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DAQP-063-21

July 27, 2021

Hal Lee
Graymont Western US Incorporated
585 West Southridge Way
Sandy, UT 84070
nstettler@graymont.com

Dear Mr. Lee,

The DAQ has received your four-factor analysis for the Graymont Western Cricket Mountain Power Plant prepared for the second planning period of Utah's Regional Haze State Implementation Plan. Enclosed is an engineering review of the analysis outlining some outstanding issues for you to be aware of. Please provide the DAQ with amendments or reasoning for these issues by **August 31st, 2021**. If you have any questions, please contact John Jenks at jjenks@utah.gov or (385) 306-6510.

Sincerely,

Chelsea Cancino

Chelsea Cancino
Environmental Scientist

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Regional Haze – Second Planning Period
SIP Evaluation Report:

Graymont Western US Incorporated - Cricket Mountain Plant

Utah Division of Air Quality

July 30, 2021

SIP EVALUATION REPORT

Graymont Western US Incorporated - Cricket Mountain Plant

1.0 Introduction

The following is part of the Technical Support Documentation for the Second Planning Period of the Regional Haze SIP (aka the Visibility SIP). This document specifically serves as an evaluation of the Source facility.

1.1 Facility Identification

Name: Cricket Mountain Plant
Address: 32 Miles Southwest of Delta, Utah; Highway 257
Owner/Operator: Graymont Western US Incorporated
UTM coordinates: 4,311,010 m Northing, 343,100 m Easting, Zone 12

1.2 Facility Process Summary

Graymont Western US Inc. (Graymont) operates the Cricket Mountain Lime Plant in Millard County. The Cricket Mountain Lime Plant consists of quarries and a lime processing plant, which includes five (5) rotary lime kilns (Kilns 1 through 5). The rotary kilns are used to convert crushed limestone ore into quicklime. The products produced for resale are lime, limestone, and kiln dust. The kilns operate on pet coke and coal. Sources of emissions at this source include mining, limestone processing, rotary lime kilns, post-kiln lime handling, and truck & loadout facilities.

1.3 Facility Criteria Air Pollutant Emissions Sources

The source consists of the following emission units:

- Rotary Lime Kiln #1 rated at 600 tons of lime per 24-hour period with a preheater and baghouse emissions control system (D-85) rated at an exhaust gas flow rate 54,000 scfm and an Air to Cloth (A/C) ratio of 3.26:1. NESHAP Applicability: 40 CFR 63 Subpart AAAAA
- Rotary Lime Kiln #2 rated at 600 tons of lime per 24-hour period with a preheater, cyclone and baghouse emissions control system (D-275) rated at an exhaust gas flow rate of 48,000 scfm and an A/C ratio of 2.9:1. NESHAP Applicability: 40 CFR 63 Subpart AAAAA
- Rotary Lime Kiln #3 rated at 840 tons of lime per 24-hour period with a preheater, cyclone and baghouse emissions control system (D-375) rated at an exhaust gas flow rate of 55,000 scfm and a A/C ratio of 2.49:1. NESHAP Applicability: 40 CFR 63 Subpart AAAAA
- Rotary Lime Kiln #4 rated at 1266 tons of lime per 24-hour period with a preheater, cyclone and baghouse emissions control system (D-485) rated at an exhaust gas flow rate of 100,000 scfm and an A/C ratio of 5:1. NESHAP Applicability: 40 CFR 63 Subpart AAAAA
- Rotary Lime Kiln #5 rated at 1400 tons of lime per 24-hour period with a preheater and baghouse emissions control system (D-585) rated at an exhaust gas flow rate of 103,000 scfm and an A/C ratio of 3.5:1. NESHAP Applicability: 40 CFR 63 Subpart AAAAA

1.4 Facility Current Potential to Emit

The current PTE values for Source, as established by the most recent NSR permit issued to the source (DAQE-AN103130044-21) are as follows:

Table 2: Current Potential to Emit

Pollutant	Potential to Emit (Tons/Year)
SO_2	760.29
NO_x	3,883.85

2.0 Four Factor Review Methodology

Each source reviewed in this second planning period submitted a report on the available control technologies for SO2 and NOx emission reductions and the application of each technology to that facility. The information on available controls should consider the following four factors when analyzing the possible emission reductions:

1. Factor 1 – The Costs of Compliance
2. Factor 2 – Time Necessary for Compliance
3. Factor 3 – Energy and Non-Air Quality Environmental Impacts of Compliance
4. Factor 4 – Remaining Useful Life of the Source

Although not specifically required, the recommended approach was to follow a step-wise review of possible emission reduction options in a “top-down” fashion similar to U.S. EPA’s guidelines for review of BART or Best Available Retrofit Technology (as found in 40 CFR 51, Section 308 amendments, pub. July 5, 2005). The steps involved are as follows:

Step 1. Identify all available retrofit control technologies
Step 2. Eliminate technically infeasible control technologies
Step 3. Evaluate the control effectiveness of remaining control technologies
Step 4. Evaluate impacts and document results

The process is inherently similar to that used in selecting BACT (Best Available Control Technology) under the NSR/PSD (Title I) permitting program. DAQ evaluated the submissions from each source following the methodology outlined above. Where a particular submission may have differed from the recommended process, DAQ will make note, and provide additional information as necessary.

3.0 Analysis for SO2 Emission Reductions

Graymont did not supply an analysis for SO2 emissions. Although potential SO2 emissions in Graymont’s most recent AO could exceed 760 tons/year, Graymont supplied no information regarding SO2 emissions or controls. Perhaps this is because actual emissions of SO2 are typically far below the listed potential. The most recent inventory for the Cricket Mountain Plant showed SO2 emissions of only 40.8 tons/year.

DAQ does not agree with this approach. The source should still provide an analysis of potential controls following the recommended process outlined in Section 2 above. Given the low level of SO2 emissions, the most likely outcome of the analysis would be that no controls are recommended, but the analysis should still be supplied.

Given the lack of information in this section, DAQ cannot comment at this time.

4.0 Analysis for NOx Emission Reductions

Graymont supplied the following regarding potential NOx controls at the Cricket Mountain Plant:

Foremost, Graymont began by establishing the baseline emissions for each of the five kilns. The Baseline emissions are the average NOx emissions for years 2014-2018, based on stack test data and annual production rates. The calculations and data used were not supplied in the analysis, but do appear to match the annual emission inventory data supplied by the company to DAQ. The baseline emissions are as follows:

Kiln 1: 85.5 tons/year
Kiln 2: 60.3 tons year
Kiln 3: 50.0 tons/year
Kiln 4: 107.1 tons/year
Kiln 5: 336.1 tons/year

<u>Step 1:</u>

Graymont identified four combustion-type control systems and two post-combustion-type control systems for use in reducing NOx emissions:

Combustion controls: Reduce Peak Flame Zone Temperature, Low NOx Burners (LNB), Proper Kiln Operation, Preheater Kiln Design

Post combustion controls: Selective Catalytic Reduction (SCR), Selective Non-catalytic Reduction (SNCR)

<u>Step 2:</u>

Step 2 of the top-down control review is to eliminate technically infeasible NOx control technologies that were identified in Step 1.

Graymont provided the following for each of the Step 1 controls:

Reduce Peak Flame Zone Temperature
In a lime kiln, product quality is co-dependent on temperature and atmospheric conditions within the system. Although low temperatures inhibit NOx formation, they also inhibit the calcination of limestone. For this reason, methods to reduce the peak flame zone temperature in a lime kiln burner are technically infeasible.

Low NOx Burners
The facility currently operates low-NOx burners in the lime kilns. Coal is delivered to the burners using a direct fired system. However, to limit NOx, only enough primary air is used to sweep coal out of the mill. This is similar to using an indirect fired system, which also limits primary air to the burners while delivering fuels. Baseline emissions are based on the operation of these low NOx

burners. All alternative methods of NOx control in this analysis will assume that the kilns continue to operate these burners.

