Update of Task 3A Report for the Powder River Basin Coal Review Cumulative Air Quality Effects for 2015

Prepared for

Bureau of Land Management
Casper Field Office,
Wyoming State Office, and
Miles City Field Office

Submitted by

ENSR Corporation
Fort Collins, Colorado

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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 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 identified in the Task 2 study.

This update to the Task 3A Report provides a modeled change in impacts on air quality and AQRVs resulting from the projected RFD activities in 2015. Similar to the original Task 3A Report, impacts due to development of selected source types were evaluated at various receptor locations. Four 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;
- An improved base year emissions inventory; and
- Updated RFD emission sources and projected emissions activities to 2015.

This updated Task 3A Report details these changes, provides a summary of impacts for the revised base year (2004) and projected 2015 scenarios, and compares projected 2015 results to both the revised base year and the qualitative projections from the original Task 3A report.

ES.2 TECHNICAL APPROACH

Similar to the original Task 3A Report, this updated analysis evaluates base year impacts, and two levels of coal development: a lower production (or development) scenario and a higher 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 counties include 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 counties include 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 2015) 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 update to the Task 3A study, the original 2015 qualitative evaluations are quantitatively updated based on the same approach previously used to predict ambient air quality impacts for 2010.

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 Task1A and original Task 3A studies. The modeling domain is identical to the Task 1A and original 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 2008).

Previously, the base year inventory was developed for actual emissions in 2002; for this update, the base year emissions inventory is for year 2004. Year 2004 emission inventory data previously were developed for the Montana Statewide Oil and Gas Supplemental Environmental Impact Statement (EIS) (ALL Consulting 2006). This inventory was selected because extensive work was conducted to consolidate available emissions inventories for coal evaluation studies. The base year emissions inventory is projected into future year 2015 for upper and lower production scenarios. Key major sources were included, such as the coal-fired power plants, gas-fired power plants, and sources

that were included in the Title V (operating permit) program. The Dave Johnston Power Plant, located in Converse County, is located outside of but adjacent to the study area, and specifically was included in the base year study and in the projected emissions. Some operational adjustments were made to accommodate small sources that were presumed to be operating at less than full capacity. Emissions from other sources, including estimated fugitive dust construction emissions, were computed based on USEPA emission factors and on input data from the Wyoming Department of Environmental Quality (WDEQ).

Three years of meteorological data (2001, 2002, and 2003) were used to evaluate base year impacts from all emission sources within the PRB study area. 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. The meteorological year 2003 was then used to model impacts for all emissions sources for the revised base year and 2015 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 2015 cumulative air quality impacts for comparison to both the base year impacts and the 2015 qualitative projections from the original Task 3A report. For this updated study, the base year (2004) and projected future year (2015) impacts are evaluated using the same receptor set and modeling domain used for the Task 1A and original Task 3A reports. The base year (2004) and 2015 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. This report documents the predicted base year (2004) impacts and the predicted impacts for 2015 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 2015.

ES.3 CUMULATIVE IMPACTS

Generally, measured air quality conditions are very 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}), PM with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$), and nitrogen dioxide (NO_2) in areas located in close proximity to the study area. 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 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 the base year (2004) analysis and for both 2015 development scenarios. Peak impacts occur at isolated receptors and are likely due to a unique source-receptor relationship. The model results should not be construed as predicting an actual exceedence of any standard, but are at best forecasts that indicate 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 2015. The 2015 development scenarios show a doubling in the concentration relative to the base year for these parameters. Additionally, 2015 development scenarios show a 30 to 50 percent increase of annual PM_{10} and $PM_{2.5}$ concentrations at Wyoming near-field receptors. This level of increase would lead to exceedences of annual standards for both PM_{10} and $PM_{2.5}$.[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 except the 1-hour NO_2 impacts. The predicted 1-hour NO_2 concentrations at Montana near-field receptors for the base year (2004) did not exceed the SAAQS. Modeling for the 2015 development scenarios show a doubling in the maximum 1-hour NO_2 concentrations, which would lead to an exceedence of the

[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.

Montana 1-hour NO_2 SAAQS for two receptor locations, indicating that predicted exceedences would not be regional in nature. Although large percentage increases were predicted in annual NO_2 and 24-hour PM_{10} and $PM_{2.5}$ impacts, the levels would be well below the SAAQS.

Table ES-1
Projected Maximum Potential Near-field Impacts
(µg/m^3)

Pollutant	Averaging Time	Base Year (2004) Impacts	2015 Lower Development Scenario Impacts	2015 Upper Development Scenario Impacts	NAAQS	Wyoming SAAQS	Montana SAAQS	PSD Class II Increments
Wyoming Near-field								
NO_2	Annual	31.3	46.7	47.4	100	100	--	25
SO_2	Annual	15.3	16.2	16.2	80	60	--	20
	24-hour	112.3	119.6	119.6	365	260		91
	3-hour	462.0	814.1	814.1	1,300	1,300	--	512
$PM_{2.5}$	Annual	13.4	**18.7**	**21.4**	15	15	--	--
	24-hour	**87.6**	**179.5**	**179.5**	35	35	--	--
PM_{10}	Annual	38.4	**53.5**	**61.0**	--	50	--	17
	24-hour	**250.4**	**512.8**	**512.9**	150	150	--	30
Montana Near-field								
NO_2	Annual	3.3	6.5	6.5	100	--	100	25
	1-hour	409.0	**826.3**	**826.4**	--	--	564	--
SO_2	Annual	1.6	1.7	1.7	80	--	80	20
	24-hour	16.1	16.5	16.6	365	--	365	91
	3-hour	65.0	66.5	66.5	1,300	--	1,300	512
	1-hour	162.9	166.6	166.6	--	--	1,300	--
$PM_{2.5}$	Annual	1.0	1.8	1.9	15	--	15	--
	24-hour	10.2	15.4	20.6	35	--	35	--
PM_{10}	Annual	2.8	5.2	5.3	--	--	50	17
	24-hour	29.1	44.0	58.8	150	--	150	30

Note: -- = No standard or increment.
µg/m^3 = 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) and Wind Cave National Park (NP) base year impacts are slightly above the comparative levels for 24-hour PM_{10} in the base year. For the 2015 upper and lower development scenarios, modeling results indicate substantial increases in impacts at these areas. In the Washakie Wilderness Area (WA), modeled impacts are below the ambient standards and PSD increments, and do not demonstrate a notable increase in future years. In the other Class I areas, only the modeled 24-hour PM_{10} impacts at Badlands NP are above the PSD increment levels for the 2015 development scenarios.

In the sensitive Class II areas, modeled 24-hour PM_{10} impacts exceed the Class II 24-hour PM_{10} increments at the Crow IR and Big Horn Canyon National Recreation Area (NRA) in the upper development scenario. The modeled 24-hour PM_{10} and $PM_{2.5}$ impacts at the Crow IR and Big Horn

Canyon NRA are projected to increase by 30 to 100 percent in 2015 as a result of projected coal development. For comparison purposes, modeling results for all other sensitive Class II areas are below PSD increment levels for both the base year (2004) and 2015 development scenarios.

Table ES-2
Maximum Predicted PSD Class I and Sensitive Class II Area Impacts
(µg/m^3)

Location	Pollutant	Averaging Period	Base Year (2004) Impacts	2015 Lower Development Scenario	2015 Upper Development Scenario	PSD Class I and Class II Increments
Class I Areas						
Northern Cheyenne IR	NO_2	Annual	0.4	0.6	0.9	2.5
	SO_2	Annual	0.5	0.6	0.7	2
		24-hour	3.1	3.4	3.4	5
		3-hour	9.4	9.6	9.6	25
	$PM_{2.5}$	Annual	0.3	0.5	0.5	--
		24-hour	3.4	5.1	5.1	--
	PM_{10}	Annual	0.9	1.5	1.5	4
		24-hour	**9.6**	**14.4**	**14.6**	8
Washakie WA	NO_2	Annual	0.0	0.0	0.0	2.5
	SO_2	Annual	0.2	0.2	0.2	2
		24-hour	3.0	3.1	3.1	5
		3-hour	6.3	6.3	6.3	25
	$PM_{2.5}$	Annual	0.1	0.1	0.1	--
		24-hour	1.6	1.6	1.6	--
	PM_{10}	Annual	0.2	0.2	0.2	4
		24-hour	4.5	4.6	4.7	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	4.1	4.1	5
		3-hour	7.0	7.4	7.4	25
	$PM_{2.5}$	Annual	0.4	0.5	0.5	--
		24-hour	3.8	4.6	4.7	--
	PM_{10}	Annual	1.0	1.3	1.4	4
		24-hour	**10.9**	**13.3**	**13.5**	8
Sensitive Class II Areas						
Big Horn Canyon NRA	NO_2	Annual	0.6	0.6	0.7	25
	SO_2	Annual	0.5	0.6	0.6	20
		24-hour	3.6	3.7	4.0	91
		3-hour	14.3	14.3	14.3	512
	$PM_{2.5}$	Annual	0.5	0.5	0.7	--
		24-hour	5.9	7.8	11.9	--
	PM_{10}	Annual	1.4	1.6	2.1	17
		24-hour	16.9	22.3	**34.1**	30
Crow IR	NO_2	Annual	0.9	1.4	1.7	25
	SO_2	Annual	2.3	2.3	2.3	20
		24-hour	14.4	14.6	14.6	91
		3-hour	76.8	77.0	77.0	512
	$PM_{2.5}$	Annual	0.8	1.0	1.4	--
		24-hour	7.2	9.4	14.3	--
	PM_{10}	Annual	2.2	2.9	4.1	17
		24-hour	20.5	26.9	**40.7**	30

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

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. All but a few of the sensitive Class II areas have more than 100 days per year with greater than a 10 percent change. The most significant visibility change to sensitive Class II areas 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)	2015 Lower Development Scenario	2015 Upper Development Scenario
	No. of Days >10%	Change in No. of Days > 10%	Change in No. of Days > 10%
Class I Areas			
Badlands NP	218	26	26
Bob Marshall WA	8	0	0
Bridger WA	144	2	2
Fitzpatrick WA	91	2	2
Fort Peck IR	105	10	10
Gates of the Mountain WA	55	0	0
Grand Teton NP	70	2	2
North Absaorka WA	61	3	3
North Cheyenne IR	243	32	47
Red Rock Lakes	42	2	2
Scapegoat WA	27	1	1
Teton WA	57	4	4
Theodore Roosevelt NP	178	5	9
UL Bend WA	77	8	10
Washakie WA	83	5	5
Wind Cave NP	262	18	19
Yellowstone NP	84	2	2
Sensitive Class II Areas			
Absaorka Beartooth WA	101	2	3
Agate Fossil Beds National Monument	251	20	20
Big Horn Canyon NRA	331	1	3
Black Elk WA	236	34	36
Cloud Peak WA	126	18	18
Crow IR	360	4	4
Devils Tower National Monument	274	25	26
Fort Belknap IR	66	6	7
Fort Laramie National Historic Site	260	10	10
Jedediah Smith WA	79	1	1
Jewel Cave National Monument	261	19	21
Lee Metcalf WA	97	2	2
Mount Naomi WA	51	1	1
Mount Rushmore National Monument	222	36	36
Popo Agie WA	139	4	4
Soldier Creek WA	268	18	18
Wellsville Mountain WA	130	10	10
Wind River IR	217	2	5

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 (kg/ha/yr), 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 2015 show an increased impact at Florence Lake, leading to an impact that is above the 10 percent 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)	2015 Lower Development Scenario Change (percent)	2015 Upper Development Scenario Change (percent)	Thresholds (percent)
Bridger WA	Black Joe	67	890	4.00	4.11	4.11	10
	Deep	60	205	4.70	4.82	4.82	10
	Hobbs	70	293	3.95	4.03	4.03	10
	Upper Frozen	5	64.8	2.42	2.47	2.48	1[1]
Cloud Peak WA	Emerald	55.3	293	5.24	5.97	6.02	10
	Florence	32.7	417	9.09	10.41	10.48	10
Fitzpatrick WA	Ross	53.5	4,455	2.72	2.79	2.79	10
Popo Agie WA	Lower Saddlebag	55.5	155	6.28	6.42	6.43	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 (HAP) 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 2015 development scenarios show that impacts are predicted to be well below the acute Reference Exposure Levels (REL), non-carcinogenic Reference Concentrations for Chronic Inhalation (RfC), 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 PRB development, but 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 2015 are consistent with the findings of the current update. One important difference between this updated study and previous findings is the large increase in projected 2015 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. Additionally, revisions of the base year emissions inventory might be notable when comparing base year modeled impacts; however, it is difficult to determine if this is in fact the case since the model version and base year meteorology also were different between the two analyses. A final 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 2015.

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 have 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 doubled in 2015 at some locations.

Based on modeling results, none of the acid deposition thresholds were exceeded at Class I areas for either the base year (2004) or for the lower or upper development scenarios for 2015. 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
µg/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

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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 application (LBA) as part of the leasing process. In the coal leasing EAs and EISs that have been prepared since decertification in early 1990, 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 less 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 Casper Field 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.

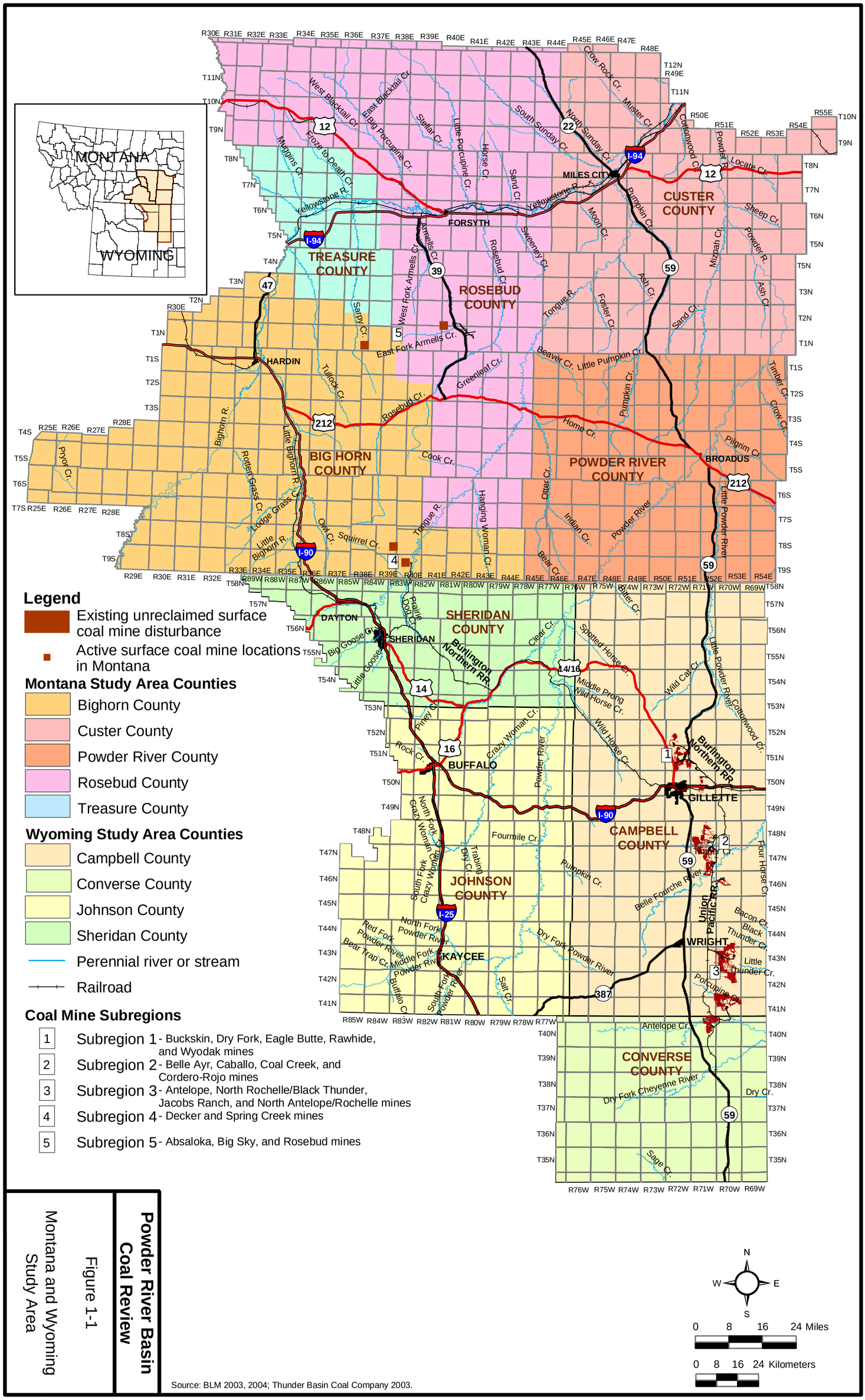
[1] http://www.blm.gov/wy/st/en/programs/energy/Coal_Resources/PRB_Coal/prbdocs.html

1.0 Introduction

The Task 2 component of the PRB Coal Review defines 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 bracket the most likely foreseeable regional coal production level and to provide a basis for quantification of related impact-causing parameters. 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 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 2015 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 had a higher level of uncertainty than is currently associated with revised projections. As the uncertainty associated with predicted developments for 2015 decreased, it became increasingly valuable to update the original Task 3A qualitative estimates for 2015 with a quantitative evaluation.

