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August 31, 2021

Ms. Chelsea Cancino *(VIA Electronic Mail)*
Environmental Scientist
Division of Air Quality
Department of Environmental Quality
195 North 1950 West
Salt Lake City, UT 84014
ccancino@utah.gov

**RE: Cricket Mountain Response to UDAQ Request for Additional Information**
**Graymont Western US, Inc.**

Dear Ms. Cancino

Graymont Western US, Inc. (Graymont) has prepared this letter in response to comments received on July 27, 2021 from the Utah Department of Air Quality (UDAQ) concerning the regional haze four-factor analysis for the Cricket Mountain Plant. This letter follows the four-factor analysis submitted on April 29, 2020.

In order to obtain a more accurate capital and operating cost estimate, Graymont commissioned a Class 4 engineering cost estimate to ascertain capital and operating costs associated with installing and operating Selective Non-Catalytic Reduction (SNCR) Nitrogen Oxides (NOx) abatement systems on Cricket Mountain kilns. The cost estimations performed by a third party engineer indicate that the total capital cost for installation of SNCR systems at Cricket Mountain exceed $6.9 MMUSD and operating costs exceed $1.4 MMUSD annually, resulting in a cost of $17,561 per ton of $NO_x$ removed based upon a 20 percent removal efficiency[1]. A factor of 20 percent was utilized based on the temperature and residence time limitations of the SNCR reaction zone for each Cricket Mountain kiln combined with the Low NOx baseline concentration already achieved through use of Low NOx Burners (LNB).[2]

Graymont also compared the current $NO_X$ emissions from Cricket Mountain to publicly available information for the Lhoist North America (LNA) rotary preheater kilns which utilize SCNR. We can share the following observations:

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[1] Cricket Mountain SNCR Cost Effectiveness Calculations are detailed in Appendix A

[2] Lhoist North America indicated in a November 2020 4-factor analysis that Kilns 1, 2 & 3 would be capable of a maximum NOx control of 20%.

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- The existing LNBs at Cricket Mountain have effectively reduced the $NO_X$ emission intensity to a level more than three times less than the pre-control $NO_X$ intensity of LNA's Nelson Plant which utilizes SNCR.

- Any additive efficiency that might be gained from Cricket Mountain's use of SNCR would be marginal, at best, as SNCR NOx removal efficiency is highly dependent upon the inlet NOx concentration, reaction zone temperature and residence time, all of these factors reduce the anticipated efficiency that can reasonably be assumed for the Cricket Mountain Kilns.

- The LNA SNCR technology for rotary lime kilns is proprietary and not unconditionally commercially available to Graymont. The technology appears to be patented, adding to its cost and the uncertainty as to its technical feasibility.

- SNCR addition at Cricket Mountain would have unintended negative environmental impacts and visibility disbenefits, including the generation of condensable particulate, an identified regional haze primary pollutant.

- The Cricket Mountain facility operates 5 rotary preheat lime kilns, each of which are substantially different technology than mid-fired cement kilns (more conducive reaction zone temperatures, higher NOx concentrations, and longer residence times). As such, it is not appropriate to draw direct comparisons with application of SNCR between cement kilns and lime kilns as referenced in your letter.

Based on Graymont's findings, requiring the installation of SNCR at Cricket Mountain would be unreasonable because it would be infeasible, unnecessary and counterproductive to making reasonable progress towards the goal of preventing future, and remedying any existing, anthropogenic impairment of visibility in mandatory Class I Federal areas in the context of Utah's pending Round 2 Regional Haze State Implementation Plan (RH SIP). Cricket Mountain's successful implementation of LNBs effectively controls NOx at the point of generation in kilns. These NOx rates are sufficient for inclusion in the UDAQ RH SIP since they are already some of the lowest achieved in the industry and far exceed what has been deemed BART at other kilns (such as the SNCR controlled kilns at the LNA Nelson Facility).

**Evaluation of Sulfur Dioxide ($SO_2$) Emissions Reductions**

As provided in the UDAQ response, the $SO_2$ emissions from the facility are very low as the reference year 2014 emissions inventory reflected 40.8 tons per year. This presents a Q/d of 0.3 for $SO_2$ which places this site in a category where potential for these emissions to impact Class 1 area visibility are very low to negligible. Consistent with this data, Utah Department of Air Quality indicated in December 2019 not to include $SO_2$ in our analysis because the emissions were so low. Please refer to Appendix B where you will find the email from Jay Baker confirming what was discussed in the meeting.

**Evaluation of Alternative Fuels**

Currently the Cricket Mountain kilns utilize coal as the fuel source for lime production. This fuel is utilized based on coal meeting the required Btu values to effectively calcine limestone within our operations. There are not comparable Btu value fuels in the required quantities currently available to the facility. Natural gas, a comparable Btu value fuel is currently not available to the site as the nearest natural gas pipeline is approximately 18 miles away and would require substantial infrastructure, easements, and process modification to connect to this supply. The resultant impact of natural gas on NOx emissions for the site would be negligible or equivalent to what is seen with the current coal combustion. Therefore, natural gas, for purposes of this regional haze analysis, would not be feasible based on the tens of millions of dollars that would be required to connect to this pipeline with no notable change in NOx emissions with natural gas.

**Vertical Kiln Technology**

In the comments received from UDAQ, Graymont was asked to investigate additional control technologies specifically vertical lime kilns. In the original four factor analysis this was not evaluated as an additional control technology as it is not an add-on control. In order to replace the existing Cricket Mountain kilns with vertical lime kilns Graymont would need to demolish the existing kilns and infrastructure to effectively build a new plant. This would be an extremely costly endeavor which would require hundreds of millions of dollars. Aside from the enormous cost to build a new plant with new vertical kilns, this could also lead to loss of customers and production volume as Cricket Mountain may not be able to produce the quantity and/or quality of lime to existing customers specifications.

**Existing Low NOx Burners at Cricket Mountain Effectively Reduce NOx Emission Intensity**

Graymont's Cricket Mountain kilns are currently equipped with LNB's that have effectively demonstrated excellent control of NOx generation during the combustion process. For purposes of comparison, the LNA Nelson, AZ facility information is utilized in our evaluation based on the availability of comprehensive information regarding application of SNCR technology. Table 1, below, compares the $NO_X$ emission limits applicable to Graymont Cricket Mountain and LNA Nelson kilns. As shown, the uncontrolled $NO_X$ emissions from the LNA Nelson plant prior to the installation of SNCR were substantially higher than the current $NO_X$ emission levels achieved by the Graymont Cricket Mountain kilns, and even higher than the Cricket Mountain emission limitations.

**Table 1. Summary of $NO_X$ Emissions from the Graymont and Lhoist Lime Kilns**

| Facility | Kiln | Pre-SCNR Actual Emissions [a, b] (lb/ton lime) | Current Calculated Permit Emission Limit [c] (lb/ton lime) | SNCR Permit Emission Limit [a] (lb/ton lime) |
|---|---|---|---|---|
| Graymont Cricket Mountain | Kiln 1 | 2.15 | 3.6 | -- |
| | Kiln 2 | 2.15 | 4.8 | -- |
| | Kiln 3 | 0.93 | 4.6 | -- |
| | Kiln 4 | 2.33 | 3.8 | -- |
| | Kiln 5 | 2.42 | 3.6 | -- |
| Lhoist Nelson | Kiln 1 | 7.59 | -- | 3.80 |
| | Kiln 2 | 5.21 | -- | 2.61 |

a. Uncontrolled emissions and the BART emission limits for the Lhoist Nelson plant kilns are obtained from the "Promulgation of Air Quality Implementation Plans; Arizona; Regional Haze and Interstate Visibility Transport Federal Implementation Plan; Proposed Rule." Federal Register Vol. 79, No. 32 (February 18, 2014). Tables 18 and 19. https://www.govinfo.gov/content/pkg/FR-2014-02-18/html/2014-02714.htm

b. Actual emissions are based on the 2014 annual emission inventory submitted by Graymont.

c. Note that Cricket Mountain does not have a permit limit on a lb $NO_X$ per ton of lime basis for kilns 1-4. These values are calculated solely for the purpose of comparison to cited Lhoist Nelson plant values and should not be construed as representing a permitted limit for the Cricket Mountain facility.

