Appendix F – Coal Creek Station NOx BART

F.1 – NOx BART analysis for Coal Creek Station Unit 1 and Unit 2

1 Introduction and Representative Operations

Coal Creek Station (CCS) is a two-unit, approximately 1,200 gross MW mine-mouth power plant consisting primarily of two steam generators and associated coal and ash handling systems. Unit 1 and Unit 2 are identical Combustion Engineering boilers firing pulverized lignite coal tangentially. Unit 1 has a heat input capacity of 6,015 MMBtu/hr; Unit 2 has a heat input capacity of 6,022 MMBtu/hr.

Unit 1 began commercial operation in 1979. Unit 2 began commercial operation in 1980. The facility is located in south central McLean County about five miles south of the town of Underwood, North Dakota and three miles west of US Highway 83. CCS receives its lignite coal from the Falkirk Mine that is operated by the Falkirk Mining Company, which is a subsidiary of the North American Coal Corporation. The average annual amount of North Dakota lignite coal combusted from 2009 through 2018 was 7.2 million tons. See Table 1 for detailed information.

Table 1: Yearly Coal Combusted (tons)

Year	Unit 1 (tons)	Unit 2 (tons)
2009	4,095,584	3,941,997
2010	3,835,877	3,284,752
2011	4,371,455	4,801,722
2012	3,645,837	3,579,986
2013	3,623,564	3,304,313
2014	3,407,090	3,528,472
2015	3,439,201	3,446,814
2016	3,355,393	2,862,056
2017	2,752,937	3,394,443
2018	3,750,337	3,667,824
Average	**3,627,728**	**3,581,238**
Combined Average	**7,208,966**	

Over the same 10-year period (2009–2018), CCS operated at an 87% annual capacity factor, as determined on an actual heat input basis. Future operations are expected to be consistent with this 10-year period and the 87% annual capacity factor was used when calculating the baseline and future projected emissions discussed in Section 2.

Table 2 displays the operational information from 2009–2018. The Annual Capacity Factor is calculated by dividing the actual heat input by the maximum potential heat input for Unit 1 ($52.69x10^6$ MMBtu/yr) and Unit 2 ($52.75x10^6$ MMBtu/yr).

Table 2: Utilization and Annual Capacity Factor

Year	Unit 1 Heat Input MMBtu/yr	Unit 2 Heat Input MMBtu/yr	Unit 1Annual Capacity Factor	Unit 2 Annual Capacity Factor
2009	49,625,416	48,220,581	0.94	0.91
2010	49,409,811	41,998,558	0.94	0.80

Year	Unit 1 Heat Input MMBtu/yr	Unit 2 Heat Input MMBtu/yr	Unit 1Annual Capacity Factor	Unit 2 Annual Capacity Factor
2011	43,014,802	46,942,626	0.82	0.89
2012	48,676,811	47,951,409	0.92	0.91
2013	48,686,810	43,924,548	0.92	0.83
2014	46,286,312	46,530,063	0.88	0.88
2015	47,059,790	46,053,317	0.89	0.87
2016	45,437,239	38,498,049	0.86	0.73
2017	37,327,033	44,826,636	0.71	0.85
2018	48,250,097	47,761,484	0.92	0.91
Average	**46,377,412**	**45,270,727**	**0.88**	**0.86**
		Combined Average	**0.87**	

2 NOx Emissions Controls and History

2.1 Existing NOx Controls

The NOx controls currently installed at CCS Units 1 and 2 consist of the following:

1) LNC3 (combination of closed coupled overfired air, separated overfired air, and low NOx burners) is installed on Units 1 and 2. This technology is considered as part of the baseline emission calculation discussed in Section 2.2.

2) DryFining™ technology has been installed and operating on Units 1 and 2 since 2010. DryFining™ is an innovative technology developed by Great River Energy that reduces moisture and refines lignite coal. The technology increases the efficiency and performance of the fuel while reducing emissions. This technology is considered part of the baseline emissions discussed in Section 2.2. Units 1 and 2 have experienced approximately 0.02 lb NOx/MMBtu of reductions since completion of DryFining™.

3) LNC3+ (LNC3 with expanded overfired air registers in conjunction with DryFining™) was installed on Unit 2 in 2007. Expanded overfired air was completed in 2007 with DryFining™ coming online in 2010. Collectively, LNC3+ became fully operational on Unit 2 in 2010. Unit 1 had expanded overfired air registers installed in the second quarter of 2020. Unit 1 is LNC3+ is expected to operate with a similar NOx profile as the LNC3+ on Unit 2.

2.2 Historical and Future Anticipated Emissions

For the purposes of this BART determination, the Department considered the operation of LNC3 with DryFining™ technology as the baseline control technology for Units 1 and 2. Even though LNC3+ (expanded overfired air registers with DryFining™) has been operational on Unit 2 since 2010 and was installed on Unit 1 in 2020, the Department found it most appropriate to perform the BART determination as if LNC3+ is not installed on either unit. This is consistent with the EPA response to comments set forth in the Federal Implementation Plan created for North Dakota (77 FR 20893):

"We evaluate potential control options based on baseline conditions, not on ongoing revisions to a facility after the baseline period. It is not reasonable to consider controls installed after the baseline period in determining BART. Such an approach would tend to lead to higher cost effectiveness values for more effective controls and encourage sources to voluntarily install lesser controls to avoid installing more effective BART controls later." [1]

This above response is still applicable, but requires additional context given the amount of time which has passed and the reductions of NOx emissions from the source over this time. To demonstrate the impact LNC3+ had on the average NOx emissions for Unit 2, the Department reviewed the five-year annual average performance rates preceding the installation of LNC3+. From 2002 through 2006, the annual average NOx performance rate in pounds per MMBtu for Units 1 and 2 was 0.22 and 0.23, respectively. The similarity of this five-year average supports the notion that Unit 1 and Unit 2 operate nearly identically with similar controls. The differences in performance rates between Unit 1 and Unit 2 since that time period can be attributed to the installation of LNC3+. This also demonstrates that Unit 1 will be able to achieve a similar annual NOx performance as Unit 2.

CCS installed LNC3+ on Unit 2 in 2010 and on Unit 1 in 2020 in advance of being required through an approved regional haze SIP amendment. As a result of CCS installing LNC3+ on Unit 2, approximately 11,700 tons of NOx emissions reductions occurred at CCS from 2010–2018. These reductions would not have occurred without the installation of LNC3+. Table 3 displays this information.

Table 3: Annual NOx Emissions since 2010

Year	Unit 1 Configuration LNC3[A] (NOx Tons)	Unit 2 Configuration LNC3+ (NOx Tons)	Difference
2010	5,199	3,473	1,726
2011	4,398	3,580	818
2012	5,102	3,556	1,547
2013	4,692	3,320	1,373
2014	4,697	3,287	1,410
2015	5,087	3,499	1,588
2016	4,327	2,564	1,763
2017	3,361	2,889	472
2018	3,985	3,010	976
Total NOx:	**40,848**	**29,176**	**11,673**

[A] LNC3 with DryFining™

Reducing NOx emissions through combustion upgrades (e.g. LNC3+) in advance of installing add-on post combustion controls (e.g. SNCR or SCR) is always recommended as the first step. Fundamentally, it is better to produce less NOx during the combustion process than it is to add-on post combustion pollution controls to remove NOx after formation. This reduces the equipment size and the associated operational and maintenance costs of the add-on controls. CCS has already taken

[1] Available at: https://www.federalregister.gov/d/2012-6586/p-547

the step to install LNC3+ on both Units. As is described in the EPA response to comments above, the installation of LNC3+ was voluntary and not required by the Department. Therefore, it should not be used in the baseline emissions. However, LNC3+ may still be selected as the appropriate BART control for both Unit 1 and Unit 2. As this BART determination demonstrates, CCS installed NOx BART controls on Unit 2 in 2010 and installed NOx BART controls on Unit 1 in 2020 with the installation of LNC3+.

The 2016–2018 three-year annual average data from LNC3 (with DryFining™) on Unit 1 and LNC3+ on Unit 2 is displayed in Table 4. Table 4 LNC3 data for Unit 1 is used as the baseline performance rate in pounds of NOx per MMBtu for both units. Table 4 LNC3+ data for Unit 2 is used as the first option of additional controls for evaluation in the current BART determination for both units. This is unique from other BART determinations because the first option of additional control is based on actual performance data from Unit 2 and not on anticipated future performance rates (like the remaining add-on control options evaluated in Section 3.1).

Table 4: Three-year NOx performance rate in lb NOx/MMBtu

Year	Unit 1 (LNC3 with DryFining™)	Unit 2 (LNC3+)
2016	0.193	0.136
2017	0.182	0.130
2018	0.166	0.126
Average	**0.180**	**0.131**

As shown in Table 4, the 3-year average NOx performance rate from Unit 1 is 0.18 lb NOx/MMBtu; this is used as the baseline performance rate for Unit 1 and Unit 2. Also shown in Table 4, the Unit 2 LNC3+ 3-year average performance rate is 0.13 lb NOx/MMBtu; this is used as the performance rate for first option of BART controls.

A benefit to taking this approach is that the Department has actual operational data reflecting the impact LNC3+ has on reducing the formation of NOx emissions at CCS, relative to LNC3. Since Unit 1 and Unit 2 are identical units, the future anticipated performance rate for LNC3+ on Unit 1 is based on actual data from Unit 2. Table 5 displays the baseline NOx emissions scenario and the tons associated with the first control option (LNC3+). Note: values displayed are for a single unit.

Table 5: Unit 1 and Unit 2 Baseline Emissions and Control Option 1

Control Scenario	Control Technology	Emissions (tons/year)
Baseline	LNC3 with DryFining™	4,143
Option 1	LNC3+	2,980

3 NOx BART Determination for Unit 1 and Unit 2

The following determination was derived using combined average historical data for both units and using the data to make a single BART determination, which applies to both units. A single NOx BART determination is made because Unit 1 and Unit 2 are identical boilers and have historically operated consistently, as discussed in Section 2.2.

