3.0 PREDICTED CUMULATIVE AIR IMPACTS

3.1 Modeled Cumulative Impacts 2020

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

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

Table 3-1
Summary of Modeled Air Quality Impacts

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

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

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

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

It is important to note that the effects of Best Available Retrofit Technology (BART) implementation were not incorporated into the presented results, since the states are still developing their implementation plan. BART implementation primarily will target emission reductions of NO_x and SO_2, precursors to particulates most involved in visibility reduction. It is anticipated that the modeled

air quality effects summarized as part of this report likely would be reduced as a result of BART regulations; however, the level of reduction cannot be determined at this time.

3.1.1 Impacts on Ambient Air Quality

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

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

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

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

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

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

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

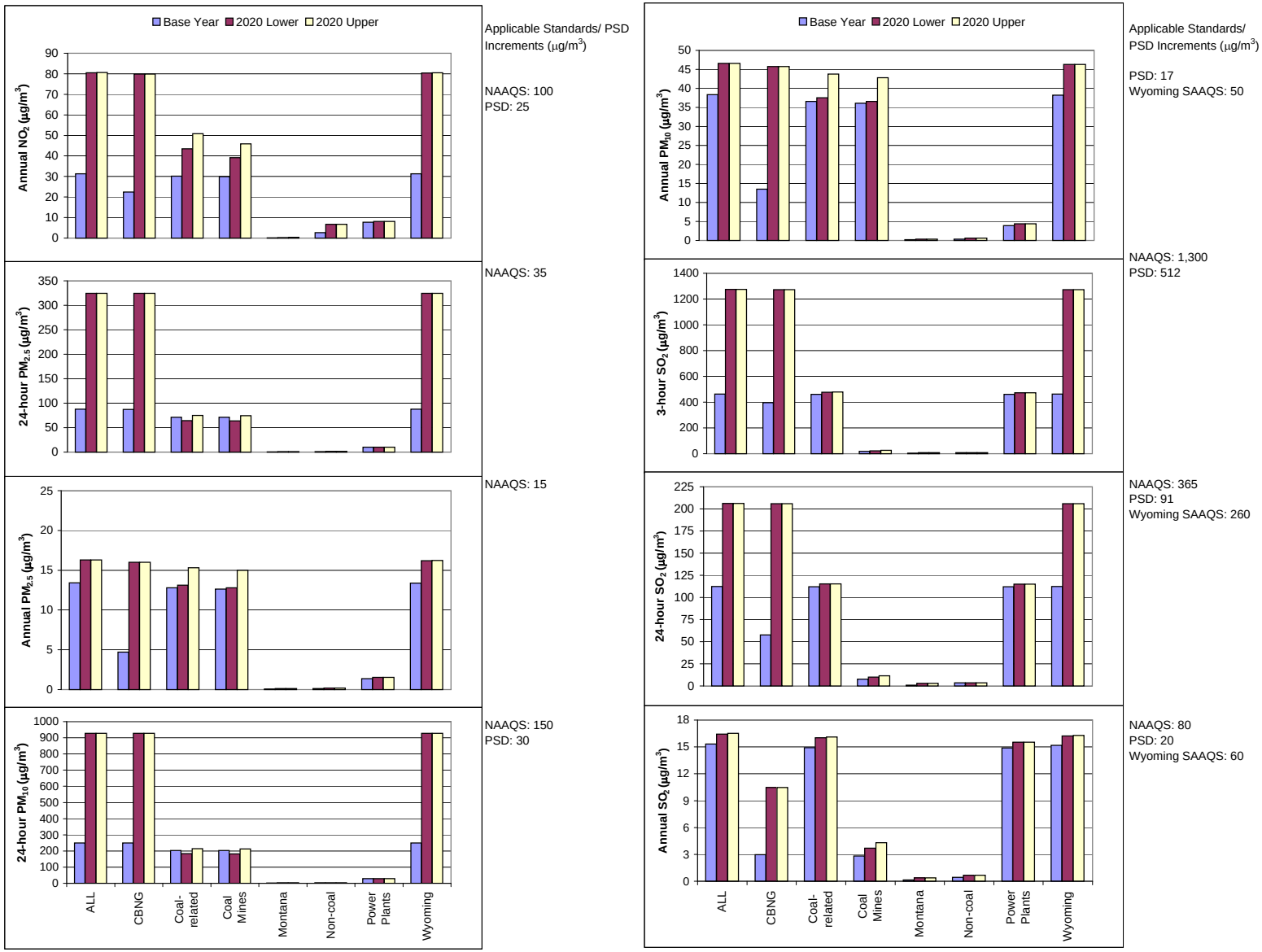
3.1.1.1 Impacts at Near-field Receptors in Wyoming

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

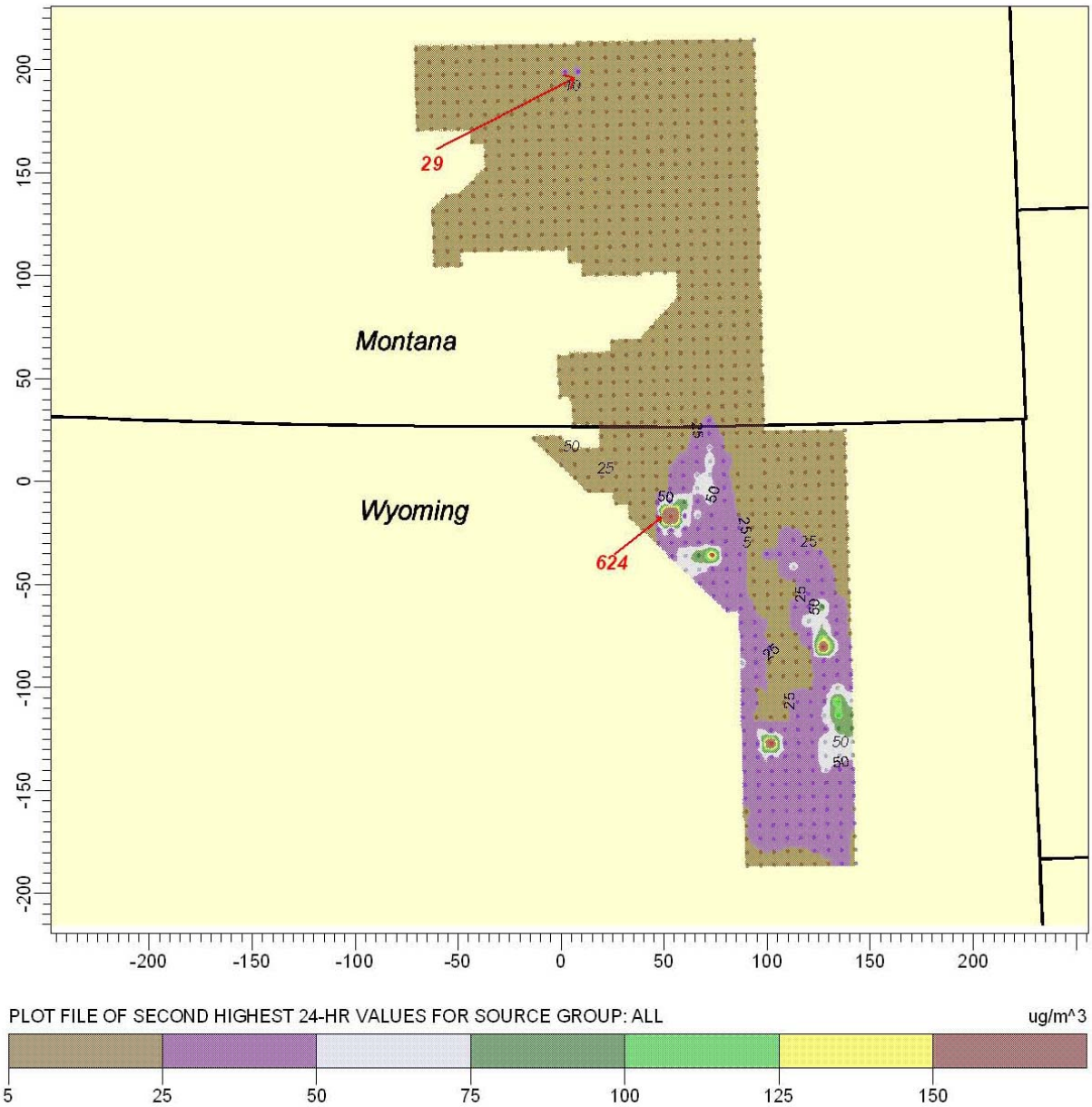
Figure 3-4 shows the modeled extent of the annual $PM_{2.5}$ impacts for the 2020 upper production scenario for all sources. This is similar to the spatial pattern depicted in **Figure 3-3**, except the maximum impacts are slightly above SAAQS, and maximum values are limited in their spatial extent.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