LNA realized this performance disparity in technologies as it too attempted to implement LNB controls at its Nelson Plant before turning to less effective SNCR. Yet, LNA was not able to make LNB work. This is explained in the 2013 Technical Support Document for Arizona's Federal Implementation Plan:

> "In 2001, LNA experimented with the installation of a bluff body LNBs on the Nelson Lime kilns. These LNB's wore out in approximately six months,

impacted production, caused brick damage, and resulted in unscheduled shutdowns for the kilns. We recognize that the staged combustion principle of LNB can present operational difficulties and potential product quality issues for lime production that are not exhibited in the cement industry. At this time, however, we consider LNB to be technically infeasible for the Nelson Plan Cement (lime) kilns, since we do not have any information to suggest otherwise at this time. The technical feasibility of LNB will be re-evaluated for lime kilns in a subsequent reasonable progress planning periods."

The site- and unit-specific feasibility of LNB emission control is supported by Graymont's successful implementation of this technology on the Cricket Mountain lime kilns. Graymont cannot speculate on why bluff body LNB's were unsuccessful at LNA's Nelson plant in 2001, but this failure forced LNA to advocate for use of its much less effective SNCR technology as BART in the Round 1 RH SIP process. Arizona proposed, and EPA approved, LNA's SNCR technology as BART. However, Graymont has demonstrated that bluff body LNBs can be successfully implemented on lime kilns and achieve NOx emission reductions that far exceed what might be achieved with SNCR. Plainly stated, Cricket Mountain's use of LNBs far exceeds what has been deemed to be BART, at least for the LNA Nelson Plant. It would be unreasonable to require Cricket Mountain to go even further in controlling NOx (i.e., beyond BART), especially when there is no evidence that such controls are needed or effective. This assertion is supported by the EPA's BART determination for the Nelson plant, where the Agency concludes that the proposed BART limit *"is consistent with the use of low-$NO_X$ burners (LNB) and SNCR as control technologies"*[3] – indicating the emission limit would be similar for either technology. As demonstrated in the table above, Graymont can achieve actual emission levels on a 12-month basis with LNB technology that are lower than the Lhoist permitted values using SNCR.

Graymont is committed to continuing the use of LNB at Cricket Mountain and achieving the attendant NOx emission reductions in the future. Further reductions from Cricket Mountain are not reasonably necessary or needed to fulfill UDAQ's RH SIP obligations. Indeed, EPA recently approved the District of Columbia RH SIP concluding that it was reasonable for the District to have excluded a source from even undergoing a four-factor analysis where that facility had already installed LNB

[3] Promulgation of Air Quality Implementation Plans; Arizona; Regional Haze and Interstate Visibility Transport Federal Implementation Plan; Proposed Rule. Federal Register Vol. 79, No. 32 (February 18, 2014). Tables 18 and 19. https://www.govinfo.gov/content/pkg/FR-2014-02-18/html/2014-02714.htm

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and was achieving low NOx emission rates. See, 86 Fed. Reg. at 19806 (April 15, 2021).

LNB technology represents a superior level of NOx control at the point of generation as compared SNCR where, in the case of the lime industry, includes unintended negative consequences that would be experienced in the form of condensable particulate formation as a byproduct of SNCR control.

**Additive Efficiency for Cricket Mountain SNCR NOx Control Beyond LNBs would be Marginal at Best**

As discussed above, Graymont has already implemented LNB control at Cricket Mountain, resulting in control efficiency comparable to, or better than, SNCR control efficiencies. As indicated in the four-factor analysis submitted by Graymont for the Cricket Mountain facility the control efficiency achieved by SNCR as a retrofit technology is highly dependent on the inlet $NO_X$ concentration, temperature of reaction zone and residence time.

Even if SNCR could provide some emission reduction for Graymont's Cricket Mountain kilns, the achievable control efficiency is expected to be much lower than the Nelson lime kilns because of Nelson's higher uncontrolled $NO_X$ emission rates. This difference is in large part due to the successful implementation of LNB's on the Cricket Mountain kilns.

While it is difficult to ascertain what the as-built additive removal of SNCR control on top of LNB control might be, we can expect that SNCR control would be poor. From LNA's Apex plant November 2020 4-Factor submission to Nevada Division of Environmental Protection (NDEP):

> *"….this (reported 50% NOx removal efficiency conducted at a different LNA facility) one example of SNCR installation on a preheater rotary lime kiln does not necessarily transfer to other lime kilns. Effectiveness of SNCR is highly source-dependent, with a variety of factors having the potential to heavily influence the quantities of NOx controlled." …."*[4]

And:

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[4]REGIONAL HAZE SECOND PLANNING PERIOD FOUR-FACTOR ANALYSIS, Lhoist North America, Apex Lime Plan, Source 00003, Page 33, Trinity Consultants, March 2020, Revised June 2020, Revised November 2020.

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*"…. 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% at (Apex plant) Kiln 1, 2 and 3 and no more than 50% at Kiln 4, can be guaranteed at the Facility's kilns without testing.*** *Trying to achieve a 50% removal efficiency on Kilns 1, 2 and 3 is more likely to result in ammonia slip which can cause its own health and visibility problems…."*[5]

LNA's acknowledgement that SNCR NOx removal is kiln specific is instructive for any expectation that the Cricket Mountain kilns could achieve greater than 20% NOx removal efficiency. Graymont agrees with LNA on this point.

Graymont does not believe it is rational or reasonable to assume that Cricket Mountain kilns are capable of an additional 50% NOx reduction. Through implementation of LNBs, the Cricket Mountain kilns show an average emission rate of 2.00 lbs of NOx / ton of lime compared to the Nelson Kilns 1 and 2 pre-control average of 6.4 lbs of NOx / ton of lime. The Nelson Kilns generated NOx emissions are more than three times greater than the current LNB emissions in Cricket Mountain. Based on the significantly reduced gas stream NOx concentrations at Cricket Mountain, the SNCR additive removal efficiency would decay making this control less effective. For kilns where LNB technology has already been applied, it is likely that any additive removal efficiency benefit would be marginal at best.

Graymont did not request a vendor guarantee for the Class 4 engineering cost estimate we received from our vendors. Vendor guarantees would be premature at the level of a Class 4 engineering estimate. Additional design and initial feasibility testing would be required to begin to make any estimate about the viability, regardless of the efficiency, of such a novel abatement system. Graymont's vendors are not, at the present time, in any position to make guarantees about removal efficiency at the current conceptual stage of this project.

Moreover, and elaborated upon below, ammonia slip from an SNCR application would result in an unintended, but material, increase in condensable particulate emissions in the form of ammonium nitrate, ammonium sulfate and ammonium chloride salts which would contribute anthropogenic with new additive impacts on visibility pollutants of concern. In this manner, a well-intended NOx abatement

[5] REGIONAL HAZE SECOND PLANNING PERIOD FOUR-FACTOR ANALYSIS, Lhoist North America, Apex Lime Plan, Source 00003, Page 33, Trinity Consultants, March 2020, Revised June 2020, Revised November 2020. Emphasis added.

project would almost certainly result in cost prohibitive, low value installations resulting in impact(s) that are counterproductive to UDAQ's RH program goals.