3.1 Step 1 – Identify All Available Retrofit Control Technologies

The BART controls that were evaluated for CCS are listed in Table 6. Each control technology is listed along with its associated performance rate and total expected emissions on a yearly basis. Expected emissions were calculated using the performance rate, the potential heat input, and the annual capacity factor (Table 2).

Table 6: NOx BART Control Options

Control Technology	Control Technology Abbreviation	Emission Rate (lb/MMBtu)	Emissions (tons/year)
low NOx burners with closed coupled overfired air	LNC3 [A]	0.18	4,143 [B]
LNC3 with expanded overfired air registers in conjunction with DryFining™	LNC3+	0.13	2,980
selective non-catalytic reduction	SNCR	0.10	2,293
selective catalytic reduction	SCR	0.08-0.06	1,830-1,380

[A] The emission rate for LNC3 includes the DryFining™ operation

[B] 0.18 lb NOx/MMBtu x 52.72×10^6 MMBtu/yr x 0.87 / 2000 = 4,140 tons NOx/year

LNC3+ was evaluated as an additional control option to reduce the formation of NOx during the combustion process. Selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR) were both evaluated as potentially available add-on controls to reduce NOx emissions post combustion.

The control technologies evaluated in Table 6 for reducing NOx emissions are consistent with the technologies evaluated for the other North Dakota lignite-fired electrical generating utilities[2] and with the BART guidelines.[3]

3.2 Step 2 – Evaluate Technically Feasible Control Technologies

1) LNC3+ is technically feasible and is currently installed and operational on Unit 1 and Unit 2. LNC3+ was installed on Unit 2 in 2010 and was installed on Unit 1 in 2020.

2) SNCR is a type of post combustion add-on control equipment. SNCR is technically feasible for both units at CCS and was reviewed as a potential additional control option after LNC3+ installation.

3) SCR is a type of post combustion add-on control equipment. The technical feasibility of SCR is uncertain at CCS. SCR was reviewed as a potential additional control option after LNC3+ installation. SCR was evaluated based on two potential arrangements, including a "high-dust" and "low-dust" system. High-dust systems are located upstream of the particulate

[2] Available at: https://www.federalregister.gov/documents/2012/04/06/2012-6586/approval-and-promulgation-of-implementation-plans-north-dakota-regional-haze-state-implementation

[3] 40 CFR Part 51 Appendix Y, Guidelines for BART Determinations under the Regional Haze Rule.

controls (electrostatic precipitator) and low-dust systems are located downstream of the particulate controls.

a. High-dust SCR systems have significant potential for catalyst surface plugging due to the high sodium concentrations in the lignite coal used at CCS. Additionally, without the completion of pilot testing, the SCR catalyst supplier was unable to ensure reliable performance and catalyst life given the significant uncertainty with potential plugging and catalyst deactivation.[4] For these reasons, a high-dust SCR system is determined to be technically infeasible. This is consistent with the Department's 2009 determination that high-dust SCR is not technically feasible for Units combusting North Dakota lignite coal.[5]

b. Low-dust SCR systems (including tail-end SCR) are located downstream of the electrostatic precipitator where most of the sodium-bearing fly ash particles are expected to be removed, potentially mitigating the issue of SCR catalyst plugging.[6] The catalyst vendor, IBDEM Ceram, and the SNCR/SCR vendor, Fuel Tech, both expressed overall concerns with North Dakota lignite coal impacts on the SCR catalyst plugging and fouling. Both independently recommended pilot scale testing be completed to obtain actual performance data and determine catalyst impacts.[7,8] Without consideration of the recommended pilot testing, a low-dust system potentially removes the concern with technical feasibility in relation to catalyst plugging. Therefore, a low-dust SCR system is determined to be technically feasible and is carried forward for further evaluation.[9]

3.3 Step 3 – Evaluate Control Effectiveness

The efficiency of the BART controls, anticipated performance rates, and the projected emission reductions for each control option are listed in Table 7. The projected emissions reductions listed in Table 7 would occur at each unit (e.g. SNCR would reduce NO_X emissions by 1,850 tons per year from both Unit 1 and Unit 2, totaling 3,700 tons per year, beyond the baseline emissions).

Table 7: Control Effectivenss and Emissions Reductions

Control Technology	Emission Rate (lb/MMBtu)	Control Efficiency	Emission Reduction (tons/year)
Baseline, LNC3[1]	0.18	--	--
LNC3+	0.13	28%	1,163
SNCR	0.10	45%	1,850
SCR	0.08-0.06	56%-67%	2,310-2,770

[4] Appendix B.4.b, p. 16-19. PDF pages 596-599.
[5] Best Available Retrofit Technology – Selective Catalytic Reduction, Technical Feasibility Analysis for North Dakota Lignite. Division of Air Quality, ND Department of Health. July 2009.
[6] Appendix B.4.b, p. 16. PDF page 596.
[7] Appendix B.4.b, Attachment A, pages 2-15 to 2-17. PDF pages 642-644.
[8] Appendix B.4.b, Attachment A, Appendix E. PDF page 696.
[9] Appendix B.4.b, p. 17. PDF page 597.

Control Technology	Emission Rate (lb/MMBtu)	Control Efficiency	Emission Reduction (tons/year)

[1] The emission rate for LNC3 includes the DryFining™ operation

Within the Updated BART Analysis, a range of performance rates for SCR were evaluated, which is why the information in Table 7 includes a range of options for SCR. The performance rates evaluated are consistent with currently available information for units operating SCRs.[10] These anticipated performance rates ranged from 0.04 to 0.08 lb NO_X per MMBtu. The performance rate of 0.04 lb NO_X per MMBtu is not listed in Table 7 due to significant uncertainty that this rate could be achieved in practice and sustained for an extended timeframe.[11,12] Therefore, the Department will not evaluate SCR at a performance rate of 0.04 lb NO_X per MMBtu for the purposes of this BART determination. Information presented throughout the remainder of this BART determination is specific to SCR at a performance rate of 0.06 and 0.08 lb NO_X per MMBtu.

3.4 Step 4 – Evaluate Impacts

3.4.1 Cost of Compliance

The cost of compliance and incremental cost for the BART controls are listed in Table 8 for a single unit. The incremental costs displayed in Table 8 were determined from LNC3+ to SNCR and from LNC3+ to SCR. The incremental cost between SNCR and SCR is not shown in Table 8 due to the high annualized cost difference in conjunction with a limited improvement in emissions reduction.

Table 8: Cost of Compliance and Incremental Cost of Compliance

Control Technology	Performance Level (lb/MMBtu)	Annual Emission Reduction (tpy)	Annualized Total Cost ($)	Cost of Compliance ($/ton)	Incremental Cost of Compliance ($/ton)
Baseline, LNC3	0.18	--	--	--	--
LNC3+	0.13	1,162	793,418	683	--
LNC3+ w/ SNCR	0.10	1,850	6,194,244	3,348	7,850
LNC3+ w/ SCR	0.08	2,309	16,122,491	6,983	13,368
LNC3+ w/ SCR	0.06	2,767	17,391,169	6,284	10,339

A detailed breakdown of the costs listed in Table 8 can be found in the Updated BART Analysis.[13] The Department has reviewed these costs and believes them to be accurate.

As displayed in Table 8, the cost of compliance for the installation of LNC3+ at CCS is $700 per ton of NO_X reduced. This represents a 0.05 lb NO_X per MMBtu improvement over the baseline performance rate and results in an annual reduction of over 1,100 tons of NO_X per unit.

[10] Appendix B.4.b, p. 17-18. PDF pages 597-598.
[11] Appendix B.4.b, p. 18-19. PDF pages 598-599.
[12] Appendix B.4.b, Attachment A, page 2-12 and 3-1. PDF pages 639 and 649.
[13] Appendix B.4.b, PDF pages 690-694, 780-800, 923-946.

If SNCR is installed along with LNC3+, a performance rate improvement of 0.03 lb NO_X per MMBtu could be achieved. This equates to an additional reduction of approximately 700 tons of NO_X per year for each unit. To provide the most conservative cost of compliance (i.e., the lowest dollar per ton of pollutant reduction) for SNCR, Table 8 does not include additional costs associated with the treating of ammoniated fly-ash or the additional cost incurred due to the loss of a saleable by-product, which would result in an increase in fly-ash disposal.[14] There is also uncertainty in the amount of saleable by-product that would be lost and the limited commercial application of the treating process; both of which are required to better understand the impacts a treating system would have at CCS.[15] Without this information, the ultimate cost of SNCR is unknown. Without taking these costs into consideration, the cost of compliance to concurrently install LNC3+ with SNCR is $3,300 per ton of NO_X reduced.

To determine the appropriate BART controls when comparing between the installation of only LNC3+ and the installation of LNC3+ with SNCR, the Department calculated the stand-alone cost of installing SNCR after LNC3+ is installed. This stand-alone cost is referred to as the incremental cost of compliance or the incremental cost effectiveness in the BART guidelines.[16] Incremental cost is a key factor to consider when selecting BART controls since it details the cost effectiveness specific to the SNCR. The incremental cost of compliance was determined to be $7,800 per ton of NO_X reduced. Therefore, even though the cost of compliance for LNC3+ with SNCR listed in Table 8 appears reasonable at $3,300 per ton, it is more accurate to represent the cost of LNC3+ at $700 per ton and the cost of SNCR after the installation of LNC3+ at $7,800 per ton. The Department believes $7,800 is an unreasonably high cost, especially in consideration of the potential increased costs through the installation of a fly-ash treating system, lost fly-ash sales, and the technological uncertainty with the treating system viability at CCS. Between LNC3+ and LNC3+ with SNCR, LNC3+ is the most appropriate BART control from the perspective of cost feasibility.