Preheater Kiln Design/Proper Combustion Practices
Proper combustion practices and preheater kiln design are considered technically feasible for Graymont and will be considered further.

Selective Catalytic Reduction
Efficient operation of the SCR process requires fairly constant exhaust temperatures (usually ± 200°F). Fluctuation in exhaust gas temperatures reduces removal efficiency. If the temperature is too low, ammonia slip occurs. Ammonia slip is caused by low reaction rates and results in both higher NOx emissions and appreciable ammonia emissions. If the temperature is too high, oxidation of the NH_3 to NO can occur. Also, at higher removal efficiencies (beyond 80 percent), an excess of NH_3 is necessary, thereby resulting in some ammonia slip. Other emissions possibly affected by SCR include increased PM emissions (as ammonia salts result from the reduction of NOx and are emitted in a detached plume) and increased SO_3 emissions (from oxidation of SO_2 on the catalyst). To reduce fouling the catalyst bed with the PM in the exhaust stream, an SCR unit can be located downstream of the particulate matter control device (PMCD). However, due to the low exhaust gas temperature exiting the PMCD (approximately 350°F), a heat exchanger system would be required to reheat the exhaust stream to the desired reaction temperature range of between 480°F to 800°F. The source of heat for the heat exchanger would be the combustion of fuel, with combustion products that would enter the process gas stream and generate additional NOx. Therefore, in addition to storage and handling equipment for the ammonia, the required equipment for the SCR system will include a catalytic reactor, heat exchanger and potentially additional NOx control equipment for the emissions associated with the heat exchanger fuel combustion.

High dust and semi-dust SCR technologies are still highly experimental. A high dust SCR would be installed prior to the dust collectors, where the kiln exhaust temperature is closer to the optimal operating range for an SCR. It requires a larger volume of catalyst than a tail pipe unit, and a mechanism for periodic cleaning of the catalyst. A high dust SCR also uses more energy than a tail pipe system due to catalyst cleaning and pressure losses. A semi-dust system is similar to a high dust system. However, the SCR is placed downstream of an ESP or cyclone. The main concern with high dust or semi-dust SCR is the potential for dust buildup on the catalyst, which can be influenced by site specific raw material characteristics present in the facility's quarry, such as trace contaminants that may produce a stickier particulate than is experienced at sites where the technology is being demonstrated. This buildup could reduce the effectiveness of the SCR technology, and make cleaning of the catalyst difficult, resulting in kiln downtime and significant costs.

No lime kiln in the United States is using any of these SCR technologies. For the technical issues noted above, tail pipe, high dust and semi-dust SCR's are considered technically infeasible at this time.

Selective Non-Catalytic Reduction
At temperatures above 2,100°F, NOx generation starts to occur as shown in the reaction below:

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

This reaction causes ammonia to oxidize and form NO instead of removing NO. When temperatures exceed 2200°F, NO formation dominates. This would likely be the case if ammonia were directly injected into the kiln tube. At temperatures below the required range, appreciable quantities of un-reacted ammonia will be released to the atmosphere via ammonia slip.

Based on the temperature profile, there are three locations in a rotary preheater lime kiln system where the ammonia /urea injection could theoretically occur: the stone/preheater chamber, the transfer chute, or after the PMCD. A fourth location that will be considered in this analysis is the kiln tube. In order for SNCR to be technically feasible, at least one of these locations must meet the following criteria: placement of injector to ensure adequate mixing of the ammonia or urea with the combustion gases, residence time of the ammonia with the combustion gases, and temperature profile for ammonia injection.

The required temperature range for the reaction may occur within the preheater. However, the location of the temperature zone varies with time and location as explained below. In each Graymont Cricket Mountain preheater, mechanical rams operate in sequence, transferring limestone, one ram at a time, from the stone chambers into the transfer chute. When a ram is in the “in” position, very little exhaust gas flows through the stone and out the duct. When the ram pulls out, the cold stone drops down and fills the stone heating chamber. The angle of repose of the stone and the configuration of the duct and chamber are such that stone does not continue to fall into the transfer chute. Hot gases, at approximately 1,950°F, then pass through the stone chamber filled with cold stone. The first gas to pass through the chamber exits the chimney at approximately 400°F. As the cold stone heats up, the exit gas temperature increases and reaches a high of approximately 600°F. The ram then strokes and pushes the heated stone into the transfer chute and starts the cycle again.