In summary, Graymont cannot characterize the potential for SNCR NOx reduction at Cricket Mountain beyond 20% because the removal efficiency of the system cannot be estimated or derived. Any vendor guarantee on the removal efficiency of a conceptual system is premature and would mean little at this time, even if a vendor were willing to provide one. Moreover, achieving additive control over and above LNB control with emission intensities three times less than LNA's Nelson Plant ensures that removal efficiencies would be marginal at best.

**SNCR Technology for Rotary Lime Kilns is not Unconditionally Commercially Available to Graymont**

Based upon available information, it appears that the SNCR technology is proprietary to LNA. Graymont conducted a patent search to identify intellectual property owned by LNA and directed toward SNCR on preheater lime kilns. Graymont identified LNA Patent 7,377,773: "Method of Reducing $NO_X$ Emissions in Rotary Preheater Mineral Kilns" from May 27, 2008. While Graymont has not investigated the validity of the patent, nor does Graymont concede the patentability of the SNCR technology, it is likely that the SNCR technology employed by LNA, specifically directed toward preheater lime kilns, is protected by a patent. The reader is directed to Appendix C wherein a discussion of LNA's SNCR patent can be reviewed.

This is consistent with conclusions made by the Illinois Environmental Protection Agency (Illinois EPA) in the Responsiveness Summary for the PSD permit application for Mississippi Lime company in 2015, where the Illinois EPA noted "Lhoist continues to note that the SNCR systems for those kilns may incorporate proprietary technology and equipment and will need to be treated as confidential business information by USEPA."[6]

As stated in the four-factor analysis, 40 CFR Subpart 51 Appendix Y defines availability, a prerequisite for determining whether a technology could be applied for the Regional Haze Rule, stating that "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." Inherent in the determination made

[6] Illinois Environmental Protection Agency Bureau of Air, "Responsiveness Summary for the Public Comment Period on the Issuance of A Construction Permit/PSD Approval for Mississippi Lime Company to Construct a Lime Plant in Prairie du Rocher, Illinois," Page 23. (September 2015). http://www.epa.state.il.us/public-notices/2014/mississippi-lime/responsiveness-summary.pdf

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by the Illinois EPA for PSD-BACT (a program with different and more stringent requirements than the regional haze program) is the conclusion that this technology is not considered unconditionally commercially available.

LNA's existing SNCR patent directed toward preheater lime kilns, if determined to be valid and patentable, could have material implications for Graymont's attached cost analysis. Graymont's current cost analysis does not make any attempt to reconcile potential intellectual property costs that might be associated with a patent license or any royalty payment structure. Were Graymont to make some assessment of those potential costs, the already infeasible costs associated with SNCR at Cricket Mountain would become even more untenable for installation.

Instead of making any attempt to represent what additional costs for intellectual property might look like beyond the costs represented in the cost analysis, Graymont instead provides UDAQ with the following disclaimers:

- Graymont has not investigated the validity of LNA's '773 Patent, nor do we concede the patentability of the LNA SNCR technology,

- It is our belief that LNA will defend its exclusive patent rights if the LNA SNCR technology is implemented by Graymont or at a minimum expect Graymont to take a license to the '773 Patent in order to implement the technology,

- Graymont notes here that project capital and operational costs represented in this letter and its attachments do not attempt to account for any licensing fees or royalties that might apply to this analysis and so estimated costs could be substantially higher than estimated in this letter and its attachments.

As UDAQ ponders its Regional Haze SIP, the agency is encouraged to consider that the implications of LNA's intellectual property holdings as they relate to Utah's Regional Haze initiative are not fully understood at this time by Graymont.

**Updated Cost Calculations and Vendor Estimate**

In order to obtain a more accurate capital and operating cost estimate for the installation of SNCR, Graymont commissioned a Class 4 engineering cost estimate. The Class 4 estimate was performed by an independent third party with a sound engineering approach.

The Class 4 results are provided in Table 2:

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**Table 2: Summary of Cricket Mountain SNCR Costs**[7]

| Kiln | Total Capital Investment | Annual Operating Cost | Total Annual Cost[8] | Tons NOx Reduced[9] | Cost Effectiveness ($/ton of NOx removed) |
|---|---|---|---|---|---|
| 1 | $1,253,169 | $181,511 | $266,806 | 13.7 | $19,519 |
| 2 | $1,253,169 | $236,442 | $321,737 | 22.8 | $14,130 |
| 3 | $1,253,169 | $160,283 | $245,578 | 10.2 | $24,191 |
| 4 | $1,253,169 | $186,881 | $272,176 | 14.6 | $18,695 |
| 5 | 1,898,051 | $667,035 | $796,223 | 70.6 | $11,270 |
| Total | **$6,910,727** | **$1,432,152** | **$1,902,520** | 131.9 | **$17,561** |

Note that Graymont's cost estimate makes no attempt to reconcile any potential intellectual property costs that might be required in the event that Graymont were forced to pursue licensing or royalty fees.

**The Technical Feasibility of SNCR on Preheater Lime Kilns is a Novel Technology Not Proven in Broad Application**

Lime kilns vary considerably in design, so implementation at two facilities does not indicate feasibility for all lime kilns. Particularly in the case of technologies that are not widely used in an industry, where the emission unit in question is as site-specific and unit-specific in its operating parameters and methods as a lime kiln, technical feasibility must be assessed on a unit-by-unit basis. Each kiln has its own design and operating conditions, with variables like temperature, residence time, and physical configuration playing a major role in whether a control technology retrofit is possible and what level of emissions control is achievable.

Graymont has reviewed the design characteristics specific to the kilns installed at the Cricket Mountain facility to determine the temperature and residence time of kiln gas in the transfer chute. The models indicated an average temperature of 1,727 °F and a maximum of 2,100 °F. For residence time, the models indicated that the average residence time of gases in the transfer chute is 0.5 seconds (maximum of 0.6 seconds). Please see Appendix E to review Graymont's temperature and residence

[7] Class 4 engineering cost estimates are detailed in Appendix D.
[8] Total Annual Cost = Annual Operating Cost + Annual cost of capital investment at 3.25% for 20 years
[9] Tons NOx reduced based upon 20% control efficiency.

time calculations. The EPA Air Pollution Control Cost Manual (CCM) cites an ideal temperature range of 1,550 °F to 1,950 °F.

The CCM also states that a residence time of 1 second is required for sources to be considered well-suited for SNCR. With a residence time of half the recommended minimum value provided by the EPA, the concerns expressed in Graymont's four-factor analysis regarding the ability of an SNCR ammonia injection system to achieve sufficient mixing for the conversion of $NO_X$ emissions are substantiated. The short residence time, in conjunction with the high dust loading in the transfer chute, pose substantial technical concerns for the feasibility of SNCR as a $NO_X$ control technology.

**SNCR Addition at Cricket Mountain would have Unintended Negative Repercussions and Generate Condensable Particulate**

As part of the regional haze program UDAQ must also consider the energy and environmental impacts of SCNR and has the flexibility to consider visibility benefits.[10] On this point, condensable particulate emissions from lime kilns occurs when cations and anion species react in the kiln system to create condensable particulate salts. Kiln exhausts are cation-limited as ample anion species are available to form salts. Sulfates, nitrates, and chloride species are present in lime kiln exhaust but do not form condensable particulate species at levels that create non-compliance with condensable particulate emission limits due typically to the relative stochiometric unavailability of a candidate cation species.

The addition of SNCR in lime kilns requires the addition of ammonia or urea to lime kiln exhausts to control NOx emissions.  While addition of reagent in lime kiln exhausts can, in favorable physical configurations with appropriate temperature and residence times, have the effect of abating NOx production, the addition of reagent will also have unintended negative effects.  Over-injection of reagent results in ammonia slip, which produces unintended ammonia emissions, but also contributes to the formation of condensable particulate.  Reactions with sulfates, chlorides and nitrates that were previously cation-limited are no longer cation-limited and robust salt formation of ammonium sulfate, ammonium chloride and ammonium nitrate are promoted.  Even when ammonia slip is limited through monitoring and injectate control, condensable particulate formation will be enhanced in the kiln system.

