Update of Task 3A Report for the Powder River Basin Coal Review Cumulative Air Quality Effects for 2020

AECOM

Prepared for

Bureau of Land Management
High Plains District Office,
Wyoming State Office, and
Miles City Field Office

Submitted by

AECOM, Inc.
Fort Collins, Colorado

December 2009

UPDATE OF TASK 3A REPORT FOR THE POWDER RIVER BASIN COAL REVIEW CUMULATIVE AIR QUALITY EFFECTS FOR 2020

Prepared for

BUREAU OF LAND MANAGEMENT
HIGH PLAINS DISTRICT OFFICE,
WYOMING STATE OFFICE, AND
MILES CITY FIELD OFFICE

Submitted by

AECOM, Inc.
Fort Collins, Colorado

December 2009

ES.1 INTRODUCTION

The Powder River Basin (PRB) of Wyoming and Montana is a major coal-producing region in the United States (U.S.). It also has produced large quantities of natural gas and oil, and has experienced significant development of coal bed natural gas (CBNG) from its coal seams. The region has a diverse set of environmental values, including proximity to some of the most pristine areas in the U.S.

This update to the Task 3A Report for the PRB Coal Review evaluates the air quality-related environmental impacts of ongoing development in the region. The Task 1A Report for the PRB Coal Review, Current Air Quality Conditions (ENSR 2005a) documented the air quality impacts of operations during a base year (2002), using actual emissions and operations for that year. The base year analysis evaluated impacts both within the PRB itself and at selected sensitive areas surrounding the region. The analysis specifically quantified impacts of coal mines, power plants, CBNG development, and other activities. Results were provided for both Wyoming and Montana source groups and receptors.

The Task 2 Report for the PRB Coal Review, Past and Present and Reasonably Foreseeable Development Activities (ENSR 2005b) depicted the range of projected coal-related development in the PRB, for selected source groups. The report identified reasonably foreseeable development (RFD) activities for the years 2010, 2015, and 2020, and was separated into selected, partially overlapping source groups, including power plants, coal mine development, conventional oil and gas and CBNG activities, and other coal-related energy development scenarios. The results of that study were used to develop changes in air pollution emission rates for source groups in 2010, 2015, and 2020 which are the basis for modeled estimates of the projected cumulative air quality impacts. The 2020 RFD scenarios from the Task 2 report were updated with current information, as applicable, and revised emissions were included in this updated analysis.

The original Task 3A report (ENSR 2006) provided a modeled change in impacts on air quality and air quality-related values (AQRVs) resulting from the projected RFD activities in 2010. Impacts of coal and other resource development were evaluated for each source group and for the various receptor groups. The Task 2 projected development for 2010 was modeled using the same model and meteorological data that were used for the base year study in the Task 1A report. Impacts for 2015 and 2020 were qualitatively projected based on modeled impacts for 2010 and expected changes in source group emissions identified in the Task 2 study. As the uncertainty associated with predicted developments for 2015 and 2020 decreased, it became increasingly valuable to update the original Task 3A qualitative estimates for 2015 and 2020 with a quantitative evaluation. In 2008, the cumulative air quality effects for 2015 were modeled, and the Task 3A study correspondingly was updated (ENSR 2008a).

This current update to the Task 3A report quantitatively updates the original Task 3A qualitative analysis based on modeled changes in impacts on air quality and AQRVs resulting from the projected RFD activities in 2020. Similar to the original Task 3A report, impacts due to development of selected source types were evaluated at various receptor locations. Several important changes that occurred during the development of the 2015 update were carried through to this 2020 update. The changes that affect the comparison of this updated report with the original Task 3A report include:

- A new version of the dispersion model used to predict air quality and AQRVs;
- Initiation of the dispersion model with a different meteorological year;
- An improved base year emissions inventory; and
- Updated RFD emission sources and projected emissions activities to 2020.

ES.2 TECHNICAL APPROACH

Similar to the original Task 3A report, this updated analysis evaluates two levels of coal development: a lower production (or development) scenario and an upper production scenario. Existing and projected sources in the study area were analyzed using base year emissions and adjusting those emissions based on the projected development level. Emissions were evaluated for sources in the study area, which comprises several counties in the PRB in both states:

- Wyoming portion of the study area comprises all of Campbell County, all of Sheridan and Johnson counties except the Bighorn National Forest lands to the west of the PRB, and the northern portion of Converse County
- Montana portion of the study area comprises the area of relevant coal mines including portions of Rosebud, Custer, Powder River, Big Horn, and Treasure counties

The study evaluates impacts on air quality and AQRVs resulting from projected development of RFD activities (for 2020) in the study area. For the original Task 3A study, a quantitative modeling assessment was used to predict ambient air quality impacts for 2010, and qualitative evaluations were made for 2015 and 2020. For this current update to the Task 3A study, the original 2020 qualitative evaluations were quantitatively updated based on the same approach previously used to predict ambient air quality impacts for 2010 and 2015.

A state-of-the-art, guideline dispersion model was used to evaluate impacts at several locations:

- Near-field receptors in Wyoming (within the PRB study area);
- Near-field receptors in Montana (within the PRB study area);
- Receptors in nearby federally designated pristine or Class I areas; and
- Receptors at other sensitive areas (sensitive Class II areas).

The U.S. Environmental Protection Agency (USEPA) guideline CALPUFF model system version 5.8 (Scire et al. 2000a,b) was used for this study, which differs from the version used in the Task 1A and original Task 3A studies. The modeling domain is identical to the Task 1A, original Task 3A, and 2015 update to the Task 3A studies and extends over most of Wyoming, southeastern Montana, southwestern North Dakota, western South Dakota, and western Nebraska. A group of agency stakeholders participated in developing the modeling protocol and related methodology that were used for this analysis (ENSR 2008b).

This updated Task 3A report uses an identical model setup, meteorological input data, and base year emissions inventory as the 2015 update. Previously, the base year inventory was developed for actual emissions in 2002; for this update, the base year emissions inventory is for year 2004. Detailed information regarding the development of the emissions information is available in the 2015 update report (ENSR 2008a) and its corresponding Technical Support Document (ENSR 2008d). The base year emissions inventory is projected into future year 2020 for upper and lower production scenarios.

The meteorological data set for 2003 was selected as the worst-case meteorological year during the 2015 update based on an analysis of visibility impacts at the nearest Class I areas. The meteorological year 2003 was then used to model impacts for all emissions sources for the revised base year and the 2015 and 2020 development scenarios. Modeling data settings generally were set to default values. Base year ozone concentrations also were incorporated into the model using measured concentrations representative of the study area.

The objective of this updated study is to provide a quantitative evaluation of projected 2020 cumulative air quality impacts for comparison to both the base year impacts and the 2020 qualitative projections from the original Task 3A report. For this updated study, the base year (2004) and projected future year (2020) impacts are evaluated using the same receptor set and modeling domain used for the Task 1A and original Task 3A reports. The 2020 development scenarios were directly modeled for this study. The only difference between the base year and future year predicted impacts is due to the projected change in emissions as a result of RFD activities in the PRB study area. This report documents the modeled impacts for 2020 under both the upper and lower development scenarios. The changes in air quality and AQRVs due to projected development in the PRB are summarized and compared with the original Task 3A qualitative projections for 2020.

ES.3 CUMULATIVE IMPACTS

Generally, measured air quality conditions are good throughout the region. The base year (2004) modeling showed that there is reason for concern regarding the short-term impacts for some pollutants including particulate matter (PM) with an aerodynamic diameter of 10 microns or less (PM_{10}) and PM with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$). The base year modeling also predicted substantial visibility impacts at the nearby Class I and sensitive Class II areas. For regulatory purposes, the Class I evaluations are not directly comparable to the air quality permitting requirements, because the modeling effort does not segregate increment-consuming sources that would need to be evaluated under the Prevention of Significant Deterioration (PSD) program. The cumulative impact analysis focuses on changes in cumulative impacts versus a comparison to PSD-related evaluations, which would apply to specific sources. Changes in predicted impacts for air quality parameters (NO_2, sulfur dioxide [SO_2], PM_{10}, and $PM_{2.5}$) were evaluated, along with changes in AQRVs at Class I and sensitive Class II areas.

It is important to note that the effects of Best Available Retrofit Technology (BART) implementation are not incorporated into the results presented below, since the states are still developing their implementation plan. It is anticipated that air quality effects from large sources summarized below likely would be reduced as a result of BART regulations.

Table ES-1 presents the modeled impacts on ambient air quality at the near-field receptors in Montana and Wyoming. Results indicate the maximum impacts at any point in each receptor group. Results are summarized for both 2020 development scenarios, and results from the base year are included for comparison purposes. Peak impacts occur at isolated receptors and are likely due to unique source-receptor relationships. The model results should not be construed as predicting an actual exceedence of any standard, but are at best indicators of potential impacts.

The results of the modeling depict the anticipated changes under both development scenarios. For the Wyoming near-field receptors, the predicted impact of the 24-hour PM_{10} and $PM_{2.5}$ concentrations show localized exceedences of the National Ambient Air Quality Standard (NAAQS) for the base year (2004), as well as for both development scenarios for 2020. The 2020 development scenarios show the concentration increases by a factor of 2.5 relative to the base year for these parameters. Additionally, 2020 development scenarios show a 20 percent increase of annual PM_{10} and $PM_{2.5}$ concentrations at peak Wyoming near-field receptors. This level of increase indicated modeled exceedences of annual standards for $PM_{2.5}$.[1] Impacts of NO_2 and SO_2 emissions are predicted to be below the NAAQS and Wyoming State Ambient Air Quality Standard (SAAQS) at the Wyoming near-field receptors.

Based on the modeling results, impacts at Montana near-field receptors would be in compliance with the NAAQS and the Montana SAAQS for all pollutants and averaging periods. Importantly, the 1-hour NO_2 concentrations at Montana near-field receptors for 2015 were predicted to exceed the SAAQS at isolated locations due to CBNG development in Wyoming; however, with the anticipated southward progression of the CBNG wells, the 1-hour NO_2 concentrations in 2020 are predicted to remain below the SAAQS. The southward progression of the CBNG wells also contributes to a

[1] At the time of publication of this report, the annual PM_{10} NAAQS have been revoked by the USEPA. The state-specific annual PM_{10} standards are still in effect. Modeled impacts are compared to the annual PM_{10} threshold for consistency with the original Task 3A Report.

predicted decrease in impacts for annual NO_2, PM_{10} and $PM_{2.5}$ relative to the base year. Although large percentage increases were predicted in SO_2 impacts, the levels would be below the ambient standards for all pollutants in the Montana near-field.

Table ES-1
Projected Maximum Potential Near-field Impacts
(µg/m³)

Pollutant	Averaging Time	Base Year (2004) Impacts	2020 Lower Development Scenario Impacts	2020 Upper Development Scenario Impacts	NAAQS	Wyoming SAAQS	Montana SAAQS	PSD Class II Increments
Wyoming Near-field								
NO_2	Annual	31.3	80.5	80.6	100	100	--	25
SO_2	Annual	15.3	16.4	16.5	80	60	--	20
	24-hour	112.3	144.3	144.3	365	260		91
	3-hour	462.0	936.7	936.7	1,300	1,300	--	512
$PM_{2.5}$	Annual	13.4	**16.3**	**16.3**	15	15	--	--
	24-hour	**87.6**	**218.4**	**218.5**	35	35	--	--
PM_{10}	Annual	38.4	46.6	46.6	--	50	--	17
	24-hour	**250.4**	**624.1**	**624.3**	150	150	--	30
Montana Near-field								
NO_2	Annual	3.3	2.5	2.6	100	--	100	25
	1-hour	409.0	440.1	442.7	--	--	564	--
SO_2	Annual	1.6	3.0	3.1	80	--	80	20
	24-hour	16.1	24.7	27.1	365	--	365	91
	3-hour	65.0	138.9	138.9	1,300	--	1,300	512
	1-hour	162.9	237.0	259.1	--	--	1,300	--
$PM_{2.5}$	Annual	1.0	0.9	0.9	15	--	15	--
	24-hour	10.2	10.2	10.2	35	--	35	--
PM_{10}	Annual	2.8	2.5	2.6	--	--	50	17
	24-hour	29.1	29.3	29.3	150	--	150	30

Note: -- = No standard or increment.
µg/m³ = microgram per cubic meter.
Bold numbers indicate potential exceedences.

Table ES-2 provides modeled impacts at the three Class I areas and two Class II areas with the greatest impacts. A comparison to SAAQS and PSD increments is provided; however, the analysis did not separate PSD increment-consuming sources from those that did not consume increment. The PSD-increment comparison is provided for informational purposes only and cannot be directly related to a regulatory interpretation of PSD increment consumption.

None of the modeled Class I areas currently have, or are predicted to have, NAAQS or SAAQS exceedences. **Table ES-2** compares the modeled impacts to the PSD Class I and sensitive Class II increment levels. At the Northern Cheyenne Indian Reservation (IR), Badlands National Park (NP) and Wind Cave NP base year impacts are slightly above the Class I comparative levels for 24-hour PM_{10} in 2020. Additionally, the SO_2 impacts at the Northern Cheyenne IR for the 3-hour and 24-hour averaging period exceed the Class I PSD increment levels. In the other Class I areas, only the modeled 24-hour SO_2 impacts at Theodore Roosevelt NP and Fort Peck IR, and 3-hour SO_2 impacts at Theodore Roosevelt NP, are above the PSD increment levels for the 2020 development scenarios; the predicted exceedences for these areas are due to sources outside the PRB study area.

Table ES-2
Maximum Predicted PSD Class I and Sensitive Class II Area Impacts
(μg/m³)

Location	Pollutant	Averaging Period	Base Year (2004) Impacts	2020 Lower Development Scenario	2020 Upper Development Scenario	PSD Class I and Class II Increments
Class I Areas						
Northern Cheyenne IR	NO_2	Annual	0.4	0.8	1.1	2.5
	SO_2	Annual	0.5	1.1	1.3	2
		24-hour	3.1	**7.1**	**12.8**	5
		3-hour	9.4	23.6	**39.7**	25
	$PM_{2.5}$	Annual	0.3	0.4	0.5	--
		24-hour	3.4	4.5	4.6	--
	PM_{10}	Annual	0.9	1.2	1.5	4
		24-hour	**9.6**	**12.9**	**13.2**	8
Badlands NP	NO_2	Annual	0.1	0.2	0.2	2.5
	SO_2	Annual	0.5	0.6	0.6	2
		24-hour	3.6	4.0	4.0	5
		3-hour	8.1	8.2	8.2	25
	$PM_{2.5}$	Annual	0.2	0.3	0.3	--
		24-hour	2.1	3.0	3.1	--
	PM_{10}	Annual	0.7	0.9	1.0	4
		24-hour	5.9	**8.5**	**8.8**	8
Wind Cave NP	NO_2	Annual	0.2	0.3	0.3	2.5
	SO_2	Annual	0.7	0.8	0.8	2
		24-hour	3.7	4.6	4.7	5
		3-hour	7.0	7.5	7.7	25
	$PM_{2.5}$	Annual	0.4	0.5	0.5	--
		24-hour	3.8	4.6	4.7	--
	PM_{10}	Annual	1.0	1.4	1.4	4
		24-hour	**10.9**	**13.0**	**13.3**	8
Sensitive Class II Areas						
Cloud Peak WA	NO_2	Annual	0.06	0.12	0.12	25
	SO_2	Annual	0.2	0.3	0.3	20
		24-hour	2.0	2.5	2.5	91
		3-hour	8.0	8.9	9.0	512
	$PM_{2.5}$	Annual	0.2	0.2	0.2	--
		24-hour	2.6	3.2	3.3	--
	PM_{10}	Annual	0.5	0.7	0.7	17
		24-hour	7.4	9.1	9.3	30
Crow IR	NO_2	Annual	0.9	3.6	4.2	25
	SO_2	Annual	2.3	2.4	2.4	20
		24-hour	14.4	14.8	14.8	91
		3-hour	76.8	77.0	77.0	512
	$PM_{2.5}$	Annual	0.8	0.8	0.8	--
		24-hour	7.2	7.2	7.2	--
	PM_{10}	Annual	2.2	2.3	2.4	17
		24-hour	20.5	20.6	20.6	30

Note: **Bold** numbers indicate potential exceedences.

In the sensitive Class II areas, there are no modeled exceedences of the Class II PSD Increments. The modeled annual NO_2 impacts at the Cloud Peak Wilderness Area (WA) and Crow IR are projected to increase by a factor of 2 to 4, respectively, in 2020 as a result of projected CBNG and coal hauling activities. For comparison purposes, modeling results for all sensitive Class II areas are below PSD increment levels for both 2020 development scenarios.

Table ES-3 provides a detailed listing of visibility impacts for all analyzed Class I and sensitive Class II areas. Modeled visibility impacts at the identified Class I areas continue to show a similar pattern as exhibited for the base year (2004), with a high number of days with a greater than 10 percent change in visibility at the most impacted Class I areas. Visibility impacts at Badlands NP, Northern Cheyenne IR, and Wind Cave NP all have greater than 10 percent change for more than 200 days a year during the base year. These Class I areas are the top three Class I areas with the highest predicted change in light extinction in 2020. All but four of the sensitive Class II areas have more than 100 days per year with greater than a 10 percent change during the base year. The most significant visibility change to sensitive Class II areas in 2020 is predicted for Black Elk WA and Mount Rushmore National Monument. Class II areas do not have any visibility protection under federal or state law.

Table ES-3
Modeled Change in Visibility Impacts at Class I and Sensitive Class II Areas

Location	Base Year (2004) No. of Days >10%	2020 Lower Development Scenario Change in No. of Days > 10%	2020 Upper Development Scenario Change in No. of Days > 10%
Class I Areas			
Badlands NP	218	44	44
Bob Marshall WA	8	0	0
Bridger WA	144	5	5
Fitzpatrick WA	91	6	6
Fort Peck IR	105	20	21
Gates of the Mountain WA	55	4	4
Grand Teton NP	70	6	6
North Absaorka WA	61	8	8
North Cheyenne IR	243	59	60
Red Rock Lakes	42	3	3
Scapegoat WA	27	2	2
Teton WA	57	8	8
Theodore Roosevelt NP	178	24	24
UL Bend WA	77	18	18
Washakie WA	83	8	8
Wind Cave NP	262	28	31
Yellowstone NP	84	5	5
Sensitive Class II Areas			
Absaorka Beartooth WA	101	10	10
Agate Fossil Beds National Monument	251	26	26
Big Horn Canyon NRA	331	1	1
Black Elk WA	236	47	47
Cloud Peak WA	126	29	30
Crow IR	360	3	3
Devils Tower National Monument	274	31	32
Fort Belknap IR	66	14	15
Fort Laramie National Historic Site	260	15	16
Jedediah Smith WA	79	3	3
Jewel Cave National Monument	261	36	37
Lee Metcalf WA	97	2	2
Mount Naomi WA	51	1	1
Mount Rushmore National Monument	222	49	52
Popo Agie WA	139	6	6
Soldier Creek WA	268	19	19
Wellsville Mountain WA	130	17	17
Wind River IR	217	9	10

For acid deposition, all predicted impacts are below the deposition threshold values for both nitrogen and sulfur compounds. There are substantial percentage increases in deposition under the lower and upper development scenarios; however, impacts remain well below the nitrogen and sulfur levels of concern (1.5 and 5.0 kilograms per hectare per year, respectively). The acid neutralizing capacity of sensitive lakes also was analyzed, and results are summarized in **Table ES-4**. The base year study indicated that none of the lakes had predicted significant impacts except Upper Frozen Lake; however, the lower and upper development scenarios for 2020 show an increased impact at Florence Lake, leading to an impact above the 10 percent change in acid neutralizing capacity (ANC). Impacts also are predicted to be above the 1 micro-equivalent per liter (µeq/L) for Upper Frozen Lake.

Table ES-4
Predicted Total Cumulative Change in Acid Neutralizing Capacity of Sensitive Lakes

Location	Lake	Background ANC (µeq/L)	Area (hectares)	Base Year (2004) Change (percent)	2020 Lower Development Scenario Change (percent)	2020 Upper Development Scenario Change (percent)	Thresholds (percent)
Bridger WA	Black Joe	67	890	4.00	4.26	4.27	10
	Deep	60	205	4.70	4.98	4.99	10
	Hobbs	70	293	3.95	4.14	4.15	10
	Upper Frozen	5	64.8	2.42	2.55	2.56	1[1]
Cloud Peak WA	Emerald	55.3	293	5.24	6.69	6.80	10
	Florence	32.7	417	9.09	11.79	11.99	10
Fitzpatrick WA	Ross	53.5	4,455	2.72	2.89	2.90	10
Popo Agie WA	Lower Saddlebag	55.5	155	6.28	6.65	6.67	10

[1]Data for Upper Frozen Lake presented in changes in µeq/L. (For lakes with less than 25 µeq/L background ANC.)

The study also modeled impacts of selected hazardous air pollutant emissions (benzene, ethyl benzene, formaldehyde, n-hexane, toluene, and xylene) on receptors with the highest ambient impacts. The near-field receptors in Wyoming and Montana were analyzed for annual (chronic) and 1-hour (acute) impacts. Model results for the base year (2004) and 2020 development scenarios show that impacts are predicted to be well below the acute Reference Exposure Levels, non-carcinogenic Reference Concentrations for Chronic Inhalation, and carcinogenic risk threshold for all hazardous air pollutants. The maximally exposed individual's carcinogenic risk factor due to benzene exposure is predicted to increase 50 percent as a result of projected development in the PRB; however, even with this substantial increase, the predicted risk is well below USEPA carcinogenic risk thresholds.

ES.4 COMPARISON TO ORIGINAL TASK 3A REPORT

With a few notable exceptions, the original Task 3A qualitative projections for 2020 are consistent with the findings of the current quantitative update. One important difference between this updated study and previous findings is the large increase in projected 2020 impacts due to CBNG development. While the original Task 3A study was based on preliminary Task 2 CBNG development production, this updated study used the final Task 2 projections for CBNG development, which were 15 to 30 percent greater than the earlier estimate. This increase suggests that while previously coal development was the most significant contributor to projected future year increases, based on this updated study, CBNG development may have a secondary, or even primary, contribution to air quality impacts. An additional change relative to the original Task 3A projections is the incorporation of new information on RFDs identified in the original Task 2 Report. Several coal-fired power plants had revised their permits since the original Task 2 and Task 3A reports, and expanded or reduced their power-generating capacity. Despite revisions to several of the tools used to analyze cumulative air quality, the overall findings and projected changes of this updated study generally are consistent with the original qualitative results for 2020.

Ambient impacts of PM_{10} continue to be a concern, as well as $PM_{2.5}$, at near-field locations and Class II areas located in proximity to the study area. While, generally, annual impacts are diminished relative to the original study, short-term impacts increased under some conditions. Essentially, coal mine operations and CBNG development would continue to dominate the PM_{10} impacts; the power plants would continue to dominate the SO_2 impacts (although they would continue to be below the standards); and the overall source groups would continue to contribute to NO_2 impacts, although impacts should remain below the national and state annual NO_2 standard.

Visibility impacts continue to be significant, and the predicted changes in the impact (number of days with greater than 10 percent change in extinction) for year 2010 are more than doubled in 2020 at some locations.

Based on modeling results, none of the acid deposition thresholds were exceeded at Class I areas for either the lower or upper development scenarios for 2020. However, there is a concern relating to the acid deposition into sensitive lakes. The model results showed that the increased deposition, largely from SO_2 emissions from power plants, exceeded the thresholds of significance for the ANC at two sensitive (high alpine) lakes. The results indicate that with increased growth in power plant operations, the reduced ANC of the sensitive lakes would become significant and would need to be addressed carefully for each proposed major development project.

ACRONYMS AND ABBREVIATIONS

μeq/L	micro equivalents per liter
$\mu g/m^3$	micrograms per cubic meter
ANC	acid neutralizing capacity
AQRV	air quality related values
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
BCF	billion cubic feet
BLM	Bureau of Land Management
CBNG	coal bed natural gas
DM&E	Dakota, Minnesota, and Eastern
EA	environmental assessment
EIS	environmental impact statement
FLAG	Federal Land Manager's Air Quality Guidance
FS	U.S. Department of Agriculture-Forest Service
HAPs	hazardous air pollutants
IDLH	Immediately Dangerous to Life or Health
IR	Indian Reservation
kg/ha/yr	kilogram per hectare per year
km	kilometer
LBA	lease by application
LAC	limits of acceptable change
MDEQ	Montana Department of Environmental Quality
mmtpy	million tons per year
MW	megawatt
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NP	National Park
NRA	National Recreation Area
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
PRB	Powder River Basin
PSD	Prevention of Significant Deterioration
RELs	Reference Exposure Levels
RfCs	Reference Concentrations for Chronic Inhalation
RFD	reasonably foreseeable development
SAAQS	state ambient air quality standards
SO_2	sulfur dioxide
U.S.	United States
USEPA	U.S. Environmental Protection Agency
WA	Wilderness Area
WDEQ	Wyoming Department of Environmental Quality

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The Powder River Basin (PRB) of Wyoming and Montana is a major energy development area with diverse environmental values. The PRB is the largest coal-producing region in the United States (U.S.); PRB coal is used to generate electricity both within and outside of the region. The PRB also has produced large amounts of oil and gas resources. Over the last decade, this region has experienced nationally significant development of natural gas from coal seams (coal bed natural gas [CBNG]).

BLM is required to complete a National Environmental Policy Act (NEPA) analysis (environmental impact statement [EIS] or environmental assessment [EA]) for each coal lease by application (LBA) as part of the leasing process. In the coal leasing EAs and EISs that have been prepared since the Powder River Regional Coal Team decertified the region in early 1990 (thereby allowing BLM to use the coal LBA process), cumulative impacts have been addressed in a separate section of the NEPA analyses to highlight the distinction between site-specific and cumulative impacts. With coal leasing continuing into the foreseeable future, and with impacts related to oil and gas development increasing beginning in the late 1990s due to development of coal bed natural gas (CBNG) in the PRB, BLM initiated studies and analyses to provide a consistent basis for evaluation of cumulative impacts in the coal leasing EISs. These studies and analyses included the PRB Coal Development Status Check (BLM 1996), Wyodak EIS (BLM 1999), PRB Oil and Gas EIS (BLM 2003), Montgomery Watson Harza (2003) study of PRB coal demand through 2020, and most recently, the PRB Coal Review.

