

**COMMONWEALTH OF VIRGINIA**  
**Department of Environmental Quality**

**Intra-Agency Memorandum**

**DATE:** April 22, 2014

**SUBJECT:** Engineering Evaluation of Prevention of Significant Deterioration Permit Application Submitted by Carmeuse Lime & Stone for its Winchester Facility (Registration No. 80504)

**TO:** Amy T. Owens, Director, Valley Regional Office

**FROM:** Kevin Covington, Air Permit Writer Senior, Valley Regional Office  
*KBC*

**AIR PERMIT MANAGER REVIEW:** Janardan R Pandey  
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**I. Executive Summary**

The O-N Minerals (Chemstone) Company, d/b/a Carmeuse Lime & Stone (“Carmeuse”), has proposed to replace the existing rotary lime kiln at its limestone quarry, limestone processing, and lime manufacturing facility located in Clear Brook (Frederick County) with two new state of the art, fuel efficient vertical lime kilns. Carmeuse refers to this facility as the “Winchester facility” (it is located about 6 miles northeast of the City of Winchester), so the Virginia Department of Environmental Quality (DEQ) does as well for consistency. The existing facility is an existing major source under 9 VAC 5 Chapter 80, and Prevention of Significant Deterioration (PSD) permitting is triggered for the proposed kiln replacement due to significant net emission increases in the following pollutants: nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), total particulate matter (PM), particulate matter having an aerodynamic diameter equal to or less than 10 microns (PM-10), particulate matter having an aerodynamic diameter equal to or less than 2.5 microns (PM-2.5), and greenhouse gases (GHG). Although emitted by the proposed new kilns, PSD permitting is not triggered for volatile organic compounds (VOC) or sulfuric acid mist (H<sub>2</sub>SO<sub>4</sub> or SAM).

The following table shows the distances between the facility and all Class I areas that are within 300 kilometers (km):

**Table 1: Distance from Facility to Class I Areas (km)**

<b>Class I Area</b>	<b>Distance from Facility (km)</b>
Shenandoah National Park	41
Dolly Sods Wilderness Area (West Virginia)	113
Otter Creek Wilderness Area (West Virginia)	135
James River Face Wilderness Area	217

PSD regulations provide reviewing authority to Federal Land Managers (FLMs) of Class I areas that may be affected by emissions from the proposed facility. In accordance with Memoranda of Understanding (MOU) between DEQ and the respective FLMs, both the National Park Service (NPS) and the National Forest Service (NFS) are given a 60-day review and comment period once provided notification that the application is considered complete. Within the first 30 days of the review period, the FLMs are asked whether or not they will provide a finding of adverse impact on visibility as a result of the proposed facility. FLMs may comment on any aspect of permit processing, but are specifically charged with protecting Air Quality Related Values (AQRVs) within the Class I areas.

PSD permit review includes a rigorous analysis of Best Available Control Technology (BACT). PSD applicants are required to provide a “top down” analysis of all technically and economically feasible control technologies. The applicant is required to employ the most stringent level of control that cannot be demonstrated to be either technically or economically infeasible. Economic feasibility takes into consideration the cost of controls required at similar recently permitted facilities.

## **II. Introduction and Background**

On February 27, 2012, the Valley Regional Office (VRO) of DEQ received an application dated February 22, 2012, from Carmeuse requesting a PSD permit to construct and operate two new state of the art vertical lime kilns at its Winchester facility. The application was deemed complete by DEQ on November 25, 2013. A description of the various applications submitted by Carmeuse for this project is provided in section II.E. below.

### **A. Site Information**

The Winchester facility is an approximately 670-acre parcel that is located about one mile east of Exit 323 of Interstate 81 in northern Frederick County. It is approximately six miles northeast of the center of the City of Winchester. The facility is currently used for limestone mining, limestone processing, and lime production (although the lime kiln has not operated

since November 2008). The Winchester facility began limestone quarrying operations in 1959 and the existing rotary lime kiln was constructed in 1996.

The Winchester facility currently operates under several DEQ air permitting registration numbers:

- **80504** – includes the existing rotary lime kiln and associated materials handling equipment;
- **80900** – includes the main quarrying operations, including the fine grinding plant and pug mill (permit dated August 11, 2010, as amended May 31, 2011 and November 21, 2013); portable stone processing plant (permit dated August 16, 2004); and a tertiary crushing and processing plant (permit dated February 24, 2005, as amended July 31, 2006);
- **81477** – a portable railcar unloading system (permit dated July 1, 2004); and
- **81485** – a portable aggregate wash plant (permit dated September 4, 2007, as amended May 24, 2010 and November 20, 2013).

The 80504 permit is the only permit that is being modified by this permitting action. However, the existing portable railcar unloading system (registration no. 81477) will be removed as part of this project, so that permit will be rescinded in the near future. Nonetheless, the emissions associated with this equipment were included in the regional emissions inventory for modeling purposes.

In addition, located immediately adjacent to Carmeuse's facility is W-L Construction & Paving's asphalt plant that is permitted under registration number **81027**. This is a drum mix asphalt plant that is rated at 400 tons per hour with a 100 MMBtu/hr aggregate dryer that is permitted to burn coal, recycled used oil, distillate oil, and natural gas. W-L Construction & Paving's asphalt plant is physically contiguous to the Winchester facility; it is located on land owned by Carmeuse; and Carmeuse supplies much of the aggregate to the asphalt plant. However, W-L Construction & Paving is an independent, unrelated corporate entity from Carmeuse, and its operations fall under a different SIC code from Carmeuse's operations.

Within VRO's jurisdiction, in addition to the Winchester facility, Carmeuse also owns and operates a limestone mining and lime production facility in Strasburg, and a limestone crushing facility in Middletown. The Strasburg facility is permitted under registration number **80252**, and it

includes a rotary lime kiln. The Middletown facility is permitted under registration number **80452**. Various portable material processing units are permitted under separate registration numbers and are home-based at one of these two facilities.

The UTM coordinates for the Winchester facility are 751.0 kilometers (km) East and 4,348.8 km North in UTM Zone 17. The two new lime kilns will be located at a base elevation of 625 feet above mean sea level.

There is gently rolling terrain around the proposed site. Three residences are located adjacent to the facility's main entrance on Brucetown Road (VA 672). The nearest school is Stonewall Elementary School, which is located on Martinsburg Pike (US-11), approximately 0.5 kilometers from the site perimeter and about 1.5 kilometers from the proposed vertical kilns. The nearest hospital is located in Winchester, approximately 10 kilometers from the facility. The only other significant air pollution source located within one mile of the facility is the adjacent asphalt plant described above. There are numerous significant sources of air pollution located within and near the City of Winchester.

There is one Class I area within 100 km of the facility – the northern end of the Shenandoah National Park is 41 km south of the facility.

## **B. Site Suitability**

In accordance with Section 10.1-1307 E of the Air Pollution Control Law of Virginia, consideration has been given to the following facts and circumstances relevant to the reasonableness of the activity involved:

1. *The character and degree of injury to, or interference with safety, health, or the reasonable use of property which is caused or threatened to be caused:*

The activities regulated in this permit have been evaluated consistent with 9 VAC 5-50-260 (Best Available Control Technology) and have been determined to meet this standard where applicable. Please see Section IV.D.2 for a description of the BACT standards included in the permit.

The existing facility is classified as a major source under the PSD program because lime plants are a listed source category and the facility has the potential to emit over 100 tons per year (tpy) of criteria pollutants. In accordance with PSD regulations, air quality modeling was conducted to predict the maximum ambient impacts of criteria pollutants emitted by the proposed modifications to the

facility. The preliminary modeling results for CO (1-hour and 8-hour averaging periods) were below applicable modeling significant impact levels (SILs) and well below applicable primary and secondary air quality standards. Accordingly, no further analyses were required for CO. In contrast, the preliminary modeling results for SO<sub>2</sub> (1-hour, 3-hour, 24-hour, and annual averaging periods), NO<sub>2</sub> (1-hour and annual averaging periods), and PM-10 (24-hour and annual averaging periods) all exceeded the applicable SILs. Consequently, a full impact analysis was conducted for each of these pollutants and averaging periods. In addition, a full impact analysis was conducted for PM-2.5 (24-hour and annual averaging periods) because there are no applicable SILs for this pollutant. The full impacts analysis shows that predicted impacts for all pollutants and averaging periods are less than the applicable National Ambient Air Quality Standards (NAAQS). Hence, the project will not cause or contribute to a NAAQS violation. DEQ's analysis of the applicant's Class II modeling is provided in Attachment B.

Carmeuse's facility is located approximately 41 kilometers from the Shenandoah National Park (SNP), which is a protected Class I area. As a result, Carmeuse must demonstrate that emissions from its proposed project will not cause an adverse impact on air quality and air quality related values (AQRVs) within SNP, in addition to any modeling that may be warranted in other areas surrounding the proposed site. Accordingly, Carmeuse, in consultation with DEQ and NPS staff, conducted extensive modeling to evaluate air quality effects within SNP. DEQ's analysis of the applicant's Class I modeling is also provided in Attachment B.

Results of modeling conducted for emissions from the proposed modifications to the facility show compliance with the health-based NAAQS for all pollutants. Furthermore, single source and cumulative modeling analyses indicate that the proposed project will not result in a violation of any PSD increment. Accordingly, approval of the proposed permit is not expected to cause injury to or interference with safety, health, or reasonable use of property.

2. *The social and economic value of the activity involved:*

The proposed new vertical kilns will produce lime 30 to 45 percent more fuel-efficiently than the existing rotary kiln. The vertical kiln design was selected by Carmeuse largely due to its superior fuel efficiency and lower emissions per ton of lime produced, as compared to the traditional rotary kiln that is being replaced. The

installation of a more efficient, less energy-intensive, and less-polluting process will provide social and environmental benefits. Economic benefits will be provided through construction jobs and approximately 25 permanent jobs once the new vertical kilns become operational.

A significant percentage of the lime produced in the proposed kilns is expected to be used for air pollution control purposes (flue gas desulfurization), which will help improve air quality in the Mid-Atlantic region. Other lime product will be used for water treatment, agricultural purposes, and soil stabilization.

3. *The suitability of the activity to the area in which it is located:*

The social and economic value of the proposed project has been evaluated relative to local zoning requirements. The local official has deemed this activity not inconsistent with local ordinances. The signed Local Governing Body Certification Form is included as Attachment A.

4. *The scientific and economic practicality of reducing or eliminating the discharge resulting from the activity:*

The state minor new source review (NSR) and federal PSD permitting programs require consideration of control technology options that account for the scientific and economic practicality for reducing or eliminating emissions. By properly implementing these Regulations through the issuance of the proposed permit, the staff has addressed the scientific and economic practicality of reducing emissions associated with this project.

The permit requires numerous pollution control strategies that will result in reduction of emissions. These include pollution prevention techniques such as use of the inherently fuel efficient vertical kiln design (as compared to the efficiency of the rotary kiln that is being replaced and other traditional rotary designs). Add-on pollution control requirements include a fabric filter baghouse to control PM, PM-10, and PM-2.5 emissions from the lime kilns, and enclosures, fabric filters, wet suppression, and paving to control PM, PM-10, and PM-2.5 emissions from the materials processing and handling activities. The feasibility of obtaining further emission reductions was reviewed through the rigorous “top-down” Best Available Control Technology (BACT) requirements of PSD review. No additional controls were found to be both technically and economically feasible.

## C. Project Summary

Carmeuse's existing facility includes several related but distinct processes: limestone quarrying, limestone processing (which consists of crushing, screening, conveying, and storage), lime manufacturing (although the rotary kiln has not operated since November 2008), and coal preparation and storage. Carmeuse proposes the following significant changes at the facility:

- Removal of the existing rotary lime kiln, with a maximum capacity to produce 20.8 tons/hr of lime, which has not operated since November 2008;
- Installation of two new vertical lime kilns, each with a maximum capacity to produce 22.0 tons/hr of lime;
- Installation of a new natural gas-fired heater for the solid fuel mill;
- Removal of the existing primary crusher and installation of a new primary crusher;
- Replacing truck hauling of kiln feed limestone with a new conveyor system;
- A new lime handling operation to further process lime that is produced offsite and then transported to the site via truck or railcar;
- Removal of certain material handling equipment (some of the existing material handling equipment will not be removed or modified) and installation of new material handling equipment; and
- Removal of the existing emergency generator and installation of one new 200-horsepower (hp) diesel-fired emergency generator.

In a lime kiln, limestone (calcium carbonate, or  $\text{CaCO}_3$ ) is calcined at high temperatures (~1,900 degrees Fahrenheit) to produce lime ( $\text{CaO}$ ) and carbon dioxide ( $\text{CO}_2$ ). The existing rotary kiln is horizontally-oriented (approximately 350 feet long) and produces lime in a continuous process. The proposed kilns are vertically-oriented (approximately 180 feet tall) and will produce lime in a batch process that features a relatively continuous load-in of limestone. The vertical kilns are parallel flow regenerative kilns. Each kiln has two vertical shafts that are connected by a crossover channel. In the "burning shaft", limestone feed, fuel, and hot combustion gases are combined and flow in parallel. At the same time, limestone feed in the "non-burning shaft" is preheated by combustion gases and the lime product cooling air from the "burning shaft". The two shafts cycle between burning and non-burning modes every ten to fifteen minutes.

The new kilns will be designed to accommodate solid fuel (coal and petroleum coke) and gaseous fuel (natural gas).<sup>1</sup> The total permitted emissions from the proposed project, including fuel burning and materials handling emissions, are shown below.

**Table 2. Total Permitted Emissions from the Proposed Project**

Pollutant	Permitted Emissions (tpy)
NO <sub>x</sub>	336.1
CO	478.1
SO <sub>2</sub>	204.5
VOC	26.4
PM	114.6
PM-10	100.5
PM-2.5	57.8
Sulfuric acid mist (SAM)	6.3
GHGs (CO <sub>2</sub> e)	363,861

The following federal regulations apply to the proposed facility:

- PSD permitting regulations for emissions of NO<sub>x</sub>, CO, SO<sub>2</sub>, PM, PM-10, PM-2.5, and GHG, including Best Available Control Technology (BACT) emissions controls.
- Maximum Achievable Control Technology (MACT), 40 CFR 63, Subpart AAAAA (National Emission Standards for Hazardous Air Pollutants for Lime Manufacturing Plants) applies to the two proposed new lime kilns and to the related limestone handling operations.
- New Source Performance Standard (NSPS), 40 CFR 60, Subpart OOO (Nonmetallic Mineral Processing Plants) applies to certain limestone processing and materials handling equipment.
- New Source Performance Standard (NSPS), 40 CFR 60, Subpart III (Stationary Compression Ignition Internal Combustion Engines) applies to the proposed new emergency generator.

<sup>1</sup> The initial application also called for liquid fuel (distillate oil/diesel fuel), but Carmeuse subsequently decided to eliminate liquid fuels.



- Maximum Achievable Control Technology (MACT), 40 CFR 63, Subpart ZZZZ (National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines) applies to the proposed new emergency generator.
- 40 CFR Part 70, Title V Operating Permit Program - An application to modify the facility's existing Title V permit is due within 12 months of the commencing operation under this PSD permit, pursuant to 9 VAC 5-80-80 C.2.

Additionally, the facility is subject to various state minor new source review permitting requirements, including state BACT for the criteria pollutants that do not trigger PSD review (VOC and SAM), and numerous general provisions.

#### **D. Process/Equipment Description**

Carmeuse has proposed installation of the following primary equipment:

- Two vertical parallel flow regenerative lime kilns (LP-VK-1 and LP-VK-2), each with a maximum capacity to produce 22.0 tons of lime per hour.

Carmeuse has proposed installation of the following ancillary equipment:

- One natural gas-fired heater to dry the solid fuel (coal/petcoke) prior to its use in the kilns, rated at 3.5 mmBtu/hr heat input (HR-610);
- One diesel-fired emergency generator, rated at 200 horsepower (EG-2);
- One primary jaw crusher (limestone) (CR-900);
- One secondary roller crusher (limestone) (RC-110);
- One two-stage roll crusher (lime) (RC-545);
- One secondary crusher (lime) (CR-901);
- Five screens (SN-120, -210, -330, -900, and -901);
- One two-deck screen (SN-902);
- Twenty-four belt conveyors (BC-xxx);

- Nine storage bins (LB-332, -334, -900, -901, -902, -903, -904, -905, and -906);
- Two skip hoists (SK-350 and SK-360);
- One screw conveyor (SC-635);
- Two bucket elevators (BE-901 and BE-902);
- Two 2,200 ton lime storage silos (LB-2303 and LB-2304);
- Three loadout spouts (LS-900, -901, and -902);
- One railcar unloader (RU-900); and
- Two pressurized solid fuel bins (DB-1, DB-2).

Carmeuse has proposed to remove the existing rotary lime kiln (LP-RK-1) and various ancillary equipment as described in Table 2-1 of its application.

### **Vertical Lime Kilns**

The two proposed new lime kilns each have the same vertical parallel flow regenerative (PFR) design. Each kiln has two vertical shafts that are connected by a crossover channel. In the “burning shaft”, limestone feed and hot combustion gases flow in parallel. At the same time, limestone feed in the “non-burning shaft” is preheated by combustion gases and the lime product cooling air. The two shafts cycle between burning and non-burning modes every ten to fifteen minutes. Each proposed kiln has a maximum rated capacity of 528 tons of lime production per day (22.0 tons/hr). Both new kilns will be designed to accommodate solid fuel (coal and petroleum coke) and gaseous fuel (natural gas).

