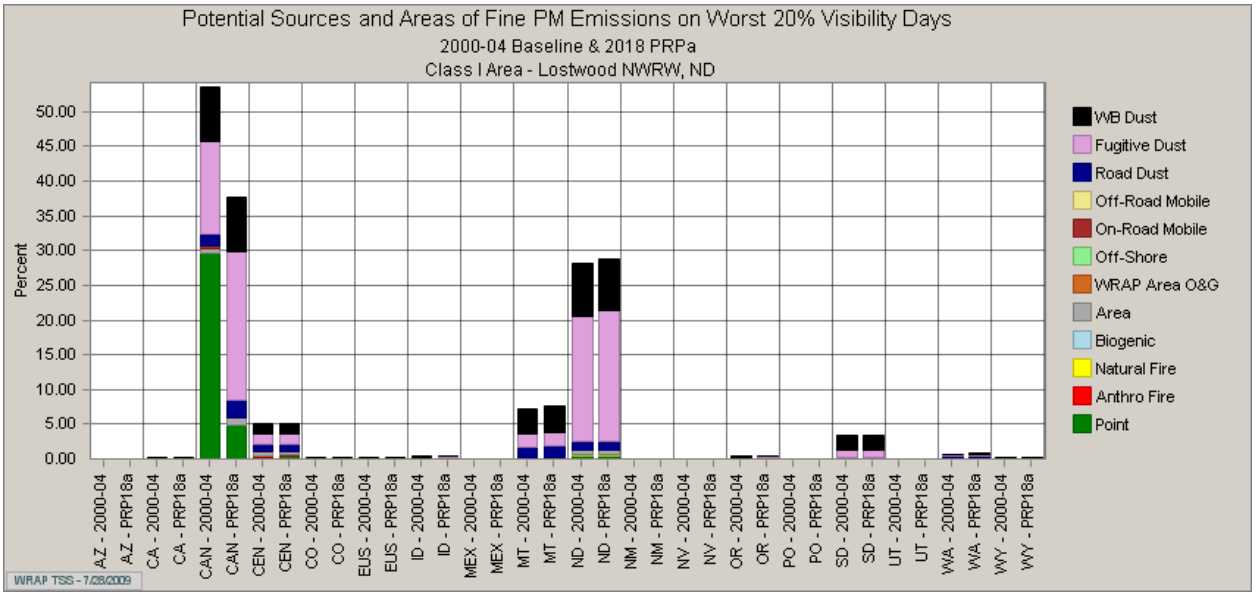


Figure 6.16

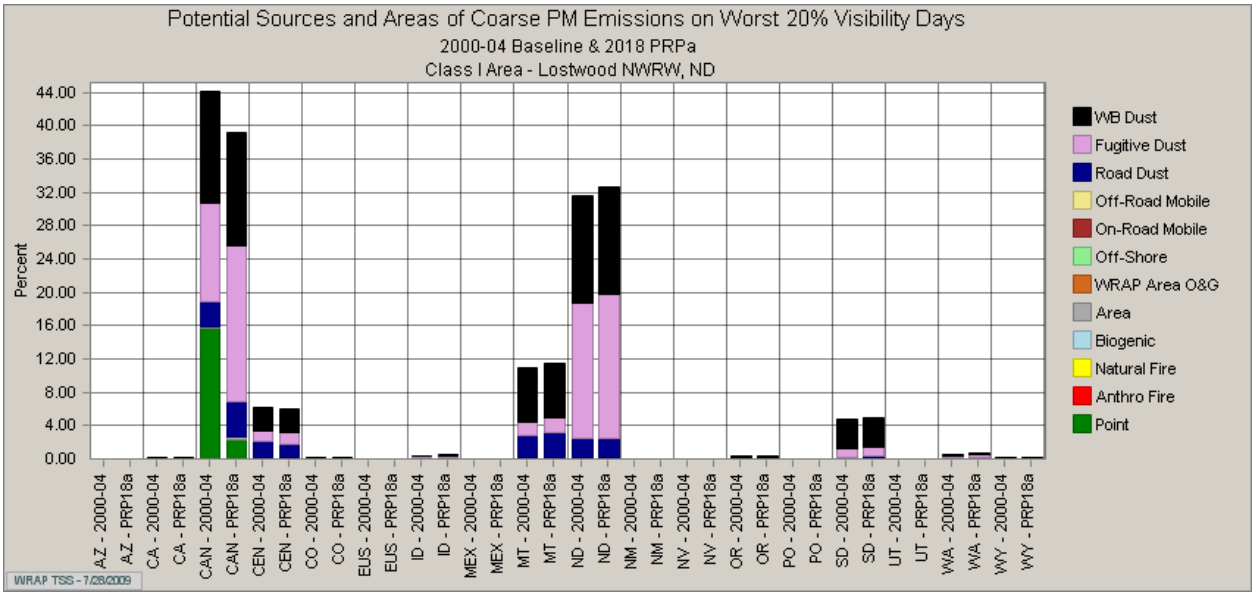


Table 6.7
Source Region Apportionment 20% Worst Days

Contributing Area	Class I Area			
	TRNP		LWA	
	SO_4	NO_3	SO_4	NO_3
North Dakota	21.1%	19.1%	17.9%	13.0%
Canada	28.3%	31.8%	45.9%	44.6%
Outside Domain	32.6%	17.9%	20.2%	14.0%
Montana	3.1%	15.0%	2.4%	9.3%
CENRAP	4.9%	2.5%	5.3%	5.1%
Other	10.5%	13.7%	8.3%	14.0%

The primary Canadian provinces which influence visibility in the Class I areas of North Dakota are Saskatchewan, Alberta, Manitoba and British Columbia. Emissions from these provinces in 2002, as reported in WRAP's TSS website, totaled more than one million tons of sulfur dioxide, 1.4 million tons of nitrogen oxides and 2 million tons of particulate matter as shown in Table 6.8.

Table 6.8
2002 Canadian Emissions (tons)

	SO_2	NO_x	PMC	PMF
Saskatchewan	126,528	292,539	364,739	78,108
Manitoba	398,806	142,685	144,928	25,403
Alberta	433,394	752,966	503,835	807,738
British Columbia	101,990	214,914	64,545	39,695

The location of sulfur dioxide and nitrogen oxides emissions, as reported by Environment Canada, are shown in Figures 6.17 and 6.18. As can be seen, the heaviest concentration of emissions of sulfur dioxide and nitrogen oxides are northwest, in the prevailing wind direction of North Dakota's Class I areas, especially the Lostwood Wilderness Area.

Figure 6.17

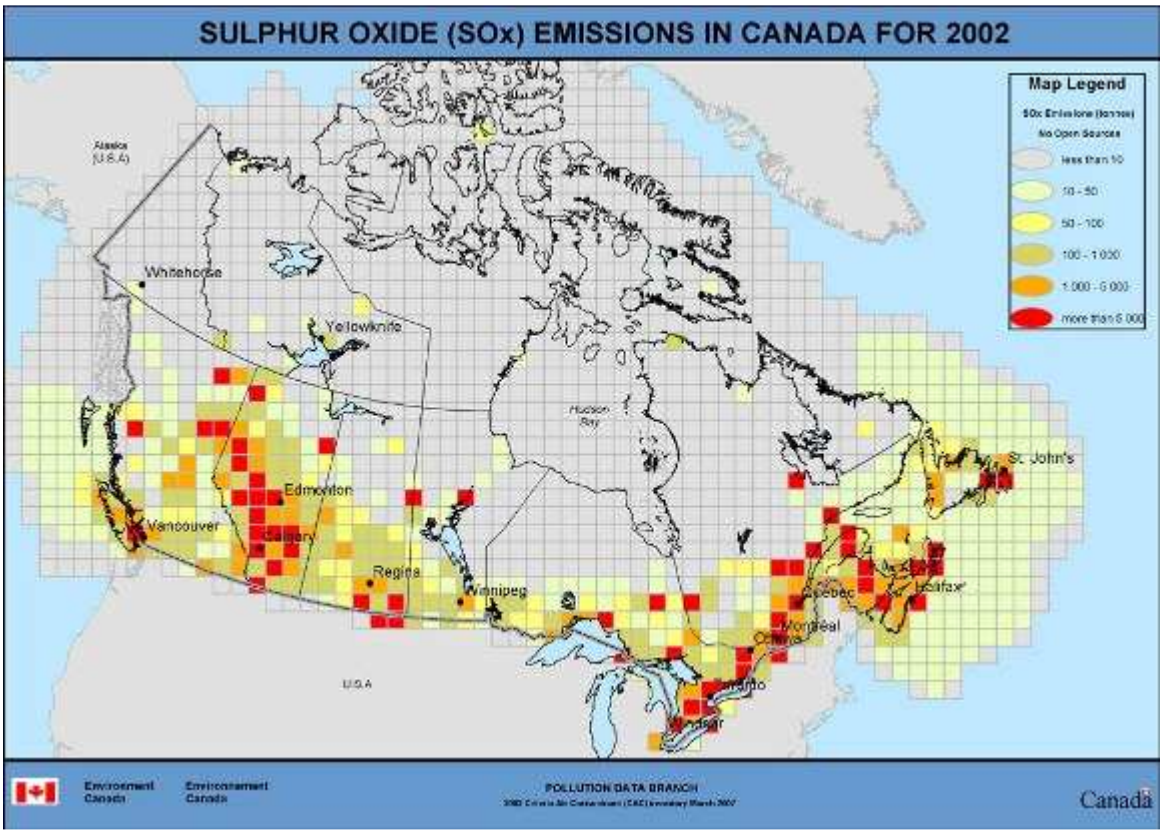
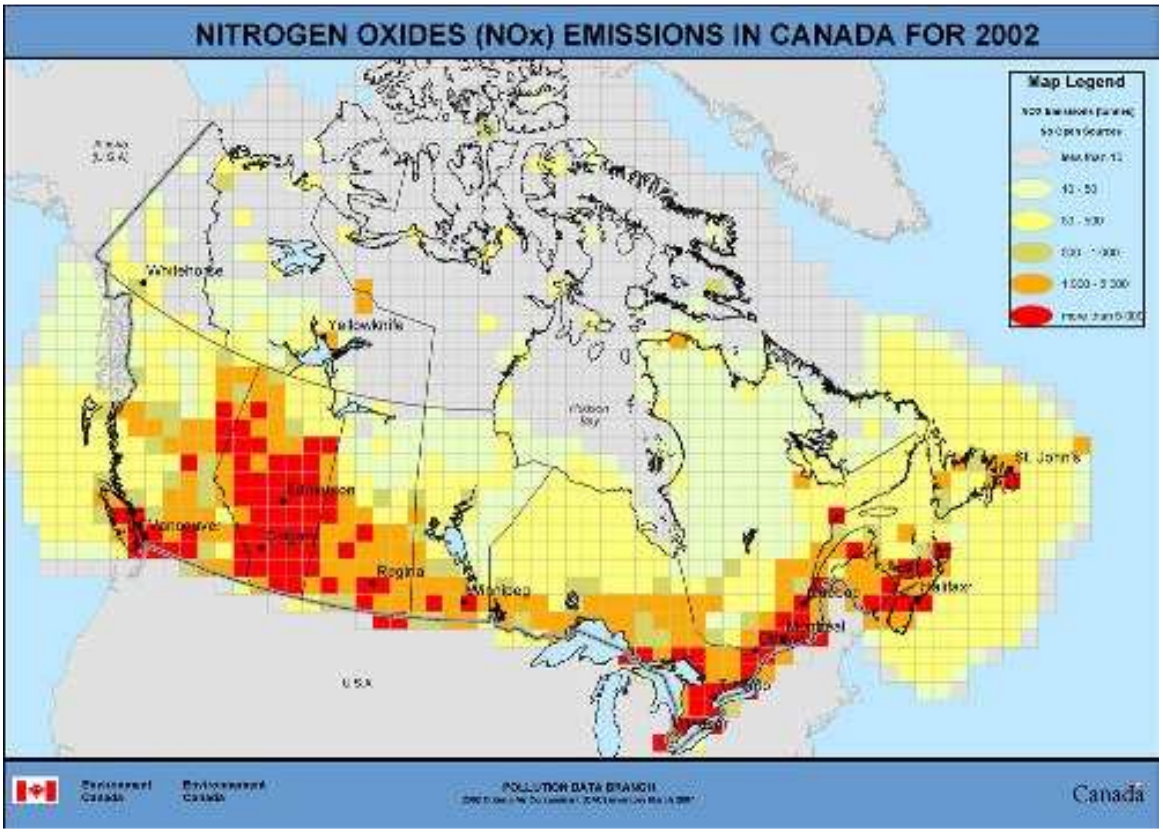

SULPHUR OXIDE (SOx) EMISSIONS IN CANADA FOR 2002
Map Legend
Alaska (U.S.A)
Whitehorse
Yellowknife
Hudson Bay
St. John's
Edmonton
Vancouver
Calgary
Regina
Winnipeg
Quebec
Halifax
Montréal
Ottawa
Toronto
Windsor
U.S.A
Environment Canada
Environment Canada
POLLUTION DATA BRANCH
Canada

Figure 6.18



Three major coal-fired electric utility steam generating plants within Saskatchewan are located just north of the U.S./Canada border within 250 km of the Lostwood Wilderness Area. During 2002, emissions from these plants totaled nearly 110,000 tons of sulfur dioxide and 38,000 tons of nitrogen oxides as shown in Table 6.9. The Boundary Dam plant, which has the largest amount of emissions, is located within 60 kilometers by LWA.

Table 6.9
Saskatchewan Power Plants 2002 Emissions (tons)

Plant	**SO_2**	**NO_x**	**PMC**	**PMF**
Boundary Dam	47,338	18,950	7,444	2.996
Shand	15,146	6,463	40	17
Poplar River	47,107	12,864	337	136

7. Best Available Retrofit Technology (BART)

7.1 Introduction

7.1.1 Overview of Paragraph 51.308(e) of the Federal Regional Haze Regulation - Best Available Retrofit Technology (BART) Requirements for Regional Haze Visibility Impairment

The requirements for Best Available Retrofit Technology (BART) are found in Section 51.308(e) of the federal regional haze regulation.

Paragraph (e) has six subparagraphs which identify the requirements as follows:

1. 51.308(e)(1) - BART for individual sources;
2. 51.308(e)(2) and (3) - An emissions trading program, or other alternative measure, rather than to require sources subject to BART to install, operate, and maintain BART;
3. 51.308(e)(4) - Participation in the EPA administered Clean Air Interstate Rule (CAIR) trading programs for sulfur dioxide and nitrogen oxides;
4. 51.308(e)(5) - Status of BART-eligible sources after a state has met the requirements for BART; and
5. 51.308(e)(6) - An exemption from BART requirements for BART-eligible sources.

Section 51.308(e) requires the State to submit an implementation plan containing emission limitations representing BART and schedules for compliance with BART for each BART-eligible source that may reasonably be anticipated to cause or contribute to any impairment of visibility in any mandatory Class I Federal area, unless the State demonstrates that an emissions trading program or other alternative measures will achieve greater reasonable progress toward natural visibility conditions, or the State participates in a Clean Air Interstate Rule (CAIR) trading program.

The Department has decided not to develop an emissions trading program or other alternate measures and is not eligible to participate in the CAIR program. Therefore only Sections 308(e)(1), (5), and (6) apply in North Dakota.

Each state implementation plan must contain two elements related to BART.

The first, found in Section 308(e)(1)(i), is the requirement that the State submit a list of the BART-eligible sources in the State.

The second requirement is detailed in Section 308 (e)(1)(ii) and requires the State to determine and include in the plan BART emission reductions for each BART-eligible source in the State which may reasonably be anticipated to cause or contribute to any impairment of visibility in any mandatory Class I area.

BART must be determined for each visibility-impairing pollutant that is emitted by a BART-eligible source which may reasonably be anticipated to cause or contribute to regional haze. The definition for BART 51.301 reads:

> Best Available Retrofit Technology (BART) means an emission limitation based on the degree of reduction achievable through the application of the best system of continuous emission reduction for each pollutant which is emitted by an existing stationary facility. The emission limitation must be established, on a case-by-case basis, taking into consideration the technology available, the costs of compliance, the energy and the non air quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.

Visibility-impairing pollutants include sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM_{10} and $PM_{2.5}$) volatile organic compounds (VOC), and ammonia (NH_3).

In developing source specific emission limits for BART, the State must take into consideration the control technology available and a number of specific factors:

- The costs of compliance;
- The energy and non-air environmental impacts of compliance;
- Any existing pollution control technology in use at the source;
- The remaining useful life of the source; and
- The degree of improvement in visibility which may reasonably be anticipated from the use of such technology.

The State has the discretion as to how much weight will be given to each of the factors.

EPA issued final guidance for the determination of BART on July 6, 2005 as 40 CFR Part 51 Appendix Y - Guidelines for BART Determinations Under the Regional Haze Rule (BART guideline).

The SIP for source-specific BART (51.308(e)(1)) must contain the requirement that each source subject to BART install and operate BART as expeditiously as practicable, but in no event later than five years after approval of the implementation plan revision by EPA.

The SIP must contain procedures to ensure control equipment is properly maintained and operated in the BART requirements (51.308(e)(1)(v)).

Paragraph 51.308(e)(5) provides that after a State has met the requirements for source-specific BART, BART-eligible sources will be subject to the core requirements of Section 51.308(d) in the same manner as other sources. This would include enforceable emissions limitations, compliance schedules and other measures as necessary to achieve the reasonable progress goals set out in the long-term strategy to attain natural conditions by 2064.

Paragraph 51.308(e)(6) provides that even where a BART-eligible source may reasonably be anticipated to cause or contribute to visibility impairment, section 169A(c) of the Clean Air Act allows for the exemption of any source from the BART requirements if it can be demonstrated that the source, by itself or in combination with other sources, is not reasonably anticipated to cause or contribute to significant visibility impairment. Significant impairment 51.301 is defined as:

> "Significant impairment means, for purposes of Section 51.303, visibility impairment which, in the judgement of the Administrator, interferes with the management, protection, preservation, or enjoyment of the visitor's visual experience of the mandatory Class I Federal area. This determination must be made on a case-by-case basis taking into account the geographic extent, intensity, duration, frequency and time of the visibility impairment, and how these factors correlate with (1) times of visitor use of the mandatory Class I Federal area, and (2) the frequency and timing of natural conditions that reduce visibility."

EPA believes that the question of whether a source can be reasonably anticipated to cause or contribute to significant visibility impairment requires an analysis of the cumulative effects of emission sources on a region. Regional modeling will be one appropriate method to determine whether a source could qualify for a BART exemption. If a significant cumulative impact is demonstrated from the sources across the relevant regional modeling domain, then any BART-eligible source in the region would most likely be found to be reasonably anticipated to cause or contribute to significant visibility impairment.

A source may apply to EPA for an exemption from the BART requirement. The EPA will grant or deny an application after providing notice and opportunity for a public hearing. Any exemption granted by EPA must have the concurrence from all affected Federal Land Managers. The requirements for an exemption are found in Section 51.303. The authority to grant an exemption is reserved to EPA and will not be delegated to a state.

7.1.2 Visibility-Impairing Pollutants of Concern

For both BART applicability and degree of visibility improvement analyses, the BART guideline specifies that only primary emissions need to be considered. These primary emissions include SO_2, NO_x, and direct particulate matter (PM) emissions specified as either coarse (PM_{10} minus $PM_{2.5}$) or fine ($PM_{2.5}$). If this distinction in size of PM emissions cannot be made, it would be appropriate to consider all PM_{10} emissions as $PM_{2.5}$.

The BART guideline also discusses volatile organic compounds (VOC) or ammonia (NH_3) emissions as possibly impacting visibility. For the BART-eligible sources identified in North Dakota, these emissions (and associated visibility impacts) are negligible, and therefore the Department will not require inclusion of VOC or ammonia species in BART-related visibility analyses.

7.1.3 BART Identification Process

The first step in preparing the RH BART SIP is to develop a list of all BART-eligible sources within the State.

The regional haze rule contains the following definitions in Section 51.301:

> BART-eligible source means an existing stationary facility as defined in this section.
>
> Existing stationary facility means any of the following stationary sources of air pollutants, including any reconstructed source, which was not in operation prior to August 7, 1962, and was in existence on August 7, 1977, and has the potential to emit 250 tons per year or more of any air pollutant. In determining potential to emit, fugitive emissions, to the extent quantifiable, must be counted.
>
> (1) Fossil-fuel fired steam electric plants of more than 250 million British thermal units per hour heat input,
> (2) Coal cleaning plants (thermal dryers),
> (3) Kraft pulp mills,
> (4) Portland cement plants,
> (5) Primary zinc smelters,
> (6) Iron and steel mill plants,
> (7) Primary aluminum ore reduction plants,
> (8) Primary copper smelters,
> (9) Municipal incinerators capable of charging more than 250 tons of refuse per day,
> (10) Hydrofluoric, sulfuric, and nitric acid plants,
> (11) Petroleum refineries,
> (12) Lime plants,
> (13) Phosphate rock processing plants,
> (14) Coke oven batteries,
> (15) Sulfur recovery plants,
> (16) Carbon black plants (furnace process),
> (17) Primary lead smelters,
> (18) Fuel conversion plants,
> (19) Sintering plants,
> (20) Secondary metal production facilities,
> (21) Chemical process plants,
> (22) Fossil-fuel boilers of more than 250 million British thermal units per hour heat input,
> (23) Petroleum storage and transfer facilities with a capacity exceeding 300,000 barrels,
> (24) Taconite ore processing facilities,
> (25) Glass fiber processing plants, and
> (26) Charcoal production facilities.

The following three steps identify the key elements in the definition of existing stationary facility and other related definitions that should be considered when determining whether a source is a BART-eligible source.

STEP 1. IDENTIFY EMISSION UNITS IN THE 26 BART LISTED SOURCE CATEGORIES.

Listed Source Categories - The facility must fall within one of the 26 listed categories in the definition of existing stationary facility. These are the same categories that are included in the definitions of major source under PSD. PSD guidance documents and case history can be used to answer any questions related to the 26 categories.

Aggregated Unit Applicability - the definition for existing stationary facility includes stationary sources. Stationary source is defined as:

> Stationary source means any building, structure, facility, or installation which emits or may emit any air pollutant.

Building, structure, or facility are defined as:

> Building, structure, or facility means all of the pollutant-emitting activities which belong to the same industrial grouping, are located on one or more contiguous or adjacent properties, and are under the control of the same person (or persons under common control). Pollutant-emitting activities must be considered as part of the same industrial grouping if they belong to the same Major Group (i.e., which have the same two-digit code) as described in the Standard Industrial Classification Manual, 1972 as amended by the 1977 Supplement (U.S. Government Printing Office stock numbers 4101-0066 and 003-005-00176-0 respectively).

Installation is defined as:

> Installation means an identifiable piece of process equipment.

The above definitions have been interpreted by EPA to mean that all of the units within the source that meet the BART criteria should be aggregated together to determine if the source is BART-eligible.

STEP 2. IDENTIFY THE STARTUP DATES OF THE EMISSION UNITS.

Date of Operation/Construction/Reconstruction - BART review is limited to units that were constructed during a 15-year window between 1962 and 1977. There are several nuances in the definition of existing stationary facility that must be considered when determining if a unit falls within this 15-year window. The unit must not have been in operation prior to August 7, 1962. In operation is defined as:

> In operation means engaged in activity related to the primary design function of the source.

The date that the unit is permitted is not important to meet this test because the focus is on actual operation of the unit.

In addition, the unit must have been in existence as of August 7, 1977. In existence is defined as:

> In existence means that the owner or operator has obtained all necessary preconstruction approvals or permits required by Federal, State, or local air pollution emissions and air quality laws or regulations and either has (1) begun, or caused to begin, a continuous program of physical on-site construction of the facility or (2) entered into binding agreements or contractual obligations, which cannot be canceled or modified without substantial loss to the owner or operator, to undertake a program of construction of the facility to be completed in a reasonable time.

The actual date a unit begins operation may not be important to meet this test. For example, a unit that did not begin operation until 1983 may still be considered BART-eligible if the unit had all the necessary preconstruction approvals or permits and had begun, or caused to begin, a continuous program of physical on-site construction of the facility, or entered into binding agreements or contractual obligations, which cannot be canceled or modified without substantial loss prior to August 7, 1977.

STEP 3. COMPARE THE POTENTIAL TOTAL EMISSIONS FOR EACH POLLUTANT FROM THE EMISSION UNITS TO THE 250 TON PER YEAR CUT OFF.

Potential Emissions - The emission units that meet the source category and date of construction or operation requirements must then be aggregated together to determine if the combined emission units have the potential to emit 250 tons per year of any air pollutant.

Potential to emit is defined as:

> Potential to emit means the maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation or the effect it would have on emissions is federally enforceable. Secondary emissions do not count in determining the potential to emit of a stationary source.
>
> Applicability for BART is determined on a pollutant-by-pollutant basis. The total emissions for each pollutant from all the units at the source remaining after step 2 above is compared to the 250 ton per year cut off.

> Pollutants to be considered include the visibility-impairing pollutants, SO_2, NO_x, $PM_{2.5}$ and PM_{10}, VOC, and NH_3.

Fugitive emissions, to the extent quantifiable, must be counted. Fugitive emissions are defined as:

> Fugitive Emissions means those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

As noted in the definition for Potential to emit, secondary emissions do not count in determining the potential to emit of a stationary source. Secondary emissions are defined as:

> Secondary emissions means emissions which occur as a result of the construction or operation of an existing stationary facility but do not come from the existing stationary facility. Secondary emissions may include, but are not limited to, emissions from ships or trains coming to or from the existing stationary facility.

A SOURCE THAT PASSES ALL THREE STEPS IS A BART-ELIGIBLE SOURCE.

7.1.4 CALPUFF Screening Model Protocol

The Department has established a protocol for BART-related dispersion modeling applicable to BART-eligible sources in North Dakota. The protocol uses the CALPUFF model and conforms to the requirements of Appendix Y to Part 51- Guidelines for BART Determinations Under the Regional Haze Rule. It follows recommendations for long range transport of Appendix W to Part 51 - The Guideline on Air Quality Models and EPA's Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. The protocol was reviewed by EPA and Federal Land Manager meteorologists in Denver, CO prior to finalizing.

The protocol, "Protocol for BART-Related Visibility Impairment Modeling Analyses in North Dakota, November 2005", is included as Appendix A.1. Both BART applicability and degree of visibility improvement analyses were conducted following this protocol.

7.1.5 Screening Impact Threshold

In general, to determine which BART-eligible sources must apply BART, single facility modeling results for PSD Class I areas are compared with a visibility threshold, expressed in deciviews. The Department will follow recommendations in the July 6, 2005 BART guideline which states:

> "A single source that is responsible for a 1.0 deciview change or more should be considered to "cause" visibility impairment; a source that causes less than a 1.0 deciview change may still "contribute" to visibility impairment and thus be subject to BART .... As

> a general matter, any threshold that you use for determining whether a source "contributes" to visibility impairment should not be higher than 0.5 deciviews."

As a practical matter, the NDDH sees no reason to distinguish among BART-eligible sources which "cause" visibility impairment versus those sources which "contribute" to visibility impairment in PSD Class I areas. Therefore, the Department will generally use one threshold to determine which BART-eligible sources must apply BART.

The Department, in accordance with the BART guidelines, used a contribution threshold of 0.5 deciview for determining which sources were subject to BART. The BART guidelines provide States the discretion to set a threshold below 0.5 deciviews if "the location of a large number of BART-eligible sources within the State and proximity to a Class I area justifies this approach." This decision was based on several factors:

- It equates to the 5 percent extinction threshold for new sources under the PSD New Source Review rules,
- It is consistent with the threshold selected by other States in the West (all selected 0.5 dv),
- It represents the limit of perceptible change

There are only a few major point sources in North Dakota affecting the Class I areas and they are mostly 100 or more miles away, downwind in the prevailing wind direction. BART screening modeling indicates the visibility impact to either be much greater than 1.0 deciview or 0.5 deciview or less (See Section 7.3.1.), and there was no clear rationale or justification for selecting a lower level.

The Department therefore has established 0.5 deciview as the threshold to determine which BART-eligible sources must apply BART and included it in the State rules. Definition 2 of NDAC Section 33-15-25-01, Definitions, is:

> "Contributes to visibility impairment" means a change in visibility impairment in a Class I federal area of five-tenths deciviews or more (24-hour average) above the average natural visibility baseline. A source exceeds the threshold when the ninety-eighth percentile of the modeling results based on any one year of the three years of meteorological data modeled exceeds five-tenths deciviews.

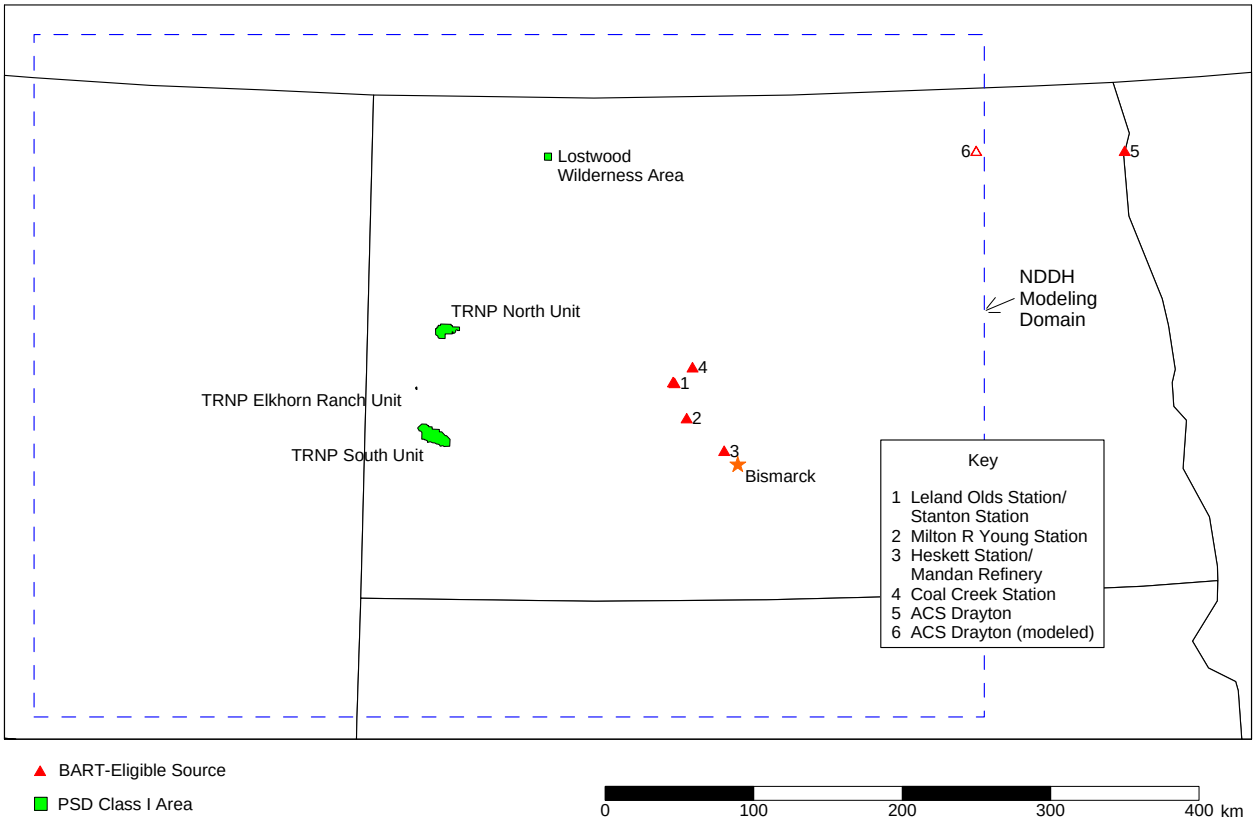
7.2 BART - Eligible Sources in North Dakota

The ten BART-eligible sources in the State of North Dakota and their locations are listed in Table 7.1. The locations of the BART-eligible sources with respect to Class I areas in North Dakota are illustrated in Figure 7.1.

Table 7.1
BART-Eligible Sources in North Dakota

Source and Unit	Location
American Crystal Sugar Company Main Boiler and Lime Kiln	Drayton, Pembina County
Basin Electric Power Cooperative Leland Olds Station Unit 1	Stanton, Mercer County
Basin Electric Power Cooperative Leland Olds Station Unit 2	Stanton, Mercer County
Great River Energy Coal Creek Station Unit 1	Falkirk, McLean County
Great River Energy Coal Creek Station Unit 2	Falkirk, McLean County
Great River Energy Stanton Station Unit 1	Stanton, Mercer County
Minnkota Power Cooperative Milton R. Young Station Unit 1	Center, Oliver County
Minnkota Power Cooperative Milton R. Young Station Unit 2	Center, Oliver County
MDU Resources Group, Inc. R. M. Heskett Station Unit 2	Mandan, Morton County
Tesoro Petroleum Corporation Mandan Refinery Carbon Monoxide Furnace	Mandan, Morton County

Figure 7.1
BART-Eligible Sources and Class I Areas in North Dakota



The BART-eligible sources were identified using the methodology in the Guidelines for BART Determinations Under the Regional Haze Rule, 40 CFR Part 51, Appendix Y, and summarized in 7.1.3.

Eight of the BART-eligible sources are fossil-fuel fired steam electric plants of more than 250 million British thermal units per hour heat input. One is a fossil-fuel fired boiler of more than 250 million British thermal units per hour heat input and a lime plant (the main boiler and the lime kiln at the American Crystal Sugar Company sugar beet processing plant at Drayton) and one is a process unit at a petroleum refinery (the carbon monoxide furnace at the Tesoro Petroleum Corporation refinery at Mandan).

7.3 Determination of BART-Eligible Sources Subject to BART

7.3.1 Sources Subject to BART

The modeled visibility impact of each of the ten BART-eligible sources listed in Table 7.1 on the Class I areas in North Dakota is shown in Table 7.2. The maximum 24-hour 98th percentile deciview represents the result for the worst year of the three years modeled (2000-2002).

The visibility impact of each BART-eligible source is considered significant if the projected change in the maximum 24-hour impact at a Class I area compared against natural conditions is equal to or greater than 0.5 deciviews. The source is then subject to BART. If the impact is less than 0.5 deciviews, the source is exempt from BART.

The modeling to determine if each BART-eligible source has a significant impact on visibility was performed by the Department using the CALPUFF model following EPA's Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts specified in the Guidelines for BART Determinations Under the Regional Haze Rule, 40 CFR Part 51, Appendix Y. The modeling protocol is included in Appendix A as Appendix A.1.

After completion of the subject-to-BART screening modeling, the eight subject-to-BART sources were notified they were subject-to-BART by letters dated November 30, 2005. These letters are attached as Appendix A.3.

The Department was contacted by Montana Dakota Utilities who requested approval to do a more refined CALPUFF screening analysis considering that the Department's results were slightly above the 0.5 deciview cutoff. MDU submitted a refined analysis in May 2006. This analysis is attached in Appendix A.2 and is discussed in 7.3.4 below.

Table 7.2
Individual BART-Eligible Source Visibility Impact on Class I Areas

Source and Unit	Class I Area	Maximum 24 Hour 98th Percentile Visibility Impact Value Deciview	Subject to BART or Exempt
American Crystal Sugar Company Main Boiler and Lime Kiln	Lostwood TRNP South Unit TRNP North Unit TRNP Elk. Ranch Unit	0.04 0.04 0.04 0.04	Exempt
Basin Electric Power Cooperative Leland Olds Station Unit 1 and Unit 2	Lostwood TRNP South Unit TRNP North Unit TRNP Elk. Ranch Unit	5.42 6.22 5.32 4.49	Subject to BART
Great River Energy Coal Creek Station Unit 1 and Unit 2	Lostwood TRNP South Unit TRNP North Unit TRNP Elk. Ranch Unit	4.04 4.48 3.56 3.04	Subject to BART
Great River Energy Stanton Station Unit 1	Lostwood TRNP South Unit TRNP North Unit TRNP Elk. Ranch Unit	1.35 1.68 1.54 1.43	Subject to BART
Minnkota Power Cooperative Milton R. Young Station Unit 1 and Unit 2	Lostwood TRNP South Unit TRNP North Unit TRNP Elk. Ranch Unit	4.88 6.69 5.58 6.10	Subject to BART
MDU Resources Group, Inc. R. M. Heskett Station Unit 2	Lostwood TRNP South Unit TRNP North Unit TRNP Elk. Ranch Unit	0.436[1] 0.428 0.397 0.388	Exempt
Tesoro Petroleum Corporation Mandan Refinery Carbon Monoxide Furnace	Lostwood TRNP South Unit TRNP North Unit TRNP Elk. Ranch Unit	0.04 0.05 0.04 0.04	Exempt

[1] MDU Refined BART Screening Results

Detailed descriptions of the seven subject-to-BART sources can be found in the Department BART Determinations in Appendix B and in the Company BART Analyses in Appendix C.

7.3.2 Exclusion of Tesoro Mandan Petroleum Refinery

The Department single-source modeling for the Tesoro Petroleum Corporation Mandan Refinery Carbon Monoxide Furnace predicted the highest maximum 24 hour 98th percentile visibility impact value to be 0.05 deciviews at Theodore Roosevelt National Park South Unit. This is a factor of 10 less than the 0.5 deciview threshold for determining whether a BART-eligible source causes or contributes to visibility impairment. Therefore, the unit is exempt and not subject to BART.

7.3.3 Exclusion of American Crystal Sugar Drayton Refinery

The Department single-source modeling for the American Crystal Sugar Company Drayton Plant Main Boiler and Lime Kiln predicted the highest maximum 24 hour 98th percentile visibility impact value to be 0.04 deciview at all ~~four~~ Class I areas. This is more than a factor of 10 less than the 0.5 deciview threshold for determining whether a BART-eligible source causes or contributes to visibility impairment. Therefore, the unit is exempt and not subject to BART.

As shown in Figure 7.1, the American Crystal Sugar Company Drayton Plant is located outside the Department's modeling domain. Even if the domain was extended eastward to incorporate the Drayton plant, the plant is located about 400 kilometers from the nearest North Dakota Class I area (Lostwood Wilderness Area), and this distance is beyond the accepted range of CALPUFF (about 300 kilometers). For modeling purposes, therefore, the Department repositioned the Drayton plant about 100 kilometers to the west, to create a virtual source located just inside the east boundary of the current modeling domain (represented by the "ACS Drayton (modeled)" source in Figure 7.1). This adjustment provided a source-receptor distance more consistent with the documented limits of CALPUFF, and should ensure results are conservative.

In addition, the Minnesota Pollution Control Agency modeled the American Crystal Sugar Company Drayton plant and found similar impact levels at the Class I areas in Minnesota, Voyagers National Park which is about 300 kilometers from the plant and Boundary Waters Canoe Area Wilderness which is about 350 kilometers from the plant.

7.3.4 Exclusion of Montana Dakota Utilities Heskett Unit No. 2

The Department single-source modeling for the Montana Dakota Utilities R.M. Heskett Station Unit 2 located near Mandan predicted the highest maximum 24 hour 98th percentile visibility impact value to be 0.82 deciview at the Theodore Roosevelt National Park South Unit, and 0.54 deciview at the North Unit, 0.61 deciview at the Elkhorn Ranch Unit and 0.58 deciview at Lost wood National Wilderness Area. Because these values were slightly above the threshold of 0.5 deciviews, Montana Dakota Utilities hired a consultant, ENSR Corporation, to perform a refined

CALPUFF modeling analysis. The ENSR analysis submitted June 9, 2006 is included as Appendix A.2.

The ENSR analysis made three refinements to the analysis performed by the Department:

- A 1 km grid size was used instead of 3 km,
- Particulate matter emissions were speciated into several components that have different light scattering potential, and
- The annual average background visibility was used instead of the annual 20 percent best day's background visibility (as per an EPA court settlement agreement).

The results of the refined ENSR analysis predicted the highest maximum 24 hour 98th percentile visibility impact value to be 0.436 deciviews at Lostwood National Wilderness area in 2001.

The Department had originally reviewed the ENSR analysis and found it acceptable. Additionally, MDU has committed to reduce the potential sulfur dioxide emissions from Heskett Unit 2 by a minimum of 70 percent within five years of EPA approval of this SIP. This would have reduced sulfur dioxide emissions to 1,660 tons per year from the 2000-2004 emissions of 2,400 tons per year, a 740 tons per year reduction. The Department had determined that Heskett Unit 2 was not subject to BART. See the Department's letter of May 8, 2007 in Appendix A.3. The FLMs and EPA have expressed concerns about the modeling that was conducted. MDU has agreed to remodel using a revised modeling protocol. The Department will reassess the determination to exclude Heskett Station Unit 2 following review of the revised modeling. Heskett Unit 2 will be addressed in a supplement to this SIP revision.

7.4 Determination of BART Requirements for Subject-to-BART Sources

7.4.1 Company BART Analyses

The Department met individually with the seven subject-to-BART sources in December 2005 and requested they complete and submit BART analyses within nine months of the notification letters dated November 30, 2005 or by September 1, 2006. The nine month time was required by NDAC 33-15-25-02.1. This was agreed to by the seven sources. They were required to address BART for sulfur dioxide, nitrogen oxides, fine particulates and condensable particulates.

The Department also requested the sources follow requirements of Appendix Y to Part 51 - Guidelines for BART Determinations Under the Regional Haze Rule in conducting their analyses.

The seven BART analyses were submitted in final form in late 2007 to early 2008. The final company BART analyses are attached as Appendix C.

7.4.2 Department BART Determinations

The Department has reviewed the company BART determinations and conducted its own determinations for each source. The BART determinations followed the methodology of Section IV of Appendix Y to Part 51 - Guidelines for BART Determinations Under the Regional Haze Rule. This includes identifying the best system of continuous emission reduction taking into account:

1. The available retrofit control options,
2. Any pollution control equipment in use at the source (which affects the availability of options and their impacts),
3. The costs of compliance with control options,
4. The remaining useful life of the facility,
5. The energy and non-air quality environmental impacts of control options, and
6. The visibility impacts analysis.

A case-by-case top down BART analysis using the five basic steps was followed. The five steps are:

STEP 1 - Identify all available retrofit technologies,
STEP 2 - Eliminate technically infeasible options,
STEP 3 - Evaluate control effectiveness of remaining technologies,
STEP 4 - Evaluate impacts and document the results, and
STEP 5 - Evaluate Visibility impacts.

The Department BART determinations are included as Appendix B. Each BART determination includes a source description including the major boiler units and the minor sources such as auxiliary boilers, emergency generators, coal/materials handling dust controls, and coal storage piles; the site characteristics; BART evaluations for the major and minor sources; and a permit to construct description.

As detailed in Appendix B, Department BART determinations included an evaluation of visibility impacts. Single-source modeling was conducted by the companies to determine the degree of visibility improvement associated with various control options for individual units. This modeling was based on EPA guidance for BART determinations[1]. The Department asked companies to provide a 90th percentile 24-hr visibility modeling result (delta-deciview) along with the 98th percentile 24-hr value referenced in the guidance, because the 90th percentile would be more consistent with the *average of 20% worst days* metric utilized for assessing visibility improvement progress under the Regional Haze Rule.

Single-source visibility modeling as provided by the affected companies was reviewed by the

[1]Federal Register, 2005. EPA Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations; Final Rule. Federal Register, July 6, 2005, Vol.70, No. 128, p. 39103-39172.

Department, and results related to visibility improvement were considered in Department BART determinations. Because the Department had concerns regarding the viability of single-source modeling in representing actual visibility improvement, however, modeling was given less weight than other factors in the BART determination process.

Though single-source modeling is specified in the BART guidance for determining degree of visibility improvement, it is clear that this modeling overstates the real single-source visibility impact, given the complexity of multiple-source emissions and chemistry actually affecting visibility impairment in Class I areas. As suggested by the logarithmic relationship between deciview and light extinction (Section 5.1), an observer's perception of visibility change is affected by the total loading of visibility-affecting species in the atmosphere. The observer's perception of visibility change, due to a reduction (or increase) in visibility-affecting emissions from one source, depends on cumulative visibility impact due to all sources. For example, a unit reduction in visibility-affecting emissions (from one source) will have only half the visual impact on the observer (delta-deciview) if total light extinction is 80 Mm^{-1} compared to the impact if total light extinction is 40 Mm^{-1}. By excluding the impact of all other sources, therefore, single-source modeling is overstating the perceived (delta-deciview) change in visibility. Based on Department experience, single-source modeling results (delta-deciview) tend to be five to seven times larger than results obtained for the same source when it is combined with all other sources in a cumulative analysis.

It is because of this anomaly that the Department has been very cautious in the interpretation of single-source modeling results, and has focused BART determinations on factors other than visibility modeling. In some instances, as discussed in Appendix B, the Department has conducted supplemental cumulative modeling to more realistically assess the visibility impact of emissions reductions associated with optional control strategies for individual sources. Cumulative modeling is consistent with the procedure for determining status with respect to *uniform rate of progress* goals, which is discussed in Section 8.

BART determinations were made for sulfur dioxide, nitrogen oxides, filterable particulate matter, and condensable particulate matter for all seven sources. A summary of the BART determinations for the main boilers by pollutant follows.

<u>Sulfur Dioxide</u>

Three of the seven sources have existing sulfur dioxide removal equipment. Great River Energy Coal Creek Station Unit 1and Unit 2 and Minnkota Power Cooperative Milton R. Young Station Unit 2 are equipped with wet limestone scrubbers. The existing scrubbers at the Coal Creek Station employ a bypass for flue gas heat and achieve a 68 percent sulfur dioxide reduction. The lime/fly ash wet scrubber at Milton R. Young Unit 2 achieves a 65 percent sulfur dioxide reduction.

Great River Energy Coal Creek Station Unit 1 and Unit 2 - The BART selected by the Department for Unit 1 and Unit 2 is a 95 percent reduction efficiency or a limit of 0.15 pounds per million Btu of heat input on a 30-day rolling average basis to be achieved by modifying the

existing wet scrubbers and the adding a new coal dryer serving both units. Unit 1 and Unit 2 emissions may be averaged provided the average does not exceed the limit.

Minnkota Power Cooperative Milton R. Young Station Unit 2 - The BART for sulfur dioxide selected by the Department for Unit 2 is a 95 percent reduction efficiency or limit of 0.15 pounds per million Btu of heat input on a 30-day rolling average basis to be achieved by modifying the existing wet scrubber. The Consent Decree for Minnkota requires a minimum of 90 percent reduction of sulfur dioxide at Unit 2. The 90 percent reduction requirement will apply when Minnkota chooses to comply with the 0.15 $lb/10^6$ Btu limit. The 90 percent reduction requirement is included in the BART permit.

Minnkota Power Cooperative Milton R. Young Station Unit 1 - Unit 1 has no existing sulfur dioxide removal equipment. The BART selected by the Department for Unit 1 is a 95 percent reduction efficiency on a 30-day rolling average basis to be achieved by the installation of a new wet scrubber. The EPA/State Consent Decree states that if Minnkota installs a wet scrubber, they must comply with a 95 percent reduction requirement with no alternative pounds per million Btu of heat input limit.

Basin Electric Power Cooperative Leland Olds Station Unit 1 and Unit 2 - Unit 1 and Unit 2 have no existing sulfur dioxide removal equipment. The BART selected by the Department for Unit 1 and for Unit 2 is a 95 percent reduction efficiency or a limit of 0.15 pounds per million Btu of heat input on a 30-day rolling average basis to be achieved by the installation of new wet scrubbing system.

Great River Energy Stanton Station Unit 1 - Unit 1 has no existing sulfur dioxide removal equipment. Unit 1 burns either lignite coal or subbituminous coal. Because these coals have different average sulfur contents, Btu contents and chemical characteristics, the Department will issue BART limits appropriate to each coal. The BART selected by the Department for Unit 1 is a 90 percent reduction on a 30-day rolling average basis burning either coal or a limit of 0.24 pounds per million Btu of heat input on a 30-day rolling average basis when burning only lignite coal, a limit of 0.16 pounds per million Btu of heat input on a 30-day rolling average basis when burning subbituminous coal, and weighted average emission limit when burning a combination of lignite and subbituminous coal.

The sulfur dioxide emissions before and after BART control, the BART controls, and the sulfur dioxide emission limits for each of the seven sources are summarized in Table 7.3.

Table 7.3
BART-Level Emissions Reductions From the 2000-2004
Sulfur Dioxide Average

Source and Unit	2000-2004 Average Emissions Tons per Year	Baseline Level of Control % Reduction	BART Level of Control % Reduction*	Control Device	Emissions after Controls Tons per Year**	Emission Reduction Tons per Year**	Emission Limit
Basin Electric Power Cooperative Leland Olds Station Unit 1	16,666	0%	95%	New Wet Scrubber	1,376	15,290	95% reduction or 0.15 lb/10^6 Btu 30 day rolling average
Basin Electric Power Cooperative Leland Olds Station Unit 2	30,828	0%	95%	New Wet Scrubber	2,530	28,298	95% reduction or 0.15 lb/10^6 Btu 30 day rolling average
Great River Energy Coal Creek Station Unit 1	14,086	68%	95%	Modified Existing Wet Scrubber and Coal Dryer	3,781	10,305	95% reduction or 0.15 lb/10^6 Btu 30 day rolling average
Great River Energy Coal Creek Station Unit 2	12,407	68%	95%	Modified Existing Wet Scrubber and Coal Dryer	3,621	8,786	95% reduction or 0.15 lb/10^6 Btu 30 day rolling average
Great River Energy Stanton Station Unit 1	8,312	0%	90%	New Spray Dryer and Fabric Filter	1,179	7,133	90% reduction or 0.24 lb/10^6 Btu (lignite) or 0.16 lb/10^6 Btu (PRB) 30 day rolling average
Minnkota Power Cooperative Milton R. Young Station Unit 1	20,148	0%	95%	New Wet Scrubber	1,007	19,141	95% reduction 30 day rolling average
Minnkota Power Cooperative Milton R. Young Station Unit 2	12,404	65%	95%	Modified Existing Wet Scrubber	2,739	9,665	95% reduction; or 90% reduction and 0.15 lb/10^6 Btu 30 day rolling average
Total	114,851	----	----	----	16,233	98,618	----

*Based on the two year baseline emission rate for BART.
** Based on the average 2000-2004 operating rate and emission rates.