Initiated in 2003, the PRB Coal Review includes the identification of current conditions (Task 1 reports), identification of reasonably foreseeable development (RFD) and future coal production scenarios (Task 2 Report), and predicted future cumulative impacts (Task 3 reports) in the PRB. All PRB Coal Review reports can be accessed from the BLM website.[1] For the air quality component of this study, the Wyoming PRB cumulative effects study area (**Figure 1-1**) comprises all of Campbell County, all of Sheridan and Johnson counties outside of the Bighorn National Forest lands to the west of the PRB, and the northern portion of Converse County. It includes all of the area administered by the Bureau of Land Management (BLM) Buffalo Field Office, a portion of the area administered by the BLM High Plains District Office, and a portion of the Thunder Basin National Grasslands, which is administered by the U.S. Department of Agriculture-Forest Service (FS). The Montana portion of the PRB cumulative effects study area for air quality (**Figure 1-1**) comprises the area of relevant coal mines including portions of Rosebud, Custer, Powder River, Big Horn, and Treasure counties. It encompasses the area administered by the BLM Miles City Field Office. State and private lands also are included in the study area.

The Task 1A Report for the PRB Coal Review, Current Air Quality Conditions (ENSR 2005a) documented the air quality impacts of operations during a base year (2002), using actual emissions and operations for that year. The base year analysis evaluated impacts both within the PRB itself and at selected sensitive areas surrounding the region. The analysis specifically looked at impacts of coal mines, power plants, CBNG development, and other activities. Results were provided for both Wyoming and Montana source groups and receptors.

[1] http://www.blm.gov/wy/st/en/programs/energy/Coal_Resources/PRB_Coal/prbdocs.html

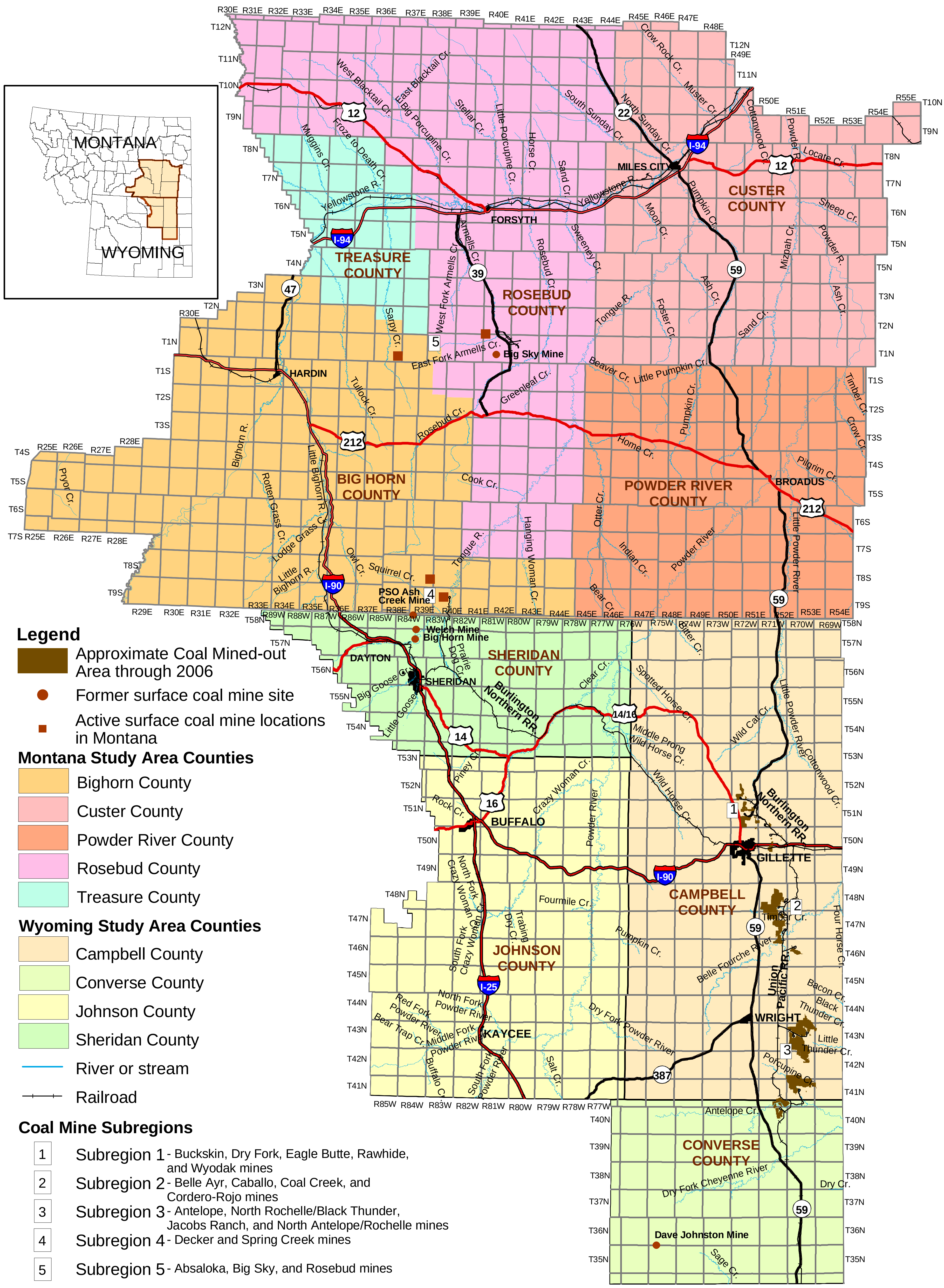
1.0 Introduction

The Task 2 component of the PRB Coal Review defined the past and present development actions in the study area that have contributed to the current environmental and socioeconomic conditions in the PRB study area. The Task 2 study also defined the projected RFD scenarios in the Wyoming and Montana PRB for years 2010, 2015, and 2020. The past and present actions were identified based on information in existing NEPA documents on file with federal and state agencies, and the Coal Development Status Check (BLM 1996). The identified RFD activities subsequently were evaluated as to their probability for occurrence. In order to account for the variables associated with future coal production, two detailed coal production scenarios (reflecting upper and lower production estimates) were projected to span the range of most likely foreseeable regional coal production levels and to provide a basis for quantification of development parameters that can be used to assess impacts. These future production levels were derived from the analysis of historic production levels and current PRB coal market forecasts, public and private information sources, and input from individual PRB coal operators; and they are summarized in the Task 2 report (ENSR 2005b). The RFD scenarios presented in the Task 2 Report provide the basis for the analysis of potential cumulative impacts in the Task 3 component of the study. The 2020 RFD scenarios from the Task 2 report were updated with current information, as applicable, and revised emissions were included in this updated analysis.

Due to the lack of detailed information for many developments beyond the next few years, the degree of uncertainty associated with the predicted developments and trends increases as the timeframe extends further into the future. As a result, the original Task 3A study (ENSR 2006) directly modeled RFD projections only for the year 2010. The original Task 3A study qualitatively evaluated cumulative air quality effects for years 2015 and 2020 based on the 2010 modeled impacts and the RFD projections from the Task 2 report. When the original Task 3A study was completed in 2006, the projected RFD activities for 2015 and 2020 had a higher level of uncertainty than is currently associated with revised projections. As the uncertainty associated with predicted developments for 2015 and 2020 decreased, it became increasingly valuable to update the original Task 3A qualitative estimates for 2015 and 2020 with a quantitative evaluation. In 2008, the cumulative air quality effects for 2015 were modeled, and the Task 3A study correspondingly was updated. The updated Task 3A report (ENSR 2008a) is referred to hereafter as the 2015 Update.[1]

This current update to the Task 3A report quantitatively updates the original Task 3A qualitative analysis of projected changes in impacts on air quality and air quality-related values (AQRVs) resulting from projected upper and lower RFD activities in 2020. This updated report is supplemental in nature and focuses exclusively on summarizing updated information and documenting any changes that have occurred since submittal of the original Task 3A Report and the 2015 Update. As the PRB Coal Review's underlying objectives and methodology have not changed since the 2015 Update report, this 2020 update to the Task 3A report does not reiterate this information, which is available in the 2015 Update (ENSR 2008a). Instead, this updated Task 3A Report details all technical changes relative to the 2015 Update report in Chapter 2.0, provides a summary of impacts for the projected 2020 scenarios in Chapter 3.0, and compares projected 2020 results to both the revised base year (2004) and to the previous qualitative projections from the original Task 3A report in Chapter 4.0.

[1] Available at http://www.blm.gov/wy/st/en/programs/energy/Coal_Resources/PRB_Coal/prbdocs.html



Note: Approximate coal mined-out areas were not available for the Montana mine sites.

Source: BLM 2009.

Powder River Basin Coal Review

Figure 1-1

Montana and Wyoming Study Area

11/09/09

1.1 Objectives

The PRB Coal Review is a regional technical study to assess cumulative impacts associated with past, present, and RFD in the PRB. The overall objectives of the PRB Coal Review have not changed from the original Task 3A Report. This current update to the Task 3A report furthers the objective of estimating the environmental impacts associated with RFD through the year 2020. The primary objective for updating the Task 3A report is to provide a quantitative evaluation of potential cumulative air quality effects for 2020.

Secondary objectives of this update are to develop the projected 2020 emissions using updated emissions from the base year (2004) and to compare the modeled impact to the previous qualitative evaluation for 2020. This objective is undertaken via a comparison of the original 2020 qualitative predictions to the quantitative evaluation performed here. Three important changes that affect the comparison of this updated report with the original Task 3A report include a new version of the dispersion model used to predict air quality and AQRVs, initiation of the dispersion model with a different meteorological year, and an improved base year emissions inventory. The 2015 Update report (ENSR 2008a) details these changes. This current update of the Task 3A report provides a summary of impacts for the projected 2020 scenarios, and compares projected 2020 results to both the revised base year (summarized in the 2015 Update report) and the qualitative projections from the original Task 3A report.

1.2 Agency Outreach, Coordination, and Review

The BLM directed the preparation of this PRB Coal Review. In order to ensure the technical credibility of the data, projections, interpretations, and conclusions of the study and ensure the study's usefulness for other agencies' needs, the BLM initiated contact with other federal and state agencies early in the study.

As part of this agency outreach and technical oversight, the BLM organized technical advisory groups. These groups were composed of agency representatives and stakeholders with technical expertise in the applicable resources. Participating agencies relative to air quality included the BLM; Wyoming Department of Environmental Quality (WDEQ); Montana Department of Environmental Quality (MDEQ); U.S. Environmental Protection Agency (USEPA); National Park Service; and FS. This technical advisory group provided comments on the original and 2008 modeling protocol (ENSR 2008b, 2005c). The 2008 modeling protocol was used for the 2015 Update and the current update for 2020; it provides additional details regarding the modeling approach and other technical details not presented in this report.

1.3 Methodology

The general methodology for updating the Task 3A report with quantitative estimates of 2020 cumulative air quality effects is unchanged relative to the original Task 3A approach used to produce quantitative estimates of 2010 cumulative effects, with the exception that Task 2 RFD projections for 2020 are the basis of the analysis rather than the projections for 2010.

1.0 Introduction

This study evaluates impacts at the same receptor groups for all of the same air quality metrics as the original Task 3A study. The evaluation of ambient air impacts includes the same pollutants (nitrogen dioxide [NO_2], sulfur dioxide [SO_2], particulate matter [PM] with an aerodynamic diameter of 10 microns or less [PM_{10}], and selected hazardous air pollutants [HAPs]), with the addition of PM with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$). Similar to the original study, the HAPs were evaluated at the near-field receptors in Montana and Wyoming, but not at the sensitive receptor areas. At the sensitive receptor areas, impacts on visibility and acid deposition also were evaluated. Like the original study, the updated study evaluates the changes in impacts for each of these fields for the projected levels of development. A comparison of the quantitative 2020 results to the qualitative 2020 projections from the original Task 3A report also is provided.

For the original Task 1A and Task 3A reports, potential impacts were modeled using meteorological data for 1996. For this current update and the previous 2015 Update to the Task 3A report, meteorological data for 2003 were used to evaluate air quality impacts in this updated study. The 2004 base year emissions inventory used for this current update is the same base year emissions inventory as was used for the 2015 Update.

For this updated Task 3A report, an updated future year emissions inventory and/or production ratios were used to estimate emissions for future year 2020. Base year emissions for most groups were increased to projected 2020 levels by a ratio that was calculated using production data for the projected development level divided by the production data for the base year. The future year scenarios then were modeled, and results were compared to base year impacts.

For this updated study, air quality impacts for the 2020 upper and lower production scenarios were modeled directly. The changes from the base year to the upper and lower development scenarios for 2020 subsequently are summarized. The summary includes a comparison of modeled ambient air quality impacts and AQRVs. The comparison includes discussion of modeled impacts relative to applicable state and federal standards and guideline values. Cumulative air quality effects predicted for 2020 also are compared to the original Task 3A qualitative results.

2.0 TECHNICAL APPROACH

2.1 Overview of Assessment Approach

The objective of the study is to evaluate impacts over a wide range of receptors centered over the PRB cumulative effects study area. The evaluation covers receptors within the PRB in both Montana and Wyoming, and it includes individual sensitive receptor groups in the region surrounding the PRB cumulative effects study area. Key aspects of the study include the selection of air emissions within the study area, the selection of a modeling system to conduct that evaluation, the selection of a receptor set (within the model system) to be used for evaluating cumulative impacts, and the selection of criteria for evaluation of impacts.

The 2020 air quality cumulative effects assessment for the PRB Coal Review, as presented in this updated Task 3A Report, evaluates the difference between modeled air quality impacts from the base year (2004) to the future year (2020) scenarios based on the projected change in emissions from the identified RFD activities. The model selected to assess cumulative air quality for both current and future conditions is the USEPA guideline model, CALPUFF. The USEPA's CALPUFF modeling system is a regulatory guideline model that was used in the original PRB Coal Review Task 3A (ENSR 2006), the 2015 Update (ENSR 2008a), and in the Montana Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006). All of these studies were directed by the BLM and have identical modeling domain and receptor grids.

This update of the Task 3A report uses an identical model setup, meteorological input data, and base year emissions inventory as was used for the 2015 Update. Detailed information regarding the development of this input information is available in the 2015 Update report (ENSR 2008a) and its corresponding Technical Support Document (ENSR 2008d).

2.2 Air Quality Modeling

The CALPUFF model is a Lagrangian puff model with the capability to simulate regional-scale, long-range dispersion as well as local-scale, short-range dispersion (Scire et al. 2000a). The model was used for the original PRB Coal Review Task 3A (ENSR 2006), the Montana Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006), and the 2015 Update Report (ENSR 2008a) to assess impacts over both near-field and far-field receptors. Since completion of the original Task 3A study (ENSR 2006), the USEPA has released a new guideline version of CALPUFF. The 2015 Update report, as well as this update to the Task 3A report, used the most recent approved version of CALPUFF. The modeling approach and technical options are identical between base year (2004) and predictive future year (previous 2015 Update and current 2020) cumulative analyses.

The CALPUFF modeling system used in this updated study has three main components:

- CALMET Version 5.8, Level 070623 (a diagnostic three-dimensional meteorological model, which develops the meteorological data for modeling input);
- CALPUFF Version 5.8, Level 070623 (the transport and dispersion model that carries out calculations of dispersion); and

- CALPOST Version 5.6394, Level 070622 (a post-processing package that is used to depict overall concentrations and impacts).

The CALPUFF modeling domain was established to be identical to that used in the PRB Oil and Gas Final EIS (BLM 2003), the original PRB Coal Review (Task 1A report [ENSR 2005a] and Task 3A report [ENSR 2006]), and the Montana Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006). The CALPUFF modeling domain, study area, and sensitive areas are shown in **Figure 2-1**. The modeling domain includes most of Wyoming and Montana, and extends into the states of Idaho, Utah, Nebraska, and North and South Dakota.

The receptor sets established for the original PRB Coal Review (Task 1A and Task 3A) are identical to the receptor sets used in this updated study. These selected receptor sets include: near-field receptors in both states, which cover the study area; receptors along boundaries and within the Class I and sensitive Class II areas identified by the technical advisory group; and other sensitive receptors, such as lakes. The locations of all receptors are shown in **Figure 2-2** and are described in detail in the original Task 3A Report (ENSR 2006), as well as the modeling protocols (ENSR 2005c, 2008b).

2.3 Meteorological Data and Analyses

The meteorological data set for 2003 was selected as the worst-case meteorological year based on an analysis of visibility impacts at the nearest Class I areas for the base year (2004). The meteorological year 2003 was used to model all impacts presented in this updated report.

2.4 Emissions Input Data

The objective of the air quality component of the PRB Coal Review, including the 2020 update for the Task 3A report, is to assess the predicted change in air quality and related impacts given a predicted change in RFD-related activities in the PRB. The key assumptions used for the update to the Task 3A report include the following:

- Where actual source characteristics (e.g., stack height, temperature, etc.) exist in provided emissions inventories, they were used. Where source characteristics were lacking, representative source characteristics generically were developed for each source type;

- A state-specific emission rate, determined by state-specific presumptive-best available control technology (BACT) levels, were applied to minor group sources (e.g., CBNG sources);

- USEPA regulations mandating future use of ultra-low sulfur fuels and future model engine emission limits were not incorporated into future year emissions due to the level of uncertainty surrounding the rate of replacement of existing engines and implementation of these regulations;

- No specific facility boundaries (for ambient air) were developed for individual sites; and

- Emissions were broadly characterized and do not represent actual short-term emission rates.

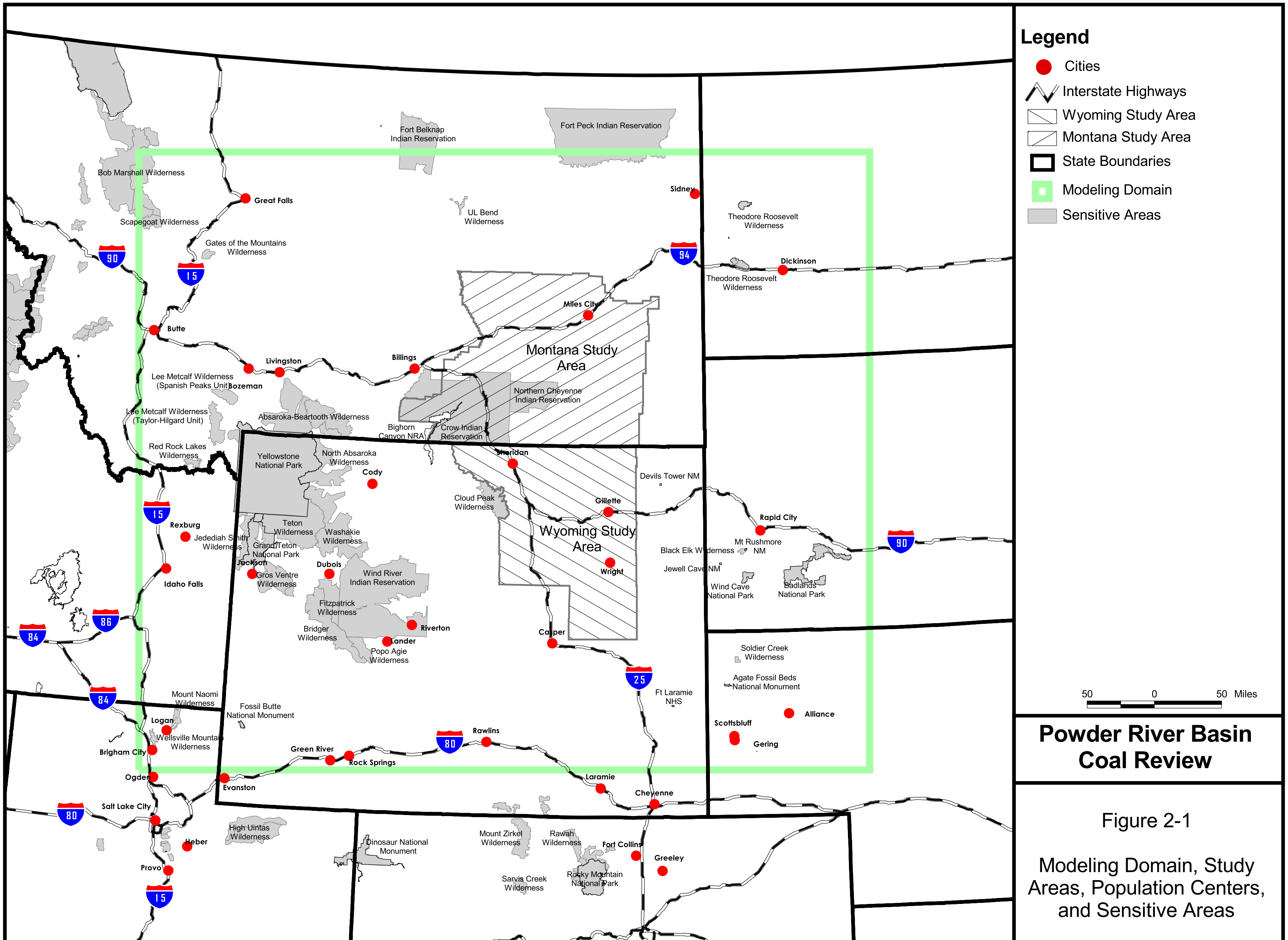


Figure 2-1

Modeling Domain, Study Areas, Population Centers, and Sensitive Areas

12/15/05

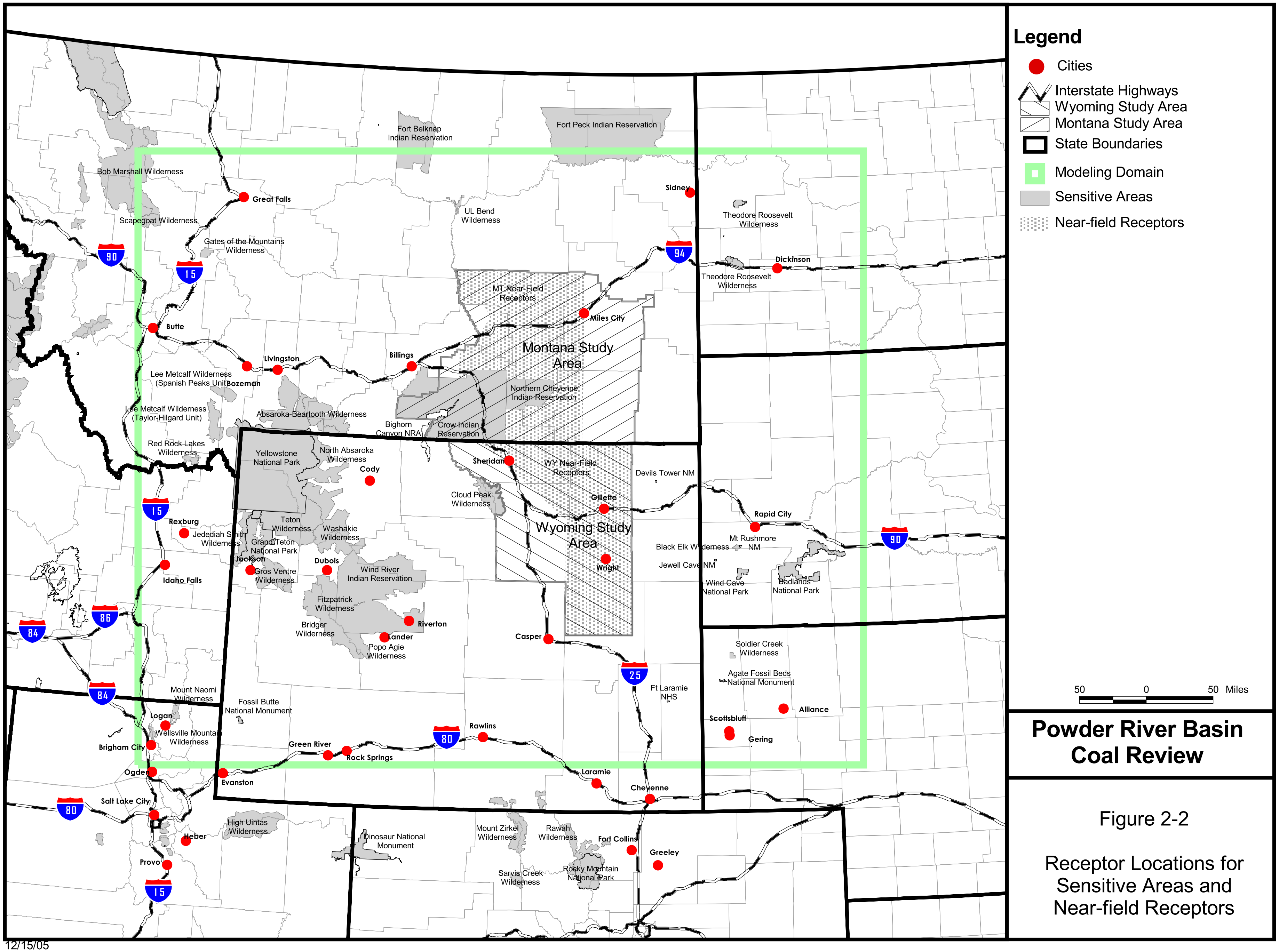


Figure 2-2

Receptor Locations for Sensitive Areas and Near-field Receptors

The emission sources were separated into various emission source groups for separate analyses. For regional modeling of this magnitude, it is not expected that a single source would dominate predicted impacts. Rather, for a more detailed understanding of projected changes in 2020, it is beneficial to compare impacts resulting from source types (e.g., CBNG, coal mining, etc.), or source locations (e.g., Montana, Wyoming, or other states). In this manner, the dominant source types or source locations can be more easily identified for future planning efforts. The emission source groups for which separate modeling results were analyzed included:

- All sources combined
- Coal production-related sources (from both states, including mines, power plants, railroads, and coal conversion facilities) (Note: the Tongue River Railroad only was included in the upper development scenario for 2020)
- Coal mines (in both states)
- Montana sources (all sources located in Montana)
- Wyoming sources (all sources located in Wyoming)
- CBNG sources (all CBNG producing sources)
- Power plants (includes coal- and gas-fired power plants in Wyoming and Montana)
- Non-coal sources (roads, urban areas, miscellaneous sources, conventional oil and gas, non-coal power plants [excludes CBNG sources]).