The PFR design is an improved and relatively new design for lime kilns. In contrast to a rotary kiln, in a vertical kiln the combustion gases travel in the same direction as the limestone feed and the lime product. The parallel flow results in optimum heating conditions. The hot combustion gasses are in contact with the limestone feed, which is capable of absorbing a large amount of heat, for a longer period of time. A vertical kiln delivers fuel via burning lances, as opposed to standard burners. The burning lances are uniformly spaced throughout the limestone feed. The

lances are completely covered with stone, so there is no large combustion area at the front of the kiln. Instead, the burning of fuel occurs in the voids between the stones. The proposed kilns have 28 individual lances (burners) in each shaft, which reduces the process temperature (as compared to rotary kilns) and spreads the heat uniformly across the shafts.

Vertical kilns have improved thermodynamic characteristics due to the regenerative preheating of the combustion air. Each vertical kiln has two shafts and combustion is cycled between these shafts every ten to fifteen minutes. Limestone feed in the preheating zone of the non-combustion shaft acts as a regenerator: it absorbs heat from the exhaust gases from the combustion shaft, and it also preheats combustion air for the following cycle.<sup>2</sup> Fuel efficiency in a vertical kiln is enhanced (as compared to a rotary kiln) by lower operating temperatures. Although calcination occurs at about 1,900 degrees Fahrenheit, the back end of a rotary kiln reaches 2,000 to 2,200 degrees. In contrast, a vertical kiln does not exceed 1,900 degrees, which results in less fuel consumption.

Moreover, vertical kilns utilize the limestone feed more efficiently. The industry standard for rotary kilns is a 2:1 limestone feed to lime product ratio. In other words, it takes 2 tons of limestone to produce 1 ton of lime in a rotary kiln. Vertical kilns, however, process the limestone more efficiently, so less limestone is needed to produce a given amount of lime. Vertical kilns are generally capable of a 1.8:1.0 limestone to lime ratio. However, to be conservative, Carmeuse has assumed a 1.9:1.0 ratio in its production and emissions calculations. For example, the limestone feed throughput limit in Condition 19 of the permit is derived as follows:

$$\frac{157,000 \text{ ton lime}}{\text{year-kiln}} \times 2 \text{ kilns} \times \frac{1.9 \text{ ton limestone}}{1.0 \text{ ton lime}} = 596,600 \text{ ton limestone}$$

Combustion and cooling air is metered into the kiln in precise amounts with positive displacement blowers. Limestone feed and fuel are metered into the kiln in precise amounts through weigh

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<sup>2</sup> By way of contrast, conventional rotary lime kilns are counter-flow systems. The combustion gases and the product travel in opposite directions. Fuel is introduced into a rotary kiln via a single large high temperature burner in a combustion chamber over the finished product. A rotary kiln acts as a large, open combustion chamber. Only about 10% of its volume contains limestone feed and lime product; the balance remains open for the combustion of the fuel.

vessels. A computer controls all of the inputs into each combustion cycle. The amount of combustion air can be controlled by the operator to adjust the flame length within the bed of limestone feed.

### **Limestone Processing and Handling**

The existing facility includes an open pit limestone quarry and associated equipment, such as rock crushers, conveyors, screens, and limestone stockpiles. The existing primary crusher will be replaced by a new primary jaw crusher with a larger capacity of approximately 5,000,000 tpy.<sup>3</sup> Certain other equipment will be upgraded to modernize the quarrying and materials handling processes that will support the two new vertical lime kilns.

### **Lime Handling**

The existing facility includes lime handling equipment that serves the existing rotary lime kiln. Additional lime processing and loading equipment will be added because the two new vertical kilns can produce different grades of lime.

Carmeuse is also seeking authorization to implement an additional lime handling process. This process will enable the facility to receive via truck or railcar lime that is produced offsite, and then to further process the lime to meet specific customer needs. This process has two purposes: it will enable Carmeuse to sell lime before the new vertical kilns become operational, and it will allow the facility to continue selling lime whenever one or both kilns are offline. This additional lime handling process involves the installation of the following additional equipment:

- Two bucket elevators (BE-901 and BE-902);
- One 2-deck screen (SN-902);
- One secondary crusher (CR-900);
- One belt conveyor (BC-914);
- One 120-ton loadout weigh bin (LB-904);
- One loadout spout (LS-901);
- One truck dump hopper (HOP-900);
- One railcar unloader (RU-900); and

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<sup>3</sup> 950,000 tpy of this capacity will be used in the lime kilns or processed on related equipment (per Condition 42 of the permit). The remainder of this capacity is addressed in the permit for the aggregate plant, which is under Registration Number 80900.

- Three additional dust collectors (DC-900, -901, and -902).

Fabric filters will control particulate matter emissions from this new process. The lime throughput limit in Condition 71 of the permit of 471,000 tpy reflects the production limit for both kilns (314,000 tpy) and an additional 157,000 tpy of lime that could be brought in from offsite and further processed on this equipment.

### **Solid Fuel Handling**

The existing facility uses coal as a fuel for the existing rotary kiln. Most of the existing coal handling equipment will remain in place. New storage bins and associated equipment will be added to allow the facility to also use petroleum coke (petcoke) as a solid fuel for the two new vertical kilns. A new natural gas-fired, 3.5 MMBtu/hr solid fuel heater will be added to the solid fuel milling process. The two proposed vertical lime kilns are the only equipment at the facility that will use solid fuel.

### **Diesel-Fired Emergency Generator**

Carmeuse proposes to remove the facility's existing 150-hp diesel-fired emergency generator and replace it with one new 200-hp diesel-fired emergency generator. The Company is requesting authorization to operate the emergency generator for up to 500 hours per year. The emergency generator will operate ancillary equipment to maintain the safety of personnel and process equipment. The proposed diesel-fired generator was manufactured pursuant to NSPS Subpart IIII for Stationary Compression Ignition Internal Combustion Engines for the 2013 manufacturing year.

## **E. Permitting Timeline**

A pre-application meeting was held at VRO on February 16, 2012. NPS representatives participated in this meeting by telephone. Carmeuse's application for the PSD permit is dated February 22, 2012, and was received by VRO on February 27, 2012. DEQ's Initial Letter of Determination (ILOD), which provides DEQ's initial review of the application, was sent to Carmeuse on March 28, 2012. Carmeuse's response to DEQ's ILOD is dated May 25, 2012, and was received by VRO on May 29, 2012.

Carmeuse submitted an amended application dated July 31, 2012, that presented alternative operating scenarios for limestone crushing and lime crushing that the Company wanted permitted. By the fall, Carmeuse had

refined its plans and determined which of the alternative operating scenarios it wanted permitted. Consequently, Carmeuse submitted a revised comprehensive application dated October 12, 2012, that was received by DEQ on October 22, 2012. However, the October 2012 application included a “base case” for lime handling operations and an “alternative operating scenario” that allowed for the delivery of lime to the facility by truck and railcar. Another face-to-face meeting was held at DEQ on November 6, 2012, to discuss the application processing timeline (including the required public notices and meetings) and various substantive issues.

The following spring, the company further refined its engineering for this project and decided to use a different manufacturer for the vertical lime kilns, which resulted in enough changes (including a reduction from three emergency generators to two) to warrant the submission of another revised, comprehensive application. Carmeuse’s application dated May 13, 2013 was received by DEQ on that same day. This application did not include any alternative scenarios, and the company seeks authorization for delivery of lime via truck and railcar as part of this project.

Subsequently, the project experienced further refinement, including the removal of certain materials handling emission points (for example, one conveyor was moved underground, and the number of coke bins was reduced from four to two) and the reduction in emergency generators from two to one. Moreover, after submission of its May 13, 2013 application, the company had submitted amendment and supplemental information about ten times, resulting from refinements to the modeling protocols for PM-2.5, and additional information was still required. For these reasons, DEQ and Carmeuse agreed that another comprehensive revised application would be appropriate. This application is dated July 26, 2013, and was received by DEQ on August 1, 2013. Another meeting was held between Carmeuse and DEQ, including management from both parties, on July 26, 2013 to discuss the permitting timeline, including the required public participation activities and FLM involvement.

At that meeting, Carmeuse accepted that the permit could not be issued by November 26, 2013, due to the extensive public participation requirements for PSD permits. Consequently, the project would not net out of PSD review for sulfur dioxide (this is discussed in more detail in section IV.A below). Therefore, sulfur dioxide needed to be added to the Class II and Class I modeling, and a top-down BACT analysis was required for sulfur dioxide. Because of these additions and other changes to the application, Carmeuse submitted another revised comprehensive application dated September 24, 2013. This is the official application of record for this permit. All of the earlier applications described above have been

superseded by the September 24, 2013 application, and are no longer relevant to this permit.

All amendment and supplemental information that had been submitted previously to DEQ has been incorporated into each subsequent revised comprehensive application, so those previous submissions do not need to be separately identified. The application was deemed complete on November 25, 2013, upon submission of the final Class II modeling report, which included sulfur dioxide (the final Class I modeling report was received earlier).

This project has evolved significantly during the permitting process, as reflected in the various applications that have been submitted. This project has experienced numerous design changes, including two different manufacturers for the vertical kilns; numerous changes in the materials handling equipment; and a reduction in the number of emergency generators from three to two, and then to just one.

Numerous additional meetings were held throughout the permitting process, usually involving Carmeuse's environmental manager and DEQ's air permitting staff and/or air permit manager.

Carmeuse's Class II modeling protocol was received by DEQ's Office of Air Quality Assessments (AQA) on May 2, 2012. The AQA approved Carmeuse's Class II modeling protocol in January 2013. Carmeuse's Class I modeling protocol was received by AQA on February 19, 2013, and the AQA approved it that same month. Representatives of the FLM for the Shenandoah National Park participated in the review of the Class I modeling protocol. Carmeuse's preliminary Class II modeling results were received by AQA on July 23, 2013, and the final Class II modeling report was received by AQA on November 25, 2013. Carmeuse's preliminary Class I modeling results were received by DEQ on July 26, 2013, and the final Class I modeling report was received by DEQ on September 25, 2013. The AQA approved all of the modeling in its "Technical Review..." memorandum dated December 10, 2013 (which is included as Attachment B).

Carmeuse intends to commence construction on the proposed project immediately upon issuance of the PSD permit. The kilns will be constructed sequentially instead of concurrently, and commercial operation of the first new vertical lime kiln is expected to begin in approximately September 2015.

### III. Emissions Calculations

#### A. Criteria Pollutants

Emissions from the project will be from the two proposed vertical lime kilns, other fuel burning equipment (the solid fuel dryer and the diesel emergency generator), and the materials processing and handling activities. Emissions from the materials processing and handling activities – the primary crusher, screens, conveyors, etc. – are limited to the various particulate matter emissions (total PM, PM-10, and PM-2.5) because all materials processing and handling equipment is powered by electricity from the grid (as opposed to being powered by integrated engines). Emissions from the vertical lime kilns consist of products of combustion and CO<sub>2</sub> emissions resulting from the calcination process. Table 3 below provides the maximum hourly and annual emissions from the kilns. Emissions calculations conducted by Carmeuse, and verified by DEQ, are included in Attachment C.<sup>4</sup>

**Table 3: PTE for the Lime Kilns**

Pollutant	Each Kiln <sup>1</sup>		Total for Both Kilns	
	lb/hr	tpy	lb/hr	tpy <sup>2</sup>
NO <sub>x</sub>	46.95	167.52	93.9	335.0
CO	66.0	238.26	132.0	476.5
SO <sub>2</sub>	28.6	102.18	57.2	204.4
VOC	3.6	13.00	7.1	26.0
PM/PM-10	7.2	25.87	14.3	51.7
PM-2.5	5.6	20.15	11.2	40.3
H <sub>2</sub> SO <sub>4</sub>	0.9	3.16	1.8	6.3
GHG (CO <sub>2</sub> e) <sup>3</sup>	50,727	181,005	101,455	362,010

- 1 Values are taken from Table B.4-2 in the application, which assumes 357 days of operation per year.
- 2 Totals include startup/shutdown emissions for 8 days per year, from Table B.4-5.
- 3 All GHG values used in the permit and engineering analysis are based on the current Global Warming Potential (GWP) values as published at 78 Fed.Reg. 71904 (November 29, 2013).

The only emission rates shown in Table 3 above that are different from the calculations provided in the application are the hourly and annual NO<sub>x</sub> emissions. In Table B.1-4 of the application, Carmeuse shows a summary of NO<sub>x</sub> emissions test data consisting of 21 tests on vertical kilns in

<sup>4</sup> Note that in the sample calculations following Table B.1-2, the airflow and temperature values shown for the VOC emission factor calculation are for the specific kiln that was tested, which are different from the proposed kilns.



Europe while burning petcoke. After adding a safety factor, Carmeuse derived a proposed NO<sub>x</sub> emission limit of 2.50 lb/ton of lime produced. In contrast, DEQ used the European emission limit of 350 milligrams per normal cubic meter (mg/nm<sup>3</sup>) because the proposed kilns have been designed by a European company and their vertical kilns presumably are capable of meeting the European standard. Using the expected operational parameters for the proposed kilns for airflow (48,000 ft<sup>3</sup> per minute) and temperature (248 degrees Fahrenheit, which equals 393 degrees Kelvin), DEQ derived a NO<sub>x</sub> emission limit of 2.13 lb/ton of lime produced, which is the NO<sub>x</sub> emission limit in the proposed permit:

$$\text{NO}_x = \frac{350\text{mg}}{1\text{nm}^3} * \frac{1\text{g}}{1000\text{mg}} * \frac{1\text{lb}}{453.4\text{g}} * 48,000 \frac{\text{ft}^3}{\text{min}} * \frac{293\text{K}}{393\text{K}} * \frac{1\text{m}^3}{35.3\text{ft}^3} * \frac{60\text{min}}{1\text{hr}} * \frac{1\text{hr}}{22 \text{ ton lime}} = \frac{2.134 \text{ lb}}{\text{ton lime}}$$

Carmeuse requested annual emission limits in the permit that are combined for both lime kilns. However, since the two lime kilns will be constructed sequentially instead of simultaneously, the annual emission limits established in Condition 27 of the permit are specified for each kiln individually.

There are also fuel combustion emissions from the solid fuel dryer (HR-610) and the emergency generator (EG-2). Emissions from the solid fuel dryer are limited because this unit will burn only natural gas and due to its small size (3.5 MMBtu/hr). These emissions are shown in Table 6 below.

Emissions from the emergency generator are based on the NSPS Subpart III limits for Stationary Compression Ignition Internal Combustion Engines. The emergency generator will use ultra-low sulfur distillate oil having a maximum sulfur content of 0.0015% by weight per federal requirements. Annual emissions are calculated based on 500 hours of operation, and are shown in Table 4 below. Actual usage of the emergency generator, and thus its emissions, are expected to be much lower than these values.

**Table 4: PTE for the Emergency Generator**

<b>Pollutant</b>	<b>EG-2 (tpy)</b>
NO <sub>x</sub> <sup>a</sup>	0.33
CO <sup>a</sup>	0.29
SO <sub>2</sub> <sup>b</sup>	0.10
VOC <sup>a, c</sup>	0.33
PM/PM-10/ PM-2.5 <sup>a</sup>	0.02
GHG (CO <sub>2</sub> e)	57.3

<sup>a</sup> Based on emission factors from NSPS Subpart IIII limits for Stationary Compression Ignition Internal Combustion Engines (ref. 40 CFR 89.112 Table 1) and 500 hours of operation annually. NO<sub>x</sub> emissions are assumed to be worst case as entire NMHC + NO<sub>x</sub> emission standard is used for NO<sub>x</sub> emission factor.

<sup>b</sup> lb/MMBtu based on fuel sulfur.

<sup>c</sup> VOC = non-methane hydrocarbons (NMHC).

Materials processing operations at the facility include processing the limestone feed material, the solid fuels (coal and petcoke), and the lime product. These materials processing operations are significant sources of PM, PM-10, and PM-2.5. The other significant source of these three related pollutants is dust from truck traffic on unpaved roads within the facility. These emissions are set forth in Table 5 below.

**Table 5: PTE for the Materials Processing Operations (tpy)**

Pollutant	Limestone Handling <sup>1</sup>	Solid Fuel Handling <sup>2</sup>	Lime Handling <sup>3</sup>	Road Dust <sup>4</sup>	Total
PM	19.91	6.15	28.11	8.57	62.8
PM-10	12.11	6.12	28.15	2.24	48.7
PM-2.5	3.36	2.44	11.24	0.29	17.4

- 1 Includes all limestone handling emissions points (see Table B.6-2 in the application), all limestone storage piles (Table B.6-3), and DC-906 (Table B.6-3). These values are based on the 950,000 tpy throughput limit established in Condition 42 of the permit. However, the modeling used the full 5,000,000 capacity of the new primary crusher (CR-900).
- 2 Includes the enclosed coke pile and dump hopper (see Table B.7-2 in the application), the coal/coke dust collectors (Table B.7-3), and the outdoor coal/coke pile (Table B.7-6).
- 3 Includes the twelve lime handling dust collectors (see Table B.8-1 in the application).
- 4 See Table B.9-2 in the application.

A summary of estimated annual emissions from the proposed facility, showing the contribution from each emission unit type, is shown in Table 6 below.