Nitrogen Oxides

There are many different technologies available for controlling nitrogen oxides emissions from coal fired boilers. The technical feasibility for a particular technology is dependent on the type and size of the boiler and the type of coal being combusted. The types of boiler used at the seven BART sources in the state are cyclone (3), tangentially-fired pulverized coal (2), and wall-fired pulverized coal (2). The types of coal burned in the state are lignite coal with varying

characteristics from several different mines near the plants and subbituminous coal from the Powder River Basin (PRB) in Wyoming and Montana.

The nitrogen oxides control technologies that are applicable to a particular boiler are listed in the Company BART Analyses in Appendix C and in the Department BART Determinations in Appendix B.

One technology, selective catalytic reduction (SCR), has one of the highest nitrogen oxides removal rates (in the range of 90 percent) and has been commercially installed on many different types of boilers burning different types of coal. However, it has never been installed on any type of boiler burning North Dakota lignite. The only pilot scale testing conducted on North Dakota lignite failed after two months. The seven BART sources determined SCR is not technically feasible for installation on boilers in North Dakota burning lignite coal. The Department agrees that high dust SCR is not technically feasible; however, low dust and tail end SCR are considered technically feasible. A detailed discussion on the technical feasibility of SCR is provided in Appendix B.5. The BART for nitrogen oxides for each source follows:

Basin Electric Power Cooperative Leland Olds Station Unit 1 - This unit is a wall-fired pulverized coal boiler combusting primarily lignite coal (80-100%) and PRB subbituminous coal (20-0%). The existing nitrogen oxides control equipment is low NO_x burners installed in 1995. The BART selected by the Department is a limit of 0.19 pounds per million Btu of heat input on a 30-day rolling average basis. This limit is to be achieved by the installation of selective noncatalytic reduction (SNCR) and basic separated overfire air (SOFA).

Basin Electric Power Cooperative Leland Olds Station Unit 2 - This unit is a cyclone boiler combusting primarily lignite coal (80-100%) and PRB subbituminous coal (20-0%). The unit has no existing nitrogen oxides control equipment. The BART selected by the Department is a limit of 0.35 pounds per million Btu of heat input on a 30-day rolling average basis. This limit is to be achieved by the installation of selective noncatalytic reduction (SNCR) and advanced separated overfire air (ASOFA).

Great River Energy Coal Creek Station Unit 1 and Unit 2 - Unit 1 and Unit 2 are identical tangentially-fired pulverized coal boilers combusting lignite coal. The existing nitrogen oxides control equipment is low NO_x burners (LNB) and separated overfire air (SOFA). The BART selected by the Department for each unit is a limit of 0.17 pounds per million Btu of heat input on a 30-day rolling average basis. This limit is to be achieved by the use of the existing low NO_x burners (LNB) and modified/additional separated overfire air (SOFA).

Great River Energy Stanton Station Unit 1 - Unit 1 is a wall-fired pulverized coal boiler combusting PRB subbituminous coal and lignite coal. The existing nitrogen oxides control equipment is low NO_x burners. The BART selected by the Department is a limit of 0.29 pounds per million Btu of heat input on a 30-day rolling average basis when burning only lignite coal, a limit of 0.23 pounds per million Btu of heat input on a 30-day rolling average basis when burning subbituminous coal, and a weighted average emission limit when burning a combination of lignite and subbituminous coal. These limits are to be achieved by the installation of low NO_x burners (LNB), overfire air (OFA), and selective noncatalytic reduction (SNCR).

Minnkota Power Cooperative Milton R. Young Station Unit 1 and Unit 2 - Unit 1 and Unit 2 are both cyclone boilers burning lignite coal. The units have no existing nitrogen oxides control equipment. The BART selected by the Department for Unit 1 is a limit of 0.36 pounds per million Btu of heat input on a 30-day rolling average basis and for Unit 2 is a limit of 0.35 pounds per million Btu of heat input on a 30-day rolling average basis. These limits will be achieved by the installation of selective noncatalytic reduction (SNCR) and advanced separated overfire air (ASOFA). These limits do not apply during startup. During startup, NO_x emissions from Unit 1 shall not exceed 2070.1 pounds per hour on a 24-hour rolling average basis and 3995.6 pounds per hour from Unit 2 on a 24-hour rolling average basis.

The nitrogen oxides emissions before and after BART control, the BART controls, and the nitrogen oxide emission limits for each of the seven sources are summarized in Table 7.4.

Table 7.4
BART-Level Emissions Reductions From the 2000-2004
Nitrogen Oxides Average

Source and Unit	2000-2004 Average Emissions Tons per Year	Baseline Level of Control % Reduction	BART Level of Control % Reduction*	Control Device	Emissions after Controls Tons per Year**	Emission Reduction Tons per Year**	Emission Limit
Basin Electric Power Cooperative Leland Olds Station Unit 1	2,501	0%	42%	SOFA and SNCR	1,744	757	0.19 lb/10^6 Btu 30 day rolling average
Basin Electric Power Cooperative Leland Olds Station Unit 2	10,422	0%	54.5%	ASOFA and SNCR	5,904	4,518	0.35 lb/10^6 Btu 30 day rolling average
Great River Energy Coal Creek Station Unit 1	5,116	0%	30%	SOFA	4,285	831	0.17 lb/10^6 Btu 30 day rolling average
Great River Energy Coal Creek Station Unit 2	5,391	0%	30%	SOFA	4,104	1,287	0.17 lb/10^6 Btu 30 day rolling average
Great River Energy Stanton Station Unit 1	2,048	0%	45%	LNB, Overfire Air and SNCR	1,425	623	0.29 lb/10^6 Btu lignite coal 0.23 lb/10^6 Btu PRB coal 30 day rolling average
Minnkota Power Cooperative Milton R. Young Station Unit 1	8.665	0%	58.1%	ASOFA and SNCR	3,857	4,808	0.36 lb/10^6 Btu 30 day rolling average
Minnkota Power Cooperative Milton R. Young Station Unit 2	14,705	0%	58.0%	ASOFA and SNCR	6,392	8,313	0.35 lb/10^6 Btu 30 day rolling average
Total	48,848	----	----	----	27,711	21,137	----

*Based on the two year baseline emission rate for BART.
** Based on the average 2000-2004 average operating rate.

Filterable Particulate Matter

Filterable particulate matter is solid and liquid (non-condensable) matter that is captured in the front half of EPA test method five, the standard test method for determining particulate emissions from boilers.

The existing control devices for filterable particulate matter on all seven boilers are dry electrostatic precipitators (ESPs) with control efficiencies of 99+ percent. Each unit has an existing particulate emission limit of 0.1 pounds per million Btu of heat input.

Recent test results submitted to the Department show the actual emissions from the seven units average 0.03 to 0.05 pounds per million Btu of heat input with occasional values approaching 0.07 pounds per million Btu of heat input.

Upgrading or replacing existing ESPs could reduce the particulate emission rates to 0.013 to 0.015 pounds per million Btu of heat input. However, the BART analyses conducted by the sources indicate the cost effectiveness in dollars per ton is unreasonable and there is very little benefit to visibility in the federal Class I areas.

The existing particulate emissions from all seven boilers are very low, ranging from 74 tons per year, 2000-2004 average, at Stanton Station Unit 1 to 589 tons per year, 2000-2004 average, at Coal Creek Station Unit 2. The BART screening modeling indicates the maximum visibility impact improvement from reducing actual existing emissions levels of approximately 0.03 pounds per million Btu of heat input to 0.015 pounds per million Btu of heat input at any Class I area from any of the seven sources was 0.037 deciviews 98th percentile or less. Detailed particulate emissions data and modeling visibility impact improvement data for each source can be found in the Department BART determinations in Appendix B.

The Department has determined that the BART for filterable particulate matter for all seven sources is no additional controls and allowable particulate emission rate of 0.1 pounds per million Btu of heat input be reduced to 0.07 pounds per million Btu of heat input for five of the seven units. The Minnkota Power Cooperative Milton R. Young Station Unit 1 and Unit 2 are subject to an EPA/State consent decree for New Source Review violations. The consent decree requires filterable particulate emissions not to exceed 0.030 pounds per million Btu of heat input. Therefore 0.030 pounds per million Btu of heat input will be the BART limit for these two units.

Condensable Particulate Matter (PM_{10})

Condensable particulate matter is made up of both organic and inorganic substances. Organic condensable particulate matter will be made up of organic substances, such as volatile organic compounds, which are in a gaseous state through the air pollution control devices but will eventually turn to a solid or liquid state. The primary inorganic substance expected from the boiler is sulfuric acid mist, with lesser amounts of hydrogen fluoride and ammonium sulfate.

Since sulfuric acid mist is the largest component of condensable particulate matter, controlling it will control most of the condensable particulate matter. The options for controlling sulfuric acid mist are the same options for controlling sulfur dioxide. These include wet and dry scrubbers. Three of the sources have existing wet scrubbers that will be upgraded. Three of the remaining four units will be equipped with new wet scrubbers and one with a dry scrubber/baghouse system. These technologies will achieve greater than 40-60 percent reduction of sulfuric acid mist emissions. Changes that would provide additional reductions are economically infeasible considering the minimal improvement in visibility that could be achieved.

The control of volatile organic compounds at power plants is generally achieved through good combustion practices. The Department is not aware of any BACT determination at a power plant that resulted in any control technology being used. BACT has been found to be good combustion practices which are already in use since it minimizes the amount of fuel to generate electricity.

EPA document AP-42, Compilation of Air Pollutant Emission Factors, indicates the emission rate of condensable particulate matter could be expected to be 0.02 pounds per million Btu. This emission rate is less than the current emissions of filterable particulate matter and the emissions of filterable particulate matter were determined to have a negligible impact on visibility.

Having considered all the factors, the Department has determined that BART for condensable particulate matter is represented by good sulfur dioxide control and good combustion control. Since the primary constituent of condensable particulate matter is sulfuric acid mist which is controlled proportionately to the sulfur dioxide controlled, the BART limit for sulfur dioxide can act as a surrogate for condensable particulate matter along with a requirement for good combustion practices.

BART Modifications Description

A summary description of the BART modifications proposed at each of the seven subject-to-BART sources follows:

Basin Electric Power Cooperative Leland Olds Station Unit 1 and Unit 2 - A wet scrubbing system will be installed to remove sulfur dioxide from the flue gas of each unit. Nitrogen oxides emissions from Unit 1 will be controlled by basic separated overfire air (SOFA) and selective noncatalytic reduction (SNCR). Nitrogen oxides from Unit 2 will be controlled by advanced separated overfire air (ASOFA) and selective noncatalytic reduction (SNCR).

Great River Energy Coal Creek Station Unit 1 and Unit 2 - Sulfur dioxide emissions will be controlled by the installation of a coal drying system; the installation of trays or new liquid distribution rings (LDRs) and high flow mist eliminators (MEs) in the existing wet scrubbers; the elimination of the bypass of the wet scrubbers and the modification of the existing stacks for wet operating conditions. Nitrogen oxides emissions will be controlled by the installation of an additional level of separated overfire air (SOFA) in each boiler.

Great River Energy Stanton Station Unit 1 - Sulfur dioxide emissions will be controlled by the installation of a spray dryer and fabric filter system (dry scrubber). Nitrogen oxides emissions will be controlled by the installation of low-NO_x burners plus overfire air plus selective noncatalytic reduction (SNCR) technology.

Minnkota Power Cooperative Milton R. Young Station Unit 1 and Unit 2 - Sulfur dioxide emissions will be controlled by the installation of a new wet scrubber on Unit 1 and by upgrading the existing wet scrubber on Unit 2. Nitrogen oxides emissions from both units will be reduced using advanced separated overfire air (ASOFA) and selective noncatalytic reduction (SNCR).

The control technology to be installed on each source unit is described in more detail in the company BART determinations in Appendix C and the Department BART determinations in Appendix B.

7.4.3 Summary of Emission Reductions

BART for the BART-eligible sources in the State of North Dakota that are significant contributors to visibility impairment in a Class I area are shown in Tables 7.3 and 7.4 for sulfur dioxide and nitrogen oxides. BART is the emission limit for each pollutant based on the degree of reduction achievable through the application of the best system of continuous emission reduction, taking into consideration the technology available, the costs of compliance, the energy and the non-air quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology. The Department BART determination analysis for each BART-eligible source is included in Appendix B.

The application of BART to all BART-eligible sources provides an estimated emission reduction from the 2000-2004 average baseline emissions of 98,618 tons per year of sulfur dioxide and 21,137 tons per year of nitrogen oxides. These reductions are shown in Tables 7.3 and 7.4 for each source and in total.

BART for each BART-eligible source was determined using the methodology in the Guidelines for BART Determinations Under the Regional Haze Rule. 40 CFR Part 51, Appendix Y.

7.5 Air Pollution Control Permit to Construct for Subject-to-BART Sources

Section V of Appendix Y to Part 51 - Guidelines for BART Determinations Under the Regional Haze Rule requires the State establish enforceable emission limits that reflect the BART determinations and require compliance within a given period of time. In particular, the State must establish an enforceable emission limit for each subject emission unit at the source and for each pollutant subject to review that is emitted from the source. The Department worked closely

with the staff of the EPA Region 8 Air Programs office to ensure the permit template contents and language were acceptable to meet the requirements of Section V.

The emission limits, monitoring, recordkeeping and reporting requirements specified in the Department BART determination for each subject-to-BART source are included in a federally enforceable Air Pollution Control Permit to Construct that will be issued by the Department to the owner/operator of the facility before the SIP is submitted to EPA. The permits are issued by the Department under existing authority pursuant to NDAC Chapter 33-15-14 and Chapter 33-15-25.

There are four Permits to Construct, one for both Unit 1 and Unit 2 at the Basin Electric Power Cooperative Leland Olds Station, one for both Unit 1 and Unit 2 at the Great River Energy Coal Creek Station, one for Unit 1 at the Great River Energy Stanton Station, and one for Unit 1 and Unit 2 at the Minnkota Power Cooperative Milton R. Young Station. The four permits are included in Appendix D.

7.5.1 Enforceable Emission Limits

Enforceable emission limits that reflect the BART determinations are included in each Air Pollution Control Permit to Construct as permit condition II.A.1. Conditions for sulfur dioxide are in II.A.1.a., nitrogen oxides in II.A.1.b., and filterable (non-condensable) particulate matter in II.A.1.c. Each Air Pollution Control Permit to Construct is incorporated as a part of this Regional Haze SIP.

As required by Section V of Appendix Y, the limitations for sulfur dioxide and nitrogen oxides specify an averaging time of a 30-day rolling average, and contain a definition of “boiler operating day” which is any 24-hour period between 12:00 midnight and the following midnight during which any fuel is combusted at any time at the steam generating unit.

7.5.2 Monitoring, Recordkeeping, and Reporting Requirements

Monitoring, recordkeeping, and reporting requirements have been included in each Air Pollution Control Permit to Construct. The owner/operator is required to conduct monitoring, recordkeeping and reporting as required by NDAC Chapter 33-15-14-06, Title V Permit to Operate and NDAC 33-15-21, Acid Rain Program (40 CFR 72, 75, and 76). The conditions in each source’s existing Title V operating permit will be revised as necessary to cover the new BART emissions limits as they are included these permits. Monitoring requirements are found in permit condition II. A. 4, recordkeeping requirements are found in II.A.5, and reporting requirements are found in II. A. 6.

7.5.3 Operating and Maintenance Requirements

Item 51.308(e)(1)(v) of the EPA BART rule requires that each source subject to BART maintain the control equipment and establish procedures to ensure such equipment is properly operated. This requirement is also included in the state rules at NDAC 33-15-25-02.3.

Each Air Pollution Control Permit to Construct has condition II. B. 4 which requires that the owner shall at all times, including periods of startup, shutdown, and malfunction, maintain and operate the BART unit(s) and all other emission units including associated air pollution equipment and fugitive dust suppression operations in a manner consistent with good air pollution control practices for minimizing emissions.

7.5.4 Compliance Date

The Department is requiring that each source subject to BART shall install and operate BART as expeditiously as practicable but in no event later than five years after approval of the implementation plan revision by EPA as required by Section V of Appendix Y to 40 CFR Part 51 and Item 51.308(e)(1)(iv) of the EPA BART Rule. This requirement is also included in the State rule as NDAC 33-15-25-02.2.

This requirement is included Condition II. A. 2 in the Air Pollution Control Permit to Construct to be issued for each source subject to BART. The permits will be issued after the close of the public comment period for this implementation plan before it is submitted to EPA for approval. When this implementation plan is approved by EPA, a Title V operating permit will be issued for each source incorporating the conditions of the permits to construct.

8. Visibility Modeling

8.1 Introduction

Computer modeling to determine progress with respect to visibility improvement goals was conducted in support of this North Dakota Regional Haze SIP. The Regional Haze Rule[2] (Rule) specifies that modeling must be applied to demonstrate reasonable progress toward the goal of achieving natural visibility conditions in each PSD Class I area by 2064. As discussed in Section 5.4, the *uniform rate of progress* defines the visibility improvement which would be needed for each planning period to achieve natural visibility conditions by 2064. The first planning period begins at the end of the baseline (2004) and terminates in 2018. The visibility improvement progress needed by 2018 (or 2018 target) is determined by interpolating from the uniform rate of progress glide path, as illustrated in Figure 5.5.

Modeling analyses completed in support of the North Dakota SIP and discussed here address the first planning period, and the 2018 target. These analyses assume that the 2018 goal for each Class I area is the uniform rate of progress (glide path) target for 2018. The Regional Haze Rule, however, gives states the option of establishing *reasonable progress goals* which are independent of the uniform rate of progress. The reasonable progress goals established by a state for 2018 will not necessarily equal the uniform rate of progress target for 2018 (see Section 10).

To demonstrate reasonable progress with respect to visibility goals for the first planning period, the Rule specifies that visibility on the 20 percent worst (most impaired) days must improve, while visibility on the 20 percent best (least impaired) days must not deteriorate, between the base period (2000-2004) and 2018. Computer modeling was used to project future visibility, accounting for proposed BART controls and other visibility-affecting emissions increases/decreases. Modeling was applied in a relative sense. Baseline and projected future emission inventories were modeled to develop a future/baseline prediction ratio (relative response factor). The ratio was then applied to baseline monitoring data for visibility-affecting species to project future visibility.

The Western Regional Air Partnership (WRAP) regional planning organization has established a Regional Modeling Center (RMC) to assist member states, including North Dakota, with modeling to determine status with respect to the 2018 goals. The RMC has applied a chemically sophisticated grid model (CMAQ), on a regional basis, to project future visibility in Class I areas in the WRAP region[3]. The RMC has developed comprehensive base period and future period visibility-affecting emission inventories to use with CMAQ, and has performed numerous studies

[2] 40 CFR 51.308

[3] Tonnesen, G., R. Morris, Z. Adelman, et. al., 2006. 2006 Report for the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC). Western Regional Air Partnership, Denver, CO 80202.

using base period model and monitoring data to evaluate CMAQ performance[4]. Finally, the RMC has applied CMAQ to project 2018 visibility for each Class I area in the WRAP region, including the Theodore Roosevelt National Park and Lostwood Wilderness Class I areas in North Dakota.

To supplement work done by the WRAP RMC, the North Dakota Department of Health (NDDoH) has conducted further modeling analysis to address 2018 visibility goals for North Dakota Class I areas. Though the NDDoH utilized WRAP RMC results in assessing progress with respect to visibility goals in North Dakota Class I areas, the NDDoH also recognized it would have to develop further modeling capability for visibility projection in order to address weight of evidence issues not included in WRAP modeling, such as discounting the impact of international sources. In addition, the NDDoH had concerns regarding the spatial resolution of the WRAP CMAQ simulations, particularly for large point sources.

The RMC is applying CMAQ on a national basis using a grid resolution of 36 km, with no plume-in-grid treatment. This means that emissions from point sources are immediately mixed uniformly throughout a 36 km (square) grid cell volume, which may overstate the dilution of the plume, and the speed of chemical reactions for species contained in the plume. This may be problematic, especially for sources located relatively near Class I areas. Consequently, the contribution of visibility-affecting species from these sources may be misrepresented for both base period and future period modeling. This limitation in treatment of point sources is recognized in CMAQ documentation[5].

The NDDoH utilized a hybrid modeling approach for determining status with respect to the visibility goals. This approach involved nesting the local NDDoH CALPUFF domain within the WRAP National CMAQ domain, and applying the Lagrangian CALPUFF model in a retrospective sense to more realistically define plume geometry for local point sources. To implement the nesting, hourly output concentrations from WRAP CMAQ were used to set hourly boundary conditions for CALPUFF. The use of CMAQ output to set CALPUFF boundary conditions has been suggested by Escoffier-Czaja and Scire[6]. Location of the NDDoH CALPUFF domain within the National CMAQ domain is illustrated in Figure 8.1.

Given limitations in the CALPUFF chemistry for other species, the NDDoH hybrid modeling system was used for simulation of SO_2-SO_4-NO_X-HNO_3-NO_3 chemistry and transport, and thus sulfate (SO_4) and nitrate (NO_3) predictions, only. Results for all other visibility-affecting

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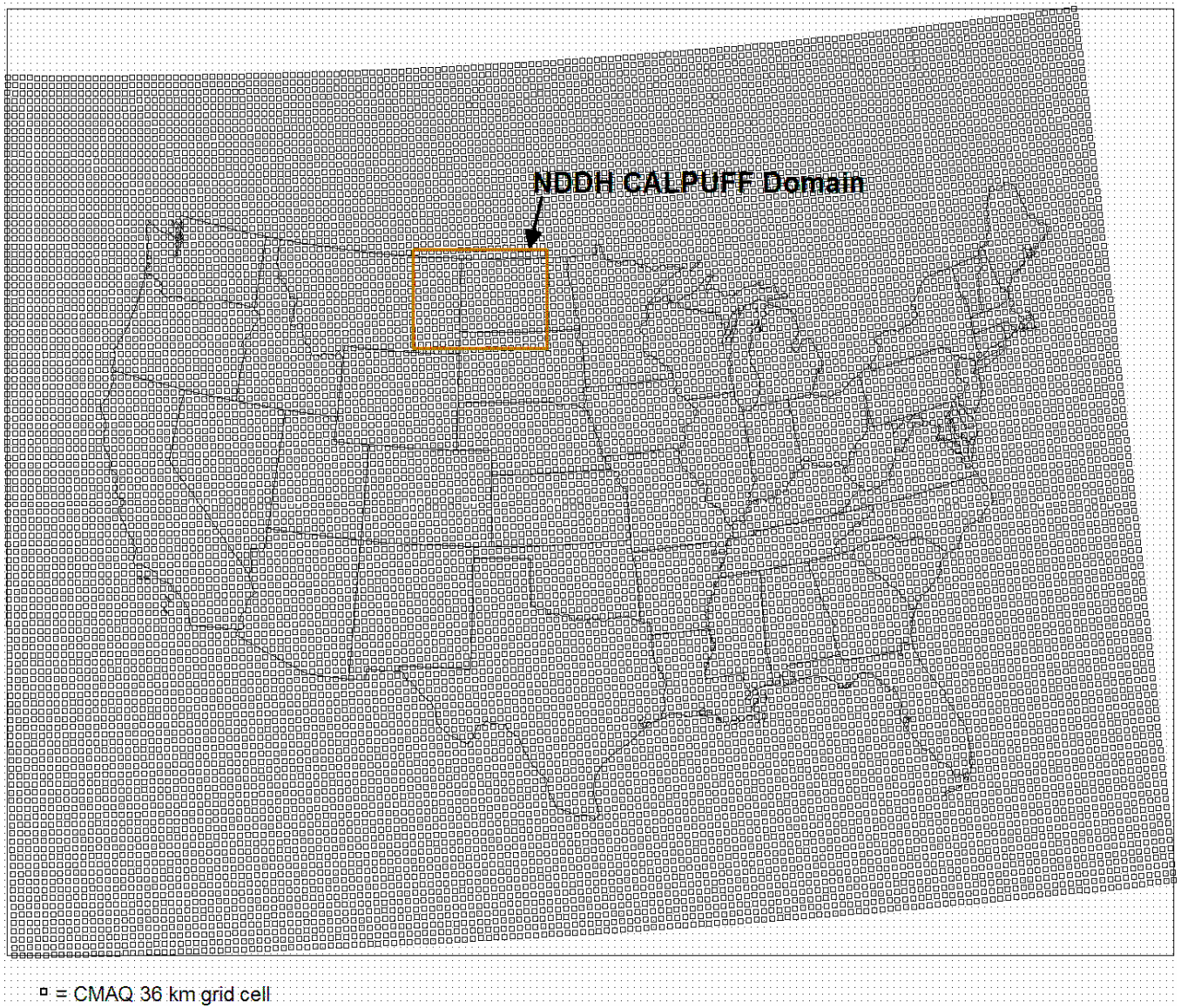
[4] See WRAP RMC web site at http://pah.cert.ucr.edu/aqm/308/

[5] EPA, 1999. Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. Office of Research and Development, Washington DC 20460.

[6] Escoffier-Czaja, C., and J. Scire, 2005. Comments on the Computation of Nitrate Using the Ammonia Limiting Method in CALPUFF. Appendix A, Draft Protocol for the Application of the CALPUFF Model for Analyses of Best Available Retrofit Technology (BART), VISTAS.

Figure 8.1
WRAP CMAQ Domain and NDDoH CALPUFF Domain



species, including organic carbon mass (OMC), elemental carbon (EC), fine particulate (Soil), and coarse particulate (CM), were obtained directly from the CMAQ output for the grid cell containing each subject Class I area IMPROVE monitor. CMAQ output was combined with CALPUFF results for sulfate and nitrate in order to perform necessary light extinction calculations. In this way, the NDDoH benefits from the sophistication of the RMC approach for other particulate components, which reflect a very small percentage of emissions from the local point sources of concern.

WRAP and NDDoH protocols for modeling visibility progress goals generally adhere to EPA *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*[7]. An evaluation of modeling system performance was conducted first. Then baseline (2000-2004) and future (2018) emission scenarios were modeled in order to develop relative response factors (RRFs). Finally, RRFs were applied to baseline IMPROVE monitoring data to project future visibility in North Dakota Class I areas.

Class I areas in North Dakota include the three units of Theodore Roosevelt National Park (TRNP), and the Lostwood Wilderness Area (LWA). IMPROVE monitors are located at the TRNP South Unit and LWA, only. Therefore, these two Class I areas were the focus of the modeling analyses. Locations of North Dakota Class I areas, IMPROVE monitor sites, and larger visibility-affecting sources are depicted in Figure 8.2.

While this presentation (Section 8) addresses both WRAP and NDDoH visibility modeling analyses, focus is on the NDDoH modeling as WRAP procedures are extensively documented elsewhere. The WRAP protocol for regional haze visibility modeling is summarized in *2006 Report for the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC)*[8]. The NDDoH protocol for regional haze progress goal modeling is attached as Appendix E to this document.

8.2 Regional Haze Metrics

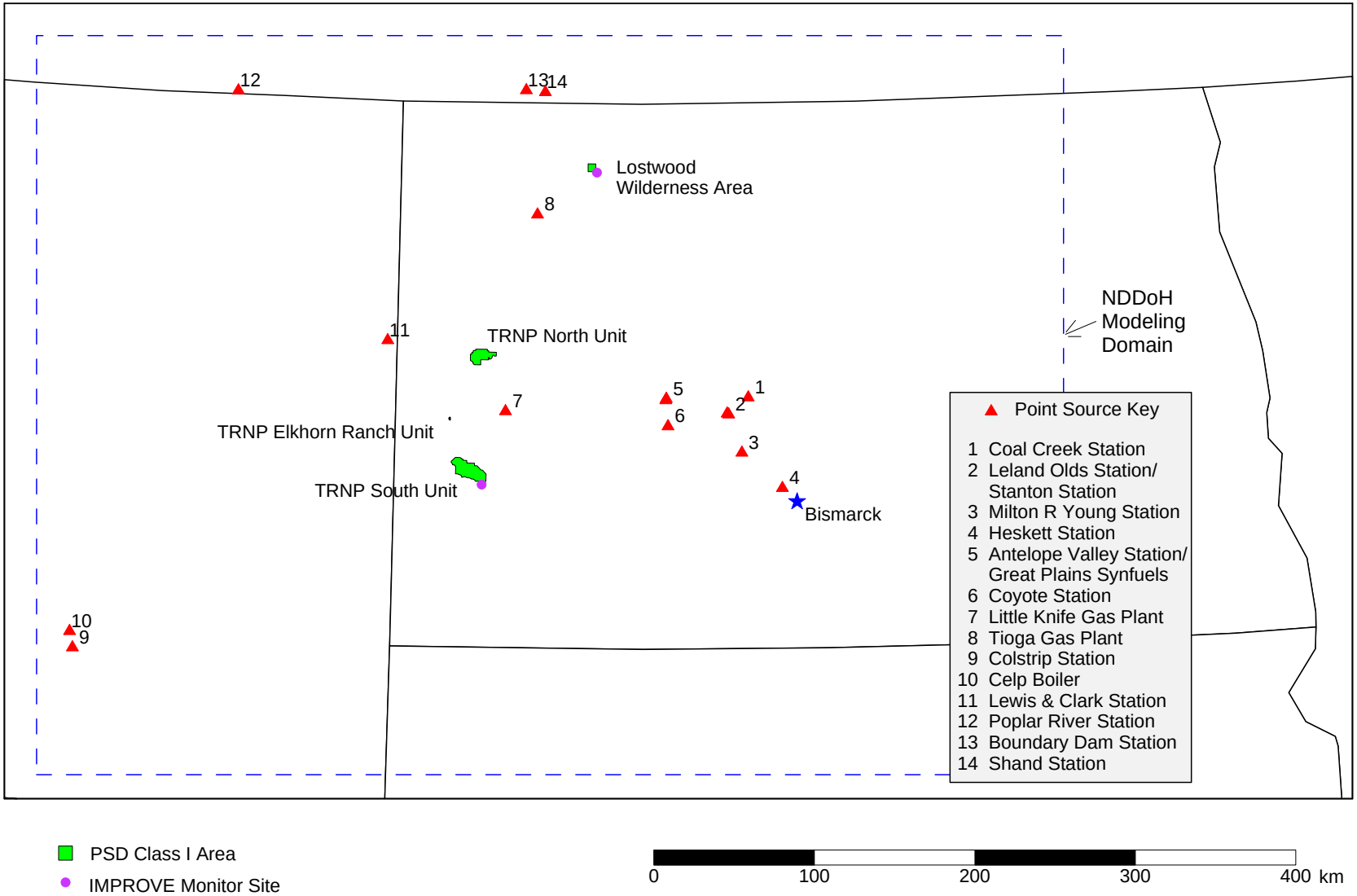
To address progress in visibility improvement, modeling is used to provide mass concentrations of visibility-affecting species. These concentrations are translated into light extinction using the IMPROVE algorithm. Finally, light extinction is converted to deciviews to accommodate comparison with visibility goals. Use of the deciview metric to assess baseline visibility, natural visibility, and improvement in visibility was discussed in Section 5.

Calculation of light extinction from visibility-affecting aerosol concentrations for the WRAP

[7] EPA, 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze. Publication No. EPA 454/B-07-002, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

[8] See supra note 3.

Figure 8.2
Larger Point Sources and PSD Class I Areas



RMC and NDDoH regional haze analyses is based on the "new" IMPROVE algorithm[9]. This new system was seen to reduce bias associated with use of the "old" IMPROVE algorithm, and was adopted as an alternative by the IMPROVE Steering Committee in December 2005. The new algorithm splits ammonium sulfate, ammonium nitrate, and organic mass concentrations into two fractions: small and large. The new algorithm for light extinction is:

$$
\begin{aligned}
b_{ext} = \; & 2.2 \times f_s(RH) \times [\text{small amm. sulfate}] + 4.8 \times f_L(RH) \times [\text{large amm. sulfate}] \\
& + 2.4 \times f_s(RH) \times [\text{small amm. nitrate}] + 5.1 \times f_L(RH) \times [\text{large amm. nitrate}] \\
& + 2.8 \times [\text{small organic mass}] + 6.1 \times [\text{large organic mass}] \\
& + 10.0 \times [\text{elemental carbon}] \\
& + 1.0 \times [\text{fine soil}] \\
& + 1.7 \times f_{ss}(RH) \times [\text{sea salt}] \\
& + 0.6 \times [\text{coarse mass}] \\
& + \text{Rayleigh scattering (site-specific)} \\
& + 0.33 \times [NO_2 \text{ (ppb)}]
\end{aligned}
$$

where

b_{ext} = light extinction in units of inverse megameters (Mm^{-1}),
$f_s(RH)$ = function of relative humidity for small size fraction,
$f_L(RH)$ = function of relative humidity for large size fraction,
$f_{ss}(RH)$ = function of relative humidity for sea salt,
all species concentrations (with exception of NO_2) are provided in ug/m^3,
amm. sulfate / amm. nitrate means ammonium sulfate / ammonium nitrate.

Apportionment of total sulfate concentrations into small and large size fractions is defined:

$$[\text{large amm. sulfate}] = \frac{[\text{total amm. sulfate}]^2}{20\ ug/m^3}, \text{ for } [\text{total amm. sulfate}] < 20\ ug/m^3$$

$$[\text{large amm. sulfate}] = [\text{total amm. sulfate}], \text{ for } [\text{total amm. sulfate}] \geq 20\ ug/m^3$$

$$[\text{small amm. sulfate}] = [\text{total amm. sulfate}] - [\text{large amm. sulfate}]$$

Similar equations are used to apportion total ammonium nitrate and total organic matter concentrations into small and large size fractions.

A solution for the NO_2 term in the extinction algorithm is problematic as the IMPROVE network does not include NO_2 sampling. However, WRAP and the NDDoH have determined that the NO_2 term has very little impact on total light extinction. A review of observational NO_2 data from an NDDoH monitoring site in Theodore Roosevelt National Park revealed that readings were less than the minimum detectable level of 2.0 ppb more than 80% of the time in 2002.

[9] IMPROVE, 2005. New IMPROVE algorithm for estimating light extinction approved for use. The IMPROVE Newsletter, Volume 14, Number 4. Air Resource Specialists, Inc., Fort Collins, CO 80525.

Accordingly, both WRAP and the NDDoH have omitted the NO_2 term in analyses for future visibility.

The IMPROVE network does include sampling for sea salt. But monitored values are very low in North Dakota Class I areas. Further, the WRAP RMC found that the CMAQ model was not a reliable predictor for sea salt. Therefore, WRAP has omitted sea salt as a modeled species, and both WRAP and the NDDoH are assuming a relative response factor of 1.0.

Light extinction is converted to deciview using the following relationship:

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

where

dv = deciview,
b_{ext} = light extinction in units of inverse megameters (Mm^{-1}).

Visibility goals are generally expressed as deciviews.

8.3 Projection of Future Visibility

Methodology for WRAP and NDDoH projection of future visibility is based on EPA *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*[10]. The guidance proposes a relative modeling approach to project future (2018) visibility, in order to determine compliance status with respect to visibility goals at Class I areas. Implementation of the relative modeling approach relies on relative response factors (RRFs) which represent the modeled impact of the future (visibility affecting) source emissions inventory divided by the modeled impact of the baseline source inventory at Class I areas. These RRFs are applied to baseline IMPROVE monitoring data to project future visibility for each Class I area.

Per the Regional Haze Rule, projection of future visibility is needed for the 20% worst and 20% best visibility days at each Class I area. The 20% worst days and 20% best days are determined from Class I area IMPROVE monitoring data for each year for the 5-year baseline period 2000-2004. Because IMPROVE sampling occurs once every three days, the maximum number of monitored days per year would be 122, and the maximum number of 20% worst or best days per year would be 24.

According to the EPA guidance, worst-day RRFs are developed by comparing the future average predicted mass concentration for 20% worst days to the baseline average predicted mass concentration for 20% worst days, for each visibility affecting species. The 20% worst modeled days are temporally consistent with the worst monitored days, which requires that modeling is

[10] See supra note 7.

based on 2000-2004 meteorological data (i.e., meteorological data used for modeling represents the same period as baseline monitoring), if all five years are modeled[11]. For each visibility affecting species (SO_4, NO_3, OMC, EC, Soil, CM), a single RRF is developed for each Class I area. The RRF is calculated by dividing the predicted future concentration averaged over all worst days by the predicted baseline concentration averaged over all worst days. Then, future concentrations for each species are projected by multiplying the RRF by the observed species concentration on each of the baseline worst days. The same process is used to develop best-day RRFs, and project best-day concentrations.

The RRF approach can be expressed mathematically:

$$X^{i,j}_{of} = X^{i,j}_{ob}\,(RRF^{i}) = X^{i,j}_{ob}\,(\bar{X}^{i}_{pf}/\bar{X}^{i}_{pb})$$

where

$X^{i,j}_{of}$ represents projected observed future concentration for species i on day j (each of 20% worst days for each baseline year),

$X^{i,j}_{ob}$ represents **o**bserved baseline (IMPROVE data) concentration for species i on day j (each of 20% worst days for each baseline year),

$\bar{X}^{i}_{pf}$ represents average predicted future concentration for species i (average of 20% worst days),

$\bar{X}^{i}_{pb}$ represents average predicted baseline concentration for species i (average of 20% worst days),

RRF^{i} represents the relative response factor for species i.

The same system is applied to project 20% best day concentrations.

The set of projected future worst-day concentrations (including all species above) is converted to light extinction through application of the IMPROVE equation (Section 8.2) for each day, then daily light extinction is converted to deciview for each day. Finally, projected daily deciview is averaged over all worst-case days for each year, then averaged over all years to produce the single future value needed to address visibility goals for each Class I area. This procedure is repeated for projected future best-day concentrations.

Both the WRAP RMC and the NDDoH followed this general methodology for projecting future visibility-affecting species concentrations, and subsequently, worst day and best day future deciview.

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[11] Because of the resource demands of the CMAQ model, the WRAP RMC limited their visibility modeling analysis to the use of 2002 meteorology, only. Consequently, the NDDoH analysis was likewise limited to 2002 meteorology. The RRFs developed from modeling based on 2002 meteorology were then applied to all five years of monitoring data for future projection.

8.4 WRAP Visibility Modeling Methodology

The Western Regional Air Partnership (WRAP) is a Regional Planning Organization (RPO) representing the western states, including North Dakota. WRAP is one of five RPOs which together cover all states in the country. These RPOs are responsible for assisting states in the development of State Implementation Plans (SIPs) and Tribal Implementation Plans (TIPs) to address requirements of the Regional Haze Rule, and to assist with other air quality issues.

WRAP has established a Regional Modeling Center (RMC) to conduct visibility modeling and provide technical modeling guidance to support regional haze SIPs and TIPs for western states. This RMC reflects a consortium of technical expertise from University of California Riverside, University of North Carolina, and ENVIRON International Corporation. With funding from the western states, the RMC conducted an extensive modeling effort to project future visibility for each Class I area in the western United States, including the Class I areas in North Dakota.

WRAP RMC visibility modeling methodology is largely described in *Final Report for the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC) for the Project Period March 1, 2004 through February 28, 2005*[12] and *2006 Report for the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC)*[13]. Specific documentation for most recent baseline and future modeling cases is provided in *2002 Planning Simulation Version D*[14] and *2018 Preliminary Reasonable Progress Simulation Version A*[15], respectively. These and other resources can be obtained from the WRAP web site at http://pah.cert.ucr.edu/rmc.

Primary modeling tools used by the WRAP RMC include:

- the Fifth-Generation Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5) meteorological modeling system,
- the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions modeling system,
- the Community Multiscale Air Quality (CMAQ) air quality modeling system, and

[12] Tonnesen, G., R. Morris, Z. Adelman, et. al., 2005. Final Report for the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC) for the Project Period March 1, 2004, through February 28, 2005. Western Regional Air Partnership, Denver, CO 80202.

[13] See supra note 3.

[14] WRAP, 2008. 2002 Planning Simulation Version D. Western Regional Air Partnership, Denver, CO 80202.

[15] WRAP, 2008. 2018 Preliminary Reasonable Progress Simulation Version A. Western Regional Air Partnership, Denver, CO 80202.

- the PM Source Apportionment Technology extension (PSAT) of the Comprehensive Air Quality Model (CAMx).

The modeling domain established by the RMC includes all of the contiguous United States, and parts of Mexico and Canada (see Figure 8.1). The RMC used the MM5 model to develop the meteorological fields necessary for execution of CMAQ and PSAT within the domain. Grid cell size was specified as 36 kilometers in the horizontal direction, and vertical structure was defined by 19 layers of varying depth. Because of resource and time constraints (primarily related to CMAQ and PSAT), preparation of meteorological data was limited to Year 2002 of the baseline period.

Emissions inventory development for WRAP RMC visibility modeling relied primarily on the EPA National Emissions Inventory (NEI), and information collected from states and other RPOs. County emissions data for visibility affecting species, as well as all other species necessary to execute the chemistry in CMAQ and PSAT, were collected and processed into the format required by SMOKE. Then SMOKE was executed to apportion emissions to the appropriate grid cell and vertical layer within the modeling domain, on an hourly basis. Where appropriate, temporal emissions patterns were applied during the execution of SMOKE. All source categories shown in Table 8.1 were accounted for in the processing of emissions data in SMOKE.

Table 8.1
WRAP RMC Source Categories

Source Category	
Stationary Point Sources	Road Dust
Stationary Area Sources	Fugitive Dust
On-Road Mobile	Wind-Blown Dust
Off-Road Mobile	Wild Fires
Biogenic	Natural Fires
Oil & Gas	Anthropogenic Fires
Offshore Platforms	Agricultural Ammonia
Offshore Shipping	

The WRAP RMC has included three basic emissions cases in their visibility modeling, for performance evaluation and the development of relative response factors.

- Case BASE02b reflects year 2002 emissions which are concurrent with the year 2002 meteorology. WRAP used this case for performance evaluations.

- Case PLAN02d reflects a composite interpretation of emissions for the 2000-2004 period. WRAP used this case for the baseline period to generate relative response factors.

- Case PRP18a (Preliminary Reasonable Progress 2018 Scenario A) reflects projected year 2018 emissions. Case PRP18a represents base period emissions projected to 2018, accounting for estimates of the effect of BART controls, and assuming other growth and control factors. WRAP used this case for the future period to generate relative response factors.

Note that WRAP recently completed modeling for an updated Case PRP18b future emissions scenario, as discussed in Section 6. Because NDDoH visibility modeling was initiated and largely completed well before the WRAP PRP18b emissions inventory and modeling results were available, however, Case PRP18b is not included in the visibility modeling results discussed in this SIP. For North Dakota sources, Case PRP18b reflects only a slight decrease in emissions relative to Case PRP18a. Therefore, results and conclusions of the visibility analyses reported here would not be meaningfully changed with the use of Case PRP18b emissions.

To define boundary conditions for the WRAP modeling domain, species concentrations for the perimeter of the domain were derived from the global GEOS-CHEM model.

Before beginning production modeling for development of RRFs, the WRAP RMC conducted extensive performance evaluations for both CMAQ and CAMx/PSAT. These performance evaluations were used to refine emissions inventories and other input conditions. CMAQ was subsequently applied to baseline (PLAN02d) and future (PRP18a) emissions inventories to generate RRFs and project future visibility in Class I areas. Development of RRFs and projection of future visibility followed default EPA methodology[16], as outlined in Section 8.3. Finally, PSAT was applied to assess source and species attribution for projected visibility impacts.

Results of WRAP RMC modeling for North Dakota Class I areas are reviewed in Section 8.6.2.

8.5 NDDoH Visibility Modeling Methodology

In support of the North Dakota Regional Haze SIP, the North Dakota Department of Health (NDDoH) conducted refined progress goal visibility modeling to supplement and update the modeling conducted by WRAP RMC. The NDDoH developed an in-house modeling capability to address weight of evidence issues, and concerns regarding the resolution of the WRAP CMAQ simulations, particularly as applied to large point sources located near Class I areas. As discussed in Section 8.4, WRAP RMC modeling focused on the default EPA methodology for regional haze[17], and did not address weight of evidence issues such as discounting the effect of

[16] See supra note 7.

[17] See supra note 7.

international source emissions. The RMC applied CMAQ on a regional basis using a grid resolution of 36 km, with no plume-in-grid treatment.

The NDDoH regional haze modeling constitutes a hybrid approach as it involved nesting the local NDDoH CALPUFF domain within the WRAP National CMAQ domain, and applying the Lagrangian CALPUFF model in a retrospective sense to more realistically define plume-receptor geometry for local point sources. To implement the nesting, hourly output concentrations from WRAP CMAQ modeling were used to set hourly boundary conditions for CALPUFF. CMAQ output used to set CALPUFF boundary conditions reflects corresponding WRAP cases for baseline and future emission inventories.

The hybrid modeling approach was used for simulation of SO_2-SO_4-NO_X-HNO_3-NO_3 chemistry and transport and, thus, sulfate and nitrate predictions, only. RRFs and projected future concentrations for other visibility affecting species, including organic carbon (OMC), elemental carbon (EC), fine particulate (Soil), and coarse mass (CM), were taken directly from the WRAP RMC results for North Dakota Class I areas. The deferral to WRAP CMAQ results for these species is based on limitations in the CALPUFF chemistry, and the fact that larger point sources located relatively near North Dakota Class I areas, where CMAQ resolution is a concern, are primarily emitters of SO_2 and NO_X. Further, IMPROVE measurements at North Dakota Class I areas indicate that sulfate and nitrate are primary contributors to light extinction on most worst-case days. Individual species contribution to light extinction for worst-case days at Theodore Roosevelt National Park is illustrated in Figure 8.3. Therefore, weight of evidence assessments should be most affected by changes in sulfate and nitrate concentrations.

The NDDoH used the hybrid modeling system in a supportive sense to add value to the original WRAP CMAQ modeling results for sulfate and nitrate. The hybrid system was used to adjust WRAP CMAQ results in order to offset coarseness in the CMAQ resolution for large local point sources, and in order to discount the effect of international (Canadian) sources. Procedures for adjusting WRAP CMAQ results are discussed in Section 8.5.6.

For hybrid modeling, the NDDoH used the State's point source inventory for SO_2 and NO_X, and has imported WRAP RMC data for all other source categories (and for point source SO_4 and NO_3) to apportion emissions within the CALPUFF domain. WRAP used the SMOKE emissions model[18] to develop the emissions inventory for CMAQ. The NDDoH has obtained and processed WRAP SMOKE output to define area source emissions for the CALPUFF domain. The CALPUFF area source emissions inventory includes the species SO_2, SO_4, NO_X, and NO_3. In addition, primary SO_4 and NO_3 emissions data were extracted from the SMOKE inventory for point sources, and apportioned to the CALPUFF domain as area sources. WRAP CMAQ source categories included in the CALPUFF emissions inventory are outlined in Table 8.2. Note that WRAP SMOKE output did not contain all four species for some source categories.

[18] University of North Carolina, 2007. SMOKE User's Manual. The Institute for the Environment, University of North Carolina.

Figure 8.3
IMPROVE 20% Worst Days – TRNP 2000

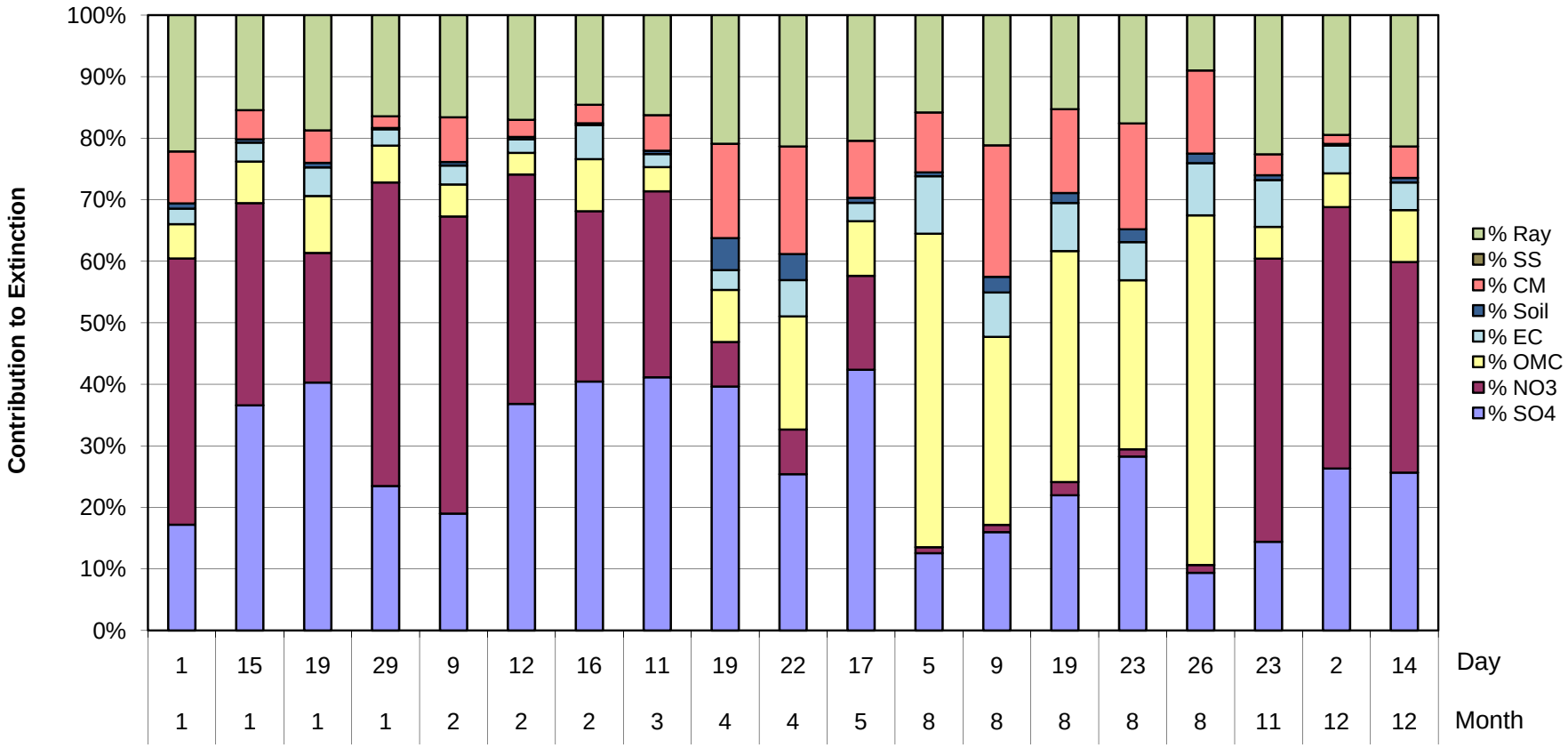


Table 8.2
CMAQ-CALPUFF Area Source Categories

Source Category	Species Included
All Fires	SO_2, NO_X, SO_4, NO_3
Biogenics	NO_X
Fugitive Dust	SO_4, NO_3
On-Road Mobile	SO_2, NO_X, SO_4
Off-Road Mobile	SO_2, NO_X, SO_4, NO_3
Road Dust	SO_4, NO_3
Oil & Gas	SO_2, NO_X
Conventional Area	SO_2, NO_X, SO_4, NO_3
Point	SO_4, NO_3

The interfacing of CMAQ and CALPUFF modeling systems for the NDDoH hybrid approach is illustrated in the flow diagram in Figure 8.4. Necessary software for processing input data and projecting future visibility has been developed by the NDDoH.