This 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 2015. This updated report is supplemental in nature and focuses exclusively on summarizing updated information and documenting any changes that have occurred since the publication of the Task 3A Report. As most of the PRB Coal Review's underlying objectives and methodology have not changed since the publication of the original Task 3A report, this update to the Task 3A report does not reiterate this information, which is available in the original Task 3A Report. Instead, this updated Task 3A Report details all technical changes relative to the original Task 3A Report in Section 2.0, provides a summary of impacts for the revised base year (2004) and projected 2015 scenarios in Section 3.0, and compares projected 2015 results to both the revised base year (2004) and to the previous qualitative projections from the original Task 3A Report in Section 4.0.



Source: BLM 2003, 2004; Thunder Basin Coal Company 2003.

Powder River Basin Coal Review

Figure 1-1

Montana and Wyoming Study Area

12/15/05

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 update to the original Task 3A report furthers the objective of estimating the environmental impacts associated with RFD through the year 2015. The primary objective for updating the Task 3A Report is to provide a quantitative evaluation of potential cumulative air quality effects for 2015.

Secondary objectives of this update are to develop the projected 2015 emissions using updated emissions from the base year (2004) and to compare the modeled impact to the previous qualitative evaluation for 2015. This objective is undertaken via a comparison of the original 2015 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. This updated Task 3A report details these changes, provides a summary of impacts for the revised base year and projected 2015 scenarios, and compares projected 2015 results to both the revised base year 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 modeling protocol for this updated study, as well as for the original study (ENSR 2008; ENSR 2005c). The modeling protocol 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 2015 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 2015 are the basis of the analysis rather than the projections for 2010.

The 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 2015 results to the qualitative 2015 projections from the original Task 3A Report is also provided.

For the original Task 1A and Task 3A reports, potential impacts were modeled using meteorological data for 1996. For this update to the Task 3A Report, meteorological data for 2001, 2002, and 2003 initially were used to evaluate base year emissions from the study area, and the year for which worst-case visibility impacts were observed was selected as the base year for use in this updated study.

For the original Task 3A Report, estimated air emissions for 2010 for the upper and lower development scenarios were based on a 2002 air emissions inventory developed as part of the identification of current conditions (Task 1A Report) scaled to 2010 based on the RFD projection scenarios developed in the Task 2 study. For this updated Task 3A Report, an updated base year inventory (2004) was used. The 2004 base year emissions inventory was modeled directly for this update. To develop a future year emissions inventory for modeling purposes, base year emissions for most groups were increased for 2015 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.

The original study only modeled air quality impacts for the 2010 lower and upper production scenarios; impacts for 2015 and 2020 were based on a qualitative evaluation of the anticipated change in emissions for source groups. For this updated study, air quality impacts for the 2015 upper and lower production scenarios were modeled. The changes from the base year to the upper and lower development scenarios for 2015 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 2015 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 2015 air quality cumulative effects 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 (2015) 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 U.S. Environmental Protection Agency (USEPA) guideline model, CALPUFF. The USEPA's CALPUFF modeling system is a regulatory guideline model that was used in both the original PRB Coal Review (ENSR 2006) and in the Montana Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006). Both of these studies were directed by the BLM and have identical modeling domain and receptor grids.

Since the conclusion of the original Task 3A study, the Montana Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006) was prepared, and newer meteorological data for the modeling domain was available for years 2001, 2002, and 2003. The base year emissions from the study area initially were modeled with each meteorological year, and the meteorological year with the worst-case visibility impact (2003) was selected to model the base year and future year scenarios for this updated study. The CALPUFF base year analysis consisted of a single year of emission inventory data (2004) evaluated with year 2003 meteorological data. The 2015 upper and lower development scenarios subsequently were modeled with meteorological year 2003 to provide a consistent basis for comparison to base year impacts.

The 2004 emission inventory developed for the Montana Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006) was used to develop the revised base year emissions inventory for the updated cumulative air quality analysis. This inventory was selected because extensive work was conducted to consolidate available emissions inventories for coal evaluation studies. This inventory includes all of the same emissions source types (e.g., coal mines, conventional oil and gas, etc.) as used in the Task 1A and original Task 3A studies.

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 PRB Coal Review to assess impacts over both near-field and far-field receptors. Since completion of the original Task 3A study, the USEPA has released a new guideline version of CALPUF. Both the original PRB Coal Review air quality modeling (ENSR 2006) and the Montana

Statewide Oil and Gas Supplemental EIS (ALL Consulting 2006) used the previous version of CALPUFF; this updated study uses the new guideline version. The modeling approach and technical options are identical between base year (2004) and predictive future year (2015) cumulative analyses.

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

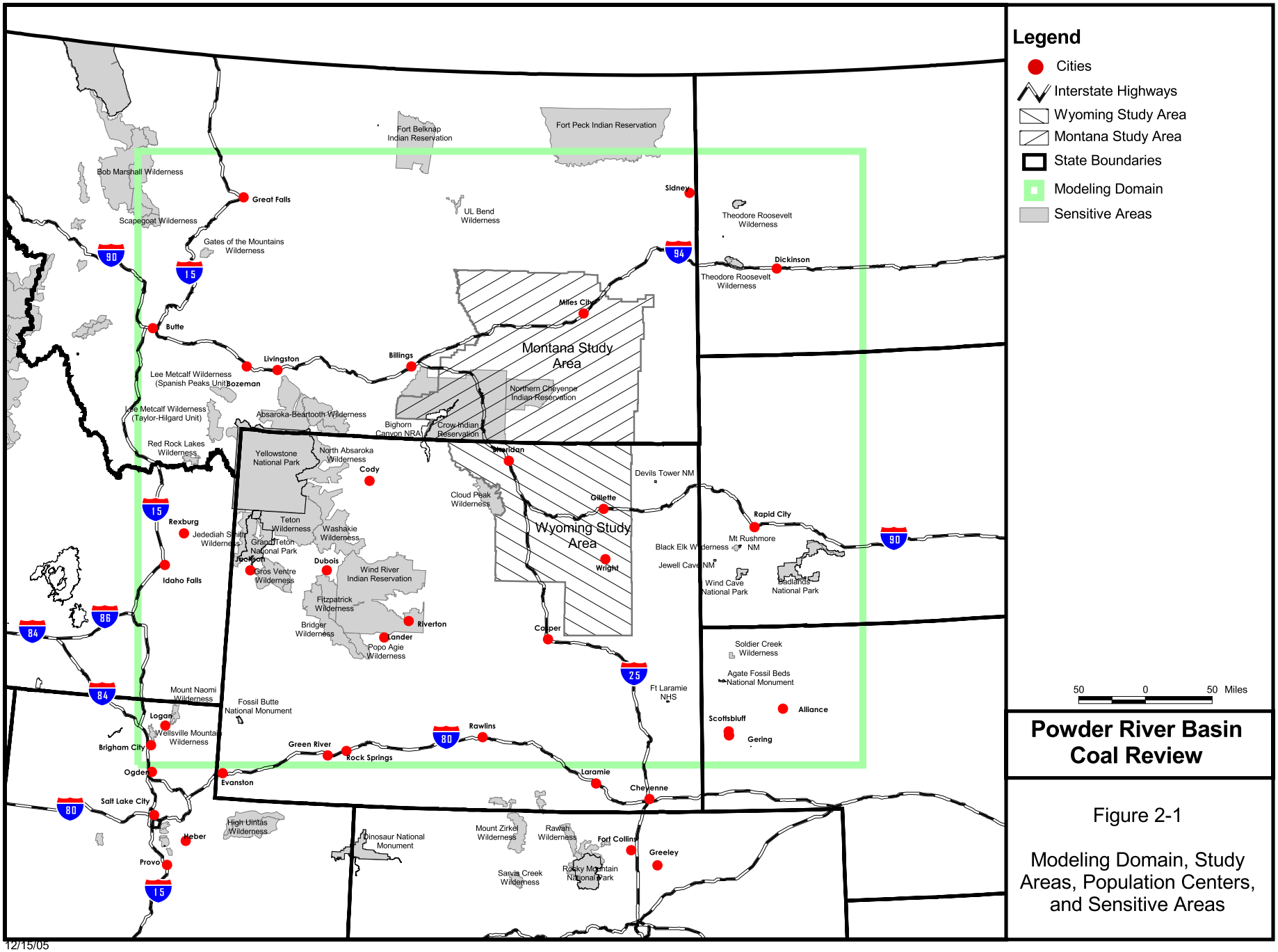
- CALMET Version 5.8, Level 070623 (a diagnostic three-dimensional meteorological model, which develops the meteorological data for modeling input);
- CALPUFF Version 5.8, Level 070623 (the transport and dispersion model that carries out calculations of dispersion); and
- CALPOST Version 5.6394, Level 070622 (a post-processing package that is used to depict overall concentrations and impacts).

The CALPUFF modeling domain report 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 are: 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, 2008).

2.3 Meteorological Data and Analyses

Three years of meteorological data (2001, 2002, and 2003) were used to evaluate base year impacts from all emission sources within the PRB study area. 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. The meteorological year 2003 was then used to model impacts for all emissions sources for the revised base year and 2015 development scenarios. The analysis included only sources within the PRB study area in order to select the worst-case meteorological year based only on PRB sources. The worst-case meteorological year was defined as the year with the highest visibility impacts, since visibility is often the limiting factor for regional air quality related analyses.



Powder River Basin Coal Review

Figure 2-1

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

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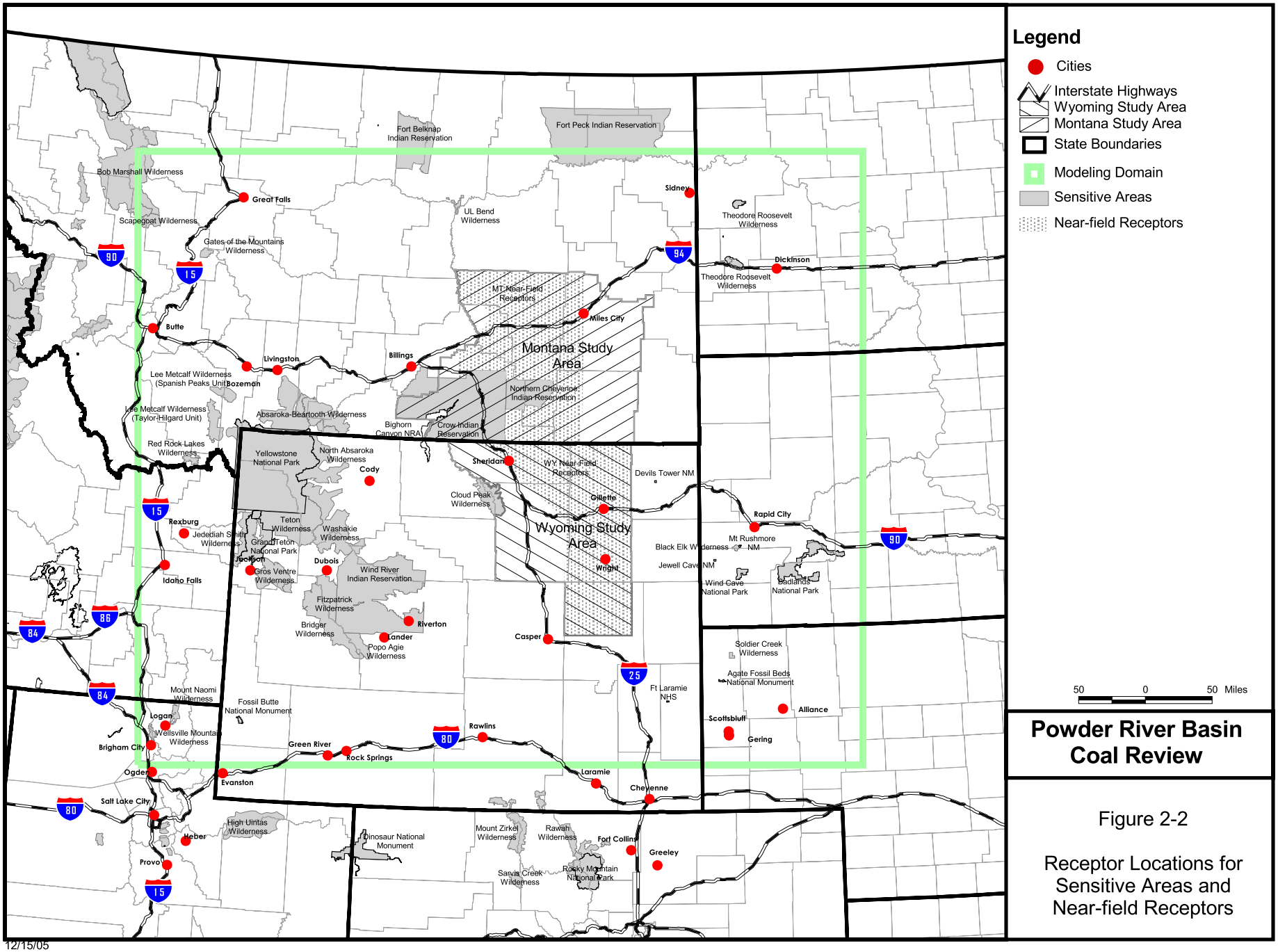

Powder River Basin Coal Review

Figure 2-2

Receptor Locations for Sensitive Areas and Near-field Receptors

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2.4 Emissions Input Data

The objective of the air quality component of the PRB Coal Review, including the 2015 update for the Task 3A Report, was 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);
- EPA 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.

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 2015, 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 2015)
- 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) (Note: At the request of the Montana BLM, the Roundup Power Plant, which is outside the PRB Coal

Review study area, was included in a separate post-processing model run. Model results with the inclusion of the Roundup Power Plant are presented in Appendix A.)

- 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 updated 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, 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, Task 2 projected future year production estimates for various resources. The results 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 2015. The methodology used to calculate emission rates for each emission source group is presented below.

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.

Table 2-1
Emissions Calculations for 2015 by Source Group

Source Group	Production Data			Adjustment Ratio		
	Base (2004)	Lower Scenario (2015)	Upper Scenario (2015)	Base (2004)	Lower Scenario (2015)	Upper Scenario (2015)
Conventional Oil and Gas Sources	39.9 BCF	39.0 BCF	39.0 BCF	1.0	0.977	0.977
CBNG Sources	338 BCF	694 BCF	694 BCF	1.0	2.053	2.053
Coal Production (Wyoming)	363 mmtpy	467 mmtpy	543 mmtpy	1.0	1.287	1.496
Coal Hauling (Wyoming)	363 mmtpy	467 mmtpy	543 mmtpy	1.0	1.287	1.496
Coal Production (Montana)	36.1 mmtpy	48 mmtpy	74 mmtpy	1.0	1.330	2.050
Power Plants	Individual Plant Adjustments					
Urban Areas	No Adjustment					
Miscellaneous	No Adjustment					

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

Different lower production and upper production values used in the ratio of emissions were applied for 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.

Emissions from the Tongue River Railroad were not included in the base year. Per the Task 2 Report, it was projected that this 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 2015. 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 this updated analysis for the 2015 upper and lower production scenarios. 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.

CBNG Sources

CBNG activity is 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 is based on the ratio of base year gas production to projected gas production, as presented in the Task 2 Report (ENSR 2005b), shown in **Table 2-1**.

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. 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

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

As part of this update to the Task 3A Report, projected RFDs previously identified in the Task 2 Report (ENSR 2005b) were re-evaluated, and updated information was incorporated into this report, as appropriate. Since development of the Task 2 Report, two coal-fired power plants have modified their permits. WYGEN 2 and Two Elk Unit 1 previously were identified RFDs in the Task 2 Report and were included in the original Task 3A Report. For this updated study, modifications to these permits and the addition of WYGEN 3 and Two Elk Unit 2 are incorporated in this analysis. WYGEN 2 originally was permitted as a 500-megawatt (MW) facility. Since the original Task 2 and Task 3A reports, a revised permit has been issued for a 100-MW facility, and a subsequent permit application for WYGEN 3 has been approved for an additional 100-MW facility (WDEQ 2006). Similarly, Two Elk Unit 1 originally was permitted as a 250-MW facility; however, a revised permit

was issued for Unit 1 as a 280-MW facility. Additionally, an application for Two Elk Unit 2, a 750-MW facility, was submitted in November 2007 and revised in January 2008 (ENSR 2008b). The revisions associated with these RFD sources have been incorporated into the emission calculations and modeling activities for the 2015 upper and lower development scenarios.

3.0 PREDICTED CUMULATIVE AIR IMPACTS

3.1 Modeled Cumulative Impacts for Base Year and 2015

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 revised base year and both the lower and upper production scenarios for 2015.

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 and the original Task 3A Reports, and extend the impacts that had been identified in that study.