**Table 6: Criteria Pollutant Emissions from the Proposed Facility (tpy)**

Pollutant	Both Vertical Lime Kilns	Emergency Generator	Solid Fuel Dryer <sup>1</sup>	Materials Processing Operations	Total
NO <sub>x</sub>	335.0	0.3	0.8	0	336.1
CO	476.5	0.3	1.3	0	478.1
SO <sub>2</sub>	204.4	0.1	0.0	0	204.5
VOC	26.0	0.3	0.1	0	26.4

Pollutant	Both Vertical Lime Kilns	Emergency Generator	Solid Fuel Dryer <sup>1</sup>	Materials Processing Operations	Total
PM	51.7	0.0	0.1	62.8	114.6
PM-10	51.7	0.0	0.1	48.7	100.5
PM-2.5	40.3	0.0	0.1	17.4	57.8
H <sub>2</sub> SO <sub>4</sub>	6.3	0.0	0	0	6.3
GHG	362,010	57	1,794	0	363,861

<sup>1</sup> Values from Table B.7-5 of the application and DEQ’s DORONG emissions spreadsheet. Note that PM/PM-10/PM-2.5 emissions resulting from the handling of the solid fuel are controlled by a fabric filter.

**B. HAPs/Toxic Pollutants**

Carmeuse provided emissions calculations for hazardous air pollutant (HAP) emissions. Table B.4-2 of the application describes the primary HAP emissions from the facility, which are hydrochloric acid (HCl) and hydrofluoric acid (HF) from the two lime kilns. Table B.4-7 summarizes emissions of all other HAP from the kilns and other emission sources. Emissions of HCl from the kilns will be 24.5 tpy, and emissions of HF from the kilns will be 3.1 tpy. Therefore, the potential HAP emissions from the proposed vertical kilns exceed both major source thresholds for HAPs, i.e., 10 tpy of a single HAP (24.5 tpy of HCl) and 25 tpy of all HAPs combined (27.6 tpy of HCl and HF). Accordingly, Carmeuse’s Winchester facility is a major source of HAP, and the major source MACT for lime plants (Subpart AAAAA) is applicable to the proposed vertical lime kilns (as described in section IV.D.6 below).

**IV. Regulatory Review and Considerations**

**A. Criteria Pollutants**

The existing facility meets the definition of “major stationary source” under 9 VAC 5 Chapter 80 Article 8 (Prevention of Significant Deterioration (PSD)) because it is a lime plant with the potential to emit (PTE) of more than 100 tpy of a regulated pollutant. See 9 VAC 5-80-1615 “major stationary source” a(1)(n) and Table 6 above (showing that the PTE for NO<sub>x</sub>, CO, SO<sub>2</sub>, and PM exceed 100 tpy). Accordingly, the emissions from the proposed project must be evaluated to determine whether there is a significant net emissions increase that subjects the project to PSD permitting.

Applicability of PSD review is evaluated on a pollutant-specific basis. 9 VAC 5 Chapter 80 Article 8 defines “significant” emissions increase

levels for several regulated pollutants; pollutants for which the proposed net emissions increase exceeds significant levels are subject to PSD review.

Table 7 below compares the maximum proposed emissions increases from Carmeuse’s proposed project with PSD significant increase levels. This comparison is commonly referred to as “Step 1” in the PSD applicability analysis. The PTE values shown in Table 7 are taken from Table 6 above, and they include the two proposed vertical kilns, all materials processing equipment, and all ancillary equipment. As shown in Table 7 below, the emissions increase is significant for the following pollutants: NO<sub>x</sub>, CO, SO<sub>2</sub>, PM, PM-10, PM-2.5, and GHG. The only criteria pollutants for which there is not a significant emissions increase are VOC and SAM. Accordingly, VOC and SAM are not subject to PSD permitting.

**Table 7: PSD Applicability Step 1 – Significant Emissions Increase (tpy)**

<b>Pollutant</b>	<b>Potential to Emit</b>	<b>PSD Significant Increase Levels</b>	<b>Is Emissions Increase Significant?</b>
NO <sub>x</sub>	336.1	40	Yes
CO	478.1	100	Yes
SO <sub>2</sub>	204.5	40	Yes
VOC (ozone)	26.4	40	<b>NO</b>
PM	114.6	25	Yes
PM-10	100.5	15	Yes
PM-2.5	57.8	10	Yes
H <sub>2</sub> SO <sub>4</sub> (SAM)	6.3	7	<b>NO</b>
GHG	363,861	75,000	Yes

In order for PSD to apply to the project, there must also be a significant net emissions increase for each given pollutant. This calculation includes emissions from the proposed project and all contemporaneous, creditable emissions increases and decreases. The contemporaneous period is defined by DEQ’s regulations as beginning on “the date five years before construction on the particular change commences”. (See 9VAC5-80-1615, “net emissions increase”, subsections b and c; see also DEQ PSD Guidance, p.3-12.)

There are no contemporaneous, creditable emissions increases or decreases for this project. Therefore, the Step 1 significant emissions

increase and the Step 2 significant net emissions increase are the same for all pollutants. The Step 2 significant net emissions increases are shown in Table 8 below.

**Table 8: PSD Applicability Step 2 – Significant Net Emissions Increase (tpy)**

<b>Pollutant</b>	<b>Potential to Emit</b>	<b>Contemporaneous Emissions Changes</b>	<b>Net Emissions Increase</b>	<b>PSD Significant Increase Levels</b>	<b>Is Net Emissions Increase Significant?</b>
NO <sub>x</sub>	336.1	-	336.1	40	Yes
CO	478.1	-	478.1	100	Yes
SO <sub>2</sub>	204.5	-	204.5	40	Yes
PM	114.6	-	114.6	25	Yes
PM-10	100.5	-	100.5	15	Yes
PM-2.5	57.8	-	57.8	10	Yes
GHG	363,861	-	363,861	75,000	Yes

Throughout much of this permitting process, Carmeuse intended to include emissions decreases from the shutdown of its existing rotary kiln in the Step 2 analysis, which would have allowed the project to net out of PSD review for sulfur dioxide. Since the existing rotary kiln last operated on November 27, 2008, construction must have commenced on the proposed vertical kilns by November 26, 2013, in order to include the rotary kiln shutdown in the contemporaneous period. However, since that date has now passed, the project will not net out of PSD review for sulfur dioxide. Carmeuse’s latest revised comprehensive application includes a top-down BACT analysis for sulfur dioxide, and its modeling now includes this pollutant as well.

Because there are no contemporaneous, creditable emissions decreases, all pollutants for which there is a Step 1 significant emissions increase also have a Step 2 significant net emissions increase, and therefore are subject to PSD permitting.

To summarize, the criteria pollutants subject to PSD review are NO<sub>x</sub>, CO, SO<sub>2</sub>, PM, PM-10, PM-2.5, and GHG. The criteria pollutants that are not subject to PSD are VOC and SAM. Of the pollutants subject to PSD, the PSD regulations require modeling analysis to demonstrate compliance with the NAAQS and PSD increments for NO<sub>x</sub>, CO, SO<sub>2</sub>, PM-10, and PM-2.5 (there are no modeling requirements for PM). The modeling results are discussed in section C below and in Attachment B.

## B. HAPs/Toxic Pollutants

As described above, the proposed vertical lime kilns (LP-VK-1, LP-VK-2) are a major source of HAP. Therefore, the vertical lime kilns are subject to the Lime MACT (which is described below). Also as discussed above and below, the diesel emergency generator (EG-2) is subject to the Subpart ZZZZ MACT. Pursuant to 9 VAC 5-60-300 C.4, these units are exempt from the state toxic pollutant regulations set forth in 9 VAC 5 Chapter 60 because they are subject to federal HAP regulations.

The only other fuel-burning unit in this project is the new natural gas-fired 3.5 MMBtu/hr solid fuel dryer (HR-610). Although gas-fired fuel-burning units with a maximum heat input rate of less than 50 MMBtu/hr are exempt from DEQ permitting regulations for criteria pollutants (per 9 VAC 5-80-1105 B.1.a.(4)), the unit's HAP emissions must be evaluated against DEQ's state toxics exemption levels (as set forth in the table "DEQ State Toxics Exemption Levels & SAAC" dated 10/24/11). As shown in Table 9 below, using AP-42 emission factors for natural gas burners, the maximum potential HAP emissions from the solid fuel dryer are below the applicable exemption levels. Therefore, this unit is not subject to the state toxics regulations.

**Table 9: HAP Emissions from the Solid Fuel Dryer (HR-610)**

HAP	HR-610 Emissions		Exemption Levels		Exempt?
	(lb/hr)	(tpy)	(lb/hr)	(tpy)	
Arsenic	6.8E-07	3.0E-06	1.3E-02	2.9E-02	Yes
Benzene	7.2E-06	3.1E-05	2.1E+00	4.6E+00	Yes
Beryllium	4.1E-08	1.8E-07	1.3E-04	2.9E-04	Yes
Cadmium	3.8E-06	1.6E-05	3.3E-03	7.3E-03	Yes
Chromium (VI)	4.8E-06	2.1E-05	3.3E-03	7.3E-03	Yes
Cobalt	2.9E-07	1.3E-06	3.3E-03	7.3E-03	Yes
Dichlorobenzene	4.1E-06	1.8E-05	2.2E+01	6.6E+01	Yes
Formaldehyde	2.6E-04	1.1E-03	8.3E-02	1.7E-01	Yes
Hexane	6.1E-03	2.7E-02	1.2E+01	2.6E+01	Yes
Lead	1.7E-06	7.5E-06	9.9E-03	2.2E-02	Yes
Manganese	1.3E-06	5.7E-06	3.3E-01	7.3E-01	Yes
Mercury	8.9E-07	3.9E-06	6.6E-04	1.5E-03	Yes
Naphthalene	2.1E-06	9.1E-06	2.6E+00	7.5E+00	Yes
Nickel	7.2E-06	3.1E-05	6.6E-03	1.5E-02	Yes
POM	3.0E-07	1.3E-06	2.6E+00	7.5E+00	Yes
Selenium	8.2E-08	3.6E-07	1.3E-02	2.9E-02	Yes
Toluene	1.2E-05	5.1E-05	1.9E+01	5.5E+01	Yes

Since each fuel-burning unit is individually exempt as described above, the proposed project is not subject to the state toxic pollutant regulations set forth in 9 VAC 5 Chapter 60.

### **C. Modeling Results**

The initial Class I and Class II air quality analyses were received by DEQ on July 25 and July 23, 2013, respectively. The Class I and Class II air quality modeling analyses conform to 40 CFR Part 51, Appendix W - Guideline on Air Quality Models and were performed in accordance with their respective approved modeling methodology that were included in a protocol that was submitted in advance by the Company.

The air quality modeling analyses results show compliance with all applicable NAAQS and PSD increments. DEQ's Office of Air Quality Assessments (AQA) reviewed and approved the applicant's Class I and Class II modeling analyses. AQA issued its "Technical Review of the Air Quality Analysis in Support of the PSD Application [for this project]" on December 10, 2013. This document is included as Attachment B.

### **D. Control Technology Standards and Analysis**

#### **1. BACT vs. LAER**

The Federal permitting process involves two methods of control technology review: Best Available Control Technology (BACT) and Lowest Achievable Emission Rate (LAER). In geographic locations where ambient pollutant concentrations exceed the NAAQS, permit applicants are required to meet LAER. LAER is defined as the lowest emission limit achieved in practice on a similar design. Only technical and environmental factors are considered, without regard to cost. In areas where pollutant concentrations are within the NAAQS, the applicant must apply BACT. BACT represents the most stringent emission limit that is technically, environmentally, and economically feasible. EPA policy requires that LAER is the first consideration in the BACT analysis. Only when LAER is proven to be environmentally or economically infeasible may BACT be less stringent than LAER. However, in no case may BACT result in an emission rate less stringent than required by federal regulations such as NSPS or MACT requirements. Frederick County is considered in attainment for all NAAQS. Therefore a BACT analysis (rather than LAER) is required for emission controls and consequently economic factors are considered.

2. BACT requirements

The EPA guidance document New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting (Draft, October 1990) prescribes that for PSD permitting, the most stringent BACT review, otherwise known as “top-down” review, be conducted. Per EPA guidance, the “top-down” BACT analysis consists of the following five steps:

1. Identify all potentially applicable control technologies;
2. Eliminate technically infeasible options;
3. Rank the remaining options by effectiveness;
4. Evaluate economic, environmental, & energy impacts; and
5. Select BACT control(s) and establish BACT emission limit(s).

Under Step 4, the most stringent or “top” alternative is evaluated first and must be established as BACT unless it is demonstrated that energy, environmental, or economic impacts justify that the most stringent technology is not feasible. If the most stringent option is eliminated, then the next most stringent control option is considered until BACT is established.

All pollutants subject to PSD review are subject to a “top-down” BACT analysis, as BACT is established on a pollutant-specific basis. For the proposed new vertical lime kilns, the pollutants subject to BACT are PM/PM-10/PM-2.5, CO, NO<sub>x</sub>, SO<sub>2</sub>, and GHGs (CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O). Emission units and pollutants addressed in the BACT determination submitted by Carmeuse consist of the vertical lime kilns (all pollutants listed above); the diesel emergency generator (all pollutants listed above); solid fuel dryer (all pollutants listed above); and the materials handling processes (only PM/PM-10/PM-2.5).

PSD procedures require that the BACT cost feasibility analysis be based upon recent permit determinations for similar facilities. Federal guidance is clear that there can be no fixed or “bright line” cost established as representative of BACT. Rather, the cost of reducing emissions, expressed in dollars per ton, is to be compared with the cost incurred by other sources of the same industry type. A listing of BACT determinations included in EPA’s RACT/BACT/LAER Clearinghouse (RBLC) for similar facilities is included as Appendix C in Carmeuse’s application. Due to the length of time between submission of Carmeuse’s initial



application and its final revised comprehensive application (17 months), DEQ required Carmeuse to update its RBLC searches for its final revised comprehensive application.

The RBLC includes two kinds of lime kilns that are quite different in their design and function: kilns that convert crushed limestone into lime (which is what Carmeuse proposes to do) and kilns at pulp mills that recover calcium (by converting it to lime) from the kraft pulping process. EPA recognized the significant differences in these kilns by establishing separate process type codes for them in the RBLC: 90.019 for limestone-to-lime kilns, and 30.231 for kraft lime kilns. Due to their significant differences, both Carmeuse and DEQ reviewed only the limestone-to-lime kilns (90.019) in the following BACT analysis and determinations.

A search of the RBLC under process type code 90.019 shows fifteen BACT determinations for projects including limestone-to-lime kilns within the past ten years. (EPA describes the 90.019 process type category as “Lime/Limestone Handling/Kilns/Storage/Manufacturing”, so it includes numerous projects that do not include lime kilns.) However, only two of these fifteen kilns are vertical kilns similar to Carmeuse’s proposed kilns; the rest are the more traditional rotary design. Consequently, some of the pollution control technologies and emission limits established for rotary kilns that are in the RBLC may not be directly applicable to the proposed vertical kilns.

The two vertical kilns are Graymont’s facility in Pleasant Gap, Pennsylvania (permitted in 2012) and Chemical Lime’s facility in Clifton, Texas (permitted in 2010). While the Texas facility is operational, to DEQ’s knowledge, construction has not yet commenced on the Pennsylvania facility.

### **Vertical Lime Kilns**

#### **Particulate Matter**

The pollutants of greatest concern generated by the vertical lime kilns are the particulate matter (PM) family, which consists of three separate but related pollutants: total PM, PM-10, and PM-2.5. Although they share many similarities, since these three pollutants are regulated independently under both state and federal regulations, each is addressed separately below, following a general discussion of the PM pollutants.

Total PM includes particles of all sizes, but it is regulated for only filterable PM. Filterable PM consists of the particles that can be captured on filter paper. Filterable PM generally results from the physical degradation of solid materials, such as chunks of limestone and lime colliding within the kiln, causing small pieces to break off. When burning solid fuel, the filterable fraction may also include tiny particles of fuel that are not completely combusted.

In contrast, PM-10 and PM-2.5 consist of both a filterable fraction and a condensable fraction. For PM-10, the filterable fraction is limited to only those particles that are 10 microns or less in diameter. For PM-2.5, the filterable fraction is limited to only those particles that are 2.5 microns or less in diameter.

Filterable particulate matter is generated within the vertical kilns from both the combustion of fuels and from the calcining process itself. The fuel, the limestone feed, and the lime product all contribute to the PM emissions from the kilns. In vertical lime kilns, the majority of the uncontrolled filterable PM is due to the frictional PM originating from the limestone feed and lime product. Consequently, the generation of additional particulate matter from the calcining process causes the uncontrolled emissions of PM, filterable PM-10, and filterable PM-2.5 from lime kilns to be significantly greater than from a boiler burning the same amount of the same kind of fuel. However, when burning solid fuels, a majority of the ash and other filterable PM that is attributable to the solid fuels becomes incorporated into the lime product. Therefore, there are only minor differences in the actual filterable PM emissions when burning natural gas as compared to solid fuels.

For PM-10 and PM-2.5, the condensable fraction results from compounds that exist in gaseous form at stack temperatures, but then condense to either liquid or solid form relatively quickly after exiting the exhaust stack and cooling to ambient temperature. Condensable PM can include compounds such as ammoniated chlorides, sulfates, nitrates, VOC, and other compounds that condense at ambient temperatures. DEQ's regulations define "regulated NSR pollutant" to include SO<sub>2</sub> and NO<sub>x</sub> as precursors for PM-2.5, per 9 VAC 5-80-1615. Consequently, the BACT analysis for SO<sub>2</sub> and NO<sub>x</sub> will be relevant for each of those respective pollutants, and for PM-2.5. (Note that condensable PM-10 and PM-2.5 does not include secondary PM formation, which is another class of liquid or solid particles that are formed tens or

even hundreds of miles downwind from the facility from chemical reactions involving NO<sub>x</sub> and SO<sub>x</sub> emissions from a facility.)