To confirm effectiveness of the hybrid CMAQ-CALPUFF modeling system, the NDDoH conducted a performance evaluation prior to commencing production modeling. The evaluation focused on performance of the hybrid system for sulfate and nitrate concentrations, and prompted changes to some model inputs to improve performance relative to observations. CMAQ performance evaluations conducted by WRAP RMC for OMC, EC, Soil, and CM species are also relevant. The NDDoH Performance evaluation is discussed in Section 8.6.1.

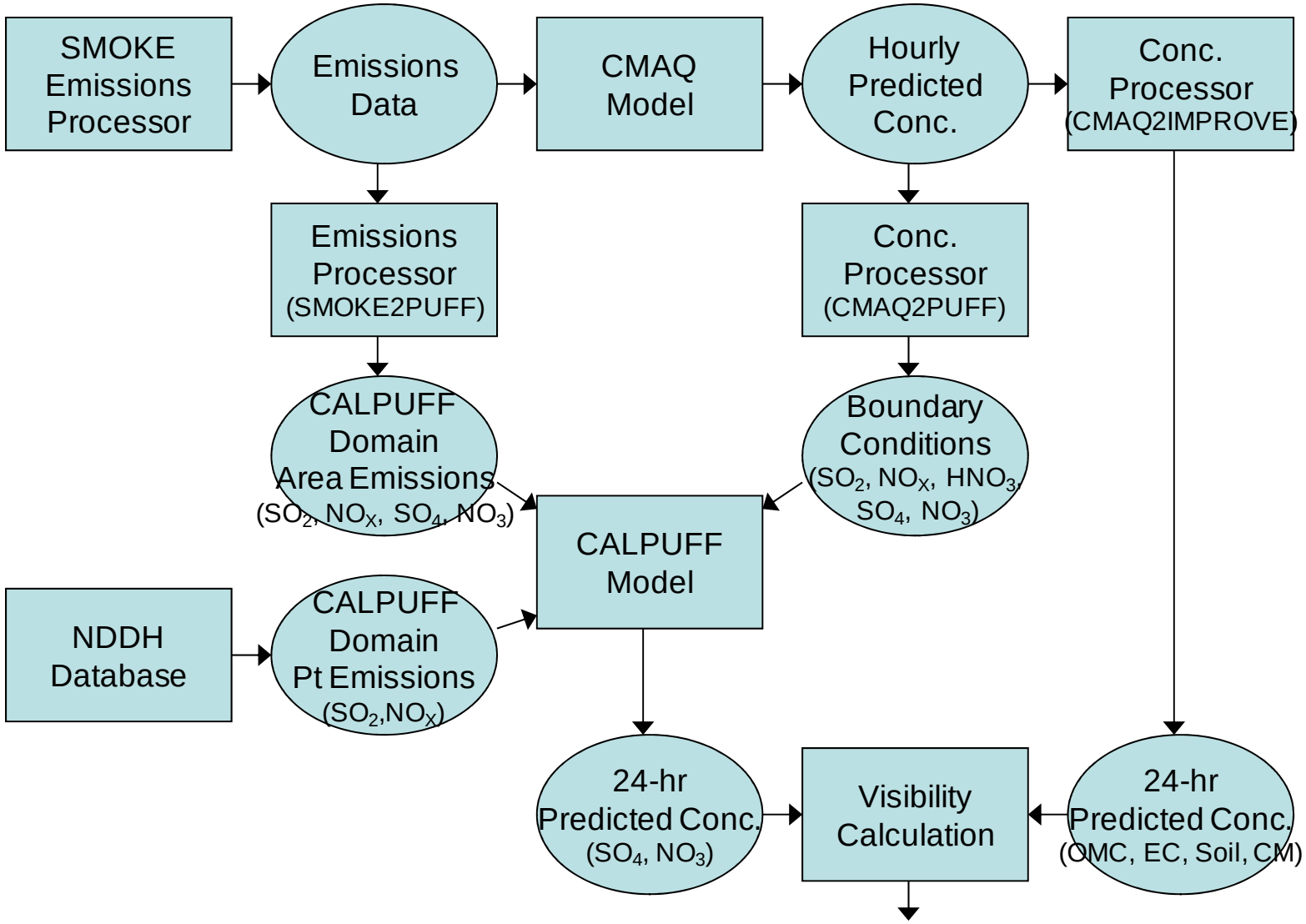
The NDDoH has obtained CMAQ emissions input data (SMOKE output) and hourly concentration output files from the WRAP RMC. CMAQ data used to set CALPUFF boundary conditions and develop the CALPUFF area source inventory will be based on WRAP cases BASE02b, PLAN02d, and PRP18a, for performance evaluation, baseline case, and future case modeling, respectively. These WRAP scenarios are described as follows.

- Case BASE02b reflects CMAQ modeling using year 2002 emissions with year 2002 meteorology. The NDDoH used this case for performance evaluations.

- Case PLAN02d reflects CMAQ modeling using composite 2000-2004 emissions with 2002 meteorology. The NDDoH used this case for the base period to generate relative response factors.

- Case PRP18a (Preliminary Reasonable Progress 2018 Scenario A) reflects CMAQ modeling using projected year 2018 emissions with 2002 meteorology. Case PRP18a represents base period emissions projected to 2018, accounting for estimates of the effect of BART controls, and assuming other growth and control factors. The NDDH used this case for the future period to generate relative response factors.

Figure 8.4
Hybrid Interfacing of CMAQ and CALPUFF Modeling Systems



Again, WRAP recently completed modeling for an updated Case PRP18b future emissions scenario, as discussed in Section 6. Because NDDoH visibility modeling was initiated and largely completed well before the WRAP PRP18b emissions inventory and modeling results were available, however, Case PRP18b is not included in the visibility modeling results discussed in this SIP. For North Dakota sources, Case PRP18b reflects only a slight decrease in emissions relative to Case PRP18a. Therefore, results and conclusions of the visibility analyses reported here, although conservative, would not be meaningfully changed with the use of Case PRP18b emissions.

The modeling system, emissions inventory, other model inputs, and procedures for the NDDoH regional haze modeling analysis are discussed in following Sections 8.5.1 through 8.5.6. A detailed, step-by-step outline of NDDoH visibility modeling procedure is also provided in Appendix E of this report.

Results of the NDDoH hybrid visibility modeling for North Dakota Class I areas are reviewed in Section 8.6.

8.5.1 Hybrid Modeling System

For sulfate and nitrate predictions, the NDDoH applied the CALPUFF model, using regional WRAP CMAQ output concentrations to set boundary conditions for the CALPUFF domain. The CALPUFF computer modeling system includes the CALMET meteorological model[19], the CALPUFF dispersion/chemistry model[20], and the POSTUTIL and CALPOST post processing programs. POSTUTIL implements the ammonia limiting method, which provides an adjustment to avoid overstating available ammonia for NO_x to NO_3 conversion chemistry in CALPUFF. In the NDDoH implementation of the CALPUFF system for production visibility modeling, the CALPOST processor was replaced with CALHAZE, a module which directly processes relative response factors and projects future visibility, using hourly output from CALPUFF (POSTUTIL) baseline and future model runs.

With the exception of CALHAZE (developed by NDDoH), CALPUFF and associated software was developed and is maintained by TRC Corporation (previously by Earth Tech, Inc.). The versions of CALPUFF and associated programs which the NDDoH utilized for regional haze modeling are summarized in Table 8.3.

[19] Earth Tech, Inc., 2000. A User's Guide for the Calmet Meteorological Model. Earth Tech, Inc., Concord, MA 01742.

[20] Earth Tech, Inc., 2000. A User's Guide for the Calpuff Dispersion Model. Earth Tech, Inc., Concord, MA 01742.

Table 8.3
CALPUFF System Versions
Applicable For Regional Haze Modeling

Program	Version	Level
CALMET	5.8	70623
CALPUFF	5.8	70623
POSTUTIL	1.56	70627

The meteorological/computational modeling domain used by the NDDoH for CALPUFF visibility modeling is illustrated in Figure 8.5. Dimensions of the domain are 639 kilometers east-west by 459 kilometers north-south, with a horizontal grid cell size of 3 kilometers. In the vertical, the domain is defined by twelve vertical layers. The domain is sized and positioned to encompass all large visibility-affecting point sources located within 250 km of North Dakota Class I areas. Because the domain is relatively large for CALPUFF modeling, all location coordinates are based on the Lambert Conformal map projection to mitigate distortions due to the earth's curvature.

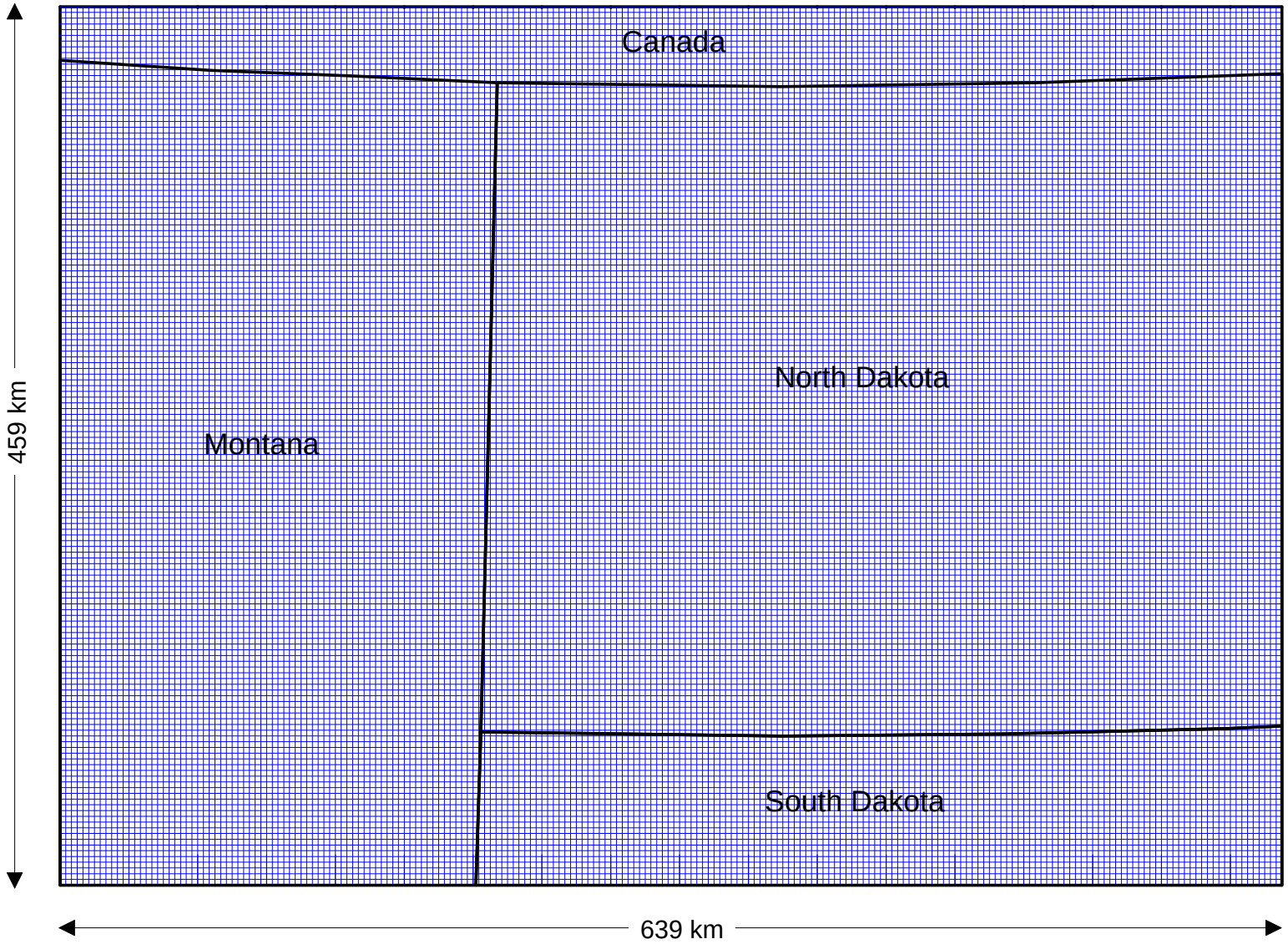
8.5.2 CALMET Input

Input requirements for the CALMET model include various meteorological and geophysical data sets, and a control input file with appropriate settings. Required meteorological data include surface, upper-air, and precipitation observations, and mesoscale model output data fields. Geophysical input data include terrain elevation and land-use data. Though CALMET may be run with mesoscale model meteorological data, alone (i.e., no observations), the EPA modeling guideline[21] recommends "blending" observations with the mesoscale model fields. Therefore, the NDDoH included surface and upper-air observations in a blended approach.

Because WRAP RMC modeling was limited to the single year 2002 meteorology due to resource limitations, the NDDoH hybrid approach was necessarily limited to the same single year of meteorology.

[21] CFR, 2005. EPA Guideline on Air Quality Models. 40 CFR (Code of Federal Regulations) Part 51, Appendix W.

Figure 8.5
CALPUFF 3-km Meteorological/Computational Grid



8.5.2.1 Meteorological Data

8.5.2.1.1 Mesoscale Model Data

NDDoH mesoscale model wind fields used with CALMET are based on the National Center for Environmental Predictions (NCEP) Rapid Update Cycle (RUC) forecast model. Mesoscale model fields in the MM5.DAT format required by CALMET were developed by a contractor[22]. The contractor obtained and archived RUC hourly initial analyses from NCEP for years 2000 through 2002. Resolution of these initial analyses was 40 km. The contractor used the ARPS Data Assimilation System (ADAS) to enhance resolution to 10 km, and converted the resultant hourly wind fields to the MM5.DAT format recognized by CALMET. The domain of these hourly wind fields is consistent with the CALMET/CALPUFF domain used by NDDoH (Section 8.5.1).

In the process of model performance evaluation, the NDDoH also tested the hybrid modeling system with the 2002 36-km MM5 data set prepared by the WRAP RMC for CMAQ modeling. Hybrid model performance was similar using either MM5 or RUC mesoscale data.

8.5.2.1.2 Surface Observations

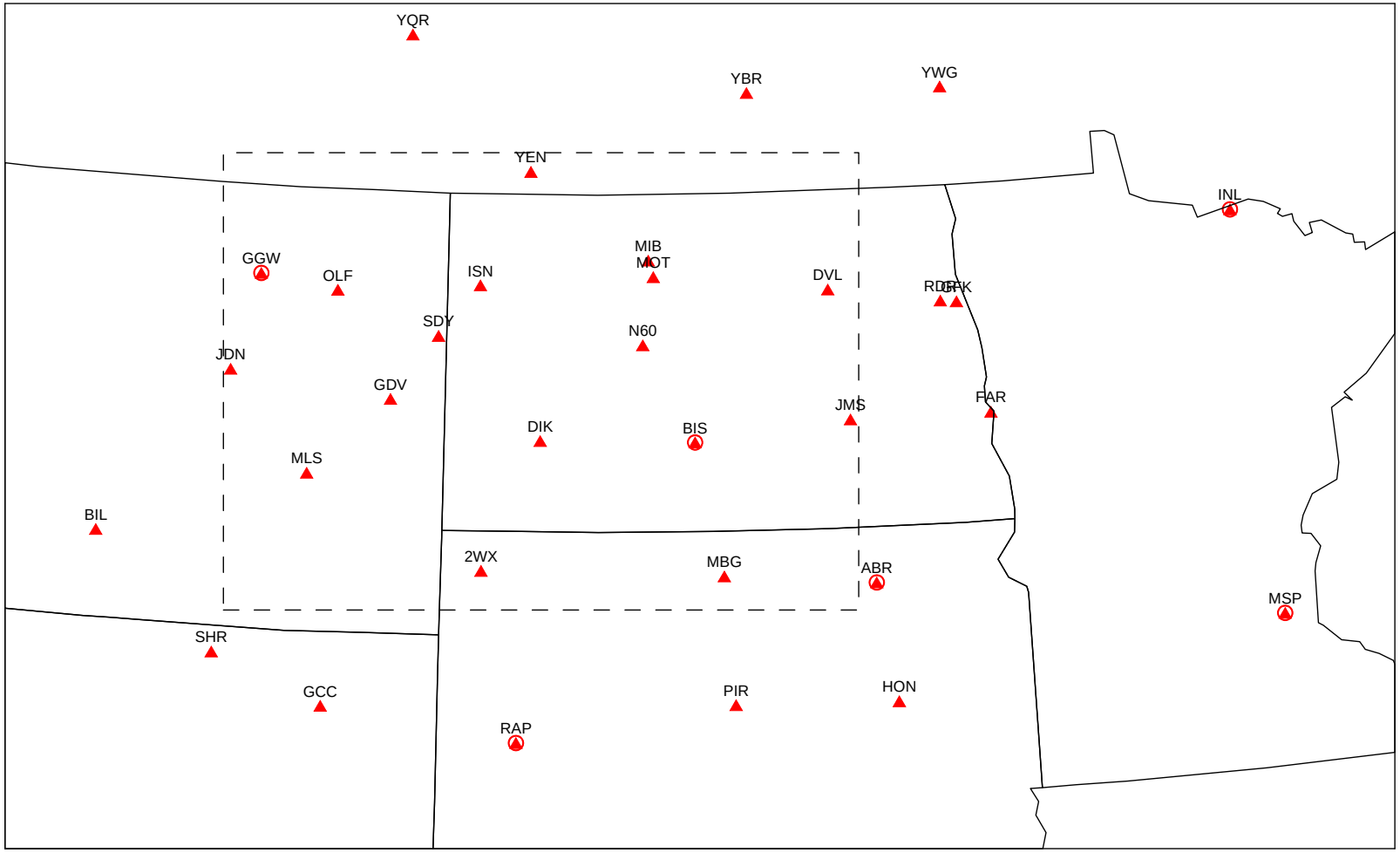
Concurrent surface observations for 2002 were obtained in surface hourly abbreviated format from the National Climatic Data Center (NCDC). Data were obtained for 40 ASOS and manual stations located within or near the NDDoH CALMET/CALPUFF domain. The ASOS/manual observations reflect data from stations operated by the National Weather Service, Federal Aviation Administration, U.S. Air Force, and Environment Canada. Locations of these stations are shown in Figure 8.6.

To compensate for well-documented deficiencies in ASOS cloud data above 12,000 feet, NDDoH also obtained concurrent GOES ASOS satellite cloud data for all selected surface stations. The satellite hourly observations included cloud amount (sky cover) and cloud height (ceiling height) data above 12,000 feet, and were therefore used to supplement the ASOS observations.

NDDoH prepared custom software to merge the ASOS and satellite data. Earth Tech utility software was then used to quality assure merged data, and convert to the format required by CALMET (SURF.DAT). Standard methods were applied to provide substitutions for missing

[22]WindLogics, 2004. RUC Analysis-Based CALMET Meteorological Data for the State of North Dakota. WindLogics, Inc., St. Paul, MN 55108.

Figure 8.6
CALMET Surface / Upper Air Meteorological Stations



▲ Surface Station

Surface + Upper-air Station

data.[23,24] The occurrence of missing data elements in the surface observations was generally very limited, and within the tolerances suggested by EPA.

8.5.2.1.3 Upper-Air Observations

Upper-air observations for 2002 were obtained from NOAA's Earth Systems Research Laboratories (ESRL) in Boulder, Colorado. Upper-air sounding files were downloaded from the website (www.fsl.noaa.gov) in the original FSL format, which is accepted for CALMET input as the option "NCDC CD-ROM". Data were obtained for six upper-air stations (NWS) located within or near the NDDoH CALMET/CALPUFF domain. Locations of these stations are also shown in Figure 8.6.

Processing of the upper-air data for CALMET input involved using Earth Tech utility software, running custom software written by NDDoH staff, and manual editing of data files. The main Earth Tech program quality checked the upper-air data files, output error messages to identify problems in the data to be corrected by the user, and converted the data to the format required by CALMET. The NDDoH custom software performed additional quality checks, and, combined with manual editing of data files, corrected additional errors or problems in the data and filled in for missing data when necessary. Substitutions for missing data generally followed standard EPA guidance. [22,23] Upper-air soundings were processed up to the 500-mb level to accommodate mixing heights up to 4000 meters above ground level at Rapid City, South Dakota. In addition, the main Earth Tech processing program had to be modified slightly (corrected) to correctly read longitude for Glasgow, Montana.

8.5.2.1.4 Precipitation Data

Hourly precipitation data for 2002 were obtained from NCDC in TD-3240 format. Data were included for 93 NWS hourly recording stations located within or near the NDDoH CALMET/CALPUFF modeling domain. Location of these stations is shown in Figure 8.7.

Earth Tech utility software was employed to quality assure the TD-3240 data, and process it into the format required by CALMET (PRECIP.DAT). No substitutions were made for missing data, because CALMET substitutes internally from the nearest available station, and the station resolution was relatively good (Figure 8.7).

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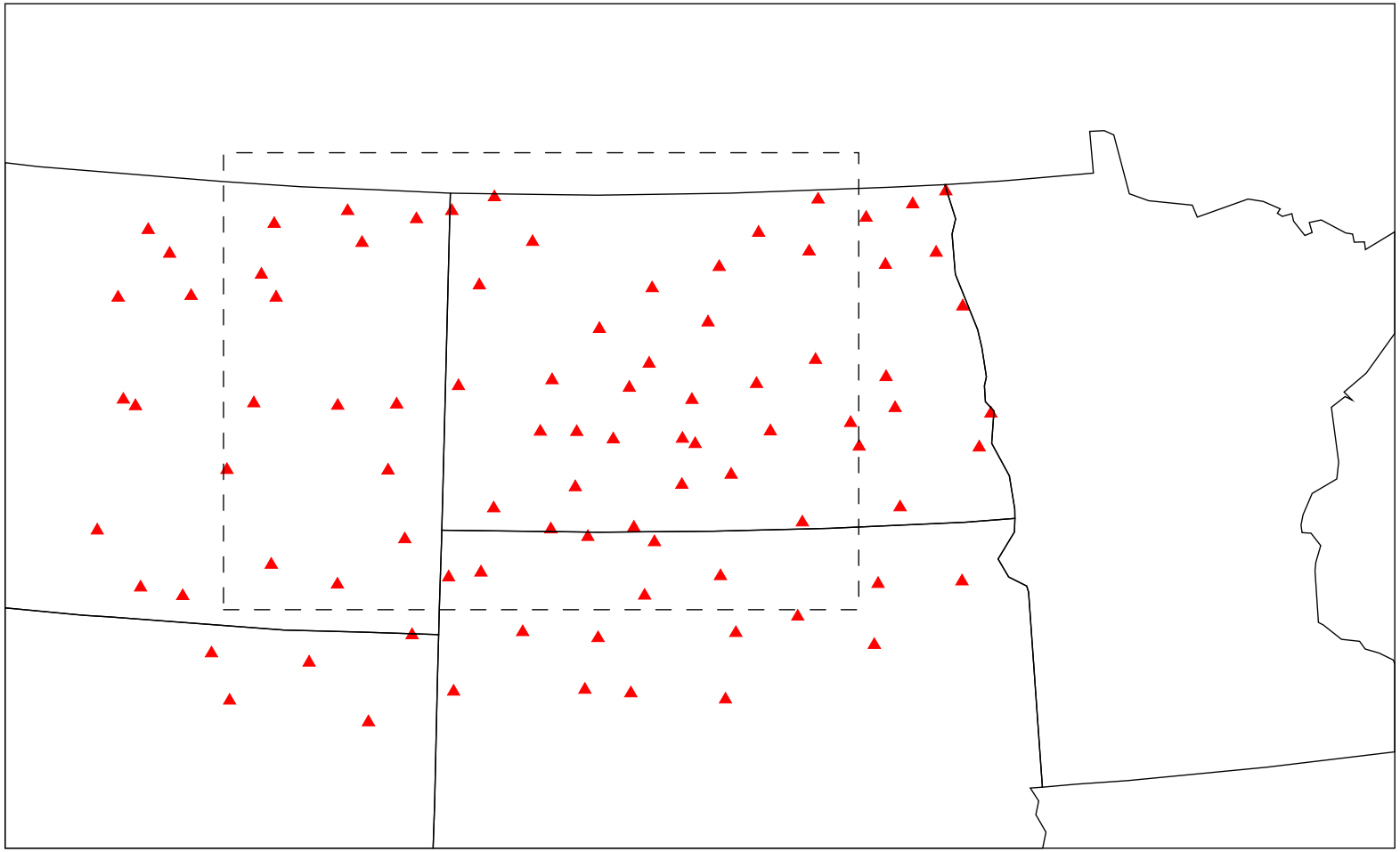
[23] Atkinson, D., and R. F. Lee, 1992. Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models.

[24] EPA, 1987. On-Site Meteorological Program Guidance for Regulatory Modeling Application. Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

Figure 8.7
CALMET Precipitation Stations



8.5.2.2 Geophysical Data

CALMET requires specification of terrain elevation, and parameters related to the land-use profile, for each grid cell in the modeling domain. The NDDoH derived terrain elevations from United States Geological Survey (USGS) GTOPO30 data sets for North America central and mountain zones. Land-use profiles were derived from the USGS Global Data Set for North America.

Using CALMET utility software, all gridded terrain and land-use data were processed into the single geophysical file (GEO.DAT) required by CALMET. NDDoH assumed default values relating surface roughness length, albedo, Bowen ratio, soil heat flux, and leaf area index to land-use type.

8.5.2.3 CALMET Control File Settings

CALMET control file settings used for processing year 2002 meteorological data for visibility analyses are generally consistent with guidance from the Interagency Workgroup on Air Quality Modeling (IWAQM)[25]. To the extent applicable, the settings are also consistent with the North Dakota alternative protocol for PSD Class I increment analyses[26].

IWAQM recommendations for CALMET control file variable settings fall into two categories. IWAQM-defined variables are those for which IWAQM provides a default value as a general recommendation for all analyses. User-defined variables are those where IWAQM recognizes the input value will need to be tailored for a given application, and default values are therefore not provided.

For visibility analyses, the NDDoH has established appropriate settings for user-defined variables, and has determined the need to adjust a limited number of IWAQM-defined variables from recommended values, as discussed below. The CALMET control file user-defined settings, as well as the IWAQM-defined settings which have been adjusted by NDDoH, are summarized in Table 8.4. IWAQM-defined settings adjusted by NDDoH have a shaded background in the Table.

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[25] EPA, 1998. IWAQM Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. Publication No. EPA-454/R-98-019, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

[26] NDDoH, 2005. A Proposed Alternative Air Quality Modeling Protocol to Examine the Status of Attainment of PSD Class I Increment. North Dakota Department of Health, Bismarck, ND 58506.

Most of the user-defined settings are intuitive, related to parameterization of the meteorological grid used with CALMET, as previously discussed. The remaining user-defined variables, (RMAX1, RMAX2, RMAX3, TERRAD, R1, R2) control the influence of mesoscale model data, station observations, and terrain features in development of the final wind field. Settings for these variables are based on the NDDoH alternative protocol for PSD Class I increment analyses.

NDDoH settings for IWAQM-defined variables are consistent with IWAQM recommendations, with limited exceptions as established in the alternative protocol for PSD Class I increment analyses. Because the use of mesoscale meteorological data is now being generally recommended for long-range modeling analyses, the IPROG variable has been changed from 0 to 14, which reflects use of MM5 format data (in this case RUC data) as the initial guess wind field. The ZUPWND setting has been changed for consistency with default values in recent versions of CALMET (the IWAQM setting reflected defaults for an older version of CALMET). Based on visual feedback testing, IWAQM settings for variables related to spatial averaging of mixing heights, MNMDAV and ILEVZI, were adjusted to provide averaging over a larger area.

Because the NDDoH CALMET/CALPUFF modeling domain extends into the western part of the upper Great Plains, maximum mixing height settings (ZIMAX/ZIMAXW) were increased from 3000 to 4000 meters to be consistent with maximum mixing heights reported for this region.[27] Note that the CALMET BIAS factors have no effect when mesoscale data are used as the initial guess wind field.

8.5.3 CALPUFF Input

Along with the CALMET-processed meteorological data, CALPUFF input requirements for NDDoH hybrid visibility modeling include emissions and stack data, background ozone data, background ammonia data, receptor locations, boundary conditions, and input control file settings. These CALPUFF input requirements are discussed here.

[27]Holzworth, 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. EPA Publication No. AP-101, Office of Air Programs.

Table 8.4
User-Defined and Non-IWAQM Settings
for CALMET Control File*

Variable	Description	Value
NSSTA	No. of surface stations	40
NUSTA	No. of upper-air stations	5
NPSTA	No. of precipitation stations	93
IBTZ	Base time zone	7
PMAP	Map projection (LCC=Lambert Conformal Conic)	LCC
FEAST	False easting at origin	0.0
FNORTH	False northing at origin	0.0
RLAT0	Origin latitude of projection	44.0N
RLON0	Central meridian of projection	102.0W
XLAT1	Latitude of 1st standard parallel for projection	46.0N
XLAT2	Latitude of 2nd standard parallel for projection	48.5N
DATUM	Datum-region for output coordinates	NWS-27
NX	No. of X grid cells	213
NY	No. of Y grid cells	153
DGRIDM	Grid spacing (km)	3.0
XORIGKM	Southwest grid cell X coordinate	-380
YORIGKM	Southwest grid cell Y coordinate	140
NZ	No. vertical layers	12
ZFACE	Cell face heights (m)	0.,20.,50.,90.,140.,200., 270.,370.,500.,1000., 1700.,2500.,4200.
NOOBS	No observation mode (0 = no)	0
IPROG	Use MM5.DAT file as initial guess wind field (14=yes)	14

Variable	Description	Value
RMAX1	Max. radius of influence of surface observation (km)	100
RMAX2	Max. radius of influence of upper-air observation (km)	200
RMAX3	Max. radius of influence over water (km)	200
TERRAD	Radius of influence of terrain features (km)	10
R1	Distance from a surface observation station at which the wind observation and the first guess field are equally weighted (km)	10
R2	Distance from an upper-air observation station at which the wind observation and the first guess field are equally weighted (km)	10
ISURFT	Surface station number used for the surface temperature for the diagnostic wind field module (Bismarck)	17
IUPT	Upper-air station number used to compute the domain-scale temperature lapse rate for the diagnostic wind field module (Bismarck)	1
ZUPWND	Bottom and top of layer through which the domain-scale winds are computed (m)	1.,2500.
MNMDAV	Max. search distance (in grid cells) for spatial averaging of mixing ht. and temperature	7
ILEVZI	Layer of winds used in upwind averaging of mixing heights	3
ZIMAX	Maximum over land mixing height (m)	4000.
ZIMAXW	Maximum over water mixing height (m)	4000.

*Shaded background indicates IWAQM-defined setting adjusted by NDDoH

8.5.3.1 Emissions Inventory

The emissions inventory utilized in the NDDoH hybrid visibility modeling analysis accounted for all SO_2-SO_4-NO_X-HNO_3-NO_3 emission sources located within and outside of the NDDoH CALPUFF domain. The impact of emission sources located outside of the domain was accounted for using the boundary condition feature of CALPUFF, with WRAP CMAQ output concentrations used to set appropriate boundary concentrations. Within the CALPUFF domain, all SO_2-SO_4-NO_X-NO_3 emissions were configured as conventional point and area sources.

Note that HNO_3 is not directly emitted by any visibility affecting source. However, HNO_3 is an important component of nitrate chemistry (both CMAQ and CALPUFF), and is provided as an output species in CMAQ. Therefore, HNO_3 is included as a boundary concentration for CALPUFF boundary conditions, but it is not directly emitted by any of the visibility affecting sources configured within the CALPUFF domain.

For SO_2-SO_4-NO_X-NO_3 sources located within the NDDoH CALPUFF domain and within the North Dakota border, stack data for point sources, including stack operating parameters and SO_2 and NO_X emission rates, were obtained from an internal Department database. Point source data were reviewed by NDDoH to confirm viability of all stack parameters, and emission rates were updated, if necessary, to reflect values representative of the 2000-2004 period.

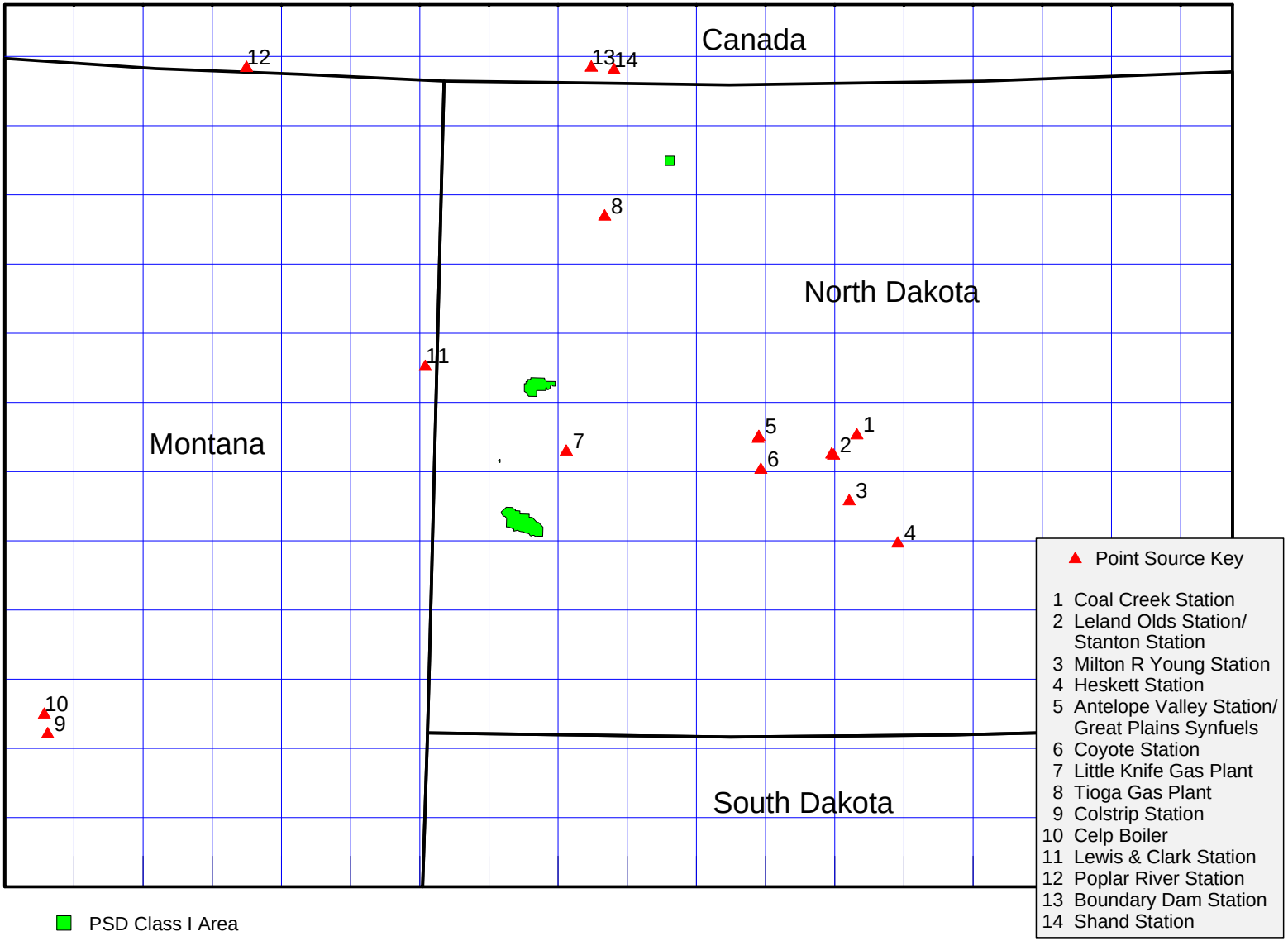
For SO_2 and NO_X point sources located within the NDDoH CALPUFF domain, but outside of North Dakota (South Dakota, Montana, Canada), the NDDoH obtained appropriate stack parameters and emission rates from governing agencies representing these jurisdictions. Most Montana data was obtained directly from the facility operators. Data representing the 2000-2004 period were requested. Data were reviewed by NDDoH to confirm viability of all stack parameters.

Note that the size threshold for configuring visibility-affecting sources as point versus area is generally connected to the availability of point source data in the National Emissions Inventory (NEI). All point sources included in the NEI (and located within the NDDoH CALPUFF domain) were configured as point sources for the visibility analysis. The exception is oil and gas related SO_2 sources for which the NDDoH maintains a separate database. These oil and gas related sources, though not included in the NEI, were also configured as point sources for the visibility analysis.

The location of larger visibility-affecting point sources within the CALPUFF domain is depicted in Figure 8.8.

All remaining SO_2-SO_4-NO_X-NO_3 sources located within the NDDoH CALPUFF domain, but not included in the North Dakota or adjoining jurisdiction's point source inventories, were configured as 36-kilometer area sources using a predefined grid structure in CALPUFF. The area-source grid is illustrated in Figure 8.8. Emission rates for the CALPUFF area source grid were developed using WRAP CMAQ input (SMOKE output) for the CMAQ grid cells located within the NDDoH CALPUFF domain. The NDDoH obtained the SMOKE output data from WRAP RMC. Because the location and orientation of the CMAQ and CALPUFF grids are not

Figure 8.8
NDDoH Domain - Locations of Larger Point Sources and 36-km Area Source Grid



consistent, software was developed by NDDoH to accurately apportion emissions from 36-kilometer CMAQ grid cells to the 36-kilometer CALPUFF area source grid.

Based on availability in WRAP SMOKE output, the CALPUFF area source emissions inventory included the source categories and species summarized in Table 8.2 . Note that SMOKE output did not include all four species (SO_2-SO_4-NO_X-NO_3) for some source categories. Although NDDoH developed a conventional point source inventory for SO_2 and NO_X, the NDDoH database did not include primary SO_4 and NO_3 emissions for point sources. Therefore, SO_4 and NO_3 emissions for the point source category were obtained from WRAP SMOKE output, and these components of point source emissions were configured as area sources in CALPUFF.

Based on testing during the performance evaluation, and on consultation with Joe Scire (TRC)[28,29], area sources in CALPUFF were configured for best model performance, and to be more consistent with the grid cell treatment in CMAQ. This involved proper settings for the CALPUFF "release height" and "initial sigma z" input parameters for area sources.

Emission rates used for both point and area sources reflect total actual tons per year. CALPUFF apportions these total emissions, on a temporal basis, equally to each hour of the year. The NDDoH tested the use of temporal profiles to vary emission rates on a seasonal, monthly, or hourly basis, but found that such adjustments made little difference in the hybrid model performance evaluation (see Section 8.6.1). For example, North Dakota electrical generating stations (EGUs) were modeled using an annual profile of actual hourly emissions for SO_2 and NO_X, and results (compared to default total tons per year modeling) were unchanged for most of the metrics included in the comparison. The NDDoH attributes this finding to the fact that the characterization of model output used for developing RRFs is the *average* of the 20 percent worst or best day predictions, and this longer-term average was also the focus of the performance evaluation. Using the average of 20 percent of the days in a year serves to dampen out differences attributable to shorter-term temporal variations in emissions.

To address hybrid model performance and the development of RRFs, the NDDoH prepared separate emissions inventories for base period, future period, and performance evaluation scenarios. SMOKE data used to apportion area source emissions was based on WRAP cases BASE02b, PLAN02d, and PRP18a for performance evaluation, base period, and future period modeling, respectively. These WRAP cases are described as follows.

- Case BASE02b reflects use of year 2002 emissions with year 2002 meteorology. NDDoH used this case for performance evaluations.

- Case PLAN02d reflects use of composite 2000-2004 emissions with 2002 meteorology. NDDH used this case for base period modeling to generate relative response factors.

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[28] TRC, 2008. Telephone consultation with Joe Scire, May 29, 2008. Joe Scire, TRC Corporation, Lowell, MA 01854.

[29] Joe Scire previously affiliated with Earth Tech, Inc.

- Case PRP18a (Preliminary Reasonable Progress 2018 Scenario A) reflects use of projected year 2018 emissions with 2002 meteorology. Case PRP18a represents base period emissions projected to 2018, accounting for estimates of the effect of BART controls, and assuming other growth and control factors. NDDoH used this case for future period modeling to generate relative response factors.

To complete emission inventories for the three modeling scenarios, the NDDoH developed point source inventories (SO_2 and NO_X) consistent with the WRAP cases. For EGUs, the inventory for performance evaluation was based on actual emissions for 2002, while the base period inventory assumed the five-year average of 2000-2004 actual emissions. The future period inventory for EGUs included emission reductions consistent with BART controls (see Section 6.2), but remained consistent with base period emissions for non-BART facilities. The possible addition of new EGUs was also accounted for in the future inventory (e.g., the potential "Gascoyne 500" EGU was added to the future inventory).

For point sources other than EGUs (reflecting generally small sources), the source inventory for performance evaluation was based on 2002 actual emissions, and the inventory for base period and future period modeling was relatively consistent with that used for the performance evaluation. For non-EGU point sources, little change in the emissions inventory is expected between base and future periods. Emissions increases associated with new sources will be no greater (and likely less) than emissions decreases associated with retiring sources.

When considering weight of evidence options in the NDDoH hybrid visibility modeling analysis, emissions inventories as described above were adjusted to eliminate sources. For example, when exercising the option to discount the impact of international sources, all Canadian sources of visibility affecting emissions (SO_2-SO_4-NO_X-NO_3) were eliminated from the base and future period inventories (see Section 8.6.3.1). Weight of evidence assumptions are discussed in Section 8.6.3.

In developing its emission inventories for hybrid modeling using the default EPA methodology, as well as weight of evidence options, the NDDoH adjusted WRAP future period emissions (PRP18a) for NO_X associated with oil and gas related sources. The total North Dakota oil and gas NO_X emissions estimated by WRAP for the future inventory was about 4.5 times higher than the total estimate for the baseline inventory. Based on recent projections from the North Dakota Department of Mineral Resources, oil and gas activity in 2018 is expected to be about 2 to 2.5 times higher than the 2002 level.[30] Moreover, in a subsequent telephone consultation, WRAP representatives admitted that 2018 estimates of NO_X related to oil and gas activity in North Dakota may have been overstated[31]. Therefore, the NDDoH applied a constant correction to WRAP future oil and gas NO_X emissions for all area sources in North Dakota, such that total 2018 emissions are 2.5 times higher than total baseline emissions for oil and gas related NO_X.

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[30] ND Department of Mineral Resources, 2008. December 2, 2008 Electronic Communication from Lynn Helms to Terry O'Clair.

[31] WRAP, 2008. December 12, 2008 Telephone Communication between representatives of WRAP and NDDoH.

The NDDoH also had concerns regarding WRAP estimates of future Soil (fine particulate) emissions. Because the NDDoH is not directly modeling the Soil species, this concern was related to the RRF developed by WRAP for North Dakota Class I areas. The Soil RRFs applied by WRAP are 1.13 for TRNP and 1.11 for LWA. Both values imply some significant increase in future Soil emissions (or precursors). Given recent increases in the practice of conservation tillage farming in North Dakota and adjoining states, and recent decreases in the existence of summer fallow (retiring a portion of cultivated land for one growing season), an increase in Soil emissions between the baseline and 2018 seems unlikely, with a decrease probable. This issue is discussed in more detail in Section 9.5.2. The NDDoH addressed the Soil inconsistency by adjusting the TRNP and LWA RRFs to 1.0 to implement the default EPA methodology, as well as weight of evidence options. This value is probably still conservative, but more in line with current and predicted future farming practices than RRFs developed by WRAP.

8.5.3.2 Boundary Conditions

Boundary conditions account for the additive impact of all emission sources located outside of the CALPUFF domain. Out-of-domain source emissions generally constitute a large component of total predicted concentrations for sulfate and nitrate species.

The NDDoH is using the boundary condition feature of CALPUFF to effectively nest the CALPUFF domain within the WRAP CMAQ domain to facilitate its hybrid modeling approach. The use of CMAQ output to set CALPUFF boundary conditions has been suggested by Escoffier-Czaja and Scire[32]. Location of the NDDoH CALPUFF domain within the WRAP CMAQ domain was illustrated in Figure 8.1.

To implement the feature in CALPUFF, a supplemental boundary condition data file must be provided as part of the CALPUFF input conditions. In this file, the user provides the length and location of boundary segments which follow the perimeter of the Calpuff domain. For each segment, the concentration of each species being modeled is provided, and an air mass depth is assigned. Species concentrations for boundary segments can be updated as frequently as hourly.

For NDDoH hybrid visibility modeling, the length of boundary segments was set to match the resolution of the CALPUFF meteorological/computational grid, which is 3 kilometers. Accordingly, a boundary segment was placed adjacent to each computational grid cell along the perimeter of the domain. Boundary segment hourly concentrations for SO_2-SO_4-NO_X-HNO_3-NO_3 species were taken from CMAQ hourly output concentration files provided by WRAP RMC. For each segment, concentrations from the 36-km CMAQ grid cell containing the largest part of the segment were utilized. A constant air mass depth of 3000 meters was assumed for all boundary segments. (Though air mass depth of 1000-2000 meters is nominally suggested in

[32] See supra note 6.

guidance for CALPUFF boundary conditions[33], the NDDoH found the use of 3000 meters provided better agreement with observations in performance evaluations.)

Separate boundary condition files were prepared for cases BASE02b, PLAN02d, and PRP18a for performance evaluation, baseline, and future hybrid modeling, respectively.

8.5.3.3 Ozone Background

CALPUFF utilizes background ozone values in its chemistry module. The model accepts either a single constant background ozone value, or an input file of hourly ozone values commensurate with the period of meteorological data. The NDDoH uses the hourly ozone file option with CALPUFF, and would regard this as the appropriate implementation for visibility modeling (this is also the IWAQM default option). The hourly ozone file was constructed using year 2002 hourly ozone data obtained from four NDDoH monitoring sites located within the corridor of primary plume transport between major electric generating stations and Theodore Roosevelt National Park (TRNP). These monitoring sites include Hannover, Beulah, Dunn Center and TRNP South Unit. As indicated in Section 8.5.3.6, a constant ozone background value (30 ppb) is also provided in the CALPUFF control file, so that it can be substituted when the hourly value is missing. This value represents the approximate annual average for North Dakota ozone monitoring sites.

8.5.3.4 Ammonia Background

The need for ammonia background concentrations in CALPUFF is also related to chemistry processing. CALPUFF accepts either a single annual value, or twelve monthly averages from a single site. To achieve a more realistic seasonal progression of sulfate and nitrate predictions, the NDDoH used monthly average ammonia background values for CALPUFF hybrid visibility modeling input (note that temporal ammonia resolution is improved to hourly in the POSTUTIL processing step described in Section 8.5.4).

Monthly average ammonia concentrations suitable for visibility modeling in North Dakota are provided in Table 8.5. These values were derived from data collected at the State's ammonia monitor located near Beulah. Hourly monitor data from years 2001-2002 (data not available for year 2000) were filtered to eliminate data from wind directions associated with sources causing a local bias, then remaining data were processed to produce the monthly averages. The Table 8.5 values should be generally representative of background ammonia concentrations in western North Dakota.

[33] See supra note 6.

Table 8.5
Monthly Ammonia Background Concentrations*

Month	Value (ppb)
Jan	1.22
Feb	1.23
Mar	1.60
Apr	1.94
May	2.29
Jun	1.63
Jul	1.65
Aug	1.69
Sep	0.98
Oct	1.04
Nov	1.37
Dec	1.06

* Data reflect NDDoH Beulah monitoring site.

8.5.3.5 Receptors

Receptors for NDDoH visibility progress goal modeling are located at the TRNP and Lostwood NWA IMPROVE monitoring sites. In its guidance for regional haze modeling[34], EPA recommends including nearby receptors or grid cells in order to provide spatial averaging of the design concentration. Use of a spatial average addresses possible "migration" of the predicted peak, and some uncertainties in the formulation of the model and model inputs. Therefore, the NDDoH used a 3 by 3 receptor grid (9 receptors) which is centered on the IMPROVE site, at each Class I area. Receptor spacing in the grid is 5 kilometers. Receptor elevation was set to the ground elevation of the IMPROVE monitor site for all 9 receptors in the grid.

Recognizing that visibility is not necessarily a "ground level" concept, the NDDoH also tested the effect of elevated or "flag pole" receptors. A sensitivity test was conducted using a flag pole elevation of 18 meters, which is one-half the height of the surface layer used in WRAP CMAQ modeling. Results of this test showed a negligible difference compared to predictions for ground level receptors.

[34] See supra note 7.

8.5.3.6 CALPUFF Control File Settings

CALPUFF control file settings used for NDDoH hybrid visibility analyses are generally consistent with IWAQM guidance[35]. To the extent applicable, the settings are also consistent with the North Dakota alternative protocol for PSD Class I increment analyses[36].

IWAQM recommendations for CALPUFF control file settings fall into two categories. IWAQM-defined variables are those for which IWAQM provides a default value as a general recommendation for all analyses. User-defined variables are those where IWAQM recognizes the input value will need to be tailored for a given application, and default values are therefore not provided.