All costs associated with the SCRs are provided for the high-dust arrangement. High-dust systems are generally considered more economical than low-dust systems since less equipment is required during operation. Exhaust gas re-heat and cooling systems are among the additional costs required with low-dust SCR systems.[17,18] The cost of compliance will increase significantly with the additional equipment needed for a low-dust SCR system.[19] Without taking these added costs into consideration, the cost to install LNC3+ concurrently with SCR is (at a minimum) $6,300 per ton of NO_X reduced. Using the same logic applied in the SNCR discussion in the above paragraph, the incremental cost to install SCR after LNC3+ is $10,300 per ton. Additionally, for consistency with the BART guidelines[20], the Department calculated the incremental cost between SNCR and SCR. This resulted in an incremental cost of $12,200 per ton. The Department believes all these costs are

[14] Appendix B.4.b, p. 25-26. PDF pages 605-606.
[15] Appendix B.4.b, Attachment B. PDF page 837.
[16] 40 CFR Part 51 Appendix Y, Guidelines for BART Determinations under the Regional Haze Rule
[17] Appendix B.4.b, p. 17 and 23. PDF pages 597 and 603.
[18] Appendix B.4.b, Attachment A, page 2-16. PDF page 643.
[19] Appendix B.4.b, Attachment A, Appendix B. PDF page 684.
[20] Calculate the incremental cost effectiveness for each dominant option, which is the difference in total annual costs between that option and the next most stringent option, divided by the difference in emissions, after controls have been applied, between those two control options.

unreasonably high, especially in consideration of the technological uncertainty with SCR and the added costs associated with the exhaust reheat and cooling systems.

3.4.2 Energy and Non-air Quality Environmental Impacts

LNC3+ is determined to have negligible energy and/or non-air quality environmental impacts. LNC3+ technology reduces the formation of NO_X during the combustion process and does not affect items such as: auxiliary power consumption, water usage, potential fly ash sales, and/or ammonia slip, which are all potential impacts associated with SNCR and/or SCR.

The largest potential non-air quality environmental impact with SNCR is the potential for producing ammoniated fly-ash, which could inhibit or severely limit CCS from selling fly-ash for beneficial use (e.g. concrete additive).[21] This ammoniated fly-ash has the largest impact on non-air quality environmental impacts since ammoniated fly-ash not being sold for beneficial use could end up significantly increasing the amount of fly-ash disposed of in landfills. The production of ammoniated fly-ash also reduces any economic benefit CCS receives from selling this by-product. SNCR also requires a significant increase in water consumption for the injection skid. Additionally, ammonia slip from the SNCR will likely result in nitrogen being carried through the scrubber water that is routed to the evaporation ponds, causing potential issues with pond maintenance.[22]

Low-dust SCR has the same potential non-air quality environmental impacts as SNCR regarding increased water consumption and ammonia slip. There is also increased power and fuel consumption required with SCR related equipment and from the gas reheat and cooling systems.[23]

The non-air quality environmental impacts for SNCR and SCR are significant, but not significant enough to eliminate them as a control option.

3.4.3 Remaining Useful Life

Coal Creek Station is expected to operate beyond the life of the control equipment[24], therefore, remaining useful life was not considered.

3.5 Step 5 – Evaluate Visibility Impacts

CCS conducted dispersion modeling to assess the potential visibility improvement from the use of add-on NO_X controls. The modeling was conducted in accordance with the “Protocol for BART-Related Visibility Impairment Modeling Analysis, Great River Energy Coal Creek Station” approved by EPA Region 8 on August 7, 2019.[25]

The first modeled scenario (Model Scenario 0) in Table 9 was performed to establish the baseline visibility impairment on North Dakota’s Class I Areas from 2000–2002 (pre-BART controls for all pollutants). Model Scenario 1 reflects the post-SO_2 BART approved controls and associated emission rates. The remaining modeling scenarios (Model Scenarios 2 through 6) reflect the application of the potential NO_X BART controls evaluated in this BART Determination.[26] It is important to note that CCS

[21] Appendix B.4.b, Attachment B. PDF page 837.
[22] Appendix B.4.b, Attachment A, p. 4-23. PDF page 674.
[23] Appendix B.4.b, Attachment A, p. 4-23. PDF page 674.
[24] Appendix B.4.b, p. 27. PDF page 607.
[25] Appendix B.4.b, Attachment E. PDF pages 911-917.
[26] Appendix B.4.b, p. 27-28. PDF pages 607-608.

was required to perform modifications to the wet gas scrubber in order to reduce sulfur dioxide (SO_2) emissions as required by the earlier partially approved Regional Haze SIP.[27] No particulate matter (PM) controls were required in the partially approved Regional Haze SIP; however, the enhanced SO_2 controls had a beneficial impact on reducing PM emissions. This information is summarized in Table 9.

Table 9: Emissions Rates Modeled for Determination of Visibility Impact

Modeling Scenario	NO_X Control Technology	NO_X Emissions Rate (lb/hr)[A]	SO_2 Control Technology	SO_2 Emissions Rate (lb/hr)[A]	PM Emissions Rate (lb/hr)[A,B]
0	LNC3	1797	Pre-BART	5351	233
1	LNC3 (with DryFining™)	1233	Post-BART	967	90
2	LNC3+	898	Post-BART	967	90
3	LNC3+ w/ SNCR	695	Post-BART	967	90
4	LNC3+ w/ SCR (0.06)[C, D]	415	Post-BART	967	199
5	LNC3+ w/ SCR (0.06)[C, E]	415	Post-BART	967	141
6	LNC3+ w/ SCR (0.06)[C, F]	415	Post-BART	967	90

[A] Maximum 24-hour emissions rate in pounds, averaged between both units
[B] No particulate matter controls were selected as BART, decrease from Scenario 0 to 1 resulted from SO_2 BART
[C] Refers to an anticipated annual NO_X performance level of 0.06 lb/MMBtu
[D] Additional 109 lb/hr PM results from anticipated sulfuric acid formation from SCR; 5% SO_2 to SO_3 oxidation rate
[E] Additional 51 lb/hr PM results from anticipated sulfuric acid formation from SCR; 2.5% SO_2 to SO_3 oxidation rate
[F] No anticipated sulfuric acid formation from SCR; 0% SO_2 to SO_3 oxidation rate

In Table 9, the reason for the increase in PM emissions from Model Scenario 3 to 4 is from the anticipated sulfuric acid mist formation from SCR application. This anticipated increase results from an SO_2 to SO_3 oxidation rate of 5%.[28] The reason for the high oxidation rate is due to the uncertainty regarding the technical feasibility of SCR on units that combust North Dakota lignite coal and the high boiler flue gas temperatures at CCS. Given the uncertainty, the Department believes the 5% oxidation rate provided by the SCR catalyst vendor is the most appropriate value to use for this BART determination. However, since the 5% SO_2 to SO_3 oxidation rate is outside the range of what is typically expected[29], a recommendation was made to conduct additional modeling using more conservative (lower) SO_2 to SO_3 oxidation rates. Therefore, CCS conducted additional modeling using lower SO_2 to SO_3 oxidation rates of 0% and 2.5%. This modeling was performed to evaluate the potential change in visibility by lowering the SO_2 to SO_3 oxidation rate. This additional modeling was provided to the Department in a report dated February 27, 2020, “Coal Creek Station BART for NO_X Emissions – Visibility Impairment Modeling Results for Additional SCR SO_2 Oxidation Scenarios”,

[27] Available at: https://www.federalregister.gov/documents/2012/04/06/2012-6586/approval-and-promulgation-of-implementation-plans-north-dakota-regional-haze-state-implementation
[28] Appendix B.4.b, Attachment A, Appendix E, p. 2. PDF page 697.
[29] Appendix B.4.b, Attachment H-1, p. 3-2. PDF page 968.

which is included as Appendix F.3. This report also provides additional technical details that support the uncertainty of the SO_2 to SO_3 oxidation rate.

As discussed in Section 3.3, the performance level for SCR installation on North Dakota lignite-fired units is uncertain and was provided at three performance rates (0.04, 0.06, and 0.08 lb NO_X per MMBtu). Due to the uncertainty in sustaining the 0.04 lb NO_X per MMBtu performance rate, the Department did not consider the visibility results from the modeling associated with this rate. For informational purposes, these results are available in Appendix F.3.[30] With the information currently available, the Department has determined 0.06 lb NO_X per MMBtu as the lowest sustainable performance rate for SCR at CCS. In turn, modeling the projected maximum pounds of NO_X emitted per 24-hours in association with the performance rate of 0.06 lb NO_X per MMBtu will result in the largest potential improvement on visibility (i.e. 0.08 lb NO_X per MMBtu modeling would only show less of a visibility improvement).

Before determining the potential visibility improvements for the NO_X BART controls evaluated, baseline visibility impairment was established. A baseline visibility impairment was established for Model Scenarios 0 and 1. As is shown in Table 9, Model Scenario 0 uses pre-BART emissions data for NO_X, SO_2¸and PM. Model Scenario 1 uses post-SO_2 BART SO_2 and PM emissions data in addition to the collective impact DryFining™ had on SO_2, PM, and NO_X emissions. Model Scenario 0 visibility impairment is shown in Table 10 and Model Scenario 1 visibility impairment is shown in Table 11. These Tables show the maximum impairment on visibility for the 98th percentile at each of the North Dakota Class I Areas. The Class I areas in North Dakota are Theodore Roosevelt National Park (TRNP) and Lostwood National Wildlife Refuge (Lostwood). TRNP consists of the South Unit, the North Unit, and the Elkhorn Ranch.

Table 10: Model Scenario 0 Baseline Visibility Impairment in Deciviews

Year	TRNP South Unit	TRNP North Unit	TRNP Elkhorn Ranch	Lostwood
2000	1.96	1.78	1.41	2.16
2001	1.65	1.38	1.63	2.84
2002	3.13	2.69	2.17	1.98

As shown in Table 10, the maximum potential visibility impairment for Model Scenario 0 occurs in calendar year 2002 and is 3.13 deciviews at TRNP South Unit. This is the pre-BART and pre-DryFining™ controls baseline.

Table 11: Model Scenario 1 Baseline Visibility Impairment in Deciviews

Year	TRNP South Unit	TRNP North Unit	TRNP Elkhorn Ranch	Lostwood
2000	0.66	0.65	0.60	0.92
2001	0.47	0.57	0.53	0.87
2002	1.28	1.15	0.99	0.69

[30] Appendix F.3, Tables 1 through 12a.