[10] See, *e.g.,* Responses to Comments on Protection of Visibility: Amendments to Requirements for State Plans; Proposed Rule (81 FR 26942, May 4, 2016), Docket Number EPA–HQ–OAR–2015–0531, U.S. Environmental Protection Agency at 186; August 2019, EPA issued ''Guidance on Regional Haze State Implementation Plans for the Second Implementation Period'' (''2019 Guidance'') at 36–37.

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Generation of additional condensable particulate creates two practical problems relative to this discussion. First, increases of condensable particulate salt formation will have the immediate effect of increasing PM2.5/PM10 emissions from the Cricket Mountain kilns. Condensable particulate emissions from the Cricket Mountain kilns are currently emitted at a rate where Graymont can remain in compliance with PM10 and PM2.5 emission limits. Addition of reagent to the kiln exhaust will remove the cation-limited condition in the kiln exhausts and promote additional condensable salt formation not accounted for in Graymont's current air permit. Graymont anticipates that if SNCR systems are required on Cricket Mountain kilns that the addition of more cation species will require study to characterize condensable salt formation increases and to develop a program to increase the PM10 and PM2.5 emission limits at Cricket Mountain.

A second problem envisioned if SNCR were required at Cricket Mountain would be post control generated sources of ammonium nitrate, ammonium sulfate and ammonium chloride emissions produced as PM10 emissions. SNCR would not benefit visibility at the Class I areas if NOx reductions would simply be replaced by PM10 emissions.[11] It is noteworthy to recall that condensable particulate emissions cannot be controlled by gas stream filtration. Condensable particulate emissions can only be controlled by limiting the availability of condensable particulate salt-forming species in the kiln system – which means avoiding the installation of SNCR.

Another environmental impact associated with retrofitting SNCR on the Cricket Mountain facility would be the addition of ammonia or urea storage and handling systems. Anhydrous ammonia and aqueous ammonia above 20 percent are considered dangerous to human health. SNCR also creates potential safety hazards associated with the transportation of anhydrous ammonia.[12]

If you have any questions or comments about the information presented in this letter, please do not hesitate to call me at 814-353-2106 or Nate Stettler at 801-716-2621.

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[11] NDEP recognized the potential visibility disbenefits of SNCR in previous BART analyses. See, Revised Nevada Division of Environmental Protection BART Determination Review of NV Energy's Tracy Generating Station Units 1, 2 and 3(revised October 15, 2009); Revised Nevada Division of Environmental Protection BART Determination Review of NV Energy's Fort Churchill Generating Station Units 1 and 2 (revised October 15, 2009).

[12] NDEP recognized the potential for ammonia releases in previous BART analyses. *Supra*, fn. 21.

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Sincerely,

John A. Maitland
Director, Corporate Affairs, Environment & Sustainability North America
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Attachments

cc:

Blake Bills, Graymont
Robert Covington, Graymont
Hal Lee, Graymont
Nate Stettler, Graymont

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# Appendix A

Cricket Mountain SNCR Cost Effectiveness Calculations

# Cost Estimate

## Total Capital Investment (TCI)*

| SNCR Capital Costs ($SNCR_{cost}$) | |
|---|---|
| Kiln 1 | $1,253,169 |
| Kiln 2 | $1,253,169 |
| Kiln 3 | $1,253,169 |
| Kiln 4 | $1,253,169 |
| Kiln 5 | $1,898,051 |
| Total SNCR Capital Costs ($SNCR_{cost}$) = | $6,910,727 |

*Based on class 4 engineering cost estimate

## Annual Costs*

| Total Annual Cost (TAC) | |
|---|---|
| TAC = Direct Annual Costs + Indirect Annual Costs | |
| Kiln 1, Kiln 2, Kiln 3, Kiln 4, Kiln 5 Combined | $1,902,520 |

| Direct Annual Costs (DAC) | |
|---|---|
| Kiln 1, Kiln 2, Kiln 3, Kiln 4, Kiln 5 Combined | $1,432,152 |

| Indirect Annual Cost (IDAC) | |
|---|---|
| IDAC = Capital Recovery Costs | |
| Capital Recovery Costs | $470,368 |
| Rate = | 3.25% |
| Years = | 20 |

*Based on class 4 engineering cost estimate

## Cost Effectiveness*

| Cost Effectiveness = Total Annual Cost/ NOx Removed/year | | |
|---|---|---|
| Cost Effectiveness = | $17,561 | per ton of NOx removed |
| | | |
| Total Annual Cost (TAC) = | $1,902,520 | |
| | | |
| Kiln 1 | 19,519.0 | per ton of NOx removed |
| Kiln 2 | 14,130.0 | per ton of NOx removed |
| Kiln 3 | 24,191.0 | per ton of NOx removed |
| Kiln 4 | 18,695.0 | per ton of NOx removed |
| Kiln 5 | 11,270.0 | per ton of NOx removed |

*tons of Nox reduced based on 20% control efficiency

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# Appendix B

# Email from UDAQ Regarding $SO_2$ Analysis

**From:** Jay Baker
**To:** Nate Stettler
**Subject:** Re: Graymont Four Factor Analysis
**Date:** Tuesday, January 7, 2020 9:32:35 AM

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Nate,
That is correct. Your SO2 emissions are so low that they don't warrant a control measure analysis. You just need to perform a four factor analysis for NOx.

Thanks for checking with me on this.

Jay Baker

Environmental Scientist

(801) 536-4015

airquality.utah.gov

On Mon, Jan 6, 2020 at 3:05 PM Nate Stettler <nstettler@graymont.com> wrote:

> Jay,
>
> We have begun working on the four factor analysis for the Cricket Mountain facility and I just wanted to confirm one thing we spoke about when we met in December. You had said that because the SO2 emission were so low at Cricket Mountain that we need only evaluate NOx emissions in the four factor analysis. Would you please confirm this to be correct?
>
> Thanks,
>
> **Nate Stettler, CIH, CSP**
>
> Senior HSE Specialist and Lead Auditor
>
> **GRAYMONT**
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# Appendix C

## LNA SNCR Technology Michael Best Legal Memo

Michael Best

# Memorandum

**VIA EMAIL**

Client Matter: 212321-9001

**To:** Hal Lee, Graymont Western US

**From:** Gayle A. Bush
Todd E. Palmer

**Date:** March 9, 2021

**Subject:** LNA SNCR Technology

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Graymont Western US Inc. (Graymont) owns and operates the Pilot Peak lime kiln facility located near West Wendover, Nevada. The Pilot Peak Facility achieves low NOx emission rates through the utilization of low NOx burner (LNB) technology in its kilns. Nonetheless, the Nevada Division of Environmental Protection (NDEP) has initially selected the Pilot Peak Facility for an analysis of additional NOx emission control measures that might demonstrate reasonable further progress towards achieving Nevada's visibility improvement goals in the State's Round 2 regional haze SIP. Lhoist North America (LNA) has developed SNCR technology for use on lime kilns and has installed the technology at five facilities. NDEP has suggested that the Pilot Peak Facility also utilize the LNA SNCR technology to further reduce NOx emissions beyond what is already being achieved with LNBs. LNA has informed NDEP that the technology capital costs are approximately $500,000 per kiln to install; however, Graymont believes the costs will be substantially higher.

There is not much information available regarding the LNA SNCR technology or whether LNA has sought or received patents for its technology. Graymont asked Michael Best to conduct a patent search to determine whether LNA has any patents or patent applications for its SNCR technology, and to learn more about the SNCR technology it is pushing regulators to require. In summary, we identified one granted patent that is owned by LNA and is related to use of SNCR technology for NOx emission reduction in a rotary preheater mineral kiln.