For visibility analyses, the NDDoH has established appropriate settings for user-defined variables, and has determined the need to adjust a limited number of IWAQM-defined variables from recommended values, as discussed below. The CALPUFF control file user-defined settings, as well as the IWAQM-defined settings which have been adjusted by NDDoH, are summarized in Table 8.6. IWAQM-defined settings adjusted by NDDoH have a shaded background in the table.

Most of the user-defined settings are intuitive, involving variables related to defining the meteorological/computational grid, variables related to the Lambert map projection, and the use of default values for dry and wet deposition parameterization. The variable IRESPLIT was set such that puffs are eligible for splitting on any hour of the day.

NDDoH settings for IWAQM-defined variables are equivalent to IWAQM recommendations, with exception of settings for a limited number of variables related to puff splitting, dispersion, and mixing height. Variable MSPLIT was set to allow puff splitting, as this option is generally recommended when modeling source-receptor distances of 200 km or more. Based on performance testing of the CALPUFF model for PSD Class I increment modeling[37], the NDDoH used adjusted settings for dispersion-related variables MDISP and MPDF, and for variables IVEG and ROLDMAX, as these adjustments provided better model performance. NDDoH settings for MDISP and MPDF, reflecting the use of micrometeorological variables in calculating dispersion, are also more consistent with dispersion treatment in the local-scale model AERMOD[38]. Values for background ozone and ammonia (variables BCKO3 and

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[35] See supra note 20

[36] See supra note 21.

[37] See supra note 21.

[38] EPA, 2004. User's Guide for the AMS/EPA Regulatory Model – AERMOD. Publication No. EPA-454/B-03-001, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27701.

Table 8.6
User-Defined and Non-IWAQM Settings
for CALPUFF Control File*

Variable	Description	Value
IBTZ	Base time zone	7
NSPEC	Number of chemical species	5
NSE	Number of chemical species emitted	4
MSPLIT	Allow puff splitting (1=yes)	1
MDISP	Method used to compute dispersion coefficients	2
MPDF	PDF used for dispersion under convective conditions (1=yes)	1
PMAP	Map projection (LCC=Lambert Conformal Conic)	LCC
FEAST	False easting at origin	0.0
FNORTH	False northing at origin	0.0
RLAT0	Origin latitude of projection	44.0N
RLON0	Central meridian of projection	102.0W
XLAT1	Latitude of 1st standard parallel for projection	46.0N
XLAT2	Latitude of 2nd standard parallel for projection	48.5N
DATUM	Datum-region for output coordinates	NWS-27
NX	No. of X grid cells	213
NY	No. of Y grid cells	153
NZ	No. vertical layers	12
DGRIDM	Grid spacing (km)	3.0
ZFACE	Cell face heights (m)	0.,20.,50.,90.,140.,200.,270.,370.,500.,1000.,1700.,2500.,4200.
XORIGKM	Southwest grid cell X coordinate	-380
YORIGKM	Southwest grid cell Y coordinate	140

Variable	Description	Value
IBCOMP	Southwest X-index of computational grid	1
JBCOMP	Southwest Y-index of computational grid	1
IECOMP	Northeast X-index of computational grid	213
JECOMP	Northeast Y-index of computational grid	153
Dry Gas Dep.	Chemical parameters of gaseous deposition species	Model defaults
Dry Part. Dep.	Chemical parameters of particulate deposition species	Model defaults
IVEG	Vegetative state in unirrigated areas (2=active and stressed vegetation)	2
Wet Dep.	Wet deposition parameters	Model defaults
BCKO3	Monthly ozone background concentration (ppb)	30.0**
BCKNH3	Monthly ammonia background concentration (ppb)	Table 8.5
XMAXZI	Maximum mixing height	4000.
IRESPLIT	Hours when puff is eligible for vertical split	hours 1-24
ROLDMAX	Vertical puff split allowed only when the ratio of last hour's mixing height to max. mixing height experienced by the puff is smaller than this value	0.33
NSPLITH	Number of puffs that result when a puff is split horizontally	5
SYSPLITH	Minimum sigma-y (grid cell units) of puff before it may split horizontally	1.0
SHSPLITH	Minimum puff elongation rate (SYSPLITH/hr) due to wind shear, before it may split horizontally	2.0
CNSPLITH	Minimum concentration (g/m^3) in puff before it may split horizontally	1.0E-07
NREC	Number of discrete receptors	18

* Shaded background indicates IWAQM-defined setting adjusted by NDDoH
**Use same value for each month.

BCKNH3, respectively) were set to be consistent with local monitoring data. Maximum mixing height (XMAXZI) was set to 4000 meters for consistency with CALMET settings.

8.5.4 POSTUTIL Input

Because CALPUFF allows the full amount of the specified background concentration of ammonia to be available to each puff for forming nitrate, the same ammonia may be used multiple times, resulting in an overestimate of nitrate formation. The POSTUTIL processor provides repartitioning of total nitrate at the *receptor* location to adjust for over-counting of ammonia in the CALPUFF chemistry. This repartitioning in POSTUTIL is commonly referred to as the ammonia limiting method[39]. The repartitioning process in POSTUTIL generates a modified hourly concentration file in the same format as the input CALPUFF hourly concentration file. Species HNO_3 and NO_3, only, are modified in the repartitioning process. Concentrations for all other species remain unchanged.

To implement the ammonia limiting method, POSTUTIL requires an input control file, the hourly concentration output file from CALPUFF, and (optionally) an hourly file of ammonia background concentrations. Among other intuitive input assignments (file names and carryover of settings from CALPUFF), the POSTUTIL input control file specifies the setting for the MNITRATE parameter, which is related to the method of nitrate repartitioning. The control file also provides the source and temporal resolution for ammonia background concentrations to be used in nitrate repartitioning. POSTUTIL provides for the use of annual, monthly, or hourly ammonia background concentrations from a single site. By allowing use of hourly ammonia background, POSTUTIL improves on the maximum temporal resolution available in CALPUFF (monthly).

The POSTUTIL processor also accommodates the 3-step ammonia limiting method, which is used to determine the contribution of a subgroup of sources (from the complete source inventory) to total nitrate formation. Effectively, the 3-step method allows consideration of the effect of excluded sources on the model chemistry (e.g., excluded sources still "use up" some of the available ammonia). The MNITRATE parameter is used to control processing for each step of the 3-step sequence. The 3-step ammonia limiting method requires three separate executions of POSTUTIL. Input/output for the 3 steps, along with appropriate MNITRATE settings, is outlined in Table 8.7.

[39] Escoffier-Czaja, C., and J. Scire, 2002. The Effects of Ammonia Limitation on Nitrate Aerosol Formation and Visibility Impacts in Class I Areas. Earth Tech, Inc., Extended Abstract. 12th Joint Conference on the Applications of Air Pollution Meteorology with the Air and Waste Management Association, American Meteorological Society, J5.13.

Table 8.7
3-Step Ammonia Limiting Method

Step	MNITRATE Setting	Description
1	1	Using CALPUFF hourly concentration file for entire source inventory as input, repartitioning is performed based on entire source inventory. Modified hourly concentration file is created (affects HNO_3 and NO_3 species).
2	0	Using Step 1 modified hourly file as input, new species names are assigned to HNO_3 and NO_3 (HNO3ALL and NO3ALL). Hourly concentration file containing only renamed species is created.
3	2	Using both CALPUFF new hourly concentration file for source group (subset of entire source inventory in Step 1) and Step 2 hourly concentration output file (HNO3ALL and NO3ALL species representing entire source inventory), repartitioning is performed based on the source group contribution to the entire source inventory. Modified hourly concentration file is created (affects HNO_3 and NO_3 species).

The NDDoH utilized POSTUTIL and the ammonia limiting method in its hybrid modeling analysis. The NDDoH developed an hourly ammonia background concentration file to use with POSTUTIL repartitioning. To create the hourly file, observed hourly ammonia concentrations were obtained from the State's Beulah monitoring site (the only ammonia site in North Dakota) for the three-year period 2001-2003. Hourly data for the three years were filtered to eliminate data from wind directions associated with sources causing a local bias. Then the three years were averaged together, on a temporally consistent basis, to produce a single hourly file considered representative of 2002, and appropriate for use with 2002 meteorological data modeling. Years 2001 and 2003 were incorporated in an averaging scheme because year 2002 contained missing periods of hourly data, and some additional data were lost due to filtering as described above. Finally, smoothing was applied to the resultant hourly data set, in the form of a 24-hour running average, to dampen the effect of discontinuities in the ammonia data.

The resultant background hourly ammonia file was tested during the performance evaluation of the hybrid modeling system (Section 8.6.1). While the adjusted Beulah data provided good modeled comparisons with TRNP observed nitrate, the LWA nitrate observations were consistently under predicted. The NDDoH found that agreement with LWA nitrate observations was significantly improved if hourly values in the ammonia file are approximately doubled. Moreover, the NDDoH found empirical evidence (discussed below) that ammonia levels in the vicinity of LWA would be typically higher than ammonia levels at TRNP. Therefore, the

NDDoH applied the original hourly ammonia file (above) for all POSTUTIL processing associated with TRNP, and doubled the hourly ammonia profile for all POSTUTIL processing associated with LWA.

In addition to performance evaluation results, there is empirical support for the assumption of higher ammonia background at LWA than at TRNP and Beulah. Figure 8.9 provides an illustration of ammonia emissions density (tons/year/square mile) for North Dakota counties and adjoining Canadian provinces. These data were obtained from the WRAP RMC 2004/2005 report[40], and represent ammonia input conditions for CMAQ modeling. As shown in the figure, the TRNP and LWA IMPROVE sites, and the Beulah monitoring site, are all located in counties with the lowest ammonia emissions density (0.000-0.001 tons/year/square mile). However, the proximity of the LWA site is such that prevailing local winds (northwest and southeast wind direction) will likely direct higher density ammonia emissions from Saskatchewan (0.075-0.25 tons/year/square mile) and Ward county (0.005-0.025 tons/year/square mile) toward the LWA site.

For comparing predicted visibility progress with respect to the default (EPA) glide path, the NDDoH applied the basic ammonia limiting method, presented as Step 1 in Table 8.7. In order to determine progress in the context of weight of evidence arguments, such as discounting the effect of Canadian emissions, it was necessary to apply the 3-step ammonia limiting method (Section 8.6.3).

POSTUTIL output was subsequently processed with the NDDoH CALHAZE program to project future visibility (Section 8.5.5).

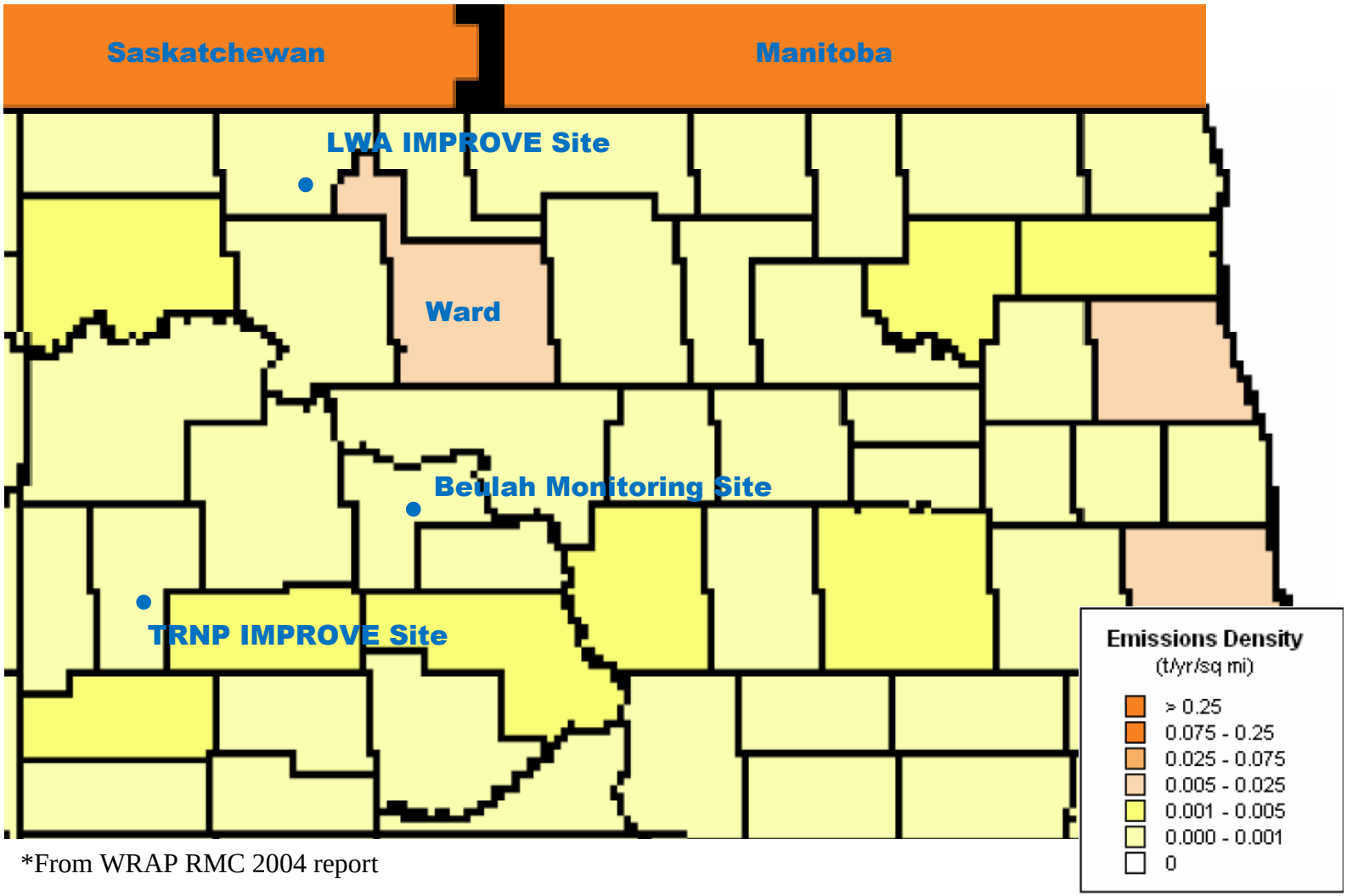
8.5.5 CALHAZE

The NDDoH has developed a software system to generate relative response factors (RRFs) from WRAP CMAQ and NDDoH CALPUFF (POSTUTIL) hourly concentration output files for baseline and future scenarios, project future concentrations of visibility affecting aerosols by applying RRFs to baseline IMPROVE data, and convert projected future concentrations to visibility (deciview). This system is informally known as CALHAZE. CALHAZE represents the final step in the NDDoH hybrid visibility modeling sequence (CALMET-CALPUFF-POSTUTIL-CALHAZE). Effectively, CALHAZE replaces CALPOST.

CALHAZE accesses NDDoH CALPUFF (POSTUTIL) hourly concentration files for baseline and future scenarios to generate 20 percent worst/best day RRFs for sulfate and nitrate. CALHAZE accesses WRAP CMAQ hourly concentration files (provided by WRAP RMC) for baseline and future scenarios to generate 20 percent worst/best day RRFs for all other visibility

[40] Tonnesen, G., R. Morris, Z. Adelman, et. al., 2005. Final Report for the Western Regional Air Partnership (WRAP) Regional Modeling Center (RMC) for the Project Period March 1, 2004, through February 28, 2005, Appendices A Through E. Western Regional Air Partnership, Denver, CO 80202.

Figure 8.9
NH_3 Emissions Density for North Dakota Counties and Adjoining Canadian Provinces*



*From WRAP RMC 2004 report

affecting species. RRFs are applied to IMPROVE baseline monitoring (2000-2004) data files, obtained from the WRAP TSS (Technical Support System) internet site (http://vista.cira.colostate.edu/tss/), to project future concentrations of each visibility affecting species for each worst/best day for each year. Next, CALHAZE applies the new IMPROVE algorithm to calculate light extinction (using projected future concentrations) for each worst/best day for each year. Finally, deciview is calculated for each worst/best day, and averaged across all worst/best days and all years. CALHAZE repeats this procedure for each Class I area. CALHAZE incorporates the default EPA methodology to calculate RRFs and future deciview (Section 8.3).

Input files required by CALHAZE, as applied by NDDoH, are summarized:

1) WRAP CMAQ hourly concentration output file for baseline scenario (2002),

2) WRAP CMAQ hourly concentration output file for future scenario (2018),

3) NDDoH CALPUFF (POSTUTIL) hourly concentration output file for baseline scenario (2002 results for both TRNP and LWA receptors),

4) NDDoH CALPUFF (POSTUTIL) hourly concentration output file for future scenario (2018 results for both TRNP and LWA receptors),

5) IMPROVE daily baseline monitoring data for TRNP (2000-2004),

6) IMPROVE daily baseline monitoring data for LWA (2000-2004).

CMAQ hourly concentrations are taken from the grid cell containing the North Dakota Class I area. Note that all additional parameters necessary for calculating light extinction, via the new IMPROVE algorithm, are provided in the IMPROVE baseline monitoring data files. This includes function of relative humidity for sea salt and small and large size fractions, and the Rayleigh scattering coefficient. Consistent with WRAP RMC conclusions addressing the viability of CMAQ coarse mass predictions, CALHAZE forces a RRF of 1.0 for the coarse mass species. As discussed in Section 8.2, a constant RRF of 1.0 is also applied for sea salt.

As an option, the CALHAZE system also accepts a control input file which allows the user to set RRF for each species, and set the visibility target (in deciviews), for each Class I area. Use of this feature was necessary when applying the normalization procedure described in Section 8.5.6.

The NDDoH has applied the CALHAZE software to complete the hybrid modeling procedure and visibility projections for North Dakota Class I areas. To address quality assurance issues with respect to the CALHAZE system, the NDDoH has successfully cross-checked CALHAZE output with data on the TSS internet site. For example, the worst-day RRFs generated by CALHAZE for elemental carbon, organic mass, fine soil, and coarse mass for North Dakota Class I areas agree exactly with the corresponding values obtained from the TSS site.

8.5.6 Hybrid System Used to Adjust WRAP CMAQ Modeling Results

Based on performance testing of direct hybrid model predictions (operational evaluation), as conducted by NDDoH (see Section 8.6.1), the hybrid CMAQ-CALPUFF modeling system performed well in replicating observed concentrations of SO_4 and NO_3. However, performance regarding sensitivity to changes in NO_X emissions (diagnostic evaluation) was not good, with the hybrid modeling system significantly overstating future case nitrate formation compared to predictions obtained by WRAP using CMAQ alone. The NDDoH concluded this anomaly is an artifact of the chemistry in CALPUFF, and acknowledges that CMAQ chemistry is superior.

For this reason, the NDDoH chose not to accept direct hybrid modeling system results to independently address progress with respect to regional haze goals. Rather, the NDDoH used the hybrid modeling system in a supportive sense to add value to the original WRAP CMAQ modeling results. The hybrid system was used to provide a "correction" to WRAP CMAQ results in order to offset coarseness in the CMAQ spatial resolution for large, local point sources. Similarly, the hybrid system was applied to adjust WRAP CMAQ results in order to discount the effect of international (Canadian) sources. (WRAP did not provide regional haze modeling results which discount the impact of international sources, a modeling interpretation which had been requested by EPA and others, and which the NDDoH wanted to include in its weight of evidence discussion.)

8.5.6.1 Adjusting WRAP CMAQ Modeling Results for Local Point Sources

To address the concern regarding spatial resolution of the WRAP CMAQ simulations for local point sources, the NDDoH concluded that the hybrid modeling system could be used in an indirect manner to apply a reasonable and conceptually simple "correction" to the WRAP CMAQ RRFs (relative response factors) for sulfate and nitrate. Given that CALPUFF has the capability of treating point sources as well as area sources, all point sources within the NDDoH CALPUFF domain can be allocated (converted) to area sources, or more specifically to a 36-km area source grid, in order to emulate the coarse treatment of point sources in CMAQ. Then a correction factor can be established which adjusts the WRAP CMAQ prediction based on the predicted difference between point sources treated as conventional point sources and point sources treated as area sources (i.e., CMAQ emulation) with the hybrid model. This adjustment can be expressed

$$\overline{\chi}_{NDDH} = \overline{\chi}_{CMAQ}\left(\frac{\overline{\chi}_{HybridPt}}{\overline{\chi}_{HybridArea}}\right) \qquad (8-1)$$

where

> $\overline{\chi}_{NDDH}$ is the adjusted average concentration (sulfate or nitrate) for 20% worst days. Note that both WRAP and NDDoH were consistent in basing 20% worst days on IMPROVE monitoring data (2002),

$\overline{\chi}_{CMAQ}$ is the average concentration for 20% worst days obtained by WRAP using CMAQ,

$\overline{\chi}_{HybridPt}$ is the average concentration for 20% worst days predicted by the hybrid model when point sources (within the NDDoH CALPUFF domain) are treated as conventional point sources,

$\overline{\chi}_{HybridArea}$ is the average concentration for 20% worst days predicted by the hybrid model when point sources (within the NDDoH CALPUFF domain) are allocated as 36-km area sources.

The ratio $\overline{\chi}_{HybridPt}$ / $\overline{\chi}_{HybridArea}$ in the equation is effectively a correction factor to address the coarse resolution of local point sources in CMAQ. Equation 8-1 can be thought of as an emulation of the result CMAQ would have produced had the plume-in-grid feature been deployed for local point sources (WRAP did not deploy CMAQ plume-in-grid for regional haze modeling). The Equation 8-1 adjustment involves modifying only the point source component of the hybrid model emissions inventory. Boundary conditions and sources originally treated as area sources (Section 8.5.3.1) remain equivalent in *HybridPt* and *HybridArea* emissions inventories.

Equation 8-1 is applicable for both baseline and future period modeling. Recall that the RRF for each species is defined[41],

$$RRF = \left(\frac{\overline{\chi}_{Future}}{\overline{\chi}_{Baseline}}\right)$$

where $\overline{\chi}_{Future}$ is the future 20% worst day average concentration and $\overline{\chi}_{Baseline}$ is the baseline 20% worst day average concentration. Therefore, if the future period implementation of Equation 8-1 is divided by the baseline period implementation of Equation 8-1, it follows that the adjustment for CMAQ treatment of point sources can be specified in terms of RRF,

$$RRF_{NDDH} = RRF_{CMAQ}\left(\frac{RRF_{HybridPt}}{RRF_{HybridArea}}\right) \qquad (8-2)$$

where

RRF_{NDDH} is the adjusted relative response factor ultimately used by NDDoH to project future concentrations of sulfate and nitrate,

RRF_{CMAQ} is the relative response factor obtained by WRAP using CMAQ,

[41] See supra note 7.

$RRF_{HybridPt}$ is the relative response factor produced by the hybrid model when point sources (within NDDoH CALPUFF domain) are treated as conventional point sources,

$RRF_{HybridArea}$ is the relative response factor produced by the hybrid model when point sources (within NDDoH CALPUFF domain) are allocated as 36-km area sources.

Thus, Equation 8-2 was used by NDDoH to implement the adjustment for WRAP CMAQ treatment of point sources. The adjustment was utilized for 20% best days as well as 20% worst days, and was applied for each Class I area in North Dakota. It was applied directly to the RRFs from WRAP CMAQ modeling (specific day option[42]), which are shown in Table 8.8.

Table 8.8
WRAP CMAQ RRF
(Specific Day Option)

	TRNP Worst Day	**TRNP Best Day**	**LWA Worst Day**	**LWA Best Day**
SO_4	0.92	1.02	0.91	1.02
NO_3	0.92	0.93	0.96	0.89
OMC	1.01	1.01	1.05	1.01
EC	0.72	0.78	0.73	0.74
Soil	1.13	1.08	1.11	0.96
CM	1.00	1.00	1.00	1.00

To develop the *HybridArea* CALPUFF input files, all point source emissions were allocated to the CALPUFF 36-km area source grid, which is discussed in Section 8.5.3.1 and shown in Figure 8.8. The CALPUFF "effective height" (plume height) and "initial sigma z" area source input parameters were used to assign point source emissions to discrete vertical "layers" which are consistent with the WRAP CMAQ layers. Effective height is based on stack height plus plume rise as calculated externally.

[42] In addition to the EPA-recommended specific day option for generating RRFs, WRAP also generated RRFs and projected future visibility based on monthly and quarterly weighting. The NDDoH used the specific day option exclusively in hybrid visibility modeling.

To complete emulation of the WRAP CMAQ 36-km grid resolution, receptor treatment was also addressed in the *HybridArea* input files. Effective "receptor" resolution in WRAP CMAQ is limited to the average concentration in the 36-km surface grid cell volume containing the Class I area IMPROVE site. To emulate WRAP CMAQ in *HybridArea* input files, the NDDoH averaged across a uniform receptor grid which filled the CALPUFF area-source 36-km grid cell containing each IMPROVE site (Figure 8.8). Receptors were spaced at 3 km for a total of 12 x 12 or 144 discrete receptors for each Class I area. Note that this type of receptor averaging was only applied in CALPUFF runs for CMAQ emulation (*HybridArea*), and not in runs for conventional point source treatment (*HybridPt*) or performance evaluation.

Given that the NDDoH hybrid modeling was limited to sulfate and nitrate species (and precursors), the Equation 8.2 adjustment was also limited to sulfate and nitrate species. The RRFs for all other light affecting species were taken directly from WRAP CMAQ modeling, as shown in Table 8.8. Therefore, it is likely that the correction for CMAQ resolution of point sources, in terms of the total projected future light extinction, is somewhat understated. However, the primary contributors to light extinction from the local point sources of concern in North Dakota are sulfate and nitrate.

The Equation 8.2 adjustment as applied by NDDoH also accounted for the WRAP overestimate of future oil and gas related NO_X emissions in North Dakota, as discussed in Section 8.5.3.1. This error affected the future period modeling only. Therefore, the *HybridArea* input file (CMAQ emulation) for the future period included WRAP estimated NO_X emissions for oil and gas, while the *HybridPt* input file for the future period included the NDDoH corrected future NO_X emissions for oil and gas. (The base period NO_X emissions in both cases were based on WRAP estimates for 2002.) This accounting for the WRAP error in future oil and gas NO_X emissions was not expected to make a significant difference in results.

When applying the Equation 8.2 adjustment, the NDDoH found the ratio $RRF_{HybridPt}$ to $RRF_{HybridArea}$ to be consistently less than 1.0, providing a resultant RRF_{NDDH} which was significantly lower than the WRAP CMAQ RRF, with subsequently lower projected future concentrations and greater projected visibility improvement than predicted by WRAP. This expected response is related primarily to the resolution of modeling systems as applied to local point sources. When local point sources are treated as conventional point sources, the higher density point-source plumes cause higher predictions at the IMPROVE monitor site (for both baseline and future periods) such that the future reduction in emissions from local point sources may cause a relatively large impact compared to the more static contribution of all other sources (area and boundary). When local point sources are configured as 36-km area sources, the associated diluted plumes cause lower predictions compared to the contribution of all other sources (other area and boundary), such that the future reduction in emissions may be overwhelmed by the more static contribution of other sources.

8.5.6.2 Discounting the Impact of Canadian Sources

In the process of analyzing progress with respect to visibility goals, it was necessary for the NDDoH to address the impact of Canadian sources north of the International border. This

interpretation of modeling results was requested by EPA and others, and was an important element of the NDDoH weight of evidence discussion (see Section 8.6.3). No specific guidance is provided for this type of analysis. The method used by NDDoH was to eliminate Canadian sources from the baseline and future emissions inventories used to develop RRFs, and to develop a modified glide path which discounts the effect of Canadian sources. This approach is similar to methods proposed by CENRAP[43] and others.

Again, the NDDoH implemented its procedure for discounting Canadian sources in terms of an adjustment to WRAP CMAQ modeling results. If Canadian sources are eliminated from baseline and future emissions inventories for conventional point sources, Equation 8-2 becomes

$$RRF_{NDDH} = RRF_{CMAQ}\left(\frac{RRF_{HybridPt-C}}{RRF_{HybridArea}}\right) \qquad (8-3)$$

where

> $RRF_{HybridPt-C}$ represents the resultant relative response factor after eliminating Canadian sources from the conventional point source baseline and future emissions inventories used with the hybrid modeling system.

Equation 8-3 was used by the NDDoH to develop adjusted RRFs for sulfate and nitrate. Note that with the implementation of Equation 8-3, the adjustment to discount the impact of Canadian sources is effectively "added on" to the adjustment for WRAP CMAQ point source resolution.

To complete the illustration, the impact of Canadian sources must also be discounted from the glide path used to assess progress with respect to visibility goals. In this case, the NDDoH applied the hybrid modeling system exclusively to estimate the baseline starting point (deciview) of the modified glide path. The estimation process involved adjusting the IMPROVE baseline concentration for each worst-case day for the five-year period 2000-2004, in order to approximate the daily observations without the impact of Canadian sources. The estimation procedure for each worst-case day can be expressed

$$\chi_{obs(us)} = \chi_{obs}\left(\frac{\overline{\chi}_{pred(us)}}{\overline{\chi}_{pred}}\right) \qquad (8-4)$$

where

> $\chi_{obs(us)}$ is the estimated sulfate or nitrate concentration for one worst case day of IMPROVE monitoring data for all non-Canadian sources (plus natural background),

[43] CENRAP, 2007. CENRAP Policy Oversight Group (POG) - Summary of PM Source Apportionment Modeling and 2018 Projection Approaches. Power Point presentation, Joint Workgroup Meeting, Kansas City, Missouri, March 7, 2007.

χ_{obs} is the original IMPROVE observed sulfate or nitrate concentration for the worst case day,

$\overline{\chi}_{pred(us)}$ is the average prediction for 20% worst days when hybrid model is applied for non-Canadian sources only (Year 2002 baseline emissions inventory),

$\overline{\chi}_{pred}$ is the average prediction for 20% worst days when hybrid model is applied for the entire source inventory (Year 2002 baseline emissions inventory).

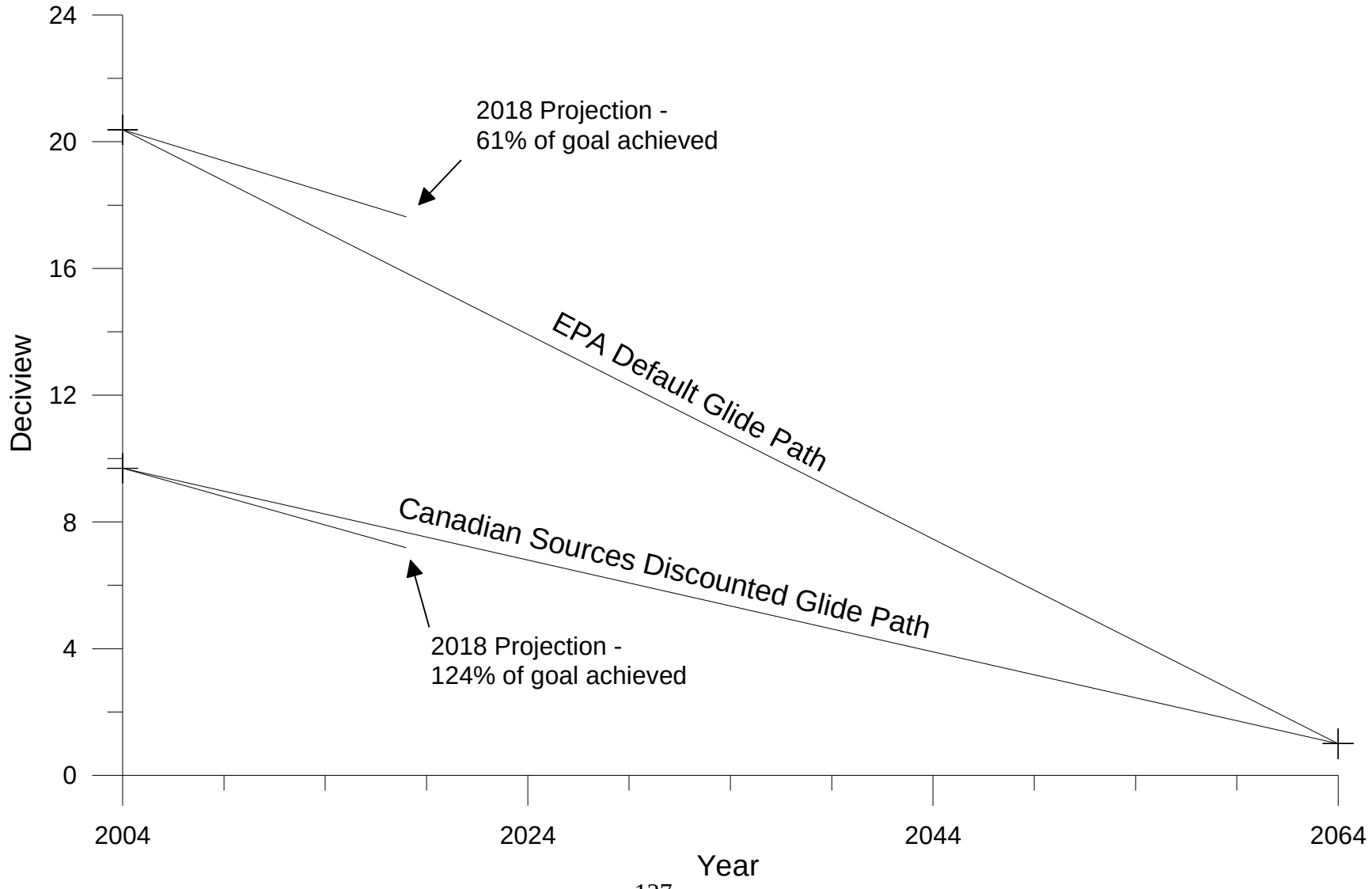
Using the adjusted worst day observations for sulfate and nitrate, along with the original IMPROVE worst day observations for all other visibility-affecting species, light extinction and deciview were calculated for each 20% worst day of the 2000-2004 period. Finally, the five-year average deciview was calculated to set the starting point for the "Canadian sources discounted" glide path for 20% worst days.

The NDDoH next considered the end point (2064) of the modified glide path. When adjusting baseline and future emissions inventories to exclude Canadian sources, the intent of NDDoH was to eliminate the impact of non-natural sources only, leaving the contribution of all other non-Canadian sources plus natural sources. Therefore, an adjustment was made to CALPUFF boundary conditions (baseline and future) to eliminate the contribution of Canadian source emissions, while retaining the impact of natural Canadian sources of sulfate and nitrate. This adjustment is described in Section 8.6.3.1. And recall that the NDDoH adjustment does not affect the impact of all other visibility-affecting species on the glide path. As such, the NDDoH concluded that it was not necessary or appropriate to change the end point (default natural conditions) of the modified glide path.

A modified glide path is illustrated in Figure 8.10, for a hypothetical case where Canadian source emissions contribute about one-half of total visibility degradation.

Using the modified glide path, the NDDoH applied RRFs generated using Equation 8-3 to the adjusted starting point to estimate visibility improvement progress by 2018 (see Section 8.6.3.1). As expected, visibility improvement increased significantly when Canadian sources were discounted. Canadian source emissions were discounted only for 20% worst days, as the impact of Canadian sources was not problematic in meeting visibility goals for best days.

Figure 8.10
Illustration of Visibility Improvement Using EPA Default Glide Path and Canadian Sources Discounted Glide Path



8.6 Modeling Process and Results

The NDDoH hybrid modeling system was applied to adjust WRAP CMAQ results, using input conditions and procedures as described in Section 8.5. A performance evaluation was conducted first to ensure that selected inputs were producing viable results relative to observed concentrations of sulfate and nitrate. (Note that the performance evaluation was based on predictions taken directly from hybrid model output, rather than adjusted WRAP CMAQ output.) Next, the hybrid modeling system was executed in default production mode to determine progress with respect to the glide path and URP target based on default EPA methodology. Finally, the hybrid modeling system was applied to test several weight of evidence scenarios. NDDoH hybrid results and WRAP CMAQ results were compared for the default EPA methodology.

8.6.1 Hybrid CMAQ-CALPUFF Performance Evaluation

The NDDoH conducted a limited operational evaluation to assess performance of the hybrid CMAQ-CALPUFF modeling system. The focus of the evaluation was to assess performance in reproducing observed concentrations of sulfate and nitrate at IMPROVE monitoring sites in North Dakota. These sites include the Theodore Roosevelt National Park South Unit (TRNP) and the Lostwood Wilderness Area (LWA). Alternative input options which might improve performance were also explored. To the extent applicable, the performance evaluation followed EPA guidance for Regional Haze modeling analyses[44].

An emissions inventory for the performance evaluation was developed by NDDoH. WRAP CMAQ hourly concentration output (SO_2-SO_4-NO_X-HNO_3-NO_3) for Case BASE02B was used to set hourly boundary conditions for CALPUFF. The emissions inventory (SO_2-NO_X) for the point source category was developed using data from the NDDoH emissions database for 2002, and sources were configured as conventional point sources in CALPUFF. This inventory included point sources located in adjacent parts of South Dakota, Montana, and Canada, which are included in the NDDoH CALPUFF domain (see Figure 8.5). This inventory also included SO_2 emissions associated with oil and gas production facilities (treaters and flares) in North Dakota, which did not appear to be accounted for in the WRAP inventory for BASE02B. Emission rates for the point source inventory reflect actual emissions for Year 2002.

All other source categories (see Table 8.2) were treated as area sources in CALPUFF, and the emissions inventory (SO_2-SO_4-NO_X-NO_3) for these categories was based on WRAP CMAQ input (SMOKE output) for all sources other than point sources. Software was prepared and implemented to apportion the gridded SMOKE output emissions for BASE02B into a 36-km area source grid structure developed for the NDDoH CALPUFF domain (Figure 8.8), on a consistent spatial basis. Emission rates for this area source inventory reflect annual averages for the SMOKE data.

[44] See supra note 7.

The CALPUFF modeling system (CALMET-CALPUFF-POSTUTIL-CALPOST) was applied for SO_2-SO_4-NO_X-NO_3 source inventories and boundary conditions as described above. All other input conditions were consistent with the description of the hybrid modeling system in Section 8.5. Single receptors were placed at the TRNP and LWA IMPROVE sites. Monthly average ammonia data were utilized from the Beulah monitoring site in both CALPUFF and POSTUTIL.

After initial application of CALPUFF for the performance evaluation, it was concluded that certain scientifically-defensible adjustments to CALPUFF input conditions may improve performance for the hybrid modeling system, and should be investigated. Thus, the performance evaluation evolved into a suite of tests which are described below.

1) Test 1 - Calpuff executed with default input conditions, as outlined above. Air mass depth for boundary conditions was set to 2000 meters.

2) Test 2 - CALPUFF as in Test 1, but using CEMS 2002 hourly emissions data (SO_2, NO_X) for point sources, where available.

3) Test 3 - CALPUFF as in Test 1, but using WRAP MM5 12 km 2002 mesoscale data in CALMET, rather than the default NDDoH RUC 2002 mesoscale data.

4) Test 4 - CALPUFF as in Test 1, but increasing air mass depth for boundary conditions from 2000 to 3000 meters.

5) Test 5 - CALPUFF as in Test 1, but with addition of SO_4 and NO_3 emissions from point sources. (Previous tests excluded this component, because SO_4 and NO_3 emissions are not included in the NDDoH point source inventory. For Test 5, an SO_4-NO_3 emissions inventory was derived from SMOKE gridded output for the point source category, and configured as area sources for CALPUFF.)

6) Test 6 - CALPUFF as in Tests 4 and 5 (air mass depth = 3000 meters, SO_4 and NO_3 emissions from point sources included), but area sources configured as 4 separate groups to account for varying release heights of different source types, and Beulah hourly profile used for background NH_3 in POSTUTIL. (Area sources were configured as a single CALPUFF group in previous tests.)

7) Test 7 - CALPUFF as in Test 6, but Beulah hourly NH_3 profile doubled for LWA.

Results of the performance evaluation are summarized in Tables 8.9 and 8.10. Table 8.9 compares predicted NO_3 and SO_4 concentrations to observed concentrations for both IMPROVE sites, while Table 8.10 provides predicted-to-observed ratios. Note that both tables include a column labeled “CMAQ only”, which provides the original WRAP CMAQ results for Case BASE02B.

Table 8.9
Hybrid CMAQ-CALPUFF Performance Evaluation
Observed and Predicted Concentrations Year 2002 (ug/m^3)

	Observed	Hybrid CMAQ-CALPUFF Predicted*							CMAQ only
		Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	
TRSU NO3									
90th Percentile Day	**1.21**	1.50	1.46	1.55	1.43	1.47	1.21	1.21	1.62
Avg 20% Worst Days	**1.42**	1.59	1.59	1.65	1.56	1.59	1.41	1.41	1.84
Annual Average	**0.50**	0.71	0.71	0.73	0.70	0.71	0.53	0.53	0.57
TRSU SO4									
90th Percentile Day	**1.88**	1.72	1.72	1.66	1.77	1.72	1.79	1.79	1.60
Avg 20% Worst Days	**2.43**	1.96	1.97	1.83	1.96	1.98	1.99	1.99	1.76
Annual Average	**1.03**	0.90	0.90	0.86	0.90	0.91	0.91	0.91	0.84
Lostwood NO3									
90th Percentile Day	**1.95**	1.48	1.50	1.56	1.47	1.44	1.13	1.76	2.04
Avg 20% Worst Days	**2.33**	1.55	1.55	1.61	1.52	1.50	1.30	2.03	2.34
Annual Average	**0.79**	0.70	0.70	0.73	0.69	0.67	0.47	0.80	0.79
Lostwood SO4									
90th Percentile Day	**2.22**	2.06	2.03	1.90	2.07	2.19	2.21	2.21	2.43
Avg 20% Worst Days	**2.49**	2.21	2.21	2.09	2.22	2.35	2.36	2.36	2.74
Annual Average	**1.18**	1.07	1.07	1.03	1.08	1.15	1.17	1.17	1.32

* Test 1 - Calpuff run with default BART screening protocol + full emissions inventory + boundary conditions
Test 2 - Calpuff as in Test 1 but using CEMS hrly emissions (SO2, NOX) where available
Test 3 - Calpuff as in Test 1 but using WRAP MM5 12km mesoscale data (in CALMET)
Test 4 - Calpuff as in Test 1 but assuming boundary air mass depth as 3000 m rather than 2000 m
Test 5 - Calpuff as in Test 1 but with addition of NO3 and SO4 emissions from point sources
Test 6 - Calpuff as in Test 1 but assuming boundary air mass depth as 3000 m (Test 4) and with addition of NO3 and SO4 emissions from point sources (Test 5). Area sources configured as 4 groups and Beulah hourly profile used for backgound NH3.
Test 7 - Calpuff as in Test 6 but Beulah hourly NH3 profile doubled for Lostwood

Table 8.10
Hybrid CMAQ-CALPUFF Performance Evaluation
Predicted to Observed Ratios 2002

	Hybrid CMAQ-CALPUFF*							CMAQ
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	only
TRSU NO3								
90th Percentile Day	1.24	1.21	1.28	1.18	1.21	1.00	1.00	1.34
Avg 20% Worst Days	1.12	1.12	1.16	1.10	1.12	0.99	0.99	1.30
Annual Average	1.42	1.42	1.46	1.40	1.42	1.06	1.06	1.14
TRSU SO4								
90th Percentile Day	0.91	0.91	0.88	0.94	0.91	0.95	0.95	0.85
Avg 20% Worst Days	0.81	0.81	0.75	0.81	0.81	0.82	0.82	0.72
Annual Average	0.87	0.87	0.83	0.87	0.88	0.88	0.88	0.82
Lostwood NO3								
90th Percentile Day	0.76	0.77	0.80	0.75	0.74	0.58	0.90	1.05
Avg 20% Worst Days	0.67	0.67	0.69	0.65	0.64	0.56	0.87	1.00
Annual Average	0.89	0.89	0.92	0.87	0.85	0.59	1.01	1.00
Lostwood SO4								
90th Percentile Day	0.93	0.91	0.86	0.93	0.99	1.00	1.00	1.09
Avg 20% Worst Days	0.89	0.89	0.84	0.89	0.94	0.95	0.95	1.10
Annual Average	0.91	0.91	0.87	0.92	0.97	0.99	0.99	1.12

* Test 1 - Calpuff run with default BART screening protocol + full emissions inventory + boundary conditions
Test 2 - Calpuff as in Test 1 but using CEMS hrly emissions (SO2, NOX) where available
Test 3 - Calpuff as in Test 1 but using WRAP MM5 12km mesoscale data (in CALMET)
Test 4 - Calpuff as in Test 1 but assuming boundary air mass depth as 3000 m rather than 2000 m
Test 5 - Calpuff as in Test 1 but with addition of NO3 and SO4 emissions from point sources
Test 6 - Calpuff as in Test 1 but assuming boundary air mass depth as 3000 m (Test 4) and with addition of NO3 and SO4 emissions from point sources (Test 5). Area sources configured as 4 groups and Beulah hourly profile used for backgound NH3.
Test 7 - Calpuff as in Test 6 but Beulah hourly NH3 profile doubled for Lostwood

As shown in Tables 8.9 and 8.10, the three metrics selected to measure performance for this evaluation are 90th percentile day concentration (24-hour average), average of 20% worst days concentration, and annual average concentration. The first two metrics were selected for consistency with the time scale that applies to regional haze modeling, i.e., average of the 20% worst or 20% best days. The third metric, annual average concentration, is a measure of the model's ability to accurately conserve total annual mass. The comparison between predicted and observed concentrations for the first two metrics is unpaired in time.

Results in Tables 8.9 and 8.10 indicate that the hybrid modeling system performed well, in general. Even for the initial Test 1, predictions were well within a factor of two of observations. In most cases, the hybrid system predictions were closer to observations than predictions from CMAQ, alone. Table 8.10 illustrates that the hybrid system slightly over-predicted observations for TRNP NO_3, and slightly under-predicted, otherwise.

A comparison of results for Tests 1 through 5 reveals very little difference in predictions. The implication is that the input changes reflected in Tests 2 through 5 did not add significant value to the hybrid model's ability to accurately reproduce observations. The increased temporal resolution obtained by using the CEMS hourly emissions for applicable point sources (Test 2) provided no consistent improvement. Test 3 results suggest that the NDDoH RUC mesoscale data is consistent with the WRAP MM5 mesoscale data. Test 4 results indicate that Calpuff is not very sensitive to boundary air mass depth. Even the addition of point source NO_3 and SO_4 emissions in Test 5 achieved no meaningful improvement in predictions, suggesting that sources configured as area sources in CALPUFF may have only a small contribution to the total prediction.

While the operational evaluation to compare predictions with observations was being conducted, the NDDoH also undertook a preliminary diagnostic evaluation[45] to assess the response of the hybrid modeling system to changes in NO_X and SO_2 emissions. In response to significant reductions in both SO_2 and NO_X emissions, the NDDoH found that the hybrid system responded reasonably well with correspondingly lower SO_4 predictions, but seemed to overstate NO_3 predictions for the reduced emission scenario. In fact, NO_3 concentrations actually increased under some assumptions, possibly an overreaction to the newly freed ammonia in the reduced SO_2 emissions scenario (SO_2 preferentially scavenges ammonia in the CALPUFF chemistry). This behavior was not as obvious in the WRAP CMAQ results for baseline versus future predictions.

To address the problematic NO_3 response, the NDDoH discussed the issue with Joe Scire (TRC)[46], a recognized CALPUFF expert in the regulatory modeling community. Mr. Scire indicated that TRC testing has shown that the NO_3 response may improve if hourly background ammonia is used rather than monthly average values. Also, Mr. Scire provided some insight on configuring area sources in CALPUFF to be more consistent with the area source treatment in CMAQ. This involves proper settings for the CALPUFF "release height" and "initial sigma z" input parameters for area sources. The NDDoH retested after incorporating Mr. Scire's

[45] See supra note 7.

[46] See supra note 28.

suggestions, i.e., using hourly ammonia background and reconfigured area sources. Although the NO_3 response improved, predicted reductions were still not consistent with CMAQ.

As a result of the initial diagnostic performance testing, the NDDoH concluded that the use of hourly ammonia background concentrations is preferable to the use of monthly averages, and that CALPUFF inputs for area sources should be reconfigured. Additional operational evaluation tests (Tests 6 and 7) were thus conducted to determine how these changes would affect the comparison with observations. Test 6 was conducted by first assuming a boundary air mass depth of 3000 meters (Test 4) and accounting for NO_3 and SO_4 emissions from point sources (Test 5). Then area sources were configured as suggested by Scire, including the use of 4 area source groups to account for varying release heights for different source categories (as opposed to one group in Tests 1-5). Finally, Test 6 included use of the Beulah hourly ammonia profile in POSTUTIL.

Results of Test 6, as shown in Tables 8.9 and 8.10, indicate significantly improved performance with respect to TRNP NO_3, but worse performance for LWA NO_3. Results for SO_4 were not significantly affected. This tendency for conflicting results for TRNP and LWA NO_3 was also exhibited in Tests 1 through 5, and led the NDDoH to conclude that the Beulah data may not be representative of ammonia background for both TRNP and LWA. Moreover, the actual ammonia background affecting LWA may be significantly higher than the background affecting TRNP.