As shown in Table 11, the maximum potential visibility impairment for Model Scenario 1 occurs in calendar year 2002 and is 1.28 deciviews at TRNP South Unit. The largest difference in visibility impairment from Model Scenario 0 to 1 is in year 2001 at Lostwood and is a difference of 1.97 deciviews. The difference of 1.97 deciviews is the maximum calculated visibility improvement resulting from SO_2 BART controls in conjunction with DryFining™. Model Scenario 1 is the current baseline scenario.

Once the current baseline visibility impairment was established, the potential visibility improvements, in deciviews, were determined. The potential difference in visibility impairment between model scenarios is the calculated visibility improvement associated with the implementation of the NO_X control technology. The visibility improvements for the BART controls evaluated in Table 9 have been summarized for each year (2000, 2001, and 2002) in Table 12, Table 13, and Table 14, respectively. The average visibility improvements from 2000–2002 are shown in Table 15. Each table shows the maximum improvement in visibility for the 98th percentile at each of the North Dakota Class I Areas. The row displaying Model Scenario 1 results depicts the visibility improvement resulting from SO_2 BART and DryFining™ (i.e. the difference between Model Scenario 0 and 1). The remaining model scenarios depict the visibility improvements between Model Scenario 1 and the respective model scenario. For example, the Model Scenario 4 results display the visibility change between Model Scenario 1 and Model Scenario 4. Results from Model Scenario 2 through Model Scenario 6 are used to evaluate the potential visibility improvement resulting from the NO_X BART controls evaluated in this BART determination.

Table 12: Combined Unit 1 and 2 98th Percentile Deciview Improvement for Year 2000

Modeling Scenario	TRNP South Unit	TRNP North Unit	TRNP Elkhorn Ranch	Lostwood
1[A]	*1.30*	*1.13*	*0.81*	*1.24*
2	0.11	0.11	0.10	0.19
3	0.15	0.17	0.16	0.28
4	0.07	0.10	0.15	0.07
5	0.16	0.17	0.20	0.23
6	0.23	0.25	0.25	0.39

[A] Displayed for informational purposes, shows impact of SO_2 BART and DryFining™

Table 13: Combined Unit 1 and 2 98th Percentile Deciview Improvement for Year 2001

Modeling Scenario	TRNP South Unit	TRNP North Unit	TRNP Elkhorn Ranch	Lostwood
1[A]	*1.18*	*0.81*	*1.10*	*1.97*
2	0.06	0.07	0.08	0.13
3	0.08	0.15	0.13	0.16
4	-0.02	0.01	0.05	-0.10
5	0.06	0.13	0.11	0.06
6	0.11	0.24	0.16	0.21

[A] Displayed for informational purposes, shows impact of SO_2 BART and DryFining™

Table 14: Combined Unit 1 and 2 98th Percentile Deciview Improvement for Year 2002

Modeling Scenario	TRNP South Unit	TRNP North Unit	TRNP Elkhorn Ranch	Lostwood
1[A]	*1.85*	*1.55*	*1.19*	*1.29*
2	0.23	0.18	0.18	0.12
3	0.37	0.30	0.28	0.19
4	0.23	0.31	0.17	-0.01
5	0.40	0.40	0.28	0.13
6	0.55	0.48	0.43	0.26

[A] Displayed for informational purposes, shows impact of SO_2 BART and DryFining™

Table 15: Average Combined Unit 1 and 2 98th Percentile Deciview Improvement from 2000–2002

Modeling Scenario	TRNP South Unit	TRNP North Unit	TRNP Elkhorn Ranch	Lostwood
1[A]	*1.44*	*1.16*	*1.03*	*1.50*
2	0.13	0.12	0.12	0.15
3	0.20	0.21	0.19	0.21
4	0.09	0.14	0.12	-0.02
5	0.20	0.23	0.20	0.14
6	0.30	0.33	0.28	0.29

[A] Displayed for informational purposes, shows impact of SO_2 BART and DryFining™

As is shown for Model Scenario 1 of Table 12 through Table 15, the maximum improvement SO_2 BART in conjunction with DryFining™ had on visibility was 1.97 deciviews in year 2001, with an average of 1.50 deciviews of improvement from 2000–2002. Both improvements occurred at Lostwood. The maximum of 1.97 with an average of 1.50 deciviews represents a significant modeled improvement on visibility as a result of SO_2 BART in conjunction with DryFining™.

For the reasons outlined earlier in this Section, the Department believes the most accurate information to use when evaluating visibility improvement for the NO_X controls evaluated is shown in Model Scenarios 2 through 4 of Table 12 through Table 15.

Model Scenario 2 displays the deciview improvement from the installation of LNC3+. Average Model Scenario 2 visibility improvements ranged from 0.12 to 0.15 deciviews, with a combined average visibility improvement of 0.13 deciviews. A maximum improvement of 0.23 deciviews was modeled at TRNP South Unit in the year 2002.

Model Scenario 3 displays the deciview improvement from the installation of LNC3+ with SNCR. Average Model Scenario 3 visibility improvements ranged from 0.19 to 0.21 deciviews with a combined average visibility improvement of 0.20 deciviews. A maximum improvement of 0.37 deciviews was modeled at TRNP South Unit in the year 2002.

Model Scenario 4 displays the deciview improvement from the installation of LNC3+ with SCR at the vendor expected 5% SO_2 to SO_3 oxidation rate. Average Model Scenario 4 visibility improvements ranged from -0.02 to 0.14 deciviews with a combined average visibility improvement of 0.09 deciviews.[31] A maximum improvement of 0.31 deciviews was modeled at TRNP North Unit in the year 2002.

The maximum modeled visibility improvement for all the NO_X controls evaluated comes from the Model Scenario 6, which is the hypothetical 0% SO_2 to SO_3 oxidation rate. Average Model Scenario 6 visibility improvements ranged from 0.28 to 0.33 deciviews with a combined average visibility improvement of 0.30 deciviews. A maximum improvement of 0.55 deciviews was modeled at TRNP South Unit in the year 2002. These results are representative of the expected cumulative visibility improvement from Unit 1 and Unit 2 due to the installation of SCR with an annual performance level of 0.06 lb NO_X per MMBtu and a 0% SO_2 to SO_3 oxidation rate. Even with this conservative methodology, these modeled visibility improvements are minimal.

None of the NO_X BART controls modeled were shown to have a significant impact on improving visibility in North Dakota's Class 1 Areas. Therefore, when determining the appropriate NO_X BART controls, visibility did not contribute significantly to the BART selection.

3.6 Step 6 – Select BART

In consideration of the BART related factors addressed in Section 3.1 through 3.5, the Department has determined the appropriate NO_X BART technology for CCS Units 1 and 2 to be a combination of closed coupled overfired air, separated overfired air, and low-NO_X burners with expanded overfired air registers in conjunction with DryFining™. This has been referred to as LNC3+ throughout this BART determination. LNC3+ technology is currently installed on Unit 1 and Unit 2 at Coal Creek Station.

The selection of LNC3+ as BART is supported in this BART determination due to the following reasons:

- Cost feasible at $700 per ton of NO_X reduced while providing a 28% reduction from the baseline emissions rate (See Table 7 and Table 8)
- Has negligible energy and non-air quality environmental impacts (See Section 3.4.2)

The selection of SNCR as BART is not supported in this BART determination due to the following reasons:

- Not cost feasible due to an incremental cost of $7,800 per ton of NO_X reduced relative to LNC3+, while only providing an additional 17% reduction in NO_X (See Table 7 and Table 8)
- Has potentially significant non-air quality environmental impacts (See Section 3.4.2)
- Has a minimal average visibility improvement of 0.07 deciviews beyond the improvement achieved by the installation of LNC3+ (See Table 15)

[31] The -0.02 represents additional modeled impairment to be expected with SCR installation resulting from the additional PM (as sulfuric acid mist).

The selection of SCR as BART is not supported in this BART determination due to the following reasons:

- Technical feasible concerns without undertaking of pilot scale testing (See Section 3.2)
- Not cost feasible at an incremental cost of $10,300 per ton of NO_X reduced relative to LNC3+ (See Table 7)
- Has potentially significant non-air quality environmental impacts (See Section 3.4.2)
- Has a minimal average visibility improvement of 0.17 deciviews beyond the improvement achieved by the installation of LNC3+ (See Table 15)

Recent performance data for LNC3+ on Unit 2, as outlined in Table 4, indicates a sustained annual average performance rate of approximately 0.13 lb NO_X per MMBtu. This annual average performance rate should not be misconstrued as achievable on a shorter-term basis (e.g. 30-day rolling average). There is inherent variability with shorter-term operations due to unit load swings and variable sodium concentrations in North Dakota lignite coal.[32,33] To account for this variability, the Department is proposing a BART NO_X emissions limit on Unit 1 and Unit 2 of 0.15 lb NO_X per MMBtu on a 30-day rolling average basis. The 30-day rolling average limits are consistent with the BART guidelines[34], and a limit of 0.15 lb NO_X per MMBtu on a 30-day rolling average is achievable in practice. A 5–15% upward adjustment from an annual average to establish a shorter-term limit is consistent with Department and EPA experience.[35]

The proposed limit of 0.15 lb NO_X per MMBtu on a 30-day rolling average is less than the presumptive BART limit established in Table 1 of the BART guidelines for tangential-fired lignite units. Table 1 of the guidelines indicates a presumptive BART limit of 0.17 lb NO_X per MMBtu on a 30-day rolling average.[36]

4 Permit to Construct

The emission limits, monitoring, recordkeeping and reporting requirements will be included in a federally enforceable Air Pollution Control Permit to Construct that will be issued to the owner/operator of the facility. Monitoring for NO_X will be accomplished by using the continuous emission monitors required by 40 CFR 75 for the Acid Rain Program. The owner/operator will be required to conduct recordkeeping and reporting as required by NDAC 33.1-15-14-06, Title V Permit to Operate and NDAC 33.1-15-21, Acid Rain Program (40 CFR 72, 75 and 76).

Permit to Construct No. PTC21001 is included in Appendix F.2.