We conducted a patent search to identify any US patents or patent applications 1) owned by LNA, or its related companies, and 2) related to SNCR technology. The search yielded about 58 active and 69 expired/abandoned patents/applications for LNA and its related companies. Based on our understanding of SNCR technology, we analyzed the patent search results and identified U.S. Patent No. 7,377,773 ("the '773 Patent") as the only result relevant to SNCR technology.

The '773 Patent was filed on August 3, 2006 by Chemical Lime Company and granted on May 27, 2008. The '773 Patent will expire on September 8, 2026. Post-grant, Chemical Lime Company changed its name to Lhoist North America, Inc.

Generally speaking, the ‘773 Patent relates to a method for reducing NOx emissions from rotary preheater mineral kilns by coupling the temperature control and gas composition afforded by high temperature mixing systems with the injection of nitrogen containing chemical additives at a predetermined location and within an optimal temperature window. The method is specifically directed to rotary preheater limestone kilns.

The ‘773 Patent includes 9 claims that define its invention, and what LNA has the exclusive right to make, use, sell and offer for sale. Two of the claims are independent (claims 1 and 9), which include the broadest recitation of LNA’s invention, and remaining claims 2-8 depend from claim 1.

The ‘773 Patent claims as its invention a method of reducing NOx emissions in a rotary preheater limestone kiln having a feed zone, a preheat zone, a calcining zone and a cooling and discharge zone. Independent claim 1 requires each of the following elements, or an equivalent thereof:

1. Feeding a supply of limestone to the feed zone;
2. Moving the limestone through the preheat zone having a preheat temperature range resulting from the circulation of hot gases from the calcining zone to the preheat zone, the preheated limestone being passed to an upper end of the calcining zone where the limestone is heated to a temperature and for a time sufficient to convert the limestone to quicklime;
3. Introducing a source of ammonia or an ammonia precursor at a point where the temperature in the kiln is within 1600°F to 2200°F;
4. Injecting turbulent air at a preselected point or points downstream of the preheat zone; and
5. Passing the calcined limestone from the calcining zone to the cooling and discharge zone and discharging the resulting quicklime from the kiln.

Independent claim 9 requires elements 1, 2, 4 and 5 listed above for claim 1, or an equivalent thereof, as well as:

6. Introducing a source of ammonia or an ammonia precursor into the limestone upstream of the primary region of the calcining zone;
7. Introducing the source of ammonia or an ammonia precursor at a point where the kiln temperature is generally in the preheat temperature range from about 1600°F to 2200°F.

Because no information is available directly from LNA or NDEP as to what the LNA SNCR technology entails, we are assuming that the LNA SNCR technology mentioned by NDEP is the SNCR technology described and patented by the ‘773 Patent. Therefore, the LNA SNCR technology is not commercially available to Graymont because it is protected by the ‘773 Patent and LNA has the exclusive right to make, use, sell and offer for sale the LNA SNCR technology.

We have not investigated the validity of the ‘773 Patent, nor do we concede the patentability of the LNA SNCR technology. However, because the LNA SNCR technology is patented, it is our belief that LNA will defend its exclusive patent rights if the LNA SNCR technology is implemented by Graymont or at a minimum expect Graymont to take a license to the ‘773 Patent in order to implement the LNA SNCR technology.

If Graymont is required to implement the LNA SNCR technology, it will likely need to do so subject to a license from LNA to the ‘773 Patent as the LNA SNCR technology is not commercially available without a patent license. Any license will likely be subject to a license fee, which will incur additional costs associated with an implementation of the LNA SNCR technology at the Pilot Peak Facility.

Most patent licenses are subject to one or more of the following types of license fees: an up-front license fee, continuous lump sum license fee payments, and/or rolling royalty fee payments. In our experience, license fees are difficult to predict as average fees and rates are typically industry specific, there is uncertainty and changes in market over the term of the patent, and most importantly licenses are subject to negotiation between the licensor and licensee.

Due to the factors listed above, predicting an up-front license fee or continuous lump sum license fee payment is challenging. Estimating potential license fee costs associated with a royalty fee presents challenges as well; however, there are for-fee services available that will provide average royalty rate information on an industry-by-industry basis, as well as by deal-type. These resources can be used as a starting point for estimation purposes.

Under a license based on a reasonable royalty, the fee might be based on a production metric associated with the Pilot Peak Facility and the LNA SNCR technology. For example, the royalty could be based on sales revenue of the final product or a production quantity, such as weight of produced quicklime (e.g., price per pound produced). In our experience, royalties for non-exclusive licenses based on net sales are typically 1% to 5% of the net sales. We did identify one article from an on-line legal service provider (Patent Licensing Royalty Rates | UpCounsel 2020) that referenced an average royalty rate for energy and environmental industries as 8% and construction industries as 5.6%; however, this estimate is based on royalties offered by others in comparable industries and does not truly compare similar deals. Based on the above information, we would guess that a royalty for a license to the ‘773 Patent could be in the range that would add significant expense to the cost of installing and operating the LNA SNCR technology – assuming the patent is valid.

In summary, implementing the LNA SNCR technology at the Pilot Peak Facility would incur additional costs associated with the ‘773 Patent that are beyond the estimated $500,000 per kiln capital cost to install. In order to implement the LNA SNCR technology, Graymont would need to negotiate a license with LNA for use of the technology.

GAB:mgd

Attachments

GRAYMONT

# Appendix D

Class 4 Engineering Cost Estimate for Cricket Mountain SNCR Capital and Operating Costs