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

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



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



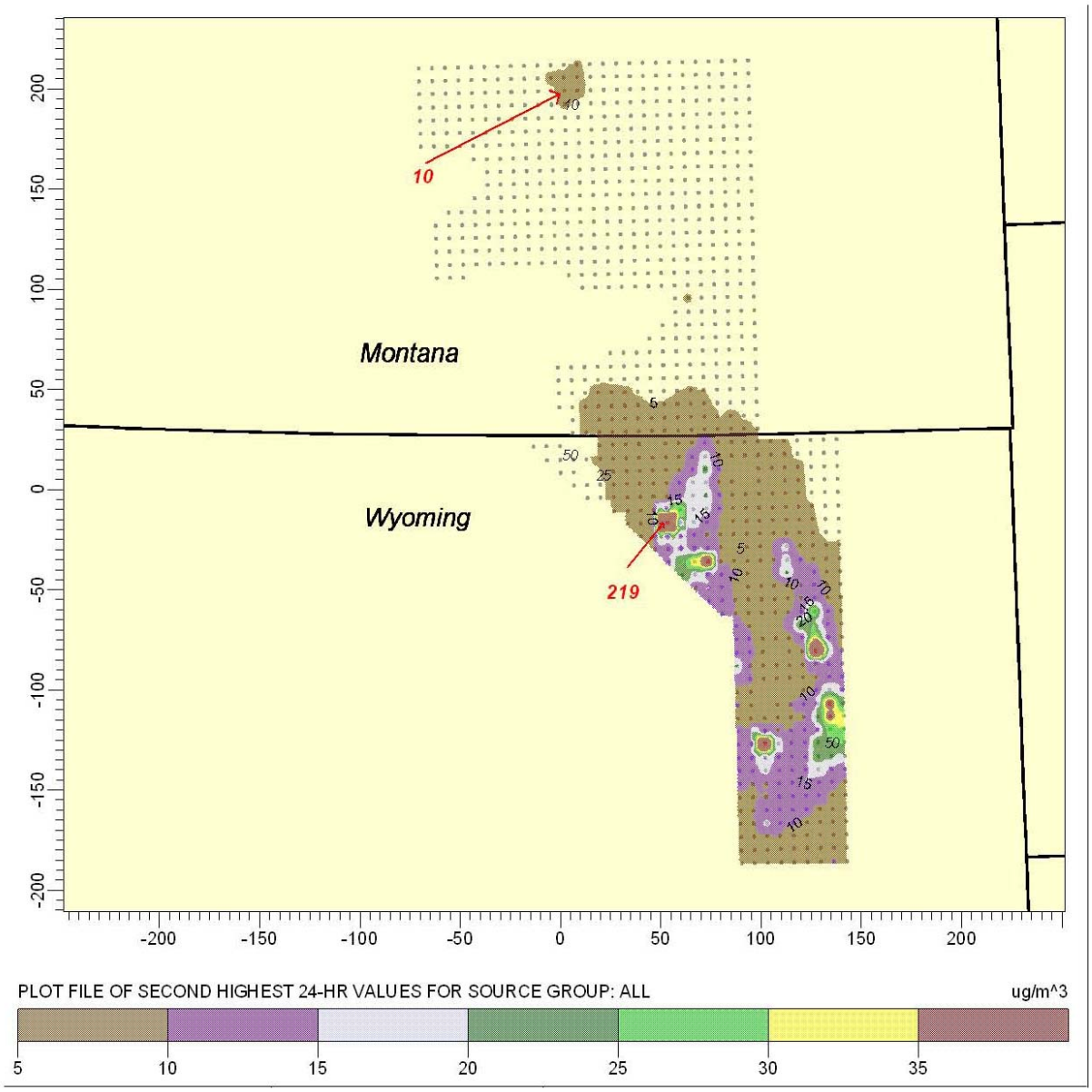
Powder River Basin Coal Review

Figure 3-2

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

Note: Includes all sources.