Table 3-1
Summary of Modeled Air Quality Impacts

Air Quality Metric		Base Year Impacts	Year 2015 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_{10} and $PM_{2.5}$ in the near-field, as well as short-term NO_2 at receptors close to the study area, are above applicable NAAQS and SAAQS,.
	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 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 47 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

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

[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.

It is important to note that the effects of Best Available Retrofit Technology (BART) implementation are 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 air quality effects summarized as part of this report likely will 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 Summary Document (TSD) 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. This ensured that the results were representative of the broad area in the PRB study area, rather than unduly affected by a specific source, although there are still receptors with high impacts due to a single source-receptor configuration.

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 are generally 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. The maximum (first highest) 1-hour impacts are reported for receptors within the state of Montana.

3.1.1.1 Impacts at Near-field Receptors in Wyoming

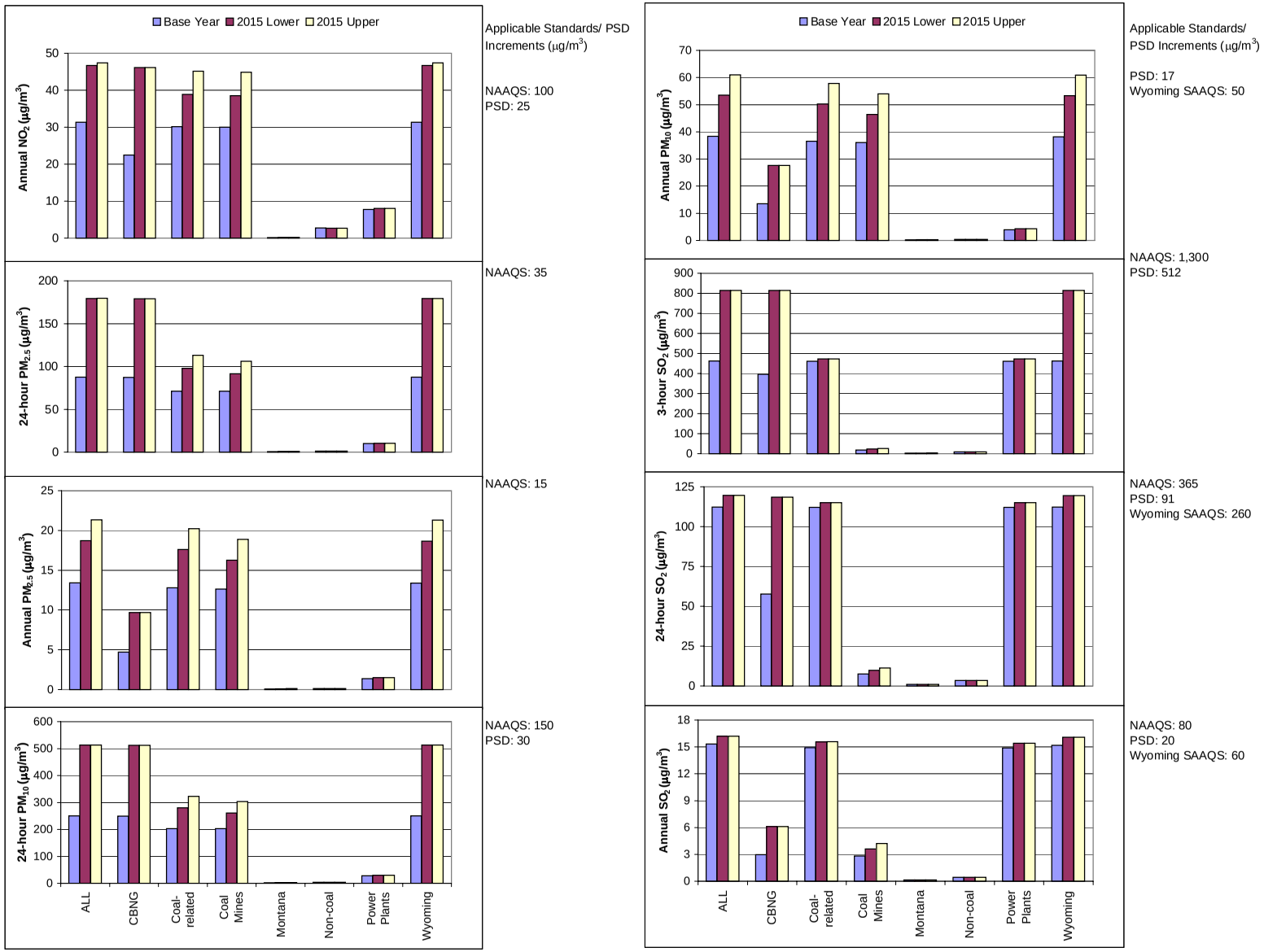
Results for the near-field receptor grid for Wyoming are presented in **Figure 3-1**. The figure shows the impacts at the maximum receptor for each modeling scenario: the base year (2004), 2015 lower production scenario, and 2015 upper production scenario. The maximum modeled impacts on Wyoming near-field receptors that result from each individual source group are identified in the figure. Data are provided for each ambient standard and PSD increment level for NO_2, SO_2, and PM_{10}, and the ambient standard for $PM_{2.5}$. The graphs in **Figure 3-1** provide a comparison of modeled impacts at the maximum receptor for each source group. The impact from one source group would not likely be at the same receptor as that of the other source group; therefore, the results for each group generally are not additive.

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 [µg/m^3] and 35 µg/m^3, respectively) for the base year as well as for both of the 2015 scenarios, primarily as a result of CBNG operations and coal mining activities. The combined impacts from all sources for the 2015 upper production scenario are predicted to be nearly three times the standard for PM_{10} and five 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 2015 upper production scenario, the modeled impacts are above 150 µg/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 exceedences are an over-prediction since future locations of activities likely will change. The approach used in this analysis scaled base year emissions based on projected 2015 production levels at current source 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 2015 upper production scenario are the same as PM_{10} (shown in **Figure 3-2**). The only substantial difference is that the small areas in **Figure 3-2** with predicted SAAQS exceedences are somewhat larger for $PM_{2.5}$. A large portion of the short-term impacts for all scenarios are associated with CBNG sources, while longer term impacts are associated with coal mining.

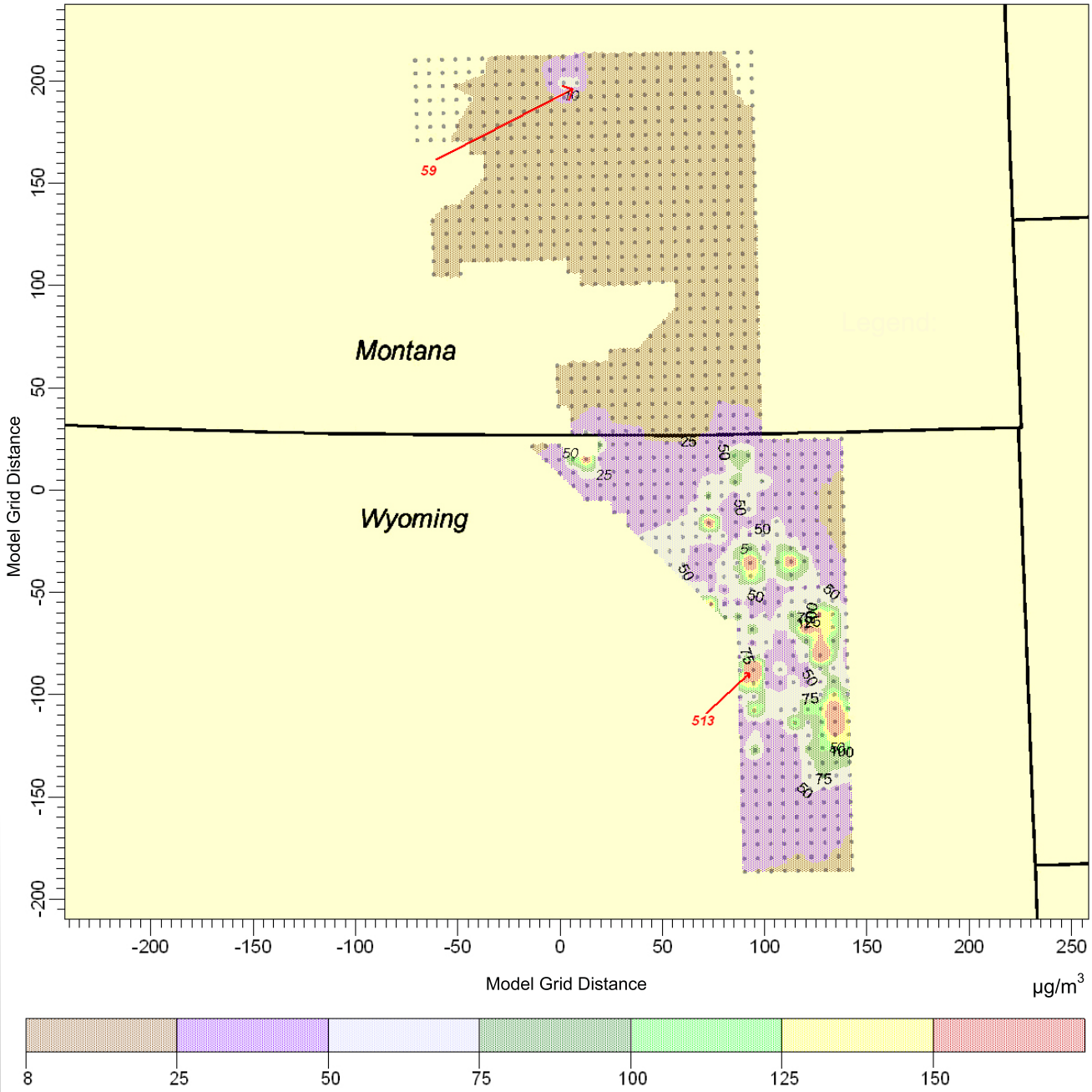
Figure 3-3 depicts the modeled extent of the annual PM_{10} impacts for the 2015 upper production scenario for all sources. This is similar to the spatial pattern depicted in **Figure 3-2**, except the maximum impact is in a different location of the study area and potential SAAQS exceedences are limited in their spatial extent. For the 2015 production scenarios, the modeled impacts on the annual PM_{10} and $PM_{2.5}$ levels would be above the Wyoming and national standard (50 µg/m^3 and 15 µg/m^3, respectively) at the maximum receptor in Wyoming. The SAAQS exceedences (greater than 50 µg/m^3) are confined to two hotspots in the Wyoming near-field receptor grid. The annual $PM_{2.5}$ spatial pattern is similar to the spatial pattern shown for annual PM_{10} with somewhat reduced impacts.

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

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



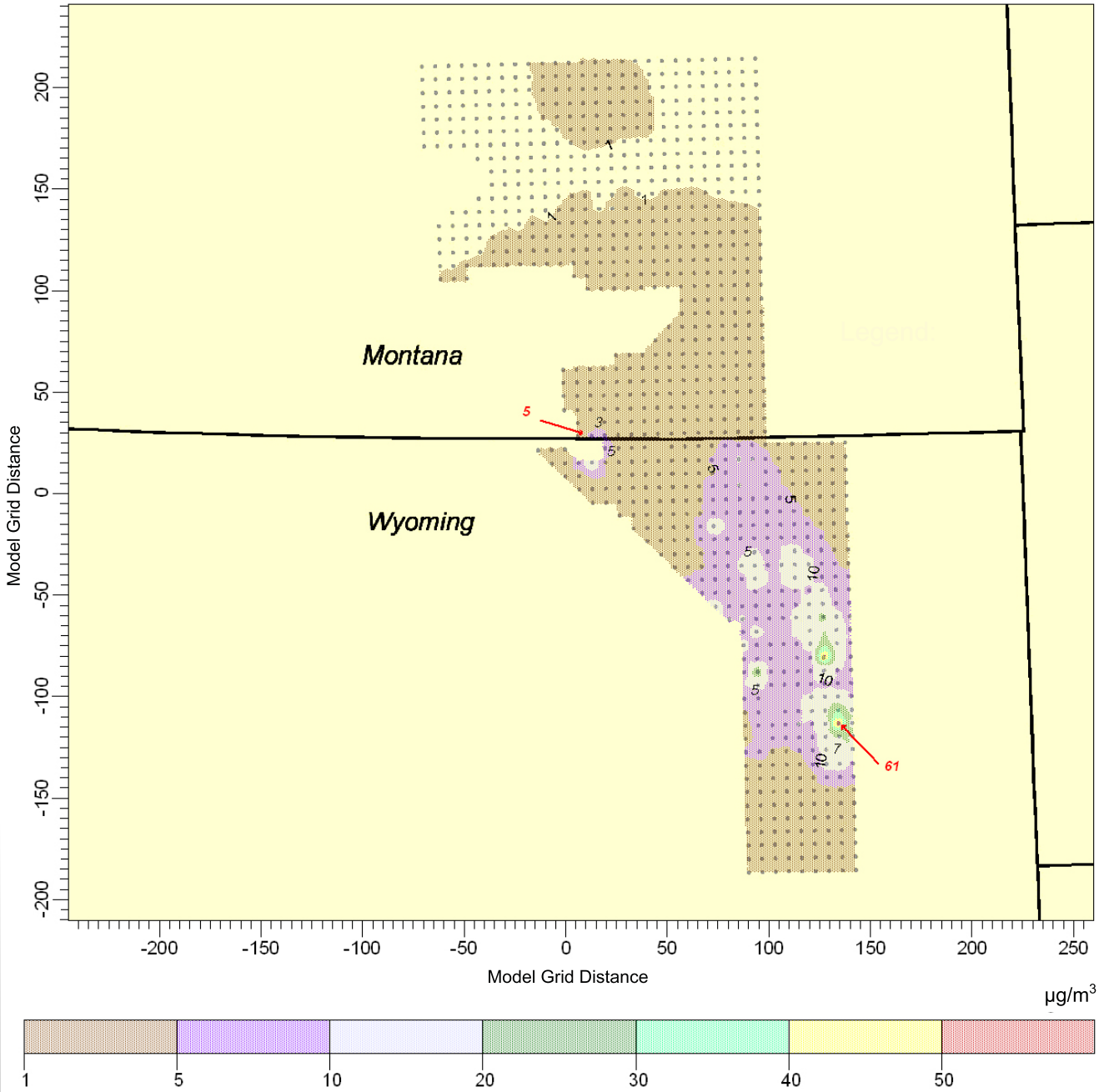
Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario



Powder River Basin Coal Review

Figure 3-2
24-hour PM_{10} Concentrations for Near-field Receptors – 2015 Upper Production Scenario

Note: Includes all sources.



Note: Includes all sources.

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Figure 3-3
Annual PM_{10} Concentrations for Near-field Receptors – 2015 Upper Production Scenario

evaluation of PSD increment consumption. The regulatory agency has the authority and responsibility to determine if an exceedence or violation has occurred.

The modeled impacts of SO_2 emissions were well below the ambient standards, but the PSD Class II increment levels are exceeded for short-term periods. Generally, it appears that the 3-hour impacts for all scenarios are associated with CBNG sources, while the 24-hour and annual impacts are associated with 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 75 percent relative to the base year as a result of CBNG activities affecting the short-term impacts. Impacts for other averaging periods have only moderate increases (3 to 8 percent) relative to the base year.

3.1.1.2 Impacts at Near-field Receptors in Montana

Figure 3-4 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 3-5**. Projected impacts are all well below the state and national standards, except the potential impacts of 1-hour NO_2, which are predicted to exceed the SAAQS in 2015.

As shown in **Figures 3-2** and **3-3**, the modeled PM_{10} 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 in the future year scenarios. No formal increment consumption analysis was completed; therefore, this comparison is not a valid PSD increment consumption evaluation.