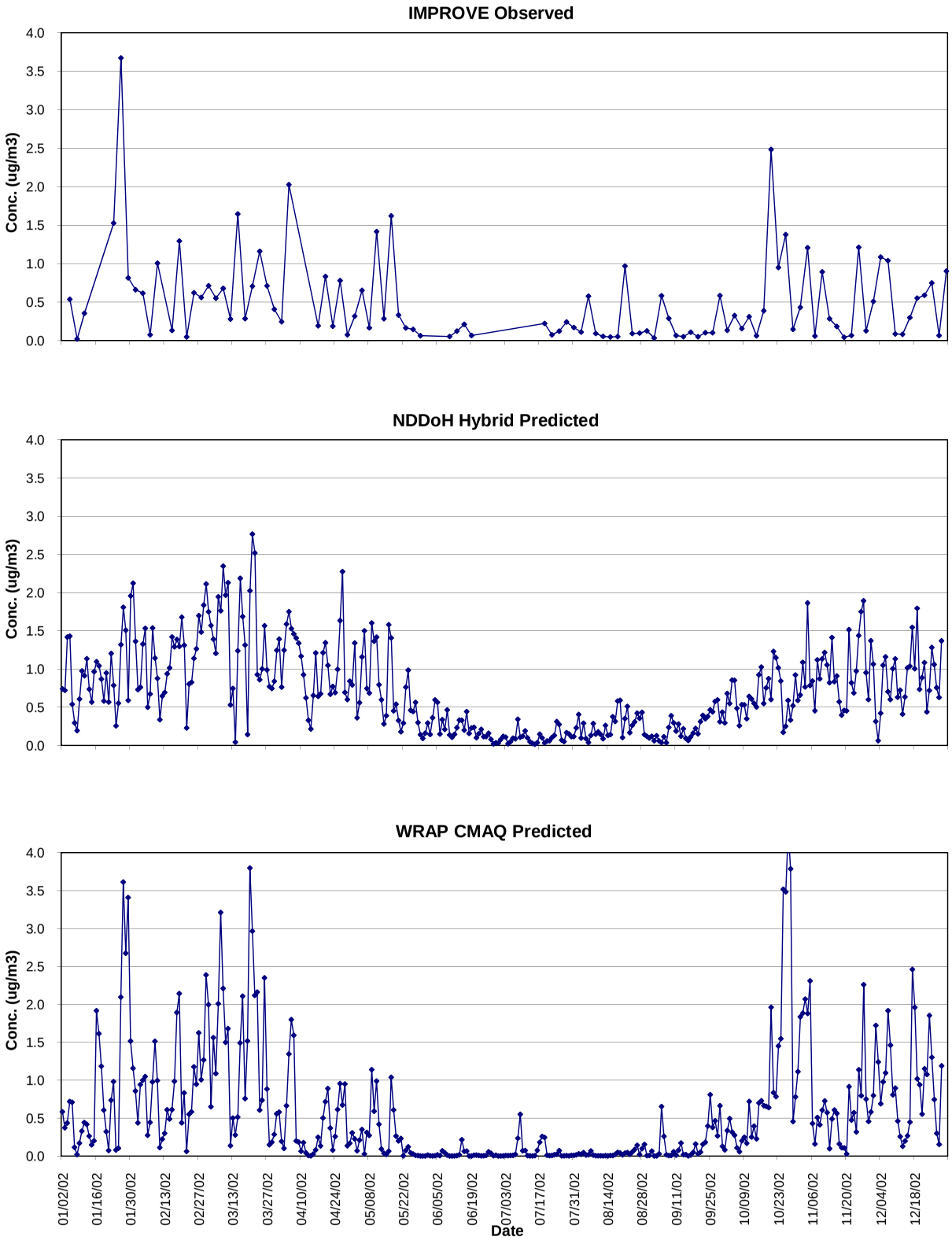
In Test 7, the NDDoH found that observational agreement for LWA NO_3 can be vastly improved if the ammonia hourly backgound values are approximately doubled (for LWA only). All other conditions for Test 7, including the ammonia background for TRNP, remain the same as in Test 6. NO_3 predictions for Test 7 in Tables 8.9 and 8.10 now show good agreement with observations at both TRNP and LWA.

Finally, the NDDoH developed time series plots (consistent with Test 1 assumptions) to compare temporal patterns of predictions with observations for year 2002. In Figure 8.11, daily model predictions for nitrate at TRNP are compared with IMPROVE observations for 2002 (note that observations are only available for every third day). Time series for both NDDoH hybrid predictions and WRAP CMAQ predictions are included. As shown in the figure, both modeling systems appear to reproduce the general seasonal pattern of nitrate observations, with significantly lower concentrations in the summer. When compared with observations, the overall magnitude of predictions for the hybrid modeling system appears better, as CMAQ seems to under predict in the summer (many daily values very close to 0.0) and over predict otherwise. CMAQ, however, may be more effective in reproducing some of the peak observed concentrations (paired in time).

In summary, the NDDoH concluded that the hybrid modeling system performs effectively, and should be used for local visibility modeling. Further, agreement with sulfate and nitrate observations would be optimized using the following input conditions with the hybrid system:

- use RUC mesoscale data for CALMET,

Figure 8.11
Observed and Predicted Time Series TRNP NO_3 2002



- use boundary air mass depth of 3000 meters,
- include SO_4 and NO_3 emissions from point sources,
- configure area sources as four groups,
- use Beulah hourly background ammonia for TRNP, and
- use double Beulah hourly background ammonia for LWA.

8.6.2 Results for Default EPA Methodology

8.6.2.1 Cumulative Results

The NDDoH hybrid modeling system was applied to adjust WRAP CMAQ results, using input conditions and procedures consistent with optimal model performance, and described in Section 8.5. Hybrid modeling for the default EPA methodology included the entire emissions inventory. NDDoH projections for 2018 visibility are compared here with WRAP RMC projections for 2018 visibility, based on default EPA methodology.

Results of WRAP CMAQ and NDDoH hybrid visibility modeling for the default EPA scenario are summarized in Table 8.11. The table includes visibility projections for North Dakota Class I areas for 20% worst monitored days and 20% best monitored days. The table includes deciview values for baseline conditions, natural conditions, and the 2018 uniform rate of progress (URP) target. WRAP and NDDoH projections provided in the table include the absolute visibility projection in deciviews, and the percentage of the visibility target achieved by the projection. Note that the URP target and projected percentage of target are not included for best days, because the Regional Haze Rule specifies the URP target only for worst days. The requirement for best days is simply that the visibility projection for 2018 is no higher than the baseline monitored value.

As shown in Table 8.11, the NDDoH projections for 20% worst days indicate greater progress with respect to the 2018 goals than the WRAP projections, but both sets of projections fall well short of the URP targets. The WRAP projection constitutes 24.0 percent of the visibility goal at Theodore Roosevelt National Park (TRNP), while the NDDoH projection is 37.1 percent of the goal at that Class I area. For Lostwood Wilderness Area (LWA), WRAP projects 16.7 percent of the URP goal while the NDDoH projects that 26.3 percent of the goal will be achieved.

Table 8.11
WRAP and NDDoH Visibility Modeling Results
Uniform Rate of Progress – Default EPA Methodology

Class I Area	20% Worst/Best Days	2000-2004 Baseline Conditions (dv)	2064 Natural Conditions (dv)	2018 URP Target (dv)	WRAP 2018 Projected Visibility (dv)	WRAP 2018 Projected Percent of Target	NDDoH 2018 Projected Visibility (dv)	NDDoH 2018 Projected Percent of Target
Theodore Roosevelt National Park	Worst	17.80	7.8	15.47	17.24	24.0	16.91	38.1
	Best	7.76	3.04	-----	7.67	-----	7.62	-----
Lostwood Wilderness Area	Worst	19.57	8.0	16.87	19.12	16.7	18.85	26.7
	Best	8.19	2.92	-----	8.06	-----	8.10	-----

Figure 8.12
TRNP Uniform Rate of Progress – EPA Default Methodology

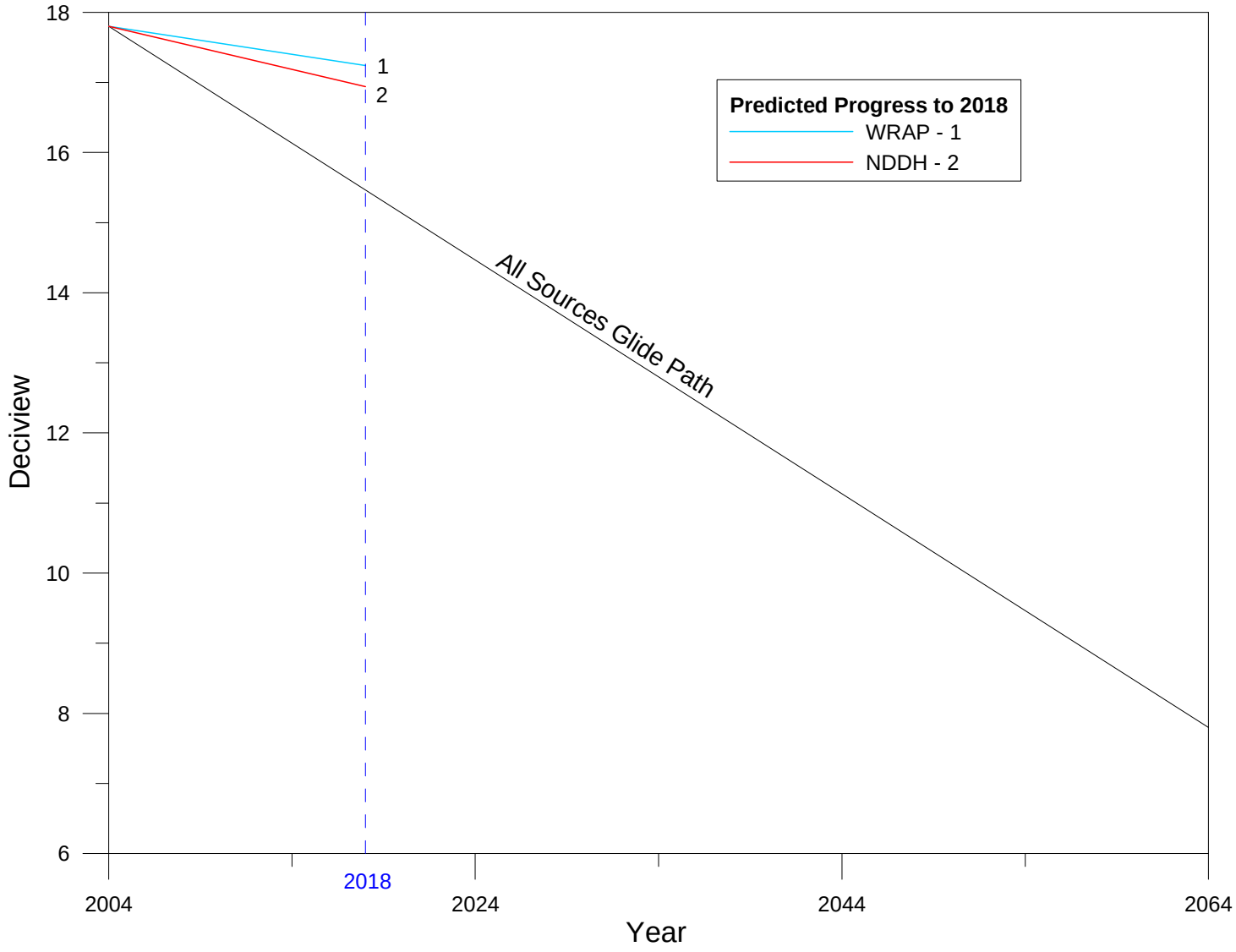
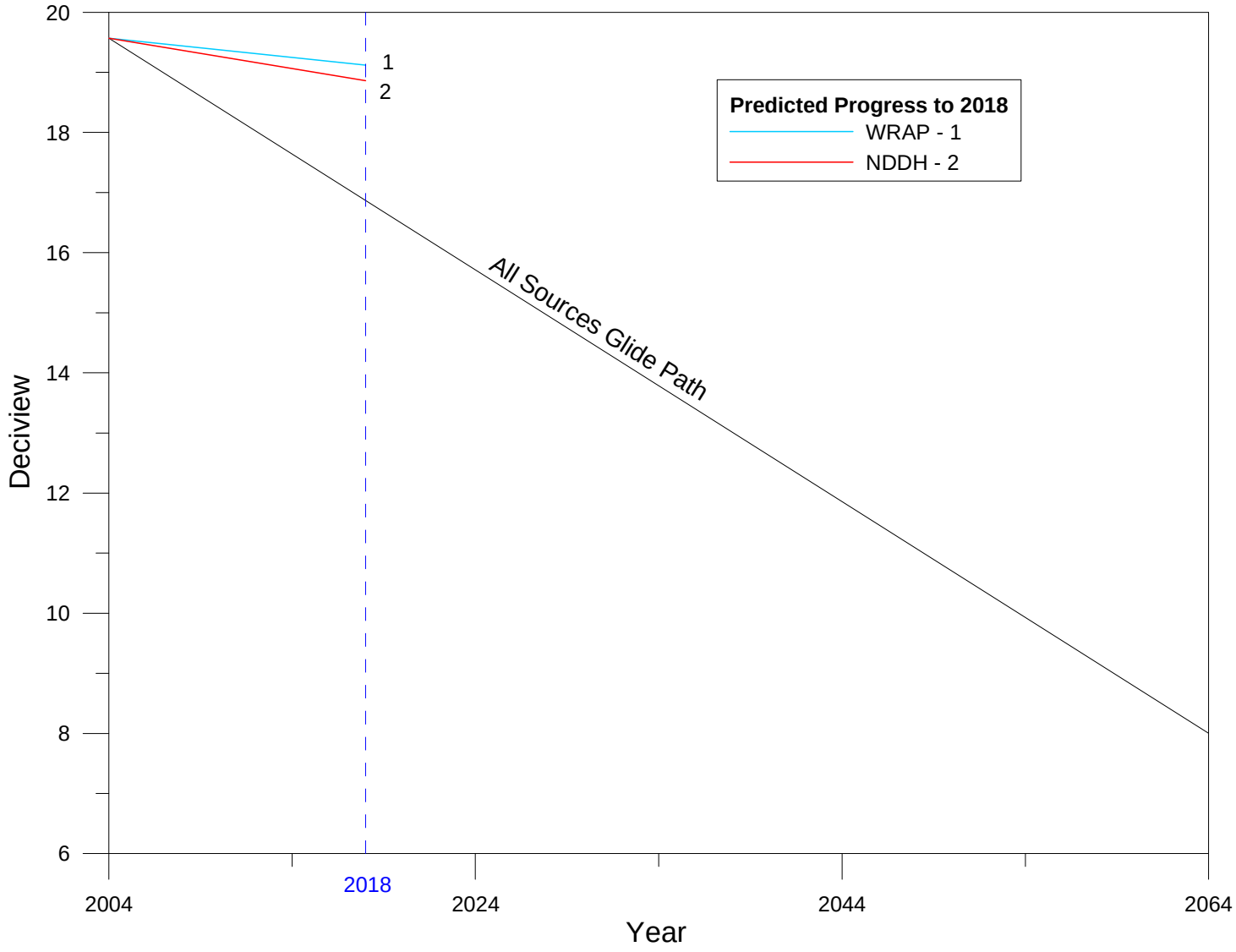


Figure 8.13
LWA Uniform Rate of Progress – EPA Default Methodology



On the 20% best monitored days, both WRAP and NDDoH predictions in Table 8.11 illustrate that 2018 visibility will be better than baseline monitored values for both TRNP and LWA Class I areas. The WRAP 2018 projection of 7.67 deciviews and the NDDoH 2018 projection of 7.63 deciviews compare favorably with the baseline value of 7.76 deciviews for TRNP. At the LWA Class I area, the WRAP 2018 prediction of 8.06 deciviews and the NDDoH prediction of 8.10 deciviews both fall below the baseline value of 8.19 deciviews. Thus, requirements of the Regional Haze rule for the 20% best days will be satisfied.

Worst-day results of WRAP and NDDoH visibility modeling for the EPA default scenario are graphically interpreted with respect to the uniform rate of progress in Figure 8.12 and Figure 8.13 for TRNP and LWA, respectively. The "all sources" glide paths in Figures 8.12 and 8.13 originate with the monitored baseline deciview value in 2004, and terminate with the natural background deciview value in 2064. Using the same point of origination, the projected visibility progress is plotted against the glide path in each figure.

Figures 8.12 and 8.13 illustrate how NDDoH hybrid modeling projects better visibility improvement to 2018 than WRAP CMAQ modeling for both Class I areas. The figures also illustrate how far WRAP and NDDoH projections are from meeting the 2018 URP targets for 20% worst day visibility.

8.6.2.2 Apportionment by Species

The contribution of individual visibility-affecting species to total observed and projected light extinction for 20% worst/best days is discussed here. According to the IMPROVE algorithm, light affecting species include sulfate (SO_4), nitrate (NO_3), organic carbon (OMC), elemental carbon (EC), fine soil (Soil), coarse material (CM), and sea salt (SS). An additional component of light extinction which is included in the IMPROVE algorithm is Rayleigh scattering (Ray), which was also addressed in the projection of future visibility.

IMPROVE speciated monitoring data for 20% worst days at TRNP and LWA are summarized in the bar charts of Figures 8.14 and 8.15, respectively. The figures provide the percentage contribution of each visibility-affecting species, as well as Rayleigh scattering, to each 20% worst visibility day in baseline year 2004. The worst days are identified by month and day of the month at the bottom of the charts.

As seen in Figures 8.14 and 8.15, most of the 20% worst day light extinction at North Dakota Class I areas is dominated by sulfate and nitrate contributions. Rayleigh scattering is also a significant component, but otherwise the contribution of other visibility-affecting species (OMC, EC, Soil, CC, and SS) is generally very small. The exception is worst days in late July and August, where organic carbon replaces sulfate and nitrate as the dominate contributor to extinction. This pattern was similar in other years of IMPROVE baseline data (2000-2003). A possible explanation is that fugitives associated with agricultural burning, prescribed burning within Class I areas, and wild fires may be the largest contributors to light extinction during late July and August, while emissions from conventional large point sources are the largest contributors during the remainder of the year.

Figure 8.14
IMPROVE 20% Worst Days – TRNP 2004

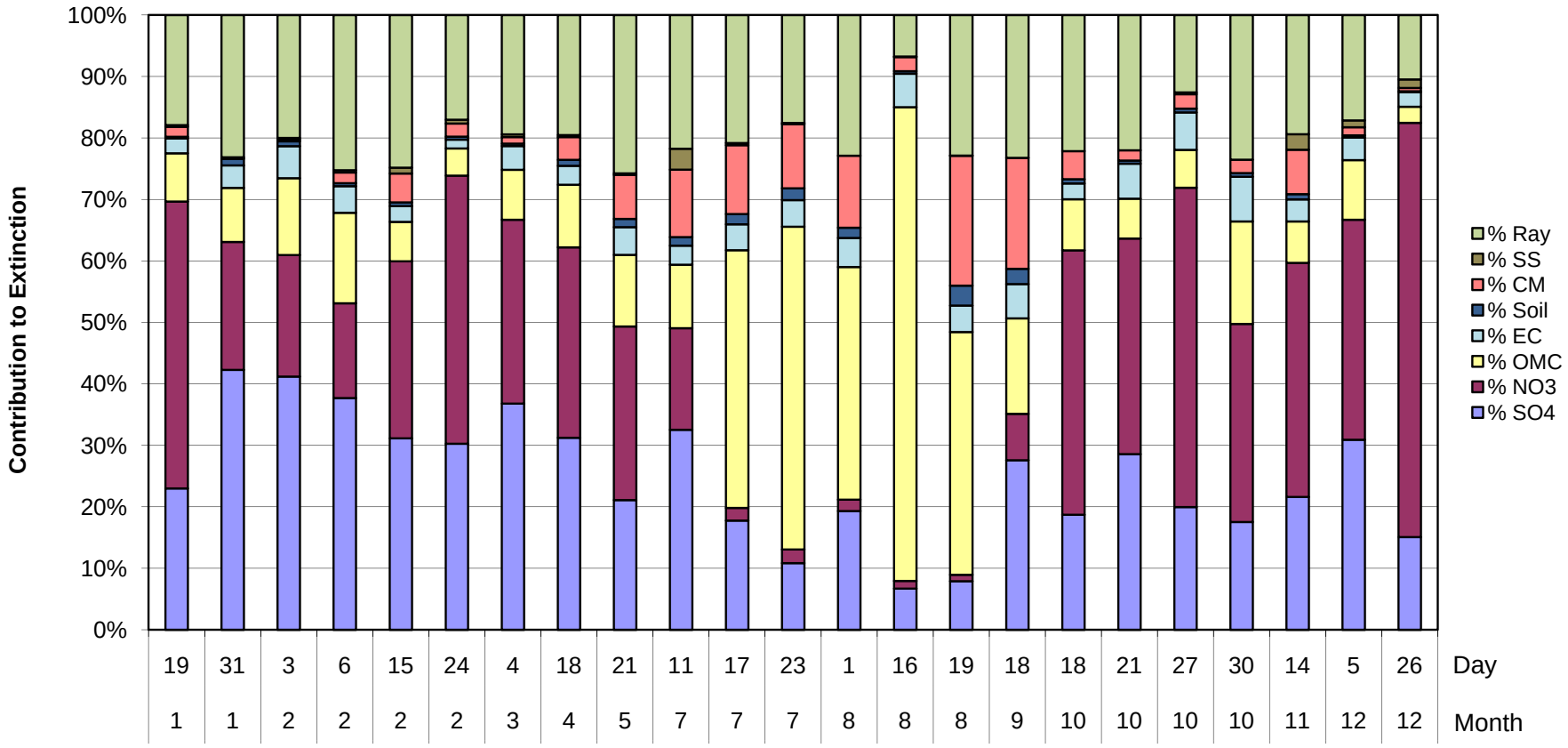


Figure 8.15
IMPROVE 20% Worst Days – LWA 2004

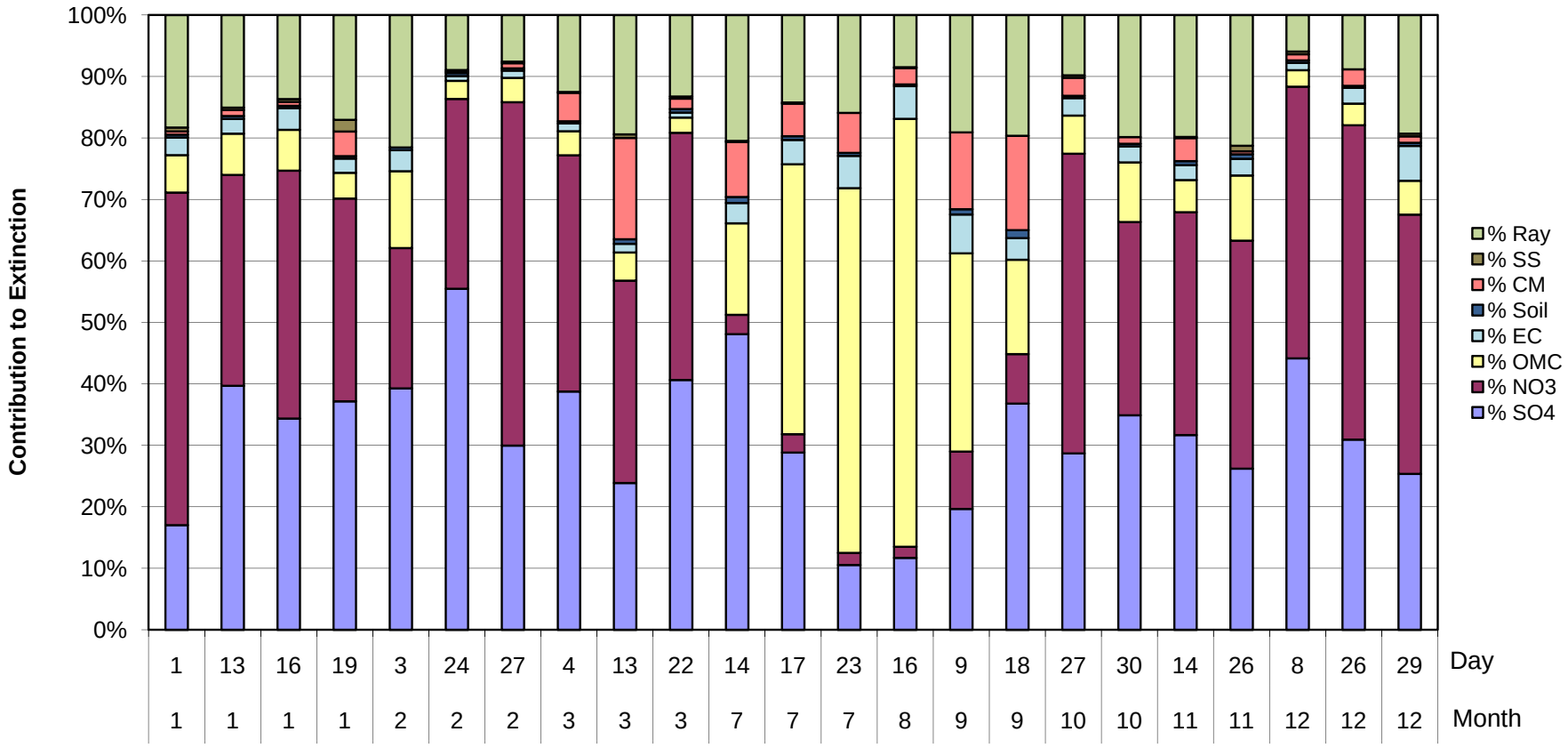


Table 8.12
Summary of WRAP CMAQ Visibility Projections for Worst 20% Days at TRNP

	Class I Area Visibility Summary: Theodore Roosevelt NP, ND **Visibility Conditions:** Worst 20% Days **RRF Calculation Method:** Specific Days (EPA) **Emissions Scenarios:** 2000-04 Baseline (plan02d) & 2018 PRP (prp18a)						
	Monitored	**Estimated**		**Projected**			
	2000-04 Baseline Conditions (Mm-1)	2064 Natural Conditions (Mm-1)	2018 Uniform Rate of Progress Target (Mm-1)[1]	2018 Projected Visibility Conditions (Mm-1)	Baseline to 2018 Change In Statewide Emissions (tons / %)	Baseline to 2018 Change In Upwind Weighted Emissions[2] (%)	Baseline to 2018 Change In Anthropogenic Upwind Weighted Emissions[2] (%)
Sulfate	17.53	1	12.23	15.94	-97,376 -57%	-21%	-21%
Nitrate	13.74	1.04	9.85	12.5	-37,211 -16%	27%	36%
Organic Carbon	10.82	3.92	8.95	10.94	-1,692 -19%	-3%	-8%
Elemental Carbon	2.75	0.32	2.13	1.98	-2,451 -51%	-28%	-44%
Fine Soil	0.9	0.97	0.91	1.02	1,212 2%	5%	10%
Coarse Material[3]	4.82	3.66	4.54	Not Applicable	12,744 4%	4%	13%
Sea Salt[3]	0.07	0.24	0.11		Not Applicable		
Total Light Extinction	61.62	22.14	48.41	58.26			
Deciview	17.8	7.8	15.47	17.24			

WRAP TSS

1) 2018 Uniform Rate of Progress Target for Best 20% Days is not defined.
2) Results based on Weighted Emissions Potential analysis using the 2000-04 Baseline (plan02d) & 2018 PRP (prp18a) emissions scenarios.
3) Visibility projections not available due to model performance issues.

Table 8.13
Summary of WRAP CMAQ Visibility Projections for Best 20% Days at TRNP

	Class I Area Visibility Summary: Theodore Roosevelt NP, ND **Visibility Conditions:** Best 20% Days **RRF Calculation Method:** Specific Days (EPA) **Emissions Scenarios:** 2000-04 Baseline (plan02d) & 2018 PRP (prp18a)						
	Monitored	**Estimated**		**Projected**			
	2000-04 Baseline Conditions (Mm-1)	2064 Natural Conditions (Mm-1)	2018 Uniform Rate of Progress Target (Mm-1)[1]	2018 Projected Visibility Conditions (Mm-1)	Baseline to 2018 Change In Statewide Emissions (tons / %)	Baseline to 2018 Change In Upwind Weighted Emissions[2] (%)	Baseline to 2018 Change In Anthropogenic Upwind Weighted Emissions[2] (%)
Sulfate	3.82	0.44	Not Applicable	3.88	-97,376 -57%	-9%	-9%
Nitrate	1.52	0.31	Not Applicable	1.41	-37,211 -16%	37%	49%
Organic Carbon	1.98	0.74	Not Applicable	1.99	-1,692 -19%	-4%	-8%
Elemental Carbon	0.93	0.1	Not Applicable	0.73	-2,451 -51%	-28%	-42%
Fine Soil	0.4	0.21	Not Applicable	0.43	1,212 3%	6%	13%
Coarse Material[3]	2.19	0.72	Not Applicable	Not Applicable	12,744 6%	6%	18%
Sea Salt[3]	0.03	0.03	Not Applicable		Not Applicable		
Total Light Extinction	21.86	13.57	Not Applicable	21.67			
Deciview	7.76	3.04	Not Applicable	7.67			

WRAP TSS

1) 2018 Uniform Rate of Progress Target for Best 20% Days is not defined.
2) Results based on Weighted Emissions Potential analysis using the 2000-04 Baseline (plan02d) & 2018 PRP (prp18a) emissions scenarios.
3) Visibility projections not available due to model performance issues.

Table 8.14
Summary of WRAP CMAQ Visibility Projections for Worst 20% Days at LWA

	Class I Area Visibility Summary: Lostwood NWRW, ND **Visibility Conditions:** Worst 20% Days **RRF Calculation Method:** Specific Days (EPA) **Emissions Scenarios:** 2000-04 Baseline (plan02d) & 2018 PRP (prp18a)						
	Monitored	**Estimated**		**Projected**			
	2000-04 Baseline Conditions (Mm-1)	2064 Natural Conditions (Mm-1)	2018 Uniform Rate of Progress Target (Mm-1)[1]	2018 Projected Visibility Conditions (Mm-1)	Baseline to 2018 Change In Statewide Emissions (tons / %)	Baseline to 2018 Change In Upwind Weighted Emissions[2] (%)	Baseline to 2018 Change In Anthropogenic Upwind Weighted Emissions[2] (%)
Sulfate	21.4	1.05	14.61	19.21	-97,376 -57%	-9%	-9%
Nitrate	22.94	1.1	15.56	21.94	-37,211 -16%	-16%	-19%
Organic Carbon	11.05	3.79	9.07	11.68	-1,692 -19%	-7%	-11%
Elemental Carbon	2.84	0.36	2.21	2.07	-2,451 -51%	-32%	-40%
Fine Soil	0.62	0.95	0.7	0.69	1,212 2%	-14%	-19%
Coarse Material[3]	3.93	3.74	3.89	Not Applicable	12,744 4%	-3%	-5%
Sea Salt[3]	0.26	0.52	0.32		Not Applicable		
Total Light Extinction	74.05	22.52	55.93	70.78			
Deciview	19.57	8	16.87	19.12			

WRAP TSS

1) 2018 Uniform Rate of Progress Target for Best 20% Days is not defined.
2) Results based on Weighted Emissions Potential analysis using the 2000-04 Baseline (plan02d) & 2018 PRP (prp18a) emissions scenarios.
3) Visibility projections not available due to model performance issues.

Table 8.15
Summary of WRAP CMAQ Visibility Projections for Best 20% Days at LWA

	Class I Area Visibility Summary: Lostwood NWRW, ND **Visibility Conditions:** Best 20% Days **RRF Calculation Method:** Specific Days (EPA) **Emissions Scenarios:** 2000-04 Baseline (plan02d) & 2018 PRP (prp18a)						
	Monitored	**Estimated**		**Projected**			
	2000-04 Baseline Conditions (Mm-1)	2064 Natural Conditions (Mm-1)	2018 Uniform Rate of Progress Target (Mm-1)[1]	2018 Projected Visibility Conditions (Mm-1)	Baseline to 2018 Change In Statewide Emissions (tons / %)	Baseline to 2018 Change In Upwind Weighted Emissions[2] (%)	Baseline to 2018 Change In Anthropogenic Upwind Weighted Emissions[2] (%)
Sulfate	4.39	0.42	Not Applicable	4.47	-97,376 -57%	-1%	-1%
Nitrate	1.86	0.34	Not Applicable	1.65	-37,211 -16%	-16%	-19%
Organic Carbon	2.26	0.66	Not Applicable	2.27	-1,692 -19%	-8%	-12%
Elemental Carbon	0.71	0.1	Not Applicable	0.52	-2,451 -51%	-31%	-38%
Fine Soil	0.34	0.22	Not Applicable	0.33	1,212 3%	-20%	-25%
Coarse Material[3]	2.31	0.63	Not Applicable	Not Applicable	12,744 6%	-6%	-10%
Sea Salt[3]	0.03	0.03	Not Applicable		Not Applicable		
Total Light Extinction	22.89	13.4	Not Applicable	22.58			
Deciview	8.19	2.92	Not Applicable	8.06			

WRAP TSS

1) 2018 Uniform Rate of Progress Target for Best 20% Days is not defined.
2) Results based on Weighted Emissions Potential analysis using the 2000-04 Baseline (plan02d) & 2018 PRP (prp18a) emissions scenarios.
3) Visibility projections not available due to model performance issues.

WRAP CMAQ modeling results for the default EPA methodology were used to review the contribution of individual visibility-affecting species to projected light extinction for 20% worst/best days (NDDoH hybrid modeling did not include all species). Summaries of WRAP CMAQ modeling results including 2018 projections for individual species are provided in Tables 8.12 through 8.15. Tables 8.12 and 8.13 provide speciated summaries (averages) of 20% worst and best days, respectively, for TRNP. Tables 8.14 and 8.15 address speciated summaries of 20% worst and best days, respectively, for LWA. The tables include light extinction values for baseline conditions, natural conditions, 2018 uniform rate of progress target, and 2018 projected visibility conditions for each visibility-affecting species. Values for total light extinction and deciview are provided as well (note these values are consistent with results in Table 8.11). Note that 2018 projected values are not provided for CM and SS species, due to model performance issues. For these species, WRAP (and NDDoH) assumed an RRF of 1.0, and set the 2018 projection equal to the monitored baseline value.

In reviewing the 20% worst day summaries for TRNP and LWA in Tables 8.12 and 8.14, respectively, sulfate and nitrate are found to be the largest contributors to light extinction. This is true for both baseline monitored conditions and for future (2018) projected conditions. Because of its dominance in the late summer months, organic carbon is also a major overall contributor to 20% worst day light extinction for both baseline monitored and future projected conditions. As discussed previously, WRAP modeling results for 20% worst days (summarized in Tables 8.12 and 8.14) indicate the total light extinction URP target will not be achieved at either TRNP or LWA. Further, results for individual species indicate the URP species-specific target will be met only for elemental carbon and sea salt.

The 20% best day summaries for TRNP and LWA are reported in Tables 8.13 and 8.15, respectively. With exception of sea salt, all species appear to be significant contributors to light extinction on 20% best days. Sulfate is the largest contributor at both TRNP and LWA. As shown in the tables, the 2018 projected light extinction is lower than the baseline light extinction for both Class I areas. Thus, Regional Haze Rule requirements for 20% best days will be satisfied at TRNP and LWA for the first planning period.

Note that the WRAP projected emissions values for nitrate (NO_X) in Tables 8.12 through 8.15 are not consistent with the levels used by NDDoH in hybrid modeling. The NDDoH adjusted the WRAP NO_X emissions associated with oil and gas activity, as described in Section 8.5.3.1.

8.6.2.3 Apportionment by Source Group

As established in Section 8.6.2.2, sulfate and nitrate are the primary contributors to 20% worst day visibility in North Dakota Class I areas. In its hybrid modeling analysis, the NDDoH tracked the contribution of source groups to the total predicted sulfate and nitrate concentration for 20% worst days, in order to enhance the interpretation of modeling results. Contributions are available for the following source groups:

- North Dakota electrical generating units (EGU),
- all other point sources within the CALPUFF domain,

- all sources modeled as area sources within the CALPUFF domain,
- North Dakota oil and gas related sources (O&G), and
- boundary conditions representing the impact of all sources located outside of the CALPUFF domain.

Focus is on the ND EGU and boundary condition groups because of their relatively small and large contributions, respectively. O&G contributions are available for sulfate, only.

Contributions of the above source groups to 20% worst day average predictions, based on NDDoH hybrid modeling, are illustrated in Figures 8.16 through 8.19. Predictions for the base period (2000-2004) are compared with predictions for the future period (2018) in the figures. Contributions for sulfate at TRNP are compared in Figure 8.16. Figure 8.17 provides contributions for sulfate at LWA. Source group contributions for nitrate at TRNP are illustrated in Figure 8.18. Finally, Figure 8.19 addresses contributions for nitrate at LWA. Source group contributions in the figures reflect the percent of the total average predicted concentration for 20% worst days.

As consistently shown in Figures 8.16 through 8.19, the contribution of North Dakota EGUs to total sulfate and total nitrate is relatively small, while the contribution of boundary conditions is relatively large. This is true for both baseline and future projections. For sulfate, boundary conditions contributed no less than two-thirds of the total at North Dakota Class I areas. For nitrate, the boundary condition contribution was no less than 59 percent. The contribution of North Dakota EGUs to sulfate was no more than 21 percent, and to nitrate was no more than 6 percent, at North Dakota Class I areas.

As shown in Figures 8.16 and 8.17, the reduced impact from North Dakota EGUs due to BART controls is apparent. The projected future contribution of North Dakota EGUs to sulfate is less than one-half the baseline contribution for both TRNP and LWA. The difference for other source groups is less pronounced, although an exception would be area sources at LWA, where the baseline contribution of 4.0 percent is reduced to 2.4 percent in 2018. In comparing future with baseline contributions in Figures 8.16 and 8.17, it appears the contribution of boundary conditions is increasing as the contribution of North Dakota EGUs decreases in the future (other source groups remain relatively stable).

In Figures 8.18 and 8.19, the difference between future and baseline contributions for nitrate is less apparent than for sulfate. Percentage contributions for nitrate remained relatively stable from baseline to future for both Class I areas. Reduction in NO_X emissions due to BART controls was less than BART reductions for SO2, but the NO_X reduction was still significant. This lack of response to future BART reductions in NO_X may be linked to the CALPUFF chemistry, and the tendency observed in the performance evaluation (Section 8.6.1) for NO_3 production to overreact to newly freed ammonia from the lower production of SO_4.

Figure 8.16
Hybrid Modeling Results
Source Group Contributions to 20% Worst Day SO_4 at TRNP (Base & Future)

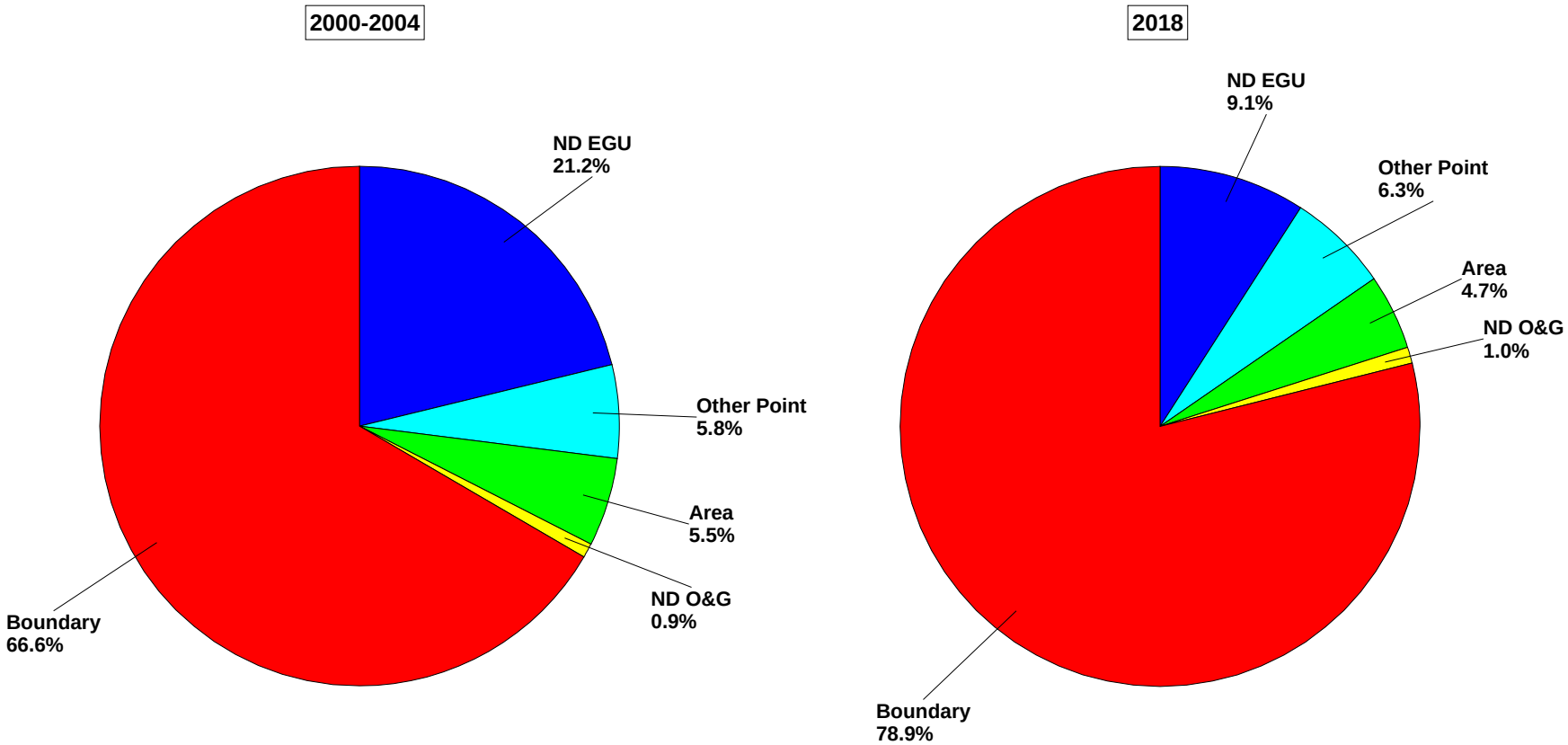


Figure 8.17
Hybrid Modeling Results
Source Group Contributions to 20% Worst Day SO_4 at LWA (Base & Future)

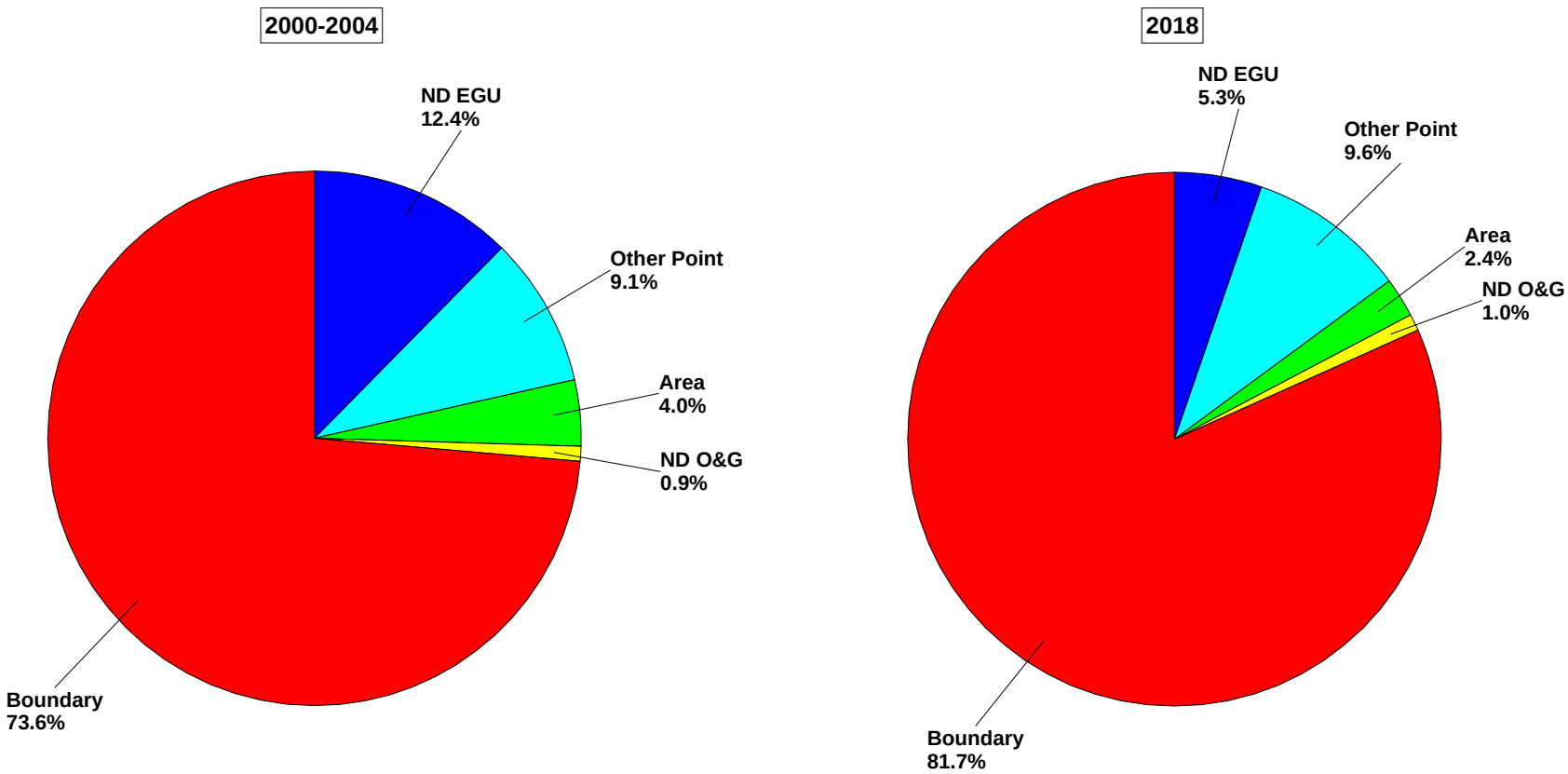


Figure 8.18
Hybrid Modeling Results
Source Group Contributions to 20% Worst Day NO_3 at TRNP (Base & Future)

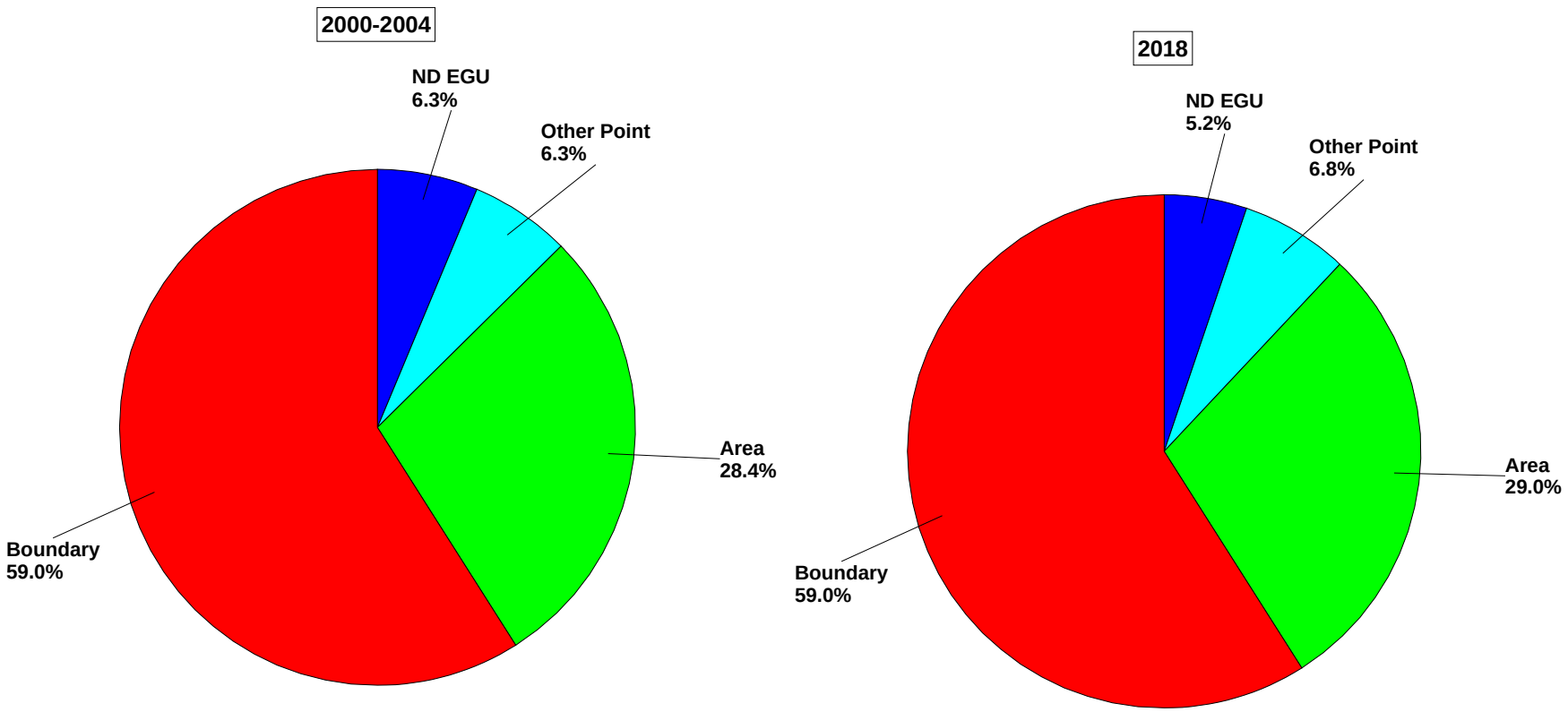
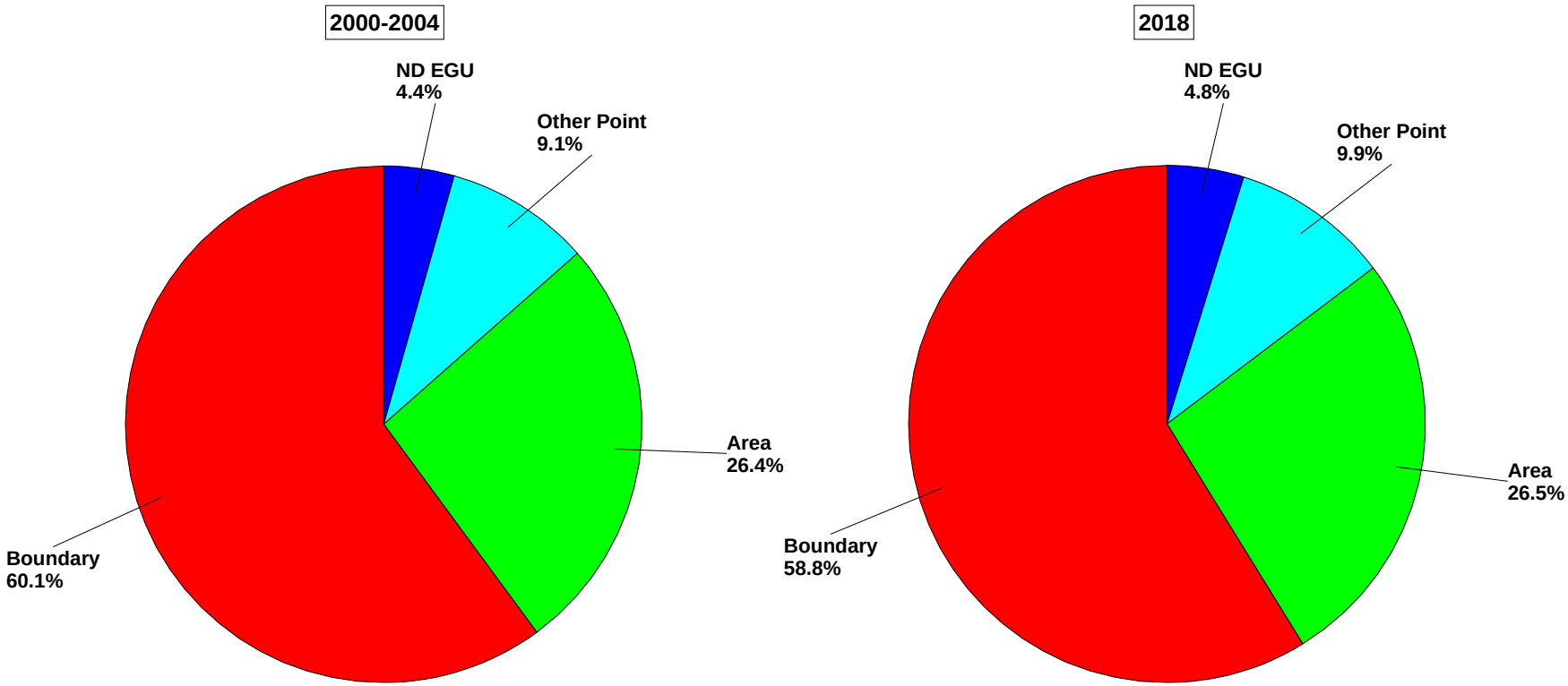


Figure 8.19
Hybrid Modeling Results
Source Group Contributions to 20% Worst Day NO_3 at LWA (Base & Future)



NDDoH hybrid modeling results were further refined in order to extract the contribution of all North Dakota sources to total predicted sulfate and nitrate concentrations for 20% worst days. This additional source group includes all North Dakota EGUs, all North Dakota point sources other than EGUs, and all North Dakota emissions modeled as area sources. Because the NDDoH CALPUFF domain excludes the far eastern part of North Dakota, some adjustments in inventory and procedure were necessary to estimate the contribution of this source group.