08/20/09



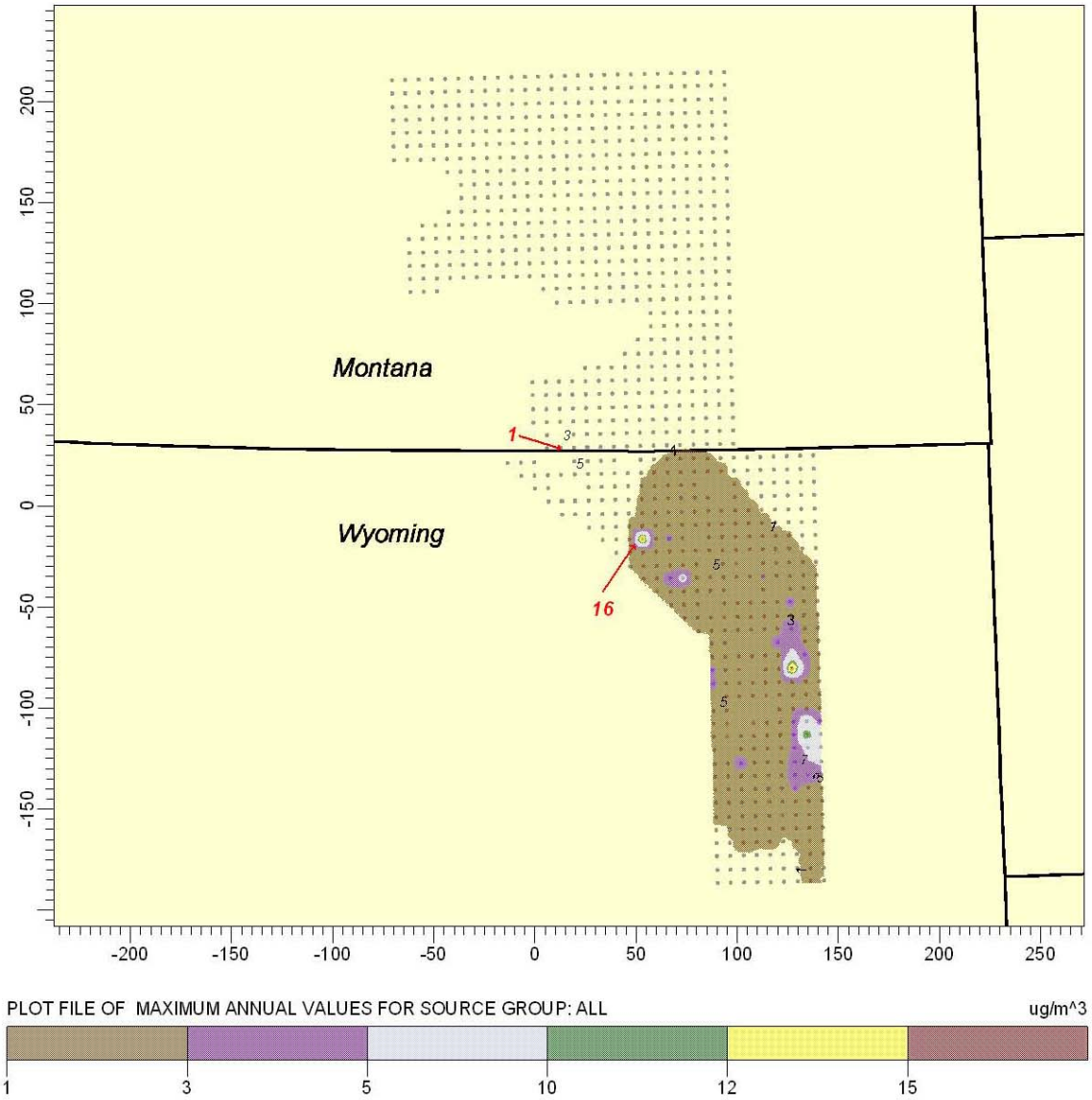
Powder River Basin Coal Review

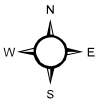
Figure 3-3

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

Note: Includes all sources.

08/20/09





Powder River Basin Coal Review

Figure 3-4

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

Note: Includes all sources.

08/20/09

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

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

3.1.1.2 Impacts at Near-field Receptors in Montana

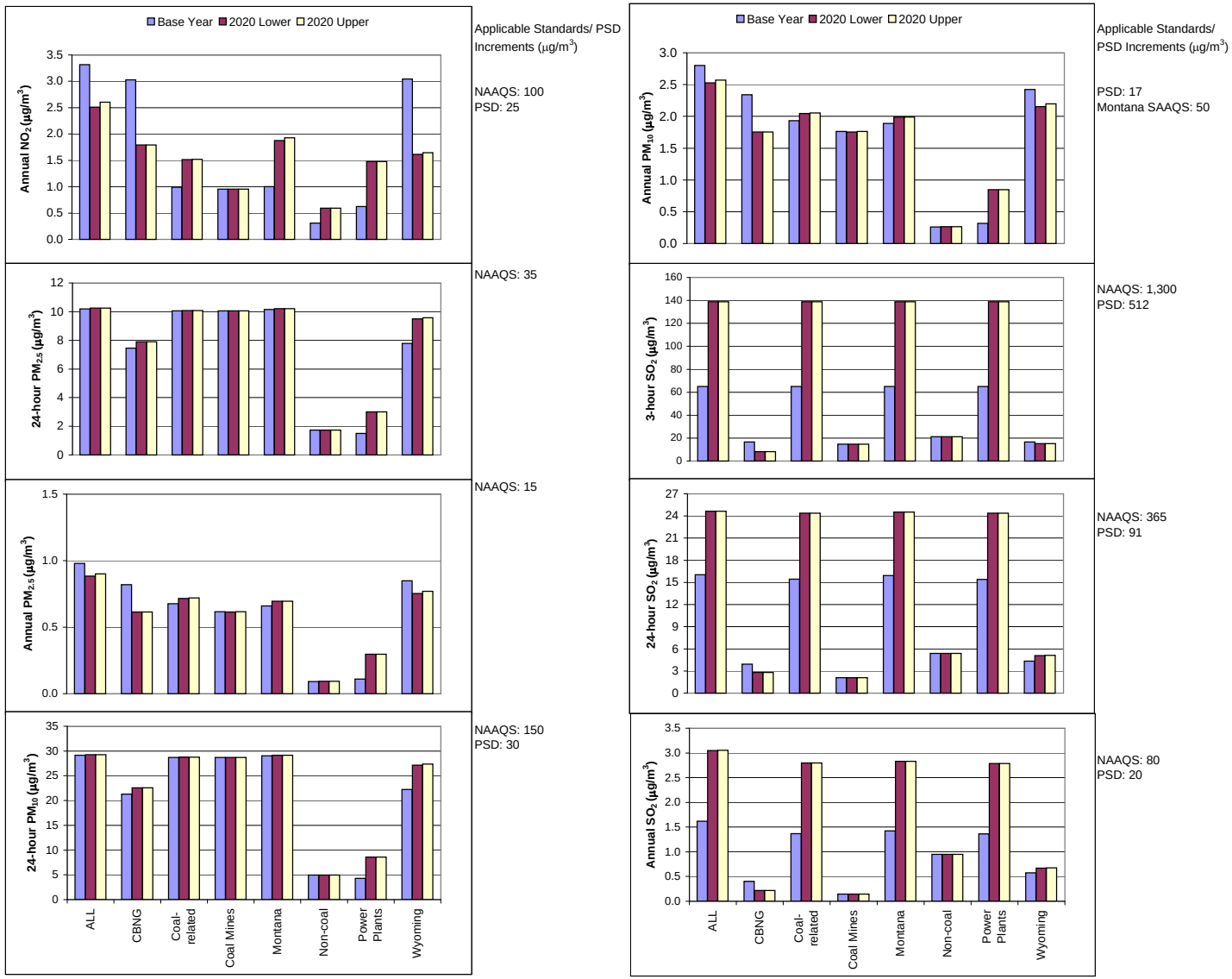
Figure 3-5 provides a similar analysis for near-field receptors in Montana, providing the maximum modeled impact for each source group as well as the total predicted maximum. The modeled impacts and a comparison to the 1-hour Montana standards for SO_2 and NO_2 are provided in **Figure 3-6**. Projected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