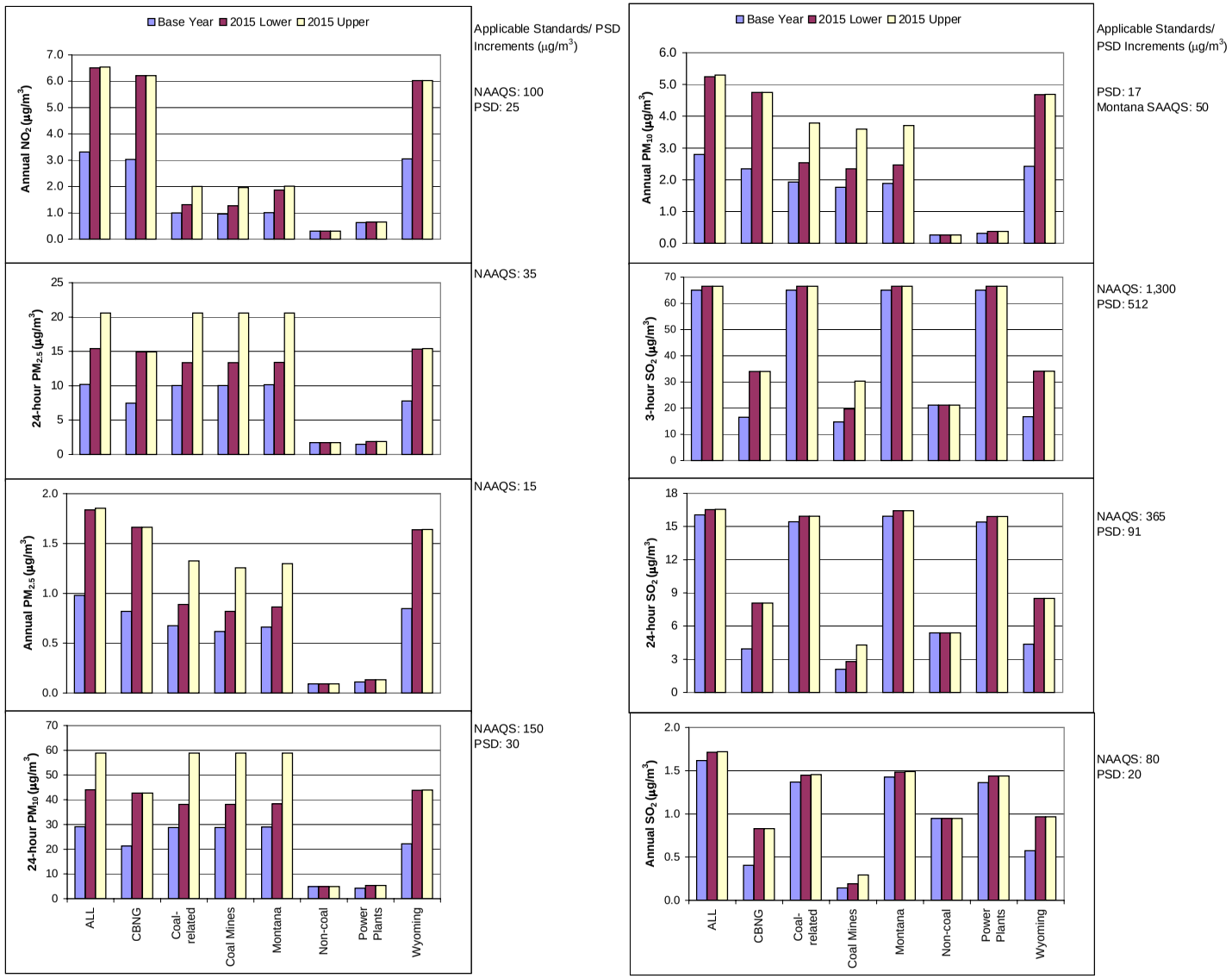
Based on the modeling results, the annual NO_2 impacts in Montana would be well below the ambient standard and PSD increment. However, future year (2015) 1-hour impacts (shown in **Figure 3-6**) are predicted to exceed the state 1-hour standard in two isolated locations strongly influenced by local sources. Wyoming CBNG operations appear to be a substantial contributor to the maximum 1-hour NO_2 impact predicted for 2015, while the upper production scenario indicates a potential exceedence caused by Montana coal mining. An acceptable adjustment of 0.75 was used to convert the NO_x impacts 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 the coal-fired power plant sources, the majority of which are located in Wyoming. The modeled impacts showed that increases of SO_2 impacts are predicted to be minor, resulting largely from additional coal-fired power plants.

3.1.2 Air Quality Impacts at Class I Area Receptors

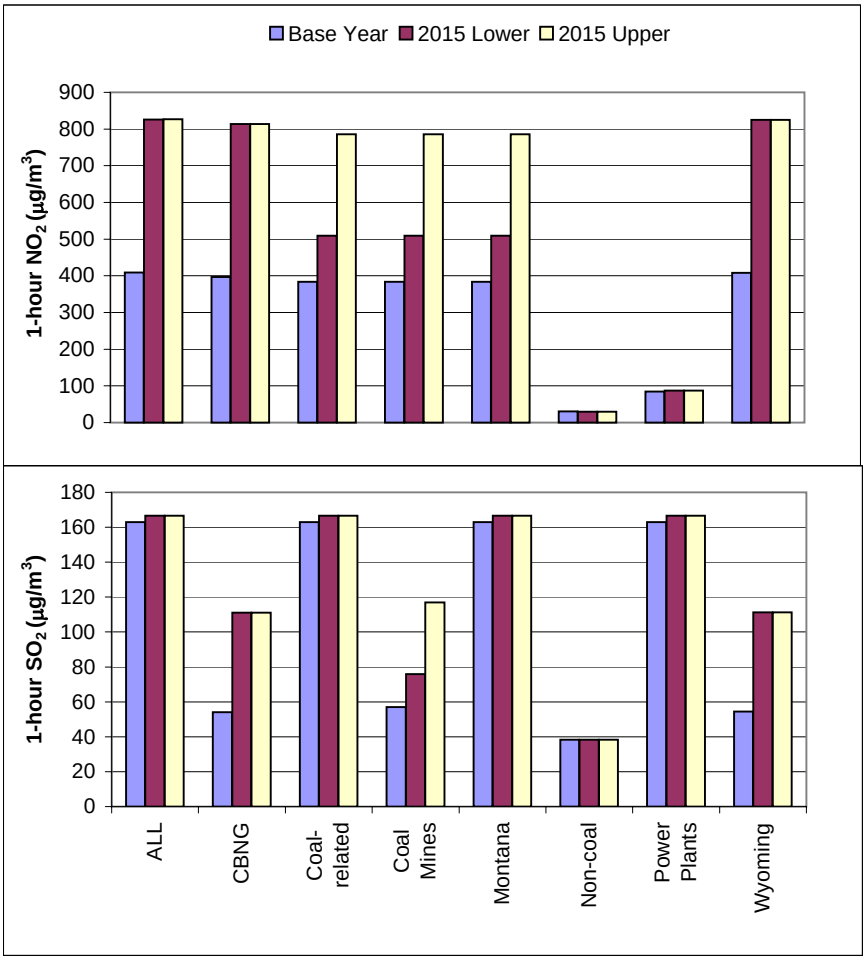
As discussed in Chapter 2.0, the impacts at Class I areas also were modeled, with separate assessments for each Class I receptor group. The modeled impacts were all well below the ambient standards for all air pollutants. For comparison only, the 24-hour PM_{10} and the 3- and 24-hour SO_2 impacts were above the Class I PSD increments for the base and future year scenarios at several

Figure 3-4
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at Montana Near-field Receptors



Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario

Figure 3-5
Change in Modeled Concentrations of 1-hour NO_2 and SO_2
at Montana Near-field Receptors

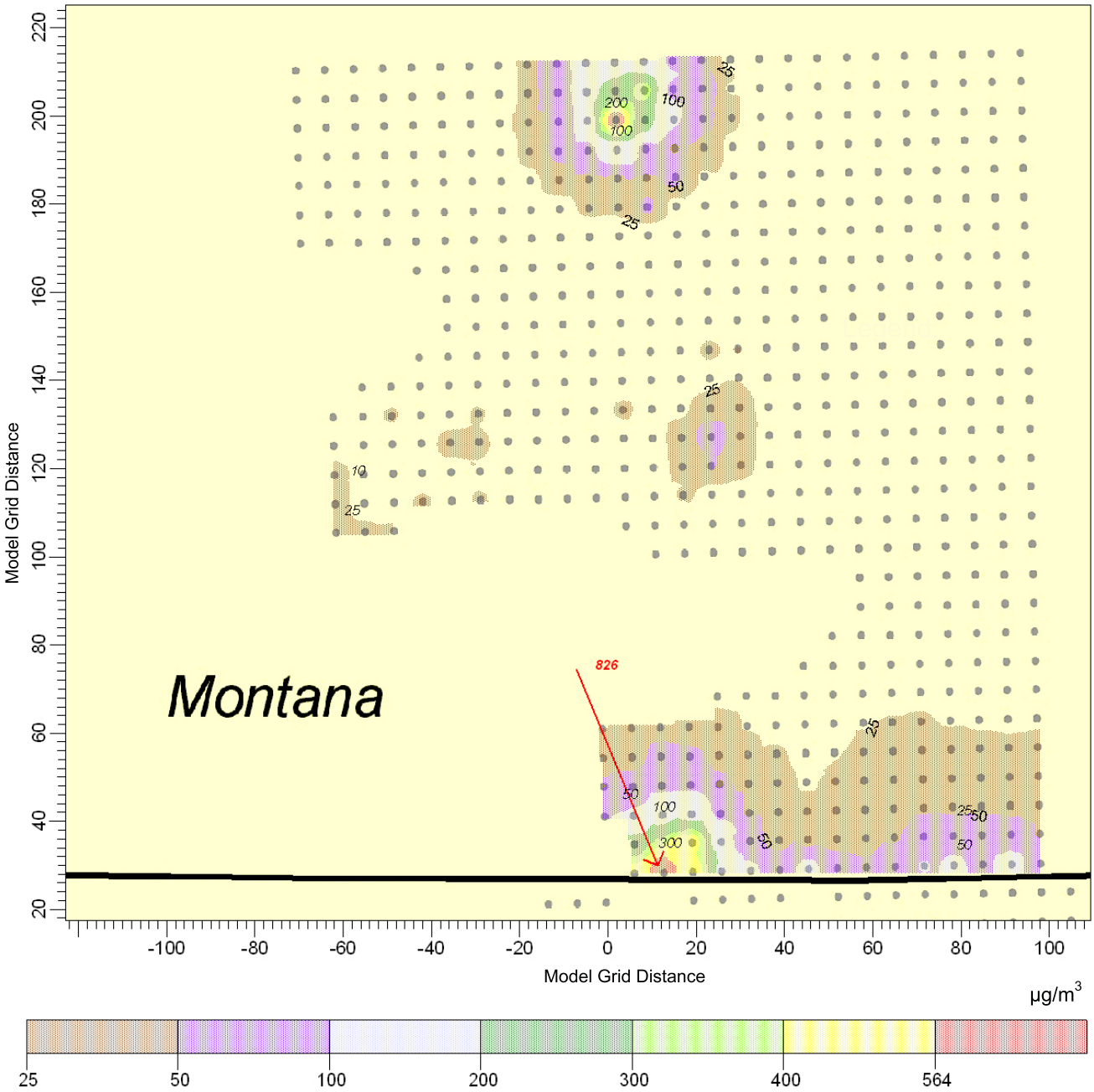


Applicable Standards/
Montana Standards (µg/m^3)

Montana SAAQS: 564

Montana SAAQS: 1,300

Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario



Note: Includes all sources.
Assumes 75 percent NO_x to NO_2 conversion.

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Figure 3-6
1-hour NO_2 Concentrations for Montana Near-field Receptors – 2015 Upper Production Scenario

Class I areas. The Class I areas with the highest PM_{10} impacts were the Northern Cheyenne IR in Montana, Washakie Wilderness Area (WA) in Wyoming, and Wind Cave National Park (NP) in South Dakota. The Class I areas with the highest SO_2 impacts were Theodore Roosevelt NP and Fort Peck IR.

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 for 24-hour PM_{10} impacts. 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 base year 24-hour PM_{10} impacts are predicted to increase by up to 50 percent in the future year scenarios, primarily as a result of increases in Wyoming sources (predominantly CBNG development). SO_2 and NO_2 impacts are less than 1 percent of the national and state standards.

Two additional Class I areas also were analyzed, including the Washakie WA (**Figure 3-8**) and Wind Cave NP (**Figure 3-9**). These areas represent the closest Class I areas east and west of the PRB study area, and should provide a representative depiction of impacts at the Class I areas in western Wyoming and western South Dakota. 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 impacts are between 60 to 80 percent of the comparable PSD increments.

The PM_{10} impacts at the Washakie WA are approximately half of the comparative 24-hour Class I PSD increment and approximately 5 percent of the annual increment. 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 13.4 $\mu g/m^3$, versus a Class I PSD increment level of 8 $\mu g/m^3$.

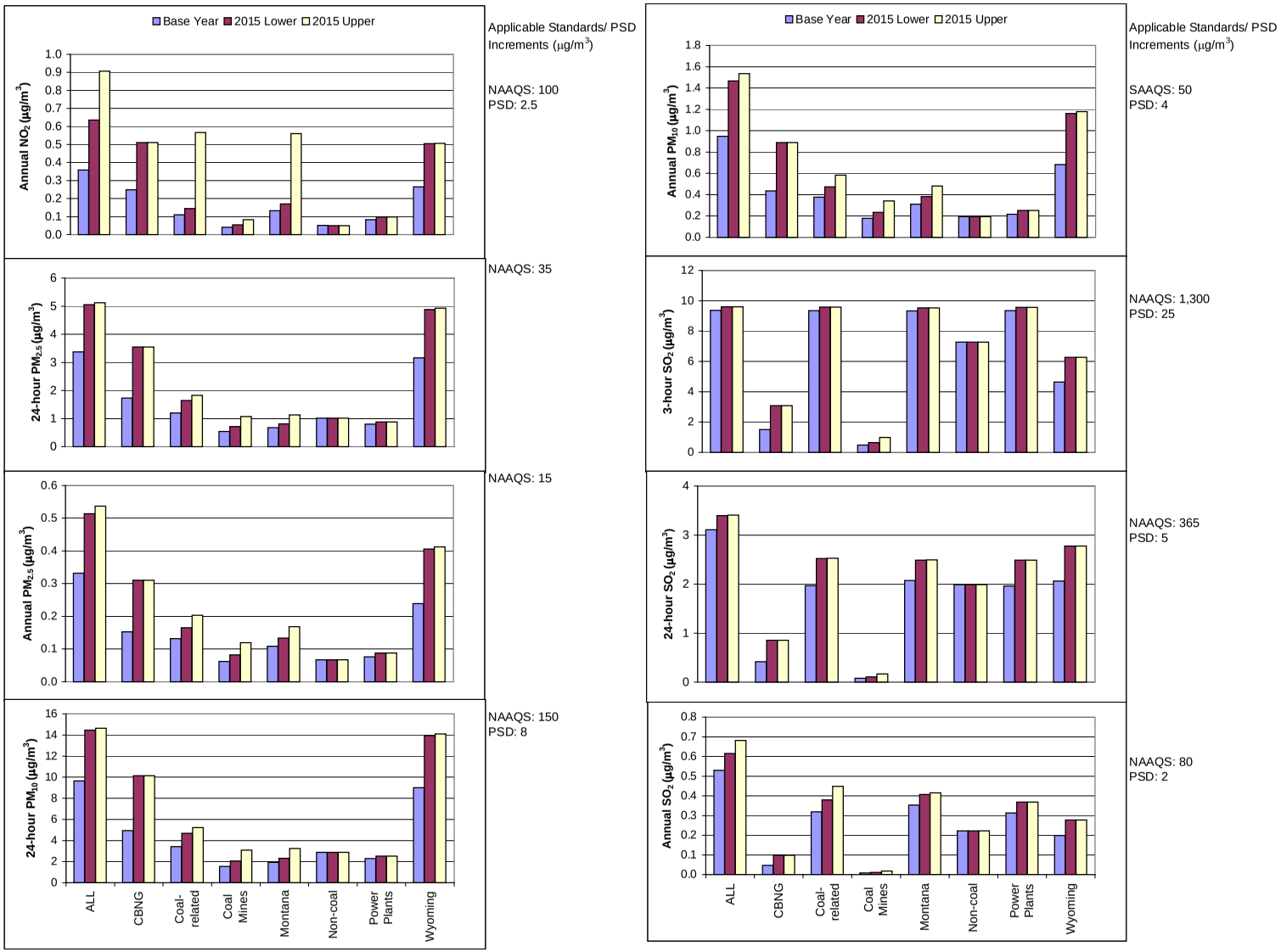
The predicted 3- and 24-hour SO_2 impacts exceeded the Class I PSD increments at Theodore Roosevelt NP and Fort Peck IR due to sources outside of the PRB study area. The maximum modeled impacts are less than 5 percent of the national and state standards for all pollutants at Theodore Roosevelt NP and Fort Peck IR.