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[32] Appendix B.4.b., p. 3 and 34-35. PDF page 583 and 615-615.
[33] Appendix B.4.b., Attachment D. PDF page 904-909.
[34] 40 CFR Part 51 Appendix Y, Guidelines for BART Determinations under the Regional Haze Rule
[35] Available at: https://www.federalregister.gov/documents/2012/04/06/2012-6586/approval-and-promulgation-of-implementation-plans-north-dakota-regional-haze-state-implementation#p-426
[36] 40 CFR Part 51 Appendix Y, Guidelines for BART Determinations under the Regional Haze Rule

F.2 – Coal Creek Station NOx BART Permit to Construct

AIR POLLUTION CONTROL
PERMIT TO CONSTRUCT

Pursuant to the Air Pollution Control Rules of the State of North Dakota (North Dakota Administrative Code Article 33.1-15, Chapter 33.1-15-14 and Chapter 33.1-15-25), the North Dakota Department of Environmental Quality hereby issues a Permit to Construct for the following source:

I. **General Information**:

A. **Permit to Construct Number**: PTC21001

B. **Source**:

1. **Name**: Coal Creek Station

2. **Location**: 2875 Third Street SW
Underwood, ND 58576-9596

3. **Source Type**: Fossil-fuel fired steam electric plant (EGU) with a nominal generating capacity of over 1,200 megawatts

4. **Equipment at the Facility Subject to NO_X BART**:

Unit 1 - Coal-fired boiler (nominal 6,015 x 10^6 Btu/hour heat input)

Unit 2 - Coal-fired boiler (nominal 6,022 x 10^6 Btu/hour heat input)

C. **Owner/Operator**:

1. **Name**: Rainbow Energy Center

2. **Address**: TBD

II. **Permit Conditions**:

The Permit to Construct only establishes the emission limits and other requirements if, and when, EPA approves those limits as part of the Regional Haze SIP. The source shall be operated in accordance with the terms of this Permit to Construct and the Title V Permit to Operate until a revised Title V Permit to Operate is issued. The source is subject to all applicable rules, regulations, and orders now or hereafter in effect of the North Dakota Department of Environmental Quality and to the conditions specified below:

A. **Special Conditions**:

1. **Definitions**: Terms not defined below shall have the meaning given them in the Clean Air Act or EPA's regulations implementing the Clean Air Act. For purposes of this permit:

   a. *Boiler operating day* means a 24-hour period between 12 midnight and the following midnight during which any fuel is combusted at any time in the EGU. It is not necessary for fuel to be combusted for the entire 24-hour period.

   b. *Continuous emission monitoring system or CEMS* means the equipment required by this permit to sample, analyze, measure and provide, by means of readings recorded at least once every 15 minutes (using an automated data acquisition and handling system (DAHS)), a permanent record of NO_x emissions, other pollutant emissions, diluent or stack gas volumetric flow rate.

   c. *NO_x* means nitrogen oxides.

   d. *Unit* means any of the EGU's identified in section I.B.

   e. *30-day rolling average*, as used in this permit, shall be determined by calculating an arithmetic average of all hourly rates for the current boiler operating day and the previous 29 boiler operating days. A new 30-day rolling average shall be calculated for each boiler operating day. Each 30-day rolling average rate shall include start-up, shutdown, emergency and malfunction periods unless those periods are exempt by this permit. The 30-day rolling average emission rate is calculated as follows:

      - Calculate the hourly average emission rate for any hour in which any fuel is combusted in the boiler.

      - Calculate the 30-day rolling average emission rate as the arithmetic average of all valid hourly average emission rates for the 30 successive boiler operating days.

2. **Emission Limits**: Coal Creek Station Unit 1 and Unit 2 shall not emit or cause to be emitted NO_x in excess of 0.15 pounds per million British Thermal Units (0.15 $lb/10^6$ Btu) averaged over a 30-day period (30-day rolling average). The emission limit applies to both units at all times including startup, shutdown, emergency and malfunction.

3. **Compliance Date**: Compliance with the emission limits and other requirements of this permit is required when the U.S. Environmental Protection Agency approves this permit as a part of the Regional Haze SIP.

4. **Continuous Emission Monitoring (CEM)**: The emissions from each unit shall each be measured by continuous emission monitors (CEM) for NO_x, CO_2 and flow. The monitoring requirements under Condition II.A.5 shall be the compliance determination method for NO_x.

5. **Monitoring Requirements and Conditions**:

   a. Compliance determination: At all times Coal Creek Station shall maintain, calibration and operate a CEMS, in full compliance with the requirements found at 40 CFR Part 75, to accurately measure NO_x, diluent and stack gas volumetric flow rate from each unit. The CEMS shall be used to determine compliance with the emission limits in Section II.A.2.

   b. Methods:

      1. For any hour in which fuel is combusted in a unit, Coal Creek Station shall calculate the hourly average NO_x concentration in lb/MMBtu at the CEMS in accordance with the requirements of 40 CFR Part 75. At the end of each boiler operating day, the owner/operator shall calculate and record a new 30-day rolling average emission rate in lb/MMBtu from the arithmetic average of all valid hourly emission rates from the CEMS for the current boiler operating day and the previous 29 successive boiler operating days.

      2. An hourly average NO_x emission rate in lb/MMBtu is valid only if the minimum number of data points, as specified in 40 CFR Part 75, is acquired by both the NOx pollutant concentration monitor and the diluent monitor (O_2 or CO_2).

      3. Data reported to meet the requirements of this section shall not include data substituted using the missing data substitution procedures of Subpart D of 40 CFR Part 75, nor shall the data have been bias adjusted according to the procedures of 40 CFR Part 75.

4. The Department may require additional performance audits of the CEM systems.

5. Coal Creek Station shall maintain and operate air pollution control monitoring equipment in a manner consistent with the manufacturer's recommended Operations and Maintenance (O&M) procedures, or a site-specific O&M procedure (developed from the manufacturer's recommended O&M procedures). Coal Creek Station shall have the O&M procedures available on-site and provide the Department with a copy when requested.

5. **Recordkeeping Requirements**:

Coal Creek Station shall maintain the following records for at least five years:

a. All CEMS data, including the date, place and time of sampling or measurement; parameters sampled or measured and results.

b. Records of quality assurance and quality control activities for emissions measuring systems including, but not limited to, any records required by 40 CFR Part 75.

c. Records of all major maintenance activities conducted on emission units, air pollution control equipment and CEMS.

d. Any other records required by 40 CFR Part 75.

6. **Reporting**:

a. Coal Creek Station shall submit quarterly excess emissions reports no later than the 30th day following the end of each calendar quarter. Excess emissions means emissions that exceed the emissions limits specified in Section II.A.2. The reports shall include the magnitude, date(s) and duration of each period of excess emissions, specific identification of each period of excess emissions that occurs during startups, shutdown and malfunctions of the unit, the nature and cause of any malfunction (if known) and corrective action taken or preventative measures adopted.

b. Coal Creek Station shall submit quarterly CEMS performance reports, to include dates and duration of each period during which the CEMS was inoperative (except for zero and span adjustments and calibration checks), reason(s) why the CEMS was inoperative and steps taken to prevent recurrence, any CEMS repairs or adjustments and results of any CEMS performance tests required by 40 CFR Part 75 (Relative Accuracy Test Audits, Relative Accuracy Audits and Cylinder Gas Audits).

c. When no excess emissions have occurred or the CEMS has not been inoperative, repaired or adjusted during the reporting period, such information shall be stated in the report.

d. Coal Creek Station shall submit a semi-annual report for all monitoring records required under Condition II.A.5 on forms supplied or approved by the Department. All instances of deviations from the permit must be identified in the report. A monitoring report shall be submitted within 45 days after June 30 and December 31 of each year.

e. Coal Creek Station shall submit an annual compliance certification report within 45 days after December 31 of each year on forms supplied or approved by the Department.

f. Coal Creek Station shall submit an annual emission inventory report on forms supplied or approved by the Department. This report shall be submitted by March 15 of each calendar year. Insignificant units/activities listed in this permit do not need to be included in the annual emission inventory report.

B. **General Conditions**:

1. Nothing in this section shall preclude the use, including the exclusive use, of any credible evidence or information, relevant to whether a source would have been in compliance with requirements of this section if the appropriate performance or compliance test procedures or method had been performed.

2. This permit shall in no way permit or authorize the maintenance of a public nuisance or danger to public health or safety.

3. Coal Creek Station shall comply with all State and Federal environmental laws and rules. In addition, Coal Creek Station shall comply with all local building, fire, zoning, and other applicable ordinances, codes, rules and regulations.

4. Coal Creek Station shall at all times, including periods of startup, shutdown, and malfunction, maintain and operate Unit 1 and Unit 2 and all other emission units including associated air pollution equipment and fugitive dust suppression operations in a manner consistent with good air pollution control practices for minimizing emissions.

5. Any duly authorized officer, employee or agent of the North Dakota Department of Environmental Quality may enter and inspect any property, premise or place at which the source listed in Item I.B. of this permit is or will be located at any time for the purpose of ascertaining the state of compliance with the North Dakota Air Pollution Control Rules and the conditions of this permit.

6. Any violation of a condition issued as part of this approval to construct is regarded as a violation of construction authority and is subject to enforcement action.

7. The conditions of this permit herein become, upon the effective date of this permit, enforceable by the Department pursuant to any remedies it now has or may in the future have, under the North Dakota Air Pollution Control Law, NDCC Chapter 23.1-06. Each and every condition of this permit is a material part thereof and is not severable.

FOR THE NORTH DAKOTA DEPARTMENT
OF ENVIRONMENTAL QUALITY

Date:_________________________ By:____

F.3 – Coal Creek Station BART Support

February 27, 2020

VIA ELECTRONIC MAIL

David Stroh
North Dakota Department of Environmental Quality
918 E. Divide Ave., 2nd Floor
Bismarck, ND 58501-1947

RE: Coal Creek Station BART for NOx Emissions – Visibility Impairment Modeling Results for Additional SCR SO_2 Oxidation Scenarios

Dear Mr. Stroh:

Pursuant to recent conversations with you and Great River Energy (GRE) staff, GRE understands that the US EPA Region 8 and federal land managers provided feedback to you on the September 2019 NOx BART report concerning the estimated degree of sulfur dioxide (SO_2) oxidation resulting from the selective catalytic reduction (SCR) technology control scenario. This letter provides additional technical information regarding SO_2 oxidation resulting from the SCR control scenario at Coal Creek Station. Additionally, Barr Engineering Co. (Barr) has prepared supplemental dispersion modeling analyses of visibility impacts for the SCR control scenario at different levels of SCR-related SO_2 oxidation for informational purposes.