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

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

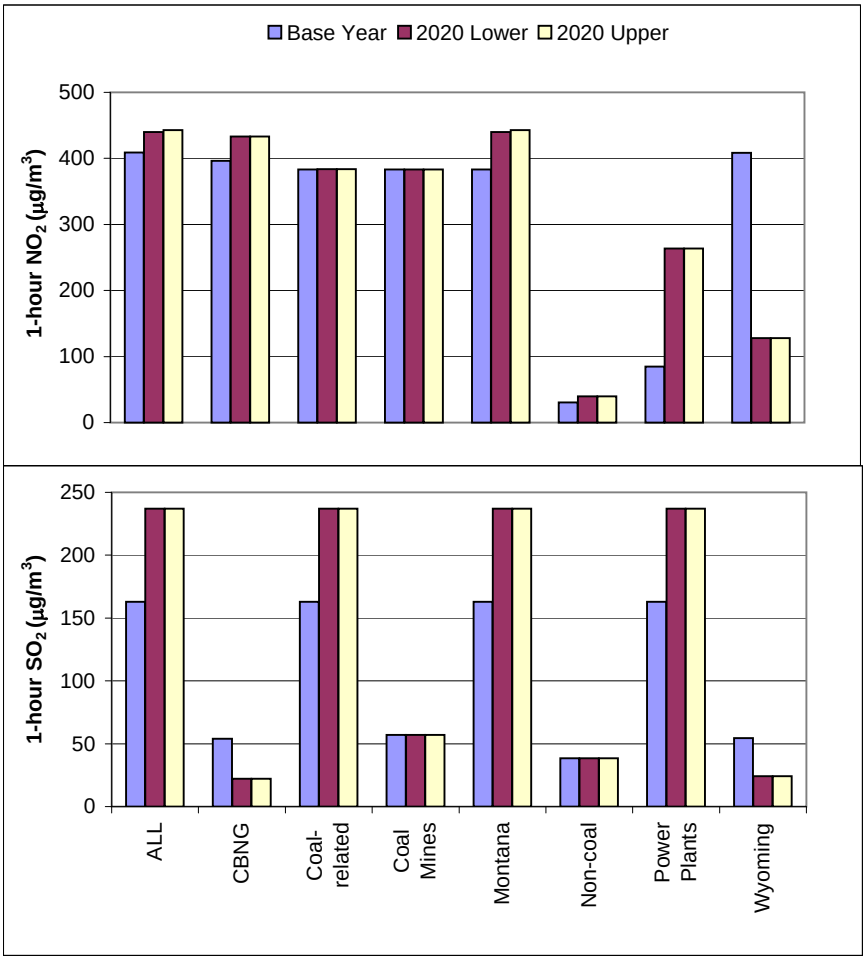
Based on the modeling, the SO_2 impacts in Montana would be well below the applicable standards and PSD increment levels. The projected maximum impacts from SO_2 emissions are attributable to emissions from Montana coal-fired power plant sources. The modeled impacts showed that increases of SO_2 impacts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

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



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

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



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

Montana SAAQS: 564

Montana SAAQS: 1,300

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

3.1.2 Air Quality Impacts at Class I Area Receptors

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

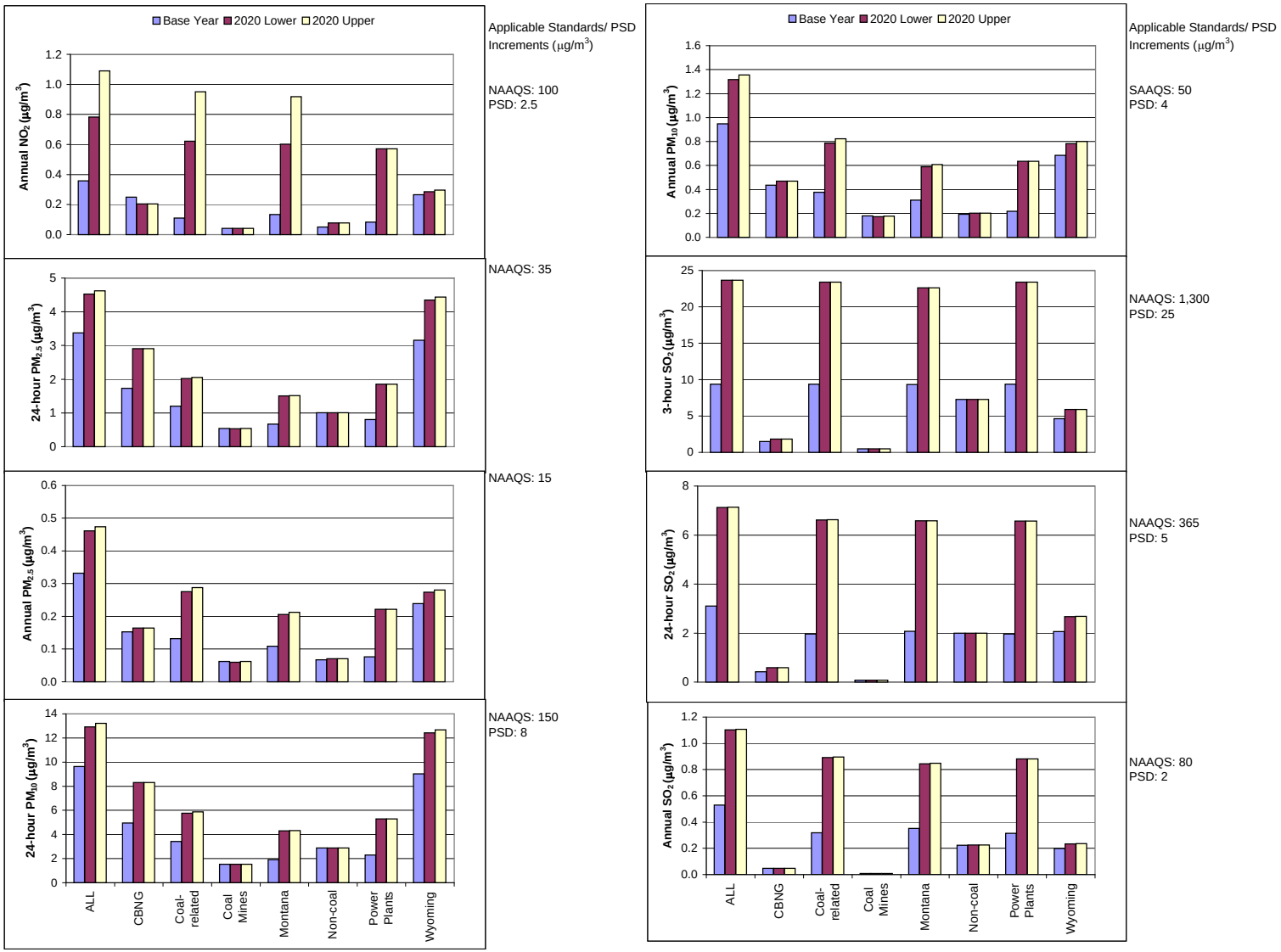
The results for the Northern Cheyenne IR are provided in **Figure 3-7**. The modeled impacts were all well below the ambient standards and the PSD increments for all air pollutants, except the projected impacts are above the 24-hour PM_{10} and SO_2 increment levels. For comparison only, the 24-hour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