Based upon information provided by Carmeuse and on DEQ's own research, it appears that the majority of the condensable PM emissions from a lime kiln result from the presence of sulfur. There are two potential sources of sulfur in a lime kiln: the limestone feed and the fuel. Regardless of its source, once sulfur is present within the kiln, it is initially oxidized to SO<sub>2</sub>, and then in an excess air environment, it further oxidizes to SO<sub>3</sub>. Upon exiting the stack and cooling down, the SO<sub>3</sub> reacts with water vapor to form SAM, which is a liquid that is included as condensable PM. Accordingly, control strategies for condensable PM emissions from lime kilns should focus on SO<sub>2</sub> control.

#### Total PM Control

As discussed above, total PM consists only of filterable PM; condensables are not included. Four control technologies were identified by Carmeuse as being potentially available to reduce total PM emissions from the kilns:

1. Baghouse (>99% efficiency);
2. Electrostatic Precipitator (ESP) (>99% efficiency);
3. Wet Scrubbing (up to 99% efficiency); and
4. Venturi Scrubber (<90% efficiency).

(1) Baghouse. Carmeuse has proposed the use of a baghouse as BACT for total PM. Since this is the most efficient technology available and is commonly selected as BACT for lime kilns (as shown in the RBLC), DEQ agrees that a baghouse constitutes BACT for total PM. Consequently, the other three alternatives – each of which have been shown to be equally or less effective than a baghouse – do not need to be discussed herein.

A baghouse consists of numerous individual fabric filters that are arrayed in rows and enclosed in a housing. Flue gas enters one side of the baghouse and passes through one of the individual fabric filters before being drawn out of the other side of the baghouse. Particulate matter is captured on the outside surface of the fabric filters, where it forms a particulate cake. Periodically, the particulate cake is removed by shaking or pulsing the fabric filters, which causes the cake to fall into a collection bin at the bottom of the baghouse. The cleaning frequency is managed to balance the pressure drop across the fabric filters (which impacts

the energy required to draw the flue gas through the baghouse) versus the wear and tear on the bags resulting from the cleaning process. Baghouses generally achieve at least 99% and frequently up to 99.9% reduction in total PM emissions.

EPA's MACT standard for lime manufacturing plants (Subpart AAAAA) includes an emission limit for PM of 0.10 lb PM per ton of stone feed (tsf). (See 40 CFR §63.7090(a) and Table 1 to Subpart AAAAA of Part 63.)

Carmeuse proposes an emission limit for total PM of 0.010 gr/dscf, which is the outlet grain loading rate for the baghouse when burning solid fuels. When burning natural gas, Carmeuse proposed a lower emission limit for total PM of 0.009 gr/dscf. These values represent what is achievable by the baghouse and are consistent with previous BACT determinations over the past decade for lime kilns as specified in the RBLC.

These proposed emission limits are more stringent than the MACT limit of 0.10 lb PM/tsf.<sup>5</sup> Compliance with this MACT is based on EPA Method 5, which determines only the filterable portion of PM, and therefore is appropriate for total PM. Carmeuse also proposes a visible emissions limit of 5 percent opacity. This value is consistent with other recently permitted lime kilns. Accordingly, DEQ agrees that BACT for total PM is 0.010 gr/dscf and a visible emission limit of 5 percent opacity.

The total PM (filterable only) emission limit for each kiln when burning solid fuel that is established in Condition 27 of the permit is calculated as follows:

$$298,300 \frac{\text{tons limestone}}{\text{each kiln}} \times \frac{0.076 \text{ lb PM}}{\text{ton limestone}} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = 11.3 \frac{\text{ton PM}}{\text{kiln}}$$

Compliance with the emission limits for total PM shall be determined through periodic stack testing using the appropriate EPA test methods. A Continuous Opacity Monitoring System (COMS) and periodic visible emissions evaluations shall be used to determine compliance with the 5% visible emission limit.

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<sup>5</sup>  $0.01\text{gr/scf} \times 30,759\text{scf/min} \times 60\text{min/hr} \times \text{lb}/7000\text{gr} \times \text{day}/440\text{tonlime} \times 24\text{hr/day} = 0.144 \text{ lb PM/ton lime}$   
 $0.144 \text{ lb PM/ton lime} \times 1 \text{ ton lime}/1.9 \text{ ton limestone} = 0.076 \text{ lb PM/ton limestone(tsf)}$

PM-10 Control

As discussed above, PM-10 consists of both a filterable fraction and a condensable fraction. Filterable PM-10 emissions are formed and controlled in the same manner as described above for total PM. The same four control technologies were identified by Carmeuse as being potentially available to reduce filterable PM-10 emissions from the kilns:

1. Baghouse (>99% efficiency);
2. Electrostatic Precipitator (ESP) (>99% efficiency);
3. Wet Scrubbing (up to 99% efficiency); and
4. Venturi Scrubber (<90% efficiency).

Carmeuse has proposed the use of a baghouse as BACT for filterable PM-10. Since this is the most efficient technology available and is commonly selected as BACT for lime kilns (as shown in the RBLC), DEQ agrees that a baghouse constitutes BACT for the filterable fraction of PM-10. Consequently, the other three alternatives – each of which are equally or less effective than a baghouse – do not need to be discussed herein. For a description of a baghouse, see the discussion on total PM control above.

BACT analyses are provided below for both SO<sub>2</sub> and NO<sub>x</sub>, because PSD is applicable to both of these pollutants for this project. Both of those BACT analyses are incorporated by reference for purposes of addressing those two pollutants as precursors to PM-10 formation. As described previously, the initiating species of the primary component of condensable PM-10 from the kilns is SO<sub>2</sub>. DEQ has concluded that BACT for SO<sub>2</sub> for this project is the inherent scrubbing of SO<sub>2</sub> that will occur within the kilns, which is expected to remove approximately 95% of the SO<sub>2</sub>. The condensable PM-10 emissions that would result from the presence of SO<sub>2</sub> will also be controlled through the inherent scrubbing.

Regarding NO<sub>x</sub> emissions as a precursor to PM-10, DEQ has concluded below that BACT for NO<sub>x</sub> emissions is the use of the efficient vertically-oriented, dual-chamber kiln design, and the use of good combustion practices. The NO<sub>x</sub> reductions resulting from these BACT measures will also serve to reduce the formation of condensable PM-10.

Carmeuse proposes a total (filterable and condensable) PM-10 emission limit of 0.33 lb/ton of lime produced, and a filterable

limit of 0.010 gr/dscf for PM-10, which is the outlet grain loading rate for the baghouse, when burning solid fuels, and 0.009 gr/dscf when burning natural gas. The filterable values represent what is achievable by the baghouse and are consistent with previous BACT determinations over the past decade for lime kilns as specified in the RBLC. Only recently have permit limits been established for condensable PM-10, and consequently, the RBLC does not include any lime kilns with emission limits that expressly include condensables. While Graymont's Pennsylvania facility has lower filterable limits,<sup>6</sup> that facility is permitted to burn only natural gas, so its particulate matter emissions may be lower than a facility burning both gas and solid fuels such as Carmeuse. This is because the baghouse for Graymont's facility presumably is designed to operate on an exhaust stream that features only natural gas as a fuel – as opposed to being able to handle both natural gas and solid fuels – which allows it to be more efficient for that single, consistent exhaust stream.

Accordingly, DEQ determines that BACT for PM-10 is 0.33 lb/ton lime (filterable and condensable), and that BACT for filterable PM-10 only when burning solid fuels is 0.010 gr/dscf, and when burning natural gas is 0.009 gr/dscf.

Compliance with the PM-10 emission limits shall be determined through periodic stack testing using the appropriate EPA test methods.

#### PM-2.5 Control

As discussed above, PM-2.5 consists of both a filterable fraction and a condensable fraction. Filterable PM-2.5 emissions are formed and controlled in the same manner as described above for total PM and PM-10. The same four control technologies were identified by Carmeuse as being potentially available to reduce filterable PM-2.5 emissions from the kilns:

1. Baghouse (>99% efficiency);
2. Electrostatic Precipitator (ESP) (>99% efficiency);
3. Wet Scrubbing (up to 99% efficiency); and
4. Venturi Scrubber (<90% efficiency).

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<sup>6</sup> For unknown reasons, EPA's RBLC does not provide PM-10/PM-2.5 limits for Chemical Lime's vertical kiln in Texas.

(1) Baghouse. Carmeuse has proposed the use of a baghouse as BACT for filterable PM-2.5. Since this is the most efficient technology available and is commonly selected as BACT for lime kilns (as shown in the RBLC), DEQ agrees that a baghouse constitutes BACT for the filterable fraction of PM-2.5. Consequently, the other three alternatives – each of which are equally or less effective than a baghouse – do not need to be discussed herein. For a description of a baghouse, see the discussion on total PM control above.

BACT analyses are provided below for both SO<sub>2</sub> and NO<sub>x</sub>, because PSD is applicable to both of these pollutants for this project. Both of those BACT analyses are incorporated by reference for purposes of addressing those two pollutants as precursors to PM-2.5 formation. As described previously, the initiating species of the primary component of condensable PM-2.5 from the kilns is SO<sub>2</sub>. DEQ has concluded that BACT for SO<sub>2</sub> for this project is the inherent scrubbing of SO<sub>2</sub> that will occur within the kilns, which is expected to remove approximately 95% of the SO<sub>2</sub>. The condensable PM-2.5 emissions that would result from the presence of SO<sub>2</sub> will also be controlled through the inherent scrubbing.

Regarding NO<sub>x</sub> emissions as a precursor to PM-2.5, DEQ has concluded below that BACT for NO<sub>x</sub> emissions is the use of the efficient vertically-oriented, dual-chamber kiln design, and the use of good combustion practices. The NO<sub>x</sub> reductions resulting from these BACT measures will also serve to reduce the formation of condensable PM-2.5.

Carmeuse proposes a total (filterable and condensable) PM-2.5 emission limit of 0.25 lb/ton of lime produced, and a filterable limit of 0.004 gr/dscf for PM-2.5, which is the outlet grain loading rate for the baghouse. Both of these values are lower than the proposed levels for PM-10. The filterable value represents what is achievable by the baghouse and is consistent with previous BACT determinations over the past decade for lime kilns as specified in the RBLC. Only recently have permit limits been established for condensable PM-2.5, and consequently, the RBLC does not include any lime kilns with emission limits that expressly include condensables. While Graymont's Pennsylvania facility has lower filterable limits, that facility is permitted to burn only natural gas, so its particulate matter emissions will inherently be lower than any facility burning solid fuels such as Carmeuse. Moreover, the baghouse for Graymont's facility presumably is designed to operate on an exhaust stream that features only natural gas as a fuel

– as opposed to being able to handle both natural gas and solid fuels – which allows it to be more efficient for that single, consistent exhaust stream.

Accordingly, DEQ determines that BACT for PM-2.5 is 0.25 lb/ton lime (filterable and condensable), and that BACT for filterable PM-2.5 only is 0.004 gr/dscf.

Compliance with the PM-2.5 emission limits shall be determined through periodic stack testing using the appropriate EPA test methods.

#### Carbon Monoxide (CO) Control

Carbon monoxide is generated within the vertical kilns from both the incomplete combustion of fuels and from the calcining process itself. The generation of additional CO from the calcining process due to incomplete oxidation of the carbon in the limestone causes the uncontrolled emissions of CO from lime kilns to be significantly greater than from a boiler consuming the same amount of solid fuel.

The primary factors influencing the generation of CO emissions due to incomplete combustion of the fuel are temperature and residence time within the combustion zone. Variations in fuel carbon content have relatively little effect on overall CO emissions. Generally the effect of the combustion zone temperature and residence time on CO emissions generation is the exact opposite of their effect on NO<sub>x</sub> emissions generation. Higher combustion zone temperatures and residence times lead to more complete combustion and lower CO emissions, but higher NO<sub>x</sub> emissions.

Carmeuse identified three potential control technologies for CO:

1. Thermal Oxidation (99% reduction);
2. Oxidation Catalyst (up to 95% reduction); and
3. Good Combustion Practices (<90% reduction).

(1) Thermal Oxidation. Thermal oxidation is a tailpipe control that is commonly used to reduce VOCs by oxidizing the carbon to CO<sub>2</sub>. It involves routing exhaust gas from the kiln through an afterburner, flare, or similar fuel-burning device to generate the high temperatures required to ensure complete oxidation, usually around 1500 degrees F. Similarly, thermal oxidation can be used



to oxidize CO to CO<sub>2</sub>. Because it is a tailpipe control that can be utilized on virtually any exhaust gas stream and there are no limitations posed by the lime kiln exhaust, thermal oxidation is technically feasible. (However, based on its absence from the RBLC, it appears that thermal oxidation has not yet been demonstrated on a lime kiln.) Thermal oxidation can achieve at least 99% elimination of CO, provided that the temperature is high enough and the residence time is long enough.

Carmeuse performed a simplified cost analysis for thermal oxidation. Considering only annual costs for the natural gas to fire the afterburner (excluding capital and construction costs, non-fuel operational costs, and maintenance costs), Carmeuse estimates the cost of thermal oxidation to be approximately \$11,800/ton of CO destroyed. Carmeuse asserts that this cost renders thermal oxidation economically infeasible.

DEQ agrees that for this project, thermal oxidation is economically infeasible for CO control. DEQ also observes that the negative environmental impacts from the additional fuel usage and the generation of additional pollutants – NO<sub>x</sub> from the high combustion temperatures; CO<sub>2</sub> from the burning of the natural gas; and CO<sub>2</sub> resulting from the oxidation of CO – outweigh the environmental benefit of reducing the CO emissions since CO is not a significant issue in Virginia (as compared to the contribution of VOC to ground-level ozone formation, which is usually the target pollutant for thermal oxidation).

(2) Oxidation Catalyst. An oxidation catalyst is a tailpipe control that reduces CO emissions by routing exhaust gas from the kiln through a catalyst that oxidizes CO to CO<sub>2</sub>. The oxidation of CO to CO<sub>2</sub> utilizes the excess air (oxygen) that is present in the exhaust gas, and the catalyst lowers the activation energy (i.e., temperature) that is required for the reaction to occur. Technical factors relating to this technology include the catalyst reactor design, optimum operating temperature, back pressure loss to the system, catalyst life, and potential collateral increases in emissions of PM and SAM.

CO catalytic oxidation reactors operate in the range of 700 to 1,100 degrees F, which due to the use of the catalyst, is significantly lower than the minimum 1,500 degrees F that is required for thermal oxidation.

In order to operate within the required temperature range, the oxidation catalyst would need to be located either before the baghouse, where the exhaust gas is closer to the proper temperature but would still require supplemental heating, or after the baghouse, where the exhaust gas would need significant reheating to reach the required temperature. Because of the heavy PM loading in the exhaust gas, an oxidation catalyst located prior to the baghouse (and thus prior to removal of the PM) would quickly be fouled by the PM and the oxidation of CO would be greatly reduced. Although oxidation catalysts used in other applications, such as on natural gas combustion turbines, last on average for approximately five years before being replaced, Carmeuse estimates that if placed before the baghouse, the catalyst would foul within a few weeks. This renders the use of an oxidation catalyst prior to the baghouse to be technically and/or economically infeasible.

The catalyst fouling issue is resolved if the oxidation catalyst is located after the PM is removed by the baghouse. However, such placement would require reheating the exhaust gas stream up to the required operating temperature for the catalyst (at least 700 degrees F). Carmeuse performed a simplified cost analysis for locating an oxidation catalyst after the baghouse. Considering only annual costs for the natural gas to reheat the exhaust gas stream (excluding capital and construction costs to install the oxidation catalyst, non-fuel operational costs, and maintenance costs), Carmeuse estimates the cost of this control option to be approximately \$10,200/ton of CO eliminated (See Table D-1.2 in the application). Carmeuse asserts that this cost renders an oxidation catalyst economically infeasible. However, Carmeuse assumed a very low 50% destruction efficiency for CO in its cost estimate. DEQ recalculated the cost effectiveness of this control option using a 90% destruction efficiency, which yields a cost of \$5,675/ton of CO eliminated. Note that these cost estimates include only the cost of natural gas for reheating; they do not include capital costs for any equipment. DEQ agrees that an oxidation catalyst located after the baghouse is economically infeasible for CO control, even at the lower estimated cost. Moreover, based on its absence from the RBLC, it appears that catalytic oxidation has not yet been demonstrated on a lime kiln.

(3) Good Combustion Practices. Good combustion practices consist primarily of controlled fuel/air mixing, maintaining the proper combustion zone temperature, and providing adequate residence time. These practices can be used to minimize the

formation of CO, and it is technically feasible to implement them on the proposed vertical lime kilns.

A review of the fifteen lime kilns in the RBLC shows that none of those permits required a tailpipe control for CO such as an oxidation catalyst or thermal oxidation. Instead, each of these examples, including both vertical lime kilns, relied upon good combustion practices as BACT for CO. Accordingly, Carmeuse asserts that BACT for CO should be the use of good combustion practices. Carmeuse acknowledges that good combustion practices are economically feasible, so it did not provide an economic analysis of this control option.

