Holcim

Holcim (US) Inc.
1260 Security Rd
Hagerstown, MD 21742

Phone301 739 1150
Fax 301 739 6708
www.holcim.com/us

July 27, 2010

Brian J. Hug
Deputy Program Manager
Air Quality Planning Program
Air and Radiation Management Administration
Maryland Department of the Environment
1800 Washington Blvd.
Baltimore, MD 21230

Re: BART 5 Factor Analysis

Dear Mr. Hug,

Please find enclosed the Best Available Retrofit Technology (BART) Five Factor Analysis for the Holcim (US) facility located in Hagerstown (Washington County) as requested by the Maryland Department of the Environment in your letter dated May 4, 2010.

This analysis covers the three visibility impairing pollutants; NOx, SO2, and $PM_{2.5}$.

Should you have any questions please feel free to call me at 301-739-1150 EXT 205.

Sincerely,

Victoria M Mock

Victoria M. Mock
Manager, Environmental

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard • Baltimore MD 21230
410-537-3000 • 1-800-633-6101

Martin O'Malley
Governor

Anthony G. Brown
Lieutenant Governor

Shari T. Wilson
Secretary

Robert M. Summers, Ph.D.
Deputy Secretary

May 4, 2010

Ms. Victoria M. Mock
Independent Cement St. Lawrence
1260 Security Road
Hagerstown, MD 21742

Re: BART Eligible Units

Dear Ms. Mock:

The Maryland Department of the Environment (MDE) has determined that your facility has units which are subject to the Best Available Retrofit Technology (BART) requirements of the federal Regional Haze Rule. BART-eligible sources are those sources with emission units:

1. Which have the potential to emit 250 tons per year or more of a visibility-impairing pollutant;
2. Which were put in place between August 7, 1962 and August 7, 1977; and
3. Whose operations fall into any of the 26 specifically listed source categories in Attachment-A.

The MDE continues to work on the Maryland Regional Haze State Implementation Plan (SIP). We have recently received comments from the USEPA (Region 3 Office). As a result, we have concluded that you are obligated to perform a BART five factor analysis for each BART-eligible unit at your facility regarding controls of each of the three visibility impairing pollutants: NO_X, SO_2 and PM2.5. The analysis must address the five statutory factors required by the Clean Air Act (CAA) which include:

1. the costs of compliance
2. the energy and non-air quality environmental impacts of compliance;
3. any existing pollution control technology in use at the source
4. the remaining useful life of the source, and
5. the degree of visibility improvement which may reasonably be anticipated from the use of BART.

The control requirements and BART analysis guidelines may be found at 40 CFR part 51 and the Federal Register Volume 70, No. 128, July 6, 2005 page 39104. The Maryland Department of the Environment is required to include your analysis in the Regional Haze SIP, therefore, please have your submission in for our review by July 31, 2010. Your cooperation in this matter is greatly appreciated. If you have any questions or require further instruction please contact Deirdre Elvis-Peterson at (410) 537-3281 or by email at delvis-peterson@mde.state.md.us.

Thank you,

Brian J Hug
Deputy Program Manager
Air Quality Planning Program
Air and Radiation Management Administration

BART FIVE FACTOR ANALYSIS

HOLCIM-HAGERSTOWN

July 31 2010

Prepared for:

HOLCIM (US) INC.
HOLCIM-HAGERSTOWN
1260 SECURITY ROAD
HAGERSTOWN, MD

Project No. 100122

SCHREIBER & YONLEY ASSOCIATES
ENVIRONMENTAL ENGINEERS

16252 Westwoods Business Park Drive • Ellisville, MO 63021 • (636) 256-7200
www.perma-fix.com/sya

1. EXECUTIVE SUMMARY

This document represents the determination of the Best Available Retrofit Technology (BART) as developed by Holcim (US) Inc. (Holcim) for their long dry Portland cement kiln located in Hagerstown, Maryland. The document includes BART determinations for sulfur dioxide (SO_2), nitrogen oxides (NO_x) and fine particulate matter $PM_{2.5}$. These determinations are based upon requirements set forth in the April 21, 2010 letter from the Maryland Department of the Environment (MDE). The five factors that must be addressed are:

1. The costs of compliance,
2. the energy and non-air quality environmental impacts of compliance,
3. any existing pollution control technology in use at the source,
4. the remaining useful life of the source, and
5. the degree of visibility improvement which may reasonably be anticipated from the use of BART.

Based on this analysis, Holcim proposes the following as BART for the Hagerstown kiln:

- PM 2.5 - Holcim proposes that compliance with the Portland Cement NESHAP also known as PC MACT (40 CFR Part 63, Subpart LLL) and compliance with the proposed Maryland ozone SIP revisions will constitute BART for $PM_{2.5}$. Compliance with these rules is expected to require the installation of Selective Non-Catalytic reduction (SNCR) onto the kiln. Compliance with these rules will provide additional control for both filterable and condensable particulate.
- NO_x – Holcim proposes that compliance with the proposed Maryland ozone SIP revisions will constitute BART for NO_x. Compliance with this rule will require the application of SNCR.
- SO_2 – Holcim has submitted a Prevention of Significant Deterioration (PSD) permit application to address the increase in SO_2 emission which occurred as a result of the installation and operation of the mid-kiln tire firing system installed in 2003 to comply with the current ozone SIP regulation (COMAR 26.11.29.15). Since the installation in 2003, Holcim has expended approximately $3.6 million dollars to control SO_2 emissions. As part of the PSD application a Best Available Control Technology (BACT) determination was conducted. The BACT concluded that the current inherent dry scrubbing constituted BACT for SO_2 and proposed a PSD limit of 795 tons per year (tpy) SO_2. Holcim proposes that this emissions limit achieved with inherent dry scrubbing also constitutes BART for SO_2.

In addition to the BACT analysis, the PSD application includes CALPUFF visibility modeling of the impact of the increased SO_2 emissions on five Class I areas. The increased SO_2 emissions impacted the visibility in these Class I areas by less than five percent of the PSD significance level for visibility impairment. Therefore add-on controls for SO_2 would not provide any significant improvement on the visibility at the Class I areas.

2. BART APPLICABILITY DETERMINATION

MDE has determined that Holcim's Hagerstown cement kiln is a BART eligible source which is subject to BART controls.

There are five Class I areas within 300 kilometers of Holcim's Hagerstown facility. These are:

1. Brigantine Wilderness Area – located 291 km east
2. Dolly Sods Wilderness Area – located 166 km southwest
3. Otter Creak wilderness Area – located 191 km southwest
4. Shenandoah National Park – located 205 km southwest
5. James River Face wilderness Area – located 279 km southwest

MDE has notified Holcim that visibility modeling conducted by MANE-VU, which utilized data from the 2002 emissions inventory for the visibility portion of the BART five factor analysis and that the BART eligible sources would not need to provide visibility modeling as part of the BART analysis. However, Holcim has a pending PSD permit application which included an increase in SO_2 emissions above the 2002 baseline. Holcim conducted a visibility impact analysis of the SO_2 emissions increase for the PSD application. MDE requested that the results of the PSD visibility analysis be included in this BART Analysis. This analysis will be discussed as a part of the SO_2 BART analysis. The CALPUFF modeling report and the Visibility Section from the PSD application is attached in Appendix A.

2.1 LIFE OF SOURCE

The Hagerstown kiln was installed in 1971. A typical life for a cement plant is around 50 years.

3. IDENTIFICATION OF AVAILABLE $PM_{2.5}$ RETROFIT TECHNOLOGIES

$PM_{2.5}$ contains both filterable and condensable particulate matter which may be emitted from the kiln stack or which may form from precursors after emission from the stack. The annual emissions reports submitted to MDE as required do not include the condensable portion of $PM_{2.5}$ and Holcim has no reliable data available upon which to estimate the condensable portion of $PM_{2.5}$.

3.1 Current $PM_{2.5}$ Controls

Holcim currently utilizes multiclones and an electrostatic precipitator (ESP) to control particulate emissions from the kiln. The emission of NO_x is a precursor to $PM_{2.5}$. The facility currently utilizes mid-kiln tire firing (installed in 2003) to comply with the ozone SIP requirements for Maryland cement plants. SO_2 emissions are also precursors to $PM_{2.5}$. The injection of mixing air and inherent dry scrubbing are utilized to control SO_2 emissions.

3.2 $PM_{2.5}$ Control Options

Maryland has revised its ozone transport rule. Hagerstown will need to install Selective Non-Catalytic Reduction (SNCR) to comply with the rule. NO_x emissions are one of the precursors to the formation of condensable $PM_{2.5}$ emissions from cement kilns.

Furthermore, the United States Environmental Protection Agency (USEPA) has proposed a new Maximum Achievable Control Technology (MACT) regulation for the Portland cement industry. This rule currently proposes to reduce the standard for existing kilns to 0.085 lb. of PM_{10} per ton clinker produced. .

3.3 Control Costs

Table 3.1 estimates the costs for the installation of an SNCR system to comply with the Maryland ozone transport limit.

Table 3.1 SNCR Cost Estimate

Holcim (US) Inc. - Hagerstown Selective Non-Catalytic Reduction		
CAPITAL COST		
Direct Capital Cost (DCC)		
Vendor Quote (VC)	1,199,740	Vendor quote.
Instrumentation and Controls (10% of VC)	119,974	ACT
Total Purchased Equipment Cost (PEC):	1,319,714	
Sales tax & freight (8% of PEC)	105,577	ACT
Direct Installation	458,300	Vendor quote
Total DCC:	**1,883,591**	

Indirect Capital Cost (ICC)		
Engineering, supervision	40,000	
Construction & field expense (10% of DCC)	188,359	
Contractor Fees (7% of DCC)	131,851	NSR Workshop
Start-up	25,000	Vendor quote
Testing (1% of DCC)	18,836	NSR Workshop
Contingencies	240,000	
Total ICC:	**644,046**	
Total Capital Cost	2,527,638	DCC + ICC
Capital Recovery Factor (7%, 15 yrs)	10.98%	ACT
Total Annualized Capital Cost	**277,521**	
OPERATING COST		
Direct Operating Cost (DOC)		
Operating labor	32,760	1 man-year @ $65,000/year
Supervision (@ 15% of operating labor)	4,914	
Maintenance labor	32,760	1 man-year @ $65,000/year
Maintenance Supervision (@ 15% of maint labor)	4,914	
Maintenance materials (1% of DCC)	18,836	
Reagent	1,527,255	19% Aqua Ammonia
Electricity	11,116	Fuel Tech
Total DOC:	**1,632,555**	
Indirect Operating Cost (IOC)		
Payroll Overhead (30% oper. Labor & sup)	11,302	NSR Workshop
Plant Overhead (26% total labor & mat.)	24,488	NSR Workshop
Property tax (1% TCC)	25,276	NSR Workshop
Insurance (1% TCC)	25,276	NSR Workshop
Administration (2% TCC)	50,553	NSR Workshop
Total IOC:	**136,896**	
Total Annual Operating Cost	**1,769,451**	
TOTAL COST		

Table 3.2 below estimates the costs for the installation and operation of a new high efficiency baghouse at Hagerstown should it be required to meet the new PC MACT standard. Baseline emissions for the cost effectiveness calculation are based upon the maximum kiln hourly production rate of 75.7 tons clinker per hour, the 2008 emissions rate of 0.39 lb. per ton clinker and the historical annual kiln operational rate of 94 percent. The controlled emissions rate calculations use the same assumptions except utilize the proposed MACT emissions rate of 0.085 lb PM10 per ton clinker.

Table 3.2 Baghouse Cost Estimate

Holcim (US) Inc. - Hagerstown Baghouse		
Capital Cost Elements		
Direct Costs		
Purchased Equipment Costs (PEC):		***$4,858,920***
	Conditioning Tower	$800,000
	Baghouse Replacement	$3,290,000
	Instrumentation (10%)	$409,000
	Sales Tax (3%)	$134,970
	Freight (5%)	$224,950
Direct Installation Costs (DIC) 85% of PEC:		***$2,672,406***
	Foundation and Supports (12% of PEC)	$583,070
	Handling and Erection (40% of PEC)	$1,943,568
	Electrical (1% of PEC)	$48,589
	Piping (30% of PEC)	$0
	Insulation for Ductwork (1% of PEC)	$48,589
	Painting (1% of PEC)	$48,589
Total Direct Cost (DC) = (PEC) + (DIC)		**$7,531,326**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$1,700,622***
	Engineering (10% of PEC)	$485,892
	Construction/Field Exp. (10% of PEC)	$485,892
	Contractor Fees (10% of PEC)	$485,892
	License	$0
	Start-up (1% of PEC)	$48,589
	Performance Test (1% of PEC)	$48,589
	Contingencies (3% of PEC)	$145,768
Site Preparation and Building (SPB) 10% of IIC:		**$170,062**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$1,870,684**
Total Capital Investment (TCI) = (DC) + (IC)		**$9,402,010**

Annualized Costs		
Direct Annual Costs		
Utilities:		
	Fuel	$0
	Power ($0.11/kWh)	$42,395
	Water($1.00/1000 gallon)	$0
Raw Materials/Chemicals:		
Operating Labor:		
	Operator Labor (1 hr/shift @ $31.50/hr)	$34,493
	Supervising Labor (15% of Operator)	$5,174
Maintenance:		
	Maintenance Labor (2 hr/shift @ $31.50/hr)	$68,985
	Maint. Supervision (15% of Maintenance)	$10,348
	Maintenance Materials (100% of Labor)	$68,985
Replacement Parts (5% of PEC):		$242,946
Waste Treatment and Disposal:		
Compliance Costs:		**$60,000**
	Performance Tests	$40,000
	Recordkeeping and Reporting	$20,000
Total Direct Annual Costs (DAC)		**$533,325**
Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$112,790
	Insurance (1% of TCI)	$94,020
	Administrative Charges (2% of TCI)	$188,040
	Capital Recovery	$1,078,411
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$1,473,261**
Total Annualized Costs (DAC + IAC)		**$2,006,587**
Baseline 2008 kiln PM10 Emissions	Tons per year PM10	87
Potential Emission Reduction		
	Max PM10 emissions at max product PCMACT limit	26
	PM10 Tons per Year Controlled	61
Cost Effectiveness	$ per Ton PM10 Reduced	**$33,016**

3.4 Other Impacts

There will be no significant increases in energy usage associated with compliance with the PC MACT limitation or from the use of SNCR. There will be no additional waste streams generated. However, there will be an ammonia slip from the stack which may combine with the SO_2 emissions from the stack gas or in the atmosphere to form condensable particulate emissions and/or a detached plume.

3.5 Visibility

The reduction in condensable particulates related to the reduction in NO_x emissions will result in some improvement in visibility. Per MDE guidance, Holcim has not attempted to quantify the impact of this control. In addition, reduction in particulate matter to comply with the upcoming new NESHAP standards will also result in some improvement in visibility

3.6 BART Determination

Holcim is proposing that compliance with the final emissions limitations in the PC MACT regulation and the Maryland ozone transport regulations will constitute BART for $PM_{2.5}$.

4. IDENTIFICATION OF AVAILABLE RETROFIT NO_X CONTROL TECHNOLOGY

4.1 Current NO_x Controls

The Hagerstown kiln installed and began operation of a mid-kiln tire firing system with mixing air technology in 2003 to comply with the Maryland ozone SIP rule (COMAR 26.11.29.15). Holcim also upgraded the kiln computer control system in both 2000 and again in 2009 and installed a low- NO_x type burner in the kiln in 2007.

4.2 NO_x Control Options

Proposed revisions to Maryland's NO_x SIP rule to control ozone transport will require the reduction of Holcim's NO_x emissions. Because of the implementation of mid-kiln tire firing, computer control of the kiln system and the installation of low-NOx burners, only two NO_x control options are potentially applicable to the Hagerstown kiln. There are:

1. Selective Non-Catalytic Reduction (SNCR)
2. Selective Catalytic Reduction (SCR)

4.2.1 SNCR

Selective Non-Catalytic Reduction (SNCR) uses a reducing agent, typically ammonia or urea, to react with NO_x to form nitrogen (N_2) and water (H_2O). The reaction kinetics are such that the temperature required for the reaction is between 870 and 1,200°C (1,600 – 2,200°F). The overall reactions between ammonia and NO_x are as follows:

$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$, and
$2\ NO_2 + 4\ NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$

Intermediate reactions take place to form the hydroxyl radical (OH^-). Ammonia reacts with the hydroxyl radical to form the amine radical (NH_2^+) and water. The amine radical is essential for the SNCR reaction to proceed.

Urea may also be used as the reducing reagent. Urea will decompose to ammonia and the SNCR reactions occur as shown above.

The installation of SNCR will require the installation of an ammonia storage tank, the installation of a rotary seal at the feed end of the kiln to allow for the ammonia piping, and ammonia injection nozzles. It will also require the installation of a computer control system and an ammonia CEMS.

The NO_x emissions reduction required by the ozone SIP regulations will be between 17 and 51 percent. The most recent year at near normal clinker production rates was 2008. This is also the year that all of the modifications implemented for SO_2 control were completed. Therefore, the 2008 NO_x emissions rate was selected for the purpose of the SNCR cost calculations.

4.2.2 SCR

Selective Catalytic Reduction (SCR) is an add-on control technology that involves reagent injection into the gas stream in the presence of a catalyst. Common reagents include aqueous ammonia (NH_3), anhydrous NH_3, and urea. In the presence of the catalyst, the injected ammonia is converted by OH* radicals to ammonia radicals (i.e., NH_2*), which react with NO_x to form N_2 and H_2O. The SCR catalyst enables the necessary reactions to occur at lower temperatures than those required for Selective Non-Catalytic Reduction (SNCR). While catalysts can be effective over a range of temperatures, the optimal temperature range for SCR is 570 - 750°F.

$$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O, \text{ and}$$
$$2\ NO_2 + 4\ NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$$

The SCR system, consisting of a vessel with a set of catalyst beds placed in series, would for a long dry cement kiln, be located after the kiln. Figure 4-1 is a simplified sketch of an SCR system for a precalciner kiln system. The reagent is injected at a controlled rate upstream of the catalyst using an injection grid designed to ensure relatively even distribution, good mixing, and minimum NH_3 slip.[1] The reagent reacts with NO_x compounds (i.e., NO and NO_2) on the surface of the catalyst in equal molar amounts (i.e., one molecule of NH_3 reacts with one molecule of NO_x) to form N_2 and water.

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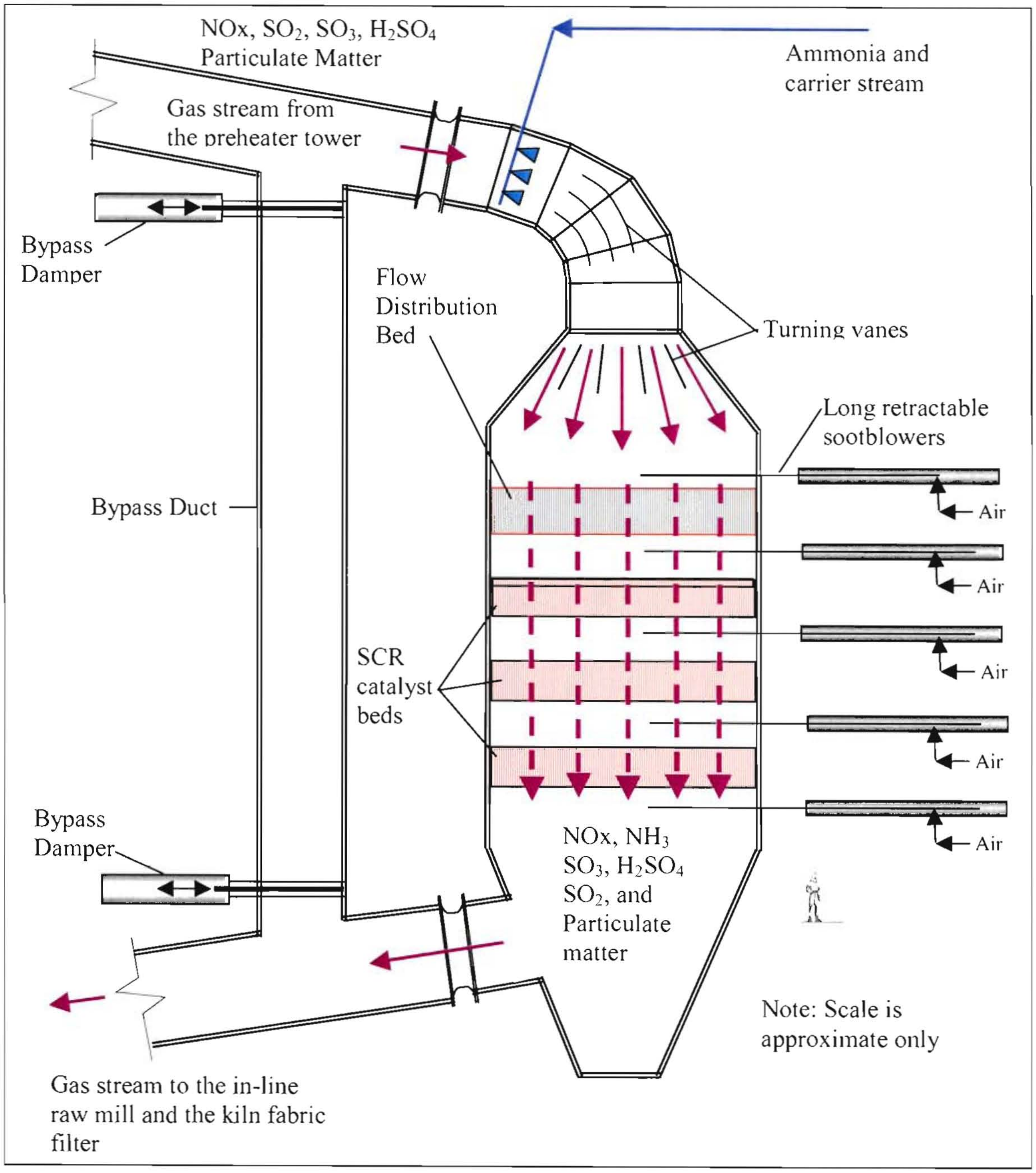
[1] Slip refers to the quantity of unreacted reagent that exits the SCR reactor.