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

3.1.3 Air Quality Impacts at Sensitive Class II Area Receptors

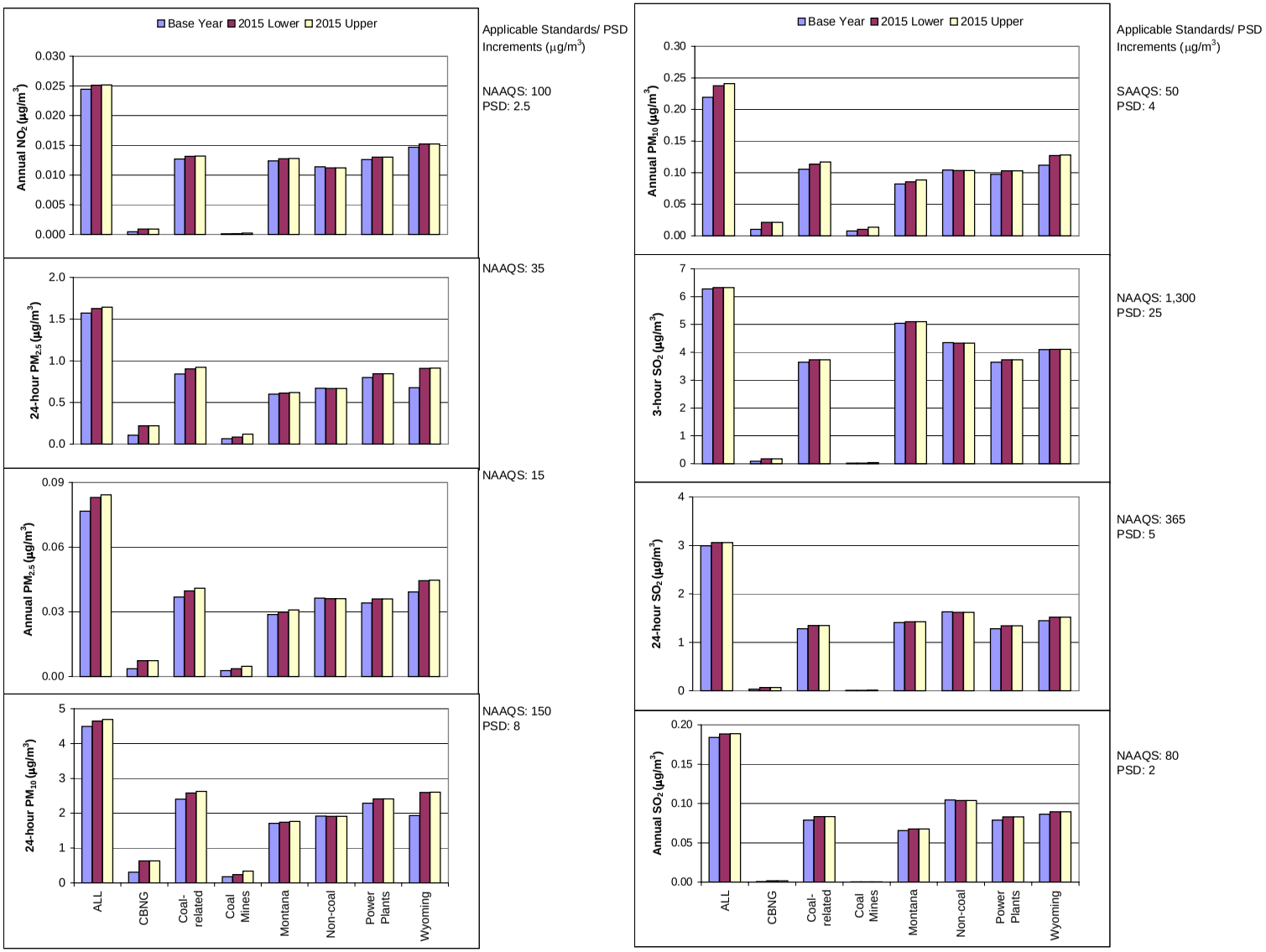
Modeled impacts at the Big Horn Canyon National Recreation Area (NRA) and Crow IR were generally higher than impacts at the other identified Class II area receptor groups for all scenarios, with the exception of SO_2 impacts, which were highest in the Wind River IR. Modeled impacts for Big Horn Canyon NRA 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, except for the 24-hour PM_{10} increment. At the Big Horn Canyon NRA, the 24-hour impacts for PM_{10} reached 34.1 $\mu g/m^3$ for the upper production scenario, compared to a Class II PSD increment level of 30 $\mu g/m^3$; however, this does not represent a formal PSD increment evaluation. Similarly, at the Crow IR, the modeled impacts do not exceed ambient standards; however, the projected increases in Montana coal-mining under the 2015 upper development scenario lead to modeled 24-hour PM_{10} impacts of 40.7 $\mu g/m^3$. All predicted impacts

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



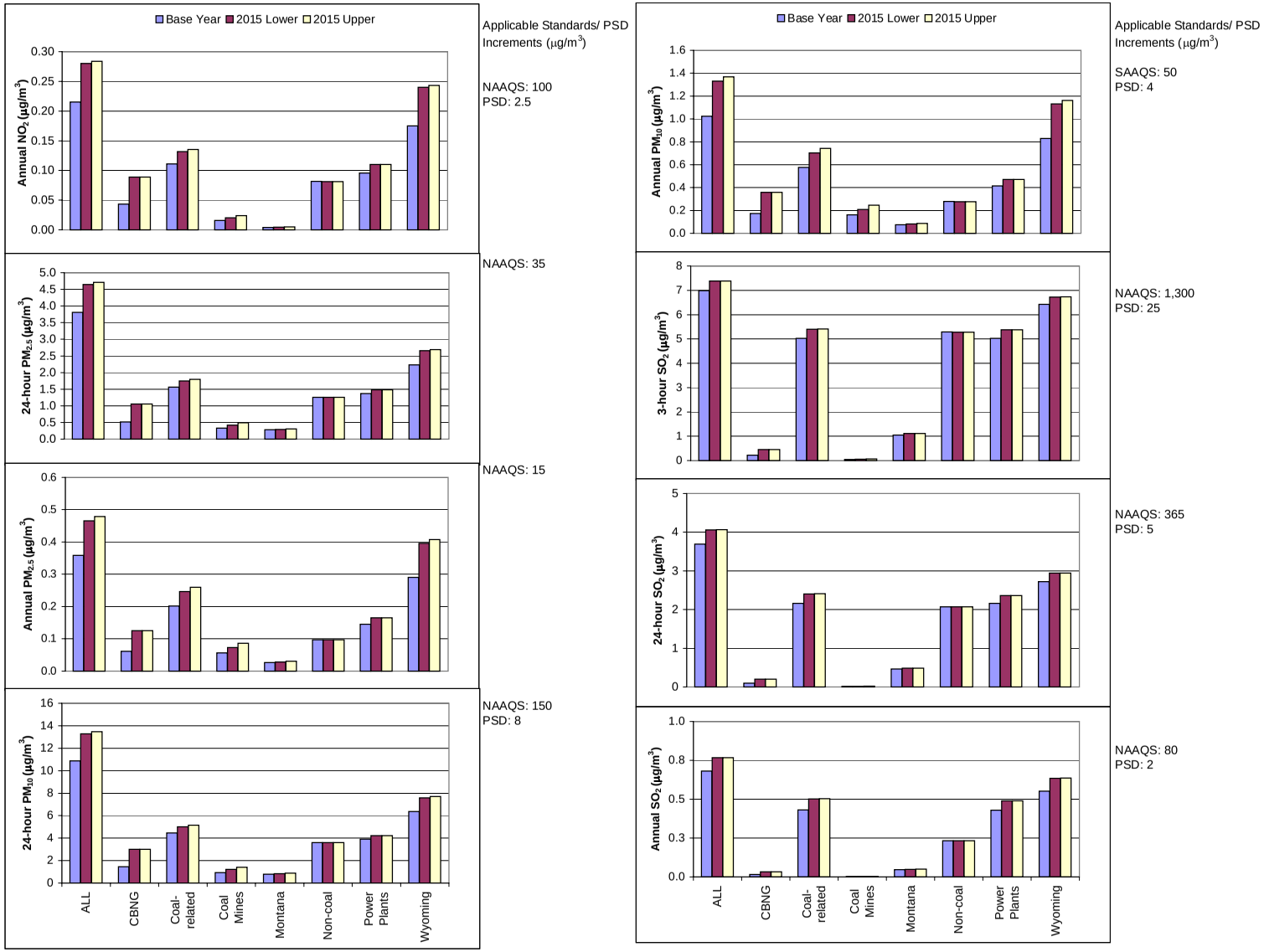
Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario

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



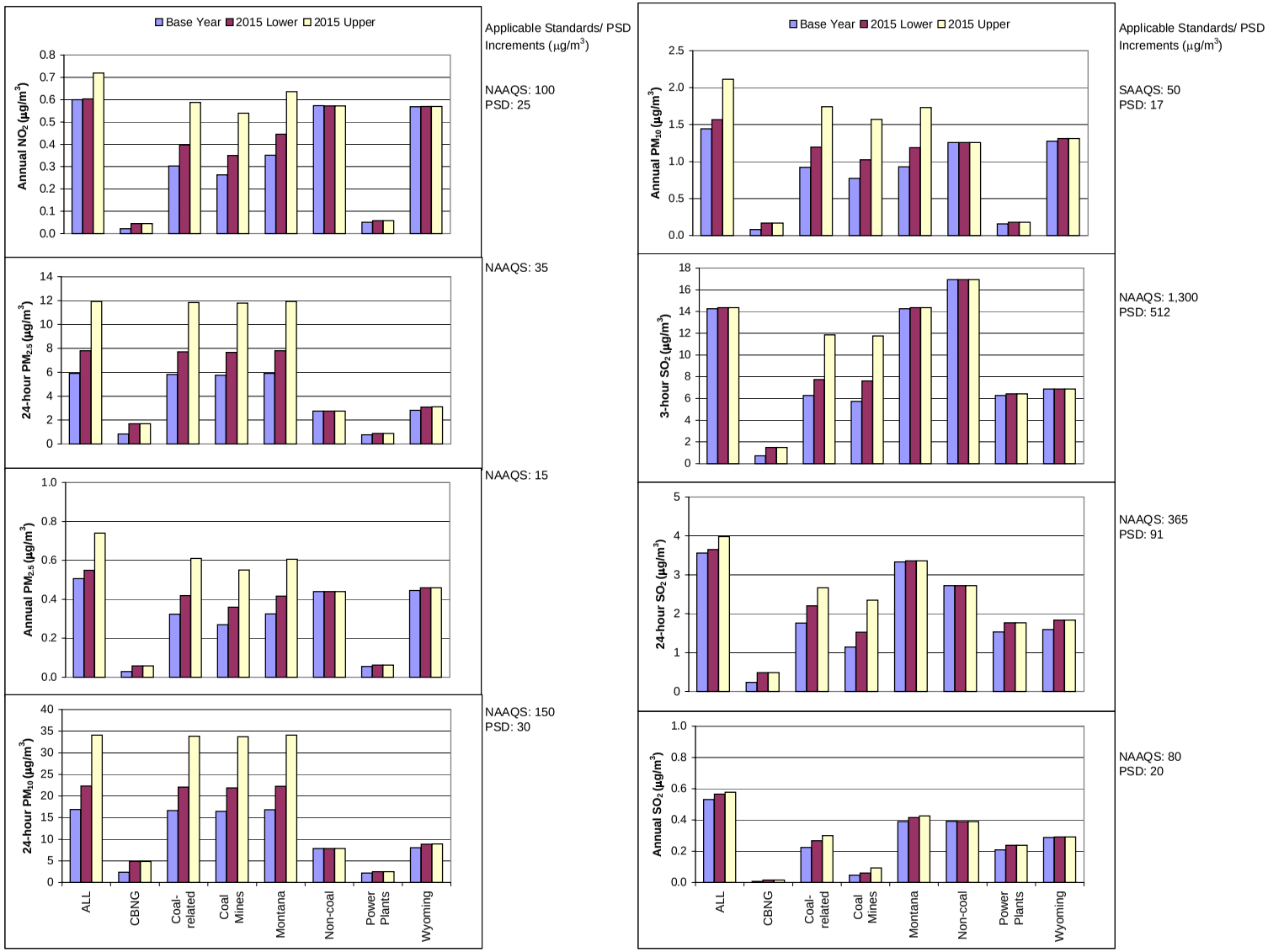
Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario

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



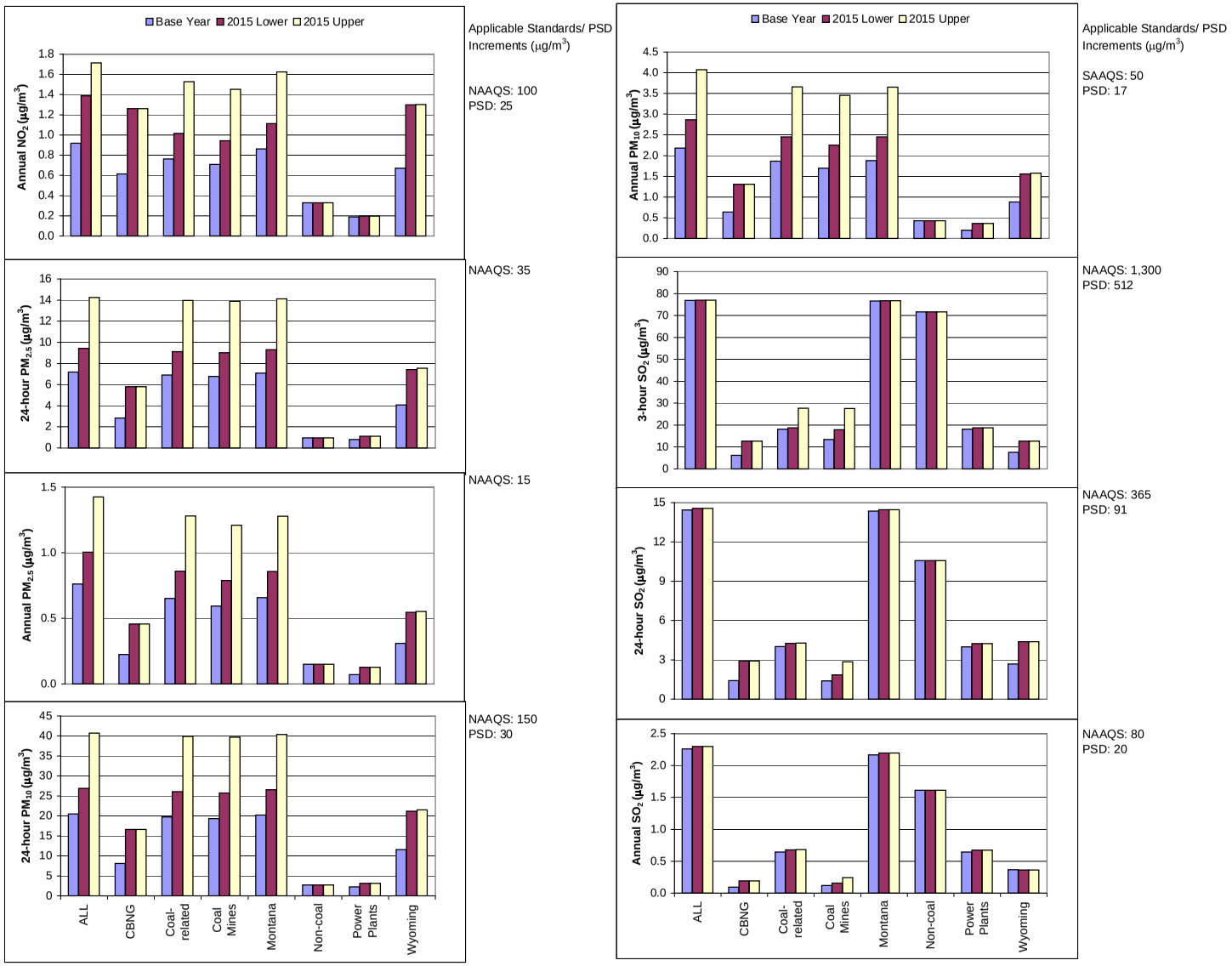
Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario

Figure 3-10
Change in Modeled Concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at Big Horn Canyon NRA



Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 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
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario

at Class II areas other than Big Horn NRA and Crow IR are well below applicable standards and PSD increments.

The largest annual impacts of NO_2 are predicted to occur at the Crow IR where the modeled impacts are less than 2 percent of the national and state standards in the upper development scenario. Modeled annual NO_2 impacts are less than 1 percent of the standard at Big Horn Canyon NRA. The largest SO_2 impacts in a Class II area occurred at the Wind River IR where base year and future year impacts were approximately 20 percent of the 3- and 24-hour Class II PSD increment, and 10 percent of the annual Class II PSD increment. At Big Horn Canyon NRA, SO_2 impacts are approximately 1 percent of the standards, but at the Crow IR, SO_2 impacts range from approximately 3 to 6 percent of the applicable standards.