# Project: Cricket Mountain SNCR Estimate

Budget Class 4
Revised: 2021-08-31
By: Sean Brinkmann

| Description | References | Qty | Unit | Material & Equipment Unit cost | Material & Equipment Cost | Qty | unit | Installation Unit cost | Installation Cost | TOTAL K5 | TOTAL K4 | TOTAL K3 | TOTAL K2 | TOTAL K1 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Penta Project Cost Estimate** | | | | | | | | | | | | | | | |
| Contractor General | | | | | | | | | 76,450 $ | 76,450 $ | 76,290 $ | 76,290 $ | 76,290 $ | 76,290 $ | |
| Construction I Equipment | | | | | | | | | 75,600 $ | 75,600 $ | 75,600 $ | 75,600 $ | 75,600 $ | 75,600 $ | |
| Civil Site Work, Parking Area and Road (Gravel access and parking for offloading delivery truck) | | | | | 6,367 $ | | | | 6,600 $ | 12,967 $ | 12,967 $ | 12,967 $ | 12,967 $ | 12,967 $ | |
| Fire Water Extension Allowance | | 100 | lnFT | | 5,249 $ | | | | 4,143 $ | 9,392 $ | 9,392 $ | 9,392 $ | 9,392 $ | 9,392 $ | |
| Ammonia Tank Piers, Secondary Containment, Roof Structure, and Pump Pad | | | | | 50,952 $ | | | | 45,800 $ | 96,752 $ | 60,051 $ | 60,051 $ | 60,051 $ | 60,051 $ | only one pump skid, with Kiln 5 |
| Fencing | | | | | 16,000 $ | | | | 4,600 $ | 20,600 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Ammonia Tank and Pump, Meter Systems | | 20000 | gal | | 284,600 $ | | | | 39,080 $ | 323,680 $ | 305,170 $ | 305,170 $ | 305,170 $ | 305,170 $ | |
| Refractory Repair Inside Kiln | Not Included | | | | | | | | | not included | not included | not included | not included | not included | assumed to be with other Kiln repair costs |
| Pipe 2" dia. from Truck Unload to Storage Tank | | 50 | lnFT | | 3,152 $ | | | | 2,750 $ | 5,902 $ | 5,202 $ | 5,202 $ | 5,202 $ | 5,202 $ | |
| Pipe 2" dia from Tank to Preheater Transfer Pumps | | 50 | lnFT | | 5,498 $ | | | | 3,410 $ | 8,908 $ | 8,908 $ | 8,908 $ | 8,908 $ | 8,908 $ | |
| Pipe 1.5" dia. from Pumps to Preheater | | 550 | lnFT | | 24,719 $ | | | | 18,904 $ | 43,623 $ | 42,900 $ | 42,900 $ | 42,900 $ | 42,900 $ | |
| Pipe 2" dia Up Preheater to Injection | | 100 | lnFT | | 3,876 $ | | | | 3,777 $ | 7,653 $ | 6,448 $ | 6,448 $ | 6,448 $ | 6,448 $ | |
| Compressed Air Tap, Piping, Receiver and Water Duel Basket Strainer, Water Pipe | | 200 | lnFT | | 31,851 $ | | | | 21,933 $ | 53,784 $ | 28,784 $ | 28,784 $ | 28,784 $ | 28,784 $ | |
| Install Injection Nozzles in Chute Below Preheater | | 4 | ea. | | 5,197 $ | | | | 7,847 $ | 13,043 $ | 13,043 $ | 13,043 $ | 13,043 $ | 13,043 $ | |
| Electrical | | 1 | lot | | 63,383 $ | | | | 63,382 $ | 126,765 $ | 92,482 $ | 92,482 $ | 92,482 $ | 92,482 $ | Kiln 5 has truck unload pumps |
| Controls | By Andritz | | | | | | hrs. | 0 $ | | By Andritz | By Andritz | By Andritz | By Andritz | By Andritz | |
| HAZOP Senior Engineer Participation | | | | | | | | | 12,000 $ | 12,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| **TOTAL FOR Penta Base Estimate** | | | | | | | | | | **887,120 $** | **737,236 $** | **737,236 $** | **737,236 $** | **737,236 $** | |
| **Penta Indirect Cost Estimate** | | | | | | | | | | | | | | | Contingency carried on total project, not specific segments to not compound contingency |
| Taxes | | | | | | | | | | not included | not included | not included | not included | not included | |
| Freight | 5% | | | | | | | | 16,184 $ | 16,184 $ | 16,184 $ | 16,184 $ | 16,184 $ | 16,184 $ | |
| Permits | | | | | | | | | 35,000 $ | 35,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Geotechnical | | | | | | | | | 10,000 $ | 10,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Surveys / Scans | | | | | | | | | 20,000 $ | 20,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Contractor Support During Commission | | 1 | | | | | | | 31,020 $ | 31,020 $ | 31,020 $ | 31,020 $ | 31,020 $ | 31,020 $ | |
| NDT Pipe Inspection | | | | | | | | | 10,000 $ | 10,000 $ | 10,000 | 10,000 | 10,000 | 10,000 | |
| Engineering | 15% | | | | | | | | | 133,068 $ | 66,534 $ | 66,534 $ | 66,534 $ | 66,534 $ | |
| Contractor Overhead and Profit | 10% | | | | | | | | | 114,239 $ | 86,097 $ | 86,097 $ | 86,097 $ | 86,097 $ | |
| **TOTAL Penta Indirect Cost Estimate** | | | | | | | | | | **369,511 $** | **209,835 $** | **209,835 $** | **209,835 $** | **209,835 $** | |
| **Andritz Automation Controls Estimate** | | | | | | | | | | | | | | | |
| PLC Equipment | | | | | | | | | 58,333 $ | 11,667 $ | 11,667 $ | 11,667 $ | 11,667 $ | 11,667 $ | |
| Instruments | | | | | | | | | 15,167 $ | 3,033 $ | 3,033 $ | 3,033 $ | 3,033 $ | 3,033 $ | |
| MCC | | | | | | | | | 39,833 $ | 7,967 $ | 7,967 $ | 7,967 $ | 7,967 $ | 7,967 $ | |
| Detailed Design & Programming | | | | | | | | | 90,667 $ | 18,133 $ | 18,133 $ | 18,133 $ | 18,133 $ | 18,133 $ | |
| Site Services and Expenses | | | | | | | | | 56,167 $ | 11,233 $ | 11,233 $ | 11,233 $ | 11,233 $ | 11,233 $ | |
| Burner management system (BMS) programing - ammonia sensors | | | | | | | | | 30,000 $ | 30,000 $ | 30,000 $ | 30,000 $ | 30,000 $ | 30,000 $ | |
| HAZOP Senior Engineer | | | | | | | | | 12,000 $ | 12,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| **TOTAL FOR Controls Estimate** | | | | | | | | | | **94,033 $** | **82,033 $** | **82,033 $** | **82,033 $** | **82,033 $** | |
| **Penta Excluded Equipment** | | | | | | | | | | | | | | | |
| Air Compressor, Dryer & Receivers | | 1 | lot | 80,176 $ | 80,176 $ | 60 | hrs. | 55 $ | 3,300 $ | 83,476 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Contractor Overhead and Profit | 10% | | | | | | | | | 8,348 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| HAZOP Facilitator | | | | | | | | | 15,000 $ | 15,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| HAZOP (Ammonia Safety Training Institute) | | | | | | | | | 12,000 $ | 12,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Emergency response equipment (level B suits: SCBA, mask, suit, gloves) | | 6 | set | 6,000 $ | 36,000 $ | | | | | 36,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Develop ammonia safety program - consultant | | | | | | | | | 10,000 $ | 10,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Develop ammonia safety program - Graymont | | | | | | 40 | hrs | 100 $ | 4,000 $ | 4,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | HSE manager |
| Develop respiratory protection program | | | | | | 60 | hrs | 100 $ | 6,000 $ | 6,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | HSE manager |
| Area ammonia sensors | | | | | | | | | 20,000 $ | 20,000 $ | 20,000 $ | 20,000 $ | 20,000 $ | 20,000 $ | |
| BMS ammonia sensors | | | | | | | | | 20,000 $ | 20,000 $ | 20,000 $ | 20,000 $ | 20,000 $ | 20,000 $ | |
| **TOTAL FOR Penta Excluded Equipment** | | | | | | | | | | **91,824 $** | **0 $** | **0 $** | **0 $** | **0 $** | |
| **CEMS** | | | | | | | | | | | | | | | |
| Project Management and Administration | | | | | | 1 | lot | 20,000 $ | 20,000 $ | 20,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| **- Equipment & Install** | | | | | | | | | | | | | | | |
| Thermo 42iQ NOx analyzers | CEMS Solutions Quote | 1 | ea. | 15,140 $ | 15,140 $ | | | | | 15,140 $ | 15,140 $ | 15,140 $ | 15,140 $ | 15,140 $ | |
| CEMS Provider Start-up, training, and Administration | CEMS Solutions Quote | | | | | 1 | lot | 14,573 $ | 14,573 $ | 14,573 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Unisearch Dual Range NH3 TDL, integrate into exiting CEMS | MSI Quote | 1 | ea. | 90,000 $ | 90,000 $ | | | | | 90,000 $ | 90,000 $ | 90,000 $ | 90,000 $ | 90,000 $ | |
| CEMLink DAS programming and configuration NH3 | VIM Budget Quote | | | | | 1 | lot | 10,500 $ | 10,500 $ | 10,500 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| NH3 TDL Installation | | | | | | 1 | ea. | 5,000 $ | 5,000 $ | 5,000 $ | 5,000 $ | 5,000 $ | 5,000 $ | 5,000 $ | |
| **- Commissioning & CEMS Certification Costs** | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mobilization and one week FTIR shakedown testing to assess injection lance placement, NOX and NH3 measurement performance etc. | Eric Ehlers, Mostardi Platt communication | | | | | 1 | lot | 33,000 $ | 33,000 $ | 33,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Laura Kinner Ph. D. oversight and review of shakedown and RATA FTIR testing of FTIR | | | | | | 1 | lot | 5,000 $ | 5,000 $ | 5,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Incremental cost for NOx and NH3 RATA testing for five kilns if performed during annual compliance test | Eric Ehlers, Mostardi Platt communication | | | | | 1 | lot | 10,000 $ | 10,000 $ | 10,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| MSI on-site for RATA test | | | | | | 1 | lot | 8,000 $ | 8,000 $ | 8,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Graymont time for training in O&M, technical requirements, and reporting recordkeeping | 16 hours technician, 16 hours Envr. Management | | | | | 32 | hr. | 88 $ | 2,800 $ | 2,800 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Graymont time for 7-day calibration drift tests and calibration error tests for certification and reporting for five kilns | 24 hours technician, 12 hours Envr. Management | | | | | 36 | hr. | 83 $ | 3,000 $ | 3,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Update QA manual for NOx and NH3 additions (does not include technical procedures or corrective action to be provided by MSI) | VIM Budget Quote | | | | | 1 | lot | 1,000 $ | 1,000 $ | 1,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Corrective action and technical procedures for NH3 monitors | | | | | | 1 | lot | 5,000 $ | 5,000 $ | 5,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| **- Condensable Particulate Issues** | | | | | | | | | | | | | | | |
| Diagnostic testing to determine effects of SNCR reagent injection on formation of condensable PM. Test two kilns at three conditions each: (injection off, low injection, high injection). Two test crews for three test days with mobilization and reporting | Eric Ehlers, Mostardi Platt communication | | | | | 1 | lot | 40,000 $ | 40,000 $ | 40,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Review and analysis of data, and EMI theoretical calculations. Graymont negotiation of Condensable PM permit limit. | | | | | | 1 | lot | 20,000 $ | 20,000 $ | 20,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| **TOTAL FOR CEMS** | | | | | | | | | | **283,013 $** | **110,140 $** | **110,140 $** | **110,140 $** | **110,140 $** | |
| **Sub-Total** | | | | | | | | | | **1,725,501 $** | **1,139,245 $** | **1,139,245 $** | **1,139,245 $** | **1,139,245 $** | |
| Contingency | | | | | | 10% | | | | 172,550 $ | 113,924 $ | 113,924 $ | 113,924 $ | 113,924 $ | |
| **TOTAL =** | | | | | | | | | | **1,898,051 $** | **1,253,169 $** | **1,253,169 $** | **1,253,169 $** | **1,253,169 $** | |