Contributions of the North Dakota only source group to total sulfate and nitrate are summarized in Table 8.16. Percentage contributions are provided for baseline and future predicted concentrations at both North Dakota Class I areas. As shown in the table, contributions from North Dakota sources are relatively small and comprise no more than 29 percent of the total prediction for 20% worst days. Significant reduction in future sulfate concentrations due to BART controls on North Dakota EGUs is again apparent.

Table 8.16
Hybrid Modeling Results
Total North Dakota Contribution to 20% Worst Days Predictions

	Class I Area	Baseline Percent	2018 Percent
SO_4	TRNP	27.3	15.0
	LWA	17.6	9.7
NO_3	TRNP	29.0	28.6
	LWA	26.4	28.7

The relatively small contributions of North Dakota EGUs (and North Dakota sources in general) and the relatively large contributions of boundary conditions to 20% worst day visibility in North Dakota Class I areas, as observed in Figures 8.16 through 8.19, and Table 8.16, translates to restricted options for meeting visibility progress goals. These results indicate that most of the visibility impact on the 20% worst days in North Dakota Class I areas is due to impact from sources located outside of the State, and beyond the jurisdiction of the NDDoH. From additional hybrid modeling, the NDDoH found that even with *all future North Dakota* SO_2 *and* NO_X

emissions reduced to zero, North Dakota Class I areas would not achieve the 2018 uniform rate of progress target (see Section 8.6.3).

Weight of evidence perspectives which address the contributions of sources located outside of North Dakota to worst day visibility at TRNP and LWA are discussed in Section 8.6.3.

8.6.2.4 Apportionment by Source Region

Visibility modeling conducted by WRAP RMC for North Dakota Class I areas included source-region attribution for all western states, central US, eastern US, Mexico, and Canada. In addition, WRAP also tracked the contribution of sources located outside of the CMAQ domain which includes the contiguous United States, southern Canada, and northern Mexico.

Results of the WRAP attribution analysis are summarized in the bar charts of Figures 8.20 through 8.23. These charts provide source-region contributions to baseline (PLAN02c) predicted concentrations of sulfate and nitrate for the 20% worst days. Figures 8.20 and 8.21 provide source region contributions for sulfate and nitrate, respectively, at TRNP. Figures 8.22 and 8.23 provide the corresponding contributions at LWA. Along with the bars labeled with familiar abbreviations for western states, the figures also include contributions with the following labels:

CAN – Canada,
CEN – Central US (CENWRAP),
EUS – Eastern US,
MEX – Mexico,
PO – Pacific Offshore, and
OD – Outside WRAP US-Canada-Mexico Modeling Domain.

The bar charts used in Figures 8.20 through 8.23 were obtained from the WRAP TSS web site. Note that the values in the charts actually reflect WRAP case PLAN02c, which is a predecessor to the updated PLAN02d. The differences between PLAN02c and PLAN02d, however, are not significant enough to affect conclusions regarding these charts.

In reviewing the bar charts of Figures 8.20 and 8.22, it is seen that emissions from North Dakota, Canada, and from outside the WRAP US-Canada-Mexico modeling domain (Figure 8.1) dominate total sulfate concentrations at North Dakota Class I areas on the 20% worst visibility days. The contribution of sources located outside the WRAP domain is larger than the contribution from North Dakota sources at both Class I areas, and the contribution of Canadian emissions is significantly larger than the contribution from North Dakota sources at both Class I areas.

From Figures 8.21 and 8.23, one observes a similar pattern of dominant source-region contributors for 20% worst day nitrate concentrations, except that Montana becomes a dominate contributor in addition to North Dakota, Canada, and sources located outside of the WRAP domain. The overall dominance of Canadian emissions is even greater for nitrate than for

Figure 8.20
WRAP Modeling Results
Source Region Contributions to 20% Worst Day SO_4 at TRNP (baseline)

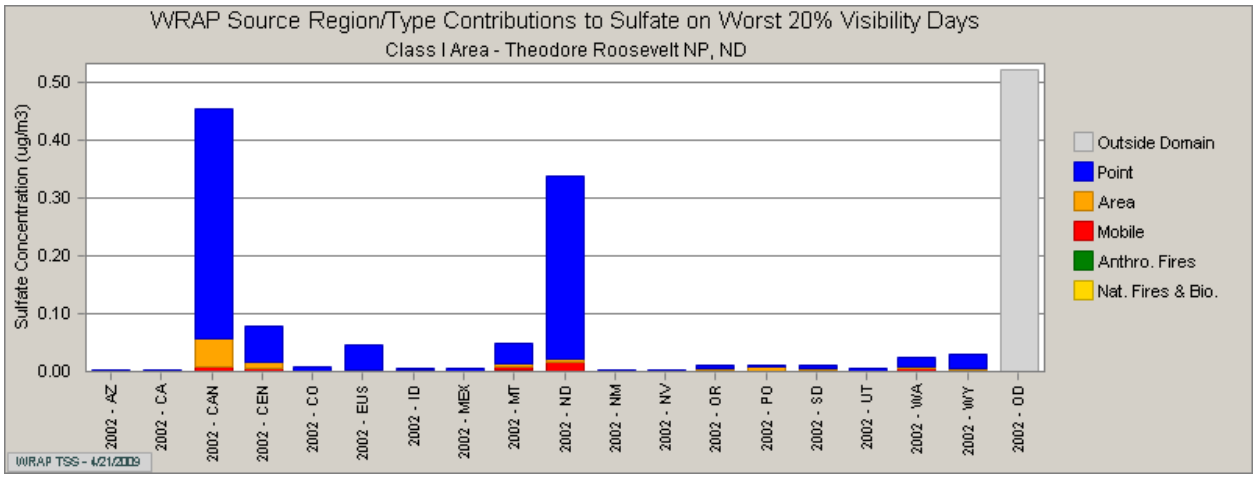


Figure 8.21
WRAP Modeling Results
Source Region Contributions to 20% Worst Day NO_3 at TRNP (baseline)

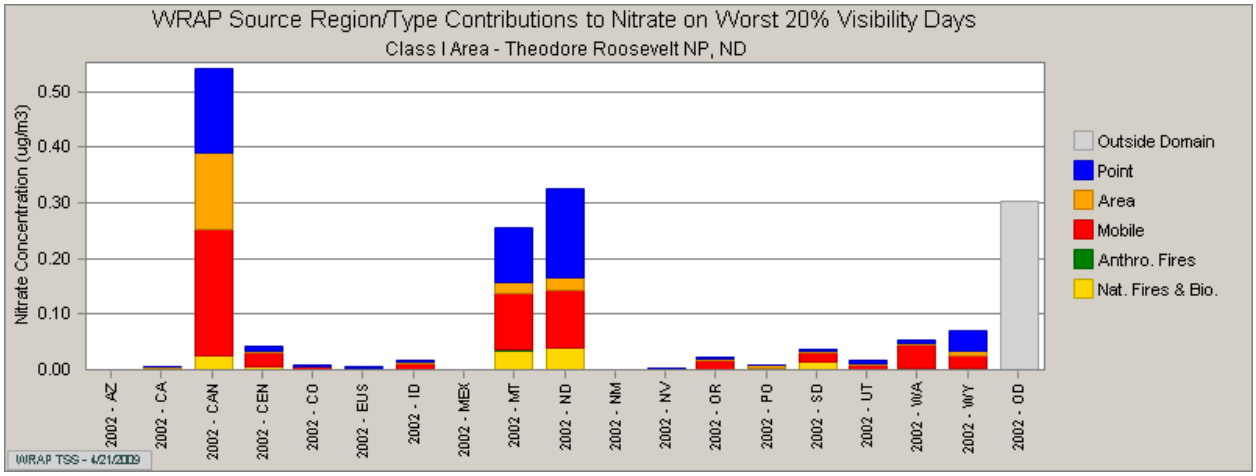


Figure 8.22
WRAP Modeling Results
Source Region Contributions to 20% Worst Day SO_4 at LWA (baseline)

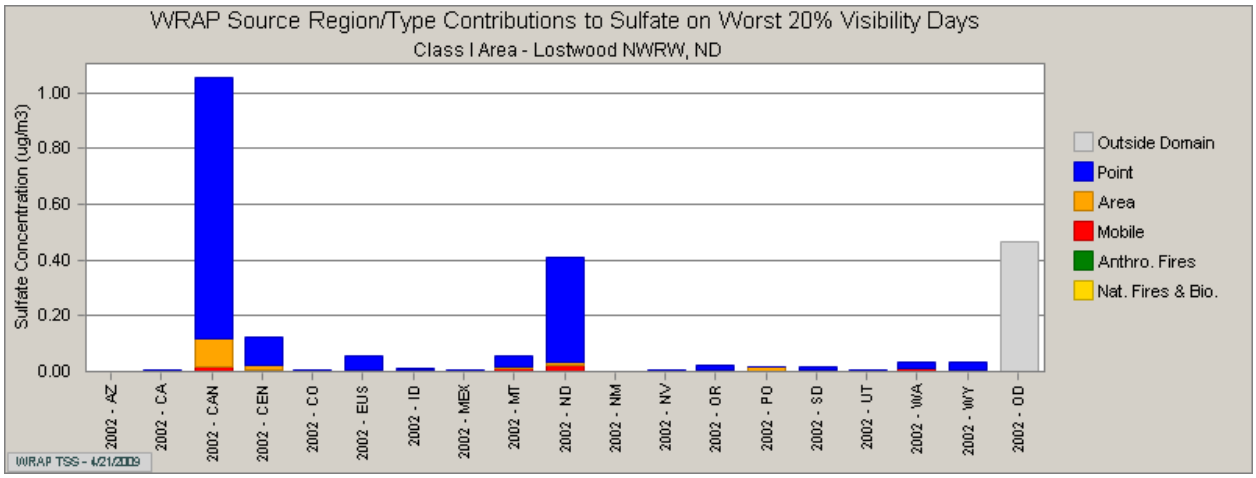
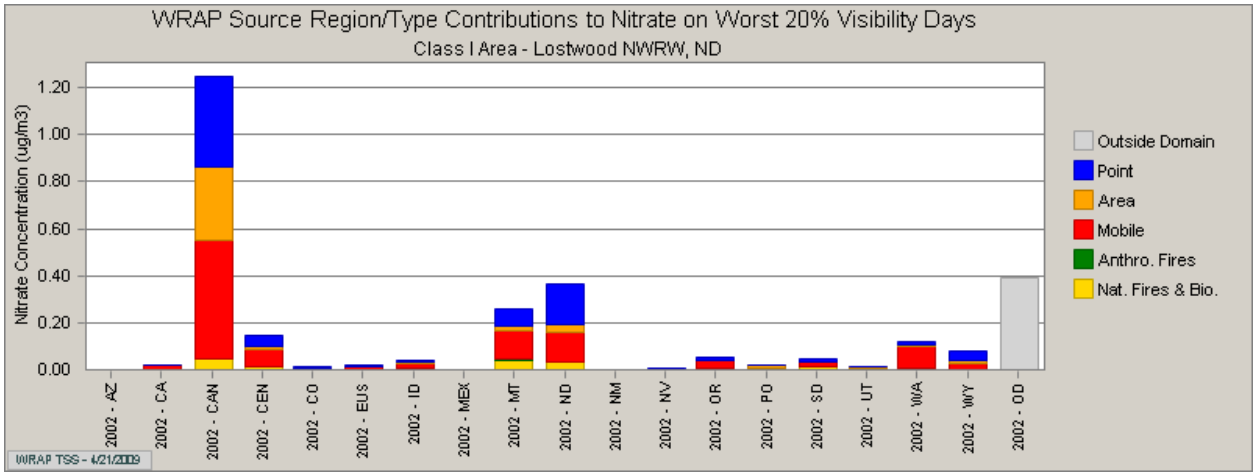


Figure 8.23
WRAP Modeling Results
Source Region Contributions to 20% Worst Day NO_3 at LWA (baseline)



sulfate, and at LWA the contribution to 20% worst day nitrate concentrations from Canadian sources is more than three times the contribution from North Dakota sources.

These source-region apportionment results illustrate that most of the contributions to 20% worst day nitrate and sulfate (species with the greatest effect on visibility impairment) at North Dakota Class I areas come from sources located outside of the state. Again, these sources are beyond the jurisdiction of the NDDoH, which poses a dilemma when seeking solutions for achieving visibility goals. This issue was addressed in the NDDoH weight of evidence interpretations which are discussed in Section 8.6.3.

8.6.2.5 Conclusions

Visibility progress modeling was conducted by WRAP and NDDoH using the default EPA methodology. This modeling was based on preliminary estimates of the effect of BART controls, and other growth and control factors. Results have been discussed in terms of general status with respect to the uniform rate of progress for North Dakota Class I areas, and in terms of apportionment by species, source group, and source region. Based on these modeling results, the following conclusions apply.

1) The uniform rate of progress goal for 2018 for 20% worst days will not be achieved at either TRNP or LWA. Therefore, weight of evidence arguments were addressed (see Section 8.6.3).

2) The Regional Haze Rule requirement for 2018 for 20% best days will be achieved at both TRNP and LWA.

3) NDDoH hybrid modeling (adjusted WRAP CMAQ) predicted better progress with respect to the 20% worst day uniform rate of progress goals than did WRAP modeling, at both TRNP and LWA.

4) Apportionment modeling results indicate the contribution of sources located outside of North Dakota is much greater than the contribution of in-state sources to 20% worst day visibility at TRNP and LWA (both baseline and 2018).

5) Though the addition of proposed BART controls substantially decreases the visibility impact of North Dakota EGUs, these EGUs comprise only a small component of total 20% worst day impact at TRNP and LWA.

6) Of the visibility affecting aerosols, sulfate and nitrate are primary contributors to 20% worst day visibility at North Dakota Class I areas.

7) The primary source-region contributors to 20% worst day visibility at TRNP and LWA are Canada, sources located outside of the WRAP modeling domain, North Dakota, and Montana (in that order).

8) When implemented as an adjustment to WRAP CMAQ modeling results, the NDDoH hybrid modeling approach is not critically tied to the parameterized CALPUFF chemistry.

8.6.3 Weight of Evidence Options

WRAP and NDDoH visibility modeling based on the default EPA methodology and glide path has been reviewed, with results as discussed in Section 8.6.2. Because projected 2018 visibility did not meet uniform rate of progress goals for 20% worst days in North Dakota Class I areas, the NDDoH pursued alternative or supplemental modeling approaches, which are discussed here. The Regional Haze Rule specifies that the State Implementation Plan may be based, in part, on evidence apart from modeling using the default EPA methodology. For example, the analysis could logically be modified to discount the impact of visibility-affecting emission sources over which the NDDoH has no jurisdiction.

These supplemental analyses are defined in the Rule as "weight of evidence" options. The following supplemental modeling analyses were conducted by NDDoH in the assessment of visibility progress goals.

1) Discounted the impact of international (in this case, Canadian) source visibility-affecting emissions on North Dakota Class I areas.

2) Discounted the impact of visibility-affecting emissions from all sources located outside of North Dakota, on North Dakota Class I areas.

3) Used the complete emissions inventory for the default EPA method, but zeroed out future SO_2 and NO_X emissions from all sources located in North Dakota (i.e., assumed 100 percent future control of all SO_2 and NO_X emissions in North Dakota), to determine progress with respect to the default glide path for North Dakota Class I Areas.

4) Based 20% worst visibility days for determining RRFs on baseline model results (CALPUFF) rather than IMPROVE monitoring data. This may be justified because neither CMAQ nor CALPUFF perform well on a "paired-in-time" basis. The resultant RRFs were still applied to 20% worst days based on IMPROVE monitoring to project future visibility.

Procedures and results for these supplemental, weight of evidence analyses are discussed in Sections 8.6.3.1 through 8.6.3.4.

8.6.3.1 Discounting the Impact of Canadian Source Emissions

The procedure used by the NDDoH to discount the impact of Canadian source emissions in the projection of future visibility at North Dakota Class I areas is consistent with the methodology described in Section 8.5.6.2. To discount the impact of Canadian source emissions on visibility projections, Canadian sources were removed from the baseline and future emissions inventories used with the hybrid modeling system to develop RRFs, and the URP glide path was adjusted by

subtracting the impact of Canadian emissions from the baseline starting value. This weight of evidence analysis was applied for 20% worst days, only. The adjusted glide path is compared with the default glide path in Figure 8.24 for TRNP and LWA.

Because the NDDoH hybrid modeling addresses S and N species only, the discounting of Canadian source impact was limited to sulfate and nitrate, only. The RRFs and projected future contribution to light extinction of other visibility affecting species remained unchanged from the default EPA methodology (i.e., included Canadian emissions). As sulfate and nitrate are the primary contributors to light extinction at North Dakota Class I areas on the 20% worst days (see Section 8.6.2.2), this limitation should not significantly impact conclusions based on this weight of evidence analysis.

Note that once the glide path has been adjusted, the URP 2018 target value changes along with the baseline starting value (the adjusted glide path terminates at the same natural background value in 2064). Therefore, it is no longer meaningful to compare the 2018 projected progress with the absolute deciview target from the default EPA methodology (Table 8.11). Instead, for this weight of evidence scenario and others, 2018 progress is expressed as a percentage of the target rather than as a specific deciview value.

The NDDoH procedure used to discount the impact of Canadian source emissions is outlined as follows.

1) Canadian sources located within the NDDoH CALPUFF domain were eliminated from the *HybridPt* baseline and future emissions inventories to be used in Equation 8-3.

2) CALPUFF hourly boundary conditions (baseline and future *HybridPt*) were adjusted to eliminate the contribution of Canadian (anthropogenic) source emissions (leaving only the contribution of natural background) for 3-km boundary segments located in Canada (see Figure 8.5). The fixed adjustment factor utilized represents the ratio of species-specific natural background light extinction to species-specific baseline monitored light extinction for the 20% worst day average, at each Class I area. The adjustment was applied to all boundary species (SO_2, SO_4, NO_X, HNO_3, and NO_3). The SO_4 ratio was used for scaling SO_4 and SO_2 species. The NO_3 ratio was used for scaling NO_3, HNO_3, and NO_X species.

3) Hybrid modeling was applied to prepare a revised glide path and 2018 target using Equation 8-4 with the revised baseline emissions inventories (non-Canadian sources only) from Steps 1 and 2, for each Class I area. The 3-step ammonia limiting method was applied to refine NO_3 concentrations for non-Canadian sources.

4) Hybrid modeling was applied to project future visibility using Equation 8-3 with the revised baseline and future emissions inventories (non-Canadian sources only) from Steps 1 and 2, for each Class I area. The 3-step ammonia limiting method was applied to refine NO_3 concentrations for non-Canadian sources.

5) The projected future deciview value was compared with the revised glide path 2018 target deciview value to calculate the percent of the 2018 target achieved, at each Class I area.

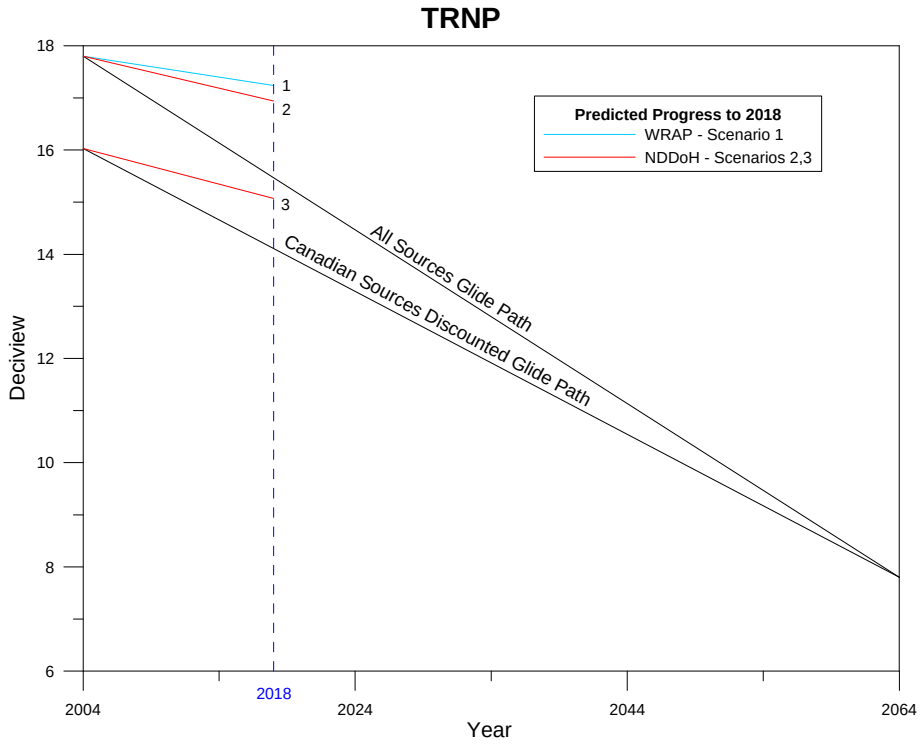
Results of the weight of evidence analysis for discounting the impact of Canadian source emissions are summarized in Table 8.17 and illustrated in Figure 8.24. Uniform rate of progress illustrations in Figure 8.24 are provided for both TRNP and LWA Class I areas. For comparison, the table and figure also include previous WRAP and NDDoH results for the complete emissions inventory and default EPA methodology from Table 8.11. WRAP results for the default EPA methodology are labeled Scenario 1 and NDDoH results for the default EPA methodology are labeled Scenario 2. They are compared with the weight of evidence entry which is identified as Scenario 3. For each scenario, the table provides percentage progress with respect to the 2018 target.

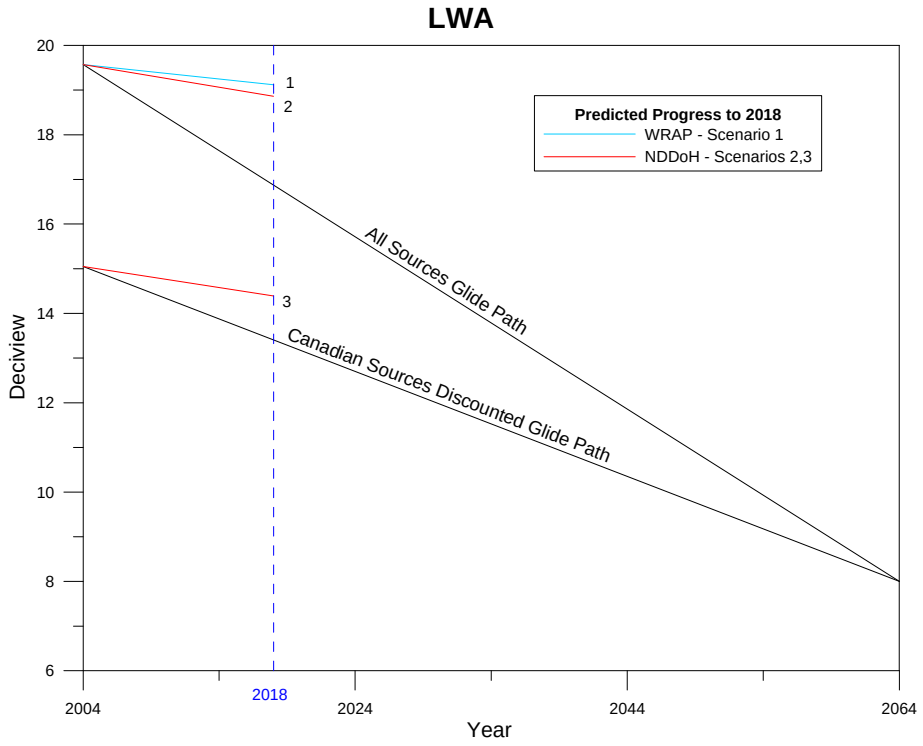
Table 8.17
NDDoH Visibility Modeling Results 20% Worst Days
Weight of Evidence – Discounting Canadian Emissions

Scenario	Description	Class I Area	Projected Percent of 2018 Target
1	WRAP CMAQ Default EPA Methodology	TRNP	24.0
		LWA	16.7
2	NDDoH Hybrid Default EPA Methodology	TRNP	38.1
		LWA	26.7
3	NDDoH Hybrid Canada Sources Discounted	TRNP	50.0
		LWA	40.2

As shown in Table 8.17 and Figure 8.24, progress with respect to the 2018 target is significantly improved when Canadian sources are discounted. The projected percent of the 2018 target with Canadian sources discounted is more than double the percentage obtained by WRAP for the default EPA methodology, and about 50 percent greater than the percentage obtained by NDDoH for the default EPA methodology, at both Class I areas. Though progress is significantly

Figure 8.24
Uniform Rate of Progress
EPA Default Methodology and Canadian Sources Discounted





improved under this scenario, the potential for greater improvement was limited because the contribution of US sources located outside of the hybrid model domain is very large (with little emissions reduction in the future), and the scenario could only address the discounted impact of SO_4 and NO_3.

8.6.3.2 Discounting the Impact of All Sources Located Outside of North Dakota

Because discounting the impact of Canadian emissions did not provide compliance with glide path targets, the NDDoH pursued other weight of evidence options. The next logical test after discounting Canadian emissions was to discount the visibility-affecting impact of all sources located outside of the jurisdiction of the NDDoH. Therefore, this new analysis discounted all contributions to North Dakota Class I areas, except for the impact of North Dakota sources and natural background. To discount the impact of *all sources located outside of North Dakota* on visibility projections, these sources were removed from the baseline and future emissions inventories used with the hybrid modeling system to develop RRFs, and the URP glide path was adjusted by subtracting the impact of these sources from the baseline starting value. This weight of evidence analysis was applied for 20% worst days, only. The adjusted glide path is compared with the default glide path in Figure 8.25 for TRNP and LWA.

Since the CALPUFF domain used by the NDDoH for hybrid visibility modeling excludes the extreme eastern part of North Dakota, area emissions for the easternmost column of the area source grid (see Figure 8.8) were adjusted upward to account for the impact of eastern North Dakota sources. Specifically, WRAP CMAQ (SMOKE) emissions for all grid cells located between the eastern edge of the CALPUFF domain and the eastern North Dakota border were added to the easternmost column of the CALPUFF area source grid. This addition was performed on a row by row basis. Because eastern North Dakota visibility affecting sources are relatively small and distant from TRNP and LWA Class I areas, this adjustment should have minimal impact on modeling results.

Because the NDDoH hybrid modeling addresses S and N species only, the discounting of out-of-state source impact was limited to sulfate and nitrate, only. The RRFs and projected future contribution to light extinction of other visibility affecting species remained unchanged from the default EPA methodology (i.e., included complete emissions inventory). As sulfate and nitrate are the primary contributors to light extinction at North Dakota Class I areas on most of the 20% worst days (see Section 8.6.2.2), this limitation should not significantly impact conclusions based on this weight of evidence analysis.

The procedure used by NDDoH to discount the impact of *all sources located outside of North Dakota* is similar to the 5-step procedure used to discount Canadian emissions, as outlined in Section 8.6.3.1., except that variables representing North Dakota sources replaced variables representing US sources in Equations 8.3 and 8.4. The procedure for discounting the impact of all out-of-state sources is outlined below.

1) All out-of-state sources located within the NDDoH CALPUFF domain were eliminated from the *HybridPt* baseline and future emissions inventories to be used in Equation 8-3.

2) As discussed above, emissions from all sources located outside of CALPUFF domain, but inside North Dakota, were added to easternmost column of CALPUFF area source grid.

3) CALPUFF hourly boundary conditions (baseline and future *HybridPt*) were scaled to eliminate the contribution of all out-of-state source emissions (leaving only the contribution of natural background) for all boundary segments. Scaling was based on the inverse distance squared weighted average of natural-to-baseline (2002) ratio from seven nearby IMPROVE monitoring locations. The ratio was obtained for the 20% worst day average SO_4 and NO_3 natural and baseline extinction for Theodore Roosevelt NP, Lostwood NWA, Medicine Lake NWA, UL Bend, Badlands NP, Wind Cave, and Voyageurs NP IMPROVE sites. The average SO_4 ratio was used for scaling SO_4 and SO_2 species. The average NO_3 ratio was used for scaling NO_3, HNO_3, and NO_X species.

4) Hybrid modeling was applied to prepare a revised glide path and 2018 target using Equation 8-4 with the revised baseline emissions inventories from Steps 1 and 2, for each Class I area (equation variables for North Dakota sources replaced variables for US sources). The 3-step ammonia limiting method was applied to determine NO_3 concentrations for North Dakota sources.

5) Hybrid modeling was applied to project future visibility using Equation 8-3 with the revised baseline and future emissions inventories from Steps 1 and 2, for each Class I area (equation variables for North Dakota sources replaced variables for US sources). The 3-step ammonia limiting method was applied to determine NO_3 concentrations for US sources.

6) The projected future deciview value was compared with the revised glide path 2018 target deciview value to calculate the percent of the 2018 target achieved, at each Class I area.

Results of the weight of evidence analysis for discounting the impact of *all sources located outside of North Dakota* are summarized in Table 8.18 and illustrated in Figure 8.25. Uniform rate of progress illustrations in Figure 8.25 are provided for both TRNP and LWA Class I areas. For comparison, the table and figure also include previous WRAP and NDDoH results for the complete emissions inventory with default EPA methodology from Table 8.11. WRAP results for the default EPA methodology are labeled Scenario 1 and NDDoH results for the default EPA methodology are labeled Scenario 2. They are compared with the new weight of evidence entry which is identified as Scenario 4. For each scenario, the table provides percentage progress with respect to the 2018 target.

As shown in Table 8.18 and Figure 8.25, progress with respect to the 2018 target is significantly improved after discounting the impact of *all sources located outside of North Dakota*, but projections do not meet the revised glide path targets. Also, the improvement is notably better at TRNP than at LWA. A likely explanation is that the location of BART sources in North Dakota, combined with prevailing meteorology, favors visibility improvement at TRNP compared with improvement at LWA (i.e., when there are no out of state influences).

Table 8.18
NDDoH Visibility Modeling Results 20% Worst Days
Weight of Evidence – Discounting All Out-of-State Sources

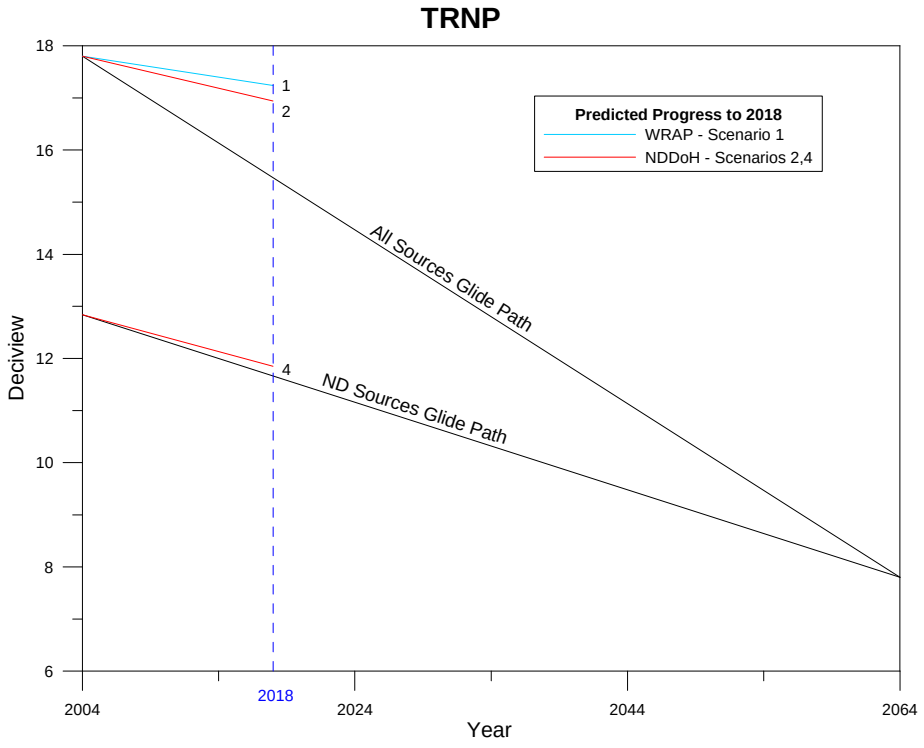
Scenario	Description	Class I Area	Projected Percent of 2018 Target
1	WRAP CMAQ Default EPA Methodology	TRNP LWA	24.0 16.7
2	NDDoH Hybrid Default EPA Methodology	TRNP LWA	38.1 26.7
4	NDDoH Hybrid All Sources Other Than ND Discounted	TRNP LWA	83.9 59.6

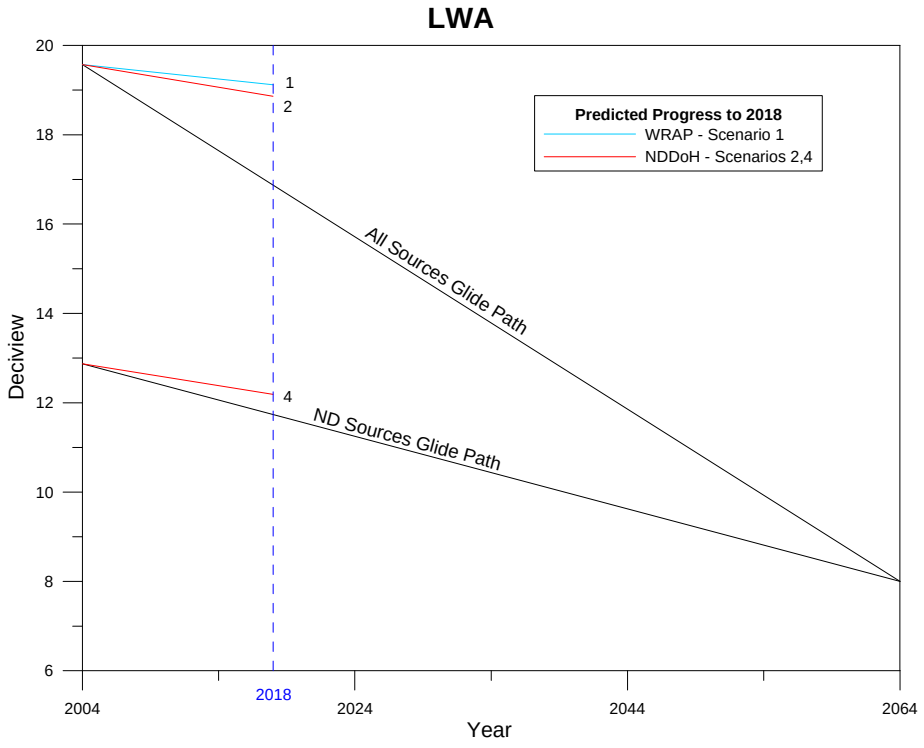
8.6.3.3 Use Default EPA Methodology with Zero North Dakota Future Emissions

The NDDoH next examined a "what if" scenario to see what would happen if all North Dakota sources were controlled to the hypothetical maximum degree and simply emitted no SO_2, SO_4, NO_X, or NO_3 in the future case. The concept here was to determine if the 2018 URP targets for the default EPA methodology for 20% worst days could be achieved even under maximum (albeit unrealistic) control conditions for North Dakota sources. Hybrid modeling for the baseline case (*HybridPt* in Equation 8-3) included the complete emissions inventory as used for the NDDoH EPA methodology analysis. Future case modeling (*HybridPt* in Equation 8-3) included the complete emissions inventory as applied by NDDoH for EPA methodology, except that all emissions for sources located in North Dakota were reset to zero. For this scenario, the glide path remains consistent with the default EPA methodology scenario.

Procedure for this new scenario followed the default EPA methodology, as discussed in Section 8.5. The only change was in the future case emissions inventory, where the emission rates for all North Dakota point and area sources were reset to zero. Note that because extreme eastern North Dakota is not included in the NDDoH CALPUFF domain, it was not possible to model the effect of zero future emissions from that part of the state. However, because visibility-affecting sources in extreme eastern North Dakota are relatively small and distant from the Class I areas

Figure 8.25
Uniform Rate of Progress
EPA Default Methodology and Non-ND Sources Discounted





which are both located in the western part of the state, this limitation should not detract from conclusions established regarding the analysis.

Results of the weight of evidence analysis involving zero future emissions for North Dakota visibility affecting sources are summarized in Table 8.19. For comparison, the table also includes previous WRAP and NDDoH results for the complete emissions inventory with default EPA methodology from Table 8.11. WRAP results for the default EPA methodology are labeled Scenario 1 and NDDoH results for the default EPA methodology are labeled Scenario 2. They are compared with the new weight of evidence entry which is identified as Scenario 5. For each scenario, the table provides percentage progress with respect to the 2018 target.

As illustrated in Table 8.19, even with all future North Dakota SO_2, SO_4, NO_X, and NO_3 emissions set to zero, the URP 20% worst day targets for 2018 are not achieved at North Dakota Class I areas. This result is consistent with earlier conclusions in this report that most of the visibility affecting impact on TRNP and LWA is coming from sources located outside of North Dakota. The implication of this weight of evidence test is that compliance with 20% worst day URP targets at North Dakota Class I areas cannot be achieved without significant additional emissions reductions from visibility affecting sources located outside of North Dakota.

Table 8.19
NDDoH Visibility Modeling Results 20% Worst Days
Weight of Evidence – Zero Future North Dakota Emissions

Scenario	Description	Class I Area	Projected Percent of 2018 Target
1	WRAP CMAQ Default EPA Methodology	TRNP LWA	24.0 16.7
2	NDDoH Hybrid Default EPA Methodology	TRNP LWA	38.1 26.7
5	NDDoH Hybrid Base Emissions Inv = Default Future Emissions Inv = All ND S and N Emissions set to zero	TRNP LWA	83.8 72.6

As indicated previously, the NDDoH CALPUFF visibility modeling was limited to the contribution of SO_2, SO_4, NO_X, and NO_3 species, only. Even if the effect of zeroing out all other visibility affecting species could have been accounted for, it is unlikely that 2018 URP targets for North Dakota Class I areas could have been achieved under this weight of evidence scenario.

8.6.3.4 Base 20% Worst Days on Modeling Results Rather than IMPROVE Monitoring Data

Though both models perform well when predicting maximum concentrations over a period of time, CMAQ and CALPUFF are less reliable when performance tests are based on predictions paired with concurrent observations. But the reliance of the Regional Haze Rule on the 20% worst/best monitored days to track visibility progress implies that the modeling system must demonstrate some skill on a temporal basis. To address possible temporal performance limitations in the NDDoH hybrid modeling system, visibility projection results based on the 20% worst monitored days were compared with results based on the 20% worst modeled days for the baseline case. The following procedure was used to develop results based on worst modeled days.

1) The hybrid modeling system was executed for the baseline case, using the emissions inventory for the default EPA methodology, and the entire year of 2002 meteorological data.

2) Daily modeling results for the baseline case were ranked in order to determine the 20% worst days (73 days) for visibility at both Class I areas (TRNP and LWA).

3) The hybrid modeling system was executed for the future (2018) case, using the emissions inventory for the default EPA methodology, and the 20% worst days determined for the baseline case in Step 2.

4) Relative response factors (RRFs) were developed from the modeling results for baseline and future cases in Steps 1 and 3, respectively.

5) RRFs were applied to IMPROVE baseline monitoring data for original 20% worst days to project future visibility.

This procedure provided deciview improvement predictions which were very similar to the original improvement predictions obtained through modeling the 20% worst IMPROVE days. Typical differences were less than five percent of the original predicted values at both Class I areas. Therefore, the NDDoH did not pursue this approach for any of the visibility modeling documented in this report (i.e., all modeling was based on the 20% worst/best IMPROVE days).

8.6.3.5 Weight of Evidence Summary and Conclusions

Results of the weight of evidence modeling analyses are summarized in Table 8.20, and in the illustrations of Figures 8.26 and 8.27. For comparison, the table and figures include results from all weight of evidence analyses, as well as previous WRAP and NDDoH results for the complete emissions inventory and default EPA methodology from Table 8.11. Scenarios are labeled as previously noted. For each scenario, the table provides percentage progress with respect to the 2018 target for 20% worst days at both North Dakota Class I areas. Figure 8.26 illustrates progress with respect to the URP glide path at TRNP for all scenarios, and Figure 8.27 illustrates progress with respect to the URP glide path at LWA for all scenarios.

Conclusions based on weight of evidence modeling analyses follow.

1) Compliance with 20% worst day URP 2018 targets at North Dakota Class I areas cannot be achieved through additional emissions reductions from North Dakota sources, alone. It will require significant additional visibility affecting emissions reductions from other western states, Canada, and from sources located outside of the WRAP CMAQ modeling domain.

2) A visibility progress analysis methodology which discounts the impact of International (Canadian) visibility affecting source emissions on 20% worst days is plausible, and was developed and implemented by the NDDoH. Using similar methodology, the NDDoH was able to also develop and implement a procedure to discount the impact of *all sources located outside of North Dakota* on 20% worst days.

3) After discounting the impact of Canadian sources, significantly greater progress (50 percent greater) was demonstrated, relative to URP 2018 targets for North Dakota Class I areas, than modeling with the entire emissions inventory. But 20% worst day targets were still not achieved.

4) After discounting the impact of *all sources located outside of North Dakota*, even greater progress was demonstrated, relative to URP 2018 targets for North Dakota Class I areas, than modeling with Canadian sources discounted. However, 20% worst day targets were still not achieved.

5) After zeroing out all future SO_2 and NO_X emissions in North Dakota under default EPA methodology (emulating a 100 percent, unrealistic control of all sources), compliance with 20% worst day targets was still not achieved at North Dakota Class I areas.

6) Basing 20% worst days on baseline model results rather than IMPROVE monitoring data made no meaningful difference in future visibility projections.

Table 8.20
NDDoH Visibility Modeling Results 20% Worst Days
Weight of Evidence Analysis Summary

Scenario	Description	Class I Area	Projected Percent of 2018 Target
1	WRAP CMAQ Default EPA Methodology	TRNP LWA	24.0 16.7
2	NDDoH Hybrid Default EPA Methodology	TRNP LWA	38.1 26.7
3	NDDoH Hybrid Canada Sources Discounted	TRNP LWA	50.0 40.2
4	NDDoH Hybrid All Sources Other Than ND Discounted	TRNP LWA	83.9 59.6
5	NDDoH Hybrid Base Emissions Inv = Default Future Emissions Inv = All ND SO_2 and NO_X Emissions set to zero	TRNP LWA	83.8 72.6

Figure 8.26
TRNP Uniform Rate of Progress
EPA Default Methodology and NDDoH Weight of Evidence

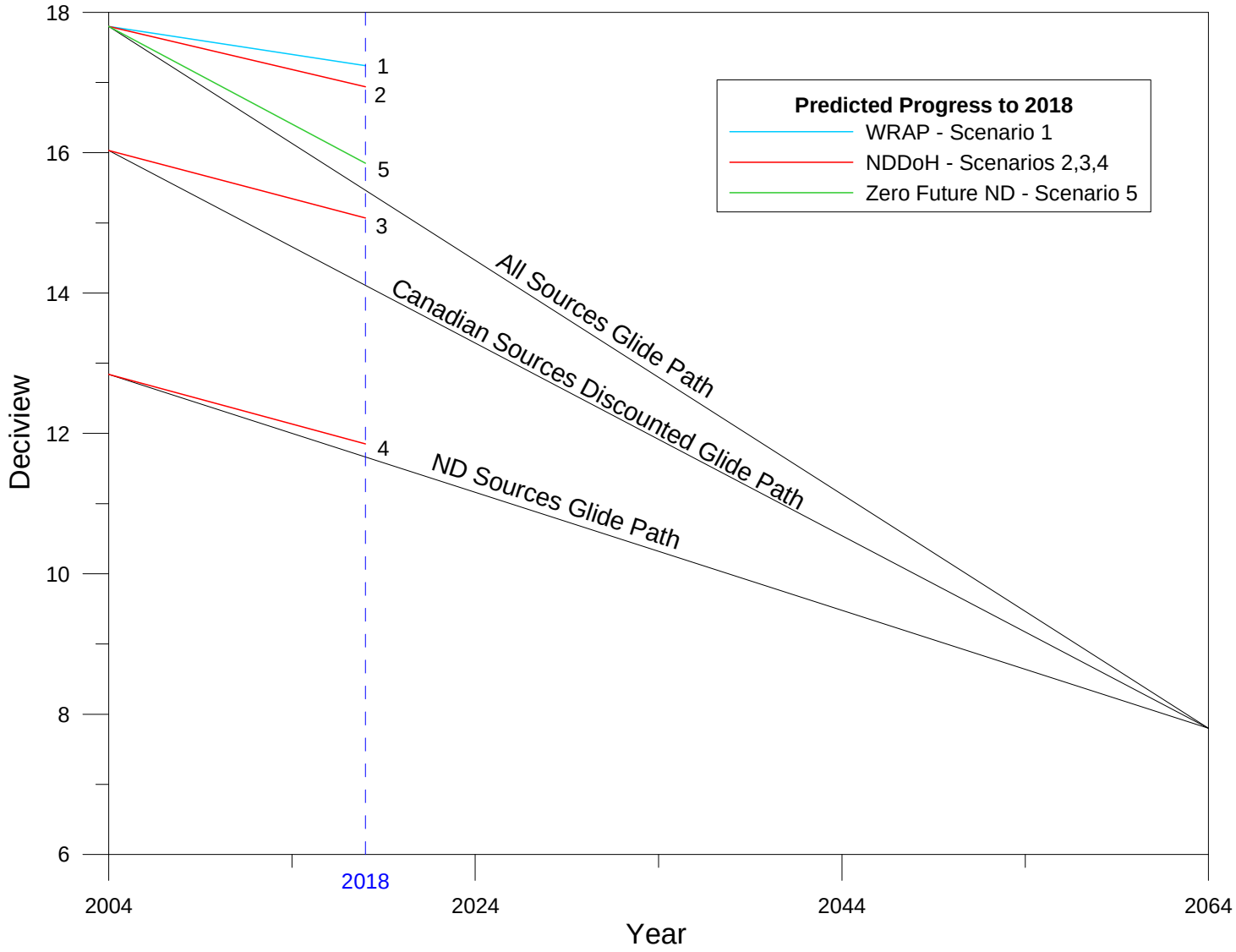
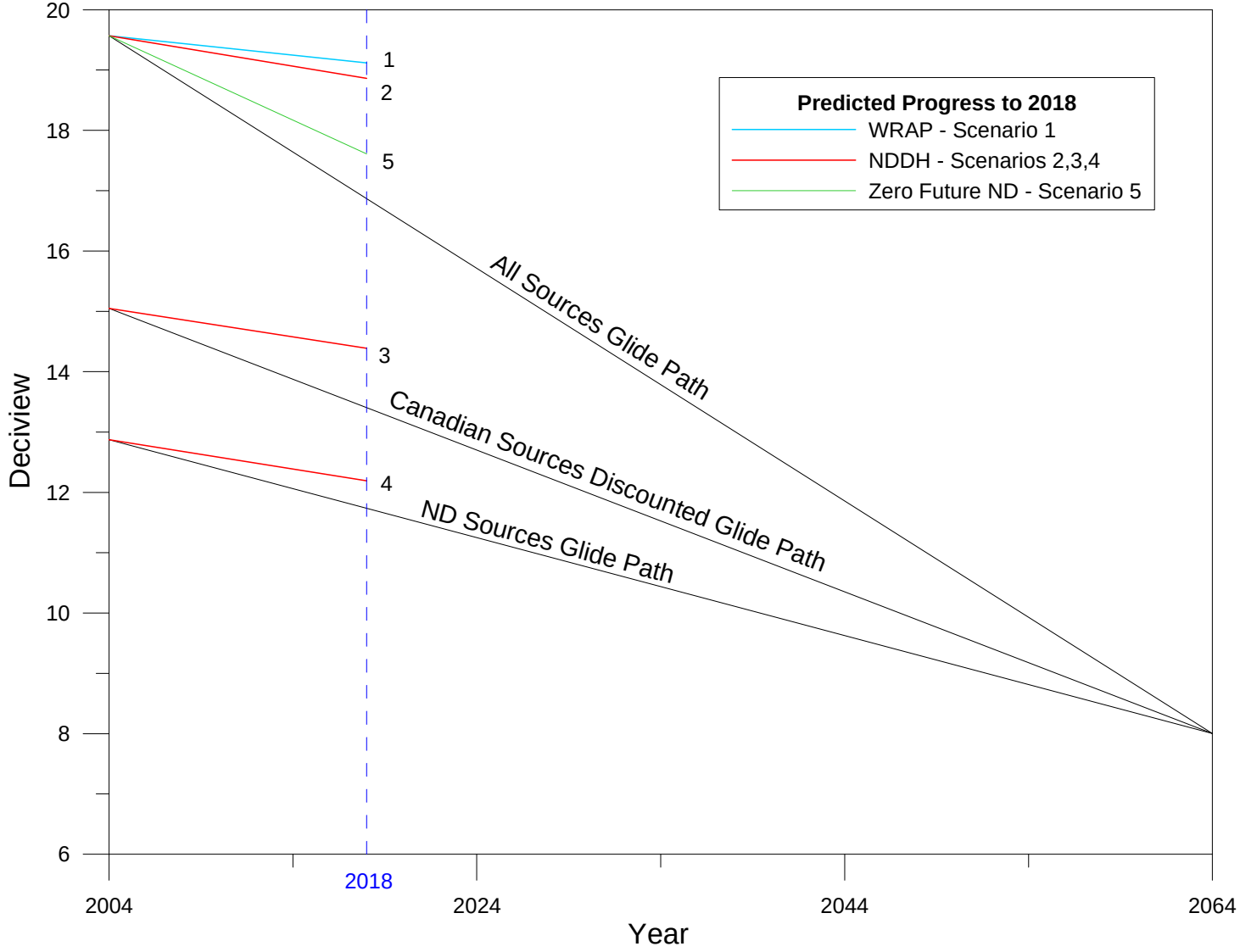


Figure 8.27
LWA Uniform Rate of Progress
EPA Default Methodology and NDDoH Weight of Evidence



9. Reasonable Progress Goals

9.1 Introduction

The Regional Haze Rule states that for each mandatory Class I Federal area located within the State and in each mandatory Class I Federal area located outside the State which may be affected by emissions from within the State, the State must establish reasonable progress goals for each area. For out-of-state Class I areas that are affected by in-state emissions, the State must consult with the affected state regarding the reasonable progress goals for those Class I areas. The reasonable progress goals (expressed in deciviews) must provide for reasonable progress towards achieving natural visibility conditions including improvement in visibility for the most impaired days (20% worst days) and ensuring no degradation in visibility for the least impaired days (20% cleanest days) over the planning period.