Current emissions from other non-coal sources, such as major roads, railroads, and urban areas, were included as separate source groups; however, it should be noted that this study only includes non-coal sources within the study area (Campbell, Johnson, Sheridan, and most of Converse counties in Wyoming; Rosebud, Custer, Powder River, Big Horn, and Treasure counties in Montana) (see **Figure 1-1**).

The 2004 emission inventory developed for the Montana Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006) was used as the revised base year emissions inventory for the current update of the cumulative air quality analysis.

Although, $PM_{2.5}$ emission rates were not uniformly available in the provided emission inventory, with the promulgation of $PM_{2.5}$ national and state ambient air quality standards (NAAQS and SAAQS, respectively), an estimate of total $PM_{2.5}$ impacts was valuable for a comprehensive evaluation of the PRB cumulative air quality effects. Therefore, total $PM_{2.5}$ impacts were indirectly estimated based on a ratio of monitored PM_{10} concentrations that were representative of impacts from sources in the region. The Lame Deer monitoring station, a site representative of the PRB study area, measures both ambient PM_{10} and $PM_{2.5}$ at a co-located site. The annual average ratio of ambient $PM_{2.5}$ to PM_{10} was calculated to be 0.35 during 2005, which is the only recent year with data recovery over 80 percent for both $PM_{2.5}$ and PM_{10}. This ratio was used to scale the modeled PM_{10} impacts to estimate $PM_{2.5}$ impacts. While evaluation of short-term $PM_{2.5}$ was limited by this technique, it is anticipated that annual $PM_{2.5}$ impacts would be appropriately representative for a region with similar sources.

Previously, the Task 2 analysis projected future year production estimates for various resources. The results summary from the Task 2 report are presented in **Table 2-1**. The changes in production were used to project emissions for the base year for this report (2004) to 2020. The methodology used to calculate emission rates for each emission source group is presented below.

Table 2-1
Emissions Calculations for 2020 by Source Group

	Production Data			Adjustment Ratio		
Source Group	**Base (2004)**	**Lower Scenario (2020)**	**Upper Scenario (2020)**	**Base (2004)**	**Lower Scenario (2020)**	**Upper Scenario (2020)**
Conventional Oil and Gas Sources	39.9 BCF	35.1 BCF	35.1 BCF	1.0	0.880	0.880
CBNG Sources	338 BCF	631 BCF	631 BCF	1.0	1.867	1.867
Coal Production (Wyoming)	363 mmtpy	495 mmtpy	576 mmtpy	1.0	1.364	1.587
Coal Hauling (Wyoming)	363 mmtpy	495 mmtpy	576 mmtpy	1.0	1.364	1.587
Coal Production (Montana)	36.1 mmtpy	56 mmtpy	83 mmtpy	1.0	1.551	2.299
Power Plants	Individual Plant Adjustments					
Urban Areas	No Adjustment					
Miscellaneous	No Adjustment					

Note: BCF = billion cubic feet
mmtpy = million tons per year

Coal Production-related Sources

For coal production-related sources, which included mines, power plants (discussed separately below), railroads, and coal conversion sources, 2004 data were used to establish representative base year conditions. Two coal development scenarios were analyzed to estimate emissions rates for the future year, a lower production scenario and an upper production scenario. The projected increase in coal production under the lower and upper production scenarios were used to scale the base year emissions to the future year emissions, as a ratio of the base year production to the projected production.

As shown in **Table 2-1**, different lower production and upper production values were applied to sources in Wyoming and Montana. The lower and upper coal production values for Wyoming are presented in Tables A-1 and A-2 of the Task 2 report (ENSR 2005b), and the lower and upper coal production values for Montana are presented in Tables A-3 and A-4 of the Task 2 report.

Several RFD coal production-related sources were identified for future year 2020 as part of the Task 2 report (ENSR 2005b). These sources were not operational during the base year (2004) and, therefore, were not included in the base year emissions inventory. An emissions inventory for these RFD sources was developed and incorporated into the 2020 modeling for this updated Task 3A report. RFD coal production-related sources include: new coal mines, new rail lines to transport the coal, coal conversion facilities, and coal-fired power plants (new power plants are described in the power plant section of this chapter).

Three RFD mines were included in the emissions inventory for this 2020 analysis. The Otter Creek Mine and Kinsey Mine in Montana are projected to be developed under the upper 2020 development scenario, but not under the lower development scenario. Figures A-3 and A-4 of the Task 2 report show the projected locations of these mines. The School Creek Mine (a newly identified RFD mine) is projected to be developed in the Subregion 3 coal mine area near Wright, Wyoming. The School Creek Mine was included in both the upper and lower development scenarios. Per information provided by the BLM (2009) the RFD estimated 2020 coal production from the Wyoming mines (**Table 2-1**) would not change as a result of the School Creek Mine development; rather the projected coal production from this new RFD mine would be offset by reduced production at the existing mines in Subregion 3. Therefore, the total coal mining emissions are consistent with Task 2 2020 projections; however, the spatial distribution of emissions differs slightly from the base year due the addition of these three new production areas.

Per the Task 2 report, it was projected that the Tongue River Railroad would not be constructed under the lower 2010 production scenario; however, it was included in the upper 2010 production scenario. This same approach was used in this updated analysis for 2020. Construction of this railroad under the upper production scenario would be dependent on development of the Otter Creek Mine in Montana. The analysis in the Draft Supplemental EIS for the Tongue River Railroad (Surface Transportation Board 2004) concluded that air quality-related impacts from railroad operations would not adversely affect the Northern Cheyenne Indian Reservation (IR).

Emissions from the proposed Dakota, Minnesota, and Eastern (DM&E) rail line expansion into the PRB were not included in the base year. Per the Task 2 Report, it was projected that this railroad would not be operational until 2015. Emissions from the DM&E were included in the upper and lower production scenarios for the 2015 Update and this current update for 2020. Only the portion of the DM&E expansion line located in the PRB study area was included in this updated analysis. Emissions were based on information presented in the Draft EIS (Surface Transportation Board 2000) for the proposed rail line.

Several existing rail lines are projected to increase their capacity in Wyoming by 2020. The increase in emissions associated with expanded carrying capacity is modeled using the scaling factor for coal hauling activities shown in **Table 2-1**. It is expected that there would be no change in the spatial location of these existing rail lines.

Two RFD coal conversion facilities are projected to be developed by 2020 based on the update of the Task 2 report (AECOM 2009). One coal to liquid plant (CTL) would be developed in Wyoming, and another coal conversion plant would be built in Montana. In the absence of additional information, the modeled emissions and release parameters were developed based on the North Rochelle CTL plant permit. Both coal production-related RFD sources were included in upper and lower development modeling as part of the “coal-related” source group (not listed in **Table 2-1**).

<u>CBNG Sources</u>

CBNG activity was evaluated separately from conventional oil and gas production for this study. Conventional oil and gas impacts were included in non-coal sources (see below). For CBNG sources, 2004 base year emissions data were scaled based on projected increases in production. The projected increase in CBNG production was based on the ratio of base year gas production to projected gas production, as presented in the Task 2 report (ENSR 2005b) and shown in **Table 2-1**.

It is projected that the spatial distribution of CBNG wells in the Wyoming PRB would change between the base year and 2020. For this updated Task 3A report, a new spatial distribution of wells was modeled for Wyoming CBNG sources. Similar to the CBNG emissions inventory for the base year in the original Task 3A report and the 2015 Update, well locations were gridded, and emissions from all wells within a single cell were modeled at the center point of the cell. This approach produces conservative results as the emissions are more spatially concentrated.

Other Non-coal Sources

Other non-coal sources included conventional oil and gas production, for which projected emissions increases were based on data developed from expected increases in conventional oil and gas activity. For other sources (urban areas, non-coal highways, and miscellaneous sources), there was no adjustment to the emission rates from the base year. For all non-coal sources, the same emission rates were used for both the lower and upper production scenarios. Many of these source emissions were developed from the original PRB Coal Review 2002 source emissions data base.

Power Plant Sources

Emissions from existing power plants in the study area, and the Dave Johnson Power Plant located outside of but adjacent to the study area, are included in the base year. For existing coal-fired power plant sources that were operational in the base year, a scaling factor was used to increase the capacity of these sources from an 88 percent capacity factor in the base year to a 90 percent capacity factor in both future year scenarios to account for a potential increase in capacity. There were no projected increases in emissions for gas-fired power plants.

For coal-fired power plants, the projected emission rates for power plants that were not operational in the base year but were projected to be operational in future years were derived from the actual power plant permit application or the power plant permit from the specified facility. This information provides for a conservative estimate since permitted emission rates are the maximum allowable emission rates. Actual emission rates from RFD power plants could be less than the allowable emissions. Where stack parameters were available, those data were used for input into the model. Emissions of NO_X, SO_2, and PM_{10} from the power plant permits were based on expected levels with BACT that would be applied to those sources. Where a coal-fired power plant permit application or permit was not available, emissions from a coal-fired power plant of equivalent size were used to estimate future year emissions. The RFD coal-fired power plants for which emissions were estimated include the following:

- WYGEN 2 and 3
- Two Elk Unit 1 and 2
- Dry Fork (also known as Basin Electric/Gillette)
- Hardin Generating Station
- Otter Creek Power Plant
- One additional 700-kilowatt of energy production (2020 upper production development scenario only)

These coal-fired power plants were included as individual sources, in addition to the existing coal-fired facilities that also were analyzed.

Projected RFDs previously identified in the Task 2 Report (ENSR 2005b) were re-evaluated as part of the 2015 Update, and updated information was incorporated into the 2015 Update report. No changes to RFD power plants were identified since the 2015 Update, with the exception of adding two RFD power plants: Otter Creek and an additional power plant in Wyoming.

3.0 PREDICTED CUMULATIVE AIR IMPACTS

3.1 Modeled Cumulative Impacts 2020

Using the model and source groups discussed in Chapter 2.0, the modeling effort determined impacts of each of the source groups on each of the receptor groups for the 2020 lower and upper production scenarios.

A summary of the key findings for each of the air quality components is provided in **Table 3-1**. The detailed analyses for each of the components are provided in this chapter. In general, the results of this modeling study support the findings presented in the Task 1A, original Task 3A, and 2015 Update reports, and extend the impacts that had been identified in those studies.

Table 3-1
Summary of Modeled Air Quality Impacts

Air Quality Metric		Base Year Impacts	Year 2020 Impacts
Concentrations	Criteria	Impacts are below NAAQS and SAAQS, except short-term PM_{10} and $PM_{2.5}$ in the near-field	Short-term and annual $PM_{2.5}$ and short-term PM_{10} are above applicable NAAQS and SAAQS at localized points.
	HAPs	Less than the RELs and RfCs for all HAPs	Less than the RELs and RfCs for all HAPs
Visibility	Far-field	Northern Cheyenne IR, Badlands NP, Wind Cave NP, and several Class II areas have more than 200 days with greater than 10 percent change in visibility	The observed spatial extent of visibility impacts increases with development. The number of days with greater than a 10 percent change in visibility increases by 0 to 60 days per year.
Atmospheric Deposition-Sulfur	level of concern	Below 5 kilograms per hectare per year (kg/ha/yr)	Below 5 kg/ha/yr
Atmospheric Deposition-Nitrogen	level of concern	Below 1.5 kg/ha/yr	Below 1.5 kg/ha/yr
Atmospheric Deposition-Lake Chemistry	ANC	Impacts above threshold values at one lake	Development increases impacts above the LAC[2] for one lake

[1]Nitrogen and sulfur deposition thresholds are published in Fox et al. (1989). The FS does not consider these values to be sufficiently protective of all areas and are currently in the process of revising these. The new nitrogen level of concern is 1.5 kg/ha/yr based on a study by Baron (2006). All predicted nitrogen deposition values are below the 1.5 kg/ha/yr level of concern.

[2]LAC refers to a 10 percent change in ANC for lakes with an ANC of 25 micro equivalents per liter (µeq/L) or more, or a threshold of 1 µeq/L for lakes with less than 25 µeq/L ANC.

Note: SAAQS = State Ambient Air Quality Standards
ANC = acid neutralizing capacity
LAC = limits of acceptable change
NAAQS = National Ambient Air Quality Standards
RELs = Reference Exposure Levels
RfCs = Reference Concentration for Chronic Inhalation
IR = Indian Reservation

It is important to note that the effects of Best Available Retrofit Technology (BART) implementation were not incorporated into the presented results, since the states are still developing their implementation plan. BART implementation primarily will target emission reductions of NO_x and SO_2, precursors to particulates most involved in visibility reduction. It is anticipated that the modeled air quality effects summarized as part of this report likely would be reduced as a result of BART regulations; however, the level of reduction cannot be determined at this time.

3.1.1 Impacts on Ambient Air Quality

Using the receptor grids identified in Chapter 2.0 along with the source groupings, the model was used to predict the impacts at each receptor point in the receptor grid. For this analysis, the results are provided for the maximum receptor in each group, which may not be the same receptor in each of the modeling scenarios. Impacts may occur at different receptors for each of the modeling scenarios, but changes in location of the maximum receptors are not identified in these results. The Technical Support Document (TSD) (ENSR 2008d) contains plots of predicted concentrations for near-field receptors.

The analysis does not separate the sources into Prevention of Significant Deterioration (PSD) increment-consuming and non-PSD increment-consuming sources. Therefore, the results cannot be used to develop a pattern of increment consumption for a particular site. The PSD increment level comparisons are for informational purposes only and do not constitute a regulatory PSD increment level consumption analysis, which would be required for evaluating larger projects by air permitting authorities.

The model results also are limited by certain assumptions regarding sources and receptors. The source characterizations are based on available data, and do not represent specific stacks or sources of fugitive emissions. The modeling sources generally are provided by area or volume, to represent multiple sources within each specified facility. The specific fence lines or exclusion areas around a modeled source also are not identified in this study. The results cannot, therefore, be interpreted as evaluating maximum impacts that might occur at the boundary or fence line of a specific source. The receptors in the near-field grid in both states were removed from modeling if their location was within 1 kilometer (km) of any source. There were several Wyoming near-field receptors located less than 1 km from modeled CBNG source locations. Results from these receptors were not included in summary tables or plots. Removal of these receptors ensured that results were representative of the broad area in the PRB study area, rather than unduly affected by a specific source. However, there are still receptors with high impacts due to a single source-receptor relationship.

Additional assumptions were made to aid in the interpretation of ambient impacts. Generally, only NO_x emission rates, and not NO_2, were provided in the emission inventory. Therefore, the maximum NO_2 impacts are assumed to be 75 percent of the maximum NO_x impacts, a standard USEPA approved method (40 Code of Federal Regulations 51, Appendix W). As was discussed in Chapter 2.0, $PM_{2.5}$ emission rates were not available in the emissions inventory as $PM_{2.5}$; instead, $PM_{2.5}$ impacts were estimated based on modeled PM_{10} emissions scaled by an annual-average ratio of ambient $PM_{2.5}$ to PM_{10}. While evaluation of short-term $PM_{2.5}$ is limited by this technique, it is anticipated that the overall magnitude of annual $PM_{2.5}$ impacts is approximately representative for a region with similar sources.

All ambient air quality impacts presented in this report generally are consistent with the definition of the standard. The annual impacts are the maximum value (first highest) for each area. Reported air quality impacts for 3-hour and 24-hour averaging periods are highest second high value at each receptor. The maximum (first highest) 1-hour impacts are reported for receptors within the state of Montana.

Ambient air quality results for specific receptor groups are presented in a series of bar graphs as discussed in Section 3.1.1.1. The graphs show each source group's maximum impacts for the base year (2004) and the 2020 upper and lower production scenarios. Data are provided for each ambient standard and PSD increment level for NO_2, SO_2, and PM_{10}, and the ambient standard for $PM_{2.5}$. It is important to note that the location of the maximum impact that results from one source group is not necessarily the same location as the maximum impact for another source group. Additionally emissions sources are aggregated into multiple source groups (e.g. coal-fired power plants are included in two source groups: power plants, and coal-related sources); therefore, the results for each source group are not additive.

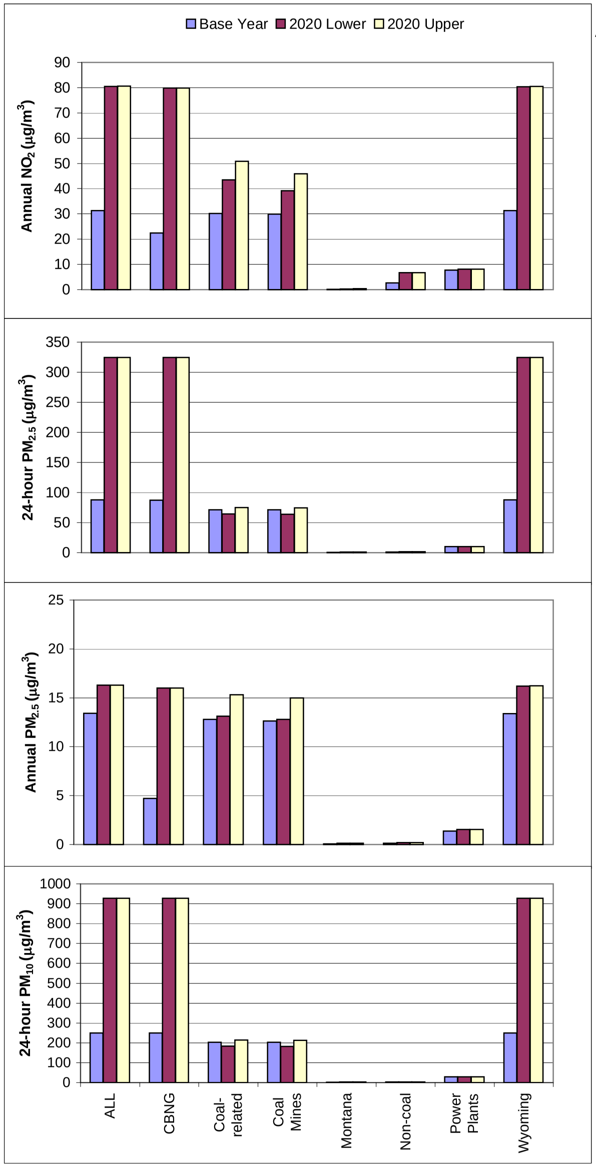
3.1.1.1 Impacts at Near-field Receptors in Wyoming

Results for the near-field receptor grid for Wyoming are presented in **Figure 3-1**. The maximum modeled impacts on Wyoming near-field receptors that result from each individual source group are identified in the figure. Based on modeling results for PM_{10}, in Wyoming, the maximum 24-hour PM_{10} and $PM_{2.5}$ impacts are predicted to exceed the NAAQS (150 micrograms per cubic meter [$\mu g/m^3$] and 35 $\mu g/m^3$, respectively) for the base year as well as for both of the 2020 scenarios, primarily as a result of CBNG operations and coal mining activities. The combined impacts from all sources for the 2020 upper production scenario are predicted to be nearly four times the standard for PM_{10} and six times the standard for $PM_{2.5}$. NO_2 and SO_2 impacts are all below their respective standards. **Figure 3-2** provides a spatial depiction of the 24-hour PM_{10} impacts at the near-field receptors from all sources. For the 2020 upper production scenario, the modeled impacts are above 150 $\mu g/m^3$ for several areas surrounding coal mines and CBNG activities in the Wyoming PRB. It is assumed that the level and spatial extent of the modeled exceedances are an over-prediction since future locations of activities are roughly estimated. The approach used in this analysis scaled base year emissions based on projected 2020 production levels at aggregated well locations, which produces conservatively high impacts. The location of maximum modeled impacts and spatial pattern of the 24-hour $PM_{2.5}$ impacts for the 2020 upper production scenario are very similar to PM_{10}, as shown in **Figure 3-3**. The only substantial difference is that the small areas in **Figure 3-2** with predicted SAAQS exceedances are somewhat larger for $PM_{2.5}$. A large portion of the short-term impacts for all scenarios are associated with CBNG sources.

Figure 3-4 shows the modeled extent of the annual $PM_{2.5}$ impacts for the 2020 upper production scenario for all sources. This is similar to the spatial pattern depicted in **Figure 3-3**, except the maximum impacts are slightly above SAAQS, and maximum values are limited in their spatial extent. For the 2020 production scenarios, the modeled impacts of the annual $PM_{2.5}$ levels would be above the Wyoming and national standard (15 $\mu g/m^3$) at the maximum receptor in Wyoming. The annual PM_{10} spatial pattern is similar to the spatial pattern shown for annual $PM_{2.5}$; however, maximum impacts are predicted to be below SAAQS.

The modeled base year impacts of NO_2 generally were about one-third of the annual standard, increasing to approximately three-quarters of the annual standard under the upper production scenario. The CBNG operations are predicted to be the largest contributor to the maximum NO_2 impacts with a secondary contribution from coal-mining activities. The combined Wyoming sources

Figure 3-1
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at Wyoming Near-field Receptors



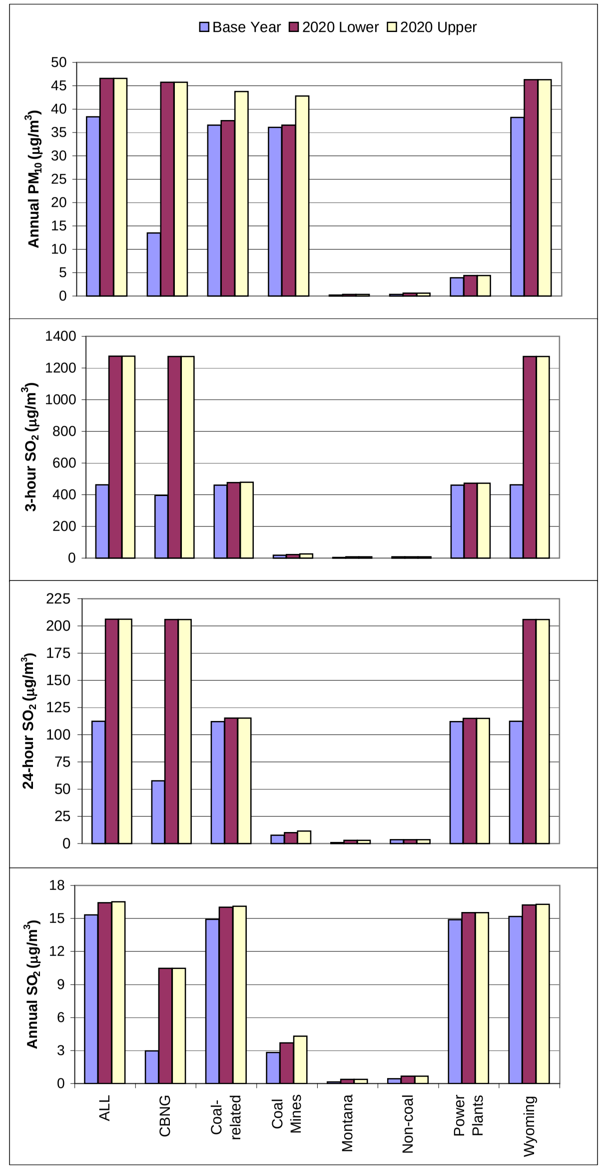
Applicable Standards/ PSD Increments (µg/m^3)

NAAQS: 100
PSD: 25

NAAQS: 35

NAAQS: 15

NAAQS: 150
PSD: 30



Applicable Standards/ PSD Increments (µg/m^3)