**CO BACT determination:** DEQ determines that BACT for CO for the proposed vertical lime kilns is the use of good combustion practices. The CO emission limit for the Chemical Lime facility is 3.5 lb CO per ton of lime produced.<sup>7</sup> Carmeuse has proposed a lower limit of 3.0 lb/ton based on the design data for its proposed kilns. The emission limit for CO established as BACT in the permit is 3.0 lb/ton of lime produced when burning solid fuel (coal or petcoke). A lower limit of 1.31 lb/ton of lime produced applies when burning natural gas. Compliance shall be determined through periodic stack testing using approved methods.

#### Nitrogen Oxides (NO<sub>x</sub>) Control

Fuel burning within the vertical kilns is the primary source of NO<sub>x</sub> emissions from the proposed project. NO<sub>x</sub> is primarily formed from the oxidation of nitrogen that is present in combustion air during the combustion process. Temperature is the dominant factor in the amount of NO<sub>x</sub> produced – higher temperatures result in more NO<sub>x</sub> formation. As described previously, the maximum temperature in a vertical kiln is about 1,900 degrees Fahrenheit, as compared to 2,000 to 2,200 degrees in a rotary kiln. Therefore, vertical kilns inherently produce less NO<sub>x</sub> than rotary kilns due to their lower maximum temperature.

Twelve control technologies were identified by Carmeuse as being potentially available to reduce NO<sub>x</sub> emissions from the kilns, which are listed below in roughly most-effective to least-effective order:

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<sup>7</sup> The Pennsylvania facility has a much lower CO limit at 0.3 lb/ton of lime, but this is because the facility is permitted to use only natural gas as a fuel.

1. Selective Catalytic Reduction (SCR)
2. Selective Non-Catalytic Reduction (SNCR)
3. Non-Selective Non-Catalytic Reduction (NSNCR)
4. Catalytic Ceramic Filter Media (CCFM)
5. Oxidation/Reduction Scrubbing (ORS)
6. Low-NO<sub>x</sub> Burners (LNB)
7. Mid-Kiln Firing (MKF)
8. Water or Steam Injection
9. Mixing Air Fans and Air Staging
10. Clean Fuels
11. Efficient Kiln Design
12. Good Combustion Practices

Carmeuse has proposed two of the least effective options – efficient kiln design and good combustion practices – as BACT. Accordingly, all of the options described above must be discussed to establish why they are not feasible for the proposed vertical lime kilns.

(1) Selective Catalytic Reduction. SCR involves the post-combustion destruction of NO<sub>x</sub> from the flue gas with a catalytic reactor. In SCR, ammonia injected into the exhaust gas reacts with NO<sub>x</sub> and oxygen in the presence of a catalyst to form nitrogen and water. The function of the catalyst is to effectively lower the activation energy (i.e., the temperature) of the NO<sub>x</sub> decomposition reaction. SCR operates within the temperature range of approximately 500 to 800 degrees F. SCR can achieve greater than 90% reduction of NO<sub>x</sub>.

SCR has been commonly used for many years to control NO<sub>x</sub> emissions from electric utility boilers, industrial boilers, and gas turbines, and more recently it has been applied to stationary diesel engines, nonroad diesel engines (such as locomotives), and on-road diesel engines (trucks). Because it is a tailpipe control that has been demonstrated in a wide variety of industrial applications, SCR is technically feasible for the proposed vertical lime kilns (although, based on its absence from the RBLC, it appears that SCR has not yet been applied to any lime kilns).

However, the dust loading in the flue gas from a lime kiln (whether the newer vertical design or the traditional rotary design) is much higher than any of the applications described above where SCR has been applied successfully. The high dust loading in the kiln exhaust would quickly foul the catalyst bed in a traditional SCR system. There are two potential options to address the high dust

loading – the use of a high-dust SCR system as the first control device or placing a traditional SCR system after the baghouse.

High-dust SCR has been successfully demonstrated on multiple pulverized coal boilers (PCBs). However, there are two important distinguishing factors between the exhaust streams from PCBs and lime kilns. First, the particulate matter control device loading typical for a PCB is approximately  $10 \text{ g/Nm}^3$ , whereas the dust loading for a lime kiln prior to a baghouse is almost an order of magnitude higher, generally in excess of  $80 \text{ g/Nm}^3$ . Second, the dust from a lime kiln is primarily calcium oxide (CaO), which is known to deactivate conventional catalysts by its conversion to calcium sulfate (while there is little or no CaO in PCB exhaust). Furthermore, there is no record of high-dust SCR having ever been used to control a lime kiln. For these reasons, DEQ finds that high-dust SCR is technologically infeasible for the proposed vertical lime kilns.

The other SCR option is to locate a traditional SCR system after the the baghouse that removes most of the PM from the exhaust stream.. The location of SCR after the baghouse requires the use of auxiliary heating of the flue gas stream in order to reach the temperature range necessary for effective operation of the SCR.<sup>8</sup> Carmeuse has conservatively estimated the cost for tailpipe SCR to be approximately \$9,950/ton of  $\text{NO}_x$  removed<sup>9</sup>, which far exceeds the control costs borne by other sources for  $\text{NO}_x$  control in attainment areas in Virginia.

In its cost estimate, Carmeuse assumed 70%  $\text{NO}_x$  control (see Table D-2.1) even though in Table 6-2 Carmeuse states the control efficiency of SCR to be between 70% and 90%. DEQ recalculated the cost effectiveness at 90% control, but with the lower  $\text{NO}_x$  emissions based on the European standard, which yields about \$9,185/ton of  $\text{NO}_x$  removed. This cost still far exceeds the control costs borne by other sources for  $\text{NO}_x$  control in attainment areas in Virginia.

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8 Any reheating of the flue gas stream would result in the generation of additional products of combustion, including more  $\text{NO}_x$ .

9 This cost is conservative (i.e., low) because it includes only the reagent, the natural gas for reheating, and the annualized capital costs for the equipment. It excludes installation costs, electricity usage, catalyst replacement, maintenance, and personnel costs.

However, since the cost of the natural gas for reheating the flue gas stream to the required temperature for SCR is a significant portion of these cost estimates, DEQ asked Carmeuse to consider splitting that reheat cost between SCR for NO<sub>x</sub> control and an oxidation catalyst for CO control. The second version of Table D.2-1 in the application (on page 5 of Appendix D) considers both control options simultaneously, with an average cost for both pollutants of \$10,171/ton of pollutant removed. However, Carmeuse's calculations assume only 50% CO removal and 50% NO<sub>x</sub> removal. DEQ recalculated this estimate using 90% pollutant removal (as DEQ did for each pollutant individually above), which yields a cost of \$5,085/ton of each pollutant removed. This cost far exceeds the cost of any CO control required previously in Virginia, so an oxidation catalyst for CO control remains economically infeasible. Since the CO portion remains economically infeasible, then the cost-sharing is not available for SCR for NO<sub>x</sub> control, so that cost remains \$9,185/ton as described above.

For the foregoing reasons, DEQ agrees that traditional SCR is economically infeasible for the vertical lime kilns.

(2) Selective Non-Catalytic Reduction. SNCR involves the injection of ammonia or urea into the flue gas stream to react with the NO<sub>x</sub> to produce elemental nitrogen (N<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), and water (H<sub>2</sub>O). SNCR can achieve NO<sub>x</sub> reductions of about 50%, and it has recently been demonstrated on a rotary lime kiln in Alabama.

Since it does not utilize a catalyst to facilitate the reduction of nitrogen, SNCR requires much higher temperatures than SCR. If applied in a lime kiln, temperatures on the order of 1600 to 2100 degrees F are required to enable the nitrogen reduction reaction without contaminating the lime product with the SNCR reagent. The only potential location for an SNCR system in a vertical lime kiln that meets this temperature requirement without potentially fouling the lime product is in the crossover channel between the two vertical kilns. However, the crossover channel is relatively small and experiences rapidly fluctuating temperatures, which render it a technically infeasible location for installing SNCR.

SNCR is technically feasible after the baghouse because there is sufficient space and by reheating the flue gas stream, the required temperature could be maintained for the appropriate amount of time. However, since SNCR requires temperatures significantly higher than SCR, the cost for natural gas for reheating the flue gas

for SNCR would far exceed the cost for reheating the flue gas for SCR, which has already been determined to be too expensive. Carmeuse estimates SNCR to cost over \$34,000 per ton of NO<sub>x</sub> removed. DEQ agrees that SNCR is economically infeasible because it far exceeds the control costs borne by other sources for NO<sub>x</sub> control in attainment areas in Virginia.

(3) Non-Selective Non-Catalytic Reduction. NSNCR is also known as “staged combustion air”, where three distinct burning zones are created. First, is the initial burn zone, where excess air leads to high temperature, oxidizing conditions where NO<sub>x</sub> is created. Second, is the secondary burn zone, where additional fuel is injected to create an environment where NO<sub>x</sub> is reduced to elemental nitrogen. Third, is the final burn zone, where air is added to re-establish oxidizing conditions to consume the remaining fuel and lower temperatures limit the formation of additional NO<sub>x</sub>.

For the proposed vertical kilns, as described previously, the fuel is fed into the kilns through fuel lances that extend into the primary chamber, where the fuel immediately contacts the heated limestone rock and combusts. Because traditional burners are not used, the fuel and limestone are commingled throughout the kiln, and there is not a traditional combustion zone, it is not possible to establish the three distinct burning zones described above. The fuel lances are an integral part of the design of the vertical kilns that cannot be replaced by traditional burners. Moreover, there are no known applications of NSNCR to either rotary or vertical lime kilns. Therefore, NSNCR is not technically feasible for the proposed vertical lime kilns.

(4) Catalytic Ceramic Filter Media (CCFM). Ceramic filter media with embedded nano-sized catalysts have recently been introduced into the air pollution control field. CCFM can remove NO<sub>x</sub> as well as PM and SO<sub>2</sub> (and this control technology is discussed again in the SO<sub>2</sub> BACT analysis below). The catalyst used for NO<sub>x</sub> removal is similar to that used in SCR except for its size. The micronized size of the catalyst particles allows the nitrogen reduction reaction to occur at somewhat lower temperatures than SCR: 350 to 700 degrees F for CCFM, as compared to 500 to 800 degrees F for SCR. As with SCR, NO<sub>x</sub> removal via ceramic filter media requires the injection of urea or ammonia into the flue gas stream before it enters the ceramic filter media.

CCFM has not yet been implemented on any lime kilns. Although this new technology has been implemented only on waste incinerators and glass furnaces to date, Carmeuse has not demonstrated that CCFM is technically infeasible for its proposed vertical lime kilns. However, this control technology will cost approximately the same as SCR (which as described above is roughly \$10,000/ton) for the following reasons: (1) both technologies have the same urea requirements because the stoichiometry is the same; (2) natural gas usage may be somewhat lower since the operating temperature range is lower (but this is not certain because there is significant overlap in the operating temperature ranges); and (3) the ceramic filter media is subject to fouling and must be periodically replaced, while there is no corresponding expense for SCR. Since the cost for CCFM is roughly the same as for SCR at approximately \$10,000 per ton, DEQ agrees with Carmeuse that CCFM is economically infeasible when evaluated solely for NO<sub>x</sub> control because it far exceeds the control costs borne by other sources for NO<sub>x</sub> control in attainment areas in Virginia.

(5) Oxidation/Reduction Scrubbing. ORS involves the injection of ozone, ionized oxygen, or hydrogen peroxide to further oxidize NO<sub>x</sub> to species that are more water soluble and are then removed by a wet scrubber. ORS is commonly used in the cement industry for wet kilns, where it has been incorporated into an existing or proposed wet scrubber. A wet scrubber is not proposed for the vertical lime kilns, and ORS does not appear to have been implemented on a lime kiln or any other dry kiln to date. For these reasons, ORS is considered technically infeasible for this project.

(6) Low-NO<sub>x</sub> Burners. LNBs are multi-channel burners that create primary and secondary combustion zones. The primary combustion zone is fuel-rich and oxygen-deficient, which limits the formation of NO<sub>x</sub>. The secondary combustion zone is oxygen-rich to ensure complete combustion, but at a lower temperature than the primary combustion zone in order to limit NO<sub>x</sub> formation. LNBs have been successfully implemented in at least 20 rotary lime kilns in the United States.

However, as described previously, the proposed vertical kilns do not use traditional fuel burners. Instead, they use 28 individual fuel lances that introduce the fuel into immediate contact with the limestone. The fuel lances are an integral part of the design of the vertical kilns that cannot be replaced by traditional burners.



Therefore, LNBs are technically infeasible for the proposed vertical lime kilns.

(7) Mid-Kiln Firing. MKF is a form of staged combustion that involves the use of a secondary fuel delivery system that is located at the midpoint of the kiln. MKF utilizes lower combustion temperatures at the primary burner to limit NO<sub>x</sub> formation and also creates reducing conditions at the secondary fuel injection point that destroys some of the NO<sub>x</sub> created in the primary combustion zone. MKF has been successfully implemented on rotary lime kilns.

As described above, however, inherent in the vertical kiln design is a fuel delivery system consisting of 28 individual fuel lances that introduce fuel throughout the kiln into direct contact with the limestone feed. Vertical lime kilns lack the traditional primary burner that is used in rotary kilns, so it is incompatible with the design of the vertical kiln to employ a NO<sub>x</sub> control strategy that manipulates combustion conditions at the primary burner and also adds a secondary burner system. Therefore, MKF is technically infeasible for the proposed vertical kilns.

(8) Water or Steam Injection. In various industrial applications, such as combustion turbines, water or steam is injected into the primary combustion zone to reduce combustion temperatures, which limits the formation of NO<sub>x</sub>. As described above, the proposed vertical kilns do not use traditional burners and the fuel is combusted in direct contact with the limestone feed. The injection of water or steam into the fuel and limestone mixture would adversely affect the calcining process. Therefore, water or steam injection is technically infeasible for the proposed vertical kilns.

(9) Mixing Air Fans and Air Staging. Mixing air fans are used in certain applications to ensure proper mixing within the combustion chamber, which prevents gas stratification within the combustion chamber. Air staging involves manipulation of the oxygen content within the primary combustion zone (less oxygen) and secondary combustion zone (more oxygen). As described above, the proposed vertical kilns do not use traditional burners and the fuel is combusted in direct contact with the limestone feed. The presence of the solid limestone in the combustion chamber would inhibit the proper operation of either mixing air fans or air staging. Therefore, both of these NO<sub>x</sub> control options are technically infeasible for the proposed vertical kilns.

(10) Clean Fuels. It is generally recognized that natural gas results in less formation of NO<sub>x</sub> than solid fuels such as coal and petcoke. In this specific application, however, the sulfur content of the fuel impacts the final lime product. Higher sulfur fuels (such as coal and petcoke) produce a lime with greater sulfur content, while lower sulfur fuels (such as natural gas) produce a lime with a much lower sulfur content that has food grade and metallurgical uses. Therefore, limiting the choice of fuels for the vertical lime kilns would limit the Company's operational flexibility (if natural gas becomes temporarily unavailable for any reason), increase its operating costs (natural gas usually costs more than coal or petcoke), and ultimately affect the lime product to be sold (by impacting the sulfur content of the lime), all of which would serve to redefine the source. A BACT option that redefines the source must be rejected.

To be conservative, Carmeuse nonetheless estimated the incremental cost of using solely natural gas instead of coal or petcoke. The Company estimates that the exclusive use of natural gas would cost approximately \$20,000 per ton of NO<sub>x</sub> avoided. Accordingly, even if this fuel restriction could be considered as potential BACT, it would be economically infeasible because it far exceeds the control costs borne by other sources for NO<sub>x</sub> control in attainment areas in Virginia.

(11) Efficient Kiln Design. As compared to the rotary lime kiln design that has been the industry standard throughout the U.S. for decades, the proposed vertical lime kilns have a far greater thermal efficiency. This results in 30 to 45 percent less fuel usage per ton of lime produced, and this lower fuel usage yields a corresponding reduction in the amount of NO<sub>x</sub> that is formed per ton of lime produced. Moreover, as described above, the fuel is combusted in direct contact with the limestone feed, which results in lower combustion temperatures that result in the formation of less NO<sub>x</sub>.

Proper kiln design is listed as BACT for NO<sub>x</sub> in the RBLC for many rotary lime kilns and it is even more appropriate as BACT for vertical lime kilns due to their inherent low-NO<sub>x</sub> properties. Because Carmeuse defines its project as the vertical lime kilns, no cost analysis is necessary for this option as the potential BACT for NO<sub>x</sub>. Carmeuse proposes efficient kiln design – specifically consisting of the use of vertical lime kilns – as part of the BACT determination for NO<sub>x</sub>. DEQ agrees that proper kiln design is an element of NO<sub>x</sub> BACT for this project.

(12) Good Combustion Practices. Good combustion practices include the feeding of fuels and air into the combustion chamber in the proper amounts and proportions; homogenization of fuels and limestone feed; the use of appropriate sensors and computer controls. Good combustion practices is listed as BACT for NO<sub>x</sub> in the RBLC for many rotary lime kilns. Carmeuse proposes good combustion practices as part of the BACT determination for NO<sub>x</sub>. DEQ agrees that good combustion practices is an element of NO<sub>x</sub> BACT for this project.

**NO<sub>x</sub> BACT Determination:** Among the twelve potential NO<sub>x</sub> control options evaluated, only two are both technically and economically feasible: efficient kiln design and good combustion practices. DEQ's BACT determination for NO<sub>x</sub> is the required use of an efficient kiln design – specifically the proposed vertical, dual chamber configuration – and good combustion practices. BACT includes a permitted emission rate of 46.95 lb NO<sub>x</sub> per hour when burning solid fuel (coal or petcoke), which is equivalent to 2.13 lb/ton of lime produced.<sup>10</sup> As described in section III.A. above, these values are based on the European standard of 350 mg/nm<sup>3</sup>. When burning natural gas, a lower limit of 22.83 lb/hr applies, which is equivalent to 1.04 lb/ton of lime produced. Compliance shall be demonstrated through periodic stack testing using approved methods.