Figure 4-1 - SCR System



There is very limited information on the use of SCR in the cement industry. No Portland cement plant has installed or operated SCR in the U.S. Therefore, SCR is not considered an available control technology. Furthermore, as previously stated, SCR requires a kiln gas temperature of between 570 and 750 degrees F for the catalytic reaction to occur. Holcim's current stack gas temperature is slightly below the lower end of the required temperature range. The gases will require at least some degree of reheat at least some of the time. To the best of Holcim's knowledge, SCR has never been installed on a long dry cement kiln. For this reason SCR is not considered to constitute BART and no further analysis of SCR was performed.

4.3 Control Costs for SNCR

The total capital investment for an SNCR system is estimated in Table ~~5.1~~ 4.1 as approximately \$2,527,638. Annual operating costs are estimated at approximately \$1,769,451 with total annual costs of approximately \$2,046,972. The baseline emissions are calculated using the maximum hourly kiln production rate of 75.7 tons per hour, the 2008 emissions rate of 10.49 lb. NO_x per ton clinker and the maximum historical annual kiln operational rate of 94 percent. Kiln emissions after controls used the same assumptions except that the NO_x emissions rate from the ozone SIP of 5.1 lb NO_x per ton clinker is utilized. This cost calculation is shown below in Table 4.1.

Table 4.1 SNCR Cost Estimate

Holcim (US) Inc. - Hagerstown Selective Non-Catalytic Reduction		
CAPITAL COST		
Direct Capital Cost (DCC)		
Vendor Quote (VC)	1,199,740	Vendor quote.
Instrumentation and Controls (10% of VC)	119,974	ACT
Total Purchased Equipment Cost (PEC):	1,319,714	
Sales tax & freight (8% of PEC)	105,577	ACT
Direct Installation	458,300	Vendor quote
Total DCC:	**1,883,591**	
Indirect Capital Cost (ICC)		
Engineering, supervision	40,000	
Construction & field expense (10% of DCC)	188,359	
Contractor Fees (7% of DCC)	131,851	NSR Workshop
Start-up	25,000	Vendor quote
Testing (1% of DCC)	18,836	NSR Workshop
Contingencies	240,000	
Total ICC:	**644,046**	
Total Capital Cost	2,527,638	DCC + ICC
Capital Recovery Factor (7%, 15 yrs)	10.98%	ACT
Total Annualized Capital Cost	**277,521**	
OPERATING COST		
Direct Operating Cost (DOC)		
Operating labor	32,760	1 man-year @ $65,000/year
Supervision (@ 15% of operating labor)	4,914	
Maintenance labor	32,760	1 man-year @ $65,000/year
Maintenance Supervision (@ 15% of maint labor)	4,914	
Maintenance materials (1% of DCC)	18,836	
Reagent	1,527,255	19% Aqua Ammonia
Electricity	11,116	Fuel Tech
Total DOC:	**1,632,555**	
Indirect Operating Cost (IOC)		
Payroll Overhead (30% oper. Labor & sup)	11,302	NSR Workshop
Plant Overhead (26% total labor & mat.)	24,488	NSR Workshop
Property tax (1% TCC)	25,276	NSR Workshop
Insurance (1% TCC)	25,276	NSR Workshop
Administration (2% TCC)	50,553	NSR Workshop
Total IOC:	**136,896**	
Total Annual Operating Cost	**1,769,451**	
TOTAL COST		

4.4 Other Impacts

There will be no significant increases in energy usage associated with the use of SNCR. There will be no additional waste streams generated by the use of SNCR. However, there will be an ammonia slip from the stack which may combine with the SO_2 emissions from the stack gas or in the atmosphere to form condensable particulate emissions.

4.5 Visibility

The reduction in NO_x emissions by the installation of the SNCR system will result in some improvement in visibility. Per MDE guidance, Holcim has not attempted to quantify the impact of the installation of SNCR on visibility at the Class I areas.

4.6 BART Determination

Holcim is proposing that compliance with the Maryland ozone transport limit will constitute BART. Compliance with this limit will be accomplished by the use of SNCR.

5. IDENTIFICATION OF AVAILABLE RETROFIT SO_2 CONTROL TECHNOLOGIES

5.1 Current SO_2 Controls

Long dry Portland cement kilns by their design, perform inherent dry scrubbing of the fuel derived SO_2 emissions and to a lesser degree for the raw material derived SO_2 emissions bypassing the combustion gases countercurrent to the calcined raw materials. The control efficiencies for inherent dry scrubbing range from 82 to 96 percent.

In addition to the inherent dry scrubbing, Holcim has spent approximately $3.6 million for capital projects and engineering services to reduce the SO_2 emissions increase that resulted from the installation of the mid-kiln tire firing system in 2003. The tire-firing system was required to comply with the current ozone SIP requirements. The additional controls that were installed to reduce the SO_2 emissions included mixing air, a new kiln ID fan and various other modifications. These changes have resulted in a reduction in SO_2 emissions from a high of 1,388 tons per year of SO_2 in 2005 to 795 tons per year as discussed in Holcim's pending PSD permit application for SO_2.

5.2 SO_2 Control Options

In the performance of the BACT determination as part of the PSD permit application, Holcim evaluated the following additional SO_2 controls:

1. Raw material substitution/selective quarrying
2. Fuel substitution with two types of lower sulfur coal
3. Dry lime scrubbing
4. Microfine lime injection
5. Wet lime scrubbing

Of these, the raw material substitution/selective quarrying option was eliminated. The sulfur content of the quarry is stable and relatively low. Approximately 85 percent of the raw materials are mined onsite. Transportation costs and transportation related emissions quickly eliminated these options as both technically and economically infeasible.

Detailed cost and environmental benefit analyses were conducted for the use of lower sulfur western and imported coals. The use of these coals would result in significant safety hazard concerns related with the high combustible content, as well as increased environmental emissions related to the significant transportation distances. These concerns combined with the extremely high costs eliminated fuel switching as neither economically nor logistically feasible.

Therefore, only add-on control technologies remain as options. It is important to note here that as a result of the $3.6 million Holcim has already invested in reducing SO_2 emissions, the SO_2 emissions concentration in the stack gas has been reduced to below 100 ppmv. The low concentration and the temperatures of the stack gases result in significantly lower maximum control efficiencies from add-on controls when compared to the emissions reductions possible from new preheater/precalciner kiln systems.

The entire BACT analysis for SO_2 from the PSD permit application, which contains detailed descriptions of the potential SO_2 control technologies and the technical and economic feasibility analyses of the technologies, is provided in Appendix B of this document.

5.3 Control Cost Estimate

The cost analyses for all of the potential SO_2 control options were performed as part of the pending PSD permit application process. Appendix B contains these detailed cost analyses. The costs of all of the control technologies were determined to be economically infeasible.

5.4 Visibility

In addition to the BACT analysis in the PSD permit application, Holcim was required by the Federal Land Manager to address potential visibility degradation associated with the proposed increase in SO_2 emissions above the PSD baseline period of January 1999 through December 2001. This analysis was required for the five Class I Areas within 300 km of the Hagerstown facility. These are as follows:

1.	Brigantine Wilderness Area	located 219 km east
2.	Dolly Sods Wilderness Area	located 166 km southwest
3.	Otter Creek Wilderness Area	located 191 km southwest
4.	Shenandoah National Park	located 205 km southwest
5.	James River Face Wilderness Area	located 279 km southwest

The CALPUFF modeling program was used to estimate the potential impact that the proposed PSD emissions rate increase would have on each of these five Class I areas. The detailed modeling analyses are contained in Appendix A. Two scenarios were completed. The first uses a PSD baseline with an adjustment for increased SO_2 emissions resulting from the degradation in the quality of the coal supply after the PSD baseline year, which is not a PSD triggering occurrence. The second scenario analyzes the visibility impact of the SO_2 emissions increase above the PSD baseline without an adjustment for coal quality degradation. Table 5.1 below shows the magnitude of the impact for scenario two, the worst-case scenario.

Table 5.1 CALPUFF Scaled Model Results for:

Brigantine Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003
SO_2	3-hour	Mg/m^3	1	0.04	0.04	0.02
	24-hour	Mg/m^3	0.2	0.02	0.01	0.01
	Annual	Mg/m^3	0.1	0.00	0.00	0.00
Extinction Change	24-hour	%	5	0.35	0.26	0.29
Sulfur	Annual	Kg/ha/yr	0.01	0.001	0.001	0.001

Otter Creek Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003
SO_2	3-hour	Mg/m^3	1	0.02	0.05	0.05
	24-hour	Mg/m^3	0.2	0.01	0.01	0.01
	Annual	Mg/m^3	0.1	0.00	0.00	0.00
Extinction Change	24-hour	%	5	0.39	0.46	0.52
Sulfur	Annual	Kg/ha/yr	0.01	0.000	0.001	0.001

Shenandoah National Park

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003
SO_2	3-hour	Mg/m^3	1	0.45	0.47	0.60
	24-hour	Mg/m^3	0.2	0.10	0.10	0.15
	Annual	Mg/m^3	0.1	0.00	0.01	0.01
Extinction Change	24-hour	%	5	1.35	1.59	2.82
Sulfur	Annual	Kg/ha/yr	0.01	0.003	0.003	0.003

James River Face Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003
SO_2	3-hour	Mg/m^3	1	0.04	0.04	0.04
	24-hour	Mg/m^3	0.2	0.02	0.01	0.01
	Annual	Mg/m^3	0.1	0.00	0.00	0.00
Extinction Change	24-hour	%	5	0.3	0.41	0.46
Sulfur	Annual	Kg/ha/yr	0.01	0.001	0.001	0.001

As can be seen from this table the highest visibility impact was at the Shenandoah National Park and was well below the Class I significance impact for visibility. When, during the performance of a PSD review, the impact on visibility is below the five percent level of significance in the PSD regulations, the Federal Land Manager is allowed to make a determination that no further evaluation of visibility is required. The impact is considered to be insignificant under PSD regulations. . Therefore, it is inferred that where the extinction changes for the proposed PSD increase in SO_2 emissions results in a less than significant impact on visibility. The use of add-on controls would not provide a significant improvement in the visibility. It should be noted that the impact on visibility at Hagerstown was modeled at an SO_2 emissions rate of 1388 TPY. The emission rate proposed by Holcim in the PSD application is 795 TPY. The visibility impact is linear with respect to the emissions rate. Therefore, the actual impact from the Hagerstown kiln will be 43% less that the levels predicted by this visibility analysis.

5.5 <u>Other Impacts Analysis</u>

As discussed in the BACT analysis, Appendix A, the add-on SO_2 controls will all increase energy usage and generate solid waste sludge which would require disposal offsite in a landfill. Additional details are contained in Appendix B.

5.6 <u>BART Determination</u>

All add-on SO_2 controls have high costs, require additional energy usage and generate a sludge that would require offsite disposal. The visibility analysis indicates that the application of any of these controls will have a less than significant improvement in visibility on the Class I areas. Therefore, Holcim believes that inherent dry scrubbing combined with the mixing air system and kiln ID fan already installed on the Hagerstown kiln constitute BART and proposes the emissions limit of 795 tpy as the BART limit for SO_2.

6. CONCLUSION

Existing and proposed regulations will require the reduction of $PM_{2.5}$, and NO_x emissions from the Hagerstown kiln. In addition, the control technologies already implemented for SO_2 control will be mandated by the PSD permit when issued. As a result of these various regulations and permitting requirements, Holcim will be required to reduce $PM_{2.5}$ and NO_x emissions below 2008 levels and may be required to install a high efficiency baghouse and will be required to install SNCR. The regulatory emissions limitations from the regulations and the PSD permit, when issued, will constitute BART for the Hagerstown kiln.

Appendix A

VISIBILITY ANALYSIS FROM OCT 2009 PSD PERMIT APPLICATION

6.5 Visibility Impact Analysis

As requested by the Maryland Department of the Environment (MDE) and the Federal Land Managers (FLM), a Class I impact analysis for the SO_2 emission increase presented in this application was conducted. EPA's New Source Review (NSR) guidance (DRAFT, October 1990 New Source Review Workshop Manual) states that a Class I impact analysis is necessary for major sources and modifications located within 100 km of a Class I area. While the nearest Class I area is located 166 km from the plant, the EPA NSR guidance states that sources more distant than 100 km should be considered for analysis if they are large and considered to have a potential for adverse impact at Class I areas.

Based on the request for analysis by the FLM, a Class I Modeling Protocol was submitted to the FLM contacts on October 8, 2008 for each Class I area listed below. A copy of the correspondence with the FLM contacts is provided in Appendix H. A copy of the Class I Modeling Protocol is provided as an attachment to the report in Appendix G.

There are five Class I areas within 300 km of the Holcim-Hagerstown facility:

1. Brigantine Wilderness – located 291km east
2. Dolly Sods Wilderness – located 166km southwest
3. Otter Creek Wilderness – located 191km southwest
4. Shenandoah National Park – located 205km southwest
5. James River Face Wilderness – located 279km southwest

In December of 2000, the "Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Phase I Report" was published. The purpose of the report was to outline a consistent approach to protecting the Air Quality Related Values (AQRVs) at each Class I area. The FLAG Phase 1 Report did not specify what thresholds should be used to determine if an emission increase will have a significant impact on sulfur and nitrogen deposition. This data was published later in the following guidance document: "Guidance on Nitrogen and Sulfur Deposition Analysis Thresholds (DAT)" published by the National Park Service and the U. S. Fish and Wildlife Service. A DAT is the amount of deposition within an area below which the impacts from a proposed project would be considered insignificant. The DAT for Eastern areas is 0.01 kilogram per hectare per year (kg/ha/yr) for total nitrogen and also for total sulfur. When the single source impacts are less than 5% extinction change for visibility and less than the DATs for deposition, FLMs do not typically object to the issuance of the permit.

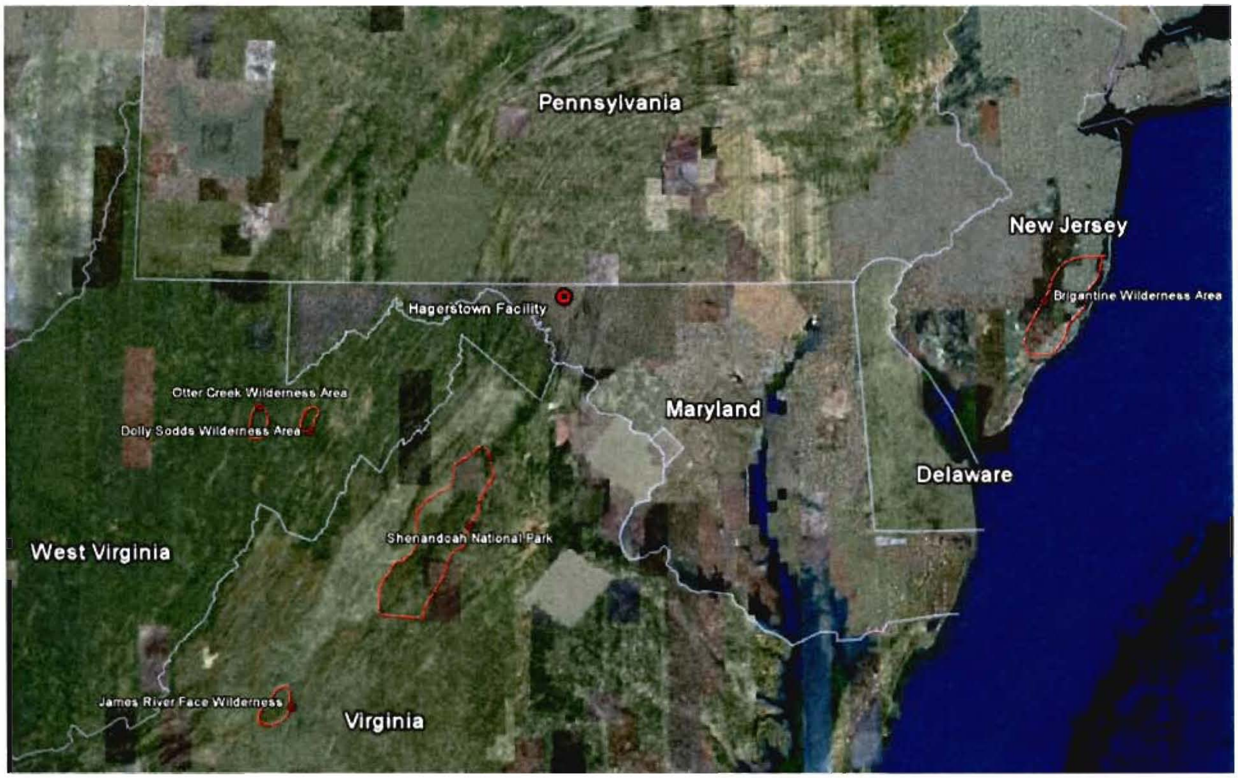
Additionally, a revised draft FLAG document has been published. The document is not final, however, it recommends using a screening formula ($Q/D <= 10$, Q=emission rate in tpy and D=distance to area in km) to determine if an emission rate is likely to have a significant impact at a specific location.

The FLMs have established threshold changes in light extinction (as a percentage of natural background) that are believed to represent potential adverse impacts on visibility. These thresholds are 5% (a potentially detectable change) and 10% (a level that may represent an unacceptable degradation).

The FLAG report states that single source modeling for ozone is not currently feasible, and FLMs will provide comments based on existing ozone concentrations at their area. Generally, as long as there is no existing vegetation damage associated with ozone in their area, the FLM is unlikely to object to the issuance of the permit.

The CALPUFF modeling system was used to estimate the potential impact the proposed facility would have on each of the five Class I areas. CALPUFF is the approved EPA long-range transport model referenced in the IWAQM report. It consists of three components: the CALMET model for processing of meteorological data; CALPUFF for the transport and dispersion calculations; and CALPOST for analysis and processing of model results.

Figure 6-1 Class I Areas within 300 km of Holcim-Hagerstown



Since the facility is located greater than 50 km from the Class I areas, the recommendations found in the "Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report" were used in the development of the air quality modeling study.

The atmospheric dispersion and atmospheric chemistry modeling for estimating visibility impacts was accomplished with the current regulatory versions of the CALPUFF modeling system, which is an EPA-guideline approach for estimating visibility impacts at distances beyond 50 km and up to a few hundred km from a Class I area. CALPUFF is the approved EPA long-range transport model referenced in the IWAQM report. It consists of three components: the CALMET model for processing of meteorological data; CALPUFF for the transport and dispersion calculations; and CALPOST for analysis and processing of model results. CALPUFF has generally been recognized as being applicable up to 300 km downwind, and is considered to become over-conservative (high) in its impact predictions beyond 300 km. Given that the Class I areas analyzed here are nearly within 300 km, the CALPUFF visibility impacts presented here are considered to be valid estimates of the impacts that should be expected from the increase in SO_2 emissions from the facility.

6.5.1 Model Input Parameters

Based on the CALPUFF input parameters listed in the modeling report (Appendix G and the parameters listed in Table 6.10, a visibility analysis was performed. The partial plume path terrain adjustment method was used. Transitional plume rise and stack tip downwash calculations were included. Nine pollutant species were modeled, with seven of them being emitted from the proposed kiln. HNO_3 and NO_3 will not be emitted directly by the facility; however, the pollutants will form in the atmosphere during transport. The particulate emissions will include condensable fine particulate notated as SO_4 (sulfates) and SOA (Secondary Organic Aerosols), as well as filterable particulates broken out into three size groups. Particulate emission speciations were based on information obtained from the NPS website at: http://www.nature.nps.gov/air/permits/ect/ectCementKiln.cfm using the spreadsheet titled 'Dry Cement Kiln ESP Example'. The receptor locations and elevations for Brigantine, Dolly Sods, Otter Creek, Shenandoah, and James River Face were obtained from the NPS website. The effects of both wet removal and dry deposition were included in the calculations. A more detailed description of modeling parameters is provided in the Class I Impact Modeling Report in Appendix G. The deposition parameters for each pollutant to be modeled are listed in Table 4-3 of the report in Appendix G.