The EPA has published guidance[1] for setting reasonable progress goals. The basic steps include:

1. Establish Baseline and Natural Visibility Conditions

2. Determine the Glidepath, or Uniform Rate of Progress

3. Identify and Analyze the Measures Aimed at Achieving the Uniform Rate of Progress

    a. Identify the key pollutants and sources and/or source categories that are contributing to visibility impairment at each Class I area. The sources of impairment for the most impaired and least impaired days may differ.

    b. Identify the control measures and associated emission reductions that are expected to result from compliance with existing rules and other available measurements for the sources and source categories that contribute significantly to visibility impairment.

    c. Determine what additional control measures would be reasonable based on the statutory factors and other relevant factors for the sources and/or source categories you have identified.

    d. Estimate through the use of air quality models the improvement in visibility that would result from implementation of the control measures you have found to be reasonable and compare this to the uniform rate of progress.

4. Establish the Reasonable Progress Goal

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[1] U.S. EPA 2007; Guidance for Setting Reasonable Progress Goals under the Regional Haze Rule: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, June 1, 2007.

9.2 Establish Baseline and Natural Visibility Conditions

The baseline visibility conditions are established in Section 5.3 while the natural visibility conditions are addressed in Section 5.4. The following table summarizes the results for North Dakota's Class I Federal areas.

Table 9.1
Baseline and Natural Visibility Conditions

Area	Baseline (dv)		Natural Conditions (dv)	
	20% Best	20% Worst	20% Best	20% Worst
TRNP	7.8	17.8	3.0	7.8
LWA	8.2	19.6	2.9	8.0

9.3 Determine the Glide Path or Uniform Rate of Progress

The uniform rate of progress necessary to achieve natural conditions is addressed in Section 5.4. The results of that analysis are as follows:

Table 9.2
Visibility Improvement Required

Area	Total Improvement Required (dv) 20% Worst Days	2018 Target Improvement (dv) 20% Worst Days
TRNP	10.0	2.3
LWA	11.6	2.7

9.4 Identify and Analyze the Measures Aimed at Achieving the Uniform Rate of Progress

A. Identify key pollutants and sources contributing to visibility impairment in each Class I area.

The key pollutants contributing to visibility degradation in North Dakota's Class I areas are sulfur dioxide and nitrogen oxides which form sulfates and nitrates (see analysis in Section 8.7.2.2). For sulfates, the contributing sources are primarily point sources in Canada, sources outside WRAP's modeling domain and point sources in North Dakota.

For nitrates, point/area/mobile sources in Canada, North Dakota, Montana and sources outside of WRAP's modeling domain area are the primary contributors (see analysis in Section 6.3 and Section 8). North Dakota sources contributed 21% of the sulfate and 19% of the nitrate at TRNP during the 20% worst days of the baseline (WRAP Case Plan 02c). At LWA, North Dakota sources contributed 18% of the sulfate and 13% of the nitrate for the same period.

Organic carbon (primary organic aerosols) is the next largest contributor to extinction in the Class I areas of North Dakota. Organic carbon contributes 17.5% of the total extinction at TRNP and 14.9% at LWA during the baseline 20% worst days. As can be seen in Figures 9.1 and 9.2, much of the organic carbon emissions in North Dakota are from the "natural fire" source category or from the "fugitive dust" category. Natural fire cannot be controlled and will vary year to year in each state. Fugitive dust is addressed in Sections 9.5.2 and 10.6.2. Off-road mobile sources of organic carbon are expected to decrease 54% by 2018.

Figure 9.1

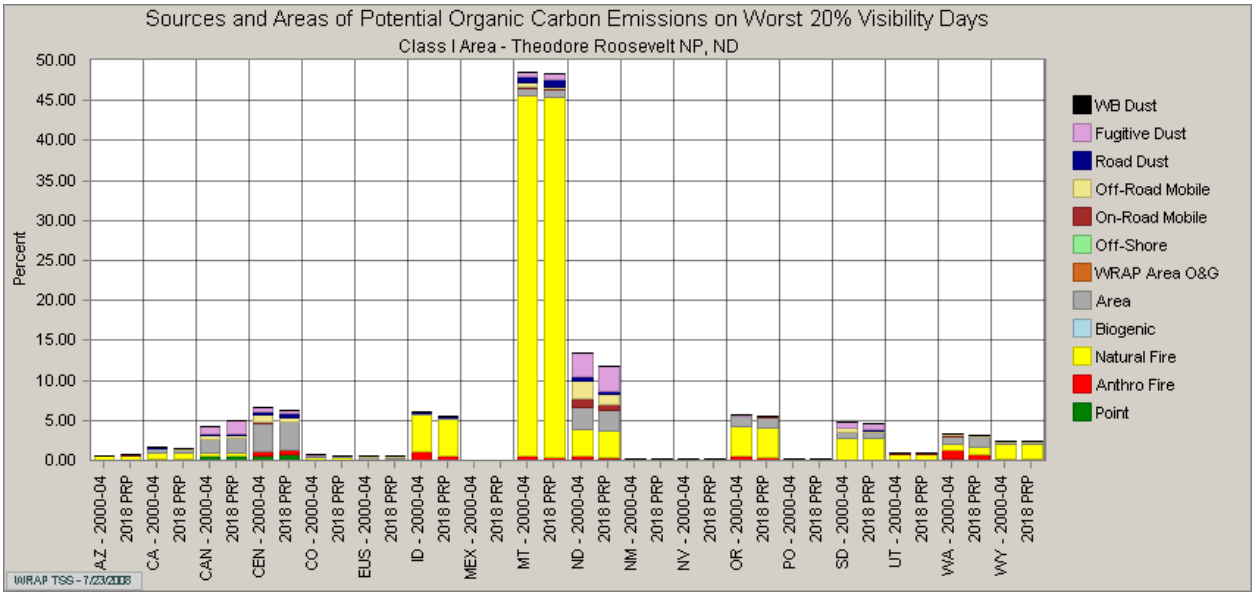
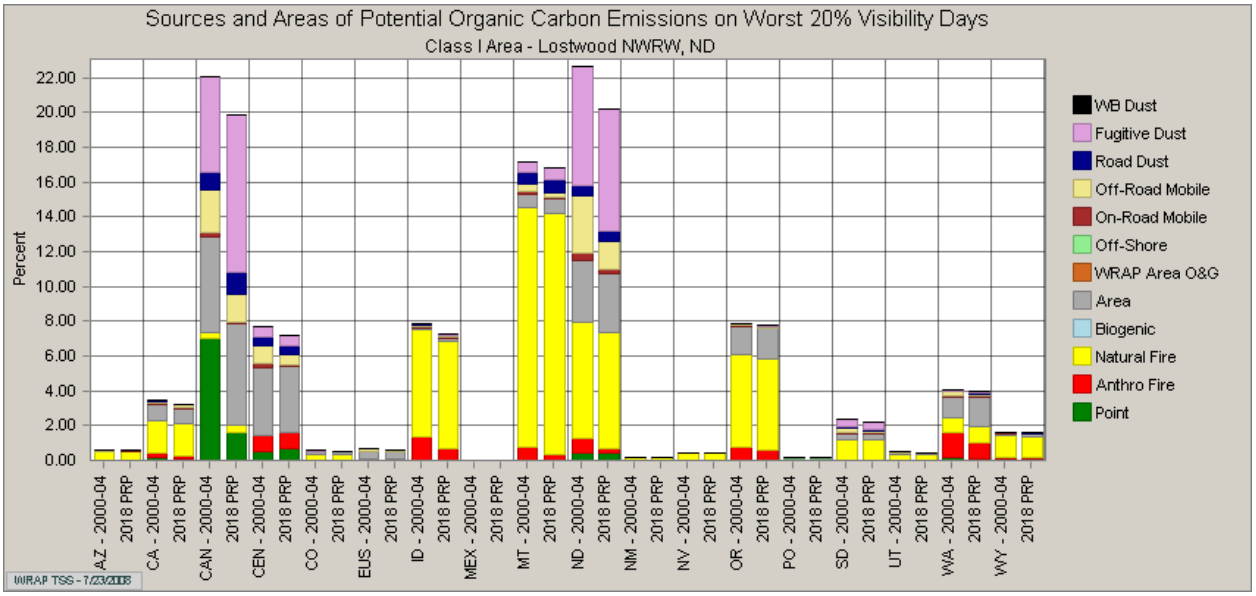


Figure 9.2



With regard to the contribution of North Dakota sources to the sulfates and nitrates concentration in the Class I areas, the sources in North Dakota are:

Table 9.3
North Dakota Sources
of
Sulfate and Nitrates
2000-2004

Area	Source	In-State Sulfate Contribution ($\mu g/m^3$)	In-State Nitrate Contribution ($\mu g/m^3$)	Percent of Total In-State Contribution	
				Sulfate	Nitrate
TRNP	Point	0.3148	0.1587	98	49
	Anthropogenic Fire	0.0002	0.0003	< 1	< 1
	Mobile	0.0151	0.1038	4	32
	Natural Fire & Biogenic	0.0002	0.0389	< 1	12
	Area	0.0071	0.0233	2	7
LWA	Point	0.3797	0.1760	92	48
	Anthropogenic Fire	< 0.0001	< 0.0001	< 1	< 1
	Mobile	0.0216	0.1197	5	33
	Natural Fire & Biogenic	0.0004	0.0362	< 1	10
	Area	0.0089	0.0334	2	9

North Dakota sources only contribute 21% of the total sulfate concentration in TRNP and 19% of the total nitrate concentration during the 20% worst days. At LWA, North

Dakota sources contribute 18% of the total sulfate and 13% of the total nitrate (see Table 2.1). Although mobile sources are a significant contributor to North Dakota's emissions that form nitrates, mobile sources in North Dakota only contribute 6% of the total nitrate concentration in TRNP and 4% in LWA during the 20% worst days (WRAP Case Plan 02c). Nitrogen oxides emissions from mobile sources are expected to decline by 51% by 2018 (see Table 6.1 and 6.3). Based on the above results, efforts to reduce sulfates and nitrates are primarily directed towards point sources of sulfur dioxide and nitrogen oxides emissions.

B. Identify the Control Measures and Associated Emission Reductions from Existing Rules

See Section 10. The WRAP has estimated that the "on-the-books" controls will reduce emissions of nitrogen oxides by approximately 28,000 tons per year, sulfur dioxide 1,700 tons per year, elemental carbon 2,700 tons per year, and fine particulate matter by 900 tons per year. Coarse particulate matter is expected to increase by 18,000 tons primarily due to fugitive dust. These "on the books" controls include:

- Tier 1 light-duty vehicle standards, beginning MY 1996;
- National Low Emission Vehicle (NLEV) standards, beginning MY 2001;
- Tier 2 light-duty vehicle standards beginning MY 2005, with low sulfur gasoline beginning summer 2004;
- Heavy-duty vehicle standards beginning MY 2004;
- Heavy-duty vehicle standards beginning MY 2007, with low sulfur diesel beginning summer 2006;
- Emission standards for new nonroad spark-ignition engines below 25 hp;
- Phase 2 emission standards for new spark-ignition hand-held engines below 25 hp;
- Phase 2 emission standards for new spark-ignition nonhand-held engines below 25 hp;
- Emission standards for new gasoline spark-ignition marine engines;
- Tier 1 emission standards for new nonroad compression-ignition engines above 50 hp;
- Tier 1 and Tier 2 emission standards for new nonroad compression-ignition engines below 50 hp including recreational marine engines;
- Tier 2 and Tier 3 standards for new nonroad compression-ignition engines of 50 hp and greater not including recreational marine engines greater than 50 hp; and
- Tier 4 emissions standards for new nonroad compression-ignition engines above 50 hp, and reduced nonroad diesel fuel sulfur levels.

Modeling by the WRAP indicates these "on-the-books" rules will improve visibility by 0.1 deciviews in the 20% worst day at TRNP and 0.2 deciviews at LWA.

C. Determine What Additional Control Measures Would be Reasonable Based on the Statutory Factors and Other Relevant Factors

See Section 9.5 and 9.6.

D. Estimate Through the Use of Air Quality Models the Improvement in Visibility that Would Result From the Implementation of the Control Measures Found to be Reasonable

See Section 9.5.

E. Establish the Reasonable Progress Goals

See Section 9.7.

9.5 Additional Controls

9.5.1 Point Sources Contributing to Visibility Impairment in the North Dakota Class I Areas

In determining reasonable progress goals for any Class I Federal area, 40 CFR 51.308(d)(1)(i)(A) requires a state to consider the costs of compliance, the time necessary for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any potentially affected sources, and include a demonstration showing how these factors were taken into consideration in selecting the goal.

In determining the cost of compliance for individual sources or source categories potentially subject to emission limitations, the following steps are suggested:

A. Identify the emission units to be controlled.

B. Identify the design parameters for emission controls, and

C. Develop cost estimates based upon those design parameters.

The Guidance for Setting Progress Goals under the Regional Haze Program states "it is not necessary for you to reassess the reasonable progress factors for sources subject to BART for which you have already completed a BART analysis."

Cost of Compliance

Step 1: <u>Identify Emission Units to be Controlled</u>

The Department has identified sulfur dioxide and nitrogen oxides as the primary pollutants that are emitted by stationary point sources that contribute most of the visibility impairment. Particulate emissions from stationary sources have very little impact on visibility in North Dakota (see Figures 6.5 and 6.6) and represent only 1% of the total PM emissions in 2002 (see Table 6.1). Therefore, PM emissions from point sources were not evaluated under this section.

Under BART, it was determined that no additional controls were required for the largest sources of PM, the electric utility steam generating units. Primary sulfuric acid mist emissions are also a very small contributor to visibility impairment. The sources that were subject to BART, the largest emitters of sulfuric acid mist, were evaluated for emissions of this pollutant. Because of the small impact of sulfuric acid mist on visibility, sulfuric acid mist was not included in the reasonable progress analysis.

To identify point sources in North Dakota that potentially affect visibility in Class I Federal areas, the list of sources subject to Title V permitting requirements was established as the starting point. This represents more than 99% of the sulfur dioxide emissions from all point sources in North Dakota that have an operating permit (Title 5 or Minor Source Operating Permit) and greater than 98% of the nitrogen oxides emissions based on 2007 data. The sources subject to BART were also eliminated from the list as suggested by EPA guidance. The Department has included all controls on BART sources that have a reasonable cost. Any controls rejected under BART would also be rejected under the four factors for determining reasonable progress. Although sources were excluded from this analysis, all sources, including sources subject to BART, will be reviewed during future planning periods.

To further evaluate the list of sources, the actual emissions from the source were compared to the distance the source is located from the nearest Class I Federal area. The Department has determined from previous BART modeling that particulate matter emissions from point sources have a very small contribution to visibility impairment in the Class I areas. Therefore, only emissions of nitrogen oxides and sulfur dioxide were evaluated in this comparison. The Department initially used the average of the 2000-2004 emission rate for this analysis. The emission rate (Q) in tons per year was divided by the distance (D), in kilometers, to the nearest Class I area. A value of Q/D greater than 10 was chosen as a point for further evaluation of those sources. A Q/D of greater than 10 was chosen based on the FLM's proposed FLAG guidance amendments initial screening criteria for sources that may affect air quality related values. In addition, EPA in the preamble to the BART Guideline states, "Our analyses of visibility impacts from model plants provide a useful example of the type of analyses that might be used to exempt categories of sources from BART. Based on our model plant analysis, EPA believes that a State could reasonably choose to exempt sources that emit less than 500 tons per year of NO_x or SO_2 (or combined NO_x and SO_2), as long as they are located more than 50 kilometers from any Class I area; and sources that emit less than 1000 tons per year of NO_x or SO_2 (or combined NO_x and SO_2) that are located more than 100 kilometers from any Class I area." EPA's criteria is equivalent to a Q/D of 10. For all sources, except EGUs, the total SO_2 and NO_x emissions from the facility were used and no distinction was made for individual units. EGU's were separated by units because they can act as stand alone facilities while other process units cannot.

Table 9.4
North Dakota Title V Sources Q/D Analysis

Permittee	Plant	$SO_2 + NO_x$ 2000-2004 Average (tons)	Nearest Class I Area	Distance to Nearest Class I Area (km)	Nearest Q/D (tons/km)
ADM Corn Processing	Walhalla Ethanol Plant	287	Lostwood	324	0.9
ADM Processing	Velva Facility	45	Lostwood	125	0.4
Alliance Pipeline	Fairmount Comp. Station	58	Voyageurs	327	0.2
Alliance Pipeline	Towner Comp. Station	57	Lostwood	120	0.5
Alliance Pipeline	Wimbledon Comp. Station	60	Lostwood	335	0.2
American Crystal Sugar Co.	Drayton Sugarbeet Plant	1,109	Voyageurs	294	3.8
American Crystal Sugar Co.	Hillsboro Sugarbeet Plant	1,085	Voyageurs	315	3.4
Basin Electric	AVS Unit 1	13,864	TRNP/NU	107	129.6
Basin Electric	AVS Unit 2	12,796	TRNP/NU	107	119.6
Bear Paw Energy	Alexander Comp. Station	139	TRNP/NU	36	3.9
Bear Paw Energy	Fort Buford Comp. Station	42	TRNP/NU	44	1.0
Bear Paw Energy	Grasslands Gas Plant	748	TRNP/NU	38	19.7
Bear Paw Energy	Lignite Gas Plant	463	Lostwood	15	30.9
Bear Paw Energy	Tree Top Comp. Station	54	TRNP/SU	17	3.2
Cargill Corn Milling	Wahpeton Facility	109	Voyageurs	320	0.3
Cargill, Inc.	West Fargo Plant	56	Voyageurs	311	0.2
Cavalier AFS	CAFS Power Plant	234	Lostwood	280	0.8
City of Fargo	Landfill	9	Voyageurs	309	<0.1
City of Minot	Landfill	1	Lostwood	80	<0.1
CNH America, LLC	Fargo Plant	1	Voyageurs	310	<0.1
Continental Resources	Medicine Pole Hills	58	TRNP/SU	94	0.6
Dakota Gasification Co.	Great Plains Synfuels	10,802	TRNP/NU	107	101.0
DMI Industries	Fargo Plant	2	Voyageurs	321	<0.1
Grand Forks AFB	Heating Plant	9	Voyageurs	342	< 0.1
Hebron Brick Company	Hebron Brick Plant	30	TRNP/SU	97	0.3
Health Care	Fargo Incinerator	4	Voyageurs	313	<0.1
Hess Corporation	Hawkeye Comp. Station	116	Lostwood	53	2.2
Hess Corporation	Tioga Gas Plant	3,655	Lostwood	35	104.4
Hillsboro MEU	Hillsboro	1	Voyageurs	318	<0.1
Idahoan Foods	Grand Forks Plant	104	Voyageurs	316	0.3
J.R. Simplot	Grand Forks Plant	53	Voyageurs	317	0.2

Permittee	Plant	$SO_2 + NO_x$ 2000-2004 Average (tons)	Nearest Class I Area	Distance to Nearest Class I Area (km)	Nearest Q/D (tons/km)
Jahner Sanitation	Landfill	1	Voyageurs	340	<0.1
Kaneb Pipeline Co.	Jamestown Plant	1	TRNP/SU	351	<0.1
LM Glasfiber	Grand Forks Plant	1	Voyageurs	325	<0.1
Minn-Dak Farmers Coop	Wahpeton Facility	601	Voyageurs	319	1.9
Minot AFB	Heating Plant	24	Lostwood	79	0.3
MDU Company	Heskett Plant Unit 1	1,269	TRNP/SU	182	7.0
Mor Tech Fab	Williston Plant	1	TRNP/NU	60	<0.1
Nordic Fiberglass	Devils Lake Plant	1	TRNP/NU	335	<0.1
NDSU	Heating Plant	500	Voyageurs	310	1.6
Northern Border Pipeline	Comp. Station No. 4	188	TRNP/NU	18	10.4
Northern Border Pipeline	Comp. Station No. 5	104	TRNP/NU	56	1.9
Northern Border Pipeline	Comp. Station No. 6	101	TRNP/SU	116	0.9
Northern Border Pipeline	Comp. Station No. 7	104	TRNP/SU	190	0.5
Northern Border Pipeline	Comp. Station No. 8	108	TRNP/SU	282	0.4
Northern Sun ADM	Enderlin Facility	105	Voyageurs	335	0.3
Otter Tail Power Company	Coyote Station	27,804	TRNP/NU	112	248.3
Petro-Hunt	Little Knife Gas Plant	422	TRNP/NU	39	10.8
Red Trail Energy	Richardton Ethanol Plant	329	TRNP/SU	74	4.4
Tesoro	Mandan Refinery	5,757	TRNP/SU	182	31.6
UND	Heating Plant	868	Voyageurs	318	2.7
Whiting Oil & Gas	Wabek Station	73	Lostwood	71	1.0
WBI Pipeline Company	Dickinson Comp. Station	137	TRNP/SU	39	3.5
WBI Pipeline Company	Glen Ullin Comp. Station	67	TRNP/SU	116	0.6
Wil Rich, Inc.	Wahpeton Plant	1	Voyageurs	317	<0.1

The Northern Border Pipeline Company Compressor Station No. 4 is powered by a natural gas turbine. In 2005, Northern Border replaced this turbine with a lower emitting turbine. From 2006-2008, the average nitrogen oxides plus sulfur dioxide emissions were 118 tons per year for a Q/D of 6.6. Because of the installation of the lower emitting turbine, this facility was eliminated from consideration of additional controls during this planning period.

The Tesoro Refining and Marketing Company's Mandan Refinery is subject to a Consent Decree which requires substantial emissions reductions. Since the baseline period, Tesoro has installed a wet scrubber and wet ESP to control sulfur dioxide emissions from the catalytic cracking unit, installed new lower emitting furnaces at the alkylation unit and are installing low NO_x burners in the boilers. From 2006-2008, the total sulfur dioxide and nitrogen oxides emissions from the

facility averaged 1,438 tons per year for a Q/D of 7.9. This ratio is expected to decline significantly when the modifications to the boilers are brought on-line. Because of these changes, this facility was not considered for additional controls during this planning period.

Since the baseline period, Bear Paw Energy has been injecting the acid gas into deep wells at their Grasslands and Lignite Gas Plants. This injection eliminates all sulfur dioxide emissions except for those emissions due to a malfunction of the injection equipment. When a malfunction occurs, the acid gas goes to a flare which will emit sulfur dioxide. In 2007, total emissions of sulfur dioxide and nitrogen oxides (including malfunctions) from the Grasslands Gas Plant were 274 tons for a Q/D of 9.8. Without malfunction emissions, the total was 52 tons for a Q/D of 1.4. At the Lignite Gas Plant, the 2007 total sulfur dioxide and nitrogen oxides emissions (including malfunctions) were 121 tons for a Q/D of 8.1. Without malfunction emissions, the total was 48 tons for a Q/D of 3.2. These malfunctions are generally unplanned, short duration-episodes (a few hours) with very high SO_2 emission rates that vary from year-to-year. Controlling emissions during these malfunctions is not feasible and the acid gas is flared to prevent the release of high concentrations of hydrogen sulfide. These two sources were eliminated based on their change to acid gas injection which greatly reduces sulfur dioxide emissions. The requirement to inject their acid gas is included in the Title V Permit to Operate for each facility.

Petro Hunt's Little Knife Gas Plant emissions include those emissions associated with malfunctions. If the malfunction emissions are eliminated, the average sulfur dioxide and nitrogen oxides emission rate for 2000-2004 is 337.7 tons for a Q/D of 8.7. The Little Knife Gas Plant has seen reduced operations recently due to a decline in gas volume. New oil wells that are being drilled are generally producing from the Bakken formation which contains sweet natural gas. In 2008, SO_2 plus NO_x emissions (including malfunctions) totaled 295 tons for a Q/D of 7.6. Because of the small amount of emissions and the expected decline in the future, the Little Knife Gas Plant was eliminated from consideration for additional control during this planning period.

All of the facilities that were eliminated from consideration for additional air pollution controls will be considered and reviewed again during future planning periods.

After review of the sources in Table 9.4, the following sources in Table 9.5 were considered for additional controls during this planning period:

Table 9.5
Sources Evaluated for Additional Control

Source	Owner	Unit	Type	Capacity
Antelope Valley Station	Basin Electric Power Coop.	1	EGU	435 MWe
Antelope Valley Station	Basin Electric Power Coop.	2	EGU	435 MWe
Coyote Station	OtterTail Power Co.	Main Boiler	EGU	450 MWe
Great Plains Synfuels Plant	Dakota Gasification Co.	Boilers A, B & S	Industrial Boilers	763 x 10^6 Btu/hr each
Tioga Gas Plant	Hess Corp.	3	Sulfur Recovery Unit	225 LTPD
Tioga Gas Plant	Hess Corp.	C1-A to F	Compressor Engines	1920-2350 BHp each

Step 2: **Identify the Design Parameters for Emission Controls**

All of the source units identified for possible additional air pollutant control are equipped with varying degrees of air pollution control equipment, as shown in Table 9.6.

Table 9.6
Remaining Sources Existing Conditions

Source	Pollutant	Control Equipment	Current[a] Emission Rate	Current[a] Control Efficiency (%)
AVS 1	SO_2 NO_x	Spray Dryer OFA	0.36 lb/10^6 Btu 0.37 lb/10^6 Btu	77 --
AVS 2	SO_2 NO_x	Spray Dryer OFA	0.38 lb/10^6 Btu 0.34 lb/10^6 Btu	76 --
Coyote	SO_2 NO_x	Spray Dryer None	0.71 lb/10^6 Btu 0.68 lb/10^6 Btu	66 --
Tioga Gas Plant SRU Engines	SO_2 NO_x	3 Stage Claus +4 bed Cold Bed Absorber None	1097 tpy 1353	98.8 --
GPSP - Boilers	SO_2 NO_x	Wet Scrubber None	2169 tpy 0.5 lb/10^6 Btu[b]	96-97 --

[a] Based on 2005-2007 data
[b] Based on 2007 data

Work is currently underway to increase the efficiency of the spray dryers at AVS I and II. This work is being done because of an expected increase in the sulfur content of the coal used at the facilities. The increase in efficiency is expected to approach 90% which the Department considers the limit of spray dryer efficiency. Even though the efficiency will be increased, no reduction in emissions is expected because of the higher sulfur coal. Because upgrades of the spray dryers are already in progress, this option was not considered at AVS I or II during this planning period. At the Coyote Station, upgrades to the spray dryer would require a detailed engineering analysis to determine if improvements are possible. For this planning period, replacing the spray dryer is evaluated. Any upgrades to the spray dryer (if possible) will produce less emissions reductions and less visibility improvement. This source will also be reevaluated during future planning periods to determine if additional controls are reasonable.

The boilers at the Great Plains Synfuels Plant (GPSP) are equipped with an ammonia reagent wet scrubbing system followed by a wet electrostatic precipitator. This system is achieving 96-97% removal of sulfur dioxide from the flue gas. This removal efficiency is comparable to BACT or BART for industrial boilers of this size. Therefore, sulfur dioxide controls for these boilers were not evaluated further during this planning period.

The following control options were reviewed for possible implementation at the remaining sources:

Table 9.7
Control Options Evaluated

Source	**Pollutant**	**Control Considered**	**Estimated Control Efficiency (%)**
AVS 1 and 2	SO_2	New Wet Scrubber	95
	NO_x	LNB SNCR SCR w/Reheat	30-75 30-75 40-90[c]
Coyote	SO_2	New Wet Scrubber	95
	NO_x	ASOFA SNCR ASOFA + SNCR SCR w/Reheat	40 30 50-60 40-90[c]
Tioga Gas Plant SRU	SO_2	Tail Gas Cleanup	99.8-99.98[a]
1920 BHp Engines	NO_x	SCR Engine Remanufacture Air-Fuel Ratio Controller Ignition Timing Retard	80-90[c] 80-90 10-40 15-30
2350 BHp Engines	NO_x	SCR	33-67
GPSP – Boilers	NO_x	SNCR[b] SCR[b]	30-40 40-90[c]

[a]Overall efficiency of the sulfur recovery unit and tail gas cleanup unit. BACT determinations range from 99.8% for existing units to 99.98% for new units.
[b]The Department has concerns whether SCR and SNCR are technically feasible for the GPSP (see DGC's comments in Appendix I).
[c]The Department considers 90% efficiency reasonable for new installations and 80% reasonable for retrofits.

Step 3: <u>Develop Cost Estimates Based on the Design Parameters</u>

The available control options were evaluated by WRAP's contractor EC/R Incorporated. The report on this evaluation is found in Appendix I.1. The cost for the wet scrubber at the Coyote Station was adjusted to represent the gross capacity of the facility (450 MWe vs 427 MWe) which is larger than EC/R evaluated. Also, the removal efficiency for a new wet scrubber was adjusted from 90% to 95%. The costs associated with the various control technologies are ~~as~~ shown in Table 9.8.

The cost effectiveness ($/ton) for new scrubbers at AVS I & II and Coyote Station is higher than at the BART sources that are not equipped with scrubbers. Because AVS and Coyote Station are already equipped with spray dryers, the cost effectiveness is higher because less sulfur dioxide will be removed than at the unit without a scrubber. The following control options were found to have an excessive cost effectiveness:

AVS 1 & 2 – Wet scrubber; SCR w/reheat; and LNB + SCR w/reheat
Coyote – SCR w/reheat and ASOFA + SCR w/reheat
Tioga Gas Plant – Tail Gas Cleanup
DGC – SNCR and SCR

The SRU at the Tioga Gas Plant is currently operating at less than 45% of its rated capacity. It is expected that the amount of sulfur recovered and emissions from the tail gas incinerator will continue to decline due to a decline in sour gas production in the area the Tioga Gas Plant serves. Most new gas produced comes from the Bakken formation which is sweet gas.

The Department has concerns whether SCR or SNCR can be successfully applied at the GPSP (see DGC comments in Appendix I). Pilot scale testing may be necessary to determine the technical feasibility of SCR or SNCR for the boilers which produce a flue gas with a high carbon dioxide and sulfur concentration.

Therefore, these control technologies were not evaluated further.

For the most efficient control options for which the cost effectiveness (as described in Table 9.8) was considered reasonable on a $/ton basis, the 2018 projected emissions were modeled by the NDDoH to determine the source-specific improvement in visibility. Cumulative modeling was conducted using the procedures (default EPA methodology), hybrid modeling system, and baseline and future (2018) emissions inventories as described in Section 8.5. The

Table 9.8
Control Options Cost

Source	Unit	Pollutant	Control Technology	Total Annualized Cost ($)	Control Efficiency (%)	Emissions Reduction (tpy)	Cost Effectiveness ($/ton)
AVS	1	SO_2	New Wet Scrubber	32,170,000	95	6,780	4,745
		NO_x	LNB	2,280,000	51	3,889	586
			SNCR	8,960,000	40	3,050	2,938
			LNB+SNCR	11,240,000	65	4,956	2,268
			SCR w/reheat[1]	44-63.2 million	80	6,100	7,213-10,360
			LNB + SCR w/reheat	46.3-65.5 million	90	6,863	6,746-9,544
AVS	2	SO_2	New Wet Scrubber	32,170,00	95	5,899	5,453
		NO_x	LNB	2,280,000	51	3,450	661
			SNCR	8,960,000	40	2,706	3,311
			LNB+SNCR	11,240,000	65	4,397	2,556
			SCR w/reheat[1]	44-63.2 million	80	5,411	8,132-11,680
			LNB + SCR w/reheat	46.3-65.5 million	90	6,087	7,606-10,761
Coyote	1	SO_2	New Wet Scrubber	33,280,000	95	12,835	2,593
		NO_x	ASOFA[1]	1,284,000	40	5,223	246
			SNCR	8,520,000	40	5,223	1,631
			ASOFA & SNCR[1]	11,245,000	55	7,182	1,566
			SCR w/reheat[1]	45.3-65.1 million	80	10,446	4,337-6,232
			ASOFA + SCR w/reheat	46.6-66.4 million	90	11,752	3,965-5,650
Tioga Gas Plant[3]	SRU	SO_2	Tail Gas Clean Up[2]	5,800,000	99.8	1,018	5,697
	1920 Hp Engines	NO_x	Air Fuel Ratio Controller	260,000	25	305	852
			Ignition Timing Retard	140,000	22	268	522
			LEC Retrofit	560,000	85	1,035	541
			SCR	1,600,000	80	974	1,643
	2350 Hp Engines		SCR	500,000	50	34	1,471
DGC	Boilers (each)		SNCR	1,690,000	30	259	6,525
			SCR	5,505,000	80	670	8,216

Notes: A) The Department does not consider high dust SCR to be technically feasible for North Dakota lignite (see BART analysis in Section 7). The uncertainties associated with designing an SCR system because of the high sodium and potassium submicron aerosols in the flue gas, even after the air pollution control equipment, dictates the use of the high end of the SCR cost range.

B) Replacement of the compressor engines with electric motors is not technically feasible since the compressor cylinder connecting rods are an integral part of the engines crankshaft.

[1]Based on BART cost estimate for Leland Olds Unit 2 and Minnkota 1 & 2 shared cost estimate.
[2]Based on an overall efficiency of the SRU and tail gas cleanup unit of 99.8%.
[3]Reductions are the total for all engines with the specified horsepower rating.

future emissions inventory was modified to reflect the control technology for each candidate source (AVS 1 EGU, AVS 2 EGU, Coyote EGU, and Tioga Gas Plant), and modeling was conducted using the revised future inventory for one source at a time. The reasonable progress goals in 40 CFR 51.308(d)(1) requires improvement in the most impaired days. The most impaired days are defined in 40 CFR 51.301 as the average visibility impairment for the twenty percent days with the highest amount of visibility impairment. Therefore, modeling addressed the 20% worst days for both TRNP and LWA Class I areas. The results for each candidate source were compared with the results using the unmodified future emissions inventory (Table 8.11) to determine the additional visibility improvement due to the tested control technology.

Modeled visibility improvement, for each candidate source/technology, is provided in Table 9.9. The single source controlled emissions (modeled tons per year) and annualized cost effectiveness (dollars per deciview) are also reported in the table. Reported visibility improvement (in deciviews) reflects the higher value for either TRNP or LWA. Note that visibility improvement reported for Coyote represents the total for both SO_2 and NO_x control technologies, and the improvement reported for the Tioga Gas Plant represents the total for all 1920 and 2350 horsepower engines. As shown in the table, predicted visibility improvement is very marginal for all candidate sources/technologies, and consequently cost per deciview is very high.

Table 9.9
Visibility Improvement and Cost Effectiveness

Source	Pollutant	Control Technology	Emissions (tpy)	Visibility Improvement (dv)*	Cost Effectiveness ($/dv)
AVS 1	NO_x	LNB+SNCR	2,358	0.01	1,124,000,000
AVS 2	NO_x	LNB+SNCR	2,144	0.01	1,124,000,000
Coyote	SO_2 NO_x	Wet Scrubber ASOFA+SNCR	1,924 5,871	0.04	1,113,000,000
Tioga G.P. 1920 BHp Engines 2350 BHp Engines	 NO_x NO_x	 LEC Retrofit SCR	 268 33	0.05	21,200,000

*Maximum Visibility Improvement (per source) at any Class I area in North Dakota. The less efficient technologies evaluated would provide less improvement.

Time Necessary for Compliance

Up to 6.5 years after SIP approval is necessary to achieve compliance (see EC/R report in Appendix I.1). Additional time may be necessary if normal maintenance outages do not coincide with the projected schedule. It is anticipated that all required changes could be implemented by 2018 depending on the date of approval of this SIP. It is not anticipated that any of the remaining sources will be retired prior to 2018.

Energy and Non-Air Impacts

All of the control technologies for the various sources will consume energy (see EC/R report in Appendix I.1). In the case of the Antelope Valley Station and the Coyote Station, this would mean less electricity available for sale. The enhancement of the sulfur dioxide scrubbing system at the Coyote Station would increase the amount of solid waste generated (ash/$CaSO_4$) which must be handled and properly disposed. However, there are no non-air impacts identified that would preclude additional reductions of SO_2 or NO_x from the facilities.

Remaining Useful Life of the Source

The following table lists the expected remaining useful life of the remaining sources.

Table 9.10
Remaining Useful Life

Source	Unit	Startup Date	Estimated Remaining Useful Life (yrs)
AVS	Unit 1	1983	20-40
	Unit 2	1985	20-40
Coyote	Unit 1	1981	20-40
Tioga Gas Plant	Engines	1954	5-

The engines at the Tioga Gas Plant are now 55 years old. Engines D and F have recently been refurbished. It is expected that the other engines could be refurbished which will extend their remaining useful life an indefinite period. Other than the engines at the Tioga Gas Plant, the remaining useful life of the affected sources would not preclude additional air pollution controls.

Reasonable Progress Goals - Required Controls for Point Sources

EPA has stated in their Guidance for Setting Reasonable Progress Goals Under the Regional Haze Program (June 1, 2007) "in assessing additional emissions reduction strategies for source categories or individual, large scale sources, simple cost effectiveness based on a dollar-per-ton calculation may not be as meaningful as a dollar per deciview calculation." It has been determined that requiring additional controls, beyond BART, on existing point sources will not substantially improve visibility in the Class I Federal Areas. The maximum combined improvement based on the Department's cumulative modeling for the average of the 20% worst days is 0.11 deciviews at LWA and 0.03 deciviews at TRNP for the most efficient control options for each source that is cost effective. Other less efficient control technology options would provide substantially less visibility improvement in the Class I areas. The total capital cost

to achieve this improvement is approximately 243 million dollars with an annualized cost of approximately 68 million dollars. Based on the data in Tables 9.8 and 9.9, the cost effectiveness is over 618 million dollars per deciview of improvement at LWA and 2.3 billion dollars per deciview at TRNP. For all sources evaluated individually and cumulatively, the cost ($/dv) is considered excessive. Therefore, no additional controls are proposed for these non-BART sources during this planning period. However, conditions at the plant and control technologies may change in the future. Therefore, all of these sources will be reevaluated during future planning periods.

9.5.2 Agricultural Tillage Operations

North Dakota has approximately 38 million acres of farm and ranch land or approximately 86% of the State's area. Working the land can contribute significant amounts of fugitive and windblown dust. The WRAP has estimated that emission sources in North Dakota put more than 420,000 tons of particulate matter into the atmosphere in 2002. Fugitive dust from agricultural activities and windblown dust from farm fields were a major contributor to these emissions. Although there was a large amount of particulate matter emissions, the effect on visibility in the North Dakota Class I areas was small, but not insignificant, as shown in Figures 9.1 and 9.2 from the WRAP's TSS. At TRNP, coarse mass and soil (fine mass) combined to contribute approximately 11% of the total extinction during the 20% worst days of the baseline period. At the Lostwood Wilderness Area, approximately 7% of the total extinction was due to coarse mass and soil. North Dakota sources contributed approximately 45 percent of the PMF and PMC at TRNP and approximately 30 percent at LWA during the 20 percent worst days in 2000-2004 (based on WRAP's weighted emissions potential analysis).

Figure 9.2
TRNP Species Apportionment
20% Worst Days

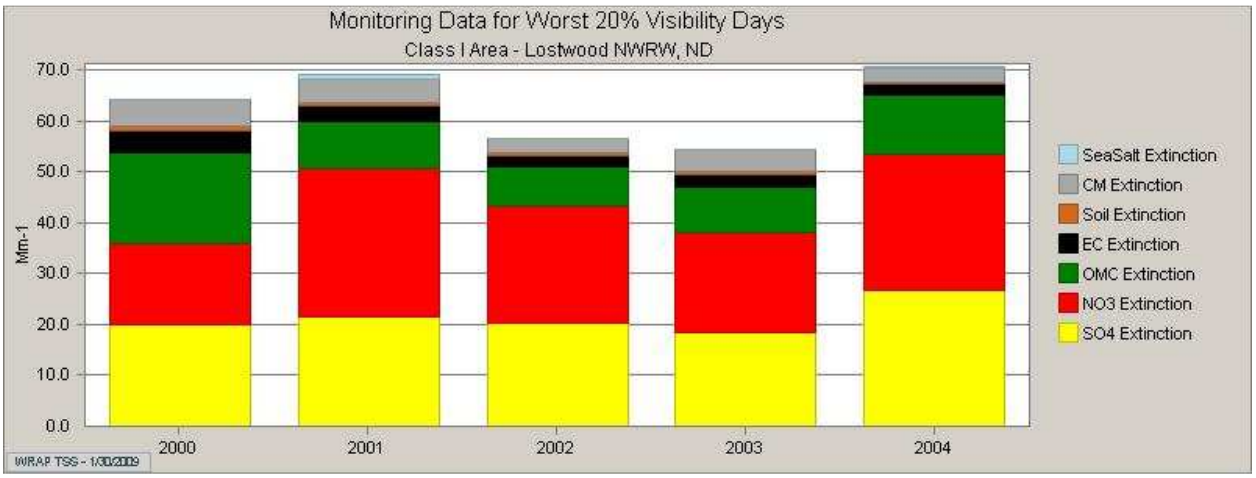
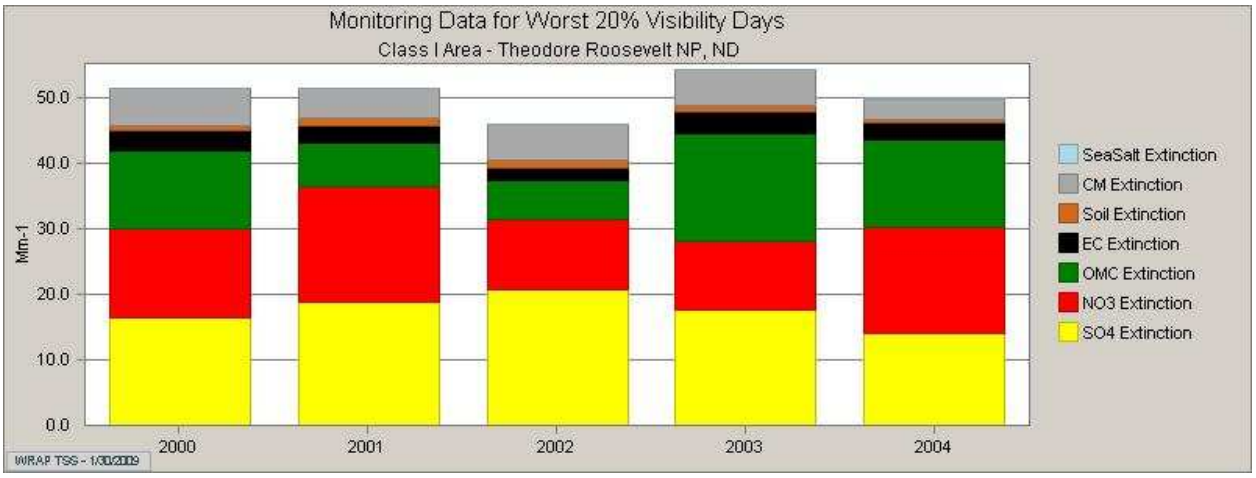


Figure 9.3
LWA Species Apportionment
20% Worst Days



The practice of conservation tillage is becoming more popular in North Dakota. The Conservation Technology Information Center (CTIC) in West Lafayette, Indiana specifies that 30 percent or more of crop residue must be left after planting to qualify as a conservation tillage system. Some specific types of conservation tillage include Minimum Tillage, Zone Tillage, No-till, Ridge-till, Mulch-till, Reduced-till, Strip-till, Rotational Tillage and Crop Residue Management. According to the Crop Residue Management survey conducted by the CTIC, total conservation tillage in North Dakota increased from 28% to 39% of total planted acres from 1998 to 2004. In general, conservation tillage practices are used more in the western part of the State (near the Class I areas) than in the eastern part of the State due to the more arid conditions, thinner topsoil and the types of crops grown. In 2006, 77% of the crop acreage in Williams County in Western North Dakota was planted using conservation tillage practices versus 28% in Sargent County (southeastern North Dakota). It is expected that conservation tillage practices will increase over the planning period. Higher fuel, equipment and labor costs will entice farmers to reduce tillage. Other added benefits include better soil moisture storage and eventually less fertilizer usage. Additionally, conservation tillage practices, such as No-till farming, help sequester carbon which can be sold as carbon credits. As carbon dioxide controls are instituted, the money earned by farmers for carbon sequestration will also provide an incentive for conservation tillage practices.

Given the small contribution of coarse mass and soil to total extinction and that conservation tillage practices are increasing, the Department concludes there is no need to implement controls on farming practices. As outlined earlier, free market incentives should increase conservation tillage which will reduce emissions. The trend of increased conservation tillage practices from 1998-2004 is expected to continue during the planning period.

Sources in this category are subject to NDAC 33-15-17-02.6 which requires agricultural activities be managed in a manner as to minimize dust from becoming airborne. The Department

will reevaluate the source category in future planning periods to determine if additional controls are required.

9.5.3 Smoke Management for Agricultural, Forest Management and Prescribed Burning

It has been determined that no additional rules or controls for smoke management are required (see Section 10.6.5). The worst short-term visibility degradation that occurs in the Class I areas is caused by prescribed burning conducted by the Federal Land Managers. In 2005, the entire LWA (5,577 acres) was burned by the FLM. In addition, 3,579 acres in the immediately adjacent Lostwood Wildlife Refuge were burned on 7 different days. Although the State of North Dakota recognizes the position of the FLMs that prescribed burning is necessary to maintain a healthy ecosystem, it must also be recognized that the actions of the FLMs that affect visibility in the Class I areas must be considered when evaluating controls for others that use prescribed burning (e.g., farming, road maintenance, etc). No additional smoke management requirements are proposed in this planning period. However, the Department will reevaluate this source category during future planning periods to determine if additional regulation is required.

9.5.4 Coyote Station

Once reductions are achieved from the BART sources, the Coyote Station will be the largest point source of NO_x emissions in North Dakota. The analysis in Section 9.5.1 indicates that additional controls on the Coyote Station are not reasonable at this time; however, the State, through recent discussions with Otter Tail Power Company, has reached an agreement whereby Otter Tail has committed to reduce NO_x emissions at the station. Otter Tail Power Company has indicated they will install equipment by July 1, 2018 in order to reduce NO_x emissions to 0.50 lb/10^6 Btu. This represents a 35% decrease from the 2008 emission rate of 0.77 lb/10^6 and 26% from the baseline emission rate evaluated in Section 9.5.1. The reductions are expected to be achieved by installing separated over fire air. This will reduce annual NO_x emissions by 4,213 tons from the 2000-2004 baseline, a 32% decrease. The mechanism/requirement for reducing NO_x emissions is included in a Permit to Construct found in Appendix A.

9.5.5 Oil and Gas Exploration and Production

Oil and natural gas production in North Dakota is generally limited to the western one-third of the State. In September 2009, there were 4,348 operating wells that produced approximately 238,000 barrels of oil per day. This is in contrast to states like Wyoming that has approximately 45,000 producing oil and gas wells and Colorado which has approximately 40,000 active wells. The primary difference is that North Dakota does not have any coal bed methane (CBM) wells. The lack of CBM wells means there are much fewer pumps, compressors and gas processing plants needed even though North Dakota produces more oil than either of these states. The baseline SO_2 and NO_x emissions from area oil and gas sources are estimated at less than 500 tons per year of each pollutant (see Table 6.1).