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

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

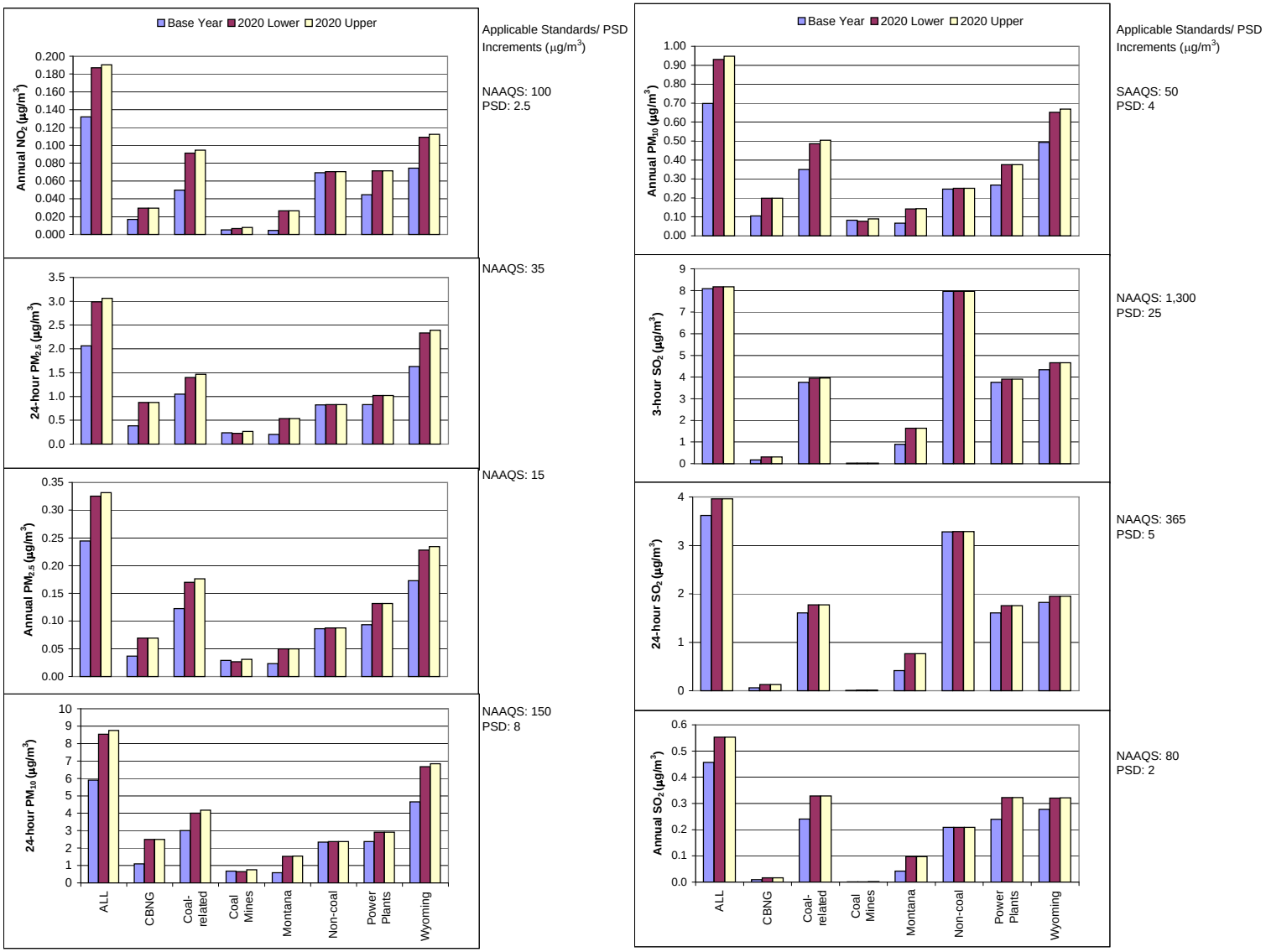
These impact data are provided for comparison only; PSD increment-consuming sources were not specifically evaluated.