| | |
|---|---|
| All Five Kilns Before Contingency | 6,282,479 $ |
| Contingency Total | 628,248 $ |
| **Grand Total** | **6,910,727 $** |

## Annual Operating Costs

| Description | References | Qty | Unit | Material / Vendor | | Qty | unit | Plant Labor/Staff | | TOTAL K5 | TOTAL K4 | TOTAL K3 | TOTAL K2 | TOTAL K1 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Unit cost | Cost | | | Unit cost | Cost | | | | | | |
| Delivered Ammonia (6000 gal Truck) K5 | Airgas Quote | 46 | Trucks | 8,403 $ | 387,635 $ | | | | | 387,635 $ | | | | | |
| Delivered Ammonia (6000 gal Truck) K4 | Airgas Quote | 10 | Trucks | 8,403 $ | 79,881 $ | | | | | | 79,881 $ | | | | |
| Delivered Ammonia (6000 gal Truck) K3 | Airgas Quote | 7 | Trucks | 8,403 $ | 55,701 $ | | | | | | | 55,701 $ | | | |
| Delivered Ammonia (6000 gal Truck) K2 | Airgas Quote | 15 | Trucks | 8,403 $ | 124,936 $ | | | | | | | | 124,936 $ | | |
| Delivered Ammonia (6000 gal Truck) K1 | Airgas Quote | 9 | Trucks | 8,403 $ | 74,999 $ | | | | | | | | | 74,999 $ | |
| Pump & valve rebuilds and maintenance | | 1 | ea. | 1,500 $ | 1,500 $ | 20 | hr. | 75 $ | 1,500 $ | 6,000 $ | 3,000 $ | 3,000 $ | 3,000 $ | 3,000 $ | 20hrs/pump skid (1 injection/Kiln & 1 transfer pump skid w/ K5) |
| Daily Inspection Ammonia Tank & Pump skids | | | | | | 182 | hr. | 75 $ | 13,650 $ | 13,650 $ | 13,650 $ | 13,650 $ | 13,650 $ | 13,650 $ | 30 minutes per day x 7 days per week of Kiln attendant |
| Containment cleanout allowance | | | | | 10,000 $ | 8 | hr. | 75 $ | 600 $ | 10,600 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Compressor and Dryer Maintenace | | | | | 4,000 $ | 16 | hr. | 75 $ | 1,200 $ | 5,200 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Tank Testing | | | | | 3,000 $ | | | | | 3,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Nozzle maintenance | | | | | 1,000 $ | 16 | hr. | 75 $ | 1,200 $ | 2,200 $ | 2,200 $ | 2,200 $ | 2,200 $ | 2,200 $ | |
| Power Consumption - Compressor - 50HP | | 3E+05 | KW | 0.06 $ | 20,490 $ | | | | | 4,098 $ | 4,098 $ | 4,098 $ | 4,098 $ | 4,098 $ | Assumes operating 90% of the year |
| Power Consumption - Injection Pumps (10 HP ea) | | 63242 | KW | 0.06 $ | 4,098 $ | | | | | 4,098 $ | 4,098 $ | 4,098 $ | 4,098 $ | 4,098 $ | Assumes operating 90% of the year |
| Power Consumption - Blowers (10 HP ea) | | 63242 | KW | 0.06 $ | 4,098 $ | | | | | 4,098 $ | 4,098 $ | 4,098 $ | 4,098 $ | 4,098 $ | Assumes operating 90% of the year |
| **Ammonia Safety Program** | | | | | | | | | | | | | | | |
| Annual 24 hour emergency response training training | | | | | 30,000 $ | 600 | hr | 75 $ | 45,000 $ | 75,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Annual 1 hr awarness training | | | | | 3,000 $ | 70 | hr | 75 $ | 5,250 $ | 8,250 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Replacemnts of SCBA tanks, masks, chem suits, gloves | | | | | 10,000 $ | | | | | 10,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| SCBA annual inspections/3 year hydristatic testing | | | | | 4,000 $ | | | | | 4,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Annula fit testing, PFT, medical clearance exams | | | | | 4,000 $ | 16 | hr | 75 $ | 1,200 $ | 5,200 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | |
| Maintain area ammonia sensors (bump test, calibrate, replace) | | | | | 5,000 $ | 50 | hr | 75 $ | 3,750 $ | 8,750 $ | 8,750 $ | 8,750 $ | 8,750 $ | 8,750 $ | |
| Maintain kiln BMS ammonia sensors (bump test, calibrate, replace sensors) maintain comunication system | | | | | 5,000 $ | 50 | hr | 75 $ | 3,750 $ | 8,750 $ | 8,750 $ | 8,750 $ | 8,750 $ | 8,750 $ | |
| Maintain Ammonia safety program/respiratory protection program | | | | | | 20 | hr | 100 $ | 2,000 $ | 2,000 $ | with Kiln 5 | with Kiln 5 | with Kiln 5 | with Kiln 5 | HSE manager |
| **- On-going Annual Costs for O&M Reporting and Recordkeeping** | | | | | | | | | | | | | | | |
| Annual calibration gases SO2/NOx blends and NH3 audit gases plus Graymont management | | | | | | | | | 2,500 $ | 2,500 $ | | | | | |
| Daily cal drift check review and brief inspection | | | | | | 87 | hr. | 75 $ | 6,500 $ | 6,500 $ | 6,500 $ | 6,500 $ | 6,500 $ | 6,500 $ | 20 minutes per day per kiln x 5 days per week of technician time |
| Preventive maintenance and corrective action | | | | | | 48 | hr. | 75 $ | 3,600 $ | 3,600 $ | 3,600 $ | 3,600 $ | 3,600 $ | 3,600 $ | 4 hrs. per month per kilns x 12 months of technician time |
| Monthly data review & reports to management re NOx emissions, NH3 slip, CEMS availability | | | | | | 36 | hr. | 100 $ | 3,600 $ | 3,600 $ | 3,600 $ | 3,600 $ | 3,600 $ | 3,600 $ | 3 hours per month per kiln x 12 months of Envr. Management time |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quarterly NH3 cylinder gas audits, laser alignment, and preventive maintenance by MSI (2 days on-site plus travel expenses) with Graymont technician support | | 4 | qtr. | 8,000 $ | 32,000 $ | 64 | hr. | 75 $ | 4,800 $ | 12,267 $ | 12,267 $ | 12,267 $ | 12,267 $ | 12,267 $ | MSI communication (assume $8000 per quarter) plus 16 hours Graymont technician time. (Assumed Cost divided equally, and scaled up for two additional kilns) |
| VIM DAS incremental annual maintenance cost | Vim Budget quote | 1 | lot | 500 $ | 500 $ | | | | | 500 $ | 500 $ | 500 $ | 500 $ | 500 $ | |
| Mobilization and one week annual FTIR RATA testing for NOx and NH3 CEMS for five kilns | | 1 | lot | 55,000 $ | 55,000 $ | 83 | hr. | 90 $ | 7,500 $ | 12,500 $ | 12,500 $ | 12,500 $ | 12,500 $ | 12,500 $ | Eric Ehlers Mostardi Platt communication plus 20 hours technician support and 30 hours Envr. Management coordination, report review and submission (Assumed Cost divided equally, and scaled up for two additional kilns) |
| Semi-Annual reporting of regulatory NOx monitoring results, QA results, CEMS downtime | | | | | | 12 | hr. | 100 $ | 1,200 $ | 1,200 $ | 1,200 $ | 1,200 $ | 1,200 $ | 1,200 $ | 6 hours per kiln per report of Envr. Management time |
| Semi-Annual reporting of regulatory NH3 monitoring results, QA results, CEMS downtime if regulatory monitor | | | | | | 12 | hr. | 100 $ | 1,200 $ | 1,200 $ | 1,200 $ | 1,200 $ | 1,200 $ | 1,200 $ | 6 hours per kiln per report of Envr. Management time |
| **TOTAL FOR COAL HANDLING** | | | | | | | | | | **606,396 $** | **169,892 $** | **145,712 $** | **214,947 $** | **165,010 $** | |
| **Sub-Total** | | | | | | | | | | **606,396 $** | **169,892 $** | **145,712 $** | **214,947 $** | **165,010 $** | |
| Contingency | | | | | | 10% | | | | 60,640 $ | 16,989 $ | 14,571 $ | 21,495 $ | 16,501 $ | |
| **TOTAL =** | | | | | | | | | | **667,035 $** | **186,881 $** | **160,283 $** | **236,442 $** | **181,511 $** | |