Besides the fact that the optimal temperature zone varies in location, the fact that the stone chamber is filled with stone makes using nozzles for injecting the ammonia/urea infeasible. For example, if a nozzle protruded from the wall of the stone chamber, the moving packed bed of rock would either knock it off or wear it off in a very short time. If the nozzle were inset into the wall of the chamber, the moving packed bed of stone would block the spray, and the ammonia or the urea mixture would simply coat a few of the stones, rather than mixing evenly throughout the gas stream. Similarly, if the nozzle were positioned at the roof of the preheater, the ammonia or urea would not be distributed throughout the gas stream. The preheater is approximately 75 percent full of stone, so ammonia or urea sprayed from the top of the preheater would have minimal residence time for distribution through the combustion gases before it would be blocked from distribution by the stone. Regardless of the choice of location for the nozzle, the ammonia or urea would not be effectively distributed through the large surface area of the preheater. These problems make application of SNCR in the stone chamber technically infeasible.

The temperature in the transfer chute is approximately 1,950°F for typical kilns. These temperatures are in the upper bound for the NOx reduction reaction. Temperatures this high reportedly resulted in approximately 30 percent NOx reduction in clean (non-dust-laden) exhaust streams. Lime kilns do not have clean exhaust streams at this location. Rather, the back end of the transfer chute is an extremely dusty environment, and therefore the exhaust stream is dust-laden. The one SNCR installation in the lime industry has achieved control efficiencies of around 50% with the injection nozzles installed in the bottom of the preheater, at the preheater cone. While this technology is certainly promising, this one example of SNCR installation on a rotary lime kiln does not necessarily transfer to other lime kilns. Effectiveness of SNCR is highly site-dependent, with a variety of factors having the potential to heavily influence the quantities of NOx controlled.

Given the significant range (35-58%) of control efficiencies found for cement kilns, a control efficiency considerably lower than the average for cement of 40% is expected given ideal temperature scenarios (many kilns in the cement industry that utilize SNCR do so in the combustion zone in the calciner, where temperatures are lower than in the kiln). Lime kilns experience significant technical barriers to successful SNCR implementation not shared by the cement industry. When compared to the cement process, lower NOx concentrations, shorter residence times, and temperatures more frequently outside the optimal range for SNCR application yield lower control efficiencies for lime kilns. Therefore, a control efficiency of no more than 20% is anticipated for the Cricket Mountain kilns. Locating an ammonia or urea injector nozzle in the chute to ensure mixing of the ammonia with the combustion gases would pose similar problems as the problems with the stone chamber location. Stones pour into the chute from the stone chamber, and in order to stabilize a nozzle for injection, the nozzle would need to be positioned out of the direct path of the flow of the stones. Further, the stone pieces that pour into the transfer chute from the chamber take up a large portion of the volume in the chute. Adequate mixing of the ammonia or urea with the combustion gases would be inhibited by the rock. The ammonia or urea would most likely end up on the stones, rather than mixing evenly throughout the gas stream. The low percent NOx reduction combined with the uncertainty of the nozzle placement and mixing requirement eliminate the transfer chute as a technically feasible option for Cricket Mountain Kilns 1 through 5.

SNCR Ammonia/Urea Injection Location - Inside Rotary Kiln
Ammonia/urea could be injected through a door or port in the kiln shell. Similar to the transfer chute, stone is traveling down the rotary kiln. Consequently, the nozzle would need to be positioned out of the direct path of the flow of the stones. Theoretically, the temperature inside a rotary lime kiln, which is above 2,200 F, would promote the formation of NO from injected ammonia. Graymont is aware that there have been trials at competing lime facilities with mid-kiln ammonia injection and transfer chute ammonia/urea injection for NOx reduction. However, the technology costs and technical details have not become publicly available, so Graymont cannot evaluate if the technology can be successfully applied specifically to the kilns at the Cricket Mountain facility. Since a mid-kiln ammonia injection and transfer chute ammonia/urea injection systems would require extended trials to determine if the technology can effectively control NOx on the Graymont lime kilns, Graymont must conclude that this type of SNCR is not "available" with respect to the Cricket Mountain plant because it is not commercially available. Since it is not commercially available, no vendor performance guarantees can be made to its success. Therefore, this technology cannot be considered technically feasible.