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



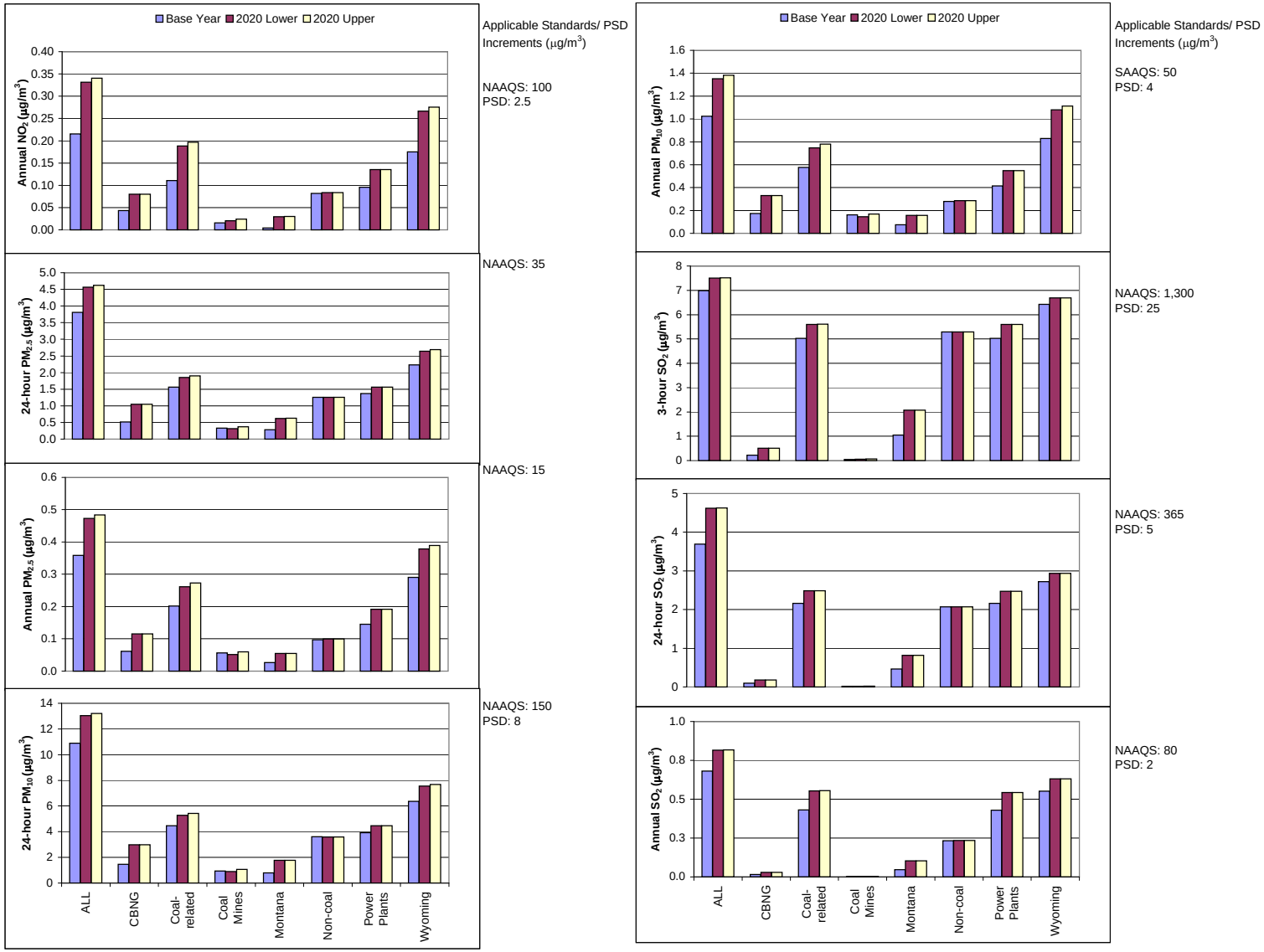
Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

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



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

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



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

3.1.3 Air Quality Impacts at Sensitive Class II Area Receptors

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

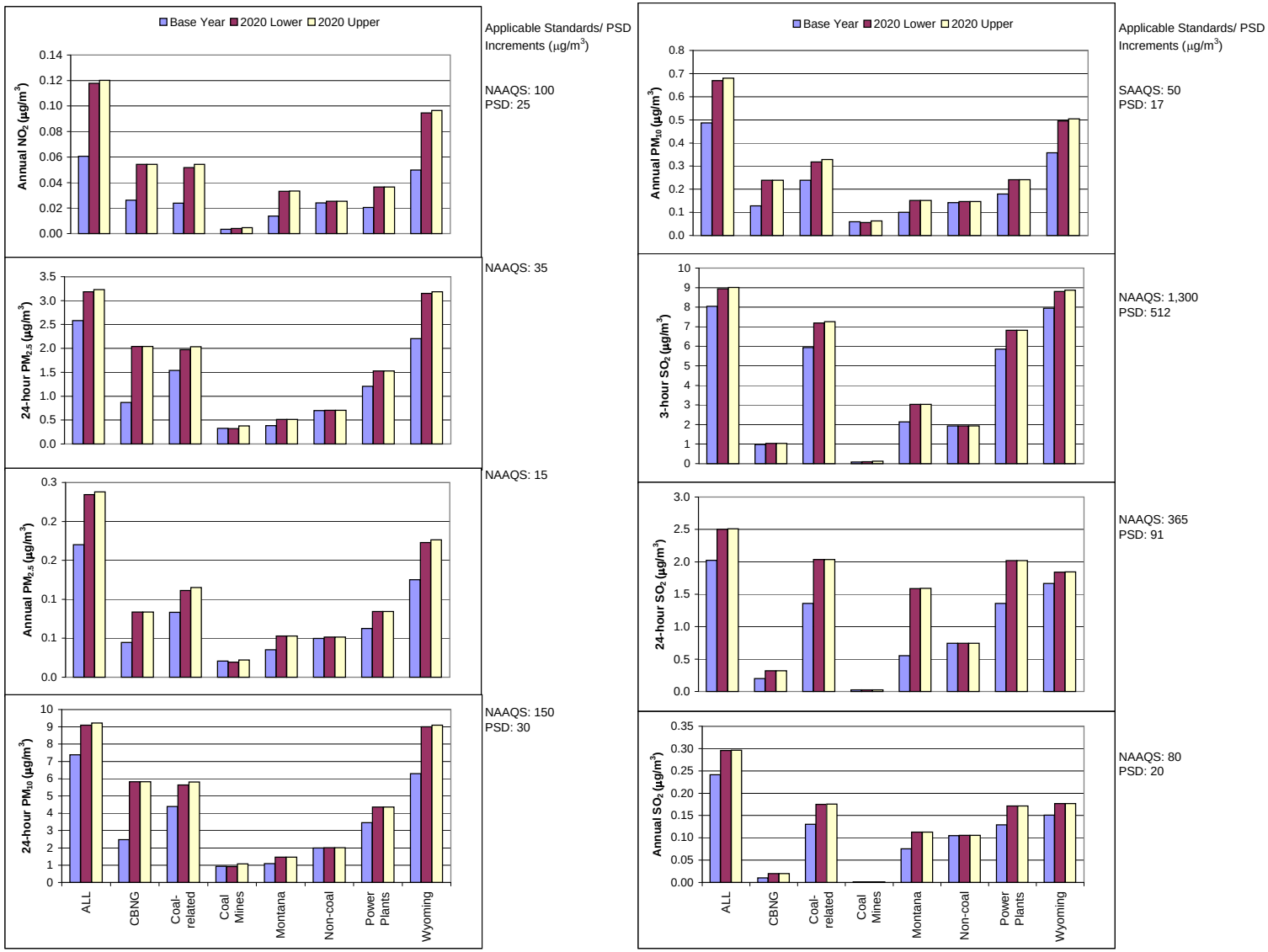
Figure 3-12 shows the base year (2004) and predicted future year (2020) modeled 1-hour NO_2 impacts at Big Horn Canyon National Recreation Area (NRA) and Crow IR. These two Class II areas have the highest modeled impacts of any modeled Class II area for the base year, yet impacts in the future years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