| | |
|---|---|
| All Five Kilns Before Contingency | 1,301,956 $ |
| Contingency Total | 130,196 $ |
| **Grand Total** | **1,432,152 $** |

| Description | References | Qty | Unit | Material / Vendor | | Qty | unit | Plant Labor/Staff | | TOTAL K5 | TOTAL K4 | TOTAL K3 | TOTAL K2 | TOTAL K1 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Unit cost | Cost | | | Unit cost | Cost | | | | | | |
| Capital over 20 Year Loan | DAQ Response | 20 | Years | | 3.25% | | | | | 129,188 $ | 85,295 $ | 85,295 $ | 85,295 $ | 85,295 $ | Per Year |
| Operational Cost annually | | | | | | | | | | 667,035 $ | 186,881 $ | 160,283 $ | 236,442 $ | 181,511 $ | Per Year |
| **TOTAL Annual Costs** | | | | | | | | | | **796,223 $** | **272,176 $** | **245,578 $** | **321,737 $** | **266,806 $** | |
| NOx Emmissions Reduced | | 20 | % | | | | | | | 70.6 | 14.6 | 10.2 | 22.8 | 13.7 | Tons/Year |
| **TOTAL $/Ton =** | | | | | | | | | | **11,270 $** | **18,695 $** | **24,191 $** | **14,130 $** | **19,519 $** | **$/Ton** |

| | | |
|---|---|---|
| **Average** | **17,561 $** | **$/Ton** |

GRAYMONT

# Appendix E

Graymont Process Engineering Temperature and Residence Time Calculations

## CM TCH Modeling Residence Time and Temperatures

| Summary Avg. TCH Temperatures | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Units | K1 | K2 | K3 | K4 | K5 | Comments |
| Avg. Production Rate | TPD | 339.46 | 360.51 | 441.29 | 689.07 | 1019.74 | Source: Aug 2018 - Aug 2021 ODE Production Data |
| Estimated Gas Vol. Flow Rate | ACFM | 84,695.70 | 81,409.57 | 127,185.39 | 183,227.62 | 256,092.25 | @ kiln feed, 36%CO2 and 1782 F K1, 1537 F K2, 1800 F K3, 1700 F K4, 1800 F K5 |
| Estimated Residence Time | sec | 0.4 | 0.4 | 1.1 | 0.8 | 1.1 | Transfer Chute Nozzle Location-Preheater stone contact |
| Max. Production Rate | TPD | 518.02 | 540.03 | 691.06 | 1205.05 | 1385.00 | Source: Aug 2018 - Aug 2021 ODE Production Data |
| Estimated Gas Vol. Flow Rate | ACFM | 129,247.20 | 121,946.35 | 190,176.27 | 320,428.46 | 334,787.42 | @ kiln feed, 36%CO2 and 1782 F K1, 1537 F K2, 1800 F K3, 1700 F K4, 1800 F K5 |
| Estimated Residence Time | sec | 0.3 | 0.3 | 0.7 | 0.4 | 0.9 | Transfer Chute Nozzle Location-Preheater stone contact |

**Average RT (sec) for Avg. TCH Temp** **0.5**

| Summary Max. TCH Temperatures | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | Units | K1 | K2 | K3 | K4 | K5 | Comments |
| Avg. Production Rate | TPD | 339.46 | 360.51 | 441.29 | 689.07 | 1019.74 | Source: Aug 2018 - Aug 2021 ODE Production Data |
| Estimated Gas Vol. Flow Rate | ACFM | 89,153.36 | 92,131.01 | 130,576.24 | 183,227.62 | 279,215.00 | @ kiln feed, 36%CO2 and 1900 F K1, 1800 F K2, 1970 F K3, 1970 F K4, 2100 F K5 |
| Estimated Residence Time | sec | 0.4 | 0.4 | 1.0 | 0.8 | 1.0 | Transfer Chute Nozzle Location-Preheater stone contact |
| Max. Production Rate | TPD | 518.02 | 540.03 | 691.06 | 1205.05 | 1385.00 | Source: Aug 2018-Aug 2021 ODE Production Data |
| Estimated Gas Vol. Flow Rate | ACFM | 136,049.68 | 138,006.38 | 204,481.56 | 320,428.46 | 379,228.23 | @ kiln feed, 36%CO2 and 1900 F K1, 1800 F K2, 1970 F K3, 1970 F K4, 2100 F K5 |
| Estimated Residence Time | sec | 0.2 | 0.2 | 0.7 | 0.4 | 0.8 | Transfer Chute Nozzle Location-Preheater stone contact |

**Average RT (sec) for Max. TCH Temp** **0.6**