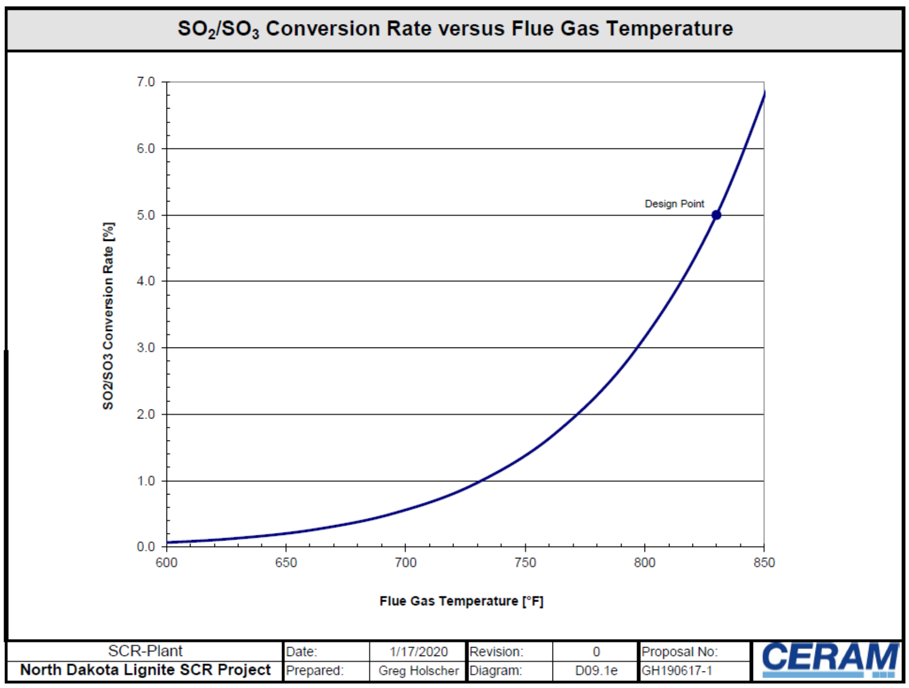
The September 2019 NOx BART report included technical documents from Barr and from Black and Veatch as well as expert information provided by other third parties. Both of the engineering consulting firms concluded that low-dust SCR as a retrofit technology at Coal Creek Station has considerable technical challenges, is not cost-effective, and would result in additional energy impacts and combustion impacts from its use.[1] Notwithstanding these conclusions pursuant to the first four BART factors, modeling analyses relevant to the fifth BART factor of evaluating visibility impacts were also conducted. As the two engineering consulting firms disagreed on the demonstrable and sustained NOx performance level for SCR at Coal Creek Station, two SCR emissions scenarios – Scenario #4A at 0.04 lb/MMBtu and Scenario #4B at 0.06 lb/MMBtu – were modeled for the change in visibility impairment.

Inputs to the visibility impacts analysis include emission rates of SO_2, NOx, and PM_{10} with its speciated components of coarse particulate, fine particulate, secondary organic aerosols, elemental carbon, and sulfate (SO_4). This last modeled component of sulfate is affected by application of SCR technology due to oxidation of SO_2 to SO_3, which is a precursor of sulfuric acid mist (SAM or H_2SO_4).

[1] High-dust SCR technology was also evaluated by these firms and was deemed technically and economically infeasible as a retrofit technology at Coal Creek Station.

The SO_2 oxidation rate due to SCR used by Barr in the modeling analysis is 5%. This oxidation rate comes from IBIDEN Ceram, an SCR catalyst vendor. It was determined by IBIDEN Ceram to be most appropriate design value based on their examination of site-specific characteristics at Coal Creek Station and with respect to their considerable experience with SCR catalysts.[2]

As follow-up to our conversations in January 2020, GRE reached out again to IBIDEN Ceram for additional technical information regarding the 5% SO_2 oxidation rate. They provided the illustration below, noting that catalyst design temperature for the GRE project is 830° F and the SO_2 to SO_3 oxidation rate is a large function of temperature. At baseload operation the flue gas exiting the economizer fluctuates between 800° and 830° F which is dependent upon coal quality and soot blowing. IBIDEN Ceram also stated that they are experienced with SCR systems that operate at elevated temperatures and that oxidation rate is exponential to temperature, regardless of fuel type.



Notwithstanding IBIDEN Ceram's analysis and since North Dakota lignite fueled units do not operate with SCR technology, there is no empirical data specific to these installations at a utility scale that can definitively conclude the SO_2 oxidation rate due to SCR at Coal Creek Station. Additionally, Electric Power Research Institute (EPRI) describes several additional variables that impact the rate of SCR-related SO_2 oxidation (i.e., fuel sulfur content, fly ash alkalinity, catalyst material and volume) as well as related measurement uncertainties between laboratory tests and field trials.[3] Because of these

[2] See the September 2019 NOx BART analysis at Attachment 1, Appendix E, for IBIDEN Ceram's analysis and their reference list of SCR projects.
[3] EPRI's report, "Estimating Total Sulfuric Acid Emissions from Stationary Power Plants," March 2018, is found in Attachment H-1 of the September 2019 NOx BART report.

considerations, Barr has calculated the sulfuric acid mist generated by SCR at an SO_2 oxidation rate of 0% and 2.5% in addition to the 5% level used in the September 2019 report.

The 0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR. The corresponding PM_{10} emissions rate for this scenario is the same as that used in Emissions Control Scenarios #1 through #3 of 90.2 lb/hr for Unit 1 and 90.3 lb/hr for Unit 2.

The 2.5% rate is chosen as a mid-point between 0% and 5%, which is representative of the range provided in EPRI's report based on other types of coals but does not recognize the specific fuel and operational considerations at Coal Creek Station in IBIDEN Ceram's analysis. Correspondingly, the 2.5% rate is used in the modeling analysis to assess the theoretical visibility impairment level at a reduced level of sulfuric acid mist formation due to SCR compared to that at 5% oxidation. The resulting generation of sulfuric acid mist at 2.5% oxidation is 51 lb/hr, compared to the 109 lb/hr generated at 5% oxidation. The corresponding PM_{10} emissions rate for this scenario is the same as that used in Emissions Control Scenarios #1 through #3 of 141.2 lb/hr for Unit 1 and 141.3 lb/hr for Unit 2.

The 0% and 2.5% oxidation rates are incorporated into individual modeling runs for Emissions Control Scenarios #4A and #4B. In summary, the results of these model sensitivity runs do not appreciably change the visibility impairment at the Class I areas, being on the order of ~0.1 delta-deciview per unit improvement.

Several tables have been updated to reflect the additional 0% and 2.5% oxidation rates for Scenarios #4A and #4B. These tables are identified and numbered in the same manner as that presented in Greg Archer's email to you on November 1, 2019.

The first sets of tables entail modeling the control options for one unit while holding the other unit at the facility at a fixed emission rate so that total facility emissions are accounted for in the model chemistry. Two potential configurations are evaluated – one holding the non-evaluated unit at Scenario 1 rates (LNC3, DryFining™, SO_2 BART – **Tables 1 to 6**), and the other holding the non-evaluated unit at Scenario 2 rates (LNC3+, DryFining™, SO_2 BART – **Tables 7 to 12**).

Modified versions of Tables 3-5 through 3-7 from the BART report are also included as **Tables 3-5a through 3-7a**, with the columns for modeled days over 1.0 and 0.5 deciviews replaced by net improvement in visibility versus Scenario 1 emissions. This provides a common basis for comparing emission controls between all tables.

Alternatively, attached is another version of tables 7 to 12 (tagged as **Tables 7a to 12a**) which calculates the net improvement versus Scenario 2 rather than versus Scenario 1. This provides a clearer comparison of control effectiveness versus LNC3+ emissions, and this approach also aligns with the expected emissions as of mid-2020 for evaluating additional controls.

Notably, the deciviews are negative in instances where SCR at the 5% oxidation rate has more of an impact as compared to Scenario 3, with SNCR. This is understandably a function of the increase in PM.

Much like SCR 0.04 and 0.06 sensitivity (Scenarios #4A and #4B, respectively), which did not materially change the conclusions, the oxidation rate sensitivity also does not materially change the conclusions.

Please contact Deb Nelson at 763-445-5208 if you have any questions regarding the four-factor analysis or wish to discuss any of the above.

Sincerely,

GREAT RIVER ENERGY

Mary Jo Roth

Mary Jo Roth
Manager, Environmental Services

c: Deb Nelson, Great River Energy
Greg Archer, Great River Energy
Joel Trinkle, Barr Engineering Co.