3.1.4 Impacts on Visibility

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

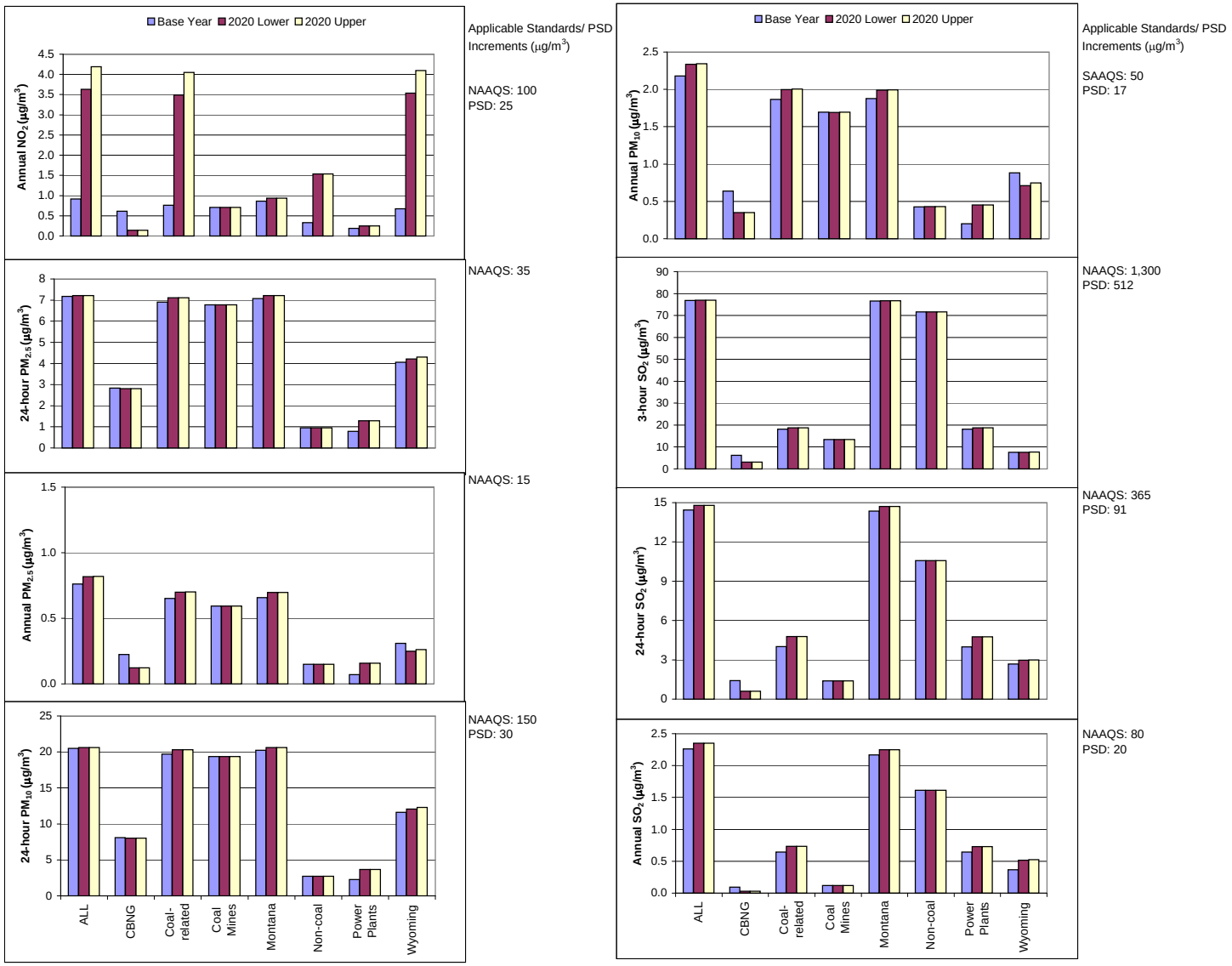
Tables 3-2 and **3-3** provide the modeled visibility impact results using “Method 6” for the lower and upper production scenarios for 2020, respectively. Based on the modeling results, those areas predicted to be the most impacted in the base year (2004) and 2015 typically are predicted to

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



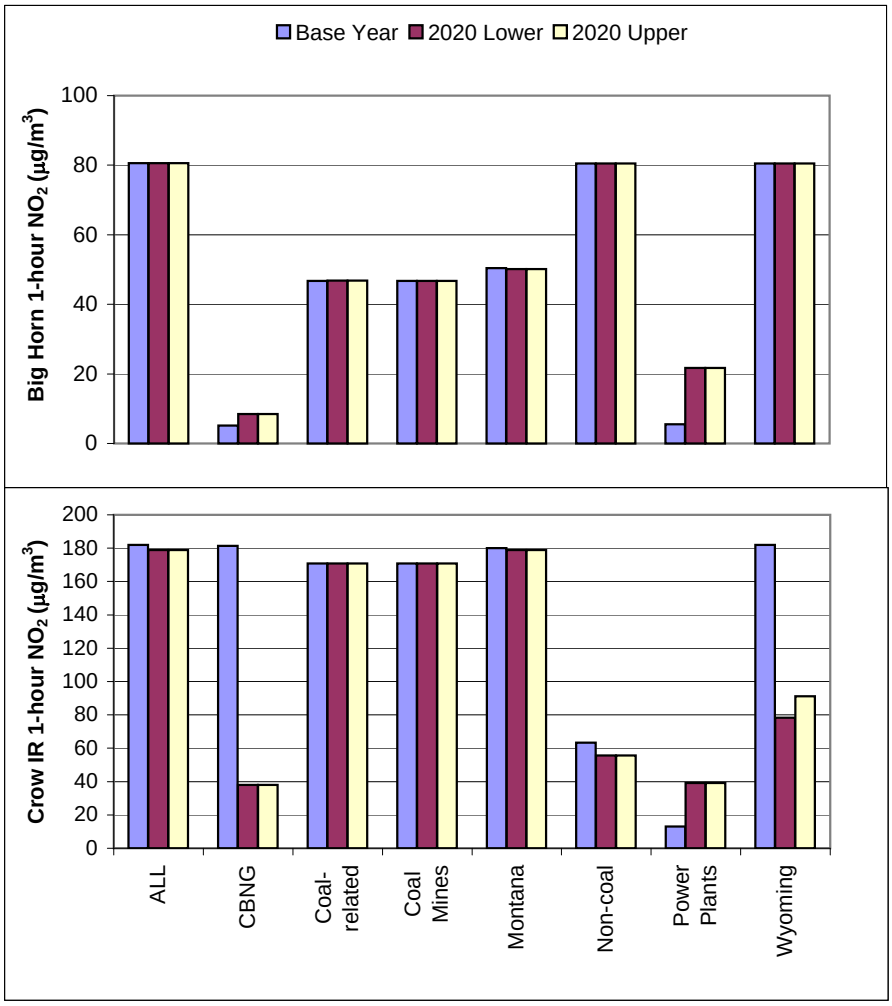
Note:
Base Year = 2004
2020 Lower = 2020 lower production scenario
2020 Upper = 2020 upper production scenario