Table 6.10 CALPUFF Emission Rates and Release Parameters

Parameter	Particle Diameter Range	Modeled Emission Rates
SO_2 (g/s)	NA	20.6
SO_4 (g/s)	NA	0.128
NO_X (g/s)	NA	1.15
SOA (g/s)	NA	0.0175
PM800 (g/s)	6.00-10.00	0.00671
PM425 (g/s)	2.50-6.00	0.0637
PM188 (g/s)	1.25-2.50	0.215
STACK HEIGHT (m)		22.73
BASE ELEVATION (m)		153.8
STACK DIAMETER (m)		2.59
EXIT VELOCITY (m/s)		22.442
EXIT TEMPERATURE (K)		573.94

The SO_2 emission rate of 20.6 g/s was modeled for the previous permit application. The CALPUFF model was not re-run. The pollutant concentrations in Sections 6.5.4 and 6.5.5 are scaled using the current emission rates of 7.08 g/s (with coal adjustment) and

12.5 g/s (without coal adjustment.) The "Extinction Changes" in these sections were not modified.

6.5.2 Visibility Analysis

As detailed in the Class I Modeling Impact Report (Appendix G), visibility impacts were estimated through the use of the modeled concentrations produced by CALPUFF and hourly relative humidity data from the CALMET output. The POSTUTIL routine was used to map the various particulate size ranges into coarse particulate, fine particulate (soil), elemental carbon, and organic aerosols, prior to analysis by CALPOST. CALPOST was used to calculate the percent change in light extinction, attributable to the project emissions, as compared to the natural background extinction within the Class I area.

In addition to the four particulate species listed above, sulfate and nitrate concentrations were included in the calculation of light extinction. Because their scattering effects are dependent on relative humidity, sulfates and nitrates are referred to as hygroscopic species. Relative humidity for the consideration of extinction from hygroscopic particles was calculated on an hourly basis from data in the CALMET results, and then averaged for each 24-hour period. This is Method 2 in CALPOST, which is the recommended method in FLAG for a refined visibility analysis. The f(RH) factor in CALPOST was capped at 95%.

All six particulate species already mentioned were included in the analysis and the default extinction efficiencies were used to convert the modeled and observed particulate concentrations to extinctions.

Background sulfate and soil concentrations of 0.3 μg/m3 and 8.5 μg/m3 were used, respectively, for all five Class I areas. The background concentrations were recommended in the FLAG Phase I report and are specific to each area. A default extinction due to Rayleigh scattering of 10 Mm-1 was used.

The FLAG Phase I report states that if the single source contribution to extinction is less than 5% the FLM is unlikely to object to the permit. The maximum predicted 24-hour extinction change is 2.82% and occurred during the year of 2003 in the Shenandoah National Park.

6.5.3 Deposition Analysis

The first step of the analysis was to sum the wet and dry deposition fluxes calculated by CALPUFF for each modeled pollutant. SO_2 and sulfate (SO_4) contribute to the total sulfur flux. The fluxes had to be corrected to account for the fact that elemental sulfur only makes up a portion of the total mass. The POSTUTIL routine was used to do the summations and adjustments to account for the differences in molecular weights. The post-processing routine was programmed to output the depositions in units of micrograms per square meter per second ($ug/m^2/s$). The results were then converted to units of kilograms per hectare per yr (kg/ha/yr).

The maximum annual total sulfur (S) depositions were then compared to the eastern Deposition Analysis Threshold (DAT) of 0.01 kg/ha/yr.

The maximum predicted annual deposition flux of total S is 0.0032 kg/ha/yr at the Shenandoah National Park for the year 2002 for the new permit limit with no coal adjustment.

6.5.4 Class I Increment Analysis Using Increment with Coal Adjustment

The maximum predicted SO_2 concentrations occurred at the Shenandoah National Park for the 2003 modeling year. The results are presented in the following tables for each Class I area.[2]

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[2] Shell Engineering & Associates, Inc., "Class I Modeling Impacts Associated with Holcim Cement Dry-Kiln SO2 Emissions Increase ", October 22, 2008.

Table 6.11 CALPUFF Scaled Model Results for Brigantine Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.02	0.02	0.01	25
	24-hour	$\mu g/m^3$	0.2	0.01	0.01	0.00	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.35	0.26	0.29	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.000	0.000	0.000	NA

Table 6.12 CALPUFF Scaled Model Results for Dolly Sods Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.03	0.03	0.04	25
	24-hour	$\mu g/m^3$	0.2	0.01	0.01	0.01	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.62	0.89	0.83	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.000	0.000	0.000	NA

Table 6.13 CALPUFF Scaled Model Results for Otter Creek Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.01	0.03	0.03	25
	24-hour	$\mu g/m^3$	0.2	0.01	0.01	0.01	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.39	0.46	0.52	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.000	0.000	0.000	NA

Table 6.14 CALPUFF Scaled Model Results for Shenandoah National Park

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.25	0.27	0.34	25
	24-hour	$\mu g/m^3$	0.2	0.06	0.06	0.08	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	1.35	1.59	2.82	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.002	0.002	0.002	NA

Table 6.15 CALPUFF Scaled Model Results for James River Face Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.02	0.02	0.02	25
	24-hour	$\mu g/m^3$	0.2	0.01	0.00	0.01	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.3	0.41	0.46	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.000	0.000	0.000	NA

The maximum predicted 3-hour, 24-hour, and annual averaging period concentrations were 0.34 $\mu g/m^3$, 0.08 $\mu g/m^3$, and 0.00 $\mu g/ m^3$, respectively.

6.5.5 Class I Increment Analysis Using Increment with No Coal Adjustment

The maximum predicted SO_2 concentrations for increment with no coal adjustment occurred at the Shenandoah National Park for the 2003 modeling year. The results are presented in the following tables for each Class I area.

Table 6.16 CALPUFF Scaled Model Results for Brigantine Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.04	0.04	0.02	25
	24-hour	$\mu g/m^3$	0.2	0.02	0.01	0.01	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.35	0.26	0.29	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.001	0.001	0.001	NA

Table 6.17 CALPUFF Scaled Model Results for Dolly Sods Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.06	0.06	0.08	25
	24-hour	$\mu g/m^3$	0.2	0.02	0.01	0.02	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.62	0.89	0.83	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.001	0.001	0.000	NA

Table 6.18 CALPUFF Scaled Model Results for Otter Creek Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.02	0.05	0.05	25
	24-hour	$\mu g/m^3$	0.2	0.01	0.01	0.01	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.39	0.46	0.52	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.000	0.001	0.001	NA

Table 6.19 CALPUFF Scaled Model Results for Shenandoah National Park

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.45	0.47	0.60	25
	24-hour	$\mu g/m^3$	0.2	0.10	0.10	0.15	5
	Annual	$\mu g/m^3$	0.1	0.00	0.01	0.01	2
Extinction Change	24-hour	%	5	1.35	1.59	2.82	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.003	0.003	0.003	NA

Table 6.20 CALPUFF Scaled Model Results for James River Face Wilderness

Pollutant	Averaging Period	Units	Class I Significance Level	Max Conc. 2001	Max Conc. 2002	Max Conc. 2003	Class I PSD Increment Std.
SO_2	3-hour	$\mu g/m^3$	1	0.04	0.04	0.04	25
	24-hour	$\mu g/m^3$	0.2	0.02	0.01	0.01	5
	Annual	$\mu g/m^3$	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.3	0.41	0.46	NA
Sulfur	Annual	Kg/ha/yr	0.01	0.001	0.001	0.001	NA

The maximum predicted 3-hour, 24-hour, and annual averaging period concentrations were 0.60 $\mu g/m^3$, 0.15 $\mu g/m^3$, and 0.01 $\mu g/m^3$, respectively.

6.6 Additional Impact Analyses

6.6.1 Toxic Air Pollutants (TAPs) Impacts

In accordance with COMAR 26.11.15.06, Holcim-Hagerstown must demonstrate compliance with the ambient impact requirements for toxic air pollutants (TAPs) emitted from the facility. Holcim-Hagerstown is a minor source for hazardous air pollutants. Potential TAP emissions were quantified using emission factors from AP-42 Table 11.6-9, maximum clinker production rates of 630,114 tons per year and 71.93 tons per hour. This is a conservative approach because actual TAP emissions are less than those predicted using general AP-42 factors. Where emission factors were known to over-predict emission rates, actual emission rates were used. TAPs emitted from the facility and the associated emission rates are listed below.

Table 6.26 TAP Potential Emission Rates

CAS #	Toxic Air Pollutant	Emission Rate (Lb/hr)	Emission Rate (Lbs/yr)
—	Arsenic and inorganic arsenic compounds	9.3510E-04	8.192
71-43-2	Benzene	1.0214E-03	8.95
—	Chromium compounds in the oxidation state VI (i.e., hexavalent chromium compounds), except sodium dichromate	3.0139E-04	2.64
56-55-3	Benz(a)anthracene	3.0930E-06	0.0271
50-32-8	Benzo(a)pyrene	9.3510E-06	0.0819
—	Beryllium and compounds	4.7474E-05	0.4159
—	Cadmium and compounds	7.6966E-05	0.6742
117-81-7	Di(2-ethylhexyl)phthalate	6.8334E-03	59.86
53-70-3	Dibenz(a,h)anthracene	4.5316E-05	0.3970
—	Dioxins and furans	3.9346E-06	0.0345
50-00-0	Formaldehyde	3.3088E-02	289.9
193-39-5	Indeno(1,2,3-cd)pyrene	6.2580E-06	0.0548
75-09-2	Methylene chloride	4.3158E-05	0.3781
67-64-1	Acetone	8.9914E-05	0.7876
7664-41-7	Ammonia	7.1931E-01	6,301
—	Barium and its soluble compounds	2.5176E-02	220.5
74-83-9	Methyl bromide	3.0930E-03	27.10
75-15-0	Carbon disulfide	7.9124E-03	69.31
108-90-7	Chlorobenzene	1.1509E-03	10.08
74-87-3	Methyl chloride	2.7334E-02	239.4
—	Copper and compounds	3.8123E-01	3,340
84-74-2	Dibutyl phthalate	2.9492E-03	25.83
76-13-1	Chlorinated fluorocarbon (Freon 113)	3.5965E-03	31.51
7647-01-0	Hydrogen chloride[a]	9.6000E-01	8,410
7439-96-5	Manganese and compounds	6.1861E-02	541.9
—	Mercury and its soluble compounds	2.5679E-03	22.50
78-93-3	Methyl ethyl ketone	2.1579E-03	18.90
91-20-3	Naphthalene	1.5825E-02	138.6
108-95-2	Phenol	7.9124E-03	69.31
129-00-0	Pyrene	3.1650E-04	2.773
—	Selenium and compounds	1.0790E-02	94.52
—	Silver and compounds	4.3878E-05	0.3844
100-42-5	Styrene	1.0790E-04	0.9452
7446-11-9	Sulfur trioxide	3.4000E+00	29,784
—	Thallium and compounds	3.8843E-04	3.403
108-88-3	Toluene	5.2078E-04	4.56
1330-20-7	Xylene	9.3510E-03	81.92
—	Zinc and compounds	3.8843E-02	340.3

[a] Values for hydrogen chloride are actual emissions as reported in the annual emission report.

A screening analysis was conducted for the TAPs listed in Table 8 to determine those that are exempt from the ambient impact requirements. First, the TAPs were evaluated with respect to the small quantity exemptions provided in COMAR 26.11.15.03(B)(3)(a) and (b). The TAPs exempted because their maximum potential emission rates are less than 0.5 pounds per hour and all screening levels are greater than 200 micrograms per cubic meter and, for Class I TAPs, the annual emission rate is less than 350 pounds per year are listed in Table 6.27.

Table 6.27 Exempt TAPs Due To Small Quantity Exemption
[COMAR 26.11.15.03(B)]

CAS #	Toxic Air Pollutant	Emission Rate (Lb/hr)	Screening Levels ($\mu g/m^3$)		
			1-Hour	8-Hour	Annual
67-64-1	Acetone	0.00009	17,807	11,871	---
108-90-7	Chlorobenzene	0.0012	---	460	---
76-13-1	Chlorinated fluorocarbon (Freon 113)	0.0036	95,808	76,646	---
78-93-3	Methyl ethyl ketone	0.0022	8,847	5,898	---
91-20-3	Naphthalene	0.0158	786	524	---
100-42-5	Styrene	0.0001	1,704	852	---
108-88-3	Toluene	0.0005	---	754	---
1330-20-7	Xylene	0.0094	6,513	4,342	---
—	Zinc and compounds	0.0388	1,000	500	---

The second step in the screening analysis required a comparison of the maximum emission rates with the premises wide allowable emission rate (AER) as specified in COMAR 26.11.16.02. The AER was determined from the chart or by calculation. The calculation of the AER followed MDEQ guidance as described below.

Four Equations were used to determine AERs based on screening levels (SL) and the chart found in the regulations.

(1) Annual, Stack & No Downwash $AER = 1664 \times SL$
(2) Annual, No Stack or Downwash $AER = 365 \times SL$
(3) Hourly Rate, Stack & No Downwash $AER = 0.0163 \times SL$
(4) Hourly Rate, No Stack or Downwash $AER = 0.00356 \times SL$

Table 6.28 Compliant TAPs Based on Allowable Emission Rates
[COMAR 26.11.16.02]

CAS #	Toxic Air Pollutant	Emission Rate (Lb/hr)	Emission Rate (Lbs/yr)	AER (Lb/hr)	AER (Lbs/yr)
—	Arsenic and inorganic arsenic compounds	0.0009	8.19	0.0016	---
71-43-2	Benzene	0.0010	8.95	0.256	2,017
—	Chromium compounds in the oxidation state VI (i.e., hexavalent chromium compounds), except sodium dichromate	0.0003	2.64	0.0016	---
—	Beryllium and compounds	0.000048	0.4159	0.00032	4
117-81-7	Di(2-ethylhexyl)phthalate	0.0068	59.86	0.49	---
—	Dioxins and furans	0.0000039	0.0345	0.00001312	0.008
50-00-0	Formaldehyde	0.0331	289.9	0.0592	800
75-09-2	Methylene chloride	0.00004	0.3781	---	16,644
7664-41-7	Ammonia	0.7193	6,301	4.07	---
—	Barium and its soluble compounds	0.0252	220.5	0.08	---
74-83-9	Methyl bromide	0.0031	27.09	0.49	---
75-15-0	Carbon disulfide	0.0079	69.31	0.49	---
74-87-3	Methyl chloride	0.0273	239.4	1.6	---
84-74-2	Dibutyl phthalate	0.0029	25.83	0.49	---
108-95-2	Phenol	0.0079	69.31	2.12	---
129-00-0	Pyrene	0.00031	2.77	0.16	---
—	Selenium and compounds	0.0108	94.52	0.032	---
—	Silver and compounds	0.000044	0.3844	0.0016	1.66
—	Thallium and compounds	0.00039	3.40	0.01	---

The TAPs listed above are in compliance with the ambient impact requirement because the maximum emission rates are all less than the allowable emission rates (AERs).

The third step in the screening analysis requires determining the maximum off-site concentration of the remaining TAPs and comparing them to the appropriate SL.

Table 6.29 Compliant TAPs Based on Maximum Off-site Concentrations

CAS #	Toxic Air Pollutant	Emission Rate (gram/sec)	Max Off-site Concentration 1-hr or 8-hr (µg/m^3)	Max Off-site Concentration Annual (µg/m^3)	Screening Levels (µg/m^3)	
					1-hr or 8-hr	Annual
—	Cadmium and compounds	0.00000971	0.000011	0.00000092	0.02	0.0036
—	Copper and compounds	0.0481	0.0530	---	2	---
7647-01-0	Hydrogen chloride	0.1210	0.1910	0.0114	117	7
7439-96-5	Manganese and compounds	0.0078	0.0086	---	2	---
—	Mercury and its soluble compounds	0.00032	0.00004	---	0.1	---
7446-11-9	Sulfur trioxide	0.4290	0.4730	---	330	---

The TAPs listed above are in compliance with the ambient impact requirement because the maximum predicted off-site concentrations of each are less than the SLs.

Four TAPs with the potential to be emitted from the cement manufacturing process had no screening levels readily available. These four compounds belong to a group of chemicals known as Polycyclic Aromatic Hydrocarbons (PAHs). PAHs are formed during the incomplete combustion of fuels, such as coal, or organic materials like tobacco and charbroiled meat. While good combustion practices minimize the formation of these compounds, trace amounts may be found in the stack exhaust of a cement kiln. The Occupational Safety and Health Administration (OSHA) has identified a permissible exposure limit (PEL) for airborne PAHs (as coal tar pitch volatiles). The limit is 0.2 mg/m^3 over an eight hour work day. This is the only available toxicity information related to the TAPs listed in Table 6.26. To complete the screening analysis, a screening level has been calculated in accordance with procedures described in COMAR 26.11.16.03(a) for combined PAHs. An 8-hour screening level of 0.002 mg/m^3 (2 μg/m^3) was calculated. The screening level was compared to predicted concentrations as described below.

Table 6.30 Compliant TAPs Based on Maximum Off-site Concentrations and Calculated Screen Levels

CAS #	Toxic Air Pollutant	Emission Rate (gram/sec)	Screening Level 8-hr (μg/m^3)	Max Off-site Concentration 1-hr or 8-hr (μg/m^3)	Max Off-site Concentration Annual (μg/m^3)
56-55-3	Benz(a)anthracene;	3.90E-07	▨	4.30E-07	3.69E-08
50-32-8	Benzo(a)pyrene;	1.18E-06	▨	1.30E-06	1.12E-07
53-70-3	Dibenz(a,h)anthracene;	5.71E-06	▨	6.30E-06	5.40E-07
193-39-5	Indeno(1,2,3-cd)pyrene;	7.89E-07	▨	8.70E-07	7.46E-08
	TOTAL PAH	8.07E-06	2.0	8.90E-06	7.63E-07

These TAPs are in compliance with ambient impact requirement because the maximum predicted off-site concentrations of the combined PAHs are less than the SL. It can be noted that the maximum off-site concentrations for each individual TAP is also below the SL.

In summary, all potential TAP emissions from the facility are in compliance with the ambient impact requirements of COMAR 26.11.15.06. This demonstrates that TAP emissions from the Holcim-Hagerstown facility will be protective of human health and the environment.

6.6.2 Impacts to Soils, Vegetation, and Animals

The analysis of soils, vegetation, and animals is based on the methodology given in the EPA document, *A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals* (guidance document).

The guidance document outlines a two-phase approach to determine possible adverse affects on soils, vegetation, and animals from pollutants. The first is for vegetation exposure to airborne pollutants. A plant's susceptibility to adverse affects from airborne pollutants is classified as sensitive, intermediate, or resistant. The minimum impact required to damage a plant is called the threshold value. Impacts above the threshold values can cause visible injuries such as premature senescence, chlorosis, necrosis, or abscission of leaves. Threshold values for each category are given in the guidance document. Airborne pollutant exposure is evaluated by comparing the maximum predicted ambient impact to the threshold value for each classification. The maximum predicted impact for a pollutant is the sum of the peak impact found through dispersion modeling and the known background concentration for the pollutant.

The air dispersion modeling discussed in Section 6.3 produced peak ambient concentrations for each averaging period. The predicted maximum off-site concentration of SO_2 (including baseline) will be compared to screening values found in the guidance.

Background concentrations were added to the maximum impacts modeled from the Holcim-Hagerstown facility and to obtain the maximum ambient impact for vegetation exposure. The results are presented in Table 6.31.

Table 6.31 Background Pollutant Concentrations

Pollutant	**Averaging Period**	**Maximum Modeled Concentration ($\mu g/m^3$)**	**Given Background Concentration ($\mu g/m^3$)**	**Maximum Ambient Concentration ($\mu g/m^3$)**
SO_2	3-hour	207.55	177.48 [a]	385.03
	24-hour	48.25	46.15 [a]	94.40
	Annual	4.70	11.54 [a]	16.24

As shown by Table 6.32 below, the maximum impacts of SO_2 are below the threshold values. Therefore, no adverse impacts to vegetation are expected from exposure to airborne pollutants. It should also be noted that the secondary NAAQS were promulgated, in part, to protect plants and animals in the environment. Holcim-Hagerstown has demonstrated compliance with both primary and secondary NAAQS standards through the PSD permitting process.

Table 6.32 Comparison of Maximum Predicted Impacts to Screening Values

Pollutant	**Averaging Time**	**Modeled Concentration ($\mu g/m^3$)**	**Background Concentration ($\mu g/m^3$)**	**Total Predicted Concentration ($\mu g/m^3$)**	**Screening Value ($\mu g/m^3$)**	**Screening Value Exceeded?**
SO_2	1-hour	517.23	---	517.23	917	No
	3-hour	207.55	177.48	385.03	786	No
	Annual	4.70	11.54	16.24	18	No

The second phase considers the possible affects on soils, vegetation, and animals due to trace element deposition. Several elements can be considered for this analysis. However, only those shown in Table 6.34 were considered for the facility, due to the availability of emission factors. Hourly emission rates as determined in Section 6.6.1 were converted to grams per second. The peak 1-hour impact for a 1 gram per sec emission rate was determined by modeling using AERMOD. This yielded a maximum concentration of 12.33 micrograms per cubic meter for a 1 gram per second emission rate. The potential 1-hour impacts for the trace elements were calculated by multiplying the peak concentration by the potential emission rate. The 1-hour concentrations can be scaled to determine concentrations for other averaging periods as described in the USEPA document, *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, EPA-454/R-92-019*[3]. The factors for converting a 1-hour average concentration to other averaging periods are shown in Table 6.33.