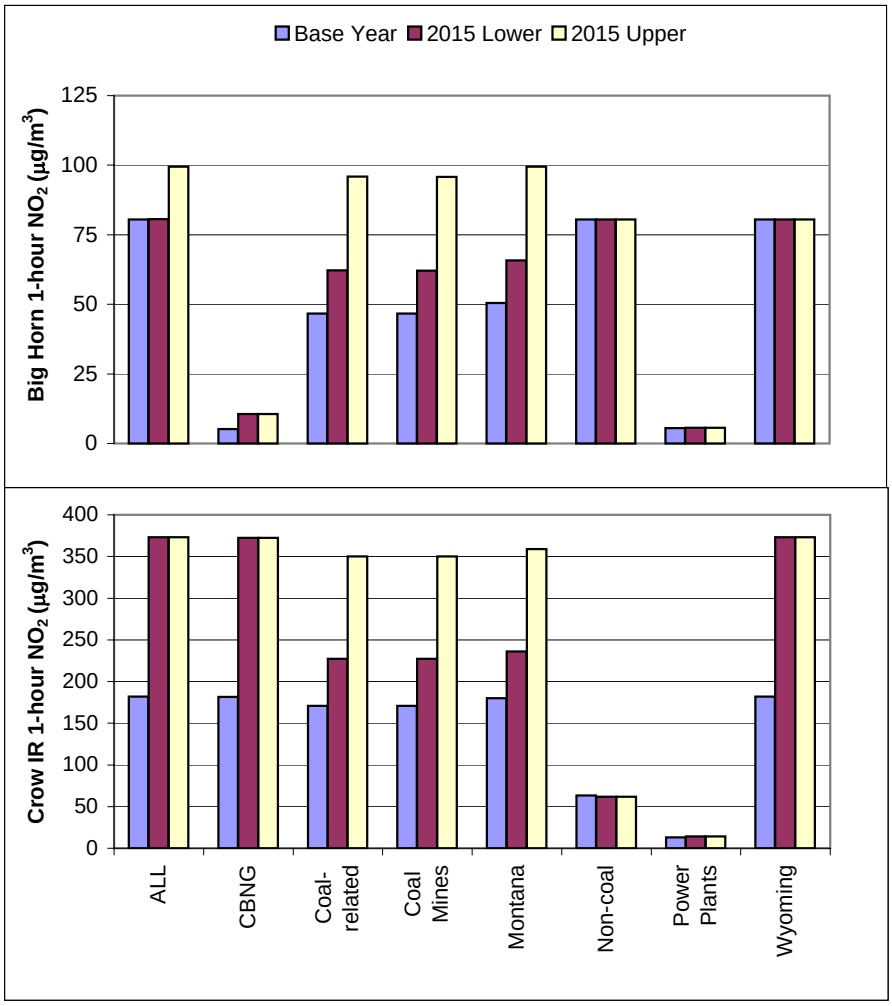
Figure 3-12 shows the base year (2004) and predicted future year (2015) modeled 1-hour NO_2 impacts at Big Horn Canyon NRA and Crow IR. These two Class II areas have the highest modeled impacts of any modeled Class II area for the base year, and projected increases in Montana mining would result in further impacts in the future years, yet impacts 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.

Table 3-2 provides the modeled visibility impacts for the base year (2004) for each of the analyzed areas. 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. For the Class II areas, the maximum impacts were at the Crow IR and the Big Horn Canyon NRA in Montana, with

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



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

Montana SAAQS: 564

Montana SAAQS: 564

Note:
Base Year = 2004
2015 Lower = 2015 lower production scenario
2015 Upper = 2015 upper production scenario

Table 3-2
Modeled Impacts on Visibility at Indicated Receptors for the Base Year (2004)[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}		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}
	5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%	
CLASS I AREAS																								
Badlands NP	283	218	334	72	25	44	199	128	134	11	3	13	63	24	47	174	97	285	176	121	129	218	156	180
Bob Marshall WA	16	8	71	0	0	1	12	5	52	0	0	0	14	6	59	4	2	65	12	5	52	2	0	9
Bridger WA	212	144	144	9	3	22	136	82	63	0	0	3	33	21	35	162	90	122	135	80	63	177	118	120
Fitzpatrick WA	157	91	115	5	0	8	95	43	69	0	0	2	35	19	49	95	47	79	91	42	68	120	69	96
Fort Peck IR	151	105	256	18	11	52	93	51	57	12	2	11	76	35	63	96	55	252	82	44	51	68	43	95
Gates of the Mountain WA	90	55	116	0	0	1	72	37	100	0	0	1	83	47	115	39	11	44	72	37	100	7	3	18
Grand Teton NP	132	70	87	1	0	8	68	34	44	0	0	3	30	16	32	78	34	75	67	34	44	65	32	64
North Absaorka WA	131	61	177	2	0	9	81	37	104	0	0	2	76	36	79	52	20	70	81	34	102	46	21	79
North Cheyenne IR	316	243	416	162	106	198	237	137	288	70	14	25	243	137	78	134	54	281	197	109	278	186	139	398
Red Rock Lakes	81	42	63	0	0	4	50	25	62	0	0	1	40	18	62	36	10	30	50	25	62	25	13	37
Scapegoat WA	44	27	65	0	0	1	34	20	56	0	0	0	39	23	64	13	3	57	34	20	56	5	2	14
Teton WA	125	57	116	2	0	7	68	32	71	0	0	2	42	20	48	62	23	44	65	32	70	57	30	91
Theodore Roosevelt NP	243	178	306	46	22	42	114	60	78	5	0	9	76	38	54	181	111	298	103	54	72	99	73	125
U.L. Bend WA	128	77	213	8	6	42	88	47	66	5	0	9	84	45	67	53	27	205	83	41	64	40	20	76
Washakie WA	147	83	189	4	1	18	98	37	113	0	0	2	72	32	89	74	33	81	97	35	112	80	44	149
Wind Cave NP	318	262	458	108	49	57	257	172	253	37	10	15	67	30	51	176	95	335	228	150	239	283	218	361
Yellowstone NP	160	84	147	1	0	7	107	51	90	0	0	3	86	47	67	79	26	54	106	50	88	53	30	66
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	190	101	167	2	0	8	136	67	100	0	0	3	159	80	100	69	34	63	136	65	98	39	16	89
Agate Fossil Beds NM	310	251	608	74	39	95	266	191	383	32	4	23	48	22	29	160	82	176	251	169	361	296	235	565
Big Horn Canyon NRA	361	331	350	41	18	73	207	114	247	86	60	224	202	127	241	355	295	161	158	70	179	348	295	257
Black Elk WA	307	236	456	82	30	43	231	152	188	21	2	13	63	26	44	175	96	364	207	136	177	258	186	265
Cloud Peak WA	209	126	678	47	27	311	131	79	491	9	3	75	89	38	51	99	41	122	127	69	416	134	84	676
Crow IR	364	360	597	151	118	170	364	352	535	364	340	504	364	356	531	278	132	133	237	133	374	255	179	585
Devils Tower NM	321	274	272	180	95	50	257	185	182	75	20	23	76	31	33	140	70	194	224	140	171	294	246	244
Fort Belknap IR	111	66	159	6	4	31	79	36	58	3	0	7	79	38	71	43	21	151	75	34	57	27	14	60
Fort Laramie NHS	313	260	727	65	28	144	276	187	484	21	6	36	40	16	45	158	76	229	261	178	449	306	238	720
Jedediah Smith WA	140	79	112	1	0	8	65	34	54	0	0	3	29	13	33	96	45	100	65	34	54	58	33	80
Jewel Cave NM	311	261	406	108	44	63	258	179	220	52	6	23	60	30	35	156	84	286	225	145	204	288	228	319
Lee Metcalf WA	167	97	81	0	0	3	134	75	53	0	0	1	137	77	63	55	17	36	134	74	53	25	13	44
Mt Naomi WA	88	51	233	1	0	5	47	32	199	0	0	2	4	1	14	62	29	81	47	31	199	59	37	223
Mt Rushmore NM	300	222	456	71	29	38	210	139	172	18	2	10	62	24	43	153	82	366	194	123	162	243	169	241
Popo Agie WA	199	139	114	13	3	32	122	69	55	0	0	4	34	20	38	142	72	68	119	68	55	165	108	91
Soldier Creek WA	321	268	589	98	41	88	282	203	394	38	12	22	59	24	33	169	81	175	266	183	373	304	242	542
Wellsville Mountain WA	209	130	239	19	9	55	119	63	112	3	1	11	69	36	91	135	77	126	116	60	110	149	93	193
Wind River IR	281	217	326	26	17	63	171	105	204	6	1	11	79	43	104	257	153	163	171	102	202	263	179	300

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

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

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 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).

Tables 3-3 and **3-4** provide the modeled visibility impact results for the lower and upper production scenarios for 2015, respectively. Based on the modeling results, those areas most impacted in the base year (2004) typically continue to be impacted by production increases in 2015. 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 2015.

To provide a basis for discussing the modeled visibility impacts resulting from increased production (emissions) under both the lower and upper production scenarios in 2015, the modeled visibility impacts for the base year (2004) (**Table 3-2**) were subtracted from the model results for 2015. The resulting changes in modeled visibility impacts are presented in **Tables 3-5** and **3-6**. 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 some receptors, 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 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).

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 20 days per year for four receptor areas under the 2015 lower production scenario and five receptor areas under the 2015 upper production scenario. 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 2015 production scenarios. Modeling results show that all areas would experience some increase in visibility impacts, with the exception of Wind River IR, which is most impacted by oil and gas decreasing activity levels.

Table 3-3
Modeled Visibility Impacts for the 2015 Lower 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}		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}
	5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%	
CLASS I AREAS																								
Badlands NP	288	244	359	132	75	90	217	156	154	24	5	17	70	25	49	173	96	285	196	137	144	239	192	239
Bob Marshall WA	19	8	71	0	0	1	12	6	53	0	0	0	14	6	60	4	2	65	12	6	53	2	0	10
Bridger WA	212	146	146	17	9	46	139	83	64	0	0	4	35	21	36	162	89	120	138	82	64	179	121	121
Fitzpatrick WA	157	93	117	11	5	16	99	45	71	0	0	3	35	19	50	93	47	78	98	44	69	121	72	97
Fort Peck IR	162	115	257	42	19	107	99	62	69	13	2	14	79	38	66	95	55	252	90	50	55	81	53	156
Gates of the Mountain WA	93	55	118	0	0	3	74	37	102	0	0	1	84	48	117	39	11	44	74	37	102	8	3	19
Grand Teton NP	133	72	87	2	1	16	72	35	45	0	0	4	30	16	32	78	34	75	70	34	45	67	35	65
North Absaorka WA	132	64	187	7	2	19	86	37	110	0	0	3	79	36	81	52	20	70	84	36	107	51	22	89
North Cheyenne IR	334	275	517	211	164	338	260	162	328	104	29	33	280	177	87	133	54	281	211	123	311	217	175	499
Red Rock Lakes	82	44	65	1	0	9	53	26	63	0	0	2	41	19	64	36	10	30	53	26	63	25	13	39
Scapegoat WA	46	28	66	0	0	2	35	20	58	0	0	1	39	25	66	13	3	57	35	20	58	5	2	15
Teton WA	125	61	124	5	2	15	72	34	76	0	0	3	43	21	50	61	23	44	69	33	73	62	34	92
Theodore Roosevelt NP	246	183	307	64	47	86	126	70	94	9	1	11	82	40	58	181	110	298	113	59	82	122	83	175
U.L. Bend WA	131	85	216	23	8	87	94	54	79	6	3	12	85	49	69	53	27	205	86	46	70	44	29	116
Washakie WA	149	88	197	9	5	37	99	43	117	0	0	3	72	33	91	73	33	80	98	39	115	84	47	151
Wind Cave NP	326	280	524	171	109	117	275	209	294	59	18	19	68	32	54	174	95	335	250	173	267	296	249	451
Yellowstone NP	162	86	156	6	1	15	110	55	96	0	0	3	87	48	69	79	26	54	108	53	93	55	32	73
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	193	103	177	9	2	17	141	70	107	0	0	4	159	82	102	69	34	63	140	68	103	46	19	101
Agate Fossil Beds NM	318	271	660	124	76	195	280	216	441	40	11	30	49	23	31	160	81	175	266	187	398	306	257	634
Big Horn Canyon NRA	362	332	443	53	41	150	218	129	302	103	72	298	220	139	315	355	295	161	166	76	199	348	295	323
Black Elk WA	315	270	505	154	83	89	250	183	220	27	7	17	67	28	46	175	96	364	228	151	199	277	230	338
Cloud Peak WA	217	144	732	70	47	572	141	87	577	13	6	96	99	43	55	98	40	121	131	80	454	148	95	732
Crow IR	364	364	746	173	151	343	364	362	687	364	355	653	364	362	676	277	129	132	265	160	423	261	194	651
Devils Tower NM	326	299	332	231	185	102	270	214	202	100	38	30	82	35	35	139	69	194	239	162	185	309	274	302
Fort Belknap IR	115	72	161	12	6	63	86	43	65	6	0	9	83	40	73	43	21	151	80	38	58	34	22	78
Fort Laramie NHS	316	270	741	104	65	296	284	204	557	30	9	46	44	18	48	155	76	226	272	186	493	311	257	743
Jedediah Smith WA	140	80	113	2	1	16	67	36	55	0	0	4	30	13	34	96	45	100	67	35	55	60	36	80
Jewel Cave NM	321	280	478	173	111	129	278	215	260	65	17	30	63	32	37	153	84	285	247	171	231	298	257	412
Lee Metcalf WA	170	99	85	2	0	7	137	76	54	0	0	1	139	79	64	55	17	36	136	76	54	26	13	47
Mt Naomi WA	90	52	238	3	2	10	50	33	204	0	0	2	4	1	15	62	29	80	49	31	204	60	39	228
Mt Rushmore NM	309	258	502	139	72	78	237	170	202	23	7	14	64	26	46	153	82	366	205	137	183	267	215	309
Popo Agie WA	200	143	122	18	13	66	124	71	56	1	0	5	35	20	39	141	71	67	122	69	56	168	111	94
Soldier Creek WA	322	286	633	144	99	180	294	229	448	56	20	28	63	27	34	169	80	174	279	199	410	313	269	598
Wellsville Mountain WA	215	140	259	31	20	114	125	68	121	4	1	14	70	36	93	135	76	125	121	65	115	153	101	194
Wind River IR	280	219	327	48	27	130	182	110	209	9	3	14	81	45	106	256	152	161	175	106	206	258	189	301

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

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

Table 3-4
Modeled Visibility Impacts for the 2015 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}		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}
	5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%	
CLASS I AREAS																								
Badlands NP	288	244	361	132	75	90	218	161	156	32	7	19	71	27	51	173	96	285	196	137	144	239	193	241
Bob Marshall WA	19	8	71	0	0	1	12	6	53	0	0	1	14	6	60	4	2	65	12	6	53	2	0	10
Bridger WA	212	146	146	17	9	46	139	84	64	0	0	5	36	21	36	162	89	120	138	82	64	179	121	121
Fitzpatrick WA	157	93	117	11	5	16	99	45	71	0	0	3	35	19	50	93	47	78	98	44	69	121	72	97
Fort Peck IR	165	115	257	42	19	107	104	65	72	24	10	17	86	45	69	95	55	252	90	50	55	81	54	157
Gates of the Mountain WA	93	55	118	0	0	3	74	37	102	0	0	1	84	48	117	39	11	44	74	37	102	8	3	19
Grand Teton NP	134	72	87	2	1	16	72	35	45	0	0	4	31	16	32	78	34	75	70	34	45	67	35	65
North Absaorka WA	132	64	189	7	2	19	86	39	112	0	0	5	80	37	82	52	20	70	84	36	107	52	22	89
North Cheyenne IR	342	290	520	211	164	338	289	190	332	149	58	49	302	197	94	133	54	261	211	123	311	217	176	501
Red Rock Lakes	82	44	65	1	0	9	53	26	63	0	0	2	41	19	64	36	10	30	53	26	63	25	13	39
Scapegoat WA	46	28	66	0	0	2	35	20	58	0	0	1	39	25	66	13	3	57	35	20	58	5	2	15
Teton WA	125	61	125	5	2	15	73	34	77	0	0	3	44	22	50	61	23	44	69	33	73	62	34	92
Theodore Roosevelt NP	247	187	307	64	47	86	130	74	95	16	2	14	84	42	60	181	110	298	113	59	82	122	83	177
U.L. Bend WA	131	87	216	23	8	87	98	54	83	16	4	16	93	52	71	53	27	205	86	46	70	44	30	118
Washakie WA	150	88	198	9	5	37	101	44	118	0	0	5	72	33	91	73	33	80	98	39	115	84	47	152
Wind Cave NP	326	281	527	171	109	117	278	211	298	69	23	23	71	35	55	174	95	335	250	173	267	296	250	454
Yellowstone NP	162	86	157	6	1	15	111	55	97	0	0	4	88	48	69	79	26	54	108	53	93	55	32	73
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	194	104	178	9	2	17	142	73	108	2	0	6	159	82	102	69	34	63	140	68	103	46	20	102
Agate Fossil Beds NM	318	271	663	124	76	195	280	217	446	45	15	35	50	25	32	160	81	175	266	187	398	306	257	636
Big Horn Canyon NRA	362	334	498	53	41	150	223	146	463	125	86	459	225	153	476	355	295	161	166	76	199	348	295	324
Black Elk WA	315	272	507	154	83	89	251	189	224	34	13	21	68	31	48	175	96	364	228	151	199	277	233	340
Cloud Peak WA	219	144	739	70	47	572	144	88	587	19	7	112	101	45	58	98	40	121	131	80	454	148	95	738
Crow IR	364	364	1041	173	151	343	364	364	986	364	364	952	364	364	973	277	129	132	265	160	423	261	194	653
Devils Tower NM	327	300	335	231	185	102	275	219	205	119	48	35	87	35	36	139	69	194	239	162	185	309	276	305
Fort Belknap IR	117	73	161	12	6	63	88	46	69	7	1	12	88	40	74	43	21	151	80	38	58	34	22	78
Fort Laramie NHS	316	270	744	104	65	296	284	206	566	39	12	54	49	18	50	155	76	226	272	186	493	311	257	746
Jedediah Smith WA	140	80	113	2	1	16	68	36	55	0	0	4	30	13	34	96	45	100	67	35	55	60	36	80
Jewel Cave NM	323	282	482	173	111	129	280	218	264	76	29	36	65	34	37	153	84	285	247	171	231	298	259	415
Lee Metcalf WA	170	99	86	2	0	7	137	76	54	0	0	1	139	79	64	55	17	36	136	76	54	26	13	47
Mt Naomi WA	90	52	238	3	2	10	50	33	204	0	0	3	4	1	15	62	29	80	49	31	204	60	39	228
Mt Rushmore NM	309	258	504	139	72	78	240	173	205	30	12	17	64	29	47	153	82	366	205	137	183	267	219	310
Popo Agie WA	201	143	124	18	13	66	126	73	56	3	0	6	35	20	39	141	71	67	122	69	56	168	111	94
Soldier Creek WA	322	286	635	144	99	180	299	233	454	64	24	33	63	31	34	169	80	174	279	199	410	313	270	600
Wellsville Mountain WA	215	140	260	31	20	114	126	68	123	6	1	16	72	37	94	135	76	125	121	65	115	153	102	194
Wind River IR	280	222	328	48	27	130	182	114	210	11	3	16	82	45	107	256	152	161	175	106	206	258	189	301