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



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

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



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

Montana SAAQS: 564

Montana SAAQS: 564

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

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

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

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

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

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

Receptor Set	All Sources			CBNG			Coal-related Sources			Coal Mines			Montana Sources			Non-coal Sources			Power Plants			Wyoming Sources		
	Number of Days > N% Change in B_{ext}		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	297	262	393	124	66	101	247	189	221	24	5	17	129	79	75	179	98	286	235	166	203	234	189	266
Bob Marshall WA	21	8	73	0	0	1	12	6	53	0	0	0	15	7	80	4	2	65	12	6	53	2	0	10
Bridger WA	215	149	154	19	13	58	145	90	86	0	0	4	44	23	45	163	91	122	143	86	64	179	125	123
Fitzpatrick WA	161	97	126	13	6	23	101	51	84	0	0	2	41	22	58	97	49	79	101	49	80	124	74	98
Fort Peck IR	167	126	257	28	16	92	124	82	92	13	2	13	110	62	91	96	56	252	115	75	67	73	52	159
Gates of the Mountain WA	95	59	118	0	0	3	79	38	102	0	0	1	89	48	117	39	11	43	79	38	102	7	3	19
Grand Teton NP	135	76	88	3	1	13	76	36	52	0	0	3	34	18	32	78	34	75	75	36	49	66	37	65
North Absaorka WA	137	69	237	7	3	19	91	43	160	0	0	2	89	46	129	52	20	70	90	41	155	53	24	92
North Cheyenne IR	355	303	550	158	113	257	330	267	360	74	20	29	342	283	171	150	61	282	306	252	325	169	132	521
Red Rock Lakes	83	45	65	2	0	9	53	28	63	0	0	2	44	20	64	36	10	30	53	28	63	26	14	39
Scapegoat WA	49	29	75	0	0	2	38	20	58	0	0	1	42	25	66	13	3	57	38	20	58	5	3	15
Teton WA	128	65	157	8	2	13	78	39	109	0	0	2	50	27	74	62	23	44	76	38	105	66	34	92
Theodore Roosevelt NP	253	202	308	57	36	79	152	99	167	7	1	11	116	74	138	182	112	298	145	88	146	114	81	190
U.L. Bend WA	144	95	237	18	8	60	118	67	146	6	1	11	118	65	126	53	28	205	109	61	132	43	27	99
Washakie WA	153	91	239	14	3	45	105	49	149	0	0	3	81	40	129	74	33	81	104	49	147	86	52	153
Wind Cave NP	334	293	564	158	99	112	304	248	383	56	18	20	149	73	89	180	98	338	287	205	332	292	247	472
Yellowstone NP	164	89	199	8	3	14	111	60	139	0	0	3	93	53	104	79	26	54	111	59	134	55	34	75
SENSITIVE CLASS II AREAS																								
Absaorka Beartooth WA	196	111	228	7	3	16	152	81	159	0	0	3	164	89	123	71	34	64	150	79	153	44	21	105
Agate Fossil Beds NM	322	277	680	119	68	182	290	230	516	40	12	31	101	52	50	166	84	178	276	209	432	310	260	648
Big Horn Canyon NRA	361	332	458	42	26	116	221	141	315	86	60	224	218	149	241	355	295	161	192	109	228	348	296	333
Black Elk WA	328	283	529	135	69	84	285	217	293	26	7	17	145	67	97	178	97	366	267	183	255	273	225	356
Cloud Peak WA	227	156	718	72	46	373	161	106	616	11	6	97	122	66	76	103	45	142	150	97	459	150	100	719
Crow IR	364	363	655	134	99	284	364	358	564	364	340	504	364	361	548	292	139	133	289	206	434	322	225	651
Devils Tower NM	343	306	332	196	141	108	315	269	234	78	21	27	173	95	83	150	77	194	296	220	192	295	253	295
Fort Belknap IR	128	81	213	12	6	40	102	58	144	4	0	8	106	57	130	43	22	151	98	54	131	31	22	73
Fort Laramie NHS	318	276	742	102	63	270	292	224	643	29	9	49	89	41	80	166	79	238	281	201	524	310	264	746
Jedediah Smith WA	142	82	113	3	1	13	74	36	55	0	0	4	34	15	34	98	45	100	71	36	55	61	40	81
Jewel Cave NM	336	298	541	160	96	116	310	249	341	64	17	30	136	63	111	161	86	288	290	202	288	293	258	435
Lee Metcalf WA	172	99	146	2	1	13	138	78	106	0	0	1	141	81	93	56	17	36	137	78	104	27	13	49
Mt Naomi WA	90	52	239	5	3	20	51	33	204	0	0	3	5	1	17	62	29	81	49	31	204	61	39	229
Mt Rushmore NM	322	274	528	131	59	76	274	199	271	23	7	14	138	64	88	159	83	368	249	174	236	263	209	325
Popo Agie WA	206	145	168	23	16	89	128	78	71	0	0	5	43	25	54	142	72	68	126	75	67	167	115	120
Soldier Creek WA	324	287	656	136	86	169	307	249	523	54	19	30	118	61	68	178	86	180	298	221	457	312	267	610
Wellsville Mountain WA	221	147	300	49	30	154	131	75	160	3	1	13	80	48	127	136	77	126	127	72	149	158	108	240
Wind River IR	281	227	343	69	45	179	187	122	240	8	1	13	90	53	145	257	153	162	180	115	236	262	198	302

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.1.5 Impacts on Acid Deposition

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

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

3.1.6 Impacts on Sensitive Lake Acid Neutralizing Capacity

The analysis of impacts of deposition of acidic substances was carried out in accordance with the screening methodology as provided by the FS (FS 2000). Data for lake neutralizing capacity were obtained from the FS web site (FS 2006), which provides data for the 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 2020.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.1.7 Analysis of Hazardous Air Pollutant Impacts

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

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

Receptor Set	Pollutant	Averaging Period[1]	Base Year (2004)	2020 Lower Development Scenario	2020 Upper Development Scenario	REL
Near-field Receptors			**All Data in µg/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.

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

3.2 Comparison to Original Study

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

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

Receptor Set	Pollutant	Averaging Period[1]	Base Year (2004)	2020 Lower Development Scenario	2020 Upper Development Scenario	Non-carcinogenic RfCs
Near-field Receptors – Non-carcinogenic Impacts			**All Data in µg/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.

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

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

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

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

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

3.2.1 Impacts on Ambient Air Quality

3.2.1.1 Wyoming Near-field Impacts

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

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

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

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

3.2.1.2 Montana Near-field Impacts

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

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

3.2.2 Impacts at Class I Area Receptors

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

3.2.3 Impacts at Sensitive Class II Areas

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

3.2.4 Impacts on Visibility

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

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

3.2.5 Impacts on Acid Deposition and Sensitive Lake Acid Neutralizing Capacity

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

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

3.2.6 Analysis of Hazardous Air Pollutant Emissions

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