Table 6.33 Averaging Time Conversion Factors

Averaging Time	Multiplying Factor
3 hours	0.9
24 hours	0.4
Annual	0.08

The trace element impact results are provided in Table 6.34.

Table 6.34 Potential Impacts from Trace Elements

Element	Emission Rate (g/s)	Potential Annual Impact ($\mu g/m^3$)
Arsenic	0.000118	0.00000944
Beryllium	0.000006	0.00000048
Cadmium	0.00000971	0.000000918
Chromium	0.0000380	0.00000359
Lead	0.006441	0.00051528
Mercury	0.00032	0.0000306

The first step in this phase is calculation of the deposition concentration (DC) in parts per million (ppm) for each trace element according to the following equation:

$$DC = 21.5 \times \frac{[N]}{[d]} \times X$$

Where: N = 40 (default lifetime of facility in years);
d = 3 (default depth of soil for deposited material in cm); and
X = maximum annual average ambient concentration of the element in g/m^3.

---

[3] USEPA, "*Screening Procedures for Estimating the Air Quality Impact of Stationary Sources*", EPA-454/R-92-019, October 1992.

Results of the DC calculations from the plant are compared to the existing background soil concentration in Table 6.35. Endogenous soil concentrations were taken from the guidance document. Increases in trace element concentrations in the endogenous soil were calculated using Equation 5.4 in the guidance document.

Table 6.35 Potential Soil Deposition of Trace Elements and Percent Increases

Trace Element	Soil Deposition Concentration (ppm)	Endogenous Soil Background Concentration (ppm)	Total Concentration (ppm)	Percent Increase in Endogenous Soil Concentration (%)
Arsenic	0.002706	6	6.002706	0.0451
Beryllium	0.000138	6	6.000138	0.0023
Cadmium	0.000263	0.06	0.060263	2.8781
Chromium	0.001029	100	100.0010	0.0016
Lead	0.147714	10	10.14771	1.4771
Mercury	0.008772	4	4.008772	1.1444
Nickel	0.002706	40	6.002706	0.0451

The guidance document suggests that an increase in the soil concentration of more than 10% is a preliminary indicator that further analysis should be done for the trace element in question. As shown in Table 6.35, none of the trace elements are predicted to cause a significant increase in soil concentration. Therefore, further analysis is not warranted.

6.6.3 Growth Impacts

A permanent increase in pollutant emissions or ambient concentrations indirectly associated with the increased SO_2 emissions is not expected. Significant increases in pollutant emissions or ambient concentrations are not expected to result from any indirect activity due to an increase in population.

6.7 Conclusions

The air dispersion modeling analyses and additional impact analyses were completed in accordance with current U.S. EPA guidance. The modeling parameters, including emission rates, represent the proposed facility parameters. The results demonstrate compliance with the applicable air quality impact requirements and emission standards.

Class I Modeling Impacts Associated with Holcim Cement Dry-Kiln SO_2 Emissions Increase

Prepared For:

Schreiber, Yonley, and Associates

Prepared By:

Shell Engineering & Associates, Inc.
2403 West Ash Columbia, MO 65203

October 22, 2008

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1.0 INTRODUCTION

Holcim Cement is proposing to increase SO_2 emissions from the existing long dry cement kiln at their Hagerstown, MD plant. The increase is necessary in order to allow for NOX reductions associated with the mid-kiln firing of tires. The use of mid-kiln firing of tires was relied upon by Maryland in their State Implementation Plan (SIP) under COMAR 11.26.29.15. Mid-kiln firing of tires was also used to demonstrate Best Available Retrofit Technology (BART) under the regional haze requirements. Due to the inverse relationship between SO_2 and NOX emissions, the facility cannot maintain plant production and NOX emission reductions without significant increases in SO_2 emissions above the existing baseline.

This document provides the analysis of air quality impact to Class I areas related to this change.

2.0 IMPACTS TO AIR QUALITY RELATED VALUES (AQRVS) IN CLASS I AREAS - OVERVIEW

The 1977 amendments to the Clean Air Act (CAA) give Federal Land Managers (FLMs) the responsibility of protecting the natural and cultural resources of their Class I area from air pollution.

Despite their responsibility, FLMs were not granted any permitting authority under the CAA. They also have no authority to establish any air quality related rules or standards. The role of the FLM is to determine if a major new, or modified, source will have an adverse impact on their area. The FLM can then provide comments to the relevant permitting authority.

In December of 2000, the "Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Phase I Report" was published. The purpose of the report was to outline a consistent approach to protecting the Air Quality Related Values (AQRVs) at each Class I area.

With respect to air pollution, FLMs are primarily concerned with three distinct areas: the degradation of visibility, the impact of ozone on vegetation, and the effect of deposition on soils and surface waters.

The FLMs have established threshold changes in light extinction (as a percentage of natural background) that are believed to represent potential adverse impacts on visibility. These thresholds are 5% (a potentially detectable change) and 10% (a level that may represent an unacceptable degradation).

The FLAG report states that single source modeling for ozone is not currently feasible, and FLMs will provide comments based on existing ozone concentrations at their area. Generally, as long as there is no existing vegetation damage associated with ozone in their area, the FLM is unlikely to object to the issuance of the permit.

The National Park Service (NPS) has established Deposition Analysis Thresholds (DAT) for Eastern and Western regions of the United States. A DAT is the amount of deposition within an area below which the impacts from a proposed project would be considered insignificant. The DAT for Eastern areas is 0.01 kilogram per hectare per year (kg/ha/yr) for total nitrogen and also for total sulfur.

In addition to the AQRVs mentioned above, 40 CFR 51.166(c) establishes Class I increment standards for SO_2, PM_{10} and NO_2. Only SO_2 was evaluated for this project.

There are five Class I areas within 300 km of the Holcim source:

1. Brigantine Wilderness – located 291km east
2. Dolly Sods Wilderness – located 166km southwest
3. Otter Creek Wilderness – located 191km southwest
4. Shenandoah National Park – located 205km southwest
5. James River Face Wilderness – located 279km southwest

Since the facility is located greater than 50 km from the Class I areas, the recommendations found in the "Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report" were used in the development of the air quality modeling study.

The CALPUFF modeling system was used to estimate the potential impact the proposed facility would have on each of the five Class I areas. CALPUFF is the approved EPA long-range transport model referenced in the IWAQM report. It consists of three components: the CALMET model for processing of meteorological data; CALPUFF for the transport and dispersion calculations; and CALPOST for analysis and processing of model results.

3.0 METEOROLOGICAL MODEL INPUT

Model-ready CALMET data based on the Vistas project (Domain 5) was used for this analysis. Vistas Domain 5 encompasses the five Class I areas and their receptors as well as the Holcim facility source. Geographical definitions used to create Vistas Domain 5 were used for this analysis.

The Lambert Conformal Conic (LCC) map projection was used. The LCC projection is generally preferred for long-range transport analyses due to its ability to account for the curvature of the earth. The projection origin was set at 40 degrees north and 97 degrees west. The matching parallels of 33 and 45 degrees north and the NWS-84 datum was used.

The Vistas Domain 5 dimensions will provide at least 50 km of buffer area surrounding both the source and receptors. The origin of the domain is 1066.005 kilometers east and 686.004 kilometers south of the projection origin. The domain is 912 kilometers wide to the east/west and 928 kilometers to the north/south directions. The domain is larger than is necessary for the CALPUFF analysis; therefore a subset Computational Grid was defined in the CALPUFF portion of the modeling. A map showing the source-receptor geometry, the meteorological domain, and the Computational Grid has been provided as Figure 3-1.

The Vistas Domain 5 meteorological model data includes a four-kilometer horizontal grid spacing and ten vertical layers ranging from 20 to 4000 meters. Mesoscale prognostic (MM5) datasets for 2001, 2002 and 2003 were used and are the latest available. The MM5 data was used as input to CALMET as the "initial guess" wind field. The initial guess field was adjusted by the model for local terrain and land use effects to generate a Step 1 wind field, and then further refined using local surface, upper air, overwater, and precipitation observations to create a final Step 2 wind field.

Suface, upper air, overwater, and preciptation station data used can be obtained from the TRC Companies, Inc. – Atmospheric Studies Group website (www.src.com/datasets/datasets_vistas.html) for VISTAS Regional Domain 5. The number of surface and precipitation stations varies by year in the VISTAS data set.

Maps showing the locations of the surface, upper air, overwater, and precipitation stations used in the model-ready meteorological data have been provided as Figure 3-2, Figure 3-3, Figure 3-4, and Figure 3-5, respectively.

Figure 3-1 Meteorological Domain and Computational Grid

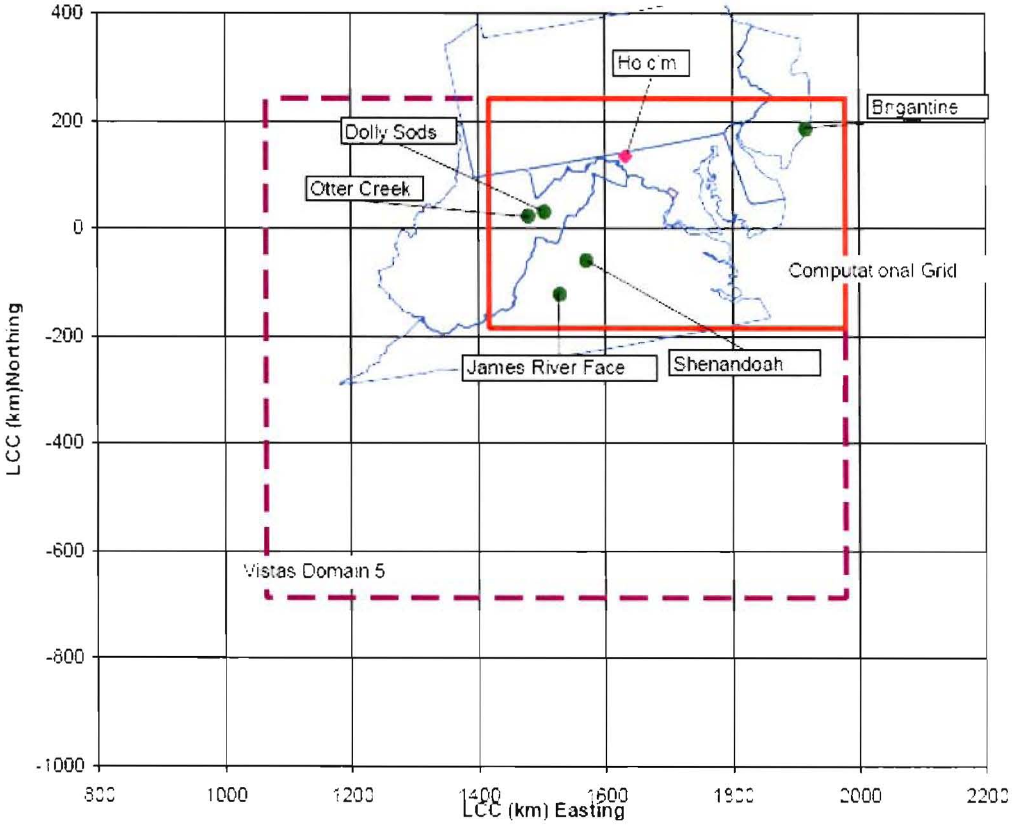

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Figure 3-2 Surface Station Locations

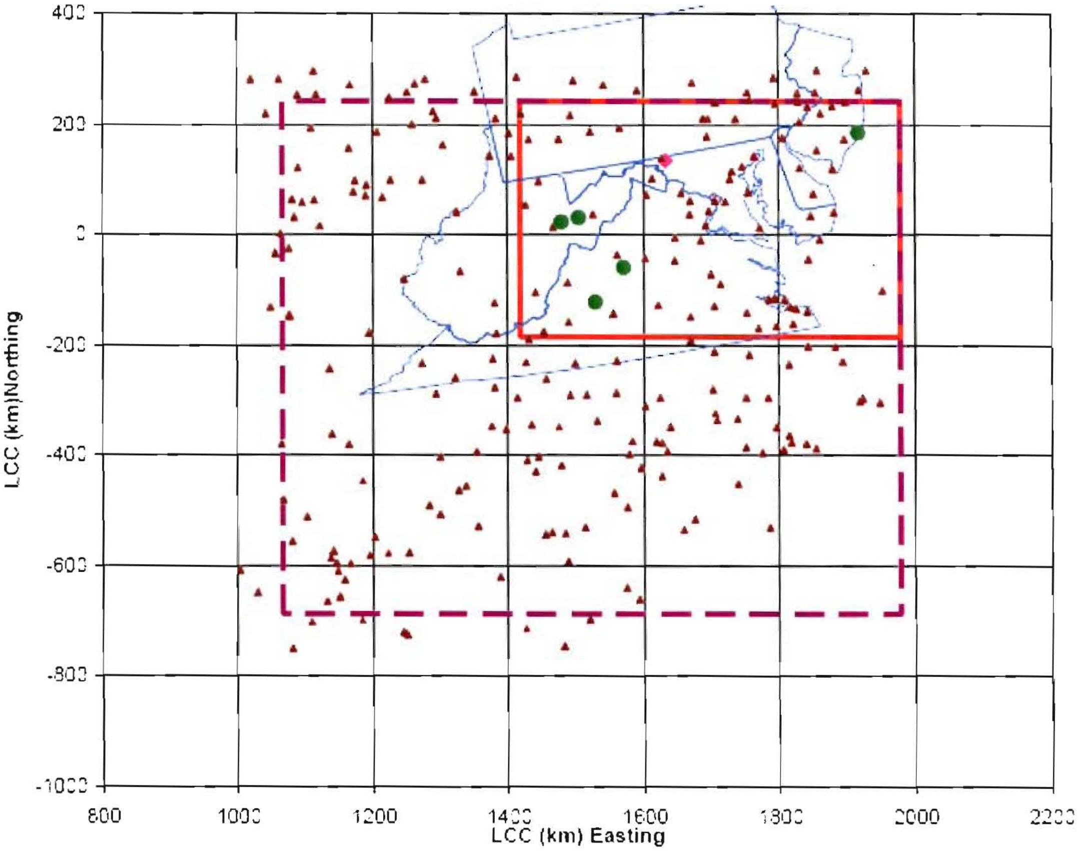

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Figure 3-3 Upper Air Station Locations

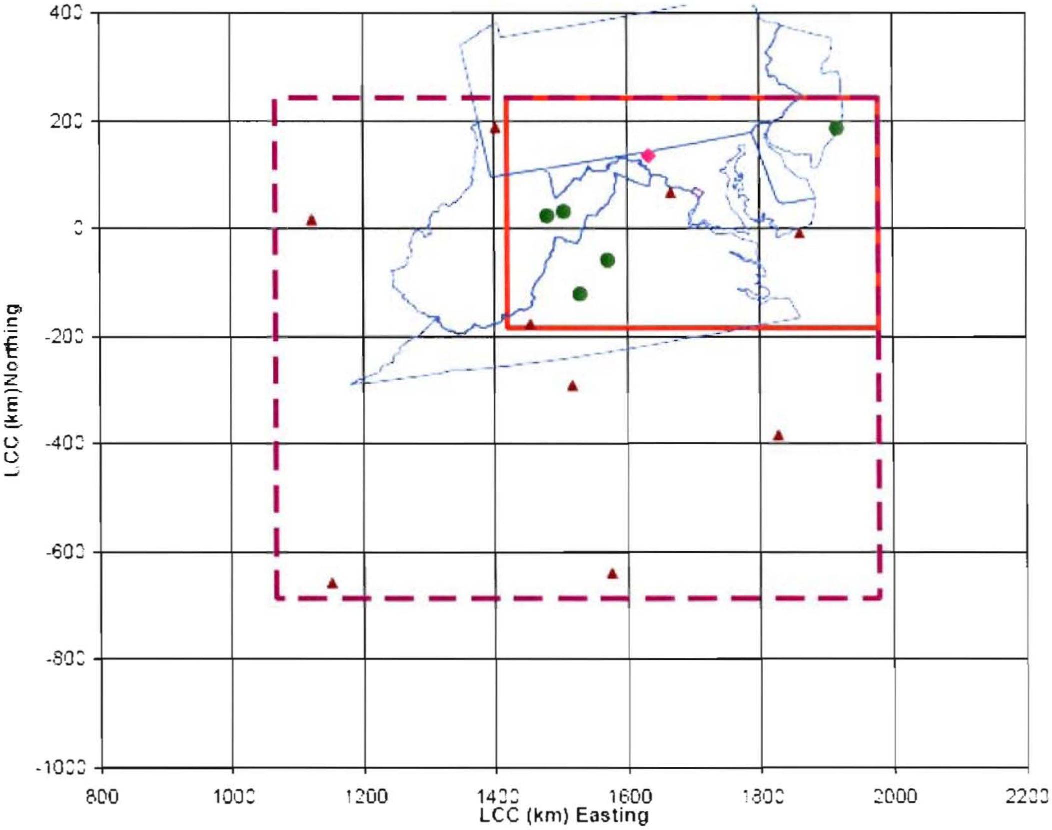

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Figure 3-4 Overwater Station Locations

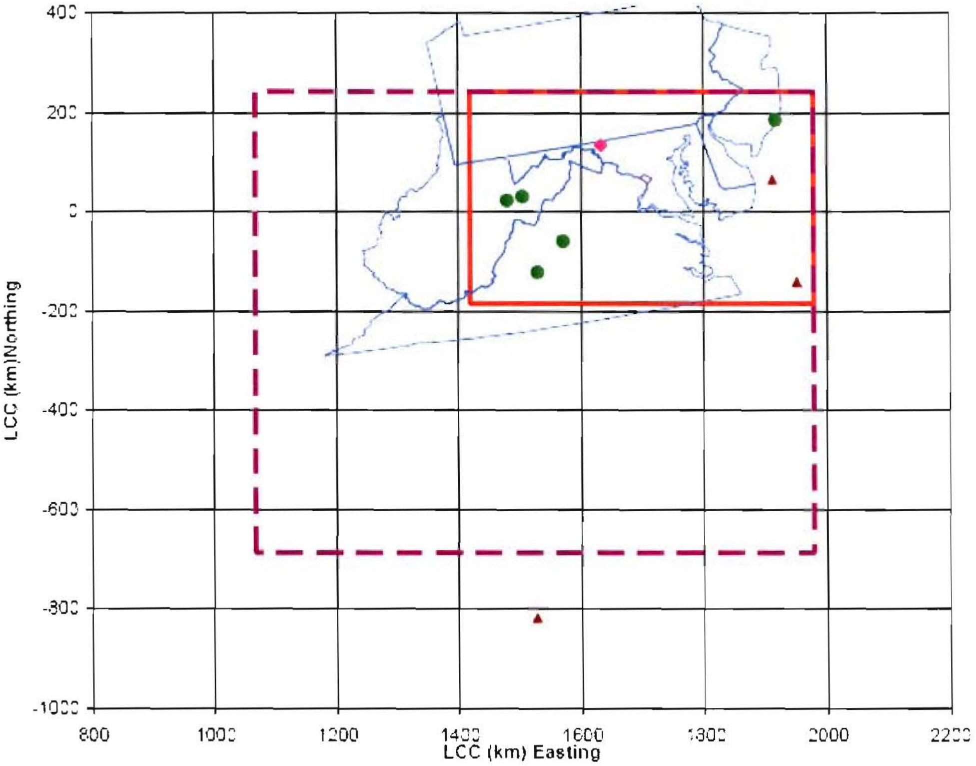
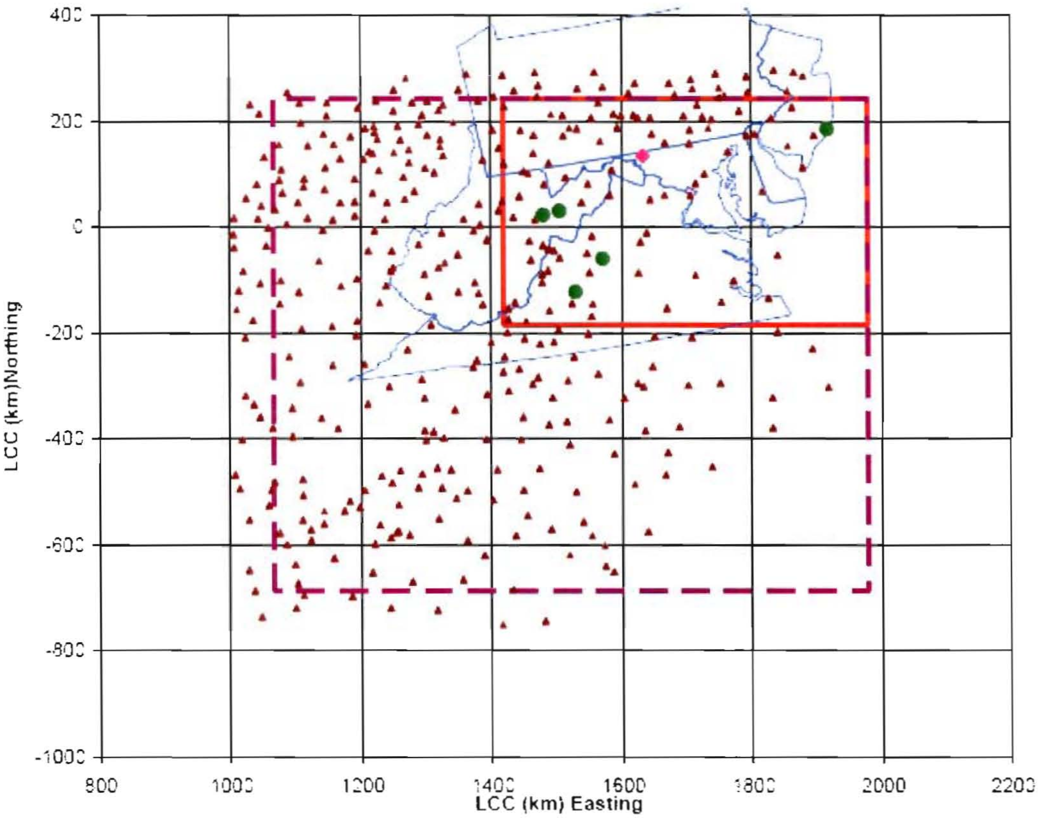


Figure 3-5 Precipitation Station Locations



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4.0 PUFF MODEL INPUT

CALPUFF, Version 5.8 is the official EPA-approved model and version for long-range transport referenced in the IWAQM report. Version 5.8 was used for this analysis.