#### Sulfur Dioxide (SO<sub>2</sub>) Control

The lime manufacturing process results in the formation of SO<sub>2</sub> from two sources: the combustion of fuel that contains sulfur and from the presence of small amounts of sulfur within the limestone feed. Sulfur present within the kiln will be oxidized to SO<sub>2</sub> due to the high temperature and the presence of oxygen necessary for combustion.

Carmeuse identified seven control mechanisms or technologies to reduce SO<sub>2</sub> emissions from the proposed kilns:

1. Inherent Dry Scrubbing (95% - base case)
2. Wet Scrubbing (98%)
3. Semi-Wet Scrubbing (Spray Dry Absorber) (90%)
4. Dry Sorbent Injection (DSI) (90%)
5. Lower Sulfur Fuels (varies)
6. Increased Oxygen
7. Catalytic Ceramic Filter Media (CCFM)

<sup>10</sup> By way of comparison, the NO<sub>x</sub> emission limit for the vertical kiln in Texas is 75 lb/hr (the limit for the Pennsylvania vertical kiln is much lower (7.9 lb/hr) because it fires only natural gas).

(1) Inherent Dry Scrubbing. In all lime kilns, some of the sulfur present in the kiln is removed through chemical reactions that naturally occur within the kiln. Calcium present in the limestone feed and lime product reacts with sulfur (whether from the limestone or the fuel) and oxygen (which is necessary for combustion of the fuel) to form calcium sulfite ( $\text{CaSO}_3$ ) and/or calcium sulfate ( $\text{CaSO}_4$ ). Both of these compounds are solids that become entrained with the lime product and/or are removed from the flue gas stream by the fabric filter baghouse that is used to control particulate matter (PM/PM-10/PM-2.5) emissions from each kiln.

Carmeuse states that modern parallel flow regenerative lime kilns such as the proposed design achieve 95% removal of  $\text{SO}_2$  through inherent dry scrubbing. Since this removal occurs naturally (or inherently) within the kiln during the lime production process, no add-on equipment is necessary and no additional expense is incurred (beyond the normal lime production expense). Therefore, inherent dry scrubbing is both technically feasible and economically feasible. Carmeuse suggests that 95% removal of  $\text{SO}_2$  via inherent dry scrubbing is the base case against which all other options must be compared. In other words, the baseline for assessing the economic feasibility of all other  $\text{SO}_2$  control options should be the 5% of the  $\text{SO}_2$  that actually exits the kilns, as opposed to the 100% of the  $\text{SO}_2$  that is theoretically present within the kilns because the inherent dry scrubbing cannot be removed or turned off. DEQ agrees with this position.

(2) Wet Scrubbing. A wet scrubber is a large reactor vessel that uses an alkaline reagent (generally a limestone or lime slurry) to oxidize  $\text{SO}_2$  to a calcium sulfate sludge. The reagent is sprayed from nozzles near the top of the vessel and falls downward due to gravity. Exhaust gases enter the vessel from the bottom and exit at the top in order to maximize interaction between the reagent and the  $\text{SO}_2$ . The calcium sulfate sludge is removed from the bottom of the vessel. Note that this is essentially the same process that will already occur within the proposed lime kilns due to the inherent dry scrubbing described above, except that wet scrubbing adds water to the lime/limestone reagent.

Wet scrubbers are commonly used to reduce  $\text{SO}_2$  emissions from large sources of sulfur dioxide such as coal-fired boilers. They can achieve up to 98% removal of  $\text{SO}_2$ . This technology is readily available and has been demonstrated in the field, and there are no

known technological limitations that would preclude its use on a lime kiln. Therefore, it is technically feasible to add a wet scrubber to the proposed lime kilns.

Using the inherent dry scrubbing as a baseline, the “uncontrolled” emissions of SO<sub>2</sub> from each kiln will be 102 tpy. Carmeuse provided cost calculations for wet scrubbing in Table D-8.1 of its application. Assuming 95% control of the 102 tpy of SO<sub>2</sub> emissions from each kiln, wet scrubbing is estimated to cost approximately \$10,000 per ton of SO<sub>2</sub> removed. This cost far exceeds the control costs borne by other sources for SO<sub>2</sub> control in Virginia. Consequently, wet scrubbing is economically infeasible for the proposed kilns.

(3) Semi-Wet Scrubbing (Spray Dry Absorber or Lime Spray Drying). A spray dry absorber also uses a large reactor vessel. A moist (i.e., semi-wet) sorbent – usually lime or calcium hydroxide – is injected into the reactor. Heat from the exhaust gases evaporates the water from the sorbent, and the sorbent’s solid surfaces react with the SO<sub>2</sub>. Dry calcium sulfate is produced, which is removed from the exhaust gases by a baghouse.

Spray dry absorbers have been used in various industrial applications. This technology is readily available and has been demonstrated in the field, and there are no known technological limitations that would preclude its use on a lime kiln. Therefore, it is technically feasible to add a spray dry absorber to the proposed lime kilns.

Carmeuse provided cost calculations for a spray dry absorber in Table D-9.1 of its application. Assuming 90% control of the 102 tpy of SO<sub>2</sub> emissions from each kiln, a spray dry absorber is estimated to cost about \$10,900 per ton of SO<sub>2</sub> removed. This cost far exceeds the control costs borne by other sources for SO<sub>2</sub> control in Virginia. Consequently, a spray dry absorber is economically infeasible for the proposed kilns.

(4) Dry Sorbent Injection (DSI). A dry sorbent injection (DSI) system directly injects a fine powder of dry sorbent into the flue gas stream. Hydrated lime is a commonly used sorbent. This alkaline sorbent readily reacts with acid gases such as H<sub>2</sub>SO<sub>4</sub>, HCl, and HF. By optimizing the injection temperature and moisture content, DSI can also effectively remove SO<sub>2</sub> as well. The dry reaction products are removed by a particulate matter collector (which is the baghouse for the proposed lime kilns).

DSI has been used in various industrial applications since the late 1980s. This technology is readily available and has been demonstrated in the field, and there are no known technological limitations that would preclude its use on a lime kiln. Therefore, it is technically feasible to add a spray dry absorber to the proposed lime kilns.

Carmeuse and DEQ have not been able to identify an application of DSI to a lime kiln. Because the temperature profiles for vertical lime kiln exhaust are different than for utility and industrial boilers, it is not known what level of SO<sub>2</sub> control could be achieved if DSI was to be applied to the proposed kilns. However, even aggressively assuming 90% SO<sub>2</sub> removal, Carmeuse calculates that DSI would cost approximately \$7,500 per ton of SO<sub>2</sub> removed (and a more conservative estimate of 50% removal yields a cost of \$13,500/ton). This cost far exceeds the control costs borne by other sources for SO<sub>2</sub> control in Virginia. Consequently, a DSI is economically infeasible for the proposed kilns, even under the best-case assumption described above.

(5) Lower Sulfur Fuels. As described previously, the sulfur that is oxidized to SO<sub>2</sub> in a lime kiln comes from both the limestone feed and the fuel that is combusted in the kiln. By reducing the sulfur content of the fuel(s) used in a kiln, SO<sub>2</sub> emissions will be reduced as well (although not necessarily linearly). Since natural gas has a very low sulfur content, only coal and petcoke are evaluated here.

**Coal:** Carmeuse has requested authorization to burn coal with a sulfur content of up to 3.0%. However, the existing rotary lime kiln at the Winchester facility (which will be removed as part of the proposed project) is permitted to burn only 1.9% sulfur coal, and the rotary lime kiln at Carmeuse's Strasburg, Virginia facility is permitted to burn coal with only 1.0% sulfur. Carmeuse asserts that while the burners in these two rotary kilns can handle the lower sulfur coals, the fuel lances in the proposed vertical kilns would be frequently plugged by the same fuel because the lower sulfur coal has a high free swelling index (FSI).

As described previously, the proposed vertical lime kilns have a fundamentally different design from traditional rotary lime kilns. A rotary kiln has a large, mostly open combustion chamber, and fuel is delivered by traditional burners and the fuel is combusted over the limestone feed. In contrast, in a vertical kiln the fuel and limestone are intermixed and fuel is delivered by 28 fuel lances

spaced throughout the kiln. The European experience, where vertical lime kilns are common, has been that solid fuel with an FSI greater than 1.5 can plug the fuel lances, which prevents fuel from entering the kiln through that lance. Although the physical and/or chemical processes that cause solid fuels with a higher FSI to plug fuel lances are not yet understood, the various vertical kiln manufacturers recommend an FSI limit of 1.5, and to Carmeuse's knowledge, the European lime industry complies with this recommendation. By way of comparison, low-sulfur, bituminous coal from the eastern U.S. typically has a FSI of about 7.0, while the FSI of petcoke is typically around 1.0.

In fact, no Eastern coals have the requisite FSI regardless of their sulfur content. Instead, Carmeuse will need to obtain coal with the requisite FSI from Colorado, which is the only known source of coal in the U.S. with the necessary FSI. While this coal generally has a low sulfur content – typically less than 1% - there is variability between mines and even between coal seams within the same mine, with some sources approaching 3% sulfur content. Accordingly, Carmeuse has requested a 3% coal sulfur content limit. Based on the limited availability of coal with the requisite FSI in the U.S., DEQ agrees that it is technically infeasible to mandate the use of coal with less than 3% sulfur. However, based on historic data for this Colorado coal, both DEQ and Carmeuse expect that coal shipments will usually be closer to 1% sulfur than to 3% sulfur.

**Petcoke:** Petroleum coke is a bottom product of the petroleum refining process. The sulfur content of petcoke is dependent on the sulfur content of the crude oil being refined. Since the crude oil content usually varies over some range, petcoke sulfur content from a given refinery is usually expressed as a range. Petcoke that is readily available will have between 5% and 7% sulfur.

One reliable source of lower sulfur petcoke was known – a refinery located in Bakersfield, California. This petcoke consistently contained less than 4% sulfur. However, that refinery is currently idled, and it is not known when – or if – the refinery will resume operations. Consequently, since lower sulfur petcoke is currently unavailable, it is technically infeasible for the proposed kilns.

(6) Increased Oxygen. Increasing oxygen levels in the kilns would convert  $\text{SO}_2$  to  $\text{SO}_3$ , which in turn reacts with the lime being produced in the kiln to yield  $\text{CaSO}_4$ . The solid calcium sulfate is then incorporated into the lime product. Calcium sulfate is an

impurity in the lime that many customers do not want. Therefore, increased oxygen is technically infeasible for lime kilns because it degrades the quality of the product. In addition, increasing oxygen levels in the kilns would have an adverse environmental impact by increasing the formation of  $\text{NO}_x$ .

(7) Catalytic Ceramic Filter Media (CCFM). Ceramic filter media with embedded nano-sized catalysts have recently been introduced into the air pollution control field. This catalytic ceramic filter media can remove  $\text{SO}_2$ ,  $\text{NO}_x$ , and PM. CCFM has not yet been implemented on any lime kilns. Although this newer technology has been implemented only on waste incinerators and glass furnaces to date, Carmeuse has not demonstrated that catalytic ceramic filter media is technically infeasible for its proposed vertical lime kilns.

With CCFM,  $\text{SO}_2$  control is achieved via sorbent injection prior to the filters. This is essentially the same mechanism as DSI, so the cost for  $\text{SO}_2$  removal via CCFM will also be roughly the same. As discussed in option 4 above, DSI has been determined to be economically infeasible; therefore, CCFM is similarly economically infeasible for  $\text{SO}_2$  removal.

Since CCFM can also remove  $\text{NO}_x$  and PM, DEQ requested Carmeuse to assess the costs of removing all three pollutants via CCFM. Because the kilns will be equipped with baghouses, for PM-2.5 control, and the baghouses will remove 99.9% of the PM-2.5, it is assumed that no significant additional PM-2.5 would be removed via CCFM. To achieve  $\text{NO}_x$  control via CCFM, the exhaust gas would require reheating to reach the temperature required for catalytic oxidation of  $\text{NO}_x$ . Based solely on the cost of natural gas for reheating – and not accounting for the costs of ammonia or catalyst replacement – Carmeuse estimates that CCFM would cost at least \$16,000 per ton of  $\text{SO}_2$  and  $\text{NO}_x$  removed. This cost far exceeds the control costs borne by other sources for  $\text{SO}_2$  or  $\text{NO}_x$  control in Virginia. Consequently, CCFM is economically infeasible for the proposed kilns even when considering its control of both pollutants.

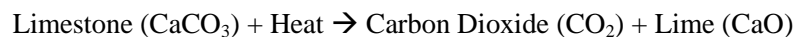
**$\text{SO}_2$  BACT determination:** Seven different options/control technologies for  $\text{SO}_2$  removal have been considered. The inherent dry scrubbing that naturally occurs during the lime production process – which cannot be turned off or removed – will eliminate approximately 95% of the  $\text{SO}_2$  emissions from the kilns. Largely because only 5% of the  $\text{SO}_2$  remains in the exhaust stream, all of



the other control options considered are economically infeasible. DEQ's BACT determination for SO<sub>2</sub> is 95% removal via inherent dry scrubbing. BACT includes a permitted emission rate of 28.60 lb SO<sub>2</sub> per hour when burning solid fuel (coal or petcoke), which is equivalent to 1.30 lb/ton of lime produced.<sup>11</sup> When burning natural gas, a much lower limit of 1.32 lb/hr applies, which is equivalent to 0.06 lb/ton of lime produced. Compliance will be monitored through the use of a CEMS for SO<sub>2</sub> and through the annual stack testing requirements established in the permit using approved methods.

#### GHG Control - CO<sub>2</sub>

Carbon dioxide is a greenhouse gas (GHG) that is generated by the kilns from both the combustion of fuels and from the calcination process. Because of the additional generation of CO<sub>2</sub> from the conversion of limestone into lime, lime kilns generate more CO<sub>2</sub> per unit of fuel consumed as compared to other processes that utilize solid fuels such as coal and petcoke:



Carmeuse included CO<sub>2</sub> in its BACT analysis for GHG. Carmeuse identified the following four potential control technologies or strategies for CO<sub>2</sub>:

1. Carbon capture and storage (CCS);
2. Low carbon fuel;
3. Efficient kiln design technology; and
4. Efficiency improvement strategies.

(1) Carbon Capture and Storage: CCS involves the separation and capture of CO<sub>2</sub> emissions from the flue gas; pressurization and perhaps short-term storage of the CO<sub>2</sub>; transportation of the CO<sub>2</sub> via pipeline; and an end-use or ultimate disposal option (such as injection into underground reservoirs). Carmeuse determined that CCS is technically infeasible for the vertical kilns for two reasons. First, CO<sub>2</sub> is present in the flue gas at atmospheric pressure and low concentration, which means that a high volume of flue gas needs to be treated relative to the amount of CO<sub>2</sub> available.

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<sup>11</sup> By way of comparison, the SO<sub>2</sub> emission limit for the Pennsylvania vertical kiln is moderately lower at 23.0 lb/hr and 0.8 lb/ton of lime; however, this kiln is permitted to fire only natural gas. For unknown reasons, EPA's RBLC does not provide SO<sub>2</sub> emission limits for Chemical Lime's vertical kiln in Texas.

Moreover, substantial energy would be required to compress the CO<sub>2</sub> for transport and to generate steam to regenerate the capture solvent, which would result in increased CO<sub>2</sub> emissions at the power source (whether onsite or at an electric utility). Second, there are neither CO<sub>2</sub> pipelines, end-users, nor geologic storage formations within a reasonable distance from the Winchester facility. In addition, Carmeuse notes that CCS has not been implemented on a lime kiln or similar facility to date. For these reasons, Carmeuse contends that CCS is technically infeasible for its proposed project.

However, in the event that it was determined by DEQ or EPA that CCS is technically feasible for its proposed project, Carmeuse also conducted an economic analysis of CCS. One of the technical limitations cited by Carmeuse is the lack of a pipeline, end-user, or permanent storage option within a reasonable distance of the facility. This same issue can also be presented as an economic limitation, because a new CO<sub>2</sub> pipeline could be constructed by, or on behalf of, Carmeuse. The Company observes that the nearest existing CO<sub>2</sub> pipeline is located near Jackson, Mississippi, and Carmeuse conservatively estimates that it would cost at least \$430 million to construct a new pipeline to connect with that one. With the maximum captured CO<sub>2</sub> estimated to be approximately 327,705 tpy, this works out to about \$1,313 per ton. By way of comparison, in one recent case from North Dakota EPA agreed that a cost of approximately \$30/ton was not economically feasible for CCS. Carmeuse also states that this cost is “significantly higher” than the total cost of its proposed project. For these reasons, Carmeuse asserts that CCS is economically infeasible.

Based on the foregoing, DEQ agrees that CCS is economically infeasible for the proposed vertical lime kilns at Carmeuse’s Winchester facility.

(2) Lowest Carbon Fuel: Different fuels produce varying amounts of CO<sub>2</sub>, with solid fuels such as coal/petcoke generally producing the most, and gaseous fuels such as natural gas generally producing the least. Therefore, requiring the use of natural gas in lieu of coal and petcoke would reduce CO<sub>2</sub> emissions.