The technology is not commercially available, as defined in 40 CFR Subpart 51, Appendix Y which states that:

Two key concepts are important in determining whether a technology could be applied: "availability" and "applicability." As explained in more detail below, a technology is considered "available" if the source owner may obtain it through commercial channels, or it is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible.

Availability in this context is further explained using the following process commonly used for bringing a control technology concept to reality as a commercial product:

The typical stages for bringing a control technology concept to reality as a commercial product are:

- Concept stage;
- Research and patenting;
- Bench scale or laboratory testing;
- Pilot scale testing;
- Licensing and commercial demonstration; and
- Commercial sales.

A control technique is considered available, within the context presented above, if it has reached the stage of licensing and commercial availability. Similarly, we do not expect a source owner to conduct extended trials to learn how to apply a technology on a totally new and dissimilar source type. Consequently, you would not consider technologies in the pilot scale testing stages of development as “available” for purposes of BART review. Commercial availability by itself, however, is not necessarily a sufficient basis for concluding a technology to be applicable and therefore technically feasible. Technical feasibility, as determined in Step 2, also means a control option may reasonably be deployed on or “applicable” to the source type under consideration.

Though the technology is not considered technically feasible for Graymont’s Cricket Mountain facility for the reasons outlined above, cost calculations for the implementation of SNCR are included for completeness assuming a 20% control efficiency for NOx.

Step 3:

As Graymont found only SNCR and LNB as potential control technologies, and as the Cricket Mountain Plant already has LNB installed, the ranking of the control technologies becomes academic.

Step 4:

Cost of Compliance
In order to assess the cost of compliance for the installation of SNCR, the EPA Control Cost Manual is used. Capital costs for the installation of the SNCR assumed a 20-year life span for depreciation, as well as the current bank prime rate of 4.75% for interest calculations. The total capital investment includes the capital cost for the SNCR itself, the cost of the air pre-heater required (per the EPA Control Cost Manual, the air preheater will require modifications for coal-fired units when SO2 control is necessary. This value is conservatively assumed for all coal-fired units evaluated for SNCR installation), and the balance of the plant. Annual costs include both direct costs such as maintenance, reagent, electricity, water, fuel, and waste disposal cost and indirect costs for administrative charges and the amortized capital costs as a capital recovery value. A retrofit factor of 1.5 is used to account for the technical barriers described above, including the existence of only one RBLC reference for an SNCR retrofit on a lime kiln, the difficulty of identifying an injection point that allows for ammonia to enter the gas stream within an optimal temperature window, the low residence times of lime kilns relative to cement kilns, and the relatively low inlet NOx concentrations that limit the effectiveness of the control technology.

SNCR Cost Calculation Summary

Kiln #	Total Capital Investment (dollars)	Total Annual Cost (dollars)	NOx Removed (tons)	Cost Effectiveness ($/ton)
1	$5,425,232	$519,152	15.5	33,571
2	$5,817,345	$552,963	10.9	50,720
3	$6,482,717	$616,847	9.0	68,276
4	$7,927,545	$755,901	19.4	39,025
5	$7,547,629	$741,500	60.8	12,199
Total	$33,200,469	$3,186,363	115.6	27,575

Timing for Compliance
Graymont believes that reasonable progress compliant controls are already in place. However, if DEQ determines SNCR is necessary to achieve reasonable progress, it is anticipated that this change could be implemented during the second planning period of regional haze (approximately ten years following EPA's reasonable progress determination).