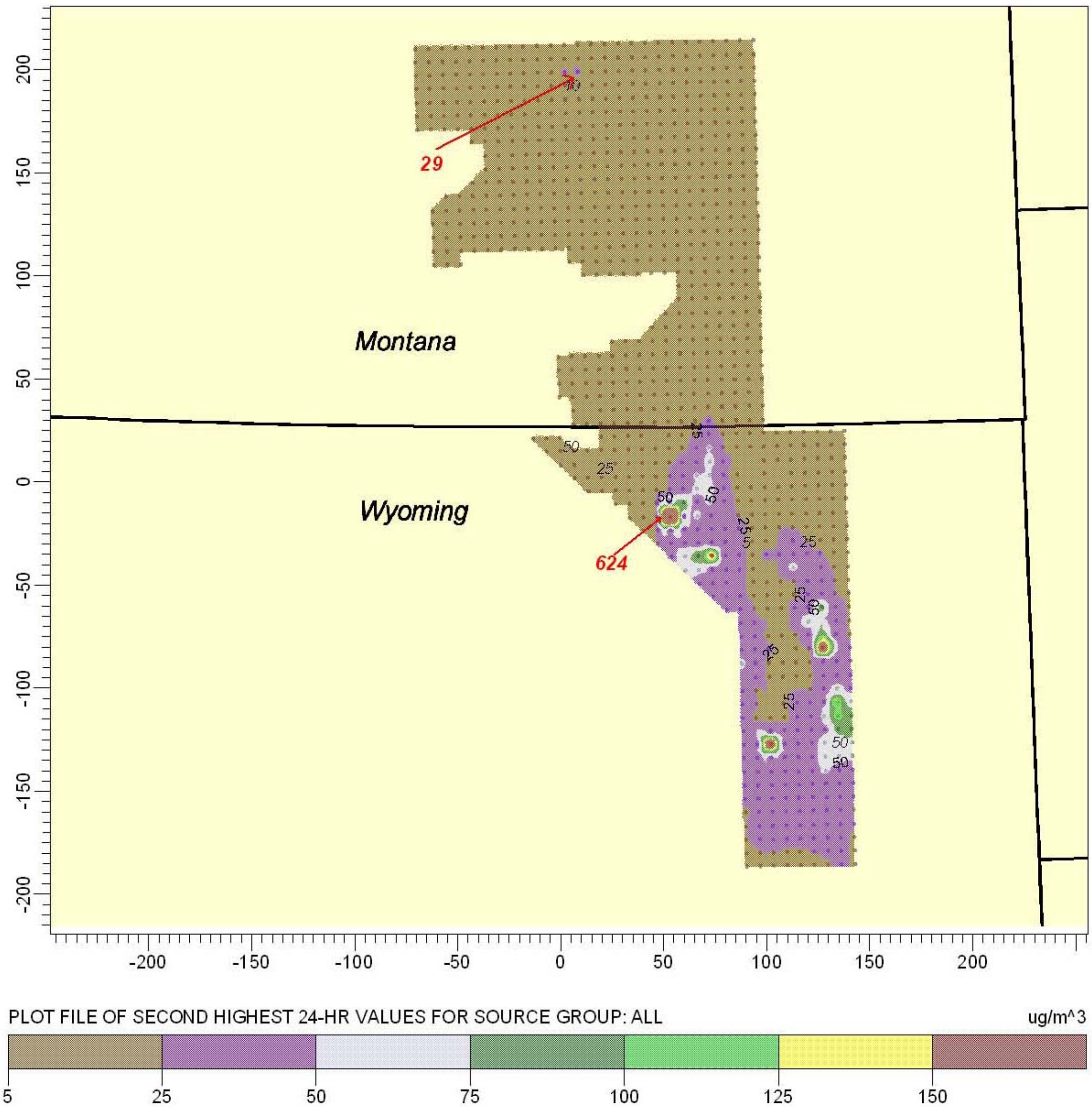
PSD: 17
Wyoming SAAQS: 50

NAAQS: 1,300
PSD: 512

NAAQS: 365
PSD: 91
Wyoming SAAQS: 260

NAAQS: 80
PSD: 20
Wyoming SAAQS: 60

Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario



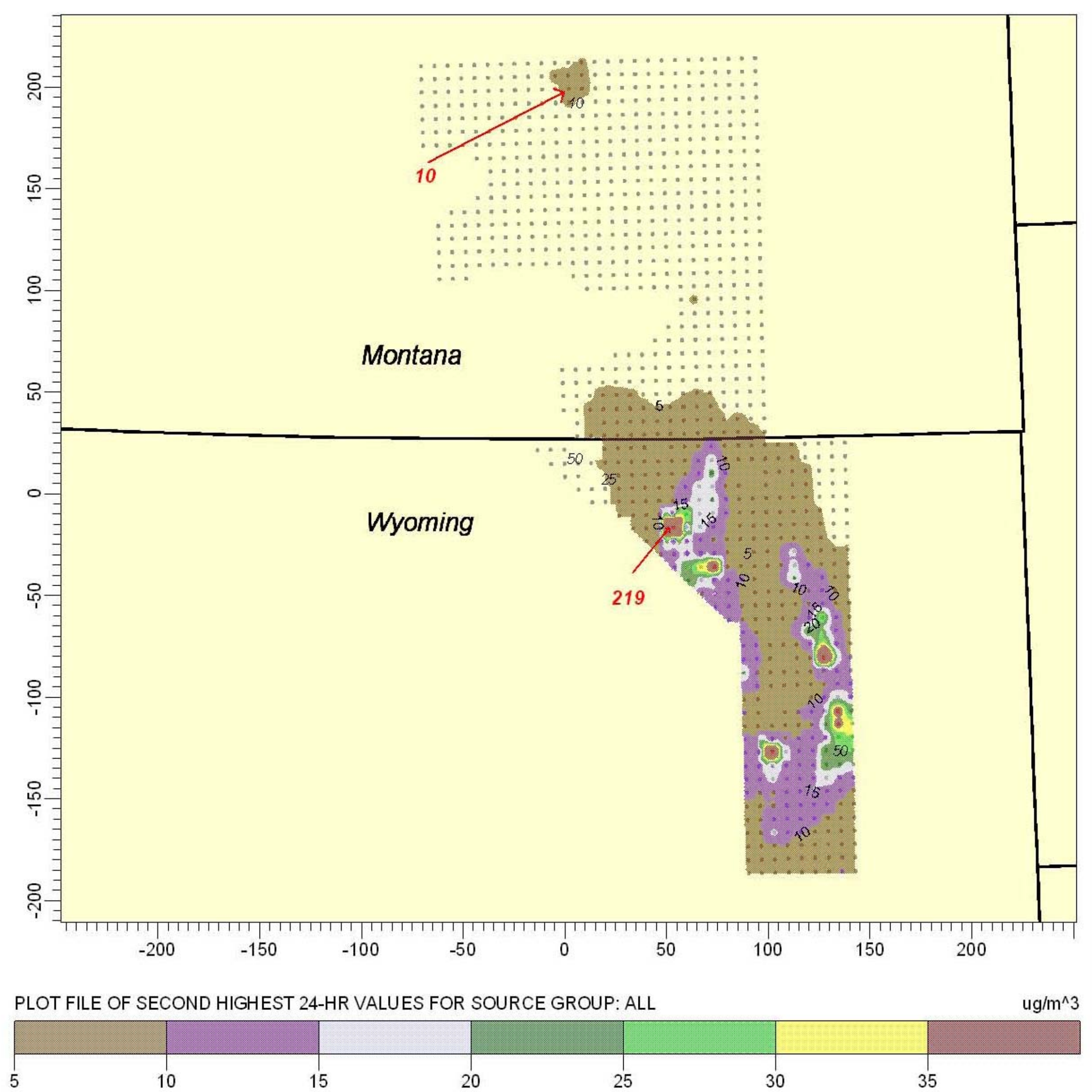
Powder River Basin Coal Review

Figure 3-2

24 Hour PM_{10} Concentrations for Near-field Receptors - 2020 Upper Production Scenario

Note: Includes all sources.

08/20/09



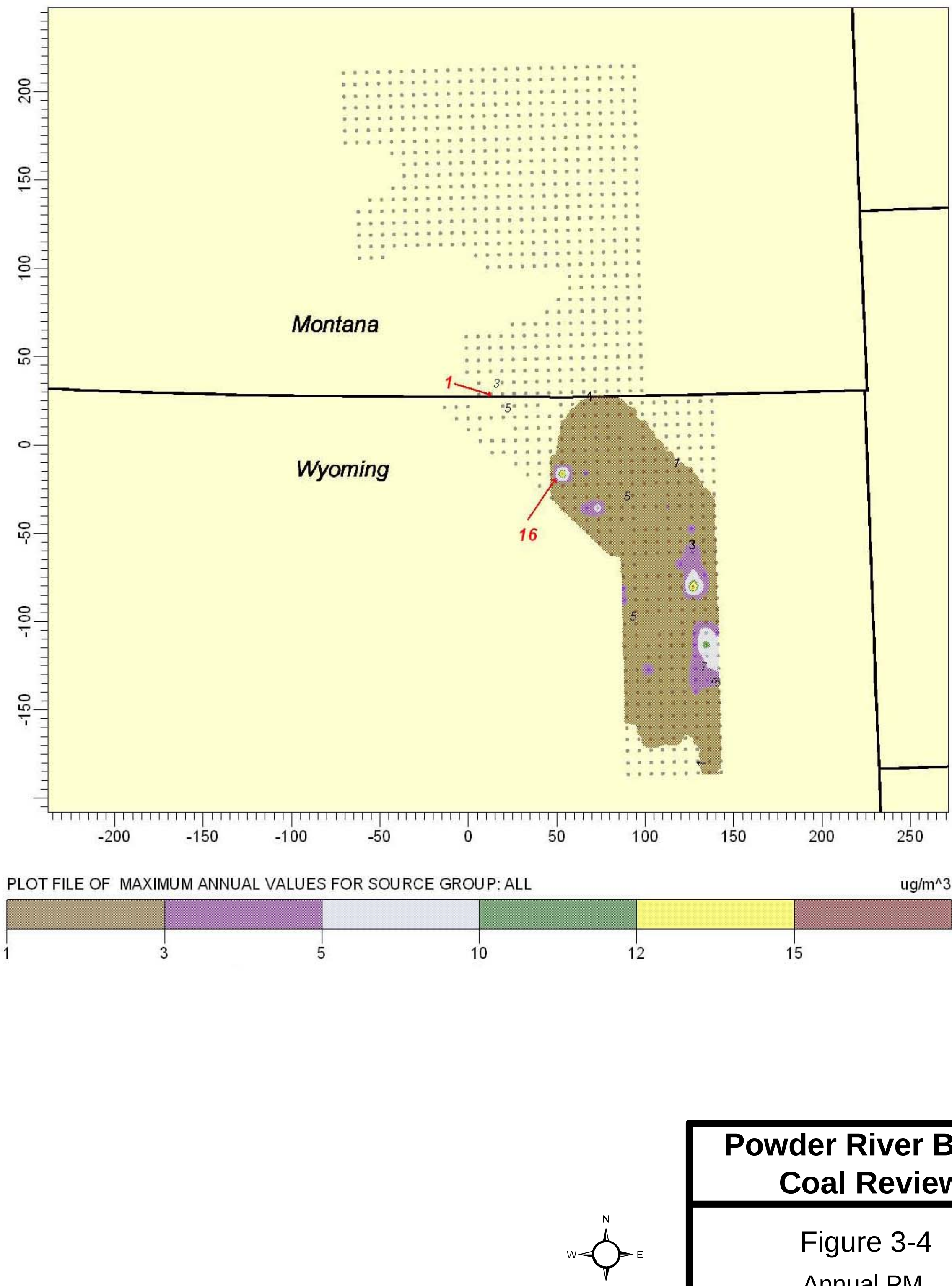
Note: Includes all sources.

Powder River Basin Coal Review

Figure 3-3

24 Hour $PM_{2.5}$ Concentrations for Near-field Receptors - 2020 Upper Production Scenario

08/20/09



Note: Includes all sources.

Powder River Basin Coal Review

Figure 3-4

Annual $PM_{2.5}$ Concentrations for Near-field Receptors - 2020 Upper Production Scenario

08/20/09

would be responsible for virtually all of the NO_2 impacts in Wyoming. While modeled NO_2 concentrations are above the PSD increment levels at the maximum receptor in Wyoming, the result is not a direct evaluation of PSD increment consumption. The regulatory agency has the authority and responsibility to determine if an exceedance or violation has occurred.

The modeled impacts of SO_2 emissions are below the ambient standards for the 3-hour and 24-hour averaging periods for both the upper and lower development scenarios and are well below the annual standards. Modeled impacts are above the PSD Class II increment levels for short-term periods. Generally, it appears that the 3-hour and 24-hour impacts for all scenarios are associated with CBNG sources, while the annual impacts are associated with coal-fired power plant emissions. Based on the modeling results, coal mining would not contribute substantially to SO_2 impacts. The 3-hour SO_2 impacts are predicted to increase by up to a factor of 2 relative to the base year, and 24-hour impacts are predicted to increase by 25 percent as a result of CBNG activities affecting the short-term impacts. Annual impacts have only moderate increases (7 to 8 percent) relative to the base year.

3.1.1.2 Impacts at Near-field Receptors in Montana

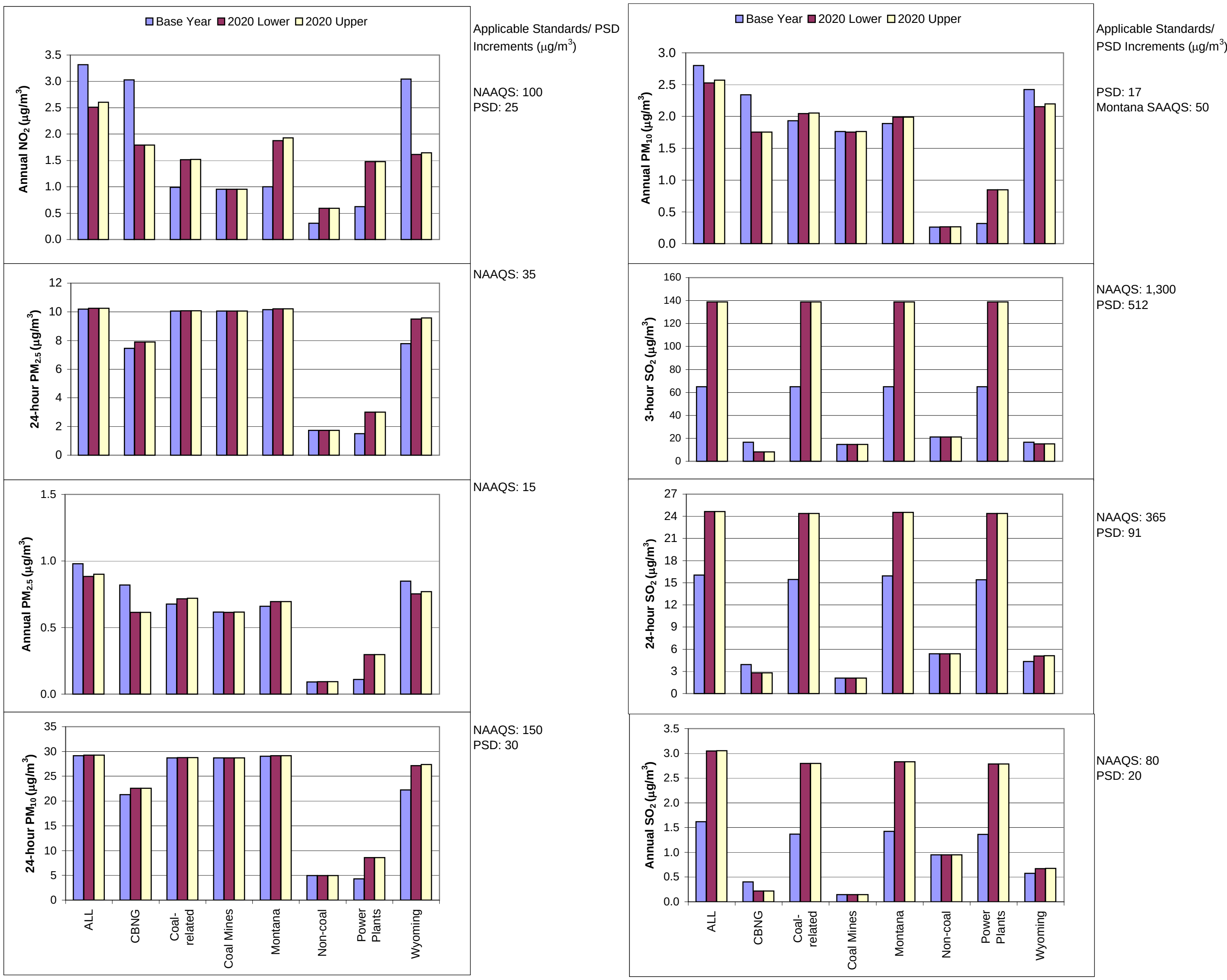
Figure 3-5 provides a similar analysis for near-field receptors in Montana, providing the maximum modeled impact for each source group as well as the total predicted maximum. The modeled impacts and a comparison to the 1-hour Montana standards for SO_2 and NO_2 are provided in **Figure 3-6**. Projected impacts are all well below the state and national standards. Notably, future year impacts of NO_2, PM_{10}, and $PM_{2.5}$ are predicted to either remain similar to the base year or decrease. Reductions in impacts are due to the anticipated southerly progression of Wyoming CBNG wells, which previously were impacting areas in Montana.

As shown in **Figures 3-2, 3-3**, and **3-4**, the modeled PM_{10} and $PM_{2.5}$ impacts in the Montana near-field are substantially less than those modeled for the Wyoming near-field. The annual and 24-hour impacts of PM_{10} and $PM_{2.5}$ emissions remained below applicable standards and the PSD increments, except for the 24-hour PM_{10} impacts, which remain just below the PSD increment in future year scenarios. No formal increment consumption analysis was completed; therefore, this comparison is not a valid PSD increment consumption evaluation.

Based on the modeling results, the annual and 1-hour NO_2 impacts in Montana would be well below the ambient standard. This is a marked improvement in the 1-hour NO_2 impacts relative to the projected impacts for 2015, where it was predicted that the 1-hour NO_2 standard would be exceeded under the 2015 upper and lower development scenarios. The modeling for 2020 suggests that as Wyoming CBNG wells move southward, short-term 1-hour NO_2 impacts in Montana would remain below the standard. The primary contributor to the maximum short-term NO_2 impacts appear to be due to projected increases in Montana CBNG production. An acceptable adjustment of 0.75 was used to convert the NO_x emissions to NO_2 impacts.

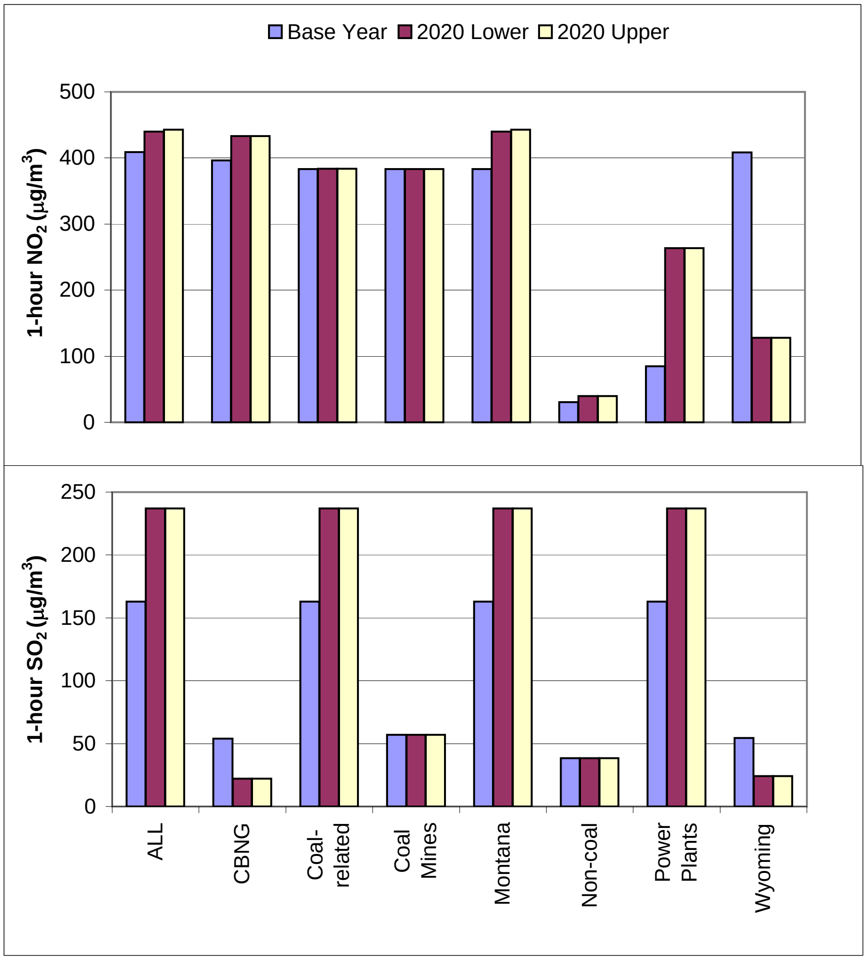
Based on the modeling, the SO_2 impacts in Montana would be well below the applicable standards and PSD increment levels. The projected maximum impacts from SO_2 emissions are attributable to emissions from Montana coal-fired power plant sources. The modeled impacts showed that increases of SO_2 impacts are predicted to approximately double for all averaging periods, resulting largely from additional coal-fired power plants.

Figure 3-5
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at Montana Near-field Receptors



Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

Figure 3-6
Change in Modeled Concentrations of 1-hour NO_2 and SO_2
at Montana Near-field Receptors



Applicable Standards/
Montana Standards ($\mu g/m^3$)

Montana SAAQS: 564

Montana SAAQS: 1,300

Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

3.1.2 Air Quality Impacts at Class I Area Receptors

As discussed in Chapter 2.0, the impacts at Class I areas also were modeled, with separate assessments for each Class I receptor group. The modeled impacts were all well below the ambient standards for all air pollutants. For comparison only, the 24-hour PM_{10} impacts were above the Class I PSD increment levels for the base and future year scenarios at the Northern Cheyenne Indian Reservation (IR), Badlands NP, and Wind Cave NP. The Class I areas with the highest SO_2 impacts were Theodore Roosevelt NP, the Northern Cheyenne IR, and Fort Peck IR. The majority of the SO_2 impacts in Theodore Roosevelt NP and Fort Peck IR occur in the base year and are not indicative of growth in the PRB region.

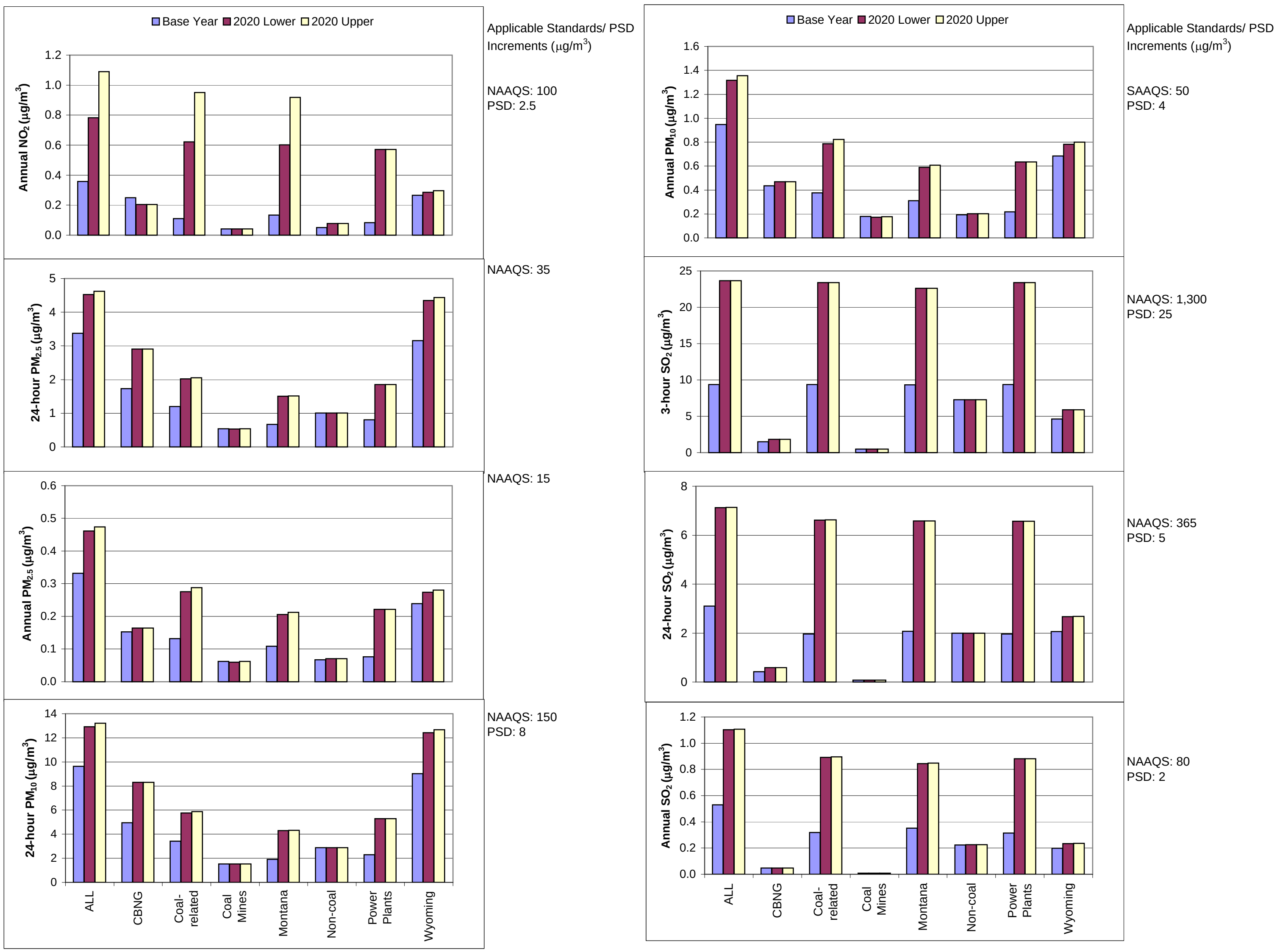
The results for the Northern Cheyenne IR are provided in **Figure 3-7**. The modeled impacts were all well below the ambient standards and the PSD increments for all air pollutants, except the projected impacts are above the 24-hour PM_{10} and SO_2 increment levels. For comparison only, the 24-hour PM_{10} impacts were above the Class I PSD increments for the base year and future year scenarios. The 24-hour PM_{10} impacts are predicted to increase by up to 40 percent from the base year to the future year scenarios, primarily as a result of increases in Wyoming sources (predominantly CBNG development). For comparison only, the 24-hour SO_2 impacts were above the Class I PSD increment levels, primarily as a result of additional coal-fired power plants in Montana. All other SO_2 and NO_2 impacts are less than 5 percent of the national and state standards.

Two additional Class I areas also were analyzed, including Badlands NP (**Figure 3-8**) and Wind Cave NP (**Figure 3-9**). These areas show modeled impacts above the comparative Class I PSD increment levels for 24-hour PM_{10} for the future year development scenarios. The PM_{10} impacts at the Badlands NP are slightly over comparative 24-hour Class I PSD increment but remain below 25 percent of the annual standard. The base year (2004) 24-hour PM_{10} impact at Wind Cave NP was 10.8 $\mu g/m^3$, and the upper production scenario was 13.3 $\mu g/m^3$, versus a Class I PSD increment level of 8 $\mu g/m^3$. For both areas, all modeled SO_2 and NO_2 impacts are near or less than 1 percent of the ambient standards, and also are below their comparative PSD increment levels. The 24-hour SO_2 combined impacts are between 80 to 95 percent of the comparable PSD increments.