Attachments

Table 1: Unit 1 Visibility Modeling Results for Year 2000 (Unit 2 Emissions Held Constant at Scenario 1 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.660	-	0.647	-	0.599	-	0.916	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.609	0.051	0.595	0.052	0.552	0.047	0.824	0.092
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.575	0.085	0.564	0.083	0.522	0.077	0.767	0.149
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.525	0.135	0.502	0.145	0.461	0.138	0.676	0.240
	2.5%	0.563	0.097	0.522	0.125	0.482	0.117	0.723	0.193
	5.0%	0.607	0.053	0.565	0.082	0.505	0.094	0.813	0.103
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.532	0.128	0.522	0.125	0.481	0.118	0.694	0.222
	2.5%	0.581	0.079	0.542	0.105	0.501	0.098	0.762	0.154
	5.0%	0.626	0.034	0.579	0.068	0.525	0.074	0.844	0.072

Table 2: Unit 1 Visibility Modeling Results for Year 2001 (Unit 2 Emissions Held Constant at Scenario 1 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.474	-	0.571	-	0.526	-	0.873	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.433	0.041	0.567	0.004	0.486	0.040	0.802	0.071
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.423	0.051	0.527	0.044	0.461	0.065	0.759	0.114
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.402	0.072	0.447	0.124	0.412	0.114	0.723	0.150
	2.5%	0.425	0.049	0.471	0.100	0.434	0.092	0.794	0.079
	5.0%	0.465	0.009	0.519	0.052	0.460	0.066	0.875	-0.002
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.409	0.065	0.473	0.098	0.428	0.098	0.734	0.139
	2.5%	0.432	0.042	0.497	0.074	0.450	0.076	0.805	0.068
	5.0%	0.471	0.003	0.533	0.038	0.476	0.050	0.886	-0.013

Table 3: Unit 1 Visibility Modeling Results for Year 2002 (Unit 2 Emissions Held Constant at Scenario 1 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	1.279	-	1.145	-	0.987	-	0.689	-
#2: LNC3+, DryFining™, SO_2 BART	-	1.164	0.115	1.070	0.075	0.890	0.097	0.628	0.061
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	1.097	0.182	1.016	0.129	0.835	0.152	0.590	0.099
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.961	0.318	0.889	0.256	0.745	0.242	0.519	0.170
	2.5%	1.005	0.274	0.929	0.216	0.802	0.185	0.564	0.125
	5.0%	1.055	0.224	0.974	0.171	0.866	0.121	0.615	0.074
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	1.005	0.274	0.930	0.215	0.775	0.212	0.538	0.151
	2.5%	1.049	0.230	0.970	0.175	0.831	0.156	0.582	0.107
	5.0%	1.099	0.180	1.015	0.130	0.895	0.092	0.633	0.056

Table 4: Unit 2 Visibility Modeling Results for Year 2000 (Unit 1 Emissions Held Constant at Scenario 1 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.660	-	0.647	-	0.599	-	0.916	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.609	0.051	0.592	0.055	0.549	0.050	0.823	0.093
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.575	0.085	0.560	0.087	0.519	0.080	0.765	0.151
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.523	0.137	0.495	0.152	0.459	0.140	0.670	0.246
	2.5%	0.564	0.096	0.515	0.132	0.479	0.120	0.719	0.197
	5.0%	0.608	0.052	0.564	0.083	0.503	0.096	0.814	0.102
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.529	0.131	0.516	0.131	0.478	0.121	0.693	0.223
	2.5%	0.580	0.080	0.536	0.111	0.499	0.580	0.080	0.536
	5.0%	0.626	0.034	0.579	0.068	0.522	0.077	0.845	0.071

Table 5: Unit 2 Visibility Modeling Results for Year 2001 (Unit 1 Emissions Held Constant at Scenario 1 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.474	-	0.571	-	0.526	-	0.873	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.434	0.040	0.567	0.004	0.484	0.042	0.801	0.072
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.423	0.051	0.527	0.044	0.458	0.068	0.757	0.116
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.402	0.072	0.447	0.124	0.406	0.120	0.724	0.149
	2.5%	0.425	0.049	0.471	0.100	0.430	0.096	0.795	0.078
	5.0%	0.464	0.010	0.521	0.050	0.457	0.069	0.876	-0.003
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.409	0.065	0.473	0.098	0.423	0.103	0.734	0.139
	2.5%	0.432	0.042	0.497	0.074	0.446	0.080	0.806	0.067
	5.0%	0.471	0.003	0.535	0.036	0.473	0.053	0.887	-0.014

Table 6: Unit 2 Visibility Modeling Results for Year 2002 (Unit 1 Emissions Held Constant at Scenario 1 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	1.279	-	1.145	-	0.987	-	0.689	-
#2: LNC3+, DryFining™, SO_2 BART	-	1.161	0.118	1.069	0.076	0.890	0.097	0.628	0.061
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	1.092	0.187	1.011	0.134	0.834	0.153	0.590	0.099
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.953	0.326	0.880	0.265	0.732	0.255	0.521	0.168
	2.5%	0.998	0.281	0.921	0.224	0.800	0.187	0.564	0.125
	5.0%	1.050	0.229	0.968	0.177	0.864	0.123	0.613	0.076
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.998	0.281	0.922	0.223	0.769	0.218	0.538	0.151
	2.5%	1.043	0.236	0.963	0.182	0.829	0.158	0.582	0.107
	5.0%	1.095	0.184	1.010	0.135	0.894	0.093	0.631	0.058

Table 7: Unit 1 Visibility Modeling Results for Year 2000 (Unit 2 Emissions Held Constant at Scenario 2 Levels for Scenarios 2 through 4B)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.660	-	0.647	-	0.599	-	0.916	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.552	0.108	0.540	0.107	0.501	0.098	0.729	0.187
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.528	0.132	0.509	0.138	0.471	0.128	0.687	0.229
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.477	0.183	0.447	0.200	0.409	0.190	0.577	0.339
	2.5%	0.515	0.145	0.476	0.171	0.430	0.169	0.646	0.270
	5.0%	0.559	0.101	0.541	0.106	0.454	0.145	0.735	0.181
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.495	0.165	0.467	0.180	0.429	0.170	0.616	0.300
	2.5%	0.534	0.126	0.487	0.160	0.450	0.149	0.684	0.232
	5.0%	0.578	0.082	0.550	0.097	0.473	0.126	0.766	0.150

Table 8: Unit 1 Visibility Modeling Results for Year 2001 (Unit 2 Emissions Held Constant at Scenario 2 Levels for Scenarios 2 through 4B)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98^{th} Percentile Δ-dV	Visibility Improvement Δ-dV	98^{th} Percentile Δ-dV	Visibility Improvement Δ-dV	98^{th} Percentile Δ-dV	Visibility Improvement Δ-dV	98^{th} Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.474	-	0.571	-	0.526	-	0.873	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.416	0.058	0.502	0.069	0.443	0.083	0.745	0.128
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.405	0.069	0.462	0.109	0.418	0.108	0.729	0.144
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.384	0.090	0.381	0.190	0.388	0.138	0.695	0.178
	2.5%	0.413	0.061	0.422	0.149	0.414	0.112	0.768	0.105
	5.0%	0.462	0.012	0.482	0.089	0.439	0.087	0.849	0.024
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.391	0.083	0.407	0.164	0.389	0.137	0.708	0.708
	2.5%	0.414	0.061	0.436	0.135	0.414	0.112	0.778	0.708
	5.0%	0.463	0.011	0.497	0.074	0.444	0.082	0.860	0.013

Table 9: Unit 1 Visibility Modeling Results for Year 2002 (Unit 2 Emissions Held Constant at Scenario 2 Levels for Scenarios 2 through 4B)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	1.279	-	1.145	-	0.987	-	0.689	-
#2: LNC3+, DryFining™, SO_2 BART	-	1.048	0.231	0.970	0.175	0.806	0.181	0.566	0.123
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.981	0.298	0.907	0.238	0.761	0.226	0.531	0.158
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.844	0.435	0.779	0.366	0.653	0.334	0.467	0.222
	2.5%	0.889	0.390	0.819	0.326	0.725	0.262	0.520	0.169
	5.0%	0.945	0.334	0.865	0.280	0.793	0.194	0.584	0.105
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.888	0.391	0.820	0.325	0.688	0.299	0.491	0.198
	2.5%	0.933	0.346	0.860	0.285	0.758	0.229	0.538	0.151
	5.0%	0.983	0.296	0.906	0.239	0.823	0.164	0.591	0.098

Table 10: Unit 2 Visibility Modeling Results for Year 2000 (Unit 1 Emissions Held Constant at Scenario 2 Levels for Scenarios 2 through 4B)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.660	-	0.647	-	0.599	-	0.916	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.552	0.108	0.540	0.107	0.501	0.098	0.729	0.187
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.527	0.133	0.508	0.139	0.471	0.128	0.687	0.229
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.477	0.183	0.442	0.205	0.409	0.190	0.573	0.343
	2.5%	0.516	0.144	0.476	0.171	0.430	0.169	0.645	0.271
	5.0%	0.560	0.100	0.540	0.107	0.453	0.146	0.737	0.179
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.496	0.164	0.463	0.184	0.429	0.170	0.613	0.303
	2.5%	0.535	0.125	0.485	0.162	0.450	0.149	0.684	0.232
	5.0%	0.578	0.082	0.549	0.098	0.473	0.126	0.769	0.147

Table 11: Unit 2 Visibility Modeling Results for Year 2001 (Unit 1 Emissions Held Constant at Scenario 2 Levels for Scenarios 2 through 4B)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	0.474	-	0.571	-	0.526	-	0.873	-
#2: LNC3+, DryFining™, SO_2 BART	-	0.416	0.058	0.502	0.069	0.443	0.083	0.745	0.128
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.405	0.069	0.462	0.109	0.417	0.109	0.729	0.144
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.384	0.090	0.381	0.190	0.387	0.139	0.696	0.177
	2.5%	0.413	0.061	0.422	0.149	0.413	0.113	0.768	0.105
	5.0%	0.461	0.013	0.484	0.087	0.440	0.086	0.850	0.023
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.391	0.083	0.407	0.164	0.389	0.137	0.708	0.165
	2.5%	0.414	0.060	0.437	0.134	0.414	0.112	0.779	0.094
	5.0%	0.462	0.012	0.499	0.072	0.443	0.083	0.860	0.013

Table 12: Unit 2 Visibility Modeling Results for Year 2002 (Unit 1 Emissions Held Constant at Scenario 2 Levels for Scenarios 2 through 4B)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#1: LNC3, DryFining™, SO_2 BART	-	1.279	-	1.145	-	0.987	-	0.689	-
#2: LNC3+, DryFining™, SO_2 BART	-	1.048	0.231	0.970	0.175	0.806	0.181	0.566	0.123
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.979	0.300	0.905	0.240	0.758	0.229	0.531	0.158
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.838	0.441	0.773	0.372	0.645	0.342	0.465	0.224
	2.5%	0.885	0.394	0.815	0.330	0.720	0.267	0.520	0.169
	5.0%	0.946	0.333	0.862	0.283	0.793	0.194	0.585	0.104
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.884	0.395	0.815	0.330	0.682	0.305	0.490	0.199
	2.5%	0.930	0.349	0.857	0.288	0.757	0.230	0.538	0.151
	5.0%	0.982	0.297	0.904	0.241	0.822	0.165	0.591	0.098