Energy Impacts and Non-Air Quality Impacts
As previously stated, the cost of energy and water required for successful operation of the SNCR are included in the calculations, which can be found in detail in Appendix B. The installation is expected to decrease the efficiency of the overall facility, particularly as significant energy and water use is needed beyond current plan operation requirements.

Remaining Useful Life
Graymont has assumed this control equipment will last for the entirety of the 20-year amortization period, which is reflected in the cost calculations.

Graymont Conclusion:
The facility currently uses low NOx burners in its five kilns to minimize NOx emissions. The use of low NOx burners is a commonly applied technology in current BACT determinations for new rotary preheater lime kilns today. The application of SCR has never been attempted on a lime kiln. SNCR has only one RBLC entry documenting implementation on a lime kiln. The use of these controls does not represent a cost-effective control technology given the limited expected improvements to NOx emission rates, high uncertainty of successful implementation, high capital investment, and high cost per ton NOX removed. Therefore, the emissions for the 2028 on-the-books/on-the-way modeling scenario are expected to be the same as those used in the "control scenario" for the Graymont Cricket Mountain facility.

5.0 DAQ Conclusion

DAQ disagrees with several points of Graymont's analysis. Setting aside the lack of SO2 analysis, DAQ found several errors in the Graymont NOx analysis which must be corrected.

1. Two additional control technologies were identified by DAQ as potential ways of reducing NOx emissions: fuel switching and alternative production techniques. The Graymont Cricket Mountain Plant is fueled by coal – alternative fuels should be investigated. Secondly, the kilns at this facility are long horizontal rotary preheater/precalciner style kilns. Other types of kilns such as vertical lime kilns should also be investigated.
2. Graymont has claimed that SNCR is not technically feasible for installation on rotary preheater kilns. However, that is not accurate as there have been other SNCR retrofits done at preheater

rotary lime kilns. Those lime kilns include the Lhoist North America O'Neal Plant in Alabama, the Unimin Corporation lime plant in Calera, Alabama, and the rotary lime kilns of the Lhoist North America Nelson Lime Plant in Arizona, as well as the Mississippi Lime Company plant in Illinois (specifically mentioned by Graymont as the only source listed on the RBLC).

3. A NOx reduction of 20% for SNCR is too low for use in the analysis, given that Graymont itself quoted the average NOx removal at cement kilns with SNCR was 40%, with the range of NOx removal efficiency between 35%-58%. At a minimum, Graymont should have evaluated the use of SNCR at 35% removal efficiency rather than merely 20%.
4. The current bank prime rate is 3.25% and not 4.75% as stated by Graymont. The economic analysis must be recalculated using the correct interest rate.
5. The cost of an air preheater was included – which appears to be a mistake based on an error (a typographical misprint) found in EPA's SNCR control cost spreadsheets. In one place the spreadsheet uses a value of 3.0 lb SO2/ton coal while in another the value is erroneously listed as 0.3 lb SO2/ton coal. Graymont apparently included the cost of the air preheater when burning coal which does not require such equipment as part of an SNCR installation.

Although DAQ has not fully evaluated these deficiencies, it has analyzed how Graymont's cost evaluation would change if the correct bank prime interest rate were used, if the cost of the air preheater were not included, and if the removal efficiency of the SNCR were increased to a minimum of 35%. To reflect the increased cost of a more efficient SNCR than that proposed by Graymont, the direct annual costs (energy, cost of ammonia, etc) were doubled as a conservative estimate. The results of these changes are as follows:

Kiln	Capital Costs ($)	Direct Annual Costs ($)	Total Annual Costs ($)	NOx Removed (tons)	Cost Effectiveness ($/ton)
1	$3,616,821	$180,574	$328,281	30	10,943
2	$3,878,230	$186,204	$343,367	22	15,608
3	$4,321,811	$208,776	$377,952	18	20,997
4	$5,285,030	$258,458	$461,703	38	12,150
5	$5,031,753	$289,720	$485,174	122	3,977

Based on these revised results, the application of SNCR may appear to be feasible, at least for Kiln #5. Additional analysis should be provided by the source to further detail these deficiencies.