The Vistas Domain 5 meteorological wind fields output from CALMET was used as inputs for the CALPUFF model. The modeled time period, map projection and domain are identical to those used to run CALMET. However, a Computational Grid containing the sources and receptors, which is a subset of the meteorological domain, was used to optimize execution. The Computational Grid extends from east-west grid number 89 through 228 and north-south grids number 127 thru 232, where each grid space is a 4kmx4km square in the Vistas 5 Domain. The Computational Grid location within the Domain is shown in Figure 3-1. The equivalent Source emission rates, background ozone concentrations, and technical options to be used within CALPUFF are addressed below.

The CALPUFF input parameters are listed in Table 4-1. The partial plume path terrain adjustment method was used. Transitional plume rise and stack tip downwash calculations were included.

Nine pollutant species were modeled, with seven of them being emitted from the proposed kiln. HNO_3 and NO_3 will not be emitted directly by the facility; however, the pollutants will form in the atmosphere during transport. The particulate emissions will include condensibles notated as SO_4 (sulfates) and SOA (Secondary Organic Aerosols), as well as filterable particulates broken out into three size groups. All particulate emissions speciation were based on information obtained from the NPS website at:

http://www.nature.nps.gov/air/permits/ect/ectCementKiln.cfm

using the spreadsheet titled 'Dry Cement Kiln ESP Example'. The kiln emission rates and the release parameters to be modeled for the proposed stack are provided in Table 4-2.

The effects of both wet removal and dry deposition were included in the calculations. The deposition parameters for each pollutant to be modeled are listed in Table 4-3.

Hourly ozone data obtained from the TRC website was input to CALPUFF, for chemical transformation with the MESOPUFF II chemical transformation scheme. The default background ozone concentration of 80 ppb was used for hours with missing data. A constant background ammonia concentration of 2.0 ppb was used. A map showing the locations of the ozone monitors is depicted in Figure 4-1.

The receptor locations and elevations for Brigantine, Dolly Sods, Otter Creek, Shenandoah, and James River Face were obtained from the NPS website. The COORDS program (developed by TRC) was used to convert the coordinates for all receptors, meteorological stations, and stack locations to LCC coordinates. A total of 583 discrete receptor locations were modeled. The locations of the individual receptors within each of the five Class I areas are shown in Figure 4-2, Figure 4-3, Figure 4-4, Figure 4-5, and Figure 4-6.

Table 4-1 CALPUFF Input Parameters

Parameter	Parameter Description	Parameter Units	Value Used
METRUN	Option to run all periods found in the met. File (0=Run period explicitly defined below)		0
IBYR	Starting Date, Year		2001-2003
IBMO	Starting Date, Month		1
IBDY	Starting Date, Day		1
IBHR	Starting Date, Hour		1
XBTZ	Base Time Zone		5
IRLG	Length of Run	Hours	8760
NSPEC	Number of chemical species modeled		9
NSE	Number of chemical species emitted		7
ITEST	Flag to stop run after setup phase (2=Continues with execution of program after setup)		2
MRESTART	Model restart configuration control flag (0=Do not read or write a restart file)		0
NRESPD	Number of periods in restart output cycle (0=File written only at last period)		0
METFM	Meteorological data format (1=CALMET binary file)		1
MPRFFM	Meteorological profile data format (1=CTDM plus tower file)		1
AVET	Averaging time	Minutes	60
PGTIME	PG averaging time	Minutes	60
MGAUSS	Vertical distribution used in the near field (1=Gaussian)		1
MCTADJ	Terrain adjustment method (3=Partial plume path adjustment)		3
MCTSG	Sub-grid scale complex terrain flag (0=Not modeled)		0
MSLUG	Near field slug model flag (0=Slug model not used)		0
MTRANS	Transitional plume rise flag (1=Transitional plume rise computed)		1
MTIP	Stack tip downwash flag (1=stack tip downwash modeled)		1
MBDW	Method used to simulate building downwash (1=ISC method)		1
MSHEAR	Vertical wind shear above the stack top flag (0=Vertical wind shear not modeled)		0
MSPLIT	Puff splitting flat (1=Puff splitting allowed)		0
MCHEM	Chemical mechanism flag (1=MESOPUFF II scheme)		1

Parameter	Parameter Description	Parameter Units	Value Used
MAQCHEM	Aqueous phase transformation flag (0=Aqueous phase transformation not modeled)		0
MWET	Wet removal flag (1=Wet removal modeled)		1
MDRY	Dry deposition flag (1=Dry deposition modeled)		1
MDISP	Method used to compute dispersion coefficients (3=PG dispersion coefficients for RURAL areas, MP coefficients in urban areas)		3
MROUGH	PG sigma-y,z adj. for roughness? (0=No)		0
MPARTL	Partial plume penetration of elevated inversion? (1=Yes)		1
MTINV	Strength of temperature inversion provided in PROFILE.DAT extended records? (0=No, computed from measured/default gradients)		0
MPDF	PDF used for dispersion under convective conditions? (0=No)		0
MSGTIBL	Sub-Grid TIBL module used for shore line? (0=No)		0
MBCON	Boundary conditions (concentration) modeled? (0=No)		0
MFOG	Configure for FOG Model output? (0=No)		0
MREG	Test options specified to see if they conform to regulatory defaults? (0=No)		1
PMAP	Map Projection (LCC=Lambert Conformal Conic)		LCC
FEAST	False easting at the projection origin	km	0
FNORTH	False northing at the projection origin	km	0
RLAT0	Latitude of the projection origin	Degrees	40N
RLON0	Longitude of the projection origin	Degrees	97W
XLAT1	Matching parallel of latitude for projection (south)	Degrees	33N
XLAT2	Matching parallel of latitude for projection (north)	Degrees	45N
DATUM	Datum region (WGS-G=WGS-84 GRS 80 Spheroid, Global coverage)		NWS-84
NX	Number of X grid cells		228
NY	Number of Y grid cells		232
NZ	Number of vertical layers		10
DGRIDKM	Grid spacing	km	4

Parameter	Parameter Description	Parameter Units	Value Used
ZFACE	Cell face heights	m	.0, 20.0, 40.0, 80.0, 160.0, 320.0, 640.0, 1200.0, 2000.0, 3000.0, 4000.0
XORIGKM	Origin X coordinate	km	1066.005
YORIGKM	Origin Y coordinate	km	-686.004
IBCOMP	Computational grid, X index of LL corner		89
JBCOMP	Computational grid, Y index of LL corner		127
IECOMP	Computational grid, X index of UR corner		228
JECOMP	Computational grid, Y index of UR corner		232
LSAMP	Logical flag indicating if gridded receptors are used (F=No)		F
NHILL	Number of terrain features		0
NCTREC	Number of special complex terrain receptors		0
RCUTR	Reference cuticle resistance	s/cm	30
RGR	Reference ground resistance	s/cm	10
REACTR	Reference pollutant reactivity		8
NINT	Number of particle-size intervals used to evaluate effective particle deposition velocity		9
IVEG	Vegetation state in unirrigated areas (1=Active and unstressed vegetation)		1
MOZ	Ozone data input option (0=use a monthly background ozone value)		1
BCKO3	Monthly ozone concentrations	ppb	80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00
BCKNH3	Monthly ammonia concentrations	ppb	2.00, 2.00, 2.00, 2.00, 2.00, 2.00, 2.00, 2.00, 2.00, 2.00, 2.00, 2.00
RNITE1	Nighttime SO2 loss rate	%/hr	0.2
RNITE2	Nighttime NOx loss rate	%/hr	2
RNITE3	Nighttime HNO3 formation rate	%/hr	2
MH2O2	H2O2 data input option (0=use a monthly background H2O2 value)		1

Parameter	Parameter Description	Parameter Units	Value Used
BCKH2O2	Monthly H2O2 concentrations	ppb	1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00
SYTDEP	Horizontal size of puff (m) beyond which time-dependent dispersion equations (Heffter) are used to determine sigma-y and sigma-z	m	550
MHFTSZ	Switch for using Heffter equation for sigma z as above (0=Don't use Heffter)		0
JSUP	Stability class used to determine plume growth rates for puffs above the boundary layer		5
CONK1	Vertical dispersion constant for stable conditions		0.01
CONK2	Vertical dispersion constant for neutral/unstable conditions		0.1
TBD	Factor for determining Transition-point from Schulman-Scire to Huber-Snyder Building Downwash scheme (0.5=ISC Transition-point)		0.5
IURB1	Range of land use categories for which urban dispersion is assumed (lower bound)		10
IURB2	Range of land use categories for which urban dispersion is assumed (upper bound)		19
MXNEW	Maximum Number of slugs/puffs release from one source during one time step		99
MXSAM	Maximum Number of sampling steps for one puff/slug during one time step		99
NCOUNT	Number of iterations used when computing the transport wind for a sampling step that includes gradual rise		2
SYMIN	Minimum sigma y for a new puff/slug	m	1
SZMIN	Minimum sigma z for a new puff/slug	m	1
SVMIN	Default minimum turbulence velocities sigma-v for each stability class over land and over water	m/s	0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370, 0.370, 0.370, 0.370, 0.370, 0.370

Parameter	Parameter Description	Parameter Units	Value Used
SWMIN	Default minimum turbulence velocities sigma-w for each stability class over land and over water	m/s	0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 0.200, 0.120, 0.080, 0.060, 0.030, 0.016
CDIV	Divergence criterion for dw/dz across puff used to initiate adjustment for horizontal convergence	1/s	.0, .0
WSCALM	Minimum wind speed allowed for non-calm conditions	m/s	0.5
XMAXZI	Maximum mixing height	m	3000
XMINZI	Minimum mixing height	m	50
WSCAT	Default wind speed classes	m/s	1.54, 3.09, 5.14, 8.23, 10.80
PLX0	Default wind speed profile power-law exponents for stabilities 1-6		0.07, 0.07, 0.10, 0.15, 0.35, 0.55
PTG0	Default potential temperature gradient for stable classes E, F	K/m	0.020, 0.035
PPC	Default plume path coefficients for each stability class		0.50, 0.50, 0.50, 0.50, 0.35, 0.35
EPSAREA	Fractional convergence criterion for numerical AREA source integration		0.000001
DSRISE	Trajectory step-length (m) used for numerical rise integration	m	1

Table 4-2 Dry Cement Kiln with ESP Emission Rates and Release Parameters

Parameter		**Value**
	Modeled Emission Rates	
SO_2 (g/s)		20.6
SO_4 (g/s)		0.128
NO_x (g/s)		1.15
SOA		0.0175
	Particle Diameter Range (um)	
PM800 (g/s)	6.00-10.00	0.00671
PM425 (g/s)	2.50-6.00	0.0637
PM188 (g/s)	1.25-2.50	0.215
	Release Parameters	
Stack Height (m)		22.73
Base Elevation (m)		153.8
Stack Diameter (m)		2.59
Exit Velocity (m/s)		22.442
Exit Temperature (K)		573.94

Table 4-3 Deposition Parameters

Pollutant	Gas-Dry Deposition					Particle-Dry Deposition		Wet Deposition	
	Diffusivity (cm2/s)	Alpha Star	Reactivity	Mesophyll Resistance (s/cm)	Henry's Law Coefficient	Geometric Mass Mean Diameter (µm)	Geometric Standard Deviation (µm)	Liquid Scavenging Coefficient (1/s)	Frozen Scavenging Coefficient (1/s)
SO2	0.1509	1000	8	0	0.04			3.00E-05	0
SO4						0.4800	2	1.00E-04	3.00E-05
NOX	0.1656	1	8	5	3.5				
HNO3	0.1628	1	18	0	1.00E-07			6.00E-05	0
NO3						0.4800	2	1.00E-04	3.00E-05
SOA						0.4800	2.0	1.00E-04	3.00E-05
PM800						8.0000	0	1.00E-04	3.00E-05
PM425						4.2500	0	1.00E-04	3.00E-05
PM188						1.8800	0	1.00E-04	3.00E-05

Figure 4-1 Ozone Monitor Locations

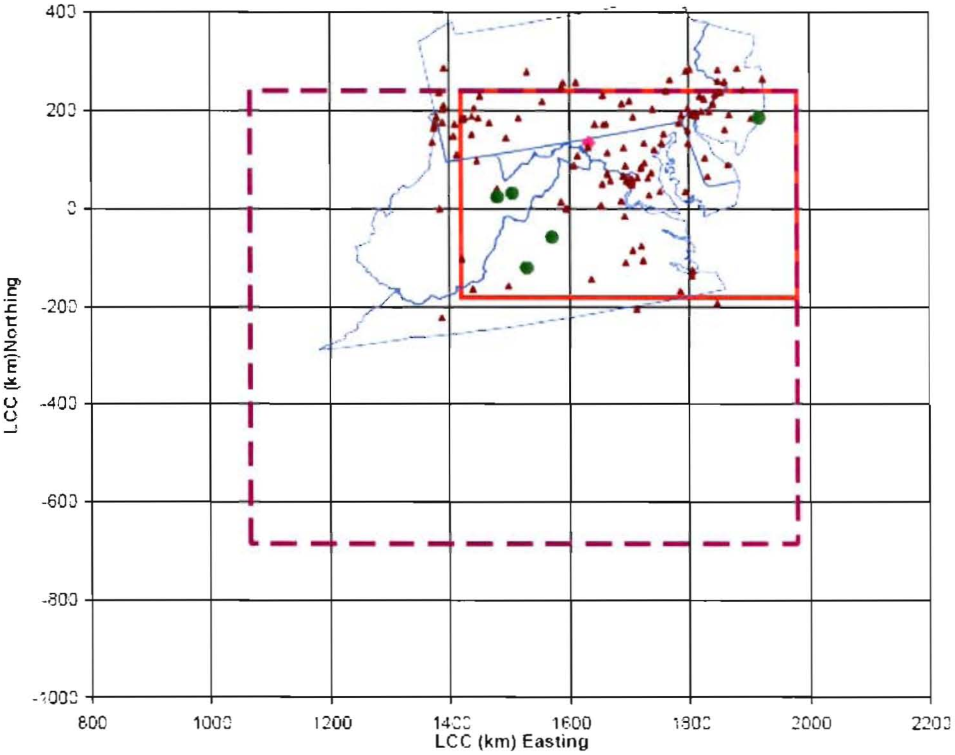

Figure 4-2 Discrete Receptor Locations – Brigantine Wilderness (FWS)

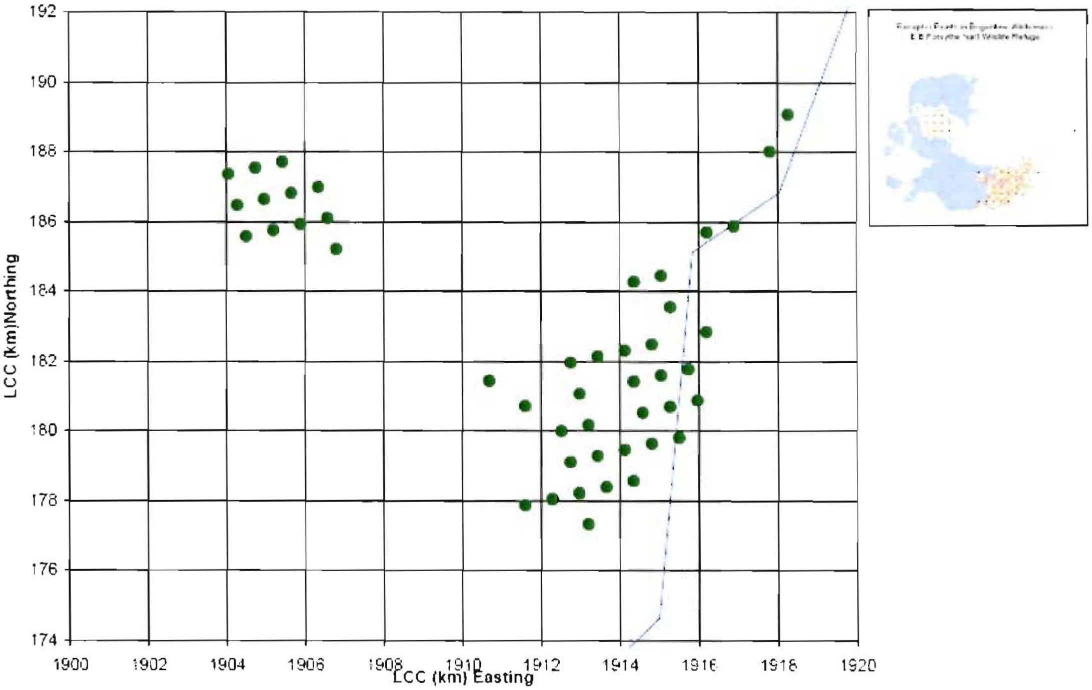

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Figure 4-3 Discrete Receptor Locations – Dolly Sods Wilderness (USFS)

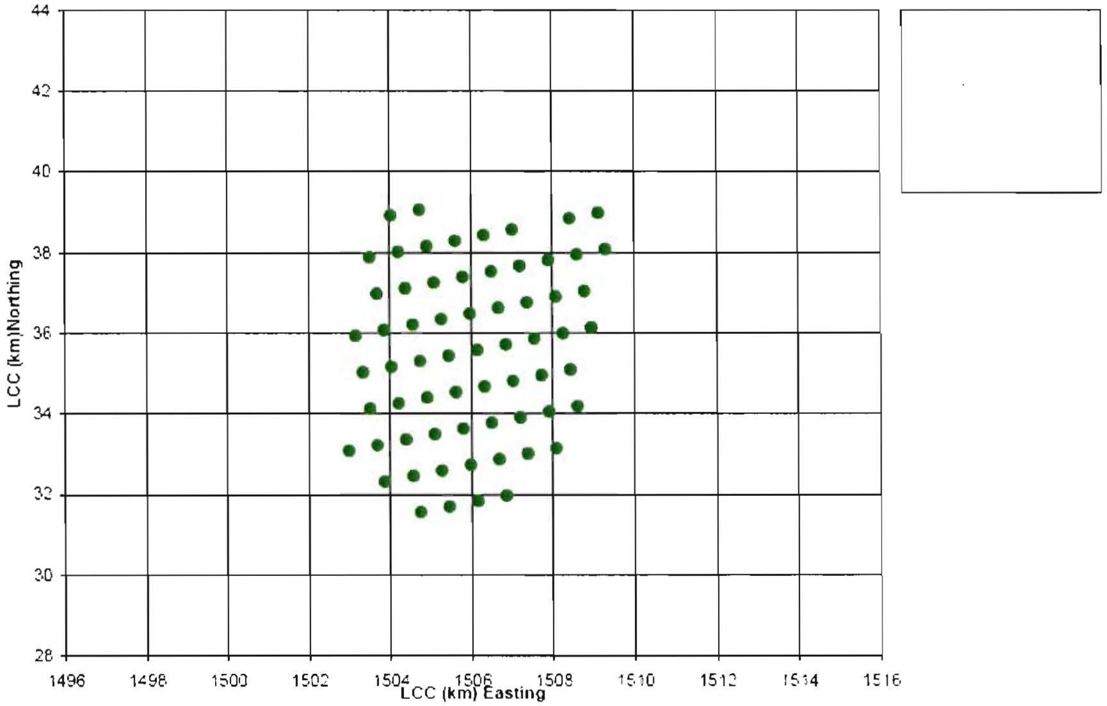


Figure 4-4 Discrete Receptor Locations – Otter Creek Wilderness (USFS)