The predicted 24-hour SO_2 impacts at Theodore Roosevelt NP and Fort Peck IR, and the 3-hour SO_2 impacts at Theodore Roosevelt NP; exceeded the Class I PSD increments; these predicted exceedances are due to sources outside of the PRB study area. The predicted 24-hour SO_2 impacts exceed the Class I PSD increments at Northern Cheyenne IR due to the addition of coal-fired power plants in Montana. The maximum modeled impacts are less than 5 percent of the national and state standards for all pollutants at Theodore Roosevelt NP, the Northern Cheyenne IR, and Fort Peck IR.

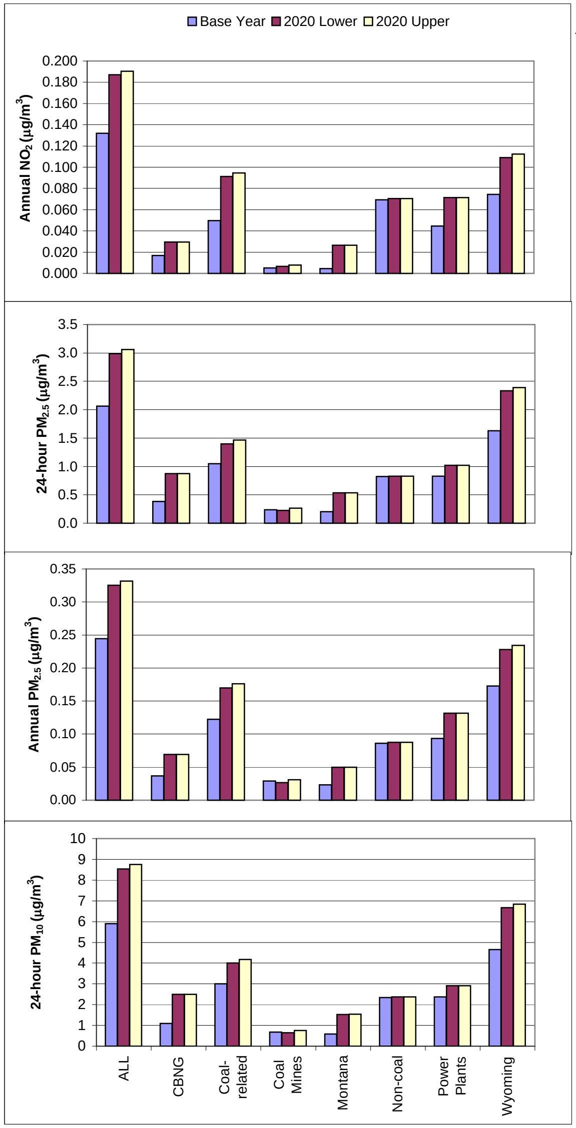
These impact data are provided for comparison only; PSD increment-consuming sources were not specifically evaluated.

Figure 3-7
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at Northern Cheyenne IR



Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

Figure 3-8
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$
at Badlands NP



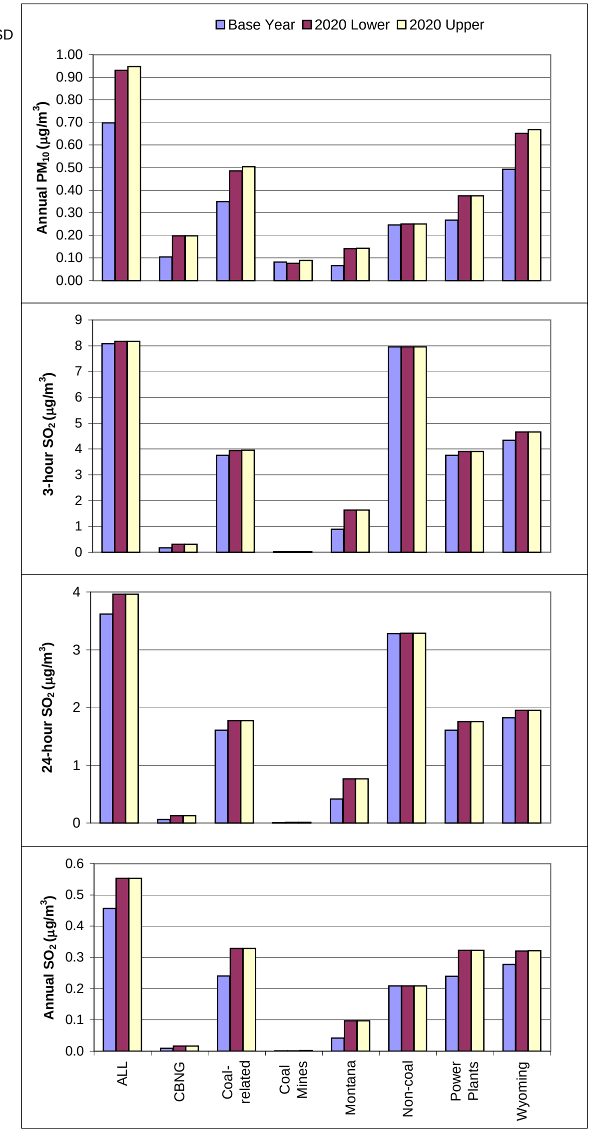
Applicable Standards/ PSD Increments (µg/m³)

NAAQS: 100
PSD: 2.5

NAAQS: 35

NAAQS: 15

NAAQS: 150
PSD: 8



Applicable Standards/ PSD Increments (µg/m³)

SAAQS: 50
PSD: 4

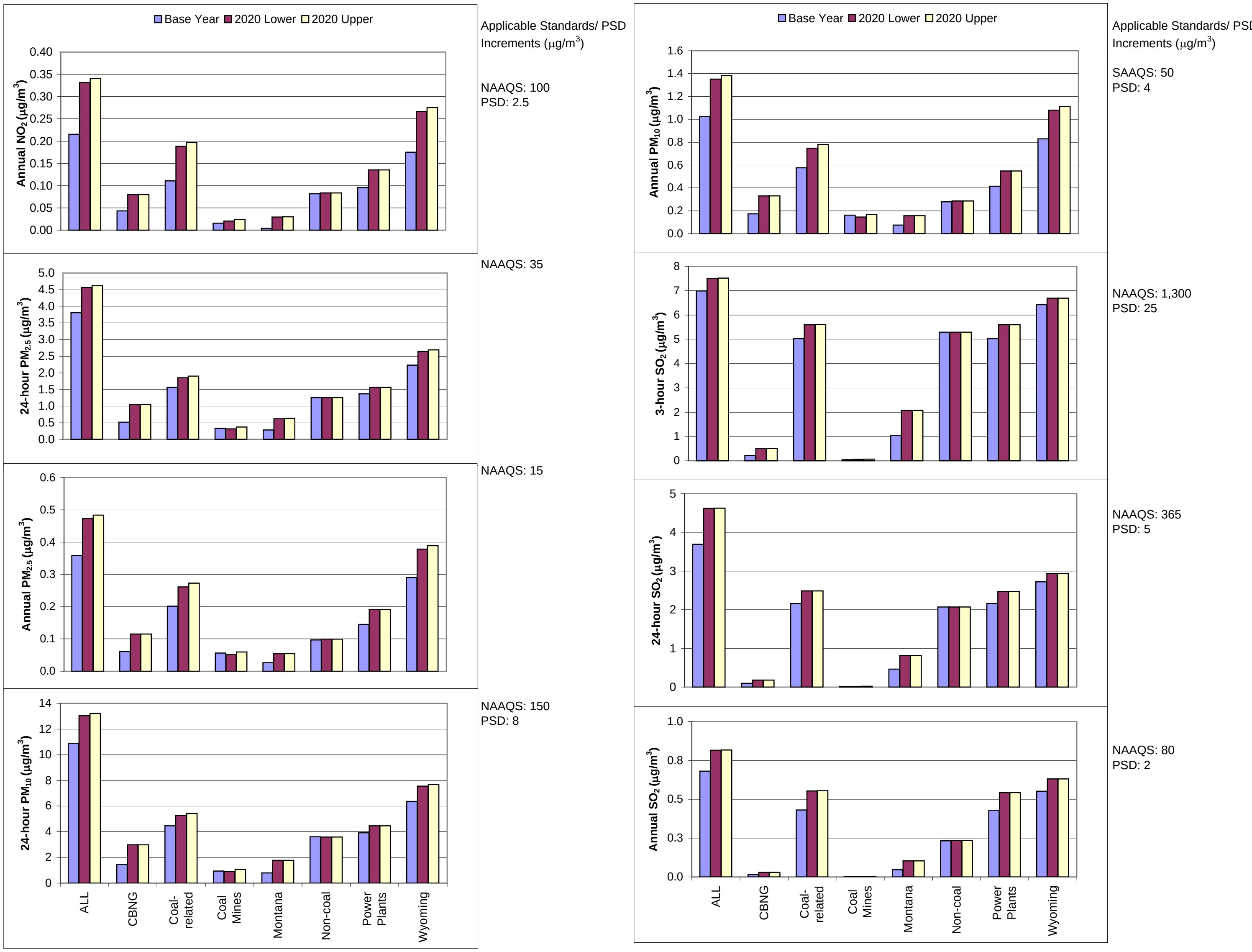
NAAQS: 1,300
PSD: 25

NAAQS: 365
PSD: 5

NAAQS: 80
PSD: 2

Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

Figure 3-9
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at Wind Cave NP



Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

3.1.3 Air Quality Impacts at Sensitive Class II Area Receptors

None of the Sensitive Class II areas evaluated for this study had predicted impacts that exceeded the ambient standards or Class II PSD increment thresholds. Modeled impacts at the Cloud Peak Wilderness Area (WA) and Crow IR demonstrated the largest changes in NO_2 impacts with respect to the base year. For PM_{10} impacts, the highest changes relative to the base year occurred at the Wind River IR. Modeled impacts for Cloud Peak Wilderness Area (WA) and Crow IR are shown in **Figure 3-10** and **Figure 3-11**, respectively. For the two Class II areas, modeled impacts were below the ambient standards, and they were below established Class II PSD increment levels. At the Cloud Peak WA, there was a marked change in NO_2 and PM_{10} impacts due to increased CBNG production shifting toward the WA. Similarly, at the Crow IR, the modeled NO_2 impacts demonstrate a marked increase due to projected coal-related RFD sources under the 2020 upper and lower development scenarios.

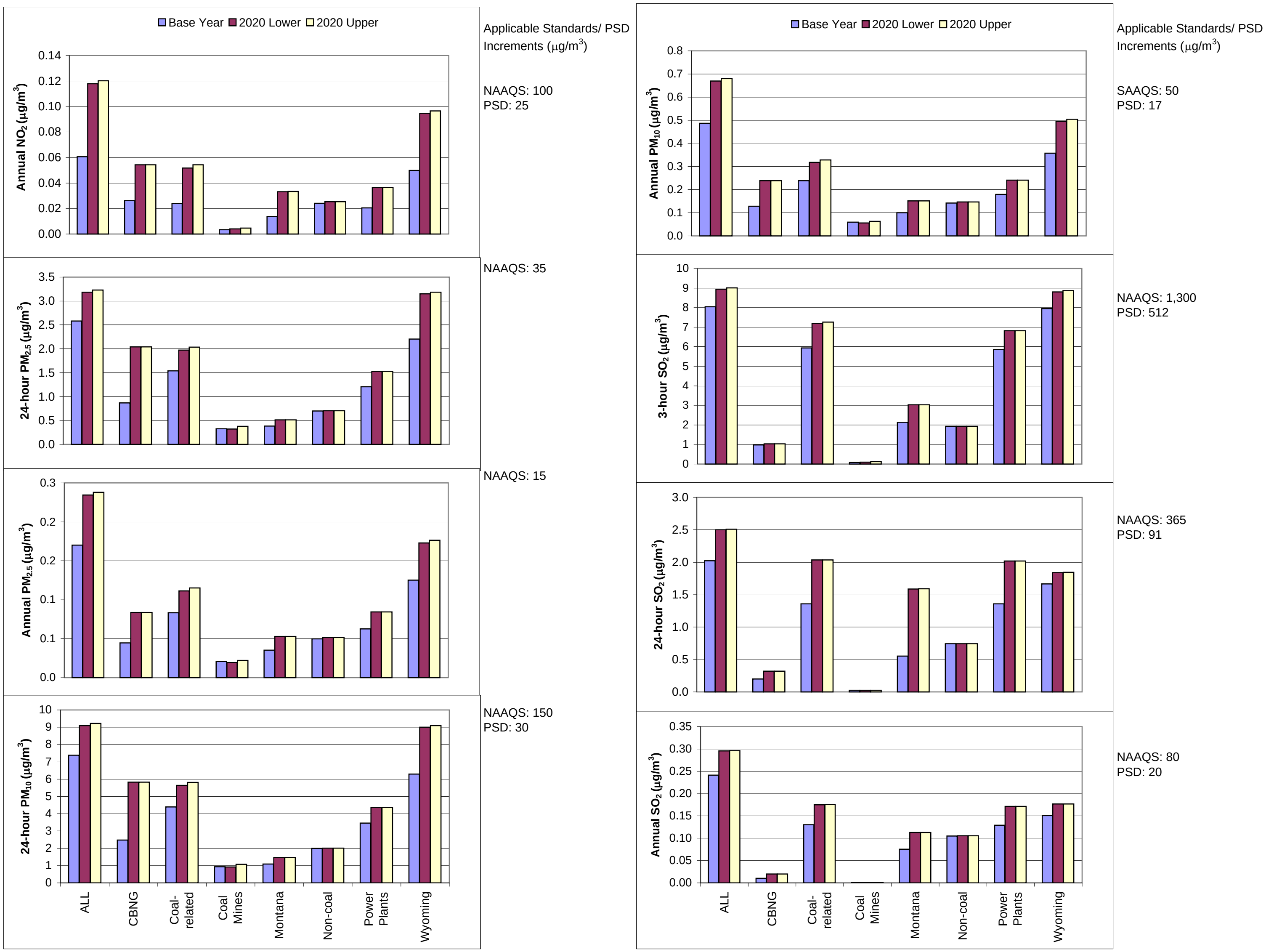
Figure 3-12 shows the base year (2004) and predicted future year (2020) modeled 1-hour NO_2 impacts at Big Horn Canyon National Recreation Area (NRA) and Crow IR. These two Class II areas have the highest modeled impacts of any modeled Class II area for the base year, yet impacts in the future years remain below the state 1-hour standard of 564 $\mu g/m^3$. It is likely that the conservative modeled impacts are greater than actual impacts. Initially, nitrogen monoxide (NO) emissions comprise the majority of NO_x emissions. NO is then converted into NO_2. Given that the conversion of NO into NO_2 typically occurs over several hours (Finlayson-Pitts and Pitts 2000), the fraction of NO_x that is NO_2 is probably substantially less than the 75 percent assumed for this study over the 1-hour averaging period.

3.1.4 Impacts on Visibility

Under the Clean Air Act, visibility has been established as a critical resource for identified Class I areas. Under the guidance of the Federal Land Managers Air Quality Workgroup (FLAG) (FLAG 2000), the impacts presented here were calculated using the same approach presented in the Task 1A and original Task 3A reports. The visibility impacts are provided using the CALPUFF modeling system and the Method 6 approach, which uses monthly relative humidity values for representative receptor groups. Visibility impacts were based on the highest 24-hour calculated extinction (reduced visibility) at the indicated source receptors. Impacts were based on FLAG speciated seasonal natural background reference visibility levels and calculated as a percent increase in extinction from the background values. Visibility impacts also can be expressed in terms of deciviews (dv), a measure for describing perceived changes in visibility. One deciview is defined as a change in visibility that is just perceptible to the average person. The study tabulated the reduced visibility at the maximum impact receptor in each of the Class I and Class II groups in terms of the maximum reduction on any one 24-hour period, the number of days annually that showed visibility reductions of 5 percent and 10 percent, which are equivalent to reductions in deciviews of 0.5 and 1 deciview, respectively. A significance threshold of 10 percent (1 deciview) has been used in this analysis to evaluate the frequency of the impact from the source groups.

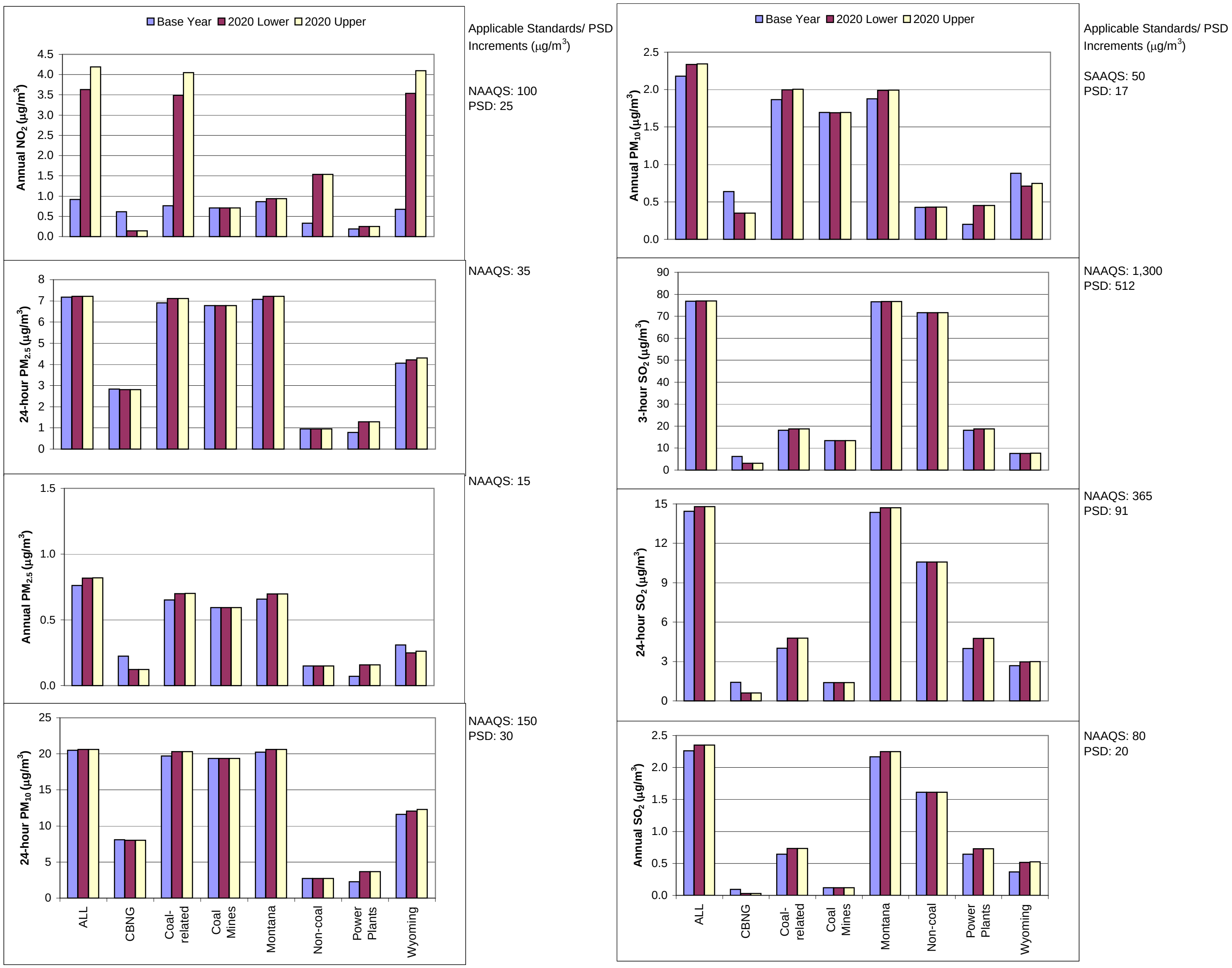
Tables 3-2 and **3-3** provide the modeled visibility impact results using "Method 6" for the lower and upper production scenarios for 2020, respectively. Based on the modeling results, those areas predicted to be the most impacted in the base year (2004) and 2015 typically are predicted to

Figure 3-10
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$
at Cloud Peak WA



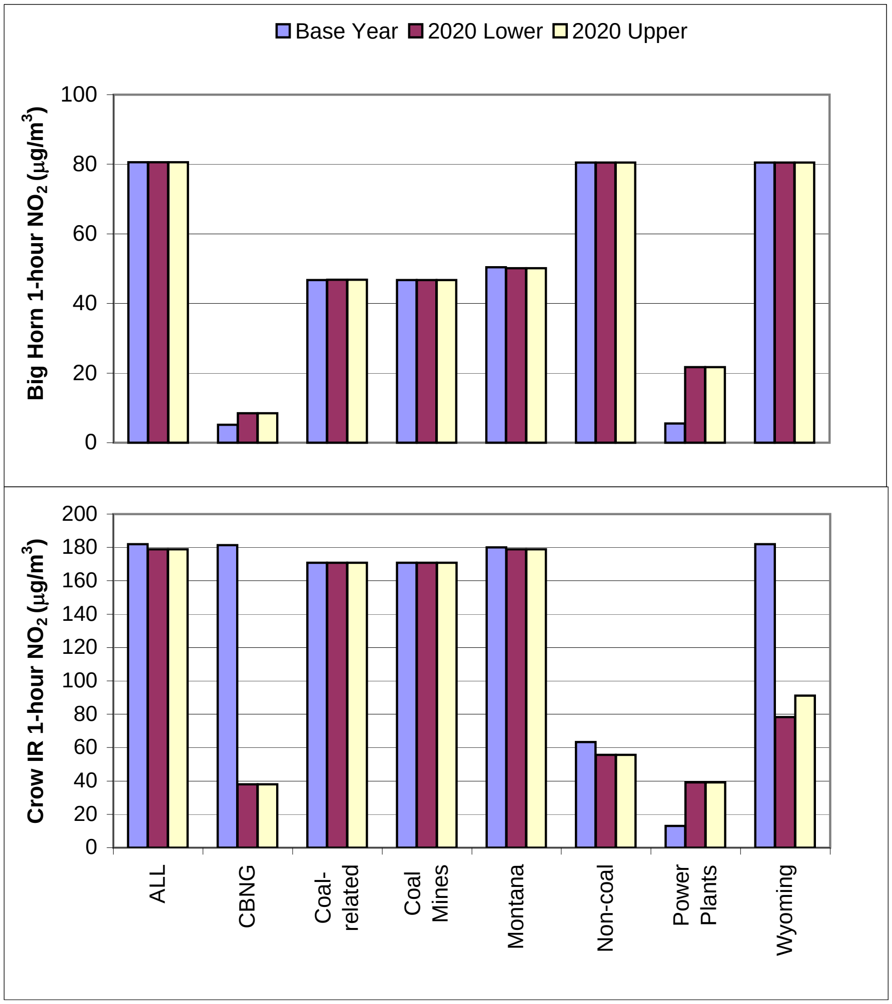
Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

Figure 3-11
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at Crow IR



Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

Figure 3-12
Change in Modeled Concentrations of 1-Hour NO_2
at Big Horn Canyon NRA and Crow IR



Applicable Standards/ Montana Standards (µg/m^3)

Montana SAAQS: 564

Montana SAAQS: 564

Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

Table 3-2
Modeled Visibility Impacts for the 2020 Lower Production Scenario[1]

	All Sources			*CBNG*			*Coal-related Sources*			*Coal Mines*			*Montana Sources*			*Non-coal Sources*			*Power Plants*			*Wyoming Sources*		
	Number of Days > N% Change in B_{ext}		*Maximum % Change in B_{ext}*	*Number of Days > N% Change in B_{ext}*		*Maximum % Change in B_{ext}*	*Number of Days > N% Change in B_{ext}*		*Maximum % Change in B_{ext}*	*Number of Days > N% Change in B_{ext}*		*Maximum % Change in B_{ext}*	*Number of Days > N% Change in B_{ext}*		*Maximum % Change in B_{ext}*	*Number of Days > N% Change in B_{ext}*		*Maximum % Change in B_{ext}*	*Number of Days > N% Change in B_{ext}*		*Maximum % Change in B_{ext}*	*Number of Days > N% Change in B_{ext}*		*Maximum % Change in B_{ext}*
Receptor Set	*5%*	*10%*		*5%*	*10%*		*5%*	*10%*		*5%*	*10%*		*5%*	*10%*		*5%*	*10%*		*5%*	*10%*		*5%*	*10%*	
CLASS I AREAS																								
Badlands NP	297	262	390	124	66	101	247	186	215	19	3	15	126	76	72	179	98	286	232	164	199	234	187	261
Bob Marshall WA	21	8	73	0	0	1	12	6	53	0	0	0	14	7	60	4	2	65	12	6	53	2	0	9
Bridger WA	215	149	154	19	13	58	144	88	64	0	0	3	44	23	44	163	91	122	141	85	64	179	125	123
Fitzpatrick WA	159	97	125	13	6	23	101	50	82	0	0	2	41	22	56	97	49	79	101	49	79	124	74	98
Fort Peck IR	167	125	257	28	16	92	123	80	84	12	2	12	108	60	89	96	56	252	114	72	66	72	51	156
Gates of the Mountain WA	95	59	118	0	0	3	79	38	102	0	0	1	88	48	117	39	11	43	78	38	102	7	3	19
Grand Teton NP	135	76	88	3	1	13	76	36	51	0	0	3	34	18	32	78	34	75	74	36	48	66	37	65
North Absaorka WA	136	69	234	7	3	19	91	43	157	0	0	2	88	45	126	52	20	70	90	41	152	53	24	91
North Cheyenne IR	350	302	544	158	113	257	322	258	352	67	15	26	338	272	161	150	61	282	300	240	323	168	131	517
Red Rock Lakes	83	45	65	2	0	9	53	28	63	0	0	2	44	20	64	36	10	30	53	28	63	26	14	39
Scapegoat WA	49	29	74	0	0	2	38	20	58	0	0	0	42	25	66	13	3	57	37	20	58	5	3	15
Teton WA	128	65	155	8	2	13	78	39	107	0	0	2	49	27	72	62	23	44	76	38	103	65	34	92
Theodore Roosevelt NP	253	202	307	57	36	79	148	96	156	5	0	9	113	73	130	182	112	298	140	85	138	114	80	187
U.L. Bend WA	143	95	228	18	8	60	116	65	138	5	0	10	115	63	119	53	28	205	107	61	125	43	27	97
Washakie WA	153	91	235	14	3	45	105	49	148	0	0	3	81	39	127	74	33	81	104	48	146	86	52	152
Wind Cave NP	334	290	559	158	99	112	301	243	368	49	12	17	144	70	85	180	98	338	283	203	325	292	246	467
Yellowstone NP	164	89	196	8	3	14	111	59	137	0	0	3	93	53	102	79	26	54	111	59	132	55	34	74
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	196	111	225	7	3	16	151	81	155	0	0	3	164	89	120	71	34	64	149	79	151	44	21	104
Agate Fossil Beds NM	322	277	676	119	68	182	289	228	499	33	8	27	99	52	45	166	84	178	276	208	427	309	258	642
Big Horn Canyon NRA	361	332	449	42	26	116	220	137	307	86	60	224	218	149	241	355	295	161	191	105	224	348	295	329
Black Elk WA	327	283	523	135	69	84	280	210	281	22	5	15	139	64	92	178	97	366	267	181	249	271	224	351
Cloud Peak WA	227	155	713	72	46	373	160	103	603	10	5	83	121	65	74	103	45	142	150	97	458	150	100	713
Crow IR	364	363	652	134	99	284	364	358	559	364	340	504	364	361	545	292	139	133	287	203	433	316	211	648
Devils Tower NM	341	305	325	196	141	108	313	261	227	69	15	23	167	86	79	150	77	194	294	217	191	295	252	290
Fort Belknap IR	127	80	205	12	6	40	102	58	136	3	0	7	105	56	123	43	22	151	97	52	125	31	22	72
Fort Laramie NHS	318	275	740	102	63	270	290	221	623	22	8	42	88	37	77	166	79	238	281	199	518	310	262	744
Jedediah Smith WA	142	82	113	3	1	13	74	36	55	0	0	3	34	15	34	98	45	100	71	36	55	61	39	81
Jewel Cave NM	335	297	532	160	96	116	308	247	326	55	9	26	131	61	105	161	86	288	286	201	281	292	256	428
Lee Metcalf WA	171	99	145	2	1	13	138	78	105	0	0	1	140	81	93	56	17	36	137	78	103	27	13	49
Mt Naomi WA	90	52	239	5	3	20	51	33	204	0	0	2	5	1	17	62	29	81	49	31	204	61	39	229
Mt Rushmore NM	320	271	522	131	59	76	271	192	260	20	5	12	133	60	83	159	83	368	248	172	231	261	209	320
Popo Agie WA	206	145	162	23	16	89	128	77	69	0	0	4	41	24	53	142	72	68	126	75	66	167	115	119
Soldier Creek WA	324	287	652	136	86	169	306	244	511	42	16	26	114	61	61	178	86	180	298	221	451	312	265	606
Wellsville Mountain WA	221	147	295	49	30	154	129	75	156	3	1	12	80	48	123	136	77	126	127	72	146	158	107	237
Wind River IR	281	226	342	69	45	179	187	120	238	6	1	12	90	53	142	257	153	162	180	115	235	262	197	302

[1] Visibility - Method 6 and monthly f(Rh) values.