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

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

Table 3-5
Change in Modeled Visibility Impacts - 2015 Lower Production Scenario Less the Base Year (2004)[1]

Receptor Set	All Sources			CBNG			Coal-related Sources			Coal Mines			Montana Sources			Non-coal Sources			Power Plants			Wyoming Sources		
	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}
	5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%	
CLASS I AREAS																								
Badlands NP	5	26	25	60	50	46	18	28	20	13	2	4	7	1	2	-1	-1	0	20	16	15	21	36	59
Bob Marshall WA	3	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0
Bridger WA	0	2	1	8	6	24	3	1	1	0	0	1	2	0	1	0	-1	-2	3	2	1	2	3	1
Fitzpatrick WA	0	2	2	6	5	8	4	2	2	0	0	1	0	0	1	-2	0	-1	7	2	2	1	3	1
Fort Peck IR	11	10	0	24	8	55	6	11	12	1	0	3	3	3	3	-1	0	0	8	6	3	13	10	61
Gates of the Mountain WA	3	0	2	0	0	2	2	0	2	0	0	0	1	1	2	0	0	0	2	0	2	1	0	1
Grand Teton NP	1	2	0	1	1	8	4	1	1	0	0	1	0	0	1	0	0	0	3	0	1	2	3	1
North Absaorka WA	1	3	10	5	2	10	5	0	7	0	0	1	3	0	2	0	0	0	3	2	5	5	1	9
North Cheyenne IR	18	32	102	49	58	139	23	25	40	34	15	8	37	40	9	-1	0	0	14	14	32	31	36	101
Red Rock Lakes	1	2	1	1	0	4	3	1	1	0	0	0	1	1	1	0	0	0	3	1	1	0	0	2
Scapegoat WA	2	1	1	0	0	1	1	0	1	0	0	0	0	2	1	0	0	0	1	0	1	0	0	1
Teton WA	0	4	8	3	2	8	4	2	5	0	0	1	1	1	1	-1	0	0	4	1	3	5	4	1
Theodore Roosevelt NP	3	5	1	18	25	44	12	10	15	4	1	3	6	2	3	0	-1	0	10	5	10	23	10	50
UL Bend WA	3	8	3	15	2	44	6	7	12	1	3	3	1	4	2	0	0	0	3	5	6	4	9	40
Washakie WA	2	5	8	5	4	19	1	6	3	0	0	1	0	1	2	-1	0	0	1	4	3	4	3	2
Wind Cave NP	8	18	66	63	60	60	18	37	41	22	8	4	1	2	3	-2	0	0	22	23	29	13	31	91
Yellowstone NP	2	2	9	5	1	8	3	4	6	0	0	1	1	1	2	0	0	0	2	3	4	2	2	7
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	3	2	10	7	2	9	5	3	7	0	0	1	0	2	2	0	0	0	4	3	5	7	3	12
Agate Fossil Beds NM	8	20	52	50	37	100	14	25	57	8	7	7	1	1	2	0	-1	-1	15	18	38	10	22	69
Big Horn Canyon NRA	1	1	93	12	23	77	11	15	55	17	12	74	18	12	75	0	0	0	8	6	20	0	0	67
Black Elk WA	8	34	48	72	53	46	19	31	32	6	5	4	4	2	2	0	0	0	21	15	22	19	44	73
Cloud Peak WA	8	18	54	23	20	261	10	8	86	4	3	21	10	5	3	-1	-1	-2	4	11	38	14	11	56
Crow IR	0	4	149	22	33	173	0	10	152	0	15	149	0	6	146	-1	-3	0	28	27	49	6	15	65
Devils Tower NM	5	25	60	51	90	53	13	29	20	25	18	7	6	4	2	-1	-1	0	15	22	15	15	28	58
Fort Belknap IR	4	6	1	6	2	32	7	7	7	3	0	2	4	2	2	0	0	0	5	4	2	7	8	18
Fort Laramie NHS	3	10	14	39	37	152	8	17	74	9	3	10	4	2	3	-3	0	-2	11	8	44	5	19	23
Jedediah Smith WA	0	1	0	1	1	8	2	2	1	0	0	1	1	0	1	0	0	0	2	1	1	2	3	1
Jewel Cave NM	10	19	72	65	67	66	20	36	40	13	11	7	3	2	2	-3	0	0	22	26	26	10	29	94
Lee Metcalf WA	3	2	5	2	0	3	3	1	1	0	0	0	2	2	1	0	0	0	2	2	1	1	0	3
Mt Naomi WA	2	1	4	2	2	5	3	1	5	0	0	1	0	0	0	0	0	-1	2	0	5	1	2	4
Mt Rushmore NM	9	36	46	68	43	40	27	31	30	5	5	3	2	2	2	0	0	0	11	14	21	24	46	67
Popo Agie WA	1	4	8	5	10	34	2	2	1	1	0	1	1	0	1	-1	-1	-1	3	1	1	3	3	3
Soldier Creek WA	1	18	44	46	58	92	12	26	54	18	8	6	4	3	1	0	-1	-1	13	16	37	9	27	57
Wellsville Mountain WA	6	10	19	12	11	58	6	5	9	1	0	3	1	0	2	0	-1	-2	5	5	5	4	8	1
Wind River IR	-1	2	2	22	10	67	11	5	5	3	2	3	2	2	2	-1	-1	-2	4	4	4	-5	10	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 3-6
Change in Modeled Visibility Impacts - 2015 Upper Production Scenario Less the Base Year (2004) [1]

Receptor Set	All Sources			CBNG			Coal-related Sources			Coal Mines			Montana Sources			Non-coal Sources			Power Plants			Wyoming Sources		
	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}	Change in Number of Days > N% Change in B_{ext}		Change in the Maximum % Change in B_{ext}
	5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%		5%	10%	
CLASS I AREAS																								
Badlands NP	5	26	26	60	50	46	19	33	21	21	4	7	8	3	4	-1	-1	0	20	16	15	21	37	61
Bob Marshall WA	3	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0
Bridger WA	0	2	1	8	6	24	3	2	1	0	0	2	3	0	1	0	-1	-2	3	2	1	2	3	1
Fitzpatrick WA	0	2	2	6	5	8	4	2	2	0	0	1	0	0	1	-2	0	-1	7	2	2	1	3	1
Fort Peck IR	14	10	0	24	8	55	11	14	15	12	8	7	10	10	5	-1	0	0	8	6	3	13	11	62
Gates of the Mountain WA	3	0	2	0	0	2	2	0	2	0	0	0	1	1	2	0	0	0	2	0	2	1	0	1
Grand Teton NP	2	2	0	1	1	8	4	1	1	0	0	1	1	0	1	0	0	0	3	0	1	2	3	1
North Absaorka WA	1	3	11	5	2	10	5	2	8	0	0	2	4	1	3	0	0	0	3	2	5	6	1	9
North Cheyenne IR	26	47	105	49	58	139	52	53	44	79	44	24	59	60	16	-1	0	0	14	14	32	31	37	103
Red Rock Lakes	1	2	1	1	0	4	3	1	1	0	0	1	1	1	1	0	0	0	3	1	1	0	0	2
Scapegoat WA	2	1	1	0	0	1	1	0	1	0	0	0	0	2	1	0	0	0	1	0	1	0	0	1
Teton WA	0	4	9	3	2	8	5	2	6	0	0	1	2	2	1	-1	0	0	4	1	3	5	4	1
Theodore Roosevelt NP	4	9	1	18	25	44	16	14	17	11	2	6	8	4	5	0	-1	0	10	5	10	23	10	52
U.L. Bend WA	3	10	3	15	2	44	10	7	17	11	4	7	9	7	4	0	0	0	3	5	6	4	10	41
Washakie WA	3	5	9	5	4	19	3	7	4	0	0	2	0	1	3	-1	0	0	1	4	3	4	3	2
Wind Cave NP	8	19	69	63	60	60	21	39	45	32	13	8	4	5	4	-2	0	0	22	23	29	13	32	93
Yellowstone NP	2	2	10	5	1	8	4	4	7	0	0	1	2	1	2	0	0	0	2	3	4	2	2	7
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	4	3	11	7	2	9	6	6	8	2	0	3	0	2	2	0	0	0	4	3	5	7	4	12
Agate Fossil Beds NM	8	20	54	50	37	100	14	26	63	13	11	12	2	3	3	0	-1	-1	15	18	38	10	22	71
Big Horn Canyon NRA	1	3	148	12	23	77	16	32	216	39	26	235	23	26	235	0	0	0	8	6	20	0	0	68
Black Elk WA	8	36	50	72	53	46	20	37	35	13	11	8	5	5	4	0	0	0	21	15	22	19	47	75
Cloud Peak WA	10	18	60	23	20	261	13	9	96	10	4	37	12	7	6	-1	-1	-2	4	11	38	14	11	63
Crow IR	0	4	444	22	33	173	0	12	451	0	24	449	0	8	442	-1	-3	0	28	27	49	6	15	68
Devils Tower NM	6	26	63	51	90	53	18	34	23	44	28	12	11	4	3	-1	-1	0	15	22	15	15	30	61
Fort Belknap IR	6	7	1	6	2	32	9	10	11	4	1	5	9	2	3	0	0	0	5	4	2	7	8	19
Fort Laramie NHS	3	10	16	39	37	152	8	19	82	18	6	18	9	2	5	-3	0	-2	11	8	44	5	19	26
Jedediah Smith WA	0	1	0	1	1	8	3	2	1	0	0	2	1	0	1	0	0	0	2	1	1	2	3	1
Jewel Cave NM	12	21	76	65	67	66	22	39	44	24	23	13	5	4	2	-3	0	0	22	26	26	10	31	96
Lee Metcalf WA	3	2	5	2	0	3	3	1	1	0	0	1	2	2	1	0	0	0	2	2	1	1	0	3
Mt Naomi WA	2	1	5	2	2	5	3	1	5	0	0	1	0	0	0	0	0	-1	2	0	5	1	2	4
Mt Rushmore NM	9	36	49	68	43	40	30	34	33	12	10	6	2	5	3	0	0	0	11	14	21	24	50	69
Popo Agie WA	2	4	10	5	10	34	4	4	2	3	0	2	1	0	1	-1	-1	-1	3	1	1	3	3	3
Soldier Creek WA	1	18	46	46	58	92	17	30	60	26	12	11	4	7	2	0	-1	-1	13	16	37	9	28	59
Wellsville Mountain WA	6	10	21	12	11	58	7	5	11	3	0	6	3	1	3	0	-1	-2	5	5	5	4	9	2
Wind River IR	-1	5	2	22	10	67	11	9	6	5	2	6	3	2	3	-1	-1	-2	4	4	4	-5	10	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.

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 U.S. Forest Service (FS) does not believe these thresholds (shown in **Tables 3-7**, **3-8**, and **3-9**) are sufficiently protective; however, until newer thresholds are established, these values are used for comparative purposes. **Table 3-7** provides a summary of base year deposition levels at the sensitive receptor areas. The highest modeled impacts are at the Northern Cheyenne IR with nitrogen and sulfur deposition reaching approximately 21 and 7 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. There was not a spatial relationship to deposition rates noted for this revised base year, as areas to the east and west of the PRB study area had similar rates of deposition.

The modeled changes in acid deposition (kg/ha/yr) under the lower and upper production scenarios for 2015 are shown in **Tables 3-8** and **3-9**, respectively. For all receptors and for both sulfur and nitrogen compounds, the combined deposition rates would not exceed the thresholds provided above. The maximum impacts would occur at the Northern Cheyenne IR.

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 10th 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 2015.

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 2015. 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.

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 2015 production scenarios show an impact of 2.5 µeq/L for Upper Frozen Lake. The increased acidification of Upper Frozen Lake is slightly above the base year (2004) impact.

Table 3-7
Modeled Deposition of Nitrogen and Sulfur for the 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	0.125	0.013	0.053	0.003	0.010	0.062	0.050	0.072	1.5
	Sulfur	0.192	0.003	0.092	0.000	0.018	0.100	0.091	0.106	5.0
Bob Marshall WA	Nitrogen	0.005	0.000	0.003	0.000	0.003	0.002	0.003	0.001	1.5
	Sulfur	0.009	0.000	0.004	0.000	0.005	0.005	0.004	0.002	5.0
Bridger WA	Nitrogen	0.155	0.002	0.063	0.000	0.009	0.090	0.063	0.141	1.5
	Sulfur	0.199	0.001	0.100	0.000	0.012	0.099	0.100	0.156	5.0
Fitzpatrick WA	Nitrogen	0.205	0.002	0.044	0.000	0.009	0.169	0.044	0.193	1.5
	Sulfur	0.136	0.000	0.072	0.000	0.013	0.081	0.072	0.106	5.0
Fort Peck IR	Nitrogen	0.071	0.005	0.022	0.002	0.020	0.046	0.020	0.020	1.5
	Sulfur	0.124	0.001	0.034	0.000	0.028	0.088	0.034	0.025	5.0
Gates of the Mountain WA	Nitrogen	0.066	0.001	0.044	0.000	0.058	0.022	0.044	0.005	1.5
	Sulfur	0.075	0.000	0.055	0.000	0.062	0.019	0.055	0.006	5.0
Grand Teton NP	Nitrogen	0.063	0.001	0.036	0.000	0.019	0.026	0.036	0.033	1.5
	Sulfur	0.146	0.000	0.046	0.000	0.019	0.101	0.046	0.050	5.0
North Absaorka WA	Nitrogen	0.075	0.002	0.045	0.001	0.039	0.031	0.045	0.034	1.5
	Sulfur	0.117	0.001	0.054	0.000	0.049	0.063	0.054	0.045	5.0
North Cheyenne IR	Nitrogen	0.314	0.139	0.131	0.023	0.096	0.066	0.114	0.227	1.5
	Sulfur	0.385	0.025	0.229	0.004	0.192	0.144	0.227	0.166	5.0
Red Rock Lakes	Nitrogen	0.056	0.000	0.043	0.000	0.041	0.012	0.043	0.009	1.5
	Sulfur	0.069	0.000	0.041	0.000	0.036	0.028	0.041	0.014	5.0
Scapegoat WA	Nitrogen	0.021	0.000	0.014	0.000	0.017	0.006	0.014	0.003	1.5
	Sulfur	0.031	0.000	0.018	0.000	0.024	0.013	0.018	0.003	5.0
Teton WA	Nitrogen	0.060	0.001	0.034	0.000	0.018	0.026	0.034	0.032	1.5
	Sulfur	0.117	0.000	0.046	0.000	0.022	0.070	0.046	0.046	5.0
Theodore Roosevelt NP Class I Area	Nitrogen	0.221	0.014	0.050	0.003	0.021	0.181	0.047	0.062	1.5
	Sulfur	0.287	0.003	0.063	0.000	0.028	0.225	0.062	0.061	5.0
U.L. Bend WA	Nitrogen	0.085	0.008	0.041	0.003	0.031	0.036	0.038	0.031	1.5
	Sulfur	0.118	0.002	0.051	0.001	0.048	0.066	0.050	0.033	5.0
Washakie WA	Nitrogen	0.081	0.002	0.043	0.001	0.025	0.036	0.042	0.051	1.5
	Sulfur	0.136	0.001	0.062	0.000	0.039	0.074	0.062	0.075	5.0
Wind Cave NP	Nitrogen	0.218	0.036	0.117	0.011	0.015	0.068	0.106	0.172	1.5
	Sulfur	0.360	0.008	0.229	0.001	0.027	0.123	0.228	0.289	5.0
Yellowstone NP	Nitrogen	0.073	0.002	0.052	0.000	0.043	0.026	0.052	0.029	1.5
	Sulfur	0.129	0.000	0.053	0.000	0.044	0.081	0.053	0.043	5.0
CLASS I / CLASS II SENSITIVE LAKES										
Black Joe Lake, Bridger WA	Nitrogen	0.104	0.002	0.052	0.000	0.009	0.049	0.052	0.089	1.5
	Sulfur	0.167	0.001	0.086	0.000	0.012	0.081	0.086	0.128	5.0
Deep Lake, Bridger WA	Nitrogen	0.110	0.002	0.054	0.000	0.009	0.054	0.054	0.095	1.5
	Sulfur	0.171	0.001	0.088	0.000	0.012	0.082	0.088	0.131	5.0
Emerald Lake, Cloud Peak WA	Nitrogen	0.120	0.018	0.060	0.003	0.027	0.042	0.057	0.084	1.5
	Sulfur	0.163	0.004	0.083	0.001	0.045	0.076	0.082	0.097	5.0
Florence, Cloud Peak WA	Nitrogen	0.123	0.020	0.062	0.003	0.025	0.041	0.059	0.089	1.5
	Sulfur	0.167	0.004	0.087	0.001	0.043	0.077	0.086	0.104	5.0
Hobbs Lake, Bridger WA	Nitrogen	0.078	0.001	0.040	0.000	0.006	0.037	0.040	0.067	1.5
	Sulfur	0.130	0.000	0.069	0.000	0.008	0.061	0.069	0.097	5.0
Lower Saddlebag, Popo Agie WA	Nitrogen	0.132	0.003	0.061	0.000	0.010	0.069	0.060	0.116	1.5
	Sulfur	0.209	0.001	0.101	0.000	0.012	0.107	0.101	0.166	5.0
Ross Lake, Cloud Peak WA	Nitrogen	0.063	0.001	0.032	0.000	0.008	0.029	0.032	0.050	1.5
	Sulfur	0.101	0.000	0.051	0.000	0.011	0.049	0.051	0.069	5.0
Upper Frozen Lake, Bridger WA	Nitrogen	0.120	0.002	0.057	0.000	0.009	0.060	0.057	0.105	1.5
	Sulfur	0.180	0.001	0.092	0.000	0.012	0.087	0.092	0.139	5.0