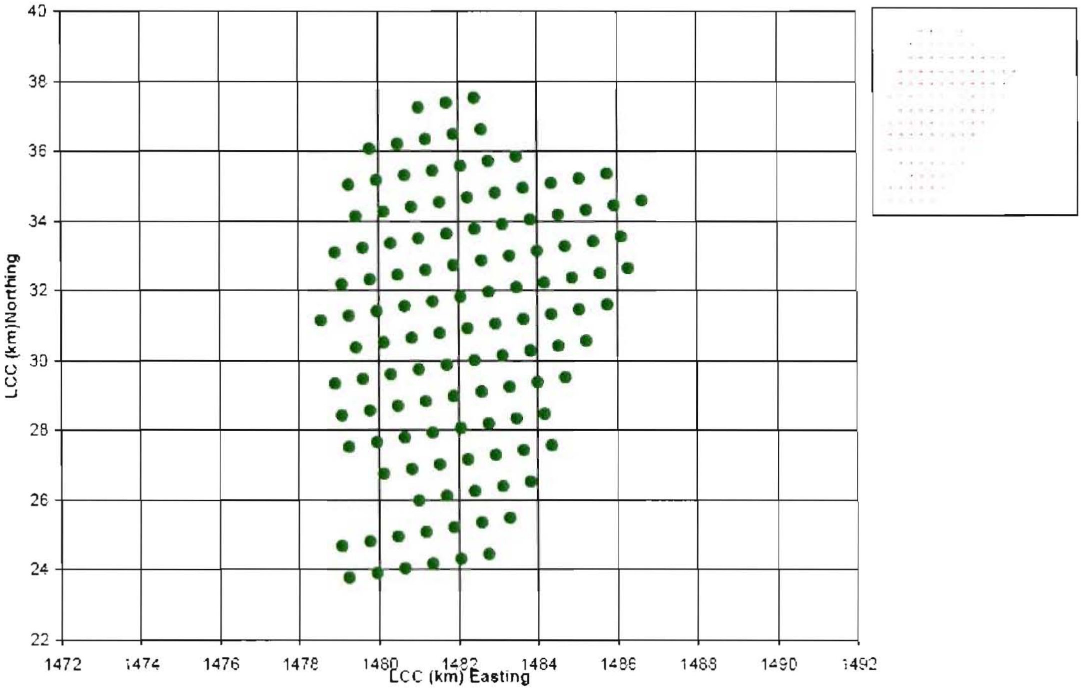


Figure 4-5 Discrete Receptor Locations – Shenandoah National Park (NPS)

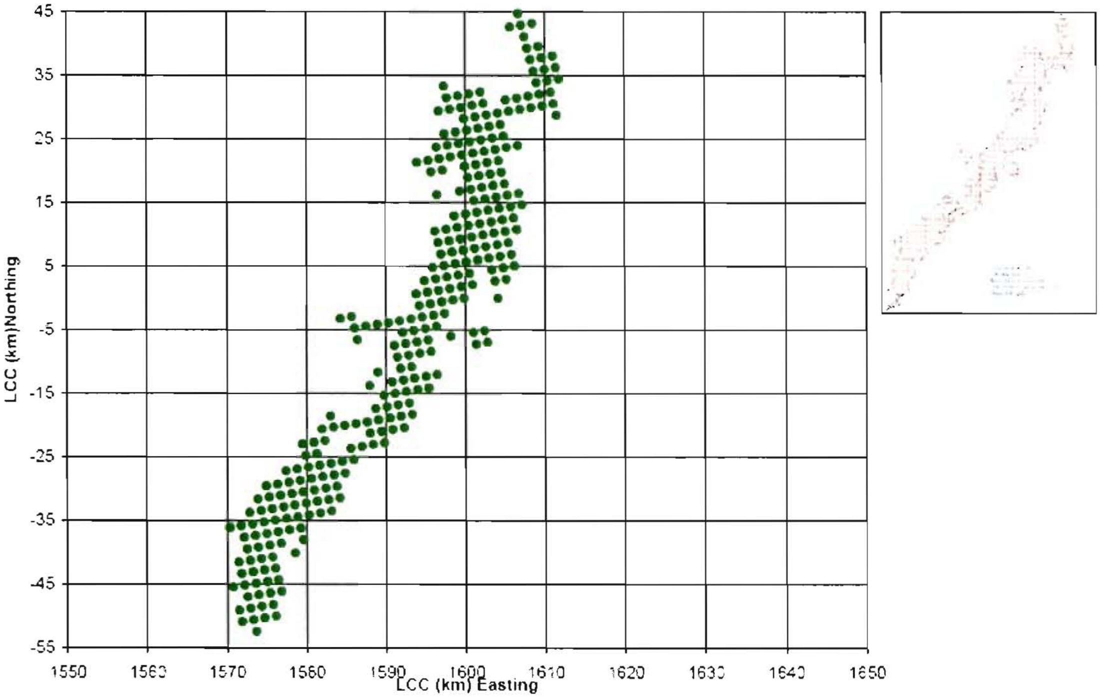
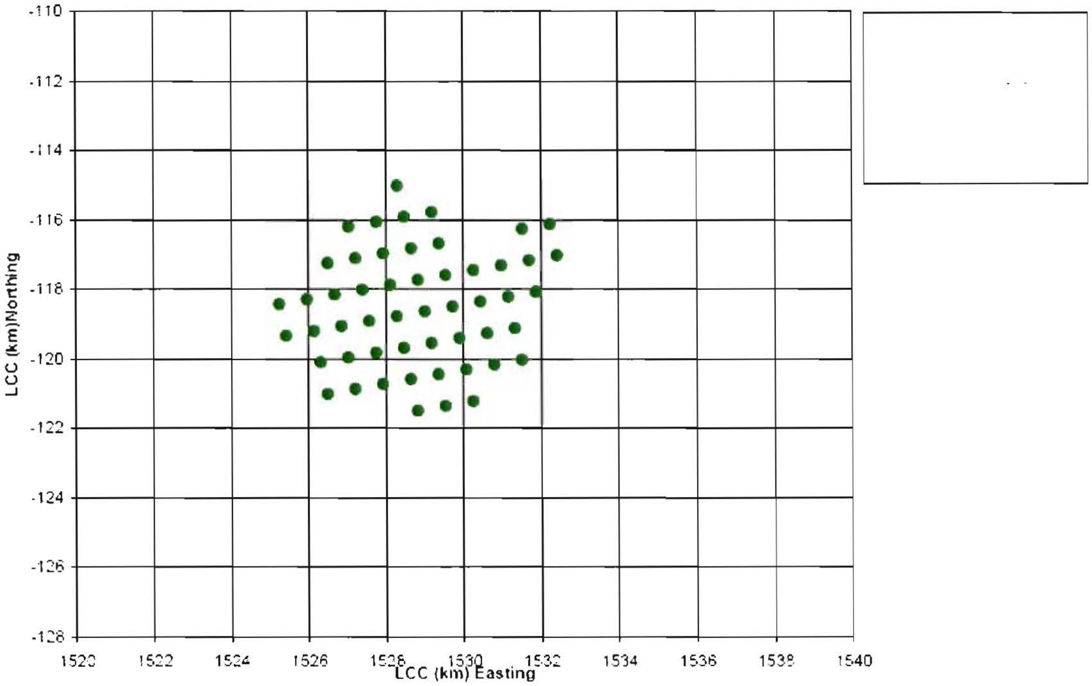


Figure 4-6 Discrete Receptor Locations – James River Face Wilderness (USFS)



5.0 MODEL RESULTS

The results of the visibility, deposition, and Class I PSD increment analyses are summarized for each analyzed Class I area in Table 5-1, Table 5-2, Table 5-3, Table 5-4, and Table 5-5. CALPOST Version 5.6394 was used for the post-processing.

5.1 Visibility Analysis

Visibility impacts were estimated through the use of the modeled concentrations produced by CALPUFF and hourly relative humidity data from the CALMET output. The POSTUTIL routine was used to map the various particulate size ranges into coarse particulate, fine particulate (soil), elemental carbon, and organic aerosols, prior to analysis by CALPOST. CALPOST was used to calculate the percent change in light extinction, attributable to the project emissions, as compared to the natural background extinction within the Class I area.

In addition to the four particulate species listed above, sulfate and nitrate concentrations were included in the calculation of light extinction. Because their scattering effects are dependent on relative humidity, sulfates and nitrates are referred to as hygroscopic species. Relative humidity for the consideration of extinction from hygroscopic particles was calculated on an hourly basis from data in the CALMET results, and then averaged for each 24-hour period. This is Method 2 in CALPOST, which is the recommended method in FLAG for a refined visibility analysis. The f(RH) factor in CALPOST was capped at 95%.

All six particulate species already mentioned were included in the analysis and the default extinction efficiencies were used to convert the modeled and observed particulate concentrations to extinctions.

Background sulfate and soil concentrations of 0.3 $\mu g/m^3$ and 8.5 $\mu g/m^3$ were used, respectively, for all five Class I areas. The background concentrations were recommended in the FLAG Phase I report and are specific to each area. A default extinction due to Rayleigh scattering of 10 Mm^{-1} was used.

The FLAG Phase I report states that if the single source contribution to extinction is less than 5% the FLM is unlikely to object to the permit. The maximum predicted 24-hour extinction change is 2.82% and occurred during the year of 2003 in the Shenandoah National Park.

5.2 Deposition Analysis

The first step of the analysis was to sum the wet and dry deposition fluxes calculated by CALPUFF for each modeled pollutant. SO_2 and sulfate (SO_4) contribute to the total sulfur flux. The fluxes had to be corrected to account for the fact that elemental sulfur only makes up a portion of the total mass. The

POSTUTIL routine was used to do the summations and adjustments to account for the differences in molecular weights. The post-processing routine was programmed to output the depositions in units of micrograms per square meter per second (ug/m^2/s). The results were then converted to units of kilograms per hectare per yr (kg/ha/yr).

The maximum annual total sulfur (S) depositions were then compared to the eastern Deposition Analysis Threshold (DAT) of 0.01 kg/ha/yr.

The maximum predicted annual deposition flux of total S is 0.0052 kg/ha/yr at the Shenandoah National Park for the year 2002.

5.3 Class I Increment Analysis

The maximum predicted SO_2 concentrations occurred at the Shenandoah National Park for the 2003 modeling year. The maximum predicted 3-hour, 24-hour, and annual averaging period concentrations were 0.99µg/m^3, 0.24µg/m^3, and 0.01µg/m^3, respectively.

Table 5-1 Model Results – Brigantine Wilderness

Pollutant	Avg Period	Units	Class 1 Significance Level	Result 2001	Result 2002	Result 2003	Class 1 PSD Increment Standard
S02	3-hour	µg/m³	1	0.07	0.07	0.04	25
	24-hour	µg/m³	0.2	0.03	0.02	0.01	5
	Annual	µg/m³	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.35	0.26	0.29	
Sulfur	Annual	kg/ha/yr	0.01	0.001	0.001	0.001	

Table 5-2 Model Results - Dolly Sods Wilderness

Pollutant	Avg Period	Units	Class 1 Significance Level	Result 2001	Result 2002	Result 2003	Class 1 PSD Increment Standard
S02	3-hour	µg/m³	1	0.10	0.10	0.13	25
	24-hour	µg/m³	0.2	0.03	0.02	0.03	5
	Annual	µg/m³	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.62	0.89	0.83	
Sulfur	Annual	kg/ha/yr	0.01	0.001	0.001	0.000	

Table 5-3 Model Results - Otter Creek Wilderness

Pollutant	Avg Period	Units	Class 1 Significance Level	Result 2001	Result 2002	Result 2003	Class 1 PSD Increment Standard
S02	3-hour	µg/m³	1	0.04	0.09	0.08	25
	24-hour	µg/m³	0.2	0.02	0.02	0.02	5
	Annual	µg/m³	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.39	0.46	0.52	
Sulfur	Annual	kg/ha/yr	0.01	0.000	0.001	0.001	

Table 5-4 Model Results - Shenandoah National Park

Pollutant	Avg Period	Units	Class 1 Significance Level	Result 2001	Result 2002	Result 2003	Class 1 PSD Increment Standard
S02	3-hour	µg/m^3	1	0.74	0.78	0.99	25
	24-hour	µg/m^3	0.2	0.17	0.17	0.24	5
	Annual	µg/m^3	0.1	0.00	0.01	0.01	2
Extinction Change	24-hour	%	5	1.35	1.59	2.82	
Sulfur	Annual	kg/ha/yr	0.01	0.005	0.005	0.005	

Table 5-5 Model Results - James River Face Wilderness

Pollutant	Avg Period	Units	Class 1 Significance Level	Result 2001	Result 2002	Result 2003	Class 1 PSD Increment Standard
S02	3-hour	µg/m^3	1	0.06	0.06	0.06	25
	24-hour	µg/m^3	0.2	0.03	0.01	0.02	5
	Annual	µg/m^3	0.1	0.00	0.00	0.00	2
Extinction Change	24-hour	%	5	0.30	0.41	0.46	
Sulfur	Annual	kg/ha/yr	0.01	0.001	0.001	0.001	

APPENDIX B

BACT ANALYSIS FROM OCT 2009 PSD PERMIT APPLICATION

5. BEST AVAILABLE CONTROL TECHNOLOGY (BACT) ANALYSIS

This section summarizes the BACT determination for sulfur dioxide.

BACT for any source is defined in COMAR 26.11.17.01(B)(3) as:

> (a) ".... an emissions limitation, including a visible emission standard, based on the maximum degree of reduction for each pollutant subject to regulation under the Clean Air Act which would be emitted from any proposed major stationary source or major modification which the Department, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for that source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combination techniques for control of the pollutant.
>
> (b) Application of best available control technology may not result in emissions of any pollutant which would exceed the emissions allowed by an applicable standard under 40 CFR 60 and 61.[4]
>
> (c) If the Department determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination of these, may be prescribed instead to satisfy the requirement for the application of best available control technology. This standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of the design, equipment, work practice, or operation, and shall provide for compliance by means which achieve equivalent results."

BACT analyses are conducted using EPA's "top-down" BACT approach, as described in EPA's *Draft New Source Review Workshop Manual* (EPA 1990). The five basic steps of a top-down BACT analysis are listed below:

Step 1: Identify potential control technologies
Step 2: Eliminate technically infeasible options
Step 3: Rank remaining control technologies by control effectiveness
Step 4: Evaluate the most effective controls and document results
Step 5: Select BACT

The first step is to identify potentially "available" control options for each emission unit triggering PSD for each pollutant under review. Available options consist of a comprehensive list of those technologies with a potentially practical application to the emission unit in question. The list includes technologies used to satisfy Lowest Achievable Emissions Rate (LAER) requirements, innovative technologies, and controls applied to similar source categories. For this analysis, the following sources were investigated to identify potentially available control technologies:

- EPA's RACT/BACT/LAER Clearinghouse (RBLC) database;
- EPA Region 4's National Control Technology (CT) database;

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[4] The Code of Federal Regulations (CFR) Title 40, Parts 60 and 61, include the New Source Performance Standard (NSPS) and National Emission Standard for Hazardous Air Pollutant (NESHAP) regulations, respectively.

- EPA's New Source Review website;
- In-house experts;
- Technical books and articles; and,
- Guidance documents and personal communications with state agencies.

After identifying potential technologies, the second step is to eliminate technically infeasible options from further consideration. To be considered feasible for BACT, a technology must be both available and applicable. In this step, it is important to ensure that the technical basis for eliminating a technology from further consideration be clearly documented based on physical, chemical, engineering, and source-specific factors related to safe and successful use of the controls.

The third step is to rank the technologies not eliminated in Step 2 in order of descending control effectiveness for each pollutant of concern. If the highest ranked technology is proposed as BACT, it is not necessary to perform any further technical or economic evaluation. Potential adverse impacts, however, must still be identified and evaluated.

The fourth step entails an evaluation of energy, environmental, and economic impacts for determining a final level of control. The evaluation begins with the most stringent control option and continues until a technology under consideration cannot be eliminated based on adverse energy, environmental, or economic impacts. The economic or "cost-effectiveness" analysis is conducted in a manner consistent with EPA's *OAQPS Control Cost Manual* Fifth Edition (EPA 1996) and subsequent revisions[5]. An important aspect of the top-down BACT methodology is the establishment of baseline emission levels used in calculating the cost-effectiveness of alternative control options. EPA's Draft *New Source Review Workshop Manual* states that baseline emissions should be a realistic upper-bound estimate of emissions taking into account physical or operational constraints and historical operating data[6].

The fifth and final step is to select as BACT the most effective of the remaining technologies under consideration for each pollutant of concern.

As described in Section 4.2, the potential SO_2 annual emissions from the kiln have increased in quantities that exceed the significance threshold and are subject to PSD requirements. Holcim-Hagerstown must install BACT for SO_2 sources at the facility and conduct an impact analysis of the increased emissions on the surrounding air quality (see Section 6). The kiln is the only emission source of SO_2 at the plant; therefore, a BACT analysis addressing controls for the kiln system as described above is presented in the following sections.

5.1 <u>Pre-Combustion SO_2 Control Options</u>

SO_2 emissions from the cement kiln are predominantly from the volatile organic sulfur contained in the raw material feed. Sulfur in the fuel affects SO_2 emissions to a lesser extent. The fuel-generated SO_2 is removed from the flue gas in the burning/transition zones of the kiln by reaction with calcium oxide (CaO) or the alkali species [sodium (Na) and potassium

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[5] Reference 13

[6] Reference 10

(K)] in the kiln. The majority of the sulfur coming into the kiln is captured (scrubbed) by the alkali components of the clinker product.

Holcim-Hagerstown can utilize coal, oil, wood waste, and tires to fuel the kiln. Mid-kiln tire burning was implemented in 2003 in response to the NO_x SIP control requirements with the expectation that an adequate reduction in NO_x emissions would be achieved. While a 30% reduction in NO_x emissions was observed, SO_2 emissions increased following the mid-kiln tire burning project implementation due to the inverse relationship between NO_x and SO_2. Holcim-Hagerstown has conducted an extensive study to determine the cause of increased SO_2 emissions, as described in Section 3. Holcim-Hagerstown has attempted to optimize kiln conditions to achieve lower SO_2 emissions; the facility has been unsuccessful in identifying adjustments that reduce SO_2 emission rates below baseline plus PSD significant levels while burning tires at mid-kiln.

5.1.1 <u>Inherent Dry Scrubbing</u>

A Portland cement kiln system inherently controls SO_2 emissions by utilizing the CaO which is formed from the calcination of the $CaCO_3$ in the limestone raw materials. The CaO reacts with SO_2 according to the following reactions:

$$CaO + SO_2 \rightarrow CaSO_3$$
$$CaSO_3 + \tfrac{1}{2} O_2 \rightarrow CaSO_4$$

The absorption of SO_2 within the process is called inherent dry scrubbing (IDS). The amount of SO_2 absorbed in the pyroprocess is dependent upon the site-specific temperature and contact time between the reactants. Once SO_2 is absorbed as $CaSO_4$ in the pryprocess, release into the atmosphere is unlikely.

Pyritic sulfur (metal sulfides) may be contained in the raw materials. However, there is less CaO available for the reaction with SO_2 at the feed end of a long dry kiln and, as a result, the IDS controls pyritic sulfur to a lesser efficiency than fuel sulfur. Organosulfur compounds may also be contained in the raw materials. However, the resulting SO_2 is typically incorporated into the clinker by the inherent dry scrubbing

IDS in a cement kiln also occurs through the reaction of SO_2 with the alkali metal oxides resulting from alkalis in the raw materials, such as sodium (Na) and potassium (K), to form sulfate salts through the following reactions:

$$2\ Na_2O + 2\ SO_2 + O_2 \rightarrow 2\ Na_2SO_4$$
$$2\ K_2O + 2\ SO_2 + O_2 \rightarrow 2\ K_2SO_4$$

The calcium and alkali sulfates formed in the pyroprocess are then chemically bound in the crystal lattice of the clinker product. A chemical balance between the available SO_2 and the alkalis (Na and K) improves the efficiency of IDS. The IDS efficiency for the Holcim-Hagerstown kiln system has ranged from 82% to 96%, depending upon the stability of kiln operations and the sulfur input into the kiln.

IDS is a technically feasible control option for SO_2 for the Holcim-Hagerstown kiln system. IDS does not require the use of reagent or additional energy nor does it create solid or liquid waste streams or additional air emissions.

5.1.2 Raw Material Substitution

In a long dry cement kiln, both pyritic sulfur and total sulfur in the raw materials can impact the emission of SO_2. The pyritic sulfur reacts with oxygen in the lower temperature zone of the kiln to form SO_2. Other types of sulfur, such as sulfates and sulfur compounds, are released in the kiln at higher temperature zones and may be emitted from the kiln stack. The use of raw materials with lower sulfur content would be expected to reduce SO_2 emissions from a long dry kiln. With few exceptions, cement plants are built at or near a source of limestone, the primary raw material for cement manufacturing. During the pyroprocessing of the raw materials, the limestone loses 44% of its weight as CO_2 by the following reaction.

$CaCO_3$ (MW100) → CaO (MW56) + CO_2 (MW44)

The limestone represents approximately 85% of the raw material feed for the Holcim-Hagerstown facility, with the balance consisting of some combination of sand, iron, mill scale, slag, and GAF. This limestone is mined on-site. The facility has a kiln feed factor of 1.58. The kiln requires 1.58 tons of raw material feed for every ton of clinker product. At a kiln production capacity of 630,114 TPY, which is based upon the highest daily production rate demonstrated in practice, the plant requires 995,580 TPY of raw material feed or 846,243 TPY of limestone. At 25 tons per truck, moving this amount of material would require more than 33,000 semitrailers of limestone per year. The environmental and economic impacts of substituting an alternate source of $CaCO_3$ make the use of an alternative raw material for the limestone from off-site infeasible.

The sulfur content of the raw materials has remained consistent for the past 10 years as shown in Table 5.1.