Carmeuse has proposed the use of multiple fuels – coal/petcoke and natural gas – in order to provide flexibility for producing lime at the lowest cost possible in consideration of constantly changing energy markets and because the sulfur content affects the quality of the lime product and in some applications higher sulfur is

desirable. Consequently, Carmeuse asserts that limiting the vertical kilns to only natural gas in order to reduce emissions would constitute an impermissible redefining of the source.

However, in the event that it was determined by DEQ or EPA that a fuel restriction could constitute BACT for its proposed project, Carmeuse provided an economic analysis of the use of natural gas as compared to coal/petcoke. The Company calculates that the cost of replacing coal/petcoke with natural gas is approximately \$80/ton of CO<sub>2</sub>e. Carmeuse asserts that this cost renders this option economically infeasible even taking into account the superior fuel efficiency of the vertical kiln design.

DEQ agrees that BACT does not require Carmeuse to select one fuel over other available alternatives, given the company's intent to produce multiple grades of lime having different sulfur content. DEQ also agrees that the estimated cost of the fuel restriction of \$80/ton of CO<sub>2</sub>e is economically infeasible. Accordingly, and for both reasons, DEQ rejects fuel restrictions as an element of BACT.

(3) Efficient Kiln Design: Carmeuse includes efficient kiln design as one element of its BACT analysis for CO<sub>2</sub>. As compared to rotary lime kilns (such as the existing unit that is being replaced), vertical lime kilns have a higher thermal efficiency due to the dual chamber design and resulting preheating of the limestone by the exhaust gases from the other chamber. This higher thermal efficiency results in 30 to 45 percent lower fuel use, which reduces emissions of all products of combustion, including CO<sub>2</sub>. Carmeuse asserts that efficient kiln design should be an element of the BACT determination for CO<sub>2</sub>. No cost analysis was provided because the efficient kiln design is inherent in the proposed vertical kilns.

DEQ recognizes and agrees that the vertical kiln design is more efficient than the existing rotary kiln and therefore has lower CO<sub>2</sub> emissions on a unit of production basis. As described above, efficient kiln design has been an element of the NO<sub>x</sub> BACT determination for several lime kilns, and is also part of the NO<sub>x</sub> BACT determination for this project. As CO<sub>2</sub> BACT determinations become more frequent, DEQ expects that efficient kiln design will be a common element of CO<sub>2</sub> BACT determinations.

Accordingly, DEQ agrees that efficient kiln design is an element of the BACT determination for CO<sub>2</sub>.

(4) Energy Efficiency Improvements: The last potential BACT element identified by Carmeuse is the implementation of various energy efficiency measures with the kilns. Any action that increases the energy efficiency of the kilns will reduce the amount of fuel used in the kilns, which will reduce CO<sub>2</sub> emissions.

Carmeuse identified the following energy efficiency measures that can be implemented with its proposed vertical kilns:

- Routine inspection and maintenance of the kilns and auxiliary equipment in accordance with the manufacturer's recommendations;
- Appropriate instrumentation and control devices to monitor and control the combustion process (combustion and cooling air is metered into the process in exact amounts with positive displacement blowers; fuel and stone are also metered in precise amounts into the kiln through weigh vessels; and a computer controls each combustion cycle exactly);
- Maximize insulation of the kilns to minimize heat loss; and
- Flue gas heat recovery by routing exhaust gases from the active chamber through the adjacent chamber to preheat the limestone.

Carmeuse proposes to implement all four of these strategies as BACT for CO<sub>2</sub>. Carmeuse accepts that these strategies are economically feasible; therefore, it did not provide a cost analysis of these strategies. Compliance with these four strategies will be demonstrated through recording of operating conditions, inspections, and kiln design.

DEQ agrees that the four energy efficiency measures identified by Carmeuse constitute the other element of BACT for CO<sub>2</sub>.

#### GHG Control – Methane

Methane (CH<sub>4</sub>) is a product of combustion of the solid fuels used for the vertical kilns, and it is a potent greenhouse gas. Methane is present in the flue gas in significant concentrations only when incomplete combustion is occurring. In addition, when natural gas – which consists primarily of methane – is used, the presence of significant methane concentrations in the flue gas can also indicate that excess fuel is being provided to the kilns.

In light of the low concentrations of methane that are expected from the kilns, there are only two control techniques available to minimize methane emissions. One is to enhance the energy efficiency of the kilns in order to reduce the amount of fuel used per unit of lime produced. The other is to employ good combustion practices to ensure that complete combustion occurs within the kilns.<sup>12</sup>

As described above, five energy efficiency measures are being required in order to reduce the generation of fuel-based CO<sub>2</sub>. These same measures will also serve to limit methane formation by reducing the amount of fuel consumed. Also as described above, various measures are being required to ensure complete combustion in order to minimize the formation of CO. These same measures will also serve to limit methane emissions by ensuring that nearly all methane present is combusted (oxidized). Accordingly, BACT for methane consists of the energy efficiency measures that are required as BACT for CO<sub>2</sub>, and the good combustion practices that are required as BACT for CO.

#### GHG Control – N<sub>2</sub>O

Nitrous oxide (N<sub>2</sub>O) is a product of combustion of the fuels used for the vertical kilns, and it is a potent greenhouse gas. N<sub>2</sub>O is present in the flue gas in significant concentrations only when incomplete combustion is occurring.

The two control strategies available for methane – energy efficiency measures and good combustion practices – are also available for N<sub>2</sub>O. While N<sub>2</sub>O catalysts are used at nitric acid production plants, the N<sub>2</sub>O concentrations are much higher in that industry. The N<sub>2</sub>O catalysts would not operate effectively at the very low N<sub>2</sub>O concentrations expected in the vertical kiln flue gas (rendering this option technically infeasible), and the catalyst system would not be cost effective at these very low concentrations (rendering this option economically infeasible as well). Accordingly, BACT for N<sub>2</sub>O consists of the energy efficiency measures that are required as BACT for CO<sub>2</sub>, and the good combustion practices that are required as BACT for CO.

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<sup>12</sup> The addition of a secondary combustion chamber, afterburner, or flare would also reduce methane emissions, but these control strategies are employed only for much higher methane concentrations than are expected from the vertical kilns. Moreover, the fuel required for any of these options would produce additional GHG emissions exceeding the amount of methane that would be eliminated.

GHG Control - Overall

Based on the foregoing BACT determinations for the three individual GHGs, the permit includes two conditions that limit GHG emissions from the vertical kilns. Condition 27 establishes an annual emission limit for all GHGs emitted from the kilns of 362,010 tpy, expressed as carbon dioxide equivalents (CO<sub>2</sub>e). Condition 28 establishes a fuel usage limitation of 3.65 MMBtu (HHV) of fuel per ton of lime produced.

Startup & Shutdown Emissions – All Pollutants

Due to their highly effective insulation and pressurized state, the proposed vertical lime kilns can be maintained at or close to their operating temperature for several days with little or no fuel firing. Consequently, these kilns will not experience traditional shutdown and startup conditions whenever there is a short-term suspension of lime production. Instead, traditional shutdown and startup conditions will occur only when the kilns are taken offline for significant maintenance. Carmeuse conservatively estimates that this will occur only once per year, and last for no more than eight days.

During cold starts, Carmeuse proposes that natural gas will be used until the kilns are brought up to their proper operating temperature, at which time coal/petcoke may be used (or natural gas use can continue). The baghouse will operate during startup and shutdown conditions, and its effectiveness is not dependent on temperature or any other conditions that may be different during startup/shutdown as compared to normal operations. Moreover, as described above, no other add-on controls are required for the kilns, so there is no other pollution control equipment that could be affected by startup/shutdown conditions.

When calculating annual emissions for this project, Carmeuse assumed 357 days of operation at maximum capacity firing coal/petcoke (the worst-case fuel), with the remaining eight days of the year burning natural gas during startup/shutdown conditions (although in reality little or no fuel will be fired during the shutdown portion of this time).

DEQ agrees that Carmeuse properly addressed startup and shutdown conditions in its emissions calculations for these emission units. DEQ agrees with Carmeuse's proposal that BACT

for cold start conditions is the use of only natural gas as a fuel until the kilns reach their normal operating temperature, which is required by Condition 21. The short-term emission limits based on natural gas firing that are specified in Condition 25 shall apply during cold starts.

### **Diesel Emergency Generator**

The proposed new 200-hp diesel-fired emergency generator (manufactured in 2012 or 2013) is classified as new emergency compression ignition (CI) engine under federal regulations. The new emergency generator will be operated only during interruptions in the normal electrical power supply to the facility and for maintenance, testing, and operator training. When the normal electric supply is not available, the emergency generator will operate ancillary equipment to maintain safety of the system and personnel.

The new engine is subject to NSPS Subpart IIII and MACT Subpart ZZZZ. The emissions calculations for the generators are based on those applicable emission limits.

Emission limits apply for NO<sub>x</sub> (along with nonmethane hydrocarbons), CO, and PM. There is no emission limit for SO<sub>2</sub> because the fuel sulfur content limit of 15 ppm (per 40 CFR 60.4027(b) and 40 CFR 80.510(b)) effectively limits SO<sub>2</sub> emissions to extremely low levels.

The emergency generator is limited to 100 hours per year for testing and maintenance under the federal regulations, and to no more than 500 hours of total operation per year by DEQ requirements for emergency generators. Emissions calculations for the emergency generator are based on 500 hours of operation per year, but actual usage – and therefore emissions – is expected to be far less than that.

Carmeuse proposes that the NSPS/MACT standards described above constitute BACT for the emergency generator that it proposes to add to the facility. In light of the limited operation of the emergency generator (no more than 500 hours per year, but usually significantly less), DEQ agrees that the applicable NSPS/MACT standards constitute BACT for this unit.

### **Solid Fuel Dryer**

The proposed project includes a small heater to dry the solid fuels prior to milling. This unit has a heat input rating of 3.5 MMBtu/hr and will fire only natural gas. Emissions from the dryer, including the flue gas from combustion, will be routed to a dedicated baghouse to control PM.

Fuel-burning units firing natural gas with a heat input rating less than or equal to 50 MMBtu/hr are exempt from DEQ's minor NSR permitting regulations per 9 VAC 5-80-1320 B.1.d. The proposed dryer is well below this permitting threshold and its maximum emissions are very low: 1.25 tpy CO and 0.75 tpy NO<sub>x</sub>. However, this unit is subject to PSD permitting.

Carmeuse proposes BACT to consist of limiting the approved fuel to natural gas and the use of good combustion practices. In light of the small size and limited emissions from this unit, DEQ agrees that BACT for this unit consists of the suggested fuel limitation, good combustion practices, and the use of a dedicated baghouse to control PM/PM-10/PM-2.5.

### **Materials Processing and Handling Equipment**

The proposed project includes numerous new and modified materials processing and handling emission units that will produce PM/PM-10/PM-2.5 emissions. These units consist of point sources such as crushers, screens, enclosed conveyors, enclosed transfer points, and storage bins, as well as fugitive sources such as storage piles, open conveyors, open transfer points, and roads. Emissions result from the processing and handling of the raw material (limestone), solid fuels (coal and petcoke), and the product (lime).

NSPS Subpart OOO applies to many of the proposed new and modified materials processing and handling emission units, which are listed in Table 4-1 in the application. (Subpart OOO also applies to many of the existing materials processing and handling units that are not being modified.) The emission units subject to Subpart OOO (its "affected facilities") are crushers, grinding mills, screening operations, bucket elevators, belt conveyors, storage bins, and enclosed loading stations.

Subpart OOO imposes an emission limit for PM/PM-10/PM-2.5 of 0.014 gr/dscf for all point sources and all other affected facilities



that are fitted with an emissions capture system. Affected facilities that are fugitive sources are subject only to a 7% opacity limit, except for crushers, for which the limit is 12%. Subpart AAAAA, which applies to some of the same limestone materials processing and handling equipment covered by Subpart OOO, provides similar requirements.

For point sources, Carmeuse has proposed as BACT the use of fabric filters with emission limits of 0.010 gr/dscf for PM/PM-10 and 0.004 gr/dscf for PM-2.5. For fugitive sources, Carmeuse has proposed wet suppression and an opacity limit of 7% (12% for crushers). Since these controls meet or exceed Subpart OOO and Subpart AAAAA requirements and represent the state of the art for materials processing and handling emission units, DEQ agrees that these controls and emission limits constitute BACT for the materials processing and handling units.

### **Roadways**

Unpaved roads can be a significant source of PM, PM-10, and PM-2.5 emissions. Paving of roadways is the most effective control available. Because the modeling results for PM-2.5 are very close to the NAAQS, Condition 92 of the permit requires that roads and operational areas of the facility that are subject to high lime product truck traffic be paved. At a minimum, all areas that were designated as paved in the PM-2.5 modeling must be paved.

#### 3. LAER

LAER applies only in nonattainment areas. Because the site of the proposed facility is attainment or unclassified for all pollutants, LAER does not apply. However, in accordance with the 1990 Draft PSD Workshop Manual, LAER technologies have been included as the most stringent technologies in the top-down BACT review.

#### 4. NESHAP (40 CFR Part 61)

National Emission Standards for Hazardous Air Pollutants (NESHAP), found at 40 CFR 61, regulate emissions of specific HAPs from a limited number of source categories. 40 CFR 61 standards are incorporated by reference into Virginia Regulations at 9 VAC 5 Chapter 60, Part II, Article 1 (Rule 6-1). None of these Part 61 regulations apply to lime kilns or the other emissions units proposed by Carmeuse.

5. RACT

Reasonably Available Control Technology (RACT) standards apply only in nonattainment areas. Because the site of the proposed facility is attainment or unclassified for all pollutants, RACT does not apply.

6. MACT (40 CFR Part 63)

Maximum Achievable Control Technology (MACT) standards, found at 40 CFR 63, designate emission standards for HAPs from specific source categories. 40 CFR 63 standards are incorporated by reference into Virginia Regulations at 9 VAC 5 Chapter 60, Part II, Article 2 (Rule 6-2).

- *40 CFR 63 Subpart AAAAA, National Emissions Standards for HAPs for Lime Manufacturing Plants*

The Lime MACT was promulgated on January 5, 2004 and applies to lime manufacturing plants that are major sources for HAP. Per Table B.4-2 of the application, the PTE for the HAP hydrochloric acid (HCl) is 24.5 tpy, and for the HAP hydrofluoric acid (HF) is 3.1 tpy (for both kilns combined). Therefore, the potential HAP emissions from the proposed vertical kilns exceed both major source thresholds for HAPs, i.e., 10 tpy of a single HAP (24.5 tpy of HCl) and 25 tpy of all HAPs combined (27.6 tpy of HCl and HF (which does not include any HAP metals)). Accordingly, the proposed new vertical kilns and associated emission units are subject to the Lime Manufacturing Plant MACT.

The Lime MACT imposes an emission limit for PM of 0.10 lb PM per ton of feed to the kiln. (Note that PM is a more easily measured surrogate for the metal HAPs that are the subject of this regulation.) The Lime MACT also establishes PM and visible emissions requirements for certain processed stone handling (PSH) that generally are consistent with the NSPS Subpart OOO requirements that are described below.

“Processed stone” is defined as limestone “that has been processed to a size suitable for feeding into a lime kiln.” Subpart AAAAA does not include crushing activities, and begins with the first storage bin(s) or storage pile(s) containing limestone that is the proper size for feeding into the lime kiln. For this project, the last limestone crusher is roller crusher RC-110, and the subsequent storage piles are Pile3 and Pile4 (both

of which are called Limestone Kilne Feed). Therefore, the PSH equipment that is subject to Subpart AAAAA begins with conveyor BC-320 (which draws limestone from Pile3 and Pile4) and ends with the Skip Hoists (Ref. Nos. SK-350 and -360), which feed the limestone into the kilns.

- *40 CFR 63 Subpart ZZZZ, National Emissions Standards for HAPs for Stationary Reciprocating Internal Combustion Engines (RICE)*

The RICE MACT was promulgated June 15, 2004 and applies to stationary reciprocating internal combustion (IC) engines located at major and area sources of HAP emissions. Per 40 CFR 63.6590(c), stationary IC engines subject to Regulations under 40 CFR Part 60 can meet the requirements of Subpart ZZZZ by meeting the requirements of 40 CFR 60 Subpart IIII for compression ignition engines. As mentioned below, 40 CFR 60 Subpart IIII applies to the proposed IC engine and the applicable requirements from Subpart IIII have been included in the permit. Therefore, no further requirements from Subpart ZZZZ apply to the diesel emergency generator.

7. NSPS (40 CFR Part 60)

New Source Performance Standards (NSPS), found at 40 CFR 60, designate emission standards for criteria pollutants (a few regulate HAPs as well) from new emissions units at specific source categories. 40 CFR 60 standards are incorporated into Virginia Regulations at 9 VAC 5 Chapter 50, Part II, Article 5 (Rule 5-5).

There are NSPS that apply to the materials handling operations and to the emergency generator, as detailed below:

- *40 CFR 60 Subpart OOO (Standards of Performance for Nonmetallic Mineral Processing Plants)*

Subpart OOO applies to various materials processing and handling operations at nonmetallic mineral processing plants, such as crushers, grinding mills, screens, bucket elevators, belt conveyors, storage bins, and certain loading and unloading activities. Limestone is included in the definition of “nonmetallic mineral” set forth in 40 CFR 60.671. Much of the existing limestone processing and handling equipment at the facility is already subject to Subpart OOO, and much of the proposed new and modified limestone processing and handling

equipment is also subject to Subpart OOO. Table 4-1 in the application describes the 33 pieces of equipment (referred to as “affected facilities” in the regulation) that are subject to Subpart OOO.