North Dakota's oil production is highly dependent on the price of oil. Several peaks in production (i.e. 1996 and 1983) have been achieved only for production to drop severely (i.e. 42% from 1983 to 2003) and then increase as the price of oil increases. Several projections have been made regarding the amount of oil that will be produced in the future, the number of wells that will be producing and the number of drilling rigs that will operate in the State. All of these projections are highly speculative because of the volatility of oil prices. The price of North Dakota crude oil reached a high of approximately $127 per barrel in 2008 and dropped to as low as $25 per barrel in 2009. The number of drilling rigs also dropped dramatically from a high of 92 in November 2008 to 35 in May 2009. WRAP has projected a 4-5 fold increase in NO_x emissions from oil and gas activities by 2018. Although emissions may increase this amount during the planning period, the North Dakota Oil and Gas Division of the State Industrial Commission believes that emissions will decrease by 2018 to a level that is 2.0 to 2.5 times the baseline emission rate. The Oil and Gas Division believes that activity associated with the major oil producing formation (Bakken formation) will be decreasing by 2018 with a peak during this planning period. However, any estimate of future activity is suspect because the future of oil prices is unknown. Because current estimates of future oil and gas activity, and emissions from that activity, are very questionable, the Independent Petroleum Association of Mountain States (IPAMS) is sponsoring development of a third, or Phase III, inventory of emissions from the Williston Basin in North Dakota. This inventory is not complete and available for this planning period. Because of the serious flaws in the Phase I and Phase II inventories, the Department believes that the Phase III inventory is necessary for any planning activities for oil and gas emissions in North Dakota.

The Q/D analysis in 9.5.1 included the larger compressor stations and natural gas processing plants (sources subject to Title V). North Dakota also permits minor oil and gas sources including small compressor stations (greater than 500 Hp), natural gas processing plants and tank batteries. The Q/D analysis indicates that only the larger facilities (i.e. larger Title V sources) have a significant impact on visibility in North Dakota Class I areas. Sulfur dioxide emissions from future oil and gas activities are not a concern because most new oil and gas production is from the Bakken formation which contains sweet (negligible sulfur content) oil and gas. In addition, engines will be required by Federal rule to use ultra low sulfur gasoline and diesel fuel. Nitrogen oxides emissions are the primary concern. These will emanate from vehicles, drilling rig engines, glycol dehydrators, flares, compressor engines, and other combustion sources. Stationary engines are subject to a number of New Source Performance Standards (NSPS) and Maximum Achievable Control Technology (MACT) standards which will help limit NO_x emissions. The EPA has also proposed a 1-hour NAAQS for NO_2. North Dakota had a 1-hour NO_2 AAQS set at 100 ppb until December of 1994. The proposed NAAQS is slightly more stringent than the former SAAQS for NO_2. If the new NAAQS for NO_2 is promulgated as proposed, the Department's experience indicates that oil and gas facilities will have to limit NO_x emissions through the use of control devices such as catalytic convertors on engines or low NO_x burners at heater/treaters or glycol dehydration unit boilers.

The WRAP, through its contractor EC/R Incorporated, has prepared an analysis of the four factors for reasonable progress for oil and gas exploration and production operations (see Appendix I.2, Section 4). Given the small amount of baseline emissions and the uncertainty of the projection of future emissions, the Department proposes no additional controls for oil and gas

exploration and production facilities at this time. The Department will continue to track oil and gas emissions and will take into consideration the Phase III inventory when it is available. During the mid planning period review, the Department will review oil and gas emissions and take action if necessary. Oil and gas emissions will also be addressed during subsequent planning periods.

9.6 Visibility Modeling and Weight of Evidence

As detailed in Section 8, modeling has been conducted by both WRAP and the NDDoH to estimate visibility improvement resulting from implementation of BART and other reasonable control measures. Modeling addressed TRNP and LWA Class I areas in North Dakota. Visibility improvement modeling accounted for the cumulative effect of BART controls, and other growth and control factors. Modeling was initially conducted using the default EPA methodology, and results were compared with the default EPA uniform rate of progress (URP). Because results based on the default EPA methodology did not achieve compliance with default URP targets for 2018, additional modeling was conducted by the NDDoH for various weight of evidence options.

Supplemental weight of evidence modeling analyses conducted by the NDDoH, which have a bearing on the selection of reasonable progress goals, include the following.

1) Discounted the impact of international (in this case, Canadian) source visibility-affecting emissions on North Dakota Class I areas.

2) Discounted the impact of visibility-affecting emissions from all sources located outside of North Dakota, on North Dakota Class I areas.

3) Used the complete emissions inventory for the default EPA method, but zeroed out future SO_2 and NO_X emissions from all sources located in North Dakota (i.e., assumed 100 percent future control of all SO_2 and NO_X emissions in North Dakota), to determine progress with respect to the default glide path for North Dakota Class I areas.

4) Conducted modeling to determine the incremental visibility improvement, and cost effectiveness ($/dv), of enhanced control technology at AVS generating station, Coyote generating station, and Tioga Gas Plant (Section 9.5.1).

Modeling results for the default EPA methodology and weight of evidence analyses are summarized in Table 9.11. In the table, Scenarios 1 and 2 represent the implementation of default EPA methodology by WRAP and NDDoH, respectively. Scenarios 3, 4, and 5 reflect the first three NDDoH weight of evidence analyses outlined above. Results for the fourth weight of evidence analysis (above) were provided in Table 9.9. Results in Table 9.11 are presented as the projected percent of the 2018 target.

From results of visibility modeling based on standard EPA methodology, and results of the weight of evidence analyses, the following conclusions are applicable to the establishment of reasonable progress goals for North Dakota Class I areas.

1) The uniform rate of progress goal for 2018 for 20% worst days will not be achieved at either TRNP or LWA.

2) Apportionment modeling results indicate the contribution of sources located outside of North Dakota is much greater than the contribution of in-state sources to 20% worst day visibility at TRNP and LWA (both baseline and 2018).

3) Though the addition of proposed BART controls substantially decreases the visibility impact of North Dakota EGUs, these EGUs comprise only a small component of total 20% worst day impact at TRNP and LWA.

Table 9.11
NDDoH Visibility Modeling Results 20% Worst Days
EPA Methodology and Weight of Evidence Analysis Summary

Scenario	Description	Class I Area	Projected Percent of 2018 Target
1	WRAP CMAQ Default EPA Methodology	TRNP LWA	24.0 16.7
2	NDDoH Hybrid Default EPA Methodology	TRNP LWA	38.1 26.7
3	NDDoH Hybrid Canada Sources Discounted	TRNP LWA	50.0 40.2
4	NDDoH Hybrid All Sources Other Than ND Discounted	TRNP LWA	83.9 59.6
5	NDDoH Hybrid Base Emission Inv = Default Future Emissions Inv = All ND SO_2 and NO_x Emissions set to zero	TRNP LWA	83.8 72.6

4) Compliance with 20% worst day URP 2018 targets at North Dakota Class I areas cannot be achieved through additional emissions reductions from North Dakota sources, alone. It will require significant additional visibility affecting emissions reductions from Canada, other western states and from sources located outside of the WRAP CMAQ modeling domain.

5) After discounting the impact of Canadian sources, significantly greater progress (50 percent greater) was demonstrated, relative to URP 2018 targets for North Dakota Class I

areas, than modeling with the entire emissions inventory but the 20% worst day targets were still not achieved.

6) After discounting the impact of *all sources located outside of North Dakota*, even greater progress was demonstrated, relative to URP 2018 targets for North Dakota Class I areas, than modeling with Canadian sources discounted. However, 20% worst day targets were still not achieved.

7) After zeroing out all future SO_2 and NO_X emissions in North Dakota under default EPA methodology (emulating a 100 percent, unrealistic control of all sources), compliance with 20% worst day targets was still not achieved at North Dakota Class I areas.

8) The use of enhanced control technology at AVS generating station, Coyote generating station, and Tioga Gas Plant provides minimal incremental improvement in 2018 visibility (Table 9.9), and does not meaningfully change status with respect to 2018 visibility goals.

Given these conclusions based on modeling, it appears most of the visibility impact at North Dakota Class I areas is due to emissions from sources located outside the jurisdiction of the NDDoH. But regardless of the extent to which visibility-affecting sources located outside of North Dakota are discounted, compliance with URP targets cannot be achieved. Further, the use of enhanced control technology on additional candidate sources (Item 8, above) within jurisdiction of the NDDoH does not provide a meaningful improvement in terms of 2018 URP visibility goals. It is not realistic to expect significant additional controls (beyond BART or other current controls) will be implemented in states or Canadian provinces apart from North Dakota before 2018. From a modeling perspective, therefore, setting reasonable progress goals for 20% worst days to be consistent with 2018 modeling results for the default EPA methodology (Table 9.11) would seem most realistic.

9.7 Establish Reasonable Progress Goals

As indicated in Section 8, control of emissions from North Dakota sources has only a small effect on visibility conditions in the North Dakota Class I areas. The source apportionment (based on WRAP modeling) for the 20% worst days in the Class I areas indicates that sources outside of North Dakota contribute from 79-87% of the sulfate or nitrate which cause the greatest visibility impairment in the North Dakota Class I areas. The source region apportionment provided by WRAP is presented in Table 9.12 for the North Dakota Class I areas. Note that the WRAP modeled contributions for North Dakota sources in Table 9.12 are somewhat smaller than the contributions based on NDDoH modeling in Table 8.16. This is because the NDDoH approach incorporated a more realistic representation of point source plumes, resulting in higher predictions for North Dakota sources (and greater visibility improvement).

Table 9.12
Source Region Apportionment 20% Worst Days

Contributing Area	Class I Area			
	TRNP		LWA	
	SO_4	NO_3	SO_4	NO_3
North Dakota	21.1%	19.1%	17.9%	13.0%
Canada	28.3%	31.8%	45.9%	44.6%
Outside Domain	32.6%	17.9%	20.2%	14.0%
Montana	3.1%	15.0%	2.4%	9.3%
CENRAP	4.9%	2.5%	5.3%	5.1%
Other	10.5%	13.7%	8.3%	14.0%

An analysis was conducted to determine if the uniform rate of progress could be achieved in the North Dakota Class I areas by controlling sulfur dioxide and nitrogen oxides emissions from in-state sources (see Section 8.7.3.3). The results indicate the uniform rate of progress cannot be achieved by reductions in North Dakota alone. If all sulfur dioxide and nitrogen oxides emissions in North Dakota were completely controlled (zero emissions), only 72.6% of the uniform rate of progress for the 20% worst days would be achieved at LWA and only 83.8% at TRNP. Significant reductions of emissions from sources outside of North Dakota will be required in order to meet the uniform rate of progress for this planning period.

North Dakota can only require emission controls for sources within its boundaries. Because of the large contribution to visibility impairment from sources outside of North Dakota, any estimate of reasonable progress on a deciview basis is tenuous at best. Any increase in emissions from sources external to North Dakota could offset any improvement from the reduction of emissions at in-state sources. By 2018, North Dakota BART controls plus other regulatory requirements are expected to reduce in-state SO_2 emissions by more than 60% and NO_x emissions by more than 25%. Table 9.13 shows the projected change in emissions for North Dakota as well as surrounding states and Canada.

Table 9.13
Projected Change in Emissions
2002-2018
(%)

	South Dakota	Montana	Minnesota	Canada	North Dakota
SO_2	-35.7	-11.8	-28.8	-6.8	-60.0
NO_x	-17.9	-26.0	-39.4	-0.8	-25.3
OC	-6.1	-3.3	-5.3	22.7	-19.4
EC	-51.1	-16.6	-28.9	75.2	-52.3
PMF	2.2	7.5	-1.3	34.8	2.0
PMC	4.2	8.8	-4.4	33.8	3.5
NH_3	0.3	1.2	33.9	-31.9	-0.3
VOC	-0.5	-0.6	2.9	-1.2	1.1
CO	-17.0	-15.9	-20.8	-11.7	-27.4

Note: Based on WRAP's Case Plans 02d and PRP18b.

Based on the analyses conducted, the reasonable progress goals in Table 9.14 are established. The analyses conducted indicate there will be no degradation in the 20% best days. The Department's modeling results show that visibility in the 20% best days will improve 0.14 deciviews at TRNP and 0.09 deciviews at LWA.

Table 9.14
Reasonable Progress Goals

Class I Area	Baseline Visibility 20% Worst Days (dv)	2018 RPG[a] 20% Worst Days (dv)	2018 RPG[b] 20% Worst Days (dv)
TRNP	17.8	16.9	17.2
LWA	19.6	18.9	19.1

[a] Based on Department's hybrid modeling approach.
[b] Based on WRAP's modeling approach.

40 CFR 51.308(d)(1)(ii) requires the State to provide for public review an assessment of the number of years it would take to attain natural conditions if visibility improvement continues at the rate of progress selected by the State as reasonable. Achieving natural conditions will require the elimination of all anthropogenic sources of emissions. Given current technology, achieving natural conditions is an impossibility. Any estimate of the number of years necessary to achieve

natural visibility conditions would require assumptions about future energy sources, technology improvements for sources of emissions, and every facet of human behavior that causes visibility impairing emissions. The elimination of all SO_2 and NO_x emissions in North Dakota will not achieve the uniform rate of progress for this, or any future planning period. Any estimate of the number of years to achieve natural conditions is questionable because of the influence of out-of-state sources. The number of years required to achieve natural conditions based on the proposed reasonable goals are as follows:

Table 9.15
Time Necessary to Achieve Natural Conditions

Class I Area	Baseline Visibility 20% Worst Days (dv)	Natural Visibility 20% Worst Days (dv)	Improvement Rate this Planning Period 20% Worst Days (dv/yr)	Years to Natural Conditions[a] 20% Worst Days
TRNP	17.8	7.8	0.06429	156
LWA	19.6	8.0	0.05000	232

[a]Based on the Department's hybrid modeling approach.

If the most efficient cost effective control options evaluated for Coyote Station, Antelope Valley Station and the Tioga Gas Plant were implemented, the number of years to reach natural conditions would be 151 years at the three units of TRNP and 201 years at LWA. Implementing additional controls at these sources will not significantly affect current visibility conditions or the amount of time necessary to achieve natural conditions.

10. Long -Term Strategy

10.1 Long -Term Strategy Requirements

40 CFR 51.308(d)(3) contains the requirements for the long-term strategy for regional haze. Each State listed in §51.300(b)(3) must submit a long-term strategy that addresses regional haze visibility impairment for each mandatory Class I Federal area within the State and for each mandatory Class I Federal area located outside the State which may be affected by emissions from the State. The long-term strategy must include enforceable emissions limitations, compliance schedules, and other measures as necessary to achieve the reasonable progress goals established by States having mandatory Class I areas. In establishing its LTS for regional haze, the State must meet requirements of §51.308(d)(3)(i) through (3)(v).

10.2 Consultation With Other States

40 CFR 51.308(d)(3)(i) requires "Where the State has emissions that are reasonably anticipated to contribute to visibility impairment in any mandatory Class I Federal area located in another State or States, the State must consult with the other State(s) in order to develop coordinated emission management strategies. The State must consult with any other State having emissions that are reasonably anticipated to contribute to visibility impairment in any mandatory Class I Federal area within the State."

North Dakota emissions are reasonably anticipated to contribute to visibility impairment in mandatory Class I Federal areas in Minnesota (Boundary Waters Canoe Area Wilderness Area and Voyageurs National Park), Montana (Medicine Lake National Wildlife Refuge Wilderness Area and U.L. Bend National Wildlife Refuge Wilderness Area), and South Dakota (Badlands National Park and Wind Cave National Park). Reasonably anticipated to contribute is considered to be a contribution of more than 5 percent to the total extinction (B_{ext}) in the Class I area. North Dakota emissions impacts on Michigan Class I areas (Isle Royal National Park and Seney National Wildlife Refuge Wilderness Area) are small or less than 5 percent of the extinction (B_{ext}). North Dakota emissions impacts on other more distant Class I areas are considered minimal. See the discussion in Section 2.4.

The NDDoH has consulted with Minnesota and Michigan as a part of the Northern Class I Areas consultation group and Minnesota individually. As a result of the consultations, Minnesota sent a memorandum dated September 19, 2007 to North Dakota and other states impacting Minnesota Class I areas. Minnesota requested a response documenting these consultations have taken place to the satisfaction of North Dakota or detailing areas where additional consultation should occur. In those states Minnesota has identified as additional contribution states, they asked such states to respond with their agreement or disagreement with Minnesota's determination of contributing states and the additional control strategies that will be evaluated. Minnesota's memorandum and the NDDoH letter of response dated August 22, 2008 are attached in Appendix J.2.

The NDDoH has consulted with Montana and South Dakota through the WRAP which we are members and as needed individually. Additionally the NDDoH has consulted with EPA Region 8 in Denver concerning the Montana Class I areas as they are preparing a FIP at the request of the State.

Minnesota, Montana and South Dakota are the only states that have emissions that are reasonably anticipated to contribute to visibility impairment in the North Dakota Class I Federal areas.

Consultation is further addressed in Section 3, Plan Development and Consultation.

10.3 Demonstration of Inclusion of Measures to Obtain RPGs in Class I Areas

40 CFR 51.308(d)(3)(ii) requires "Where other States cause or contribute to impairment in a mandatory Class I Federal area, the State must demonstrate that it has included in its implementation plan all measures necessary to obtain its share of the emission reductions needed to meet the progress goal for the area. If the State has participated in a regional planning process, the State must ensure it has included all measures needed to achieve its apportionment of emission reduction obligations agreed upon through that process."

The control measures and emission limits incorporated in this SIP for the seven electrical generating units subject to BART combined with Federal mobile source and other rules will reduce North Dakota sulfur dioxide emissions by 60 percent, nitrogen oxide emissions by 25 percent, organic carbon emissions by 19 percent and elemental carbon emissions by 52 percent. These percent reductions compare favorably with the uniform rate of progress first planning period required overall reduction by 2018 of approximately 23.3 percent (14 years ÷ 60 years x 100 = 23.3 percent). In addition, existing State smoke management and fugitive dust control rules will adequately control emissions from agricultural and forest burning and construction activities. North Dakota has met and included in this SIP all measures needed to achieve its apportionment of emission obligations agreed upon by the members of WRAP. These emission reductions will obtain North Dakota's share of emission reductions needed for Class I Federal areas in Minnesota, Michigan, Montana and South Dakota.

10.4 Documentation of the Technical Basis for Modeling, Monitoring and Emissions Information

40 CFR 51.308(d)(3)(iii) requires "The State must document the technical basis, including modeling, monitoring and emissions information, on which the State is relying to determine its apportionment of emission reduction obligations necessary for achieving reasonable progress in each mandatory Class I Federal area it affects. The State may meet this requirement by relying on technical analyses developed by the regional planning organization and approved by all State participants. The State must identify the baseline emissions inventory on which its strategies are

based. The baseline emissions inventory year is presumed to be the most recent year of the consolidated periodic emissions inventory."

North Dakota is a member of the Western Regional Air Partnership (WRAP) regional planning organization and relied on the modeling, monitoring and emissions information and technical analyses developed by WRAP.

The NDDoH relied on the use of CALPUFF for single source BART screening modeling, WRAP CMAQ and PSAT modeling, and its own hybrid CALPUFF modeling in its cumulative impact analyses. The BART modeling conformed to the requirements of the BART guidelines and is described in Section 7. The WRAP CMAQ and PSAT modeling and the NDDoH hybrid CALPUFF modeling conformed with EPA modeling guidelines and are described in Section 8.

The NDDOH relied on IMPROVE monitoring data as available on the WRAP TSS website and discussed in Section 4.

The NDDoH used the WRAP Plan02d emissions inventory for the baseline emissions year 2002 which reflects a composite interpretation of emissions for the base 2000-2004 period; and the WRAP CMAQ PRP18a (Preliminary Reasonable Progress 2018 Scenario A) emissions inventory which reflects projected year 2018 emissions. Case PRP18a represents base period emissions projected to 2018, accounting for estimates of the effect of BART controls, and assuming other growth and control factors. The Plan02d and PRP18a emissions inventories were used in modeling and are discussed further in Section 8. A later Case PRP18b emissions inventory was prepared by WRAP and included in Section 6, Sources of Visibility Impairment in North Dakota Class I Areas.

10.5 Identification of Anthropogenic Sources of Visibility Impairment

40 CFR 51.308(d)(3)(iv) requires "The State must identify all anthropogenic sources of visibility impairment considered by the State in developing its long-term strategy. The State should consider major and minor stationary sources, mobile sources and area sources."

The anthropogenic sources of visibility impairment are identified in Section, 6 Sources of Visibility Impairment in North Dakota Class I Areas.

10.6 Seven Factors That Must be Considered in Developing the LTS

40 CFR 51.308(d)(3)(v) requires "The State must consider, at a minimum, the following factors in developing its long-term strategy:

(A) Emission reductions due to ongoing air pollution control programs, including measures to address reasonably attributable visibility impairment;

(B) Measures to mitigate the impacts of construction activities;

(C) Emissions limitations and schedules for compliance to achieve the reasonable progress goal;

(D) Source Retirement and Replacement schedules;

(E) Smoke management techniques for agriculture and forestry management purposes including plans as currently exist within the State for these purposes;

(F) Enforceability of emissions limitations and control measures; and

(G) The anticipated net effect on visibility due to projected changes in point, area, and mobile source emissions over the period addressed by the long-term strategy."

10.6.1 Emission Reductions Due to Ongoing Air Pollution Control Programs

40 CFR 51.308(d)(3)(v)(A) requires an assessment of emission reductions due to ongoing air pollution control programs. Programs that are in place which will assist in reducing emissions and help achieve reasonable progress toward the national visibility goal include:

- Minor Source Permit to Construct Program (NDAC 33-15-14-02)
- Prevention of Significant Deterioration Program (NDAC 33-15-15)
- New Source Performance Standards (NDAC 33-15-12)
- Emission Standards for Hazardous Air Pollutants (NDAC 33-15-13)
- Emission Standards for Hazardous Air Pollutants for Source Categories (NDAC 33-15-22)
- Oil and Gas Production Facilities Rules (NDAC 33-15-21)
- Open Burning Requirements (NDAC 33-15-04)
- Fugitive Dust Control Requirements (NDAC 33-15-17)
- Control of Sulfur Dioxide from Point Sources (NDAC 33-15-06)
- Control of Particulate Matter (NDAC 33-15-05)
- Control Requirements for Organic Compounds Sources (NDAC 33-15-07)
- Heavy Duty Diesel Engine Standard (2007)
- Tier 2 Tailpipe Standards
- Large Spark Ignitor and Recreational Vehicle Rule
- Nonroad Diesel Rule
- Industrial Boiler MACT
- Combustion Turbine and Reciprocating Internal Combustion Engines NSPS and MACT Standards

The Federal programs are described in more detail in Section 2.5.

Some MACT standards have been vacated; however, it is expected that revised versions of these standards will be promulgated by EPA during the planning period. The Department will continue to operate a PSD program and take delegation of NSPS standards and major source MACT standards for source categories located in North Dakota. As older sources are replaced, the new applicable rules should reduce emissions.

North Dakota has implemented a reasonably attributable visibility impact (RAVI) protection program since 1987. The rules implementing this program are found in NDAC 33-15-19, Visibility Protection. The control strategy and monitoring strategy are found in Chapters 3 and 6 of the State Implementation Plan. The existing RAVI program, with the existing permitting and emissions rules listed above is compatible with those needed for regional haze and no revisions are needed or planned at this time. The NDDoH will address the periodic review and revision requirements of the long-term RAVI strategy as required by 40 CFR 51.306(c) and coordinate them with the regional haze LTS periodic progress reports required by 40 CFR 51.308(g).

10.6.2 Measures to Mitigate the Impacts of Construction Activities

40 CFR 51.308(d)(3)(v)(B) requires the consideration of measures to mitigate the impacts of construction activities. North Dakota regulates fugitive emissions by rule (NDAC 33-15-17). This rule states:

> "No person shall cause or permit fugitive emissions from any source whatsoever, including a building, its appurtenances, or a road, to be used, constructed, altered, repaired, or demolished; or activities such as loading, unloading, storing, handling, or transporting of material without taking reasonable precautions to prevent such emissions from causing air pollution as defined in section 33-15-01-04."

NDAC 33-15-17-02 also states in part:

> "No person shall emit or cause to be emitted into the ambient air from any source of fugitive emissions as specified in section 33-15-17-01 any particulate matter which:
>
> 2. Exceed the ambient air quality standards of chapter 33-15-02 at or beyond the property line of the source.
>
> 3. Exceed the prevention of significant deterioration of air quality increments of chapter 33-15-15 at or beyond the property line of the source for sources subject to chapter 33-15-15.
>
> 4. Exceed the restrictions on the emission of visible air contaminants of chapter 33-15-03, at or beyond the property line of the source.
>
> 5. Would have an adverse impact on visibility, as defined in chapter 33-15-19, on any class 1 federal area."

The Department requires permits for asphalt concrete plants and rock, sand and gravel plants which are generally associated with major construction projects. The Department requires notification of the relocation of asphalt plants in order to track the emissions from these facilities.

The Federal Class I areas in North Dakota are located in the western part of the State, generally away from the major population centers. These population centers are 40 - 500 km away from the Class I areas. Any construction in these areas should have little effect on visibility in the Class I areas because of the transport distance and prevailing winds will generally move the fugitive emissions in the opposite direction. Any impacts on visibility in a Class I area due to construction activities would most likely be associated with energy development including oil and gas well pad construction, compressor station construction and gas processing plant construction. Owners of sources subject to permitting requirements, including the above energy facilities, are subjected to fugitive dust control requirements included in the permit issued for the construction of the facility. In addition, all sources are subject to the requirements of NDAC 33-15-17. NDAC 33-15-17-03 lists the measures which are considered reasonable precautions for abating and preventing fugitive dust. These include:

1. Unpaved roads and unpaved parking areas. Abatement and preventive measures include but shall not be limited to frequent watering, addition of dust palliatives, detouring, paving, closure, speed control, or other means such as surface treatment with penetration chemicals (ligninsulfonates, oil, water, cutbacks, etc.) or methods of equal or greater effectiveness in reducing the air contaminant produced.

2. Demolition, wrecking and explosive detonation activities; earth and construction material moving, mining, and excavation activities.

    a. Abatement and preventive fugitive particulate control measures include, but are not limited to:

        (1) Wetting down, including prewatering.

        (2) Landscaping and replanting with native vegetation.

        (3) Covering, shielding or enclosing the area.

        (4) Paving, temporary or permanent.

        (5) Treating, the use of dust palliatives and chemical stabilization.

        (6) Detouring.

        (7) Restricting the speed of vehicles on sites.

        (8) Preventing the deposit of dirt and mud on improved streets and roads.

        (9) Minimizing topsoil disturbance and reclaiming as soon as possible.

b. Sequential blasting be employed whenever or wherever feasible to reduce the amounts of particulate matter.

c. Such dust control strategies as revegetation, delay of topsoil disturbance until necessary, or surface compaction and sealing, be applied.

d. Haulage equipment be washed or wetted down, treated, or covered when necessary to minimize the amount of dust becoming airborne in transit and in loading.

e. Stockpile of materials be treated to prevent blowing or the material be contained in silos or other suitable enclosures.

f. Waste disposal sites be so operated and constructed as to prevent particulate matter from becoming airborne.

g. All conveyors, transfer points, crushers, screens, and dryers be so constructed, protected, or treated as to prevent particulate matter from becoming airborne.

h. These measures also be used during period when actual construction work is not being conducted, such as on weekends and holidays.

The construction of oil well pads are normally a one or two-day undertaking. The emissions are generally ground level emissions and do not travel very far. In general, compressor stations and gas plant construction are subject to the Permit to Construct program. These permits and rules will assure that construction activities will not adversely affect visibility in any Federal Class I area.

Emissions from construction activities including construction of oil well pads, compressor stations and gas plants will be reevaluated in future Regional Haze SIP planning periods since this has the potential to be a growing source category.

10.6.3 Emissions Limitations and Schedules for Compliance

40 CFR 51.308(d)(3)(v)(C) requires the State to consider emissions limitations and schedules for compliance to achieve the reasonable progress goal in developing its LTS.

Emissions limitations and schedules for the seven BART sources are found in Section 7, Best Available Retrofit Technology (BART). They are included in the Air Pollution Control Permit to Construct for each source. The permits found in Appendix D are incorporated as part of this SIP.

10.6.4 Source Retirement and Replacement Schedules

40 CFR 51.308(d)(3)(v)(D) requires the State consider any source retirement and replacement schedules in developing its LTS. The Department is not aware of any anticipated major source retirements or replacements. Replacement of existing facilities will be managed in conformance with the existing State Implementation Plan including the Prevention of Significant Deterioration program.

The 2018 modeling conducted by WRAP included three new power plants to be located in the State. It is now unlikely that two of these plants will be built. Thus the modeling results for 2018 are probably conservative. Construction of new power plants or replacement of existing plants prior to 2018 is unlikely.

10.6.5 Smoke Management Techniques for Agriculture and Forest Management

40 CFR 51.308(d)(3)(v)(E) requires the State to consider smoke management techniques for agriculture and forestry management purposes including plans as currently exist within the State for these purposes in developing its LTS. North Dakota has an area of approximately 68,994 square miles (44.16 million acres). Of this total, 26.5 million acres is crop land, 10.98 million acres is pasture/rangeland and 236,000 acres is woodland/forest with the five State forests comprising 13,300 acres. The North Dakota State Implementation Plan contains rules which govern prescribed burning on crop land, pasture/rangeland or woodland. NDAC 33-15-04-02.2 lists the conditions that apply to any prescribed burning including:

c. Care must be used to minimize the amount of dirt on the material being burned and the material must be dry enough to burn cleanly.

d. Oils, rubber, and other materials that produce unreasonable amounts of air contaminants may not be burned.

e. The burning may be conducted only when meteorological conditions favor smoke dispersion and air mixing.

h. Except in an emergency, burning may not be conducted in such proximity of any class 1 area, as defined in chapter 33-15-15, that the ambient air of such area is adversely impacted.

i. Except in an emergency, the visibility of any class 1 area cannot be adversely impacted as defined in chapter 33-15-19.

j. Burning activities must be attended and supervised at all times burning is in progress.

Fires purposely set to woodland/forest or rangeland for the management of the land or game must be in accordance with practices recommended by State and Federal agencies and must be approved in advance by the Department (NDAC 33-15-04-02.1.e). Although agricultural crop burning does not require advanced approval by the Department, most of this burning takes place in the eastern two thirds of State away from the Class I areas in North Dakota. In general, prevailing winds carry the smoke from crop land burning away from the North Dakota Class I areas. For 2000-2004 (Case Plan 02d), the WRAP has estimated the annual emissions from fire in North Dakota as shown in Table 10.1.

Table 10.1
Annual Average Emissions from Fire (2000-2004)

Source	PM_{fine} (tpy)	PM_{coarse} (tpy)	NO_x (tpy)	SO_2 (tpy)	Organic Carbon (tpy)	Elemental Carbon (tpy)
Natural	225	441	773	250	2,214	424
Anthropogenic	596	62	1001	290	1,443	86
Total	821	503	1774	540	3,657	510

Based on the source apportionment analyses conducted by the WRAP, anthropogenic fire emissions in North Dakota contribute less than 1% of the total emissions of any of the pollutant species listed above during the 20% worst visibility days for either Lostwood Wilderness Area or Theodore Roosevelt National Park as shown in Table 10.2. The contribution of anthropogenic fire is expected to decrease by 2018. As indicated earlier, open burning is subject to regulation under NDAC 33-15-04 which specifically prohibits burning that will adversely affect visibility in any Class I area. The Department has determined that the current smoke management rules are sufficient to achieve reasonable progress toward the national visibility goal.

Table 10.2
North Dakota Anthropogenic Fire Contribution to the 20% Worst Days

Class I Area	Pollutant	Contribution 2000-2004 (%)	Contribution 2018 (%)
TRNP	SO_x	0.013	0.004
	NO_x	0.019	0.006
	POA	0.364	0.112
	EC	0.067	0.024
	PMF	0.04	0.013
	PMC	0.001	0
LWA	SO_x	0.008	0.002
	NO_x	0.024	0.007
	POA	0.823	0.252
	EC	0.13	0.046
	PMF	0.049	0.015
	PMC	0.001	0

10.6.6 Enforceability of Emission Limitations and Control Measures

40 CFR 51.308(d)(3)(v)(F) requires the State must consider the enforceability of emission limitations and control measures in developing its LTS. The BART emission limits and control measures will be included in a BART Air Pollution Control Permit to Construct that is issued to each BART source and are incorporated into this SIP. The Permit to Construct program is established in the State Air Pollution Control Rules (NDAC 33-15-14-02). The program is also approved into the State Implementation Plan. The BART permits are included in Appendix D of this SIP. Other ongoing programs are already included in the State rules. Future NSPS and MACT rules for major sources will be adopted into the State Rules and delegation will be requested from EPA.

10.6.7 The Anticipated Net Effect on Visibility Due to Projected Changes in Point, Area and Mobile Source Emissions

40 CFR 51.308(d)(3)(v)(G) requires the State consider the anticipated net effect on visibility due to projected changes in point, area, and mobile source emissions over the period addressed by the long-term strategy in developing its LTS. The anticipated net effect on visibility due to projected changes in emissions from 2004 to 2018 is discussed in Section 8, Visibility Modeling.

10.7 Prevention of Significant Deterioration

In North Dakota, new and modified existing major stationary sources triggering significance thresholds are analyzed under the Prevention of Significant Deterioration (PSD) permitting program. The PSD program rules are found in NDAC Chapter 33-15-15 and have been approved as a part of the North Dakota SIP by EPA. The PSD permitting program is an integral part of North Dakota's long-term strategy for meeting its regional haze goals.

Among other things, the PSD permit program is designed to protect air quality and visibility in Class I areas by requiring best available control technology (BACT) and involving the public in permit decisions. The PSD permitting process requires a technical air quality analysis and additional analyses to assess the potential impacts of emissions on soils, vegetation and visibility. The cumulative impacts of emissions subject to the PSD program will be evaluated to ensure there is no degradation from baseline conditions on the 20 percent worst days and the 20 percent best days.

Therefore, North Dakota's current PSD program ensures that visibility at the Class I areas will not be impacted by growth in stationary sources.

11. Commitment to Consultation, Progress Reports, Periodic Evaluations of Plan Adequacy, and Future SIP Revisions

11.1 Future Consultation Commitments

11.1.1 FLM Consultation and Coordination

40 CFR 51.308(i) contains the requirements for State and Federal Land Manger consultation and coordination. §51.308(i) reads "What are the requirements for State and Federal Land Manager coordination?

(1) By November 29, 1999, the State must identify in writing to the Federal Land Managers the title of the official to which the Federal Land Manager of any mandatory Class I Federal area can submit any recommendations on the implementation of this subpart including, but not limited to:

(i) Identification of impairment of visibility in any mandatory Class I Federal area(s); and

(ii) Identification of elements for inclusion in the visibility monitoring strategy required by § 51.305 and this section.

(2) The State must provide the Federal Land Manager with an opportunity for consultation, in person and at least 60 days prior to holding any public hearing on an implementation plan (or plan revision) for regional haze required by this subpart. This consultation must include the opportunity for the affected Federal Land Managers to discuss their:

(i) Assessment of impairment of visibility in any mandatory Class I Federal area; and

(ii) Recommendations on the development of the reasonable progress goal and on the development and implementation of strategies to address visibility impairment.

(3) In developing any implementation plan (or plan revision), the State must include a description of how it addressed any comments provided by the Federal Land Managers.

(4) The plan (or plan revision) must provide procedures for continuing consultation between the State and Federal Land Manager on the implementation of the visibility protection program required by this subpart, including development and review of implementation plan revisions and 5-year progress reports, and on the implementation of other programs having the potential to contribute to impairment of visibility in mandatory Class I Federal areas."

North Dakota commits to coordinate and consult with the Federal Land Managers as required in §51.308(i)(1) through (4).

11.1.2 Tribal Consultation

North Dakota will continue to remain in contact with those Tribes which may reasonably be anticipated to cause or contribute to visibility impairment in North Dakota mandatory Class I Federal area(s). For those Tribes that adopted a RH TIP, North Dakota will consult with them directly. For those Tribes without a RH TIP, North Dakota will consult with both the Tribe and EPA. Documentation of the consultations will be maintained.

11.1.3 Interstate Consultation and Coordination

40 CFR 51.308(d)(1)(iv) and 40 CFR 51.308(d)(3)(i) contain the requirements for interstate consultation and coordination. §(d)(1)(iv) reads:

> "In developing each reasonable progress goal, the State must consult with those States which may reasonably be anticipated to cause or contribute to visibility impairment in the mandatory Class I Federal area. In any situation in which the State cannot agree with another such State or group of States that a goal provides for reasonable progress, the State must describe in its submittal the actions taken to resolve the disagreement. In reviewing the State's implementation plan submittal, the Administrator will take this information into account in determining whether the State's goal for visibility improvement provides for reasonable progress towards natural visibility conditions." §(d)(3)(i) reads:
>
> "Where the State has emissions that are reasonably anticipated to contribute to visibility impairment in any mandatory Class I Federal area located in another State or States, the State must consult with the other State(s) in order to develop coordinated emission management strategies. The State must consult with any other State having emissions that are reasonably anticipated to contribute to visibility impairment in any mandatory Class I Federal area within the State."

In accordance with 40 CFR 51.308(d)(1)(iv) and 51.308(d)(3)(i), North Dakota commits to continue consultation with Minnesota, Montana, and South Dakota, and any other state which may reasonably be anticipated to cause or contribute to visibility impairment in federal Class I areas located within North Dakota. North Dakota will also continue consultation with Michigan, Minnesota, Montana, and South Dakota and any other state for which North Dakota's emissions may reasonably be anticipated to cause or contribute to visibility impairment in those state's federal Class I areas.

With reference to the established or updated goals for reasonable progress, should disagreement arise between another state or group of states, North Dakota will describe the actions taken to resolve the disagreement in future RH SIP revisions for EPA's consideration. With reference to

assessing or updating long-term strategies, North Dakota commits to coordinate its emission management strategies with affected states and will continue to include in its future RH SIP revisions all measures necessary to obtain its share of emissions reductions for meeting progress goals.

11.2 Commitment to Progress Reports

Requirements for the State to submit periodic progress reports are found in 40 CFR 51.308(g) which reads "Requirements for periodic reports describing progress towards the reasonable progress goals. Each State identified in §51.300(b)(3) must submit a report to the Administrator every five years evaluating progress towards the reasonable progress goal for each mandatory Class I Federal area located within the State and in each mandatory Class I Federal area located outside the State which may be affected by emissions from within the State. The first progress report is due 5 years from the submittal of the initial implementation plan addressing paragraphs (d) and (e) of this section. The progress reports must be in the form of implementation plan revisions that comply with the procedural requirements of §51.102 and §51.103. Periodic progress reports must contain at a minimum the following elements:

(1) A description of the status of implementation of all measures included in the implementation plan for achieving reasonable progress goals for mandatory Class I Federal areas both within and outside the State.

(2) A summary of the emissions reductions achieved throughout the State through implementation of the measures described in paragraph (g)(1) of this section.

(3) For each mandatory Class I Federal area within the State, the State must assess the following visibility conditions and changes, with values for most impaired and least impaired days expressed in terms of 5-year averages of these annual values.

    (i) The current visibility conditions for the most impaired and least impaired days;

    (ii) The difference between current visibility conditions for the most impaired and least impaired days and baseline visibility conditions;

    (iii) The change in visibility impairment for the most impaired and least impaired days over the past 5 years;

(4) An analysis tracking the change over the past 5 years in emissions of pollutants contributing to visibility impairment from all sources and activities within the State. Emissions changes should be identified by type of source or activity. The analysis must be based on the most recent updated emissions inventory, with estimates projected forward as necessary and appropriate, to account for emissions changes during the applicable 5-year period.

(5) An assessment of any significant changes in anthropogenic emissions within or outside the State that have occurred over the past 5 years that have limited or impeded progress in reducing pollutant emissions and improving visibility.

(6) An assessment of whether current implementation plan elements and strategies are sufficient to enable the State, or other States with mandatory Federal Class I areas affected by emissions from the State, to meet all established reasonable progress goals.

(7) A review of the State's visibility monitoring strategy and any modifications to the strategy as necessary."

In accordance with the requirements listed in 40 CFR 51.308(g) of the federal regional haze rule, North Dakota commits to submitting periodic progress reports to EPA every five years following the initial submittal of the SIP. The periodic progress reports will address at a minimum all the elements of §51.308(g). The periodic progress reports will be in the form of implementation plan revisions that comply with the procedural requirements of 40 CFR 51.102 and 51.103.

11.3 Determination of Current Plan Adequacy

Based on the findings of the 5-year periodic progress report, 40 CFR 51.308(h) requires a State to make a determination of adequacy of the existing implementation plan. §51.308(h) reads "Determination of the adequacy of existing implementation plan. At the same time the State is required to submit any 5-year progress report to EPA in accordance with paragraph (g) of this section, the State must also take one of the following actions based upon the information presented in the progress report:

(1) If the State determines that the existing implementation plan requires no further substantive revision at this time in order to achieve established visibility goals for visibility improvement and emissions reductions, the State must provide to the Administrator a negative declaration that further revision of the existing implementation plan is not needed at this time.

(2) If the State determines that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources in another State(s) which participated in a regional planning process, the State must provide notification to the Administrator and the other State(s) which participated in the regional planning process with the States. The State must also collaborate with the other State(s) through the regional planning process for the purpose of developing additional strategies to address the plan's deficiencies.

(3) Where the State determines that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources in another country, the State shall provide notification, along with available information, to the Administrator.

(4) Where the State determines that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources within the State, the State shall revise its implementation plan to address the plan's deficiencies within one year."

North Dakota commits, in accordance with 40 CFR 51.308(h), to make a determination of the adequacy of the existing implementation plan at the same time a five-year periodic progress report is due.

Should North Dakota determine that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources in another State or States, North Dakota will provide notification to the Administrator and the other State(s) and collaborate with the other States(s) through the regional planning process for the purpose of developing additional strategies to address the plan's deficiencies as required by §51.308(h)(2). In the event that no regional planning organizations or process exists, North Dakota will work directly with the other State(s).

Should North Dakota determine that the current implementation plan is or may be inadequate due to emissions from within the State itself, North Dakota will develop additional strategies to address the plan deficiencies and revise the implementation plan within one year, as required by §51.308(h)(4).

Should North Dakota determine that the implementation plan is or may be inadequate to ensure reasonable progress due to emissions from sources in another country, the State will provide notification, along with available information, to the Administrator as required by §51.308(h)(3).

Should North Dakota determine that the existing implementation plan requires no further substantive revision in order to achieve established goals for visibility improvement and emissions reductions, North Dakota will provide the Administrator a negative declaration that further revision of the existing implementation plan is not needed as required by §51.308(h)(1).

In addition, North Dakota commits to revise the implementation plan, including the reasonable progress goals, once RH SIPs from neighboring states become available and are approved by EPA, or if the unexpected or unforeseen occurs. This would include, but not be limited to, projected future emissions reductions that do not occur, are distributed differently over an alternate geographic area, or are found to be incorrect or flawed. These revisions will be made within one year as required by §51.308(h)(4). North Dakota also commits to accelerate this revision schedule if the present RH SIP is found to be significantly flawed and the 2018 reasonable progress goals cannot be reasonably attained.

11.4 Commitment to Future SIP Revisions

In addition to a SIP revision made for periodic progress reports as addressed in Section 11.2 and plan inadequacy as addressed in Section 11.3, 40 CFR 51.308(f) requires a State to revise and submit its regional haze implementation plan to EPA by July 31, 2018, and every ten years thereafter. 40 CFR 51.308(f) reads "Requirements for comprehensive periodic revisions of

implementation plans for regional haze. Each State identified in §51.300(b)(3) must revise and submit its regional haze implementation plan revision to EPA by July 31, 2018 and every ten years thereafter. In each plan revision, the State must evaluate and reassess all of the elements required in paragraph (d) of this section, taking into account improvements in monitoring data collection and analysis techniques, control technologies, and other relevant factors. In evaluating and reassessing these elements, the State must address the following:

(1) Current visibility conditions for the most impaired and least impaired days, and actual progress made towards natural conditions during the previous implementation period. The period for calculating current visibility conditions is the most recent five year period preceding the required date of the implementation plan submittal for which data are available. Current visibility conditions must be calculated based on the annual average level of visibility impairment for the most and least impaired days for each of these five years. Current visibility conditions are the average of these annual values.

(2) The effectiveness of the long-term strategy for achieving reasonable progress goals over the prior implementation period(s); and

(3) Affirmation of, or revision to, the reasonable progress goal in accordance with the procedures set forth in paragraph (d)(1) of this section. If the State established a reasonable progress goal for the prior period which provided a slower rate of progress than that needed to attain natural conditions by the year 2064, the State must evaluate and determine the reasonableness, based on the factors in paragraph (d)(1)(i)(A) of this section, of additional measures that could be adopted to achieve the degree of visibility improvement projected by the analysis contained in the first implementation plan described in paragraph (d)(1)(i)(B) of this section."

In accordance with the requirements of section 51.308 (d) and (f) of the regional haze rule, North Dakota commits to revising and submitting its regional haze SIP by July 31, 2018 and every ten years thereafter addressing current visibility conditions, effectiveness of the long-term strategy and affirming or revising the reasonable progress goal for each mandatory Class I Federal area in North Dakota.

11.5 Monitoring Strategy

North Dakota commits to review and reevaluate the adequacy of and revise as necessary the existing RAVI monitoring strategy required by Section 51.305 and the existing regional haze monitoring strategy required by Section 51.308(d)(4) as a minimum, concurrently with the 5-year periodic progress reports and the 10-year plan revisions which start July 31, 2018 and every ten years thereafter. North Dakota will coordinate all reviews, reevaluations and revisions to both monitoring strategies with each other and will consult and coordinate any revisions with EPA and FLMs. The monitoring strategies are discussed further in Section 4 of this plan.

11.6 Rules for Non-BART Point and Area Sources

The Department adopted rules in 1987 to implement Phase 1 of the federal visibility program which is Section 40 CFR 51.300 – 307 (NDAC Chapter 33-15-19 Visibility Protection, effective date October 1, 1987) and in 2006 to implement the BART portion of Phase 2 which is Paragraph 40 CFR 51.308(e) (NDAC Chapter 33-15-23 Regional Haze Requirements, effective date January 1, 2007). For a more detailed description of Phase 1 and Phase 2 of the federal visibility program see Section 2.

As a result of addressing the core requirements of the federal visibility program which are found in 40 CFR 51.308(d), the Department has determined it will be necessary to develop and adopt rules to clarify its legal authority to address emissions which adversely impact visibility in the Class I areas from non-BART and area sources which may in the future be found to be reasonably controllable and reduced (see Section 9).

The Department commits to develop and adopt necessary rules to clarify its legal authority to control and reduce emissions from non-BART and area sources that adversely impact Class I areas as expeditiously as possible but no later than December 31, 2012.

12. Public Participation and Review Process

12.1 Summary of Comments Received during Public Comment Period/Hearing

This subsection will be completed following the close of the 30 day public comment period and public hearing.

12.2 Response to Public Comments

This subsection will be completed following the close of the 30 day public comment period and public hearing.

12.3 Revisions to the State Implementation Plan

This subsection will be completed following the close of the 30 day public comment period and public hearing.

12.4 Revisions to the BART Air Pollution Control Permits to Construct

This subsection will be completed following the close of the 30 day public comment period and public hearing.

Appendix A. BART Modeling Protocols and Analyses

A.1 Protocol for BART-Related Visibility Impairment Modeling Analyses in North Dakota

A.2 Montana-Dakota Utilities Heskett Station Unit 2

A.2.1 Refined BART CALPUFF Visibility Modeling Analysis

A.2.2. Response to Concerns Regarding Heskett Unit 2 BART Exemption

A.3 Notification of Subject-to-BART Letters to BART-Eligible Sources

A.4 Coyote Station Permit to Construct

Appendix B. Department BART Determinations for Subject-to-BART Sources in North Dakota

B.1 Basin Electric Power Cooperative Leland Olds Station Units 1 and 2

B.2 Great River Energy Coal Creek Station Units 1 and 2

B.3 Great River Energy Stanton Station Unit 1

B.4 Minnkota Power Cooperative Milton R. Young Station Units 1 and 2

B.5 Best Available Retrofit Technology Selective Catalytic Reduction Technical Feasibility Analysis for North Dakota Lignite

B.6 Selective Catalytic Reduction (SCR) Technical Feasibility for M.R. Young Station

Appendix C. Company BART Analyses and Supporting Information

C.1 Basin Electric Power Cooperative Leland Olds Station Units 1 and 2

C.2 Great River Energy Coal Creek Station Units 1 and 3

C.3 Great River Energy Stanton Station Unit 1

C.4 Minnkota Power Cooperative Milton R. Young Station Units 1 and 2

Appendix D. Air Pollution Control Permit to Construct for the Subject-to-BART sources

D.1 Basin Electric Power Cooperative Leland Olds Station Units 1 and 2

D.2 Great River Energy Coal Creek Station Units 1 and 3

D.3 Great River Energy Stanton Station Unit 1

D.4 Minnkota Power Cooperative Milton R. Young Station Units 1 and 2

Appendix E. Modeling Protocol for Regional Progress Goals In North Dakota, October 3, 2008

Appendix F. Public Hearing Record

F.1 Hearing Notice

F.2 Press Release

F.3 Affidavit of Publication

F.4 Invoice of Publication

F.5 Registration List of Attendees

F.6 Hearing Transcript

F.7 Certification of Hearing

F.8 Response to Public Comments

F.9 Summary of Proceedings and Certification of Adoption of the State Implementation Plan

Appendix G. Legal Opinion of the Attorney General

Appendix H. NDAC Chapter 33-15-25, Regional Haze Requirements

Appendix I. Supplementary Information for Four-Factor Analyses For Selected Individual Facilities in North Dakota

Appendix J. Plan Development and Consultation

J.1 Consultation with Federal Land Managers
J.1.1 FLM Comments Provided on BART Portion of SIP During 60-Day Comment Period
J.1.2 NDDoH Response to FLM Comments on BART Portion of SIP in 2008
J.1.3 FLM Comments Provided During 60-Day Comment Period
J.1.4 NDDoH Response to FLM Comments

J.2 Consultation with Other States
J.2.1 Minnesota September 19, 2007 Memorandum
J.2.2 NDDoH August 22, 2008 Letter of Response

J.3 Consultation with EPA Region 8
J.3.1 EPA Comments Provided on BART Portion of SIP in 2008
J.3.2 NDDoH Response to EPA Comments on BART Portion of SIP in 2008

J.4 Consultation with Tribes