Table 5.1. Raw Material SO_3 Concentrations

Year	Kiln Feed % SO_3
1997	0.41
1998	0.44
1999	0.42
2000	0.46
2001	0.44
2002	0.44
2003	0.45
2004	0.45
2005	0.42
2006	0.41
2007	0.43

The sulfur content of the limestone does not vary significantly within the existing quarry, and boring samples indicate that it should remain consistent in the limestone quarried in the future at the facility. The use of selective quarrying to reduce the raw material sulfur input into the facility has been eliminated from this BACT analysis.

In addition, the EPA's RBLC Database does not list raw material substitution as a SO_2 control technology currently in use at recently permitted facilities. Therefore, the use of raw material substitution has been determined to be both technically and economically infeasible, and it has been eliminated from consideration in this BACT determination.

5.1.3 Fuel Substitution

The mid-kiln tire firing system was installed on Holcim-Hagerstown's kiln to lower NO_x emissions from the kiln. Holcim-Hagerstown has fired between 6% and 17% tires as a thermal substitution rate (TSR) of coal since the system has been in operation. While the tires do not have lower sulfur content than the coal the facility currently utilizes, the tires have a higher heating value; therefore, the sulfur inputs per MMBtu are lower. Holcim-Hagerstown has a target of 20% fuel substitution with tires.

Currently, Holcim-Hagerstown utilizes eastern coal, which is shipped to the facility via truck. The facility is not currently equipped to receive coal by rail. Lower sulfur coals are found in the western US and are referred to as Powder River Basin (PRB) coals. Lower sulfur coals are also potentially available internationally. Holcim-Hagerstown has evaluated available coal sources and has confirmed three possible options for coal.

1) Current coal supplied from two mines in Pennsylvania and Maryland;
2) PRB coal from the Rio Tinto mine in Montana; or
3) Columbia, South America coal – HTRM

While both the PRB and Columbian coals are lower in sulfur, their use creates significant safety concerns, logistical problems, and costs as discussed below.

Table 5.2 Characteristics and Costs for Coal Options

	Current Coal	PRB - Rio Tinto	Columbian Coal - HTRM
	2008	**2008**	**2008**
Sulfur %	1.8	0.38	0.7
Ash %	22-25	4.12	6% min - 10% max
Volatiles %	18-20	31.26	36% max
Moisture %	6.00	25.40	13.00
Hydrogen %	5.00	3.80	5.00
HCl	NA	61	46
Chlorine %	NA	NA	NA
BTU/lb	11,000	9,350	11,300
$/ST FOB Mine	$45.00	$16.00	$179.50
$/ST Transportation	$19.00	$111.00	$11.00

$/ST Transload		$5.00	$5.00
$/ST Fuel Surcharge	$0.00	$41.07	$4.07
Total Delivered $/ST	**$64.00**	**$173.07**	**$199.57**
NOTES:	- Supplier pulls out of 2 mines in PA and MD - Price shown above is contracted price for 2009	- This material would have to travel over 3 different railroads. - HT plant can not receive via rail, so it would have to travel to a transload site at Sparrow's Point MD	

Table 5.3 Characteristics of PRB Coal vs. Regular Bituminous Coal

	PRB Coal	**Bituminous Coal**
Explosivity Index	208 bar.m/s	< 180 bar.m/s
Maximum pressure developed during an explosion	115 psi	< 100 psi
Minimum explosive concentration	20 g/m³	60 g/m³
Auto-Ignition times	15-30 days	90 – 120 days

Safety Concerns

The PRB and Columbian coals contain significantly higher volatiles and moisture. The increased volatiles result in auto-ignition of the coal piles in shorter periods of time and at lower temperatures, as well as both a lower explosive concentration and higher pressure generated from explosion. As a result, the coal handling and grinding equipment must be designed for these changed and explosive conditions. This includes upgrades to the explosion containment design of the coal mill and related equipment handling the ground coal and improved material handling equipment to reduce dusting and provide better access for cleaning. In addition, the onsite coal piles would require additional monitoring and handling to prevent the buildup of conditions that might result in auto-ignition.

Coal Mill Replacement

It is likely that Holcim-Hagerstown would need to replace the existing coal mill. The low-sulfur coals have a lower heat content and higher moisture content than the current coal. A higher volume of those coals would be required. In addition, the low-sulfur coal is harder and more difficult to grind; therefore, it requires more time to dry and grind in the coal mill to the required fineness for optimum flame in the kiln. Holcim (US) Inc. recently estimated the costs associated with the installation of a new coal mill for their Clarksville, Missouri kiln, requiring a total capital investment of $11,468,763.

A projected cost for a new coal mill at the Hagerstown facility was determined using the Clarksville cost estimate and scaling down for Holcim-Hagerstown's specific kiln conditions, including the variations in the heat input required per ton of clinker.[7]

The estimated purchased equipment cost for the Clarksville coal mill and associated equipment of \$5,374,302 is multiplied by this factor to get an estimated cost for Hagerstown of \$1,865,420. This equipment cost is then inserted into a cost estimation spreadsheet based upon EPA guidance to calculate a total Capital Investment of approximately \$4.74 million for the purchase and installation of a new coal mill system for the Hagerstown facility. The cost for a new coal mill is included in the cost-effectiveness calculations for alternative fuels as discussed below.

Predicting SO_2 Reductions

Determining the reduction in SO_2 emissions associated with a reduction in fuel sulfur is complex and unique to each kiln. The relationship of sulfur to the alkalis in the raw materials and fuels, the sulfur-alkali balance, is critical to good kiln operation and product quality and effectively limits the magnitude of the potential reduction in fuel sulfur. At the Hagerstown facility, approximately 55% of the sulfur input is fuel sulfur and 45% is raw material sulfur. The alkali-sulfur balance is such that the use of the lower sulfur coals, especially the PRB coal, would upset the balance when SO_2 concentrations in the kiln gas exceed 300 ppm. A discussion of these concerns is contained in Appendix C. The discussion is based upon the assumption that a maximum of 20% of the fuel will be tires.

A comparison of the expected emissions from the use of the current coal to the alternate coals is contained in the spreadsheet in Appendix C. At 2007 actual production and tire usage rates, the use of PRB coal would result in a reduction of 383.6 TPY SO_2, and the use of the Columbian coal would result in a reduction of 303.1 TPY SO_2. At maximum potential clinker production rates, the use of the PRB coal would result in a reduction of 409.4 TPY SO_2, and the use of the Columbian coal would result in a reduction of 323.5 TPY SO_2. This represents control efficiencies ranging between 24%-32%.

It should be noted that the SO_2 reductions are calculated using a material balance approach based on the actual usage of the current coal and the Btu-equivalent amounts of replacement coals. The inherent dry scrubbing of SO_2 in the kiln is considered when calculating the emission reductions, as well.

<u>PRB Coal</u>

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[7] A typical long wet kiln requires approximately 6 MMBtu/ton of clinker. The Hagerstown kiln is a long dry kiln and requires approximately 4.5 MMBtu/ton clinker. The Clarksville kiln has a maximum clinker production rate of approximately 1,361,615 TPY. The required heat input of 6 MMBtu/ton results in a total maximum annual heat input requirement of approximately 8,169,690 MMBtu/year. The Hagerstown kiln has a maximum clinker production rate of approximately 630,114 TPY. The required heat input of 4.5 MMBtu/ton results in a total annual heat input requirement of approximately 2,835,513 MMBtu/year. The ratio of the Hagerstown heat requirements to that of Clarksville is:

$$2,835,513/8,169,690 = 0.3471$$

In order to transport the PRB coal the long distance from the mines in Montana to Holcim-Hagerstown's plant, the coal must be shipped by rail. Because of the regional nature of railroads, the coal would traverse three different railroad lines, the Burlington-Northern-Santa Fe (BNSF), the Union Pacific (UP), and the CSX. The coal would be shipped in 110-car "unit" trains. As previously stated, the Holcim-Hagerstown facility is not equipped to receive or unload coal by rail. Therefore, the unit trains would need to be trans-loaded from rail to truck at an off-site location. The closest facility equipped to provide this service is located in Sparrow's Point, Maryland. From there, the coal would travel by truck to Holcim's facility in Hagerstown.

The Hagerstown facility currently receives coal by truck on a daily basis and stores only a few hundred tons of coal in on-site piles which feed the coal mill. A separate coal pile of approximately 4,000 tons is maintained for periods when coal delivery is interrupted. A unit train of 110 cars, each containing approximately 115 tons of coal, would contain a total of 12,650 tons of coal. This amount cannot currently be accommodated at the Hagerstown facility. The Sparrow's Point facility would need to both offload the coal to storage piles and then reload it onto trucks, creating additional air emissions and storm water runoff concerns, or Holcim-Hagerstown would have to pay demurrage of between \$25 and \$40 per day for each day the railcars sit waiting to be unloaded. These costs have not been included in the cost effectiveness calculations. The current cost for PRB coal to be delivered to Holcim-Hagerstown, without demurrage or stockpiling costs, is estimated to be \$173.09 per ton. Cost-effectiveness calculations are included in Tables 5.5 and 5.7 and are a minimum of \$38,228 per ton SO_2 reduced.

In addition to the costs and logistical issues associated with the use of PRB coal, as previously stated, there are additional process and safety concerns. First, the extremely high concentrations of volatiles (in excess of 31%) in the PRB coal results in special handling and storage procedures to prevent spontaneous ignition of the coal pile. Secondly, as discussed above, the volatiles can create explosive conditions in the grinding and handling of the coal.

Columbian Coal

The Columbian coal would be transported via ship from South America to the Sparrow's Point, Maryland port in 30,000 ton vessels, three vessels at a time, for a total delivery of 90,000 tons. The material would need to be unloaded from the ship and transferred to trucks for transport to Hagerstown. As previously stated, the Holcim-Hagerstown facility has storage capacity for only a few hundred tons of coal. Therefore, either the Sparrow's Point facility or the Holcim-Hagerstown plant would need to create a storage pile for the coal capable of handling 90,000 tons. The concentrations of volatiles in the Columbian coal would require similar handling and storage concerns as those discussed for PRB coal

The current cost for delivery of Columbian coal to the Hagerstown facility, without the costs to establish a storage pile and the potential costs for an additional transfer from pile to truck, is estimated to be \$199.57 per ton.

The cost-effectiveness calculations for the use of Columbian coal are contained in Tables 5.6 and 5.8. The cost-effectiveness for the use of Columbian coal results in a minimum additional cost of $45,419 per ton of SO_2 reduced.

Conclusion

The use of both PRB coal and the Columbian coal is logistically difficult and creates increased environmental impacts from the additional transportation and handling required due to the distance from the mines. Additional safety concerns related to the auto-ignition and explosive characteristics of the lower-sulfur coals make the use of these coals technically challenging and unacceptable due to the proximity to the local population. The use of the alternate coals is not economically feasible. A summary of the analysis for fuel substitution is provided below. The detailed cost calculations follow the summary table. Due to significant safety concerns and increased off-site environmental impacts, as well as the low control efficiencies and high cost-effectiveness, fuel substitution has been eliminated from further evaluation in this BACT analysis. In addition, the EPA's RBLC Database does not list fuel substitution as a SO_2 control technology in use at recently permitted facilities.

Table 5.4 Summary of Fuel Substitution Analysis

Fuel Substitution	Minimum Cost Effectiveness per ton SO_2 removed	Environmental Considerations	Disadvantages
PRB Coal	$ 38,228	Spontaneous Combustion Explosion Hazards Safety Increased air and water emissions from coal handling and storage Transportation impacts	Lower heat content Higher volume New coal mill Transportation costs
Columbian Coal	$ 45,419	Spontaneous Combustion Explosion Hazards Safety Increased air and water emissions from coal handling, transloading and storage Transportation impacts	New coal mill Transportation costs

Table 5.5 Cost-Effectiveness Evaluation PRB Coal – 2007 Actual

Capital Cost Elements (2007 Actual with PRB Coal)		
Direct Costs		
Purchased Equipment Costs (PEC):		***$2,154,560***
	New Coal Mill and associated equipment	$1,865,420
	Instrumentation (10%)	$186,542
	Freight (5%)	$102,598
Direct Installation Costs (DIC) 85% of PEC:		***$1,831,376***
	Foundation and Supports (12% of PEC)	$258,547
	Handling and Erection (40% of PEC)	$861,824
	Electrical (1% of PEC)	$21,546
	Piping (30% of PEC)	$646,368
	Insulation for Ductwork (1% of PEC)	$21,546
	Painting (1% of PEC)	$21,546
Total Direct Cost (DC) = (PEC) + (DIC)		**$3,985,937**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$754,096***
	Engineering (10% of PEC)	$215,456
	Construction/Field Exp. (10% of PEC)	$215,456
	Contractor Fees (10% of PEC)	$215,456
	Start-up (1% of PEC)	$21,546
	Performance Test (1% of PEC)	$21,546
	Contingencies (3% of PEC)	$64,637
Site Preparation and Building (SPB) 10% of IIC:		**$0**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$754,096**
Total Capital Investment (TCI) = (DC) + (IC)		**$4,740,033**

Annualized Costs		
Direct Annual Costs		
Utilities:		
	Annual coal cost for PRB coal	$19,582,879
	Annual coal cost for Current coal	$5,661,760
	Cost increase using PRB coal	$13,921,119
Replacement Parts (5% of PEC):		$107,728
Compliance Costs:		**$0**
	Performance Tests	$0
	Recordkeeping and Reporting	$0
Total Direct Annual Costs (DAC)		**$14,028,847**

Table 5.5 Cost-Effectiveness Evaluation PRB Coal – 2007 Actual (continued)

Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$0
	Insurance (1% of TCI)	$47,400
	Administrative Charges (2% of TCI)	$94,801
	Capital Recovery	$543,682
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$685,883**
Total Annualized Costs (DAC + IAC)		**$14,714,729**
Base Line Emissions	Tons per year SO_2 using Current Coal	1,184.3
Potential Emissions	Tons per year SO_2 using PRB Coal	800.7
Potential Emission Reduction		
	SO_2 Tons per Year Reduced	383.6
Cost Effectiveness	$ per Ton SO_2 Reduced	**$38,359**

Table 5.6 Cost Effectiveness Evaluation Columbian Coal – 2007 Actual

Capital Cost Elements (2007 Actual with Columbian Coal)		
Direct Costs		
Purchased Equipment Costs (PEC):		***$2,154,560***
	New Coal Mill and associated equipment	$1,865,420
	Instrumentation (10%)	$186,542
	Freight (5%)	$102,598
Direct Installation Costs (DIC) 85% of PEC:		***$1,831,376***
	Foundation and Supports (12% of PEC)	$258,547
	Handling and Erection (40% of PEC)	$861,824
	Electrical (1% of PEC)	$21,546
	Piping (30% of PEC)	$646,368
	Insulation for Ductwork (1% of PEC)	$21,546
	Painting (1% of PEC)	$21,546
Total Direct Cost (DC) = (PEC) + (DIC)		**$3,985,937**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$754,096***
	Engineering (10% of PEC)	$215,456
	Construction/Field Exp. (10% of PEC)	$215,456
	Contractor Fees (10% of PEC)	$215,456
	Start-up (1% of PEC)	$21,546
	Performance Test (1% of PEC)	$21,546
	Contingencies (3% of PEC)	$64,637
Site Preparation and Building (SPB) 10% of IIC:		**$0**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$754,096**
Total Capital Investment (TCI) = (DC) + (IC)		**$4,740,033**

Table 5.6 Cost-Effectiveness Evaluation Columbian Coal – 2007 Actual (continued)

Annualized Costs		
Direct Annual Costs		
Utilities:		
	Annual coal cost for Columbian coal	$18,684,572
	Annual coal cost for Current coal	$5,661,760
	Cost increase using Columbian coal	$13,022,812
Replacement Parts (5% of PEC):		$107,728
Compliance Costs:		**$0**
	Performance Tests	$0
	Recordkeeping and Reporting	$0
Total Direct Annual Cost (DAC)		**$13,130,540**
Indirect Annual Costs (IAC)		
	Overhead (60% of all labor & maint matls)	$0
	Insurance (1% of TCI)	$47,400
	Administrative Charges (2% of TCI)	$94,801
	Capital Recovery	$543,682
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Cost (IAC)		**$685,883**
Total Annualized Costs (DAC + IAC)		**$13,816,423**
Base Line Emissions	Tons per year SO_2 using Current Coal	1,184.3
Potential Emissions	Tons per year SO_2 using Columbian Coal	881.2
Potential Emission Reduction		
	SO_2 Tons per Year Reduced	303.1
Cost Effectiveness	$ per Ton SO_2 Reduced	**$45,584**

Table 5.7 Cost-Effectiveness Evaluation PRB Coal – PTE

Capital Cost Elements (Potential to Emit with PRB Coal)		
Direct Costs		
Purchased Equipment Costs (PEC):		***$2,154,560***
	New Coal Mill and associated equipment	$1,865,420
	Instrumentation (10%)	$186,542
	Freight (5%)	$102,598
Direct Installation Costs (DIC) 85% of PEC:		***$1,831,376***
	Foundation and Supports (12% of PEC)	$258,547
	Handling and Erection (40% of PEC)	$861,824
	Electrical (1% of PEC)	$21,546
	Piping (30% of PEC)	$646,368
	Insulation for Ductwork (1% of PEC)	$21,546
	Painting (1% of PEC)	$21,546
Total Direct Cost (DC) = (PEC) + (DIC)		**$3,985,937**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$754,096***
	Engineering (10% of PEC)	$215,456
	Construction/Field Exp. (10% of PEC)	$215,456
	Contractor Fees (10% of PEC)	$215,456
	Start-up (1% of PEC)	$21,546
	Performance Test (1% of PEC)	$21,546
	Contingencies (3% of PEC)	$64,637
Site Preparation and Building (SPB) 10% of IIC:		**$0**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$754,096**
Total Capital Investment (TCI) = (DC) + (IC)		**$4,740,033**

Annualized Costs		
Direct Annual Costs		
Utilities:		
	Annual coal cost for PRB coal	$20,901,015
	Annual coal cost for Current coal	$6,042,857
	Cost increase using PRB coal	$14,858,159
Replacement Parts (5% of PEC):		$107,728
Compliance Costs:		**$0**
	Performance Tests	$0
	Recordkeeping and Reporting	$0
		$14,965,887

Table 5.7 Cost-Effectiveness Evaluation PRB Coal – PTE (continued)

Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$0
	Insurance (1% of TCI)	$47,400
	Administrative Charges (2% of TCI)	$94,801
	Capital Recovery	$543,682
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$685,883**
Total Annualized Costs (DAC + IAC)		**$15,651,769**
Base Line Emissions	Tons per year SO_2 using Current Coal	1,327.4
Potential Emissions	Tons per year SO_2 using PRB Coal	918.0
Potential Emission Reduction		
	SO_2 Tons per Year Reduced	409.4
Cost Effectiveness	$ per Ton SO_2 Reduced	**$38,228**

Table 5.8 Cost-Effectiveness Evaluation Columbian Coal – PTE

Capital Cost Elements (Potential to Emit with Columbian Coal)		
Direct Costs		
Purchased Equipment Costs (PEC):		***$2,154,560***
	New Coal Mill and associated equipment	$1,865,420
	Instrumentation (10%)	$186,542
	Freight (5%)	$102,598
Direct Installation Costs (DIC) 85% of PEC:		***$1,831,376***
	Foundation and Supports (12% of PEC)	$258,547
	Handling and Erection (40% of PEC)	$861,824
	Electrical (1% of PEC)	$21,546
	Piping (30% of PEC)	$646,368
	Insulation for Ductwork (1% of PEC)	$21,546
	Painting (1% of PEC)	$21,546
Total Direct Cost (DC) = (PEC) + (DIC)		**$3,985,937**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$754,096***
	Engineering (10% of PEC)	$215,456
	Construction/Field Exp. (10% of PEC)	$215,456
	Contractor Fees (10% of PEC)	$215,456
	Start-up (1% of PEC)	$21,546
	Performance Test (1% of PEC)	$21,546
	Contingencies (3% of PEC)	$64,637
Site Preparation and Building (SPB) 10% of IIC:		**$0**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$754,096**
Total Capital Investment (TCI) = (DC) + (IC)		**$4,740,033**

Table 5.8 Cost-Effectiveness Evaluation Columbian Coal – PTE (continued)

Annualized Costs		
Direct Annual Costs		
Utilities:		
	Annual coal cost for Columbian coal	$19,942,244
	Annual coal cost for Current coal	$6,042,857
	Cost increase using Columbian coal	$13,899,387
Replacement Parts (5% of PEC):		$107,728
Compliance Costs:		**$0**
	Performance Tests	$0
	Recordkeeping and Reporting	$0
Total Direct Annual Costs (DAC)		**$14,007,115**
Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$0
	Insurance (1% of TCI)	$47,400
	Administrative Charges (2% of TCI)	$94,801
	Capital Recovery	$543,682
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$685,883**
Total Annualized Costs		**$14,692,997**
Base Line Emissions	Tons per year SO_2 using Current Coal	1,327.4
Potential Emissions	Tons per year SO_2 using Columbian Coal	1003.9
Potential Emission Reduction		
	Percent Control	
	SO_2 Tons per Year Reduced	323.5
Cost Effectiveness	$ per Ton SO_2 Reduced	**$45,419**

5.2 Add-on Control Technologies

Potential add-on control technologies were identified by review of vendor information, technical papers, and recent permits issued for cement kilns. Recent permits from EPA's RACT/BACT/LAER database were reviewed for SO_2 control technologies and emission limitations. The report from the database is provided in Appendix D. This information from EPA, combined with data from state permit databases, yielded the following information.