Note:
N = N percent (5 or 10 percent as indicated).
B_{ext} = extinction coefficient for visibility.

Table 3-3
Modeled Visibility Impacts for the 2020 Upper Production Scenario[1]

Receptor Set	All Sources			CBNG			Coal-related Sources			Coal Mines			Montana Sources			Non-coal Sources			Power Plants			Wyoming Sources		
	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}	Number of Days > N% Change in B_{ext} 5%	Number of Days > N% Change in B_{ext} 10%	Maximum % Change in B_{ext}
CLASS I AREAS																								
Badlands NP	297	262	393	124	66	101	247	189	221	24	5	17	129	79	75	179	98	286	235	166	203	234	189	266
Bob Marshall WA	21	8	73	0	0	1	12	6	53	0	0	0	15	7	60	4	2	65	12	6	53	2	0	10
Bridger WA	215	149	154	19	13	58	145	90	66	0	0	4	44	23	45	163	91	122	143	86	64	179	125	123
Fitzpatrick WA	161	97	126	13	6	23	101	51	84	0	0	2	41	22	58	97	49	79	101	49	80	124	74	98
Fort Peck IR	167	126	257	28	16	92	124	82	92	13	2	13	110	62	91	96	56	252	115	75	67	73	52	159
Gates of the Mountain WA	95	59	118	0	0	3	79	38	102	0	0	1	89	48	117	39	11	43	79	38	102	7	3	19
Grand Teton NP	135	76	88	3	1	13	76	36	52	0	0	3	34	18	32	78	34	75	75	36	49	66	37	65
North Absaorka WA	137	69	237	7	3	19	91	43	160	0	0	2	89	46	129	52	20	70	90	41	155	53	24	92
North Cheyenne IR	355	303	550	158	113	257	330	267	360	74	20	29	342	283	171	150	61	282	306	252	325	169	132	521
Red Rock Lakes	83	45	65	2	0	9	53	28	63	0	0	2	44	20	64	36	10	30	53	28	63	26	14	39
Scapegoat WA	49	29	75	0	0	2	38	20	58	0	0	1	42	25	66	13	3	57	38	20	58	5	3	15
Teton WA	128	65	157	8	2	13	78	39	109	0	0	2	50	27	74	62	23	44	76	38	105	66	34	92
Theodore Roosevelt NP	253	202	308	57	36	79	152	99	167	7	1	11	116	74	138	182	112	298	145	88	146	114	81	190
U.L. Bend WA	144	95	237	18	8	60	118	67	146	6	1	11	118	65	126	53	28	205	109	61	132	43	27	99
Washakie WA	153	91	239	14	3	45	105	49	149	0	0	3	81	40	129	74	33	81	104	49	147	86	52	153
Wind Cave NP	334	293	564	158	99	112	304	248	383	56	18	20	149	73	89	180	98	338	287	205	332	292	247	472
Yellowstone NP	164	89	199	8	3	14	111	60	139	0	0	3	93	53	104	79	26	54	111	59	134	55	34	75
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	196	111	228	7	3	16	152	81	159	0	0	3	164	89	123	71	34	64	150	79	153	44	21	105
Agate Fossil Beds NM	322	277	680	119	68	182	290	230	516	40	12	31	101	52	50	166	84	178	276	209	432	310	260	646
Big Horn Canyon NRA	361	332	458	42	26	116	221	141	315	86	60	224	218	149	241	355	295	161	192	109	228	348	296	333
Black Elk WA	328	283	529	135	69	84	285	217	293	26	7	17	145	67	97	178	97	366	267	183	255	273	225	356
Cloud Peak WA	227	156	718	72	46	373	161	106	616	11	6	97	122	66	76	103	45	142	150	97	459	150	100	719
Crow IR	364	363	655	134	99	284	364	358	564	364	340	504	364	361	548	292	139	133	289	206	434	322	225	651
Devils Tower NM	343	306	332	196	141	108	315	269	234	78	21	27	173	95	83	150	77	194	296	220	192	295	253	295
Fort Belknap IR	128	81	213	12	6	40	102	58	144	4	0	8	106	57	130	43	22	151	98	54	131	31	22	73
Fort Laramie NHS	318	276	742	102	63	270	292	224	643	29	9	49	89	41	80	166	79	238	281	201	524	310	264	746
Jedediah Smith WA	142	82	113	3	1	13	74	36	55	0	0	4	34	15	34	98	45	100	71	36	55	61	40	81
Jewel Cave NM	336	298	541	160	96	116	310	249	341	64	17	30	136	63	111	161	86	288	290	202	288	293	258	435
Lee Metcalf WA	172	99	146	2	1	13	138	78	106	0	0	1	141	81	93	56	17	36	137	78	104	27	13	49
Mt Naomi WA	90	52	239	5	3	20	51	33	204	0	0	3	5	1	17	62	29	81	49	31	204	61	39	229
Mt Rushmore NM	322	274	528	131	59	76	274	199	271	23	7	14	138	64	88	159	83	368	249	174	236	263	209	325
Popo Agie WA	206	145	168	23	16	89	128	78	71	0	0	5	43	25	54	142	72	68	126	75	67	167	115	120
Soldier Creek WA	324	287	656	136	86	169	307	249	523	54	19	30	118	61	68	178	86	180	298	221	457	312	267	610
Wellsville Mountain WA	221	147	300	49	30	154	131	75	160	3	1	13	80	48	127	136	77	126	127	72	149	158	108	240
Wind River IR	281	227	343	69	45	179	187	122	240	8	1	13	90	53	145	257	153	162	180	115	236	262	198	302

[1] Visibility - Method 6 and monthly f(Rh) values.

Note:
N = N percent (5 or 10 percent as indicated).
B_{ext} = extinction coefficient for visibility.

continue to be impacted by production increases in 2020. For the Class I areas, the maximum impacts were at the North Cheyenne IR in Montana and at Wind Cave NP and Badlands NP in South Dakota. Both of these South Dakota areas are located adjacent to, and east of, the PRB study area, and are downwind of the prevailing wind direction from the PRB. In the base year (2004), modeling showed more than 200 days would be impacted with a change of 10 percent or more in extinction at each of these Class I areas. This trend continues for 2015 and 2020 projected impacts. Modeling results suggest that by 2020 these three maximum impacted Class I areas may experience change of at least 1.0 dv for more than 300 days a year.

For the Class II areas, the maximum impacts were at the Crow IR and the Big Horn Canyon NRA in Montana, with almost all days in a year impacted by 10 percent or more. Eight other Class II areas showed impacts of 10 percent or more for 200 days or more per year. These areas also are located east (downwind in the prevailing wind direction) of the PRB study area, with the exception of Wind River IR, which is to the west.

The modeling results showed that coal mining and CBNG operations had little to no impact on the visibility to the northwest of the PRB. Power plants and coal mines dominated the impacts at the Class II areas, and the impacts on the Class I areas generally were split between power plants and CBNG operations. Coal mining activities generally had a negligible impact on the visibility at all locations except for areas in close proximity to the PRB (Northern Cheyenne IR, Big Horn Canyon, and Crow IR). However, areas disproportionately impacted by CBNG development are predicted to have larger visibility impairment, relative to other areas, as CBNG development continues to expand. Likewise, areas disproportionately impacted by conventional oil and gas development (represented in the "non-coal" source group) are predicted to have an improved visible range, relative to other areas, as oil- and gas-related emissions are predicted to slow by 2020.

To provide a basis for discussing the modeled visibility impacts resulting from increased production (emissions) under both the lower and upper production scenarios in 2020, the modeled visibility impacts for the base year (2004) (**Table 3-2** in the 2015 Update report) were subtracted from the model results for 2020. The resulting changes in modeled visibility impacts are presented in **Tables 3-4** and **3-5**. The data in these tables show the projected changes in the number of days with impacts greater than 5 and 10 percent, as well as the projected incremental increase in the maximum percent change in light extinction as a result of the RFD activities. It should be noted that for most Class I areas, the model results show no change from the base year in the number of days with impacts greater than 5 percent, although the modeling results indicate that the maximum level of impacts for those days would increase. Concurrently, the model results may show a corresponding increase from the base year in the number of days with impacts above 10 percent. For such data sets, the increase in the number of days with impacts greater than 10 percent does not conflict with the fact that there is no anticipated increase in the number of days with impacts greater than 5 percent, as the data represent the change over base year (2004) conditions.

For all sources combined, the largest impacts (greater than 10 percent for 10 days or more for both production scenarios) would be to those Class I areas estimated to currently be most impacted and generally located adjacent to and to the east of the PRB study area (Northern Cheyenne IR, Badlands NP, and Wind Cave NP).

Table 3-4
Change in Modeled Visibility Impacts - 2020 Lower Production Scenario Less the Base Year (2004)[1]

Receptor Set	All Sources: Change in Number of Days > N% Change in B_{ext} 5%	All Sources: Change in Number of Days > N% Change in B_{ext} 10%	All Sources: Change in the Maximum % Change in B_{ext}	CBNG: Change in Number of Days > N% Change in B_{ext} 5%	CBNG: Change in Number of Days > N% Change in B_{ext} 10%	CBNG: Change in the Maximum % Change in B_{ext}	Coal-related Sources: Change in Number of Days > N% Change in B_{ext} 5%	Coal-related Sources: Change in Number of Days > N% Change in B_{ext} 10%	Coal-related Sources: Change in the Maximum % Change in B_{ext}	Coal Mines: Change in Number of Days > N% Change in B_{ext} 5%	Coal Mines: Change in Number of Days > N% Change in B_{ext} 10%	Coal Mines: Change in the Maximum % Change in B_{ext}	Montana Sources: Change in Number of Days > N% Change in B_{ext} 5%	Montana Sources: Change in Number of Days > N% Change in B_{ext} 10%	Montana Sources: Change in the Maximum % Change in B_{ext}	Non-coal Sources: Change in Number of Days > N% Change in B_{ext} 5%	Non-coal Sources: Change in Number of Days > N% Change in B_{ext} 10%	Non-coal Sources: Change in the Maximum % Change in B_{ext}	Power Plants: Change in Number of Days > N% Change in B_{ext} 5%	Power Plants: Change in Number of Days > N% Change in B_{ext} 10%	Power Plants: Change in the Maximum % Change in B_{ext}	Wyoming Sources: Change in Number of Days > N% Change in B_{ext} 5%	Wyoming Sources: Change in Number of Days > N% Change in B_{ext} 10%	Wyoming Sources: Change in the Maximum % Change in B_{ext}
CLASS I AREAS																								
Badlands NP	14	44	55	52	41	57	48	58	81	8	0	2	63	52	26	5	1	1	56	43	70	16	31	80
Bob Marshall WA	5	0	2	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0
Bridger WA	3	5	9	10	10	35	8	6	2	0	0	0	11	2	8	1	1	-1	6	5	1	2	7	3
Fitzpatrick WA	2	6	10	8	6	15	6	7	13	0	0	0	6	3	7	2	2	0	10	7	11	4	5	2
Fort Peck IR	16	20	1	10	5	40	30	29	27	0	0	1	32	25	26	0	1	0	32	28	14	4	8	61
Gates of the Mountain WA	5	4	2	0	0	2	7	1	2	0	0	0	5	1	2	0	0	0	6	1	2	0	0	1
Grand Teton NP	3	6	1	2	1	5	8	2	7	0	0	0	4	2	1	0	0	0	7	2	5	1	5	1
North Absaorka WA	5	8	57	5	3	9	10	6	53	0	0	0	12	9	47	0	0	0	9	7	51	7	3	12
North Cheyenne IR	34	59	129	-4	7	58	85	121	64	-3	1	1	95	135	83	16	7	1	103	131	45	-18	-8	119
Red Rock Lakes	2	3	2	2	0	5	3	3	2	0	0	0	4	2	2	0	0	0	3	3	2	1	1	2
Scapegoat WA	5	2	9	0	0	1	4	0	1	0	0	0	3	2	1	0	0	0	3	0	1	0	1	1
Teton WA	3	8	38	6	2	5	10	7	36	0	0	0	7	7	24	0	0	0	11	6	33	8	4	1
Theodore Roosevelt NP	10	24	1	11	14	37	34	36	77	0	0	1	37	35	76	1	1	0	37	31	66	15	7	62
UL Bend WA	15	18	15	10	2	18	28	18	71	0	0	0	31	18	52	0	1	0	24	20	61	3	7	21
Washakie WA	6	8	46	10	2	27	7	12	35	0	0	0	9	7	38	0	0	0	7	13	34	6	8	3
Wind Cave NP	16	28	102	50	50	55	44	71	115	12	2	2	77	40	33	4	3	2	55	53	86	9	28	106
Yellowstone NP	4	5	49	7	3	6	4	8	46	0	0	0	7	6	35	0	0	0	5	9	44	2	4	8
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	6	10	58	5	3	8	15	14	55	0	0	0	5	9	21	2	0	0	13	14	52	5	5	15
Agate Fossil Beds NM	12	26	68	45	29	87	23	37	115	1	4	4	51	30	16	6	2	2	25	39	67	13	23	77
Big Horn Canyon NRA	0	1	100	1	8	43	13	23	59	0	0	0	16	22	0	0	0	0	33	35	45	0	0	73
Black Elk WA	20	47	67	53	39	40	49	58	93	1	3	2	76	38	47	3	1	2	60	45	72	13	38	86
Cloud Peak WA	18	29	35	25	19	62	29	24	112	1	2	9	32	27	22	4	4	20	23	28	42	16	16	38
Crow IR	0	3	55	-17	-19	113	0	6	24	0	0	0	0	5	15	14	7	0	50	70	59	61	32	63
Devils Tower NM	20	31	52	16	46	58	56	76	46	-6	-5	0	91	55	46	10	7	0	70	77	20	1	6	45
Fort Belknap IR	16	14	46	6	2	10	23	22	78	0	0	0	26	18	52	0	1	0	22	18	68	4	8	12
Fort Laramie NHS	5	15	13	37	35	126	14	34	139	1	2	6	48	21	31	8	3	9	20	21	70	4	24	24
Jedediah Smith WA	2	3	1	2	1	5	9	2	1	0	0	0	5	2	1	2	0	0	6	2	1	3	6	1
Jewel Cave NM	24	36	126	52	52	53	50	68	107	3	3	3	71	31	70	5	2	2	61	56	77	4	28	109
Lee Metcalf WA	4	2	64	2	1	10	4	3	52	0	0	0	3	4	29	1	0	0	3	4	51	2	0	5
Mt Naomi WA	2	1	6	4	3	15	4	1	5	0	0	1	1	0	3	0	0	0	2	0	5	2	2	6
Mt Rushmore NM	20	49	67	60	30	38	61	53	88	2	3	1	71	36	40	6	1	2	54	49	69	18	40	79
Popo Agie WA	7	6	48	10	13	57	6	8	15	0	0	0	7	4	15	0	0	0	7	7	12	2	7	29
Soldier Creek WA	3	19	63	38	45	82	24	41	116	4	4	4	55	37	29	9	5	5	32	38	79	8	23	65
Wellsville Mountain WA	12	17	56	30	21	99	10	12	43	0	0	1	11	12	32	1	0	0	11	12	36	9	14	44
Wind River IR	0	9	17	43	28	115	16	15	34	0	0	1	11	10	38	0	0	-1	9	13	33	-1	18	1

[1] Visibility - Method 6 and monthly f(Rh) values.

Note: N = N percent (5 or 10 percent as indicated).
B_{ext} = extinction coefficient for visibility.

Table 3-5
Change in Modeled Visibility Impacts - 2020 Upper Production Scenario Less the Base Year (2004)[1]

Receptor Set	All Sources: Change in Number of Days > N% Change in B_{ext} 5%	All Sources: 10%	All Sources: Change in the Maximum % Change in B_{ext}	CBNG: Change in Number of Days > N% Change in B_{ext} 5%	CBNG: 10%	CBNG: Change in the Maximum % Change in B_{ext}	Coal-related Sources: Change in Number of Days > N% Change in B_{ext} 5%	Coal-related Sources: 10%	Coal-related Sources: Change in the Maximum % Change in B_{ext}	Coal Mines: Change in Number of Days > N% Change in B_{ext} 5%	Coal Mines: 10%	Coal Mines: Change in the Maximum % Change in B_{ext}	Montana Sources: Change in Number of Days > N% Change in B_{ext} 5%	Montana Sources: 10%	Montana Sources: Change in the Maximum % Change in B_{ext}	Non-coal Sources: Change in Number of Days > N% Change in B_{ext} 5%	Non-coal Sources: 10%	Non-coal Sources: Change in the Maximum % Change in B_{ext}	Power Plants: Change in Number of Days > N% Change in B_{ext} 5%	Power Plants: 10%	Power Plants: Change in the Maximum % Change in B_{ext}	Wyoming Sources: Change in Number of Days > N% Change in B_{ext} 5%	Wyoming Sources: 10%	Wyoming Sources: Change in the Maximum % Change in B_{ext}
CLASS I AREAS																								
Badlands NP	14	44	59	52	41	57	48	61	87	13	2	4	66	55	28	5	1	1	59	45	74	16	33	85
Bob Marshall WA	5	0	2	0	0	0	0	1	1	0	0	0	1	1	1	0	0	0	0	1	1	0	0	0
Bridger WA	3	5	10	10	10	35	9	8	3	0	0	1	11	2	9	1	1	-1	8	6	1	2	7	3
Fitzpatrick WA	4	6	11	8	6	15	6	8	15	0	0	0	6	3	8	2	2	0	10	7	13	4	5	2
Fort Peck IR	16	21	1	10	5	40	31	31	35	1	0	3	34	27	27	0	1	0	33	31	16	5	9	64
Gates of the Mountain WA	5	4	2	0	0	2	7	1	2	0	0	0	6	1	2	0	0	0	7	1	2	0	0	1
Grand Teton NP	3	6	1	2	1	5	8	2	8	0	0	1	4	2	1	0	0	0	8	2	5	1	5	1
North Absaorka WA	6	8	60	5	3	9	10	6	57	0	0	0	13	10	50	0	0	0	9	7	53	7	3	12
North Cheyenne IR	39	60	135	-4	7	58	93	130	72	4	6	4	99	146	93	16	7	1	109	143	47	-17	-7	123
Red Rock Lakes	2	3	2	2	0	5	3	3	2	0	0	0	4	2	2	0	0	0	3	3	2	1	1	2
Scapegoat WA	5	2	10	0	0	1	4	0	1	0	0	0	3	2	1	0	0	0	4	0	1	0	1	1
Teton WA	3	8	41	6	2	5	10	7	38	0	0	0	8	7	25	0	0	0	11	6	34	9	4	2
Theodore Roosevelt NP	10	24	1	11	14	37	38	39	88	2	1	2	40	36	84	1	1	0	42	34	74	15	8	66
U.L. Bend WA	16	18	24	10	2	18	30	20	80	1	1	1	34	20	60	0	1	0	26	20	68	3	7	23
Washakie WA	6	8	50	10	2	27	7	12	36	0	0	0	9	8	41	0	0	0	7	14	35	6	8	3
Wind Cave NP	16	31	106	50	50	55	47	76	129	19	8	5	82	43	37	4	3	2	59	55	94	9	29	111
Yellowstone NP	4	5	51	7	3	6	4	9	49	0	0	1	7	6	37	0	0	0	5	9	46	2	4	9
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	6	10	61	5	3	8	16	14	58	0	0	0	5	9	23	2	0	0	14	14	55	5	5	16
Agate Fossil Beds NM	12	26	72	45	29	87	24	39	132	8	8	8	53	30	21	6	2	2	25	40	72	14	25	81
Big Horn Canyon NRA	0	1	108	1	8	43	14	27	68	0	0	0	16	22	0	0	0	0	34	39	49	0	1	76
Black Elk WA	21	47	72	53	39	40	54	65	104	5	5	4	82	41	53	3	1	2	60	47	78	15	39	91
Cloud Peak WA	18	30	40	25	19	62	30	27	126	2	3	23	33	28	25	4	4	20	23	28	42	16	16	43
Crow IR	0	3	58	-17	-19	113	0	6	29	0	0	0	0	5	18	14	7	0	52	73	60	67	46	66
Devils Tower NM	22	32	59	16	46	58	58	84	53	3	1	4	97	64	49	10	7	0	72	80	21	1	7	51
Fort Belknap IR	17	15	53	6	2	10	23	22	86	1	0	1	27	19	58	0	1	0	23	20	74	4	8	13
Fort Laramie NHS	5	16	15	37	35	126	16	37	159	8	3	13	49	25	35	8	3	9	20	23	76	4	26	27
Jedediah Smith WA	2	3	1	2	1	5	9	2	1	0	0	1	5	2	1	2	0	0	6	2	1	3	7	1
Jewel Cave NM	25	37	135	52	52	53	52	70	121	12	11	7	76	33	76	5	2	2	65	57	84	5	30	116
Lee Metcalf WA	5	2	65	2	1	10	4	3	53	0	0	0	4	4	30	1	0	0	3	4	51	2	0	5
Mt Naomi WA	2	1	6	4	3	15	4	1	5	0	0	1	1	0	3	0	0	0	2	0	5	2	2	6
Mt Rushmore NM	22	52	72	60	30	38	64	60	98	5	5	3	76	40	44	6	1	2	55	51	74	20	40	83
Popo Agie WA	7	6	53	10	13	57	6	9	17	0	0	1	9	5	16	0	0	0	7	7	13	2	7	29
Soldier Creek WA	3	19	67	38	45	82	25	46	129	16	7	8	59	37	36	9	5	5	32	38	85	8	25	68
Wellsville Mountain WA	12	17	60	30	21	99	12	12	48	0	0	3	11	12	36	1	0	0	11	12	39	9	15	48
Wind River IR	0	10	17	43	28	115	16	17	36	2	0	3	11	10	41	0	0	-1	9	13	35	-1	19	2

[1] Visibility - Method 6 and monthly f(Rh) values.

Note: _N = N percent (5 or 10 percent as indicated).
B_{ext} = extinction coefficient for visibility.

A similar pattern of higher impacts to the east and near the PRB also was observed for the Class II receptor groups. The number of days with 10 percent impact or more would exceed 200 days per year for 10 Class II receptor areas under both the 2020 lower and upper production scenarios. Based on the modeling results, areas to the west of the PRB study area show a distinctly lower impact than those to the east of the PRB study area for both of the 2020 production scenarios. Modeling results show that all areas would experience some increase in visibility impacts.