Affected facilities that emit through a stack are subject to a PM emission limit of 0.014 gr/dscf. There are no opacity/visible emission limits for these affected facilities. Fabric filters are subject to various monitoring requirements, including quarterly 30-minute visible emissions inspections using EPA Method 22. Affected facilities that have fugitive emissions are subject to an opacity limit of 7 percent (12 percent for crushers).

- *40 CFR 60 Subpart IIII (Standards of Performance for Stationary Compression Ignition Internal Combustion Engines)*

Subpart IIII applies to stationary internal combustion (IC) engines with a displacement of less than 30 liters per cylinder where the model year is 2007 or later. The rule imposes emission standards on NO<sub>x</sub>, CO, and PM emissions based on the engine model year and engine use (emergency, fire pump, etc.). The subpart also requires engine owners and operators to use ultra-low sulfur fuel in the generators (distillate oil having no more than 0.0015% sulfur by weight). The applicable requirements for the new generator have been incorporated into the permit.

Since the new generator will meet the requirements of Subpart IIII, this unit does not have any further requirements under 40 CFR 63 Subpart ZZZZ (see above).

- *40 CFR 60 Subpart HH (Standards of Performance for Lime Manufacturing Plants)* is not applicable to the proposed vertical kilns because this regulation applies only to rotary lime kilns, per 40 CFR 60.340(a).
- *40 CFR 60 Subpart Kb (Standards of Performance for Volatile Organic Liquid Storage Vessels)* is not applicable to the 354-gallon diesel fuel storage tank that is incorporated into the base of the emergency electric generator unit (EG-2). Subpart Kb applies only to storage vessels having a capacity of at least 10,566.88 gallons (40 m<sup>3</sup>).
- *40 CFR 60 Subpart Y (Coal Preparation and Processing Plants)* is not applicable to the proposed coal/petcoke handling

operations. Per 40 CFR 60.250(a), Subpart Y applies to coal preparation and processing plants that process more than 200 tons of coal per day. Condition 60 of the draft permit limits coal/petcoke throughput to 168 tons per day (and 52,560 tpy), which avoids Subpart Y applicability.

8. State BACT (9 VAC 5-50-260)

Since PSD permitting is not triggered for VOC or SAM (see Table 7 above), emissions of these pollutants are not subject to the federal top-down BACT analysis. However, both pollutants are subject to the state BACT requirements provided in 9 VAC 5-50-260. The only appreciable sources of VOC and SAM are the two proposed vertical lime kilns.

Vertical Lime Kilns – Volatile Organic Compounds (VOC)

VOC emissions from this project are relatively low, at just 13.0 tpy from each vertical kiln and 26.4 tpy for all fuel-burning units (both kilns, the solid fuel dryer, and the emergency generator). The primary add-on control technology for VOC is thermal oxidation (also known as incineration). This control technology was evaluated above in the top-down PSD BACT analysis for carbon monoxide, and it has been determined to be economically infeasible with a cost of approximately \$12,000/ton to control 482 tpy of CO. Since the emissions of VOC are much lower than CO, the cost per ton to apply thermal oxidation to control VOC would be much higher, and therefore also economically infeasible.

The only other control strategy available for VOC in this application is the use of good combustion practices. Good combustion practices consist primarily of controlled fuel/air mixing, maintaining the proper combustion zone temperature, and providing adequate residence time. These practices can be used to maximize the destruction of VOC within the kilns, and it is technically feasible to implement them on the proposed vertical lime kilns. Good combustion practices are required for the control of CO, NO<sub>x</sub>, and methane based on the BACT analyses described above for those pollutants. DEQ determines that good combustion practices constitute state BACT for VOC.

Vertical Lime Kilns – Sulfuric Acid Mist (SAM or H<sub>2</sub>SO<sub>4</sub>)

A portion of the sulfur dioxide that is present in the kilns is converted to SAM, which itself is a criteria pollutant. While for

certain industries separate controls are appropriate for SAM, beyond what may be required for sulfur dioxide, DEQ is not aware of such controls being required for any lime kiln. Therefore, due to the low level of SAM emissions and the fact that sulfur dioxide and PM-2.5 are subject to PSD – and thus have undergone a top-down BACT analysis – DEQ determines that no additional controls or measures are required specifically for SAM in order to satisfy state BACT requirements.

9. State Toxics (9 VAC 5, Chapter 80, Article 7)

The two proposed vertical lime kilns are a significant source of toxic pollutants, primarily HCl and HF, as described in section III.B. above. However, the state air toxics regulations provided in Article 7 do not apply to the proposed vertical lime kilns because they are subject to federal air toxics regulations, specifically MACT Subpart AAAAA (as described in section IV.D.6 above).

## **V. Compliance Determination**

### **A. Stack testing requirements**

The permit requires initial performance testing (stack tests) for PM, PM-10 (filterable and condensable), PM-2.5 (filterable and condensable), NO<sub>x</sub>, SO<sub>2</sub>, and CO for both of the vertical kilns. Separate tests must be conducted when firing coal, petcoke, and natural gas, for a total of six initial compliance tests for each pollutant. These tests must be conducted within 60 days after each kiln achieves its maximum production rate burning each, and no later than 180 days after startup of burning each fuel in each kiln.

Subsequent performance tests will be required every year for each kiln when firing coal and when firing petcoke for a total of four separate tests, per Condition 34 of the permit. However, per Condition 35, whenever three consecutive stack tests are in compliance with the permitted emission limits (evaluated on a kiln-specific, fuel-specific, and pollutant-specific basis), then testing for that pollutant from that kiln when firing that specific fuel will be required only once every five years.

### **B. Visible emissions evaluations**

An initial visible emissions evaluation (VEE) is required concurrently with the initial performance testing for the two vertical kilns.

Subsequently, additional VEEs on one or both vertical kilns must be conducted upon request by DEQ.

Initial VEEs are required for the various materials handling units that are subject to Subparts OOO or AAAAA, as specified in the permit. These tests must be conducted within 60 days after the facility achieves its maximum production rate, and no later than 180 days after startup of the facility. Subsequent performance tests will be required upon request by DEQ.

**C. Fuel testing requirements**

The permit requires Carmeuse to obtain a certification from the fuel supplier for each shipment of coal and of petcoke to be used in the vertical kilns that specifies the heating value, sulfur content, and other relevant characteristics of the fuel. The permit also requires Carmeuse to obtain a certification from the fuel supplier for each shipment of distillate oil to be used in the emergency generator that specifies the sulfur content and that the fuel meets ASTM standards for No. 2 diesel fuel.

**D. Continuous Monitoring – COMS and CEMS**

The permit requires the use of a continuous opacity monitoring system (COMS) for each vertical kiln because of the use of a control device to reduce PM emissions. Condition 7 of the permit requires the COMS to be operated in accordance with 40 CFR Part 63, Subpart A (MACT General Provisions) and Performance Specification 1 of Appendix B to 40 CFR Part 60. The permit requires the use of a continuous emissions monitoring system (CEMS) for sulfur dioxide for each vertical kiln that will confirm the amount of “inherent scrubbing” that occurs within the kilns. Moreover, Carmeuse’s rotary kiln at its Strasburg facility has shown significant changes in sulfur dioxide emissions over time, and that unit now has CEMS for SO<sub>2</sub> in accordance with the Best Available Retrofit Technology (BART) permit for that unit. Requirements for the CEMS are provided in Conditions 8 through 10 of the permit. CEMS are not required for NO<sub>x</sub> or CO because there are no controls for these pollutants.

**E. Post-construction ambient monitoring requirements**

DEQ policy requires post-construction ambient monitoring whenever modeled concentrations of any criteria pollutant exceed 90% of the level of the applicable NAAQS. As described in section IV.C. above, Carmeuse’s modeling shows a PM-2.5 concentration of 11.99 ug/m<sup>3</sup>, as compared to the annual NAAQS of 12 ug/m<sup>3</sup>. This modeled

concentration is 99.9% of the NAAQS. Consequently, Carmeuse must perform post-construction monitoring of PM-2.5 to ensure that the NAAQS is not exceeded. The monitoring must be conducted for at least one year after normal operation of the vertical kilns is achieved. The post-construction monitoring requirements are specified in Condition 105 of the permit. Two monitors are required, and DEQ must approve Carmeuse's air quality monitoring protocol and plan.

## **F. Recordkeeping requirements**

The permit establishes extensive recordkeeping requirements in Conditions 106 (PSD) and 118 (minor NSR), which include:

- The monthly and annual production of lime;
- The hours of operation of each vertical kiln;
- The monthly and annual consumption of limestone;
- The annual throughput of lime;
- The monthly and annual throughput of fuels (coal, petcoke, natural gas, and distillate oil (diesel fuel));
- All fuel supplier certifications;
- COMS opacity data;
- CEMS sulfur dioxide data;
- Results of all performance tests and VEEs;
- Periodic visible emissions inspection results;
- Daily wet suppression spray systems results;
- Records related to startup, shutdown, and malfunction;
- Hours of operation of the emergency generator;
- A copy of the Dust Control Plan; and
- All records required by Subparts AAAAA and OOO.

The records must be available for DEQ inspection and maintained for five years.

## **VI. Public Participation**

### **A. Applicant Informational Briefing**

In accordance with Section 9 VAC 5-80-1775 C of the Regulations, the applicant held an informational briefing at 6:30 p.m. on June 26, 2012 at the Ruritan Building in Clear Brook. The briefing was advertised in the Winchester Star on May 2, 2012, which was within 30 days of Carmeuse receiving DEQ's ILOD (as required by 9 VAC 5-80-1775A). The informational briefing was held 55 days after publication of the notice (as



required by 9 VAC 5-80-1775C (which requires the briefing to be held at least 30 days but less than 60 days after publication of the notice)). Eight members of the public and two members of the media attended the applicant's informational briefing.

**B. Public Briefing**

9 VAC 5-80-1775 J specifies that a briefing be scheduled prior to the public comment period if appropriate. VRO held a public briefing at 6:00 p.m. on January 30, 2014 at the Ruritan Building in Clear Brook. The briefing required a 30-day (at minimum) notification period, and a legal advertisement for the briefing was published in the Winchester Star on December 26, 2013. Four members of the public (a family of three and one individual) attended the briefing.

**C. Public Hearing**

In accordance with 9 VAC 5-80-1775 E, VRO held a public hearing on March 11, 2014, in the Frederick County Board of Supervisors meeting room, to accept comments on the air quality impact of the proposed source, alternatives to the source, the control technology required, and other appropriate considerations. A legal advertisement for the hearing was published in the Winchester Star newspaper on February 7, 2014, which was more than 30 days prior to the public hearing. Six persons not affiliated with the applicant attended the public hearing, and four of them provided oral comments. Three persons spoke in favor of the proposed permit, and one person objected to it.

**D. Documents Concerning Public Comment Period**

The draft permit, engineering memorandum, Carmeuse's permit application, and modeling information, were made available for review in three locations: (1) at DEQ's Valley Regional Office (VRO) in Harrisonburg; (2) at the Handley Library, which is located at 100 West Piccadilly Street in Winchester (this is the closest public library to the facility that is within Virginia); and (3) online on DEQ's website at: <http://www.deq.virginia.gov/Programs/Air/PublicNotices/AirPermits.aspx>. These documents were available for review throughout the public comment period.

**E. Public Comment**

Pursuant to 9 VAC 5-80-1775 F, the public comment period must run for 45 days, 15 days of which must be after the public hearing. The public

comment period ran from February 7, 2014 through March 26, 2014. Five written comments were received, which consisted of letters from the U.S. Department of the Interior and the U.S. Environmental Protection Agency, and three letters from citizens. A Response to Comments document has been prepared by VRO, which is included as Attachment D.

## **VII. Notification of Other Government Agencies**

### **A. Local Zoning**

Because the proposed facility constitutes a major modification to an existing stationary source that is subject to air permitting regulations, a local governing body certification form is required in accordance with Department policy and § 10.1-1321.1 of the Code of Virginia. On March 2, 2012, the Zoning Administrator for Frederick County certified that the proposed facility is fully consistent with local ordinances by signing the local governing body certification form. This form was received by DEQ on March 7, 2012, and it is included as Attachment 1.

### **B. Environmental Protection Agency (EPA)**

In accordance with 9 VAC 5-80-1765, there are specific notification requirements to advise EPA of sources impacting federal Class I areas. Accordingly, a copy of the permit application and DEQ's Initial Letter of Determination were provided to EPA Region III on March 28, 2012. EPA was provided with a copy of the draft permit, draft engineering analysis, modeling analysis, and revised comprehensive application on January 29, 2014. EPA submitted written comments on March 17, 2014. VRO had a teleconference with EPA on April 22, 2014 to discuss its responses to EPA's comments. Upon issuance of the permit, VRO will promptly provide the final permit, engineering analysis, and Response to Comments document to EPA.

### **C. Federal Land Managers (FLM)**

Because of the Winchester facility's proximity to SNP (see Table 1), a protected Class I area, DEQ has worked with the Federal Land Managers (FLMs) whose responsibility it is to oversee such areas. In accordance with the Memorandum of Understanding dated March 31, 1993, between DEQ and SNP and the Jefferson National Forest, both the National Park Service (NPS) and U.S. Forest Service (USFS) were provided copies of Carmeuse's permit application and supplemental addenda, most notably the Class I and Class II modeling analyses. Numerous conference calls were conducted between NPS, Carmeuse, and DEQ to determine an

acceptable approach to the Class I air quality analyses, which are reviewed and assessed primarily by NPS. NPS was provided a copy of Carmeuse's Class I and Air Quality Related Values (AQRVs) analyses and its review is currently underway.

A copy of the permit application and DEQ's Initial Letter of Determination (ILOD) were provided to the FLMs on March 28, 2012. In a letter dated December 26, 2013, DEQ provided notification that the application was considered complete and that the FLM 60-day review period had begun. According to 9 VAC 5-80-1765 B, this notification must be provided at least 60 days before the public hearing, which is tentatively scheduled for March 6, 2014. The 60-day letter also transmitted the current application, DEQ's modeling analysis, and the public notice for the public briefing to be held on January 30, 2014. The FLMs were also provided the draft permit and draft engineering analysis on December 31, 2013. The NPS submitted written comments on March 21, 2014. Upon issuance of the permit, VRO will promptly provide the final permit, engineering analysis, and Response to Comments document to the NPS.

## **VIII. Pollution Prevention**

Site-specific pollution prevention measures have been included as requirements in the permit, such as the following:

- The vertical configuration of the two proposed lime kilns is considered a pollution prevention alternative because this design uses less fuel per ton of lime produced than the traditional rotary kiln design. The dual-chamber design, with the use of exhaust gases from one chamber to preheat the limestone in the other chamber, contributes to the higher efficiency and reduced fuel usage. The reduced fuel usage directly results in the generation of fewer pollutants per ton of lime produced.
- The use of enclosures and underground conveyors prevents the introduction of PM, PM-10, and PM-2.5 into the ambient environment from those materials handling processes.
- The fabric filters significantly reduce the quantity of PM, PM-10, and PM-2.5 that is released to the ambient environment from various materials handling processes.
- The paving of certain roads that are currently unpaved will prevent certain PM, PM-10, and PM-2.5 emissions.

## **IX. Title V Operating Permit (9 VAC 5 Chapter 80, Article 1)**

The existing facility already is required by Virginia regulations to obtain a federal operating permit under Title V of the Clean Air Act. The existing permit

VRO80504 became effective on January 24, 2008, and it expired on January 23, 2013. Carmeuse submitted a Title V renewal application that DEQ determined was timely and complete via letter dated August 1, 2012. The Regulations require that Carmeuse submit a Title V permit modification application within 12 months of the commencement of operation of the new vertical lime kilns. Due to the pending issuance of this PSD permit and the need to subsequently modify the Title V permit, DEQ and Carmeuse agreed to allow the existing Title V permit to expire and for Carmeuse to continue operating under the existing permit and the application shield until such time as it submits a revised Title V renewal application that incorporates this forthcoming PSD permit and DEQ issues the Title V permit renewal.

## **X. Acid Rain Operating Permit (9 VAC 5 Chapter 80, Article 3)**

Carmeuse is not required by Virginia Regulations to obtain a permit under the federal Acid Rain program for the proposed modifications to the Winchester facility.

## **XI. NO<sub>x</sub> and SO<sub>2</sub> Trading Programs (9 VAC 5 Chapter 140)**

Virginia has established several emissions trading programs (NO<sub>x</sub> Budget Trading Program, CAIR NO<sub>x</sub> Annual Trading Program, CAIR NO<sub>x</sub> Ozone Season Trading Program, and CAIR SO<sub>2</sub> Trading Program) to meet the requirements of EPA's budget trading programs. Carmeuse is not required by Virginia Regulations to include its Winchester facility in any of these trading programs due to the proposed modifications.

## **XII. Special Considerations**

No other special considerations have been accounted for in this PSD permit.

## **XIII. Recommendation**

Issuance of the proposed permit is recommended.

## **Attachments**

Attachment A: Local Governing Body Certification Form

- Attachment B: DEQ AQA's "Technical Review of the Air Quality Analysis in Support of the PSD Application [for this project]" on December 10, 2013
- Attachment C: Applicant's Emissions Calculations
- Attachment D: DEQ's Response to Comments

**ATTACHMENT A:**

**Local Governing Body Certification Form**

**ATTACHMENT B:**

**DEQ AQA's "Technical Review of the Air Quality Analysis in Support of the PSD Application [for this project]", dated December 10, 2013**

**ATTACHMENT C:**

**Applicant's Emissions Calculations**



**ATTACHMENT D:**

**DEQ's Response to Comments**