Table 3-5a: Year 2000 Visibility Modeling Results

Description			Visibility Impairment							
			TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Units	Oxidation Rate	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV
#0: LNC3	1 & 2	-	1.959	-	1.780	-	1.412	-	2.155	-
#1: LNC3, DryFining™, SO_2 BART	1 & 2	-	0.660	-	0.647	-	0.599	-	0.916	-
#2: LNC3+, DryFining™, SO_2 BART	1 & 2	-	0.552	0.108	0.54	0.107	0.501	0.098	0.729	0.187
#3: LNC3+, DryFining™, SO_2 BART, SNCR	1 & 2	-	0.506	0.154	0.476	0.171	0.44	0.159	0.637	0.279
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	1 & 2	0%[1]	0.389	0.271	0.375	0.272	0.302	0.297	0.516	0.400
		2.5%	0.467	0.193	0.426	0.221	0.358	0.241	0.639	0.277
		5%	0.555	0.105	0.513	0.134	0.411	0.188	0.774	0.142
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	1 & 2	0%[1]	0.427	0.233	0.394	0.253	0.352	0.247	0.525	0.391
		2.5%	0.505	0.155	0.478	0.169	0.398	0.201	0.685	0.231
		5%	0.592	0.068	0.550	0.097	0.445	0.154	0.850	0.066

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 3-6a: Year 2001 Visibility Modeling Results

Description			Visibility Impairment							
			TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Units	Oxidation Rate	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV
#0: LNC3	1 & 2	-	1.653	-	1.378	-	1.626	-	2.842	-
#1: LNC3, DryFining™, SO_2 BART	1 & 2	-	0.474	-	0.571	-	0.526	-	0.873	-
#2: LNC3+, DryFining™, SO_2 BART	1 & 2	-	0.416	0.058	0.502	0.069	0.443	0.083	0.745	0.128
#3: LNC3+, DryFining™, SO_2 BART, SNCR	1 & 2	-	0.394	0.080	0.422	0.149	0.392	0.134	0.713	0.160
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	1 & 2	0%[1]	0.352	0.122	0.299	0.272	0.341	0.185	0.645	0.228
		2.5%	0.398	0.076	0.408	0.163	0.392	0.134	0.792	0.081
		5.0%	0.462	0.012	0.53	0.041	0.450	0.076	0.956	-0.083
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	1 & 2	0%[1]	0.365	0.109	0.329	0.242	0.362	0.164	0.667	0.206
		2.5%	0.412	0.062	0.438	0.133	0.415	0.111	0.813	0.060
		5.0%	0.492	-0.018	0.560	0.011	0.476	0.050	0.976	-0.103

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 3-7a: Year 2002 Visibility Modeling Results

Description			Visibility Impairment							
			TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Units	Oxidation Rate	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV	98th % Δ-dV	Visibility Improvement Δ-dV
#0: LNC3	1 & 2	-	3.131	-	2.692	-	2.173	-	1.980	-
#1: LNC3, DryFining™, SO_2 BART	1 & 2	-	1.279	-	1.145	-	0.987	-	0.689	-
#2: LNC3+, DryFining™, SO_2 BART	1 & 2	-	1.048	0.231	0.97	0.175	0.806	0.181	0.566	0.123
#3: LNC3+, DryFining™, SO_2 BART, SNCR	1 & 2	-	0.911	0.368	0.841	0.304	0.706	0.281	0.504	0.185
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	1 & 2	0%[1]	0.678	0.601	0.578	0.567	0.482	0.505	0.393	0.296
		2.5%	0.841	0.438	0.662	0.483	0.631	0.356	0.535	0.154
		5.0%	1.010	0.269	0.790	0.355	0.744	0.243	0.667	0.022
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	1 & 2	0%[1]	0.733	0.546	0.663	0.482	0.555	0.432	0.429	0.260
		2.5%	0.882	0.397	0.746	0.399	0.703	0.284	0.560	0.129
		5.0%	1.050	0.229	0.839	0.306	0.822	0.165	0.698	-0.009

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 7a: Unit 1 Visibility Modeling Results for Year 2000 (Unit 2 Emissions Held Constant at Scenario 2 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#2: LNC3+, DryFining™, SO_2 BART	-	0.552	-	0.540	-	0.501	-	0.729	-
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.528	0.024	0.509	0.031	0.471	0.030	0.687	0.042
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.477	0.075	0.447	0.093	0.409	0.092	0.577	0.152
	2.5%	0.515	0.037	0.476	0.064	0.430	0.071	0.646	0.083
	5.0%	0.559	-0.007	0.541	-0.001	0.454	0.047	0.735	-0.006
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.495	0.057	0.467	0.073	0.429	0.072	0.616	0.113
	2.5%	0.534	0.018	0.487	0.053	0.450	0.051	0.684	0.045
	5.0%	0.578	-0.026	0.550	-0.010	0.473	0.028	0.766	-0.037

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 8a: Unit 1 Visibility Modeling Results for Year 2001 (Unit 2 Emissions Held Constant at Scenario 2 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#2: LNC3+, DryFining™, SO_2 BART	-	0.416	-	0.502	-	0.443	-	0.745	-
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.405	0.011	0.462	0.040	0.418	0.025	0.729	0.016
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.384	0.032	0.381	0.121	0.388	0.055	0.695	0.050
	2.5%	0.413	0.003	0.422	0.080	0.414	0.029	0.768	-0.023
	5.0%	0.462	-0.046	0.482	0.020	0.439	0.004	0.849	-0.104
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.391	0.025	0.407	0.095	0.389	0.054	0.708	0.037
	2.5%	0.414	0.003	0.436	0.066	0.414	0.029	0.778	-0.033
	5.0%	0.463	-0.047	0.497	0.005	0.444	-0.001	0.860	-0.115

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 9a: Unit 1 Visibility Modeling Results for Year 2002 (Unit 2 Emissions Held Constant at Scenario 2 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#2: LNC3+, DryFining™, SO_2 BART	-	1.048	-	0.970	-	0.806	-	0.566	-
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.981	0.067	0.907	0.063	0.761	0.045	0.531	0.035
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.844	0.204	0.779	0.191	0.653	0.153	0.467	0.099
	2.5%	0.889	0.159	0.819	0.151	0.725	0.081	0.520	0.046
	5.0%	0.945	0.103	0.865	0.105	0.793	0.013	0.584	-0.018
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.888	0.160	0.820	0.150	0.688	0.118	0.491	0.075
	2.5%	0.933	0.115	0.860	0.110	0.758	0.048	0.538	0.028
	5.0%	0.983	0.065	0.906	0.064	0.823	-0.017	0.591	-0.025

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 10a: Unit 2 Visibility Modeling Results for Year 2000 (Unit 1 Emissions Held Constant at Scenario 2)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#2: LNC3+, DryFining™, SO_2 BART	-	0.552	-	0.540	-	0.501	-	0.729	-
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.527	0.025	0.508	0.032	0.471	0.030	0.687	0.042
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.477	0.075	0.442	0.098	0.409	0.092	0.573	0.156
	2.5%	0.516	0.036	0.476	0.064	0.430	0.071	0.645	0.084
	5.0%	0.560	-0.008	0.540	0.000	0.453	0.048	0.737	-0.008
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.496	0.056	0.463	0.077	0.429	0.072	0.613	0.116
	2.5%	0.535	0.017	0.485	0.055	0.450	0.051	0.684	0.045
	5.0%	0.578	-0.026	0.549	-0.009	0.473	0.028	0.769	-0.040

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 11a: Unit 2 Visibility Modeling Results for Year 2001 (Unit 1 Emissions Held Constant at Scenario 2 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#2: LNC3+, DryFining™, SO_2 BART	-	0.416	-	0.502	-	0.443	-	0.745	-
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.405	0.011	0.462	0.040	0.417	0.026	0.729	0.016
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.384	0.032	0.381	0.121	0.387	0.056	0.696	0.049
	2.5%	0.413	0.003	0.422	0.080	0.413	0.030	0.768	-0.023
	5.0%	0.461	-0.045	0.484	0.018	0.440	0.003	0.850	-0.105
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.391	0.025	0.407	0.095	0.389	0.054	0.708	0.037
	2.5%	0.414	0.002	0.437	0.065	0.414	0.029	0.779	-0.034
	5.0%	0.462	-0.046	0.499	0.003	0.443	0.000	0.860	-0.115

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.

Table 12a: Unit 2 Visibility Modeling Results for Year 2002 (Unit 1 Emissions Held Constant at Scenario 2 Levels)

Description		Visibility Impairment							
		TRNP South Unit		TRNP North Unit		TRNP Elkhorn Ranch		Lostwood Wilderness Area	
Emissions Control Scenario	Oxidation Rate	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV	98th Percentile Δ-dV	Visibility Improvement Δ-dV
#2: LNC3+, DryFining™, SO_2 BART	-	1.048	-	0.970	-	0.806	-	0.566	-
#3: LNC3+, DryFining™, SO_2 BART, SNCR	-	0.979	0.069	0.905	0.065	0.758	0.048	0.531	0.035
#4A: LNC3+, DryFining™, SO_2 BART, SCR@0.04	0%[1]	0.838	0.210	0.773	0.197	0.645	0.161	0.465	0.101
	2.5%	0.885	0.163	0.815	0.155	0.720	0.086	0.520	0.046
	5.0%	0.946	0.102	0.862	0.108	0.793	0.013	0.585	-0.019
#4B: LNC3+, DryFining™, SO_2 BART, SCR@0.06	0%[1]	0.884	0.164	0.815	0.155	0.682	0.124	0.490	0.076
	2.5%	0.930	0.118	0.857	0.113	0.757	0.049	0.538	0.028
	5.0%	0.982	0.066	0.904	0.066	0.822	-0.016	0.591	-0.025

[1]0% rate is hypothetical only and is not technically supportable, but it is provided for informational purposes to assess the theoretical visibility impairment level if no additional sulfuric acid mist was created due to SCR.