3.1.5 Impacts on Acid Deposition

Emissions of NO_x and SO_2 could lead to increasing impacts of acidic deposition in the region. This study evaluated the potential increase in acid deposition as a result of the projected increase in production activity in the PRB. The base year (2004) analysis showed that impacts for all listed Class I and Class II areas would be below the established level of concern for sulfur and nitrogen deposition, which are 5 kilograms per hectare per year (kg/ha/yr) for sulfur compounds and 1.5 kg/ha/yr for nitrogen compounds. The FS does not believe these thresholds (shown in **Tables 3-6** and **3-7**) are sufficiently protective; however, until newer thresholds are established, these values are used for comparative purposes. **Tables 3-6** and **3-7** provide a summary of deposition levels for the 2020 lower and upper production scenarios, respectively, at the sensitive receptor areas. The highest modeled impacts are at the Northern Cheyenne IR with nitrogen and sulfur deposition reaching approximately 58 and 21 percent of the level of concern, respectively, due to the proximity of major coal-fired power plant units. Generally, sulfur deposition was greater than nitrogen deposition at the Class I areas analyzed. Contrary to base year impacts, there appears to be a spatial relationship to deposition rates, which generally is lower at the areas to the west of the PRB and higher toward the east. This spatial pattern is representative of the increasing density of emissions sources coupled with the prevailing wind direction.

The modeled changes in acid deposition (future year deposition minus base year deposition in kg/ha/yr) under the lower and upper production scenarios for 2020 are shown in **Tables 3-8** and **3-9**, respectively. The modeled changes in deposition levels for all receptors and for both sulfur and nitrogen compounds show a nominal change in deposition rates, with changes of less than 30 percent of the levels of concern. Similar to visibility impacts, the maximum changes in deposition levels occur in areas already most impacted in the base year. The maximum change in deposition levels occurs at the Northern Cheyenne IR and is predicted to be a result of additional coal-fired power plants rather than CBNG development, which caused the highest impacts to the Northern Cheyenne IR in the 2015 Update. The Northern Cheyenne IR impacts due to CBNG are predicted to decrease in 2020 as the Wyoming well locations are developed farther south.

3.1.6 Impacts on Sensitive Lake Acid Neutralizing Capacity

The analysis of impacts of deposition of acidic substances was carried out in accordance with the screening methodology as provided by the FS (FS 2000). Data for lake neutralizing capacity were obtained from the FS web site (FS 2006), which provides data for the 10^{th} percentile acid neutralizing capacity (ANC) values for the individual lakes that were evaluated. The threshold is intended to account for sensitive conditions that may occur with an episodic or seasonal basis. Input data to the analysis include the deposition rates that were modeled for the base year (2004), and under the lower and upper production scenarios for 2020.

Table 3-6
Modeled Deposition of Nitrogen and Sulfur - 2020 Lower Production Scenario

Receptor Set	POLLUTANT	Maximum Deposition (kg/ha/yr)								Level of Concern (kg/ha/yr)
		ALL Sources	*CBNG*	*Coal-related Sources*	*Coal Mines*	*Montana Sources*	*Non-coal Sources*	*Power Plants*	*Wyoming Sources*	
CLASS I AREAS										
Badlands NP	Nitrogen	0.170	0.024	0.086	0.004	0.032	0.063	0.075	0.097	1.5
	Sulfur	0.229	0.006	0.125	0.001	0.041	0.100	0.123	0.121	5.0
Bob Marshall WA	Nitrogen	0.006	0.000	0.004	0.000	0.004	0.002	0.004	0.002	1.5
	Sulfur	0.010	0.000	0.005	0.000	0.006	0.005	0.005	0.002	5.0
Bridger WA	Nitrogen	0.164	0.007	0.068	0.000	0.012	0.090	0.067	0.148	1.5
	Sulfur	0.206	0.002	0.106	0.000	0.015	0.099	0.106	0.161	5.0
Fitzpatrick WA	Nitrogen	0.211	0.004	0.048	0.000	0.012	0.169	0.047	0.196	1.5
	Sulfur	0.141	0.001	0.077	0.000	0.016	0.081	0.077	0.108	5.0
Fort Peck IR	Nitrogen	0.089	0.009	0.035	0.002	0.028	0.046	0.031	0.029	1.5
	Sulfur	0.139	0.002	0.049	0.000	0.040	0.088	0.048	0.030	5.0
Gates of the Mountain WA	Nitrogen	0.072	0.001	0.049	0.000	0.063	0.022	0.049	0.006	1.5
	Sulfur	0.080	0.000	0.060	0.000	0.067	0.019	0.060	0.006	5.0
Grand Teton NP	Nitrogen	0.066	0.002	0.039	0.000	0.020	0.026	0.038	0.035	1.5
	Sulfur	0.149	0.000	0.049	0.000	0.021	0.101	0.048	0.052	5.0
North Absaorka WA	Nitrogen	0.093	0.005	0.061	0.001	0.052	0.031	0.060	0.038	1.5
	Sulfur	0.133	0.001	0.070	0.000	0.063	0.063	0.070	0.048	5.0
North Cheyenne IR	Nitrogen	0.804	0.147	0.628	0.024	0.561	0.077	0.587	0.282	1.5
	Sulfur	0.954	0.028	0.796	0.004	0.727	0.145	0.790	0.197	5.0
Red Rock Lakes	Nitrogen	0.059	0.001	0.046	0.000	0.043	0.012	0.046	0.010	1.5
	Sulfur	0.072	0.000	0.044	0.000	0.038	0.028	0.044	0.015	5.0
Scapegoat WA	Nitrogen	0.023	0.001	0.016	0.000	0.019	0.006	0.016	0.003	1.5
	Sulfur	0.034	0.000	0.021	0.000	0.026	0.013	0.021	0.004	5.0
Teton WA	Nitrogen	0.069	0.003	0.041	0.000	0.023	0.026	0.040	0.035	1.5
	Sulfur	0.120	0.001	0.053	0.000	0.028	0.070	0.053	0.047	5.0
Theodore Roosevelt NP	Nitrogen	0.246	0.026	0.078	0.003	0.039	0.182	0.070	0.084	1.5
	Sulfur	0.313	0.005	0.089	0.000	0.046	0.225	0.088	0.072	5.0
U.L. Bend WA	Nitrogen	0.121	0.014	0.070	0.003	0.056	0.037	0.065	0.044	1.5
	Sulfur	0.152	0.003	0.083	0.001	0.075	0.066	0.082	0.039	5.0
Washakie WA	Nitrogen	0.097	0.006	0.055	0.001	0.038	0.036	0.054	0.057	1.5
	Sulfur	0.149	0.002	0.074	0.000	0.051	0.074	0.073	0.078	5.0
Wind Cave NP	Nitrogen	0.322	0.066	0.188	0.014	0.048	0.070	0.151	0.244	1.5
	Sulfur	0.437	0.015	0.298	0.001	0.063	0.124	0.293	0.331	5.0
Yellowstone NP	Nitrogen	0.090	0.004	0.060	0.001	0.052	0.026	0.059	0.032	1.5
	Sulfur	0.132	0.001	0.064	0.000	0.056	0.082	0.064	0.045	5.0
CLASS I / CLASS II SENSITIVE LAKES										
Black Joe Lake, Bridger WA	Nitrogen	0.114	0.007	0.057	0.000	0.012	0.050	0.056	0.096	1.5
	Sulfur	0.174	0.002	0.092	0.000	0.015	0.081	0.091	0.132	5.0
Deep Lake, Bridger WA	Nitrogen	0.119	0.007	0.059	0.000	0.012	0.054	0.058	0.102	1.5
	Sulfur	0.178	0.002	0.094	0.000	0.015	0.082	0.094	0.135	5.0
Emerald Lake, Cloud Peak WA	Nitrogen	0.165	0.031	0.090	0.004	0.047	0.044	0.080	0.109	1.5
	Sulfur	0.194	0.006	0.110	0.001	0.066	0.077	0.109	0.107	5.0
Florence, Cloud Peak WA	Nitrogen	0.174	0.037	0.093	0.004	0.046	0.043	0.083	0.120	1.5
	Sulfur	0.200	0.008	0.115	0.001	0.064	0.077	0.114	0.116	5.0
Hobbs Lake, Bridger WA	Nitrogen	0.084	0.003	0.043	0.000	0.008	0.037	0.043	0.070	1.5
	Sulfur	0.135	0.001	0.073	0.000	0.010	0.061	0.073	0.099	5.0
Lower Saddlebag, Popo Agie WA	Nitrogen	0.144	0.008	0.067	0.001	0.013	0.069	0.065	0.125	1.5
	Sulfur	0.217	0.002	0.108	0.000	0.016	0.107	0.108	0.171	5.0
Ross Lake, Cloud Peak WA	Nitrogen	0.068	0.003	0.036	0.000	0.010	0.030	0.035	0.053	1.5
	Sulfur	0.106	0.001	0.056	0.000	0.013	0.049	0.055	0.071	5.0
Upper Frozen Lake, Bridger WA	Nitrogen	0.129	0.007	0.062	0.000	0.011	0.060	0.061	0.112	1.5
	Sulfur	0.187	0.002	0.098	0.000	0.014	0.087	0.098	0.143	5.0

Table 3-7
Modeled Deposition of Nitrogen and Sulfur - 2020 Upper Production Scenario

		Maximum Deposition (kg/ha/yr)								
Receptor Set	POLLUTANT	*ALL Sources*	*CBNG*	*Coal-related Sources*	*Coal Mines*	*Montana Sources*	*Non-coal Sources*	*Power Plants*	*Wyoming Sources*	Level of Concern (kg/ha/yr)
CLASS I AREAS										
	Nitrogen	0.173	0.024	0.089	0.005	0.033	0.063	0.076	0.099	1.5
Badlands NP	Sulfur	0.231	0.006	0.128	0.001	0.044	0.100	0.126	0.121	5.0
	Nitrogen	0.007	0.000	0.004	0.000	0.004	0.002	0.004	0.002	1.5
Bob Marshall WA	Sulfur	0.010	0.000	0.005	0.000	0.006	0.005	0.005	0.002	5.0
	Nitrogen	0.165	0.007	0.069	0.001	0.012	0.090	0.067	0.148	1.5
Bridger WA	Sulfur	0.207	0.002	0.106	0.000	0.015	0.099	0.106	0.161	5.0
	Nitrogen	0.211	0.004	0.049	0.000	0.012	0.169	0.048	0.196	1.5
Fitzpatrick WA	Sulfur	0.142	0.001	0.078	0.000	0.016	0.081	0.078	0.108	5.0
	Nitrogen	0.090	0.009	0.036	0.002	0.029	0.046	0.032	0.029	1.5
Fort Peck IR	Sulfur	0.141	0.002	0.051	0.000	0.041	0.088	0.050	0.030	5.0
	Nitrogen	0.072	0.001	0.049	0.000	0.063	0.022	0.049	0.006	1.5
Gates of the Mountain WA	Sulfur	0.080	0.000	0.061	0.000	0.067	0.019	0.061	0.006	5.0
	Nitrogen	0.066	0.002	0.039	0.000	0.020	0.026	0.038	0.035	1.5
Grand Teton NP	Sulfur	0.149	0.000	0.049	0.000	0.021	0.101	0.049	0.052	5.0
	Nitrogen	0.094	0.005	0.062	0.001	0.053	0.031	0.060	0.038	1.5
North Absaorka WA	Sulfur	0.135	0.001	0.072	0.000	0.064	0.063	0.071	0.048	5.0
	Nitrogen	0.867	0.147	0.692	0.025	0.619	0.077	0.638	0.288	1.5
North Cheyenne IR	Sulfur	1.084	0.028	0.933	0.004	0.847	0.145	0.907	0.198	5.0
	Nitrogen	0.059	0.001	0.046	0.000	0.043	0.012	0.046	0.010	1.5
Red Rock Lakes	Sulfur	0.072	0.000	0.044	0.000	0.038	0.028	0.044	0.015	5.0
	Nitrogen	0.023	0.001	0.016	0.000	0.019	0.006	0.016	0.003	1.5
Scapegoat WA	Sulfur	0.034	0.000	0.021	0.000	0.026	0.013	0.021	0.004	5.0
	Nitrogen	0.070	0.003	0.041	0.000	0.023	0.026	0.040	0.035	1.5
Teton WA	Sulfur	0.120	0.001	0.053	0.000	0.028	0.070	0.053	0.047	5.0
	Nitrogen	0.247	0.026	0.080	0.003	0.040	0.182	0.071	0.085	1.5
Theodore Roosevelt NP	Sulfur	0.315	0.005	0.091	0.000	0.048	0.225	0.090	0.072	5.0
	Nitrogen	0.123	0.014	0.072	0.003	0.057	0.037	0.066	0.044	1.5
U.L. Bend WA	Sulfur	0.154	0.003	0.085	0.001	0.077	0.066	0.084	0.040	5.0
	Nitrogen	0.098	0.006	0.056	0.001	0.038	0.036	0.054	0.057	1.5
Washakie WA	Sulfur	0.150	0.002	0.074	0.000	0.052	0.074	0.074	0.078	5.0
	Nitrogen	0.330	0.066	0.196	0.016	0.050	0.070	0.153	0.250	1.5
Wind Cave NP	Sulfur	0.441	0.015	0.303	0.002	0.067	0.124	0.297	0.332	5.0
	Nitrogen	0.091	0.004	0.061	0.001	0.053	0.026	0.059	0.033	1.5
Yellowstone NP	Sulfur	0.132	0.001	0.065	0.000	0.057	0.082	0.065	0.045	5.0
CLASS I / CLASS II SENSITIVE LAKES										
	Nitrogen	0.114	0.007	0.057	0.000	0.012	0.050	0.056	0.096	1.5
Black Joe Lake, Bridger WA	Sulfur	0.174	0.002	0.092	0.000	0.016	0.081	0.092	0.132	5.0
	Nitrogen	0.120	0.007	0.059	0.000	0.012	0.054	0.058	0.102	1.5
Deep Lake, Bridger WA	Sulfur	0.178	0.002	0.094	0.000	0.015	0.082	0.094	0.135	5.0
	Nitrogen	0.168	0.031	0.093	0.004	0.049	0.044	0.081	0.111	1.5
Emerald Lake, Cloud Peak WA	Sulfur	0.197	0.006	0.113	0.001	0.069	0.077	0.111	0.107	5.0
	Nitrogen	0.177	0.037	0.097	0.004	0.047	0.043	0.084	0.122	1.5
Florence, Cloud Peak WA	Sulfur	0.203	0.008	0.119	0.001	0.067	0.077	0.117	0.116	5.0
	Nitrogen	0.084	0.003	0.044	0.000	0.008	0.037	0.043	0.070	1.5
Hobbs Lake, Bridger WA	Sulfur	0.135	0.001	0.073	0.000	0.011	0.061	0.073	0.099	5.0
	Nitrogen	0.144	0.008	0.067	0.001	0.013	0.069	0.066	0.125	1.5
Lower Saddlebag, Popo Agie WA	Sulfur	0.218	0.002	0.108	0.000	0.016	0.107	0.108	0.171	5.0
	Nitrogen	0.069	0.003	0.036	0.000	0.010	0.030	0.035	0.053	1.5
Ross Lake, Cloud Peak WA	Sulfur	0.106	0.001	0.056	0.000	0.014	0.049	0.056	0.071	5.0
	Nitrogen	0.129	0.007	0.062	0.000	0.012	0.060	0.061	0.112	1.5
Upper Frozen Lake, Bridger WA	Sulfur	0.187	0.002	0.098	0.000	0.015	0.087	0.098	0.143	5.0

Table 3-8
Change in Modeled Deposition of Nitrogen and Sulfur - 2020 Lower Production Scenario Minus Base Year (2004)

Receptor Set	POLLUTANT	Maximum Deposition (kg/ha/yr)								Level of Concern (kg/ha/yr)
		ALL Sources	*CBNG*	*Coal-related Sources*	*Coal Mines*	*Montana Sources*	*Non-coal Sources*	*Power Plants*	*Wyoming Sources*	
CLASS I AREAS										
Badlands NP	Nitrogen	0.045	0.011	0.033	0.001	0.021	0.001	0.025	0.025	1.5
	Sulfur	0.037	0.003	0.033	0.000	0.023	0.000	0.032	0.015	5.0
Bob Marshall WA	Nitrogen	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	1.5
	Sulfur	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	5.0
Bridger WA	Nitrogen	0.009	0.005	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.008	0.001	0.006	0.000	0.003	0.000	0.006	0.004	5.0
Fitzpatrick WA	Nitrogen	0.006	0.003	0.004	0.000	0.003	0.000	0.004	0.004	1.5
	Sulfur	0.005	0.001	0.005	0.000	0.003	0.000	0.005	0.002	5.0
Fort Peck IR	Nitrogen	0.018	0.004	0.013	0.000	0.008	0.000	0.011	0.009	1.5
	Sulfur	0.016	0.001	0.015	0.000	0.012	0.000	0.015	0.005	5.0
Gates of the Mountain WA	Nitrogen	0.006	0.000	0.005	0.000	0.005	0.000	0.005	0.001	1.5
	Sulfur	0.005	0.000	0.005	0.000	0.005	0.000	0.005	0.001	5.0
Grand Teton NP	Nitrogen	0.003	0.001	0.002	0.000	0.001	0.000	0.002	0.002	1.5
	Sulfur	0.003	0.000	0.003	0.000	0.002	0.000	0.003	0.002	5.0
North Absaorka WA	Nitrogen	0.018	0.003	0.016	0.000	0.014	0.000	0.015	0.004	1.5
	Sulfur	0.017	0.001	0.016	0.000	0.014	0.000	0.016	0.002	5.0
North Cheyenne IR	Nitrogen	0.489	0.008	0.497	0.001	0.464	0.011	0.473	0.055	1.5
	Sulfur	0.569	0.003	0.567	0.000	0.534	0.001	0.563	0.031	5.0
Red Rock Lakes	Nitrogen	0.003	0.001	0.003	0.000	0.002	0.000	0.003	0.001	1.5
	Sulfur	0.003	0.000	0.003	0.000	0.002	0.000	0.003	0.001	5.0
Scapegoat WA	Nitrogen	0.003	0.000	0.002	0.000	0.002	0.000	0.002	0.001	1.5
	Sulfur	0.003	0.000	0.003	0.000	0.002	0.000	0.003	0.000	5.0
Teton WA	Nitrogen	0.009	0.002	0.006	0.000	0.006	0.000	0.006	0.003	1.5
	Sulfur	0.004	0.000	0.007	0.000	0.006	0.000	0.007	0.002	5.0
Theodore Roosevelt NP	Nitrogen	0.024	0.012	0.028	0.001	0.018	0.000	0.023	0.023	1.5
	Sulfur	0.027	0.002	0.026	0.000	0.018	0.000	0.025	0.011	5.0
U.L. Bend WA	Nitrogen	0.036	0.006	0.030	0.000	0.024	0.001	0.027	0.012	1.5
	Sulfur	0.034	0.001	0.032	0.000	0.027	0.000	0.032	0.007	5.0
Washakie WA	Nitrogen	0.017	0.004	0.012	0.000	0.012	0.000	0.012	0.006	1.5
	Sulfur	0.013	0.001	0.012	0.000	0.013	0.000	0.011	0.003	5.0
Wind Cave NP	Nitrogen	0.104	0.030	0.072	0.003	0.033	0.002	0.045	0.071	1.5
	Sulfur	0.076	0.007	0.069	0.000	0.036	0.001	0.065	0.042	5.0
Yellowstone NP	Nitrogen	0.017	0.002	0.008	0.000	0.010	0.000	0.007	0.003	1.5
	Sulfur	0.003	0.000	0.012	0.000	0.012	0.000	0.012	0.002	5.0
CLASS I / CLASS II SENSITIVE LAKES										
Black Joe Lake, Bridger WA	Nitrogen	0.010	0.005	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.007	0.001	0.006	0.000	0.003	0.000	0.006	0.004	5.0
Deep Lake, Bridger WA	Nitrogen	0.009	0.004	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.007	0.001	0.006	0.000	0.003	0.000	0.006	0.004	5.0
Emerald Lake, Cloud Peak WA	Nitrogen	0.045	0.013	0.030	0.000	0.020	0.003	0.023	0.025	1.5
	Sulfur	0.031	0.002	0.028	0.000	0.021	0.001	0.027	0.010	5.0
Florence, Cloud Peak WA	Nitrogen	0.051	0.018	0.031	0.001	0.020	0.003	0.024	0.031	1.5
	Sulfur	0.033	0.003	0.029	0.000	0.022	0.001	0.028	0.011	5.0
Hobbs Lake, Bridger WA	Nitrogen	0.005	0.002	0.003	0.000	0.002	0.000	0.003	0.004	1.5
	Sulfur	0.005	0.001	0.004	0.000	0.002	0.000	0.004	0.003	5.0
Lower Saddlebag, Popo Agie WA	Nitrogen	0.012	0.006	0.006	0.000	0.003	0.000	0.005	0.008	1.5
	Sulfur	0.008	0.001	0.007	0.000	0.003	0.000	0.007	0.005	5.0
Ross Lake, Cloud Peak WA	Nitrogen	0.006	0.002	0.004	0.000	0.002	0.000	0.003	0.003	1.5
	Sulfur	0.005	0.001	0.004	0.000	0.002	0.000	0.004	0.002	5.0
Upper Frozen Lake, Bridger WA	Nitrogen	0.009	0.004	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.007	0.001	0.006	0.000	0.003	0.000	0.006	0.004	5.0

Table 3-9
Change in Modeled Deposition of Nitrogen and Sulfur - 2020 Upper Production Scenario Minus Base Year (2004)

Receptor Set	POLLUTANT	Maximum Deposition (kg/ha/yr)								Level of Concern (kg/ha/yr)
		ALL Sources	*CBNG*	*Coal-related Sources*	*Coal Mines*	*Montana Sources*	*Non-coal Sources*	*Power Plants*	*Wyoming Sources*	
CLASS I AREAS										
Badlands NP	Nitrogen	0.048	0.011	0.036	0.001	0.022	0.001	0.026	0.027	1.5
	Sulfur	0.039	0.003	0.036	0.000	0.025	0.000	0.034	0.015	5.0
Bob Marshall WA	Nitrogen	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	1.5
	Sulfur	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	5.0
Bridger WA	Nitrogen	0.010	0.005	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.008	0.001	0.006	0.000	0.003	0.000	0.006	0.005	5.0
Fitzpatrick WA	Nitrogen	0.006	0.003	0.004	0.000	0.003	0.000	0.004	0.004	1.5
	Sulfur	0.005	0.001	0.005	0.000	0.003	0.000	0.005	0.002	5.0
Fort Peck IR	Nitrogen	0.019	0.004	0.015	0.000	0.009	0.000	0.012	0.009	1.5
	Sulfur	0.017	0.001	0.017	0.000	0.013	0.000	0.016	0.005	5.0
Gates of the Mountain WA	Nitrogen	0.006	0.000	0.006	0.000	0.005	0.000	0.005	0.001	1.5
	Sulfur	0.005	0.000	0.005	0.000	0.005	0.000	0.005	0.001	5.0
Grand Teton NP	Nitrogen	0.003	0.001	0.002	0.000	0.001	0.000	0.002	0.002	1.5
	Sulfur	0.003	0.000	0.003	0.000	0.002	0.000	0.003	0.002	5.0
North Absaorka WA	Nitrogen	0.020	0.003	0.016	0.000	0.015	0.000	0.015	0.004	1.5
	Sulfur	0.018	0.001	0.018	0.000	0.016	0.000	0.017	0.002	5.0
North Cheyenne IR	Nitrogen	0.553	0.008	0.561	0.002	0.523	0.011	0.524	0.062	1.5
	Sulfur	0.699	0.003	0.704	0.000	0.655	0.001	0.680	0.032	5.0
Red Rock Lakes	Nitrogen	0.004	0.001	0.003	0.000	0.002	0.000	0.003	0.001	1.5
	Sulfur	0.003	0.000	0.003	0.000	0.002	0.000	0.003	0.001	5.0
Scapegoat WA	Nitrogen	0.003	0.000	0.002	0.000	0.002	0.000	0.002	0.001	1.5
	Sulfur	0.003	0.000	0.003	0.000	0.003	0.000	0.003	0.000	5.0
Teton WA	Nitrogen	0.010	0.002	0.007	0.000	0.006	0.000	0.006	0.003	1.5
	Sulfur	0.004	0.000	0.007	0.000	0.007	0.000	0.007	0.002	5.0
Theodore Roosevelt NP	Nitrogen	0.026	0.012	0.031	0.001	0.019	0.000	0.024	0.024	1.5
	Sulfur	0.029	0.002	0.029	0.000	0.020	0.000	0.028	0.011	5.0
U.L. Bend WA	Nitrogen	0.038	0.006	0.032	0.000	0.025	0.001	0.028	0.013	1.5
	Sulfur	0.036	0.001	0.035	0.000	0.029	0.000	0.034	0.007	5.0
Washakie WA	Nitrogen	0.017	0.004	0.013	0.000	0.013	0.000	0.012	0.006	1.5
	Sulfur	0.014	0.001	0.013	0.000	0.014	0.000	0.012	0.003	5.0
Wind Cave NP	Nitrogen	0.112	0.030	0.080	0.005	0.035	0.002	0.047	0.077	1.5
	Sulfur	0.081	0.007	0.074	0.000	0.040	0.001	0.069	0.043	5.0
Yellowstone NP	Nitrogen	0.017	0.002	0.009	0.000	0.010	0.000	0.008	0.003	1.5
	Sulfur	0.003	0.000	0.013	0.000	0.013	0.000	0.012	0.002	5.0
CLASS I / CLASS II SENSITIVE LAKES										
Black Joe Lake, Bridger WA	Nitrogen	0.010	0.005	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.007	0.001	0.006	0.000	0.003	0.000	0.006	0.004	5.0
Deep Lake, Bridger WA	Nitrogen	0.010	0.004	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.007	0.001	0.006	0.000	0.003	0.000	0.006	0.004	5.0
Emerald Lake, Cloud Peak WA	Nitrogen	0.048	0.013	0.033	0.001	0.022	0.003	0.025	0.026	1.5
	Sulfur	0.034	0.002	0.031	0.000	0.024	0.001	0.030	0.010	5.0
Florence, Cloud Peak WA	Nitrogen	0.054	0.018	0.034	0.001	0.022	0.003	0.025	0.032	1.5
	Sulfur	0.036	0.003	0.032	0.000	0.025	0.001	0.031	0.011	5.0
Hobbs Lake, Bridger WA	Nitrogen	0.006	0.002	0.004	0.000	0.002	0.000	0.003	0.004	1.5
	Sulfur	0.005	0.001	0.004	0.000	0.002	0.000	0.004	0.003	5.0
Lower Saddlebag, Popo Agie WA	Nitrogen	0.012	0.006	0.006	0.000	0.004	0.000	0.005	0.008	1.5
	Sulfur	0.009	0.001	0.007	0.000	0.004	0.000	0.007	0.005	5.0
Ross Lake, Cloud Peak WA	Nitrogen	0.006	0.002	0.004	0.000	0.002	0.000	0.003	0.004	1.5
	Sulfur	0.005	0.001	0.005	0.000	0.003	0.000	0.004	0.002	5.0
Upper Frozen Lake, Bridger WA	Nitrogen	0.010	0.004	0.005	0.000	0.003	0.000	0.004	0.007	1.5
	Sulfur	0.007	0.001	0.006	0.000	0.003	0.000	0.006	0.004	5.0

The projected changes in ANC are provided in **Table 3-10** for the analyzed lakes. Modeling results are provided for the base year (2004) analysis as well as the lower and upper production scenarios for 2020. The level of acceptable change was based on a 10 percent change in ANC for lakes with an ANC of 25 µeq/L or greater and a 1 µeq/L threshold change for lakes with an ANC value of less than 25 µeq/L.