Table 3-8
Change in Modeled Deposition of Nitrogen and Sulfur - 2015 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	0.021	0.014	0.007	0.001	0.001	0.000	0.005	0.020	1.5
	Sulfur	0.017	0.003	0.014	0.000	0.001	0.000	0.011	0.016	5.0
Bob Marshall WA	Nitrogen	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.5
	Sulfur	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.0
Bridger WA	Nitrogen	0.003	0.003	0.002	0.000	0.000	-0.002	0.002	0.002	1.5
	Sulfur	0.004	0.001	0.004	0.000	0.000	-0.001	0.003	0.003	5.0
Fitzpatrick WA	Nitrogen	-0.001	0.002	0.002	0.000	0.000	-0.004	0.001	-0.001	1.5
	Sulfur	0.002	0.000	0.003	0.000	0.000	-0.001	0.003	0.001	5.0
Fort Peck IR	Nitrogen	0.008	0.005	0.003	0.001	0.001	0.000	0.002	0.007	1.5
	Sulfur	0.006	0.001	0.005	0.000	0.001	0.000	0.004	0.005	5.0
Gates of the Mountain WA	Nitrogen	0.002	0.001	0.001	0.000	0.001	0.000	0.001	0.001	1.5
	Sulfur	0.002	0.000	0.002	0.000	0.001	0.000	0.002	0.001	5.0
Grand Teton NP	Nitrogen	0.002	0.001	0.001	0.000	0.000	0.000	0.001	0.001	1.5
	Sulfur	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.001	5.0
North Absaorka WA	Nitrogen	0.004	0.002	0.002	0.000	0.001	0.000	0.002	0.003	1.5
	Sulfur	0.004	0.001	0.004	0.000	0.002	0.000	0.003	0.002	5.0
North Cheyenne IR	Nitrogen	0.166	0.147	0.024	0.007	0.019	-0.001	0.017	0.153	1.5
	Sulfur	0.061	0.026	0.043	0.001	0.021	0.000	0.038	0.051	5.0
Red Rock Lakes	Nitrogen	0.002	0.000	0.001	0.000	0.001	0.000	0.001	0.001	1.5
	Sulfur	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.001	5.0
Scapegoat WA	Nitrogen	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.001	1.5
	Sulfur	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000	5.0
Teton WA	Nitrogen	0.003	0.001	0.001	0.000	0.001	0.000	0.001	0.002	1.5
	Sulfur	0.002	0.000	0.002	0.000	0.001	0.000	0.002	0.001	5.0
Theodore Roosevelt NP	Nitrogen	0.012	0.015	0.006	0.001	0.001	0.000	0.005	0.020	1.5
	Sulfur	0.012	0.003	0.010	0.000	0.001	0.000	0.008	0.012	5.0
U.L. Bend WA	Nitrogen	0.013	0.008	0.005	0.001	0.002	0.000	0.004	0.012	1.5
	Sulfur	0.010	0.002	0.008	0.000	0.002	0.000	0.007	0.008	5.0
Washakie WA	Nitrogen	0.004	0.002	0.002	0.000	0.001	0.000	0.002	0.004	1.5
	Sulfur	0.004	0.001	0.003	0.000	0.001	0.000	0.003	0.003	5.0
Wind Cave NP	Nitrogen	0.056	0.038	0.019	0.003	0.001	0.000	0.014	0.055	1.5
	Sulfur	0.047	0.009	0.039	0.000	0.002	0.000	0.032	0.046	5.0
Yellowstone NP	Nitrogen	0.004	0.002	0.001	0.000	0.001	0.000	0.001	0.002	1.5
	Sulfur	0.002	0.000	0.002	0.000	0.001	0.000	0.002	0.001	5.0
CLASS I / CLASS II SENSITIVE LAKES										
Black Joe Lake, Bridger WA	Nitrogen	0.004	0.002	0.002	0.000	0.000	-0.001	0.002	0.003	1.5
	Sulfur	0.003	0.001	0.003	0.000	0.000	-0.001	0.003	0.003	5.0
Deep Lake, Bridger WA	Nitrogen	0.003	0.002	0.002	0.000	0.000	-0.001	0.002	0.003	1.5
	Sulfur	0.003	0.001	0.003	0.000	0.000	-0.001	0.003	0.003	5.0
Emerald Lake, Cloud Peak WA	Nitrogen	0.025	0.019	0.006	0.001	0.002	0.000	0.004	0.023	1.5
	Sulfur	0.013	0.004	0.009	0.000	0.003	0.000	0.008	0.010	5.0
Florence, Cloud Peak WA	Nitrogen	0.027	0.021	0.007	0.001	0.002	0.000	0.005	0.025	1.5
	Sulfur	0.014	0.004	0.010	0.000	0.003	0.000	0.009	0.011	5.0
Hobbs Lake, Bridger WA	Nitrogen	0.002	0.001	0.001	0.000	0.000	-0.001	0.001	0.002	1.5
	Sulfur	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.002	5.0
Lower Saddlebag, Popo Agie WA	Nitrogen	0.004	0.003	0.002	0.000	0.000	-0.001	0.002	0.004	1.5
	Sulfur	0.004	0.001	0.004	0.000	0.000	-0.001	0.004	0.003	5.0
Ross Lake, Cloud Peak WA	Nitrogen	0.002	0.001	0.001	0.000	0.000	0.000	0.001	0.002	1.5
	Sulfur	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.002	5.0
Upper Frozen Lake, Bridger WA	Nitrogen	0.003	0.002	0.002	0.000	0.000	-0.001	0.002	0.003	1.5
	Sulfur	0.003	0.001	0.003	0.000	0.000	-0.001	0.003	0.003	5.0

Table 3-9
Change in Modeled Deposition of Nitrogen and Sulfur - 2015 Upper Production Scenario

Receptor Set	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	0.022	0.014	0.008	0.002	0.001	0.000	0.005	0.021	1.5
	0.017	0.003	0.014	0.000	0.001	0.000	0.011	0.016	5.0
Bob Marshall WA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.5
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.0
Bridger WA	0.003	0.003	0.002	0.000	0.000	-0.002	0.002	0.002	1.5
	0.004	0.001	0.004	0.000	0.000	-0.001	0.003	0.003	5.0
Fitzpatrick WA	-0.001	0.002	0.002	0.000	0.000	-0.004	0.001	-0.001	1.5
	0.002	0.000	0.003	0.000	0.000	-0.001	0.003	0.001	5.0
Fort Peck IR	0.009	0.005	0.004	0.002	0.002	0.000	0.002	0.007	1.5
	0.006	0.001	0.005	0.000	0.002	0.000	0.004	0.005	5.0
Gates of the Mountain WA	0.002	0.001	0.002	0.000	0.001	0.000	0.001	0.001	1.5
	0.002	0.000	0.002	0.000	0.001	0.000	0.002	0.001	5.0
Grand Teton NP	0.002	0.001	0.001	0.000	0.000	0.000	0.001	0.001	1.5
	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.001	5.0
North Absaorka WA	0.005	0.002	0.003	0.001	0.001	0.000	0.002	0.003	1.5
	0.004	0.001	0.004	0.000	0.002	0.000	0.003	0.002	5.0
North Cheyenne IR	0.231	0.147	0.169	0.022	0.148	-0.001	0.017	0.154	1.5
	0.065	0.026	0.047	0.004	0.024	0.000	0.038	0.052	5.0
Red Rock Lakes	0.002	0.000	0.001	0.000	0.001	0.000	0.001	0.001	1.5
	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.001	5.0
Scapegoat WA	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.001	1.5
	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000	5.0
Teton WA	0.003	0.001	0.001	0.000	0.001	0.000	0.001	0.002	1.5
	0.002	0.000	0.002	0.000	0.001	0.000	0.002	0.001	5.0
Theodore Roosevelt NP	0.012	0.015	0.008	0.002	0.002	0.000	0.005	0.021	1.5
	0.012	0.003	0.010	0.000	0.001	0.000	0.008	0.012	5.0
U.L. Bend WA	0.015	0.008	0.007	0.002	0.003	0.000	0.004	0.012	1.5
	0.010	0.002	0.008	0.001	0.002	0.000	0.007	0.008	5.0
Washakie WA	0.005	0.002	0.003	0.001	0.001	0.000	0.002	0.004	1.5
	0.004	0.001	0.003	0.000	0.001	0.000	0.003	0.003	5.0
Wind Cave NP	0.059	0.038	0.022	0.006	0.002	0.000	0.014	0.058	1.5
	0.047	0.009	0.039	0.001	0.002	0.000	0.032	0.046	5.0
Yellowstone NP	0.004	0.002	0.002	0.000	0.001	0.000	0.001	0.002	1.5
	0.002	0.000	0.002	0.000	0.001	0.000	0.002	0.001	5.0
CLASS I / CLASS II SENSITIVE LAKES									
Black Joe Lake, Bridger WA	0.004	0.002	0.002	0.000	0.000	-0.001	0.002	0.003	1.5
	0.003	0.001	0.003	0.000	0.000	-0.001	0.003	0.003	5.0
Deep Lake, Bridger WA	0.004	0.002	0.002	0.000	0.000	-0.001	0.002	0.003	1.5
	0.003	0.001	0.003	0.000	0.000	-0.001	0.003	0.003	5.0
Emerald Lake, Cloud Peak WA	0.027	0.019	0.008	0.003	0.004	0.000	0.004	0.023	1.5
	0.014	0.004	0.010	0.001	0.003	0.000	0.008	0.010	5.0
Florence, Cloud Peak WA	0.029	0.021	0.008	0.003	0.003	0.000	0.005	0.025	1.5
	0.014	0.004	0.011	0.001	0.003	0.000	0.009	0.011	5.0
Hobbs Lake, Bridger WA	0.002	0.001	0.001	0.000	0.000	-0.001	0.001	0.002	1.5
	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.002	5.0
Lower Saddlebag, Popo Agie WA	0.004	0.003	0.002	0.000	0.001	-0.001	0.002	0.004	1.5
	0.004	0.001	0.004	0.000	0.001	-0.001	0.004	0.003	5.0
Ross Lake, Cloud Peak WA	0.002	0.001	0.001	0.000	0.000	0.000	0.001	0.002	1.5
	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.002	5.0
Upper Frozen Lake, Bridger WA	0.004	0.002	0.002	0.000	0.000	-0.001	0.002	0.003	1.5
	0.004	0.001	0.004	0.000	0.000	-0.001	0.003	0.003	5.0

Table 3-10
Modeled Impacts on Acid Neutralizing Capacity of Sensitive Lakes – 2015 Production Scenarios

Location	Lake	Background ANC (µeq/L)	Area (hectares)	Base Year (2004) Change (percent)	2015 Lower Development Scenario Change (percent)	2015 Upper Development Scenario Change (percent)	Thresholds (percent)
Bridger WA	Black Joe	67	890	4.00	4.11	4.11	10
	Deep	60	205	4.70	4.82	4.82	10
	Hobbs	70	293	3.95	4.03	4.03	10
	Upper Frozen	5	64.8	2.42	2.47	2.48	1[1]
Cloud Peak WA	Emerald	55.3	293	5.24	5.97	6.02	10
	Florence	32.7	417	9.09	10.41	10.48	10
Fitzpatrick WA	Ross	53.5	4,455	2.72	2.79	2.79	10
Popo Agie WA	Lower Saddlebag	55.5	155	6.28	6.42	6.43	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).

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 impacts at one of these lakes would be only slightly above the threshold value.

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. 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.

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 1×10^{-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 2015 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 1×10^{-4} to 1×10^{-6}, as provided by the USEPA (2007).

Table 3-11
Modeled Maximum Acute Concentrations of Hazardous Air Pollutants from All Sources

Receptor Set	Pollutant	Averaging Period[1]	Base Year (2004)	2015 Lower Development Scenario	2015 Upper Development Scenario	REL
Near-field Receptors			**All Data in µg/m^3**			
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.

Table 3-12
Modeled Maximum Annual Concentrations of Hazardous Air Pollutants from All Sources

Receptor Set	Pollutant	Averaging Period[1]	Base Year (2004)	2015 Lower Development Scenario	2015 Upper Development Scenario	Non-carcinogenic RfCs
Near-field Receptors – Non-carcinogenic Impacts			**All Data in µg/m^3**			
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.

3.2 Comparison to Original Study

With a few notable exceptions, the original Task 3A qualitative projections for 2015 are consistent with the findings of the current update. One important difference between this updated study and previous findings is the large increase in projected 2015 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 2A results.

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 updated 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 2015 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. **Table 3-13** provides estimated production levels, by source groups, for the original Task 3A Report compared to values used for this updated analysis.

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	2,002
Power Plants, Montana	2,576	MW Generating Capacity	Lower	2,689	3,439	3,439	2,689	2,802	3,439
			Upper	2,689	3,439	4,189	2,689	2,802	4,189

[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 based on updated information. For this reason, the projected power plant development levels have changed for 2015 and 2020.

The comparison between this updated analysis and the qualitative projections for 2015 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 and future year air quality; therefore, the revision of predicted generating capacity did not noticeably affect the original Task 3A qualitative projections of 2015 air quality. However, changes to CBNG production had a more substantial effect on the comparison of qualitative projections for 2015 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.

3.2.1 Impacts on Ambient Air Quality

3.2.1.1 Wyoming Near-field Impacts

The original Task 3A qualitative analysis for 2015 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 exceedences of both these pollutants are projected to occur in 2015, 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** and **3-3**, exceedences still would be limited to a small area 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 2015 modeled impacts; however, under shorter averaging periods (24-hour and 3-hour) SO_2 impacts predicted for 2015 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 projected development.

The NO_2 impacts are the result of emissions from all of the 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 suggest that exceedences are unlikely.

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 two analyses, 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. 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, except for the state ambient standard for 1-hour NO_2.

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 and coal sources.

3.2.2 Impacts at Class I Area Receptors

As noted in Section 3.1.2, the projected impacts in Class I areas in 2015 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 CBNG sources in Wyoming and coal-related sources in Montana. 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 2015 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 Visibility Impacts

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 2015 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 2015, the number of days with a 10 percent change would increase to more than 40 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 2015 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 2015 also were well below the established sensitive thresholds. Increased development would not likely lead to exceedences of those thresholds for any identified sensitive areas.

3.2.6 Impact 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 2015 would not likely lead to any exceedences.

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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/m^3 arithmetic average	Same as NAAQS	50 µg/m^3, state and federal violation when more than one expected exceedance per calendar year, averaged over 3 years.
	24-hour	The 150 µg/m^3 standard has been revoked at the date of this report.	150 µg/m^3, maximum average concentration, no more than one exceedance per year.	150 µg/m^3, 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/m^3, 3-year average of annual arithmetic mean.	15 µg/m^3, annual arithmetic mean	Same as NAAQS.
	24-Hour	35 µg/m^3, 98th percentile of the 24-hour values determined for each year. 3-year average of the 98th percentile values.	35 µg/m^3, 98th percentile 24-hour average	Same as NAAQS.
SO_2	Annual	0.03 ppm (80 µg/m^3), annual arithmetic mean not to be exceeded in any calendar year.	60 µg/m^3, 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/m^3), not to be exceeded more than once in any calendar year	260 µg/m^3, 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/m^3), not to be exceeded more than once in any calendar year (secondary standard)	1,300 µg/m^3 (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/m^3 (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/m^3), 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/m^3) 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.