Table 3-10
Modeled Impacts on Acid Neutralizing Capacity of Sensitive Lakes – 2020 Production Scenarios

Location	Lake	Background ANC (µeq/L)	Area (hectares)	Base Year (2004) Change (percent)	2020 Lower Development Scenario Change (percent)	2020 Upper Development Scenario Change (percent)	Thresholds (percent)
Bridger WA	Black Joe	67	890	4.00	4.26	4.27	10
	Deep	60	205	4.70	4.98	4.99	10
	Hobbs	70	293	3.95	4.14	4.15	10
	Upper Frozen	5	64.8	2.42	2.55	2.56	1[1]
Cloud Peak WA	Emerald	55.3	293	5.24	6.69	6.80	10
	Florence	32.7	417	9.09	11.79	11.99	10
Fitzpatrick WA	Ross	53.5	4,455	2.72	2.89	2.90	10
Popo Agie WA	Lower Saddlebag	55.5	155	6.28	6.65	6.67	10

[1] Threshold value for Upper Frozen Lake is reported as the ANC in µeq/L, which is the standard for lakes with less than 25 µeq/L ANC (USFS 2000).

At Upper Frozen Lake, the base year (2004) impact was 2.4 µeq/L, which is significantly above the threshold value of 1 µeq/L for these lakes. The modeled results for both 2020 production scenarios show minor reductions to the ANC level at Upper Frozen Lake with a total ANC of 2.6 µeq/L.

For Florence Lake, the modeled base year impacts are 90 percent of the ANC threshold, and projected 2020 development levels contribute to impacts that cause an exceedance of the threshold.

The modeling results indicate that the proposed development scenarios may lead to impacts above the ANC threshold for two lakes in the region, although the percent change in predicted 2020 upper development scenario ANC values relative to the base year are 6 and 30 percent for Upper Frozen Lake and Florence Lake, respectively.

3.1.7 Analysis of Hazardous Air Pollutant Impacts

The study also modeled hazardous air pollutant (HAP) impacts from sources in the PRB study area. Only those areas with the greatest ambient air quality impacts were analyzed for HAP impacts. The greatest ambient air impacts are anticipated to occur only in the near-field. These areas included Wyoming and Montana near-field receptors for annual (chronic) and 1-hour (acute) impacts. Results of the 1-hour modeled impacts were compared to the reference exposure levels (RELs) (USEPA 2007). **Table 3-11** provides an analysis of the short-term impacts for the six analyzed compounds (benzene, ethyl benzene, formaldehyde, n-hexane, toluene, and xylene) compared to the RELs. Results show that potential impacts from these compounds would be well below the RELs at all locations.

Table 3-11
Modeled Maximum Acute Concentrations of Hazardous Air Pollutants at Near-field Receptors from All Sources

Receptor Set	Pollutant	Averaging Period[1]	Base Year (2004)	2020 Lower Development Scenario	2020 Upper Development Scenario	REL
Near-field Receptors			**All Data in μg/m³**			
Montana Near-field Receptors	Benzene	1-hour	4.9E-02	6.4E-02	9.9E-02	1,300
	Ethyl Benzene	1-hour	3.5E-03	4.7E-03	7.2E-03	35,000
	Formaldehyde	1-hour	1.2E-01	1.2E-01	1.2E-01	94
	n-Hexane	1-hour	4.0E+00	4.0E+00	4.0E+00	39,000
	Toluene	1-hour	9.0E-03	1.2E-02	1.8E-02	37,000
	Xylene	1-hour	1.1E-03	1.4E-03	2.2E-03	22,000
Wyoming Near-field Receptors	Benzene	1-hour	9.4E-02	1.2E-01	1.4E-01	1,300
	Ethyl Benzene	1-hour	6.8E-03	8.8E-03	1.0E-02	35,000
	Formaldehyde	1-hour	1.4E-01	1.4E-01	1.4E-01	94
	n-Hexane	1-hour	4.8E+00	4.8E+00	4.8E+00	39,000
	Toluene	1-hour	1.7E-02	2.2E-02	2.6E-02	37,000
	Xylene	1-hour	2.1E-03	2.6E-03	3.1E-03	22,000

[1] Data for ethyl benzene and n-hexane are based on Immediately Dangerous to Life or Health (IDLH)/100 values.

The impacts for chronic and carcinogenic risks are provided in **Table 3-12** for the Montana and Wyoming near-field receptor grids. Based on the modeling results, potential impacts from these compounds would be well below the non-carcinogenic reference concentrations for chronic inhalation (RfCs). The impacts for carcinogenic risk also are provided in **Table 3-12**. Potential impacts from these compounds would be well below the 1 x 10^{-6} risk. The greatest increase in the carcinogenic risk is for the Wyoming near-field where the carcinogenic risk due to benzene increases 52 percent under the 2020 upper production scenario relative to the base year risk. Despite the increases, these impacts remain 3 percent or less of the threshold of acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}, as provided by the USEPA (2007).

3.2 Comparison to Original Study

With a few notable exceptions, the original Task 3A qualitative projections for 2020 are consistent with the findings of the current update. One important difference between the updated Task 3A studies (for both 2015 and 2020) and the original Task 3A study is the large increase in projected 2015 and 2020 impacts due to CBNG development. While the original Task 3A study was based on preliminary Task 2 CBNG development production, this updated study used the final Task 2 (October 2005) development projections for CBNG, which were 15 to 30 percent greater than the projections used in the original Task 3A Report. This increase suggests that while previously coal development was the most substantial contributor to projected future year increases, based on the final Task 2 projections, CBNG development may have a secondary, or even primary, contribution to air quality impacts. Additionally, revisions of the base year emissions inventory might be substantial when comparing base year modeled impacts; however, it is difficult to determine if this is in fact the case because the model version and base year meteorology were not the same. Despite revisions to many of the tools used to analyze cumulative air quality impacts, the overall results and projected changes of this updated study generally are consistent with the original Task 1A and 3A results.

Table 3-12
Modeled Maximum Annual Concentrations of Hazardous Air Pollutants at Near-field Receptors from All Sources

Receptor Set	Pollutant	Averaging Period[1]	Base Year (2004)	2020 Lower Development Scenario	2020 Upper Development Scenario	Non-carcinogenic RfCs
Near-field Receptors – Non-carcinogenic Impacts			**All Data in μg/m³**			
Montana Near-field Receptors	Benzene	Annual	1.37E-04	1.80E-04	2.67E-04	30
	Ethyl Benzene	Annual	9.14E-06	1.22E-05	1.85E-05	1,000
	Formaldehyde	Annual	3.38E-03	3.38E-03	3.38E-03	9.8
	n-Hexane	Annual	1.12E-01	1.12E-01	1.12E-01	700
	Toluene	Annual	1.80E-04	1.81E-04	1.81E-04	5,000
	Xylene	Annual	2.87E-06	3.80E-06	5.70E-06	100
Wyoming Near-field Receptors	Benzene	Annual	3.82E-03	4.91E-03	5.71E-03	30
	Ethyl Benzene	Annual	2.76E-04	3.55E-04	4.12E-04	1,000
	Formaldehyde	Annual	2.13E-03	2.14E-03	2.14E-03	9.8
	n-Hexane	Annual	7.02E-02	7.02E-02	7.02E-02	700
	Toluene	Annual	7.21E-04	9.22E-04	1.07E-03	5,000
	Xylene	Annual	8.33E-05	1.07E-04	1.24E-04	100
Near-field Receptors – Carcinogenic Risk Evaluation[1]			**Risk Evaluation X 10^{-6}**			
Montana	Benzene	Annual	0.001	0.001	0.001	--
	Formaldehyde	Annual	0.031	0.031	0.031	--
Wyoming	Benzene	Annual	0.021	0.027	0.032	--
	Formaldehyde	Annual	0.020	0.020	0.020	--

[1] Benzene concentrations multiplied by risk factor: 7.8 X 10^{-6} X 0.71. Formaldehyde Concentrations multiplied by risk factor: 1.3 X 10^{-5} X 0.71.

Generally, the method used for projecting future year emissions was consistent between the original Task 3A report and this updated analysis; however, updated information was used in this analysis where available. Several coal-fired power plants have revised their generating capacity, as discussed in Section 2.4 Emissions Input Data. This information was used to project the 2020 upper and lower development scenarios accordingly. Additionally, the projected CBNG development activity had changed between the completion of the original Task 3A modeling analysis and the finalization of the Task 2 Report (ENSR 2005b, 2006). The finalized CBNG production levels from the Task 2 Report were used for this updated analysis. Importantly, new CBNG well locations were modeled for this updated analysis to depict the spatial shifting of well locations. **Table 3-13** provides estimated production levels, by source groups, for the original Task 3A report compared to values used for this updated analysis.

The comparison between this updated analysis and the earlier qualitative projections for 2020 in the original Task 3A report is affected to some extent by these updated production levels and their associated emissions. Overall, coal-fired power plants had limited effect on base year air quality; however, the incorporation of RFD power plants in Montana did affect areas in close proximity to the PRB, such as the Northern Cheyenne IR. Additionally, changes to CBNG production had a noticeable effect on the comparison of qualitative projections for 2020 and the modeled findings from this updated analysis. While previously coal development was the most significant contributor to projected future year increases, now CBNG development may have a secondary, or even primary, contribution to air quality impacts at some location.

Table 3-13
Comparison of Projected Development Levels by Source Group

Group	Base Year (2004)	Development Units	Scenario	Projected Development Levels – Original Task 3A			Projected Development Levels – Updated Analysis[1]		
				2010	2015	2020	2010	2015	2020
Conventional Oil and Gas Sources	39.9	BCF	Same for both scenarios	42.7	39.0	35.1	42.7	39.0	35.1
CBNG Sources	338	BCF	Same for both scenarios	554	530	521	640	694	631
Coal Production, Wyoming	363	mmtpy	Lower	411	467	495	411	467	495
			Upper	479	543	576	479	543	576
Coal Production, Montana	36.1	mmtpy	Lower	41	48	56	41	48	56
			Upper	51	74	83	51	74	83
Power Plants, Wyoming	512	MW Generating Capacity	Lower	1,262	1,262	1,262	1,262	2,002	2,002
			Upper	1,512	1,512	1,962	1,512	2,002	2,702
Power Plants, Montana	2,576	MW Generating Capacity	Lower	2,689	3,439	3,439	2,689	2,802	3,552
			Upper	2,689	3,439	4,189	2,689	2,802	4,302

[1] Projected development for 2010 and 2020 did not change from the Task 2 Report (ENSR 2005b), with the exception of RFD scenarios for power plants that were revised specifically for 2015 and 2020 based on updated information. For this reason, the projected power plant development levels have changed for 2015 and 2020.

3.2.1 Impacts on Ambient Air Quality

3.2.1.1 Wyoming Near-field Impacts

The original Task 3A qualitative analysis for 2015 and 2020 suggested that “coal production is anticipated to contribute substantially to impacts on the near-field receptor grid in Wyoming, particularly PM_{10} impacts … and the projected increase in coal production likely would continue to affect the PM_{10} air quality levels.” This statement is supported by the findings in this updated study. Additionally, this updated study suggests that PM_{10} impacts are indicative of $PM_{2.5}$ impacts. While, similar to previous findings, 24-hour and annual exceedances of these pollutants are projected to occur in 2020, this updated study suggests that these trends primarily are due to projected CBNG development rather than solely due to coal development. Nonetheless, as shown in **Figures 3-2, 3-3,** and **3-4**, exceedances still would be limited to small individual receptor areas in the near-field.

Power plant emissions are still projected to be the major contributors to increased annual impacts of SO_2 in the near-field receptor grid for the 2020 modeled impacts; however, under shorter averaging periods (24-hour and 3-hour) SO_2 impacts predicted for 2020 are dominated by CBNG development. Regardless of the source contribution to SO_2 impacts, the predicted impacts would continue to be well below ambient standards despite substantial increases in projected development.

The NO_2 impacts are the result of emissions from all source groups with base year impacts dominated by coal production and future year impacts predicted to result from CBNG development. At the time of the original study, it was unclear if the NO_2 standard would be exceeded in 2015 or

2020 as a result of projected development in the PRB study area, but results from this updated study do not show any exceedances.

3.2.1.2 Montana Near-field Impacts

In general the original predicted Montana near-field impacts for 2015 and 2020 are substantially different for this updated study. The base year impacts are substantially different between the original study and the updated studies (both 2015 and 2020 updates), and it is believed that this is a result of the revised emission inventory. The differences of SO_2 impacts are relatively minor, while predicted NO_2 and PM impacts are notably lower than original predictions. In addition to changes in the base year inventory, it is predicted that the CBNG shifting of well locations will reduce Montana near-field impacts relative to 2015 projections. Despite these substantial differences, the modeled impacts on the Montana near-field receptors were well below the ambient standards for all pollutants, and continue to remain below the ambient standards into the future.

In the original study, coal production contributed substantially to impacts on the near-field receptor grid in Montana, while in this updated study, the source contribution to maximum impacts includes both CBNG, power plants, and coal sources, depending on the air pollutant.

3.2.2 Impacts at Class I Area Receptors

As noted in Section 3.1.2, the projected impacts in Class I areas in 2020 would be below the ambient standards. The PM_{10} and $PM_{2.5}$ impacts at the Northern Cheyenne IR and Wind Cave NP were greater than any other Class I area, and those impacts tended to result from sources in Wyoming with no single source type clearly dominating impacts. The 24-hour PM_{10} impact at both of these Class I areas is higher than the comparative PSD increment. These results are consistent with the original study's projections.

3.2.3 Impacts at Sensitive Class II Areas

From the 2010 modeling results, the Crow IR and Cloud Peak WA showed the highest air quality impacts for the identified sensitive Class II areas. Current modeling results are consistent with the qualitative impacts from the original study, with 2020 impacts in the Crow IR predicted to be the highest of the Class II areas evaluated, and impacts at all areas remaining below ambient standards.

3.2.4 Impacts on Visibility

Model results of visibility impacts at Class I areas and identified Class II areas (Section 3.1.4) showed that a large number of days had modeled impacts for 2010 above 10 percent (1 dv) reduction in visibility at all identified areas. The base year visibility impacts for Class I areas exhibited a small decrease in this updated study relative to the original Task 3A study; however, base year impacts at Class II areas showed a marked increase, with two Class II area predicted to have more than 300 days per year with more than a 10 percent change in visibility due to regional sources. The substantial differences in base year impacts did not appreciably alter the original projected impacts for 2020 projected in the Task 3A Report. While it was predicted that in 2010 Class I areas would have an increase of up to 20 more days per year that experience greater than

10 percent change in visibility, it is predicted that in 2020, the number of days with a 10 percent change would increase to more than 60 for the Northern Cheyenne IR.

3.2.5 Impacts on Acid Deposition and Sensitive Lake Acid Neutralizing Capacity

Results of the change in ANC for the identified lakes for both 2010 and 2020 showed that deposition at two separate lakes would result in reductions in ANC greater than the established thresholds. Those lakes (Upper Frozen Lake and Florence Lake) would continue to be impacted by the increased development in the PRB study area. However, impacts to the other lakes were well below the thresholds, and expected increases in development likely would not lead to impacts at the other sensitive lakes.

Modeled impacts on acid deposition in Class I areas for 2010 and 2020 also were well below the established sensitive thresholds. Increased development would not likely lead to exceedances of those thresholds for any identified sensitive areas.

3.2.6 Analysis of Hazardous Air Pollutant Emissions

The original base year (2002) study and the analysis of development for 2010 showed that the modeled formaldehyde levels were above the 1-hour REL at the near-field receptor grid in Wyoming. For this updated study the predicted impacts for HAPs were well below all established thresholds, and increased development in 2020 would not likely lead to any exceedances.

4.0 REFERENCES

AECOM, Inc. (AECOM). 2009. Update of the Task 2 Report for the Powder River Basin Coal Review, Past and Present and Reasonably Foreseeable Development Activities. Prepared for Bureau of Land Management High Plains District Office and Wyoming State Office. December 2009.

ALL Consulting. 2006. Quantitative Review of Ambient Air Quality Impacts: Supplement to Statewide Final Oil and Gas Environmental Impact Statement and Amendment of the Powder River and Billings Resource Management Plans. Bureau of Land Management Miles City Office. August 2006.Bureau of Land Management (BLM). 2004. Coal mine 2003 disturbance area shape files provided to M. Paulson, ENSR.

Barron, J. 2006. Hindcasting Nitrogen Deposition to Determine a Critical Load. Ecological Applications 16(2). pp.433-439.

Bureau of Land Management (BLM). 2009. Information relative to the School Creek Mine emailed by M. Karbs, BLM, to D. Koontz, AECOM. July 8, 2009.

_____. 2004. Coal mine 2003 disturbance area shape files provided to M. Paulson, ENSR.

_____. 2003. Final Environmental Impact Statement and Plan Amendment for the Powder River Basin Oil and Gas Project. Wyoming State Office and Buffalo Field Office. January 2003.

_____. 1996. Coal Development Status Check Powder River Federal Coal Region Montana & Wyoming Data Tables. Data Compiled by: Wyoming Bureau of Land Management Buffalo Resource Area, Casper District, & State Offices, and Montana Bureau of Land Management Powder River Resource Area, Miles City District & State Offices.

ENSR. 2008a. Update of the Task 3A Report for the Powder River Basin Coal Review Cumulative Air Quality Effects for 2015. Prepared for the Bureau of Land Management Casper Field Office, Wyoming State Office, and Montana State Office. October 2008.

_____. 2008b. Dispersion Modeling Protocol for Cumulative Air Quality Assessment: Powder River Basin Coal Review. Prepared for the Bureau of Land Management Casper Field Office, Wyoming State Office, and Montana State Office. February 2008.

_____. 2008c. Compiled Addendum 2 to PSD Permit Application for the Two Elk Expansion Project. Prepared for Two Elk Corporation. January 2008.

_____. 2008d. Air Quality Technical Support Document for the 2015 Update to the Powder River Basin Coal Review. Prepared for the Bureau of Land Management Casper Field Office, Wyoming State Office, and Montana State Office. August 2008.

_____. 2006. Task 3A Report for the Powder River Basin Coal Review, Cumulative Air Quality Effects. Prepared for the Bureau of Land Management Casper Field Office, Wyoming State Office, and Montana State Office. February 2006.

_____. 2005a. Task 1A Report for the Powder River Basin Coal Review, Current Air Quality Conditions. Prepared for the Bureau of Land Management Casper Field Office, Wyoming State Office, and Montana State Office. September 2005.

_____. 2005b. Task 2 Report for the Powder River Basin Coal Review, Past, Present, and Reasonably Foreseeable Development. Prepared for the Bureau of Land Management Casper Field Office and Wyoming State Office. July 2005.

_____. 2005c. Dispersion Modeling Protocol for Cumulative Air Quality Assessment: Powder River Basin Coal Review. Prepared for the Bureau of Land Management Casper Field Office and Wyoming State Office. March 2005.

Federal Land Managers Air Quality Guide (FLAG). 2000. Federal Land Managers' Air Quality Relative Values Workgroup Phase I Report. December 2000.

Finlayson-Pitts, B. J. and J. N. Pitts, Jr. 2000. Chemistry of the Upper and Lower Atmosphere: Theory, Experiments, and Applications. Academic Press: San Diego, California. pp. 265.

Fox et al. 1989. A Screening Procedure to Evaluate Air Pollution Effects on Class I Wilderness Areas. Report RM-168. USDA Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Montgomery Watson Harza (MWH). 2003. Coal Planning Estimates Report. Prepared for the Bureau of Land Management Wyoming State Office. March 2003.

Scire, J. S., D. S. Strimitis, and R. J. Yamartino. 2000a. A User's Guide for the CALPUFF Disperion Model (Version 5.0). Earth Tech, Inc., Concord, Massachusetts. October 1999.

Scire, J. S., F. R. Robe, M. E. Fernau, and R. J. Yamartino. 2000b. A User's Guide for the CALMET Meteorological Model (Version 5.0). Earth Tech, Inc. Concord, Massachusetts. September 1999.

Surface Transportation Board (STB). 2004. Draft Supplemental Environmental Impact Statement – Tongue River Railroad Company, Construction and Operation, Western Alignment, Tongue River III Rosebud and Bighorn Counties, Montana. STB ID# 35117. Washington D.C. October 2004.

_____. 2000. Draft Environmental Impact Statement – Dakota, Minnesota, and Eastern Railway Corporation New Railway Retrofit Project: Appendix E, Air Quality. Technical Support Document. STB ID# 20743. Washington, D.C. September 2000.

Thunder Basin Coal Company. 2003. 2002-2003 Coal Creek Mine Annual Report. Permit No. 483-T4. February 2003.

Wyoming Department of Environmental Quality (WDEQ). 2006. Permit Application Analysis AP-3934. WDEQ, Division of Air Quality. October 2006.

U.S. Environmental Protection Agency (USEPA). 2007. Air Toxics Database. Dose-Response Assessment for Assessing Health Risks Associated with Exposures to Hazardous Air Pollutants. Office of Air and Planning Standards. Internet website: http://www.epa.gov/ttn/atw/toxsource/summary.html

U.S. Forest Service (FS). 2000. Rocky Mountain Region. Screening Methodology for Calculating ANC Change to High Elevation Lakes. December 2000.

_____. 2006. Forest Inventory and Analysis. United States Forest Service. Internet website: http://www.fia.fs.fed.us/.

Appendix A

National and State Ambient Air Quality Standards for the PRB Coal Review

Table A-1
National and State Ambient Air Quality Standards
For the PRB Coal Review

Pollutant	Averaging Period	National	Wyoming	Montana
PM_{10}	Annual	50 µg/m³ arithmetic average	Same as NAAQS	50 µg/m³, state and federal violation when more than one expected exceedance per calendar year, averaged over 3 years.
	24-hour	The 150 µg/m³ standard has been revoked at the date of this report.	150 µg/m³, maximum average concentration, no more than one exceedance per year.	150 µg/m³, state and federal violation when the 3-year average of the arithmetic means over a calendar year exceeds the standard.
$PM_{2.5}$	Annual	15 µg/m³, 3-year average of annual arithmetic mean.	15 µg/m³, annual arithmetic mean	Same as NAAQS.
	24-Hour	35 µg/m³, 98th percentile of the 24-hour values determined for each year. 3-year average of the 98th percentile values.	35 µg/m³, 98th percentile 24-hour average	Same as NAAQS.
SO_2	Annual	0.03 ppm (80 µg/m³), annual arithmetic mean not to be exceeded in any calendar year.	60 µg/m³, arithmetic mean	0.02 ppm, state violation when the arithmetic average over any four consecutive quarters exceeds the standard.
	24-hour	0.14 ppm (365 µg/m³), not to be exceeded more than once in any calendar year	260 µg/m³, maximum concentration not to be eceeded more than once per year	10 ppm, rolling average, not to be exceeded more than once every 12 consecutive months.
	3-hour	0.50 ppm (1,300 µg/m³), not to be exceeded more than once in any calendar year (secondary standard)	1,300 µg/m³ (0.50 ppm), maximum concentration not to be exceeded more than once per year.	Same as NAAQS.
	1-hour	No standard	--	0.5 ppm, not to be exceeded more than 18 times in any 12 consecutive months.
CO	8-hour	10 mg/m³ (9 ppm), maximum concentration not to be exceeded more than once per year	Same as NAAQS	9 ppm, not to be exceeded more than once over any 12 consecutive months.
	1-hour	35 ppm (40 mg/m³), maximum concentration not to be exceeded more than once per year.	Same as NAAQS	23 ppm, not to be exceeded more than once over any 12 consecutive months.
NO_2	Annual	0.053 ppm (100 µg/m³) Annual arithmetic mean	Same as NAAQS	0.05 ppm, not to be exceeded more than once over any 12 consecutive months.
	1-hour	--	--	0.30 ppm, not to be exceeded more than once over any 12 consecutive months.

[1]Hydrogen sulfide, ozone, and lead are not being modeled for this study; hence, they are not included in this table.