Table 5.9 Recently Permitted Facilities

FACILITY	CAPACITY	CONTROL TECHNOLOGY	DATE
CEMEX Brookesville – FL	3850 tpd PH/PC	Inherent Dry Scrubbing Lime Injection	2007
Continental Cement Co. – MO[8]	3300 tpd PH/PC	Inherent Dry Scrubbing	2006
Ash Grove Moapa Paiute – NV[9] (project cancelled)	NAPH/PC	Inherent Dry Scrubbing, Dry Lime Scrubbing	2006
Branford Cement Suwannee – FL[10]	127 tph PH/PC	Inherent Dry Scrubbing	2006
Lehigh Cement Mason City – IA[11]	150 tph PH/PC	Inherent Dry Scrubbing, Wet Scrubbing	2003
Lafarge Sugar Creek – MO[12]	NA PH/PC	Inherent Dry Scrubbing	2002

It is important to note that all of these recently permitted facilities are modern preheater/precalciner kilns. Therefore, the add-on control technologies would be operating at significantly different kiln gas temperature and turbulence conditions than that for a long dry kiln such as the Holcim-Hagerstown kiln. The potential add-on control technologies include wet scrubbing, dry scrubbing, and micro-fine lime injection for the control of SO_2 from the cement manufacturing process. These technologies have been used at new preheater/precalciner cement manufacturing facilities; and, for the purpose of this BACT determination, are assumed to be technically feasible for application to Holcim-Hagerstown's long dry kiln. However, because there is no experience with these technologies when applied to a long dry kiln and considering the significant difference in kiln gas characteristics between the long dry kiln and PH/PC kiln, the control efficiencies can only be estimated based upon data related to the temperatures and conditions of the kiln gases at the entrance to the control device and are not based upon any actual data from similar facilities. Because of the temperatures, the maximum control efficiencies are significantly lower than that possible for preheater/precalciner kilns.

5.3 <u>Dry Scrubbing Control Technology</u>

Dry Lime Scrubbing (DLS) consists of injecting hydrated lime, $Ca(OH)_2$, into the kiln exhaust gas. The $Ca(OH)_2$ reacts with SO_2 in the kiln gas to create fine particles of $CaSO_3$ or $CaSO_4$. The particles are collected in the particulate matter control device (PMCD) serving the kiln. The effectiveness of DLS is impacted by both the temperature and the residence time/air flow rate at the location it is injected. For Holcim-Hagerstown, the temperature at the injection point will be between 550 and 600 degrees F (287-315 degrees C), which represent the current ESP inlet and stack exit temperatures. Figure 5-1 is a plot of SO_2 reduction versus reaction temperature from an article entitled "What is Achievable with

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[8] Reference 1.

[9] Reference 5.

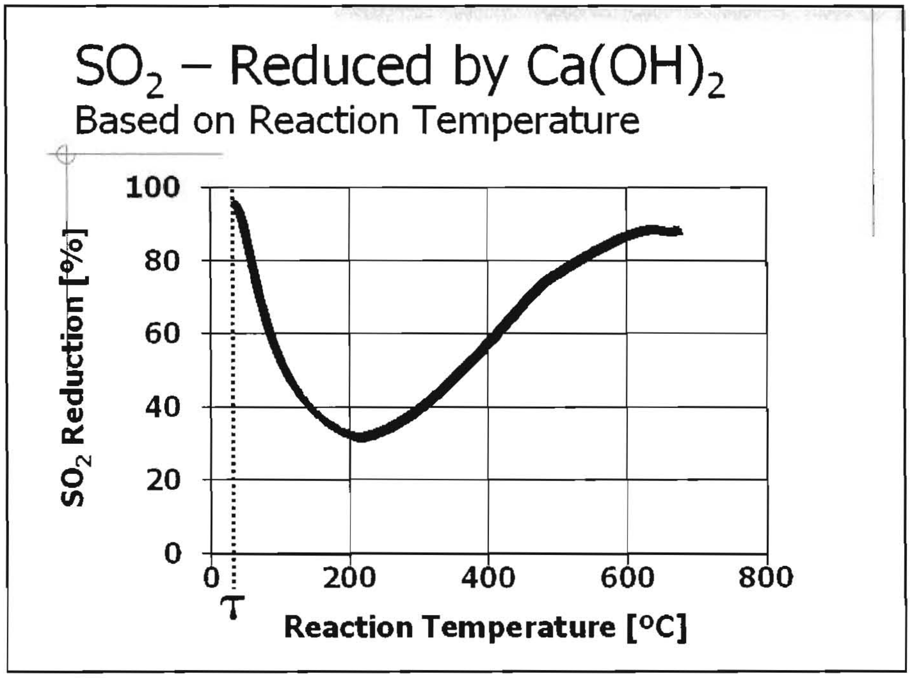
[10] Reference 4.

[11] Reference 4.

[12] Reference 2.

Today's Technologies," by Mark S. Terry, Krupp Polysius Corp., 2001[13]. As indicated on the figure, at a temperature of approximately 300 degrees C, the SO_2 reduction is approximately 40%. This estimate does not account for any reductions related to any potential limitations on mixing of the reagent and stack gas. The proposed molar ratio of lime to SO_2 is much higher than in a typical coal-fired boiler due to a number of factors, some of which include the higher CO_2 levels in the cement kiln system exhaust. The CO_2 competes with SO_2 in the reaction with lime. Holcim-Hagerstown is not aware of any other application of dry scrubber technology on a long dry kiln. In fact, there is currently only one known application of the technology on a wet kiln in Belgium (Obourg plant). Therefore, very little data is available to determine the technical feasibility of this control. Based on Holcim-Hagerstown's communication with the Obourg plant in Belgium, molar ratios of 4:1 and 6:1 have been used. Holcim-Hagerstown has assumed a molar ratio of 6:1 for cost estimation. However, due to the fact that this technology has not been previously utilized on a long dry kiln, higher molar ratios and their associated increases in costs are possible. A pilot study is required to determine the viability of this technology for the Hagerstown kiln. For purposes of this BACT analysis, the cost estimates were completed for a control efficiency of 40%.

Figure 5-1 SO_2 Dry Scrubber Efficiency



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[13] Reference 14

The current PMCD, the existing electrostatic precipitator (ESP), was not sized to handle the additional particulate matter loading that would result from this technology. As a result, the use of dry lime scrubbing would necessitate the installation of a baghouse to ensure that particulate emissions and opacity remain below permitted levels. In this case, the dry lime injection would occur following the existing ESP and prior to the inlet of a new baghouse. The Holcim-Hagerstown kiln is equipped with multiclones prior to the ESP. There is no access for dry lime injection prior to the ESP. The facility utilizes the ESP to segregate CKD based upon alkali content. Higher alkali CKD is wasted, and lower alkali CKD is returned to the kiln with the kiln feed. This reduces the quantity of CKD requiring disposal, as well as reduces the CO_2 released per ton of clinker by reusing the partially calcined CKD in lieu of additional limestone in the raw feed. This practice is part of Holcim's global goals to reduce waste generation and reduce CO_2 generation per ton of cement produced. Therefore, the ESP would continue to be used even if an additional PMCD is required to address the additional particulate loading resulting from the use of SO_2 control.

Holcim-Hagerstown is not aware of any other application of dry scrubber technology on a long dry kiln. In fact, there is currently only one known application of the technology on a wet kiln in Belgium. Therefore, very little data is available to determine the technical feasibility control efficiency or operational costs associated with the use of a dry scrubber on a long dry kiln. Regardless, Holcim-Hagerstown, for the purposes of this BACT analysis, is considering the technology to be technically feasible.

5.3.1 Environmental Analysis

An adverse environmental impact associated with the DLS system includes dry sludge generation in the form of additional dust generated by the reaction of the hydrated lime with the SO_2 in the dry scrubber and collected by the new baghouse. This will require disposal of approximately 5,825 tons of dry sludge per year. This material is not CKD. The majority of the CKD will be removed by the ESP prior to the dry scrubber. The cost for transport and disposal of this sludge material at the nearest acceptable landfill is estimated at $80 per ton, for a total annual cost of approximately $466,000.

Additional off-site environmental impacts will result from the production of and transportation of the hydrated lime reagent to the Holcim-Hagerstown facility.

5.3.2 Energy analysis

Additional electricity will be required for the lime injection pump and for the additional fan power for the new baghouse. This cost has not been quantified.

5.3.3 Economic analysis

The determination of the economic impact from implementation of the DLS involved an assessment of the capital and annual operations and maintenance costs for a unit design for 40% removal. The sum of the annualized costs is used to determine the cost effectiveness for the control device. The calculation of the component costs and the cost effectiveness is described below and summarized in Table 5.10.

The purchased equipment cost was obtained from a vendor for Holcim's Clarksville, Missouri facility. This cost was utilized for the Hagerstown facility, with the addition of a cost for a new baghouse. The capital cost for the baghouse was approximated using a quotation for a baghouse retrofit for the Clarksville kiln and adjusting by a ratio of the air flow for the two kilns and adding a cost for the baghouse housing, which was not included in the Clarksville quotation. The Clarksville quotation and the calculation for the Hagerstown kiln are contained in Appendix E. These costs do not account for the possibility that the new kiln ID fan, which was installed in 2007, may not be adequate for the addition of a baghouse. That determination would require the development of a site-specific baghouse design based upon a final dry scrubber design. The scrubber cost, added to estimates for additional out of scope items, instrumentation, sales tax and freight, and other direct installation costs (not included with the scrubber), constitutes the Direct Capital Cost (DC), which is $7,899,606.

The Indirect Capital Cost (IC) includes engineering, construction and field expenses, contractor fees, start up fees, and contingencies amounting to $1,962,160. These values were calculated based on guidance found in EPA's *New Source Review Workshop Manual – Draft, 1990*[14] and the EPA *Air Pollution Control Cost Manual, 2002.* (Note: Recent installation costs are running 200% or more of the purchase cost. The EPA manual is out of date.)[15]

The Total Capital Cost is the sum of the DC and IC. A total capital investment of $9,861,766 is projected. This is capitalized over a period of 15 years with a capital recovery factor of 7.7%, which results in an annualized capital cost estimate of approximately $1,131,145. The Direct Annual Cost (DAC) includes operating and maintenance labor and supervision, utilities, and sludge treatment and disposal. The DAC is driven by maintenance materials and sludge disposal. The Indirect Annual Cost (IAC) includes overhead, taxes and insurance costs. The annual operating cost is the sum of the DAC and IAC, and is estimated to be and $3,652,522 for 40 % SO_2 removal efficiency.

The average cost effectiveness (total annualized costs of control divided by annual emission reductions) was determined using the above information. Average cost effectiveness (ACE) is calculated as described below.

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[14] Reference 10.

[15] Reference 11.

5.3.4 Annualized Cost for Dry Scrubber

The total annualized cost (direct and indirect) for a dry scrubber system is \$3,625,522 at the estimated maximum 40% removal efficiency. The estimate of 40% control is projected based upon the anticipated gas temperatures and may not be achievable in reality. The projected actual SO_2 emission rate as calculated in Section 3.2 is 795 tons per year. This value is multiplied by the maximum control efficiency of 40% to get the tons SO_2 removed equal to 318 tons. The cost-effectiveness for a dry scrubber is estimated to be a minimum of \$11,401 per ton of SO_2 removed.

Table 5.10 Cost-Effectiveness Evaluation - Dry Scrubber 40% Efficiency

Capital Cost Elements		
Direct Costs		
Purchased Equipment Costs (PEC):		***$5,096,520***
	Dry Lime Scrubber	$1,000,000
	Baghouse Replacement	$3,290,000
	Instrumentation (10%)	$429,000
	Sales Tax (3%)	$141,570
	Freight (5%)	$235,950
Direct Installation Costs (DIC) 85% of PEC:		***$2,803,086***
	Foundation and Supports (12% of PEC)	$611,582
	Handling and Erection (40% of PEC)	$2,038,608
	Electrical (1% of PEC)	$50,965
	Piping (30% of PEC)	$0
	Insulation for Ductwork (1% of PEC)	$50,965
	Painting (1% of PEC)	$50,965
Total Direct Cost (DC) = (PEC) + (DIC)		**$7,899,606**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$1,783,782***
	Engineering (10% of PEC)	$509,652
	Construction/Field Exp. (10% of PEC)	$509,652
	Contractor Fees (10% of PEC)	$509,652
	License	$0
	Start-up (1% of PEC)	$50,965
	Performance Test (1% of PEC)	$50,965
	Contingencies (3% of PEC)	$152,896
Site Preparation and Building (SPB) 10% of IIC:		**$178,378**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$1,962,160**
Total Capital Investment (TCI) = (DC) + (IC)		**$9,861,766**
Annualized Costs		
Direct Annual Costs		
Utilities:		
	Fuel	$0
	Power ($0.11/kWh)	$0
	Water($1.00/1000 gallon)	$0
Raw Materials/Chemicals:		
	Lime ($156/ton)	$860,646
Operating Labor:		
	Operator Labor (0.5 hr/shift @ $31.50/hr)	$17,246
	Supervising Labor (15% of Operator)	$2,587
Maintenance:		
	Maintenance Labor (1.5 hr/shift @ $31.50/hr)	$17,246
	Maint. Supervision (15% of Maintenance)	$2,587
	Maintenance Materials (100% of Labor)	$17,246
Replacement Parts (5% of PEC):		$254,826

Table 5.10 Cost-Effectiveness Evaluation - Dry Scrubber 40% Efficiency (continued)

Waste Treatment and Disposal:		
	Sludge disposal ($80/ton)	$465,996
Compliance Costs:		**$60,000**
	Performance Tests	$40,000
	Recordkeeping and Reporting	$20,000
Total Direct Annual Costs (DAC)		**$1,698,381**
Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$34,148
	Insurance (1% of TCI)	$98,618
	Administrative Charges (2% of TCI)	$197,235
	Capital Recovery	$1,131,145
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$1,927,141**
Total Annualized Costs (DAC + IAC)		**$3,625,522**
Potential Emissions	Tons per year SO_2	795
Potential Emission Reduction		
	Percent Control	40
	SO_2 Tons per Year Controlled	318
Cost Effectiveness	$ per Ton SO_2 Reduced	**$11,401**

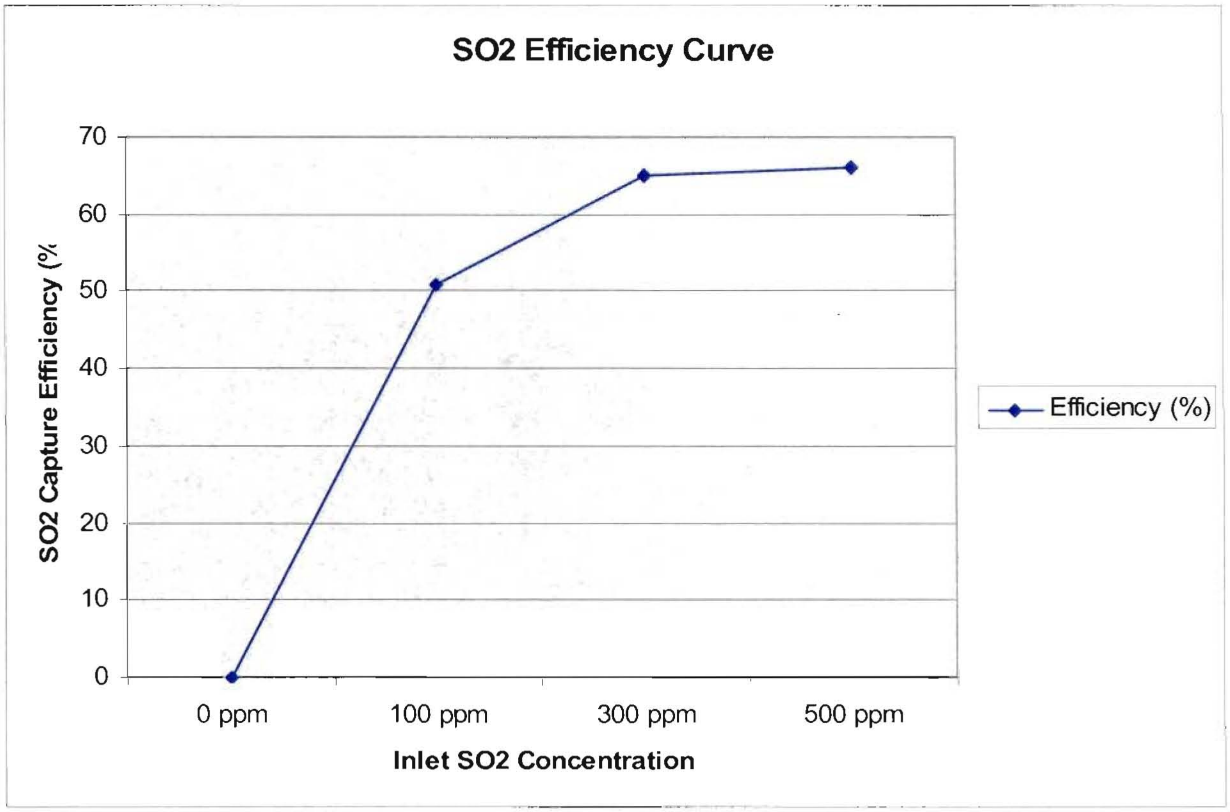
5.4 Microfine Lime Injection

Microfine lime injection utilizes an aqueous $Ca(OH)_2$ suspension in fine droplets into a kiln gas conditioning tower. The $Ca(OH)_2$ reacts with SO_2 in the kiln gas stream to create fine particles of $CaSO_3$ or $CaSO_4$ that are collected in the PMCD. For optimum effectiveness, the conditioning tower must be designed for adequate gas retention time at the gas exit temperature. Finer particles of $Ca(OH)_2$ are the most effective and efficient absorbing reagent. Although microfine lime injection has not been utilized on either long wet or long dry kilns due to the absence of existing conditioning towers, it is considered to be technically feasible with the addition of a conditioning tower and an additional PMCD. As with the DLS, the existing ESP would continue to be operated to collect and segregate the CKD to reduce the amount of CKD wasted and to return as much of the CKD as possible, given the alkali content, to the kiln feed to reduce CO_2 emissions per ton cement product. The return of a portion of the CKD to the kiln feed is also critical to the alkali-sulfur balance in the kiln system.

While it is expected that the majority of the reagent will be dried by the kiln gas and collected by the baghouse, some portion of the sludge may collect in the bottom of the conditioning tower and require removal and dewatering prior to disposal. Envirocare, a vendor for microfine lime technology, provided a quote for the Hagerstown facility that includes the installation of a conditioning tower after the existing PMCD (ESP). As was discussed for the DLS, it is not possible to place the conditioning tower prior to the ESP, nor is the ESP designed for the additional particulate loading. Therefore, a new baghouse following the conditioning tower would also be required for microfine lime injection. An adequate supply of water must be provided for the microfine lime injection system.

As with the DLS, the lower temperature range of the kiln gases at Hagerstown will result in a lower SO_2 removal efficiency. Figure 5-1 indicates a removal efficiency of 40% for the temperature of Holcim Hagerstown's kiln gases. The use of microfine lime may result in a somewhat higher SO_2 efficiency as a result of the higher reactivity of the finer lime particles. The vendor originally estimated the maximum SO_2 control efficiency of the system at 65%. As discussed above, because microfine lime has not been used on a long dry kiln at these stack gas temperatures and because the SO_2 concentration in the stack gases is very low compared to other installations, lower than 300 ppm, Holcim-Hagerstown is not confident that the 65% efficiency can be achieved. The facility contacted the vendor that provided the microfine lime quotation and discussed the impact of the reduction in SO_2 inlet concentration seen since the last kiln modification in February 2008. At an inlet concentration of 100 ppm, which reflects the concentrations that have been experienced since the last kiln modifications in February 2008, the vendor indicated that the warranty efficiency would drop to a maximum of 51%.

Figure 5-2 SO_2 Control Efficiency and Inlet Concentration



Holcim-Hagerstown is not aware of any other application of microfine lime injection on a long dry kiln. Currently, this technology is used only on PH/PC kilns. Therefore, very little data is available to determine the technical feasibility of this control efficiency or operational costs associated with the use of a microfine lime scrubber on a long dry kiln. A pilot study is required to determine the viability of this technology for the Hagerstown kiln since there is a significant difference in kiln gas characteristics between the long dry kiln and PH/PC kiln, Regardless, Holcim-Hagerstown is considering the technology to be technically feasible at a control efficiency between 40% and 51% based on the actual data and the vendor estimate. Cost Effectiveness calculations have been completed for both control efficiencies and represent the range of potential cost effectiveness.

5.4.1 Environmental Analysis

Adverse environmental impacts associated with a microfine lime injection system include sludge generation in the form of additional dust generated by the reaction of the microfine lime with the SO_2 in the conditioning tower and collected by the new baghouse. This will require disposal of between 3,066 and 3,151 tons of sludge per year. The cost for transport and disposal of this material at the nearest acceptable landfill is estimated at $80 per ton, for a total annual cost between $245,318 and $252,094.

Water at 112 gallons per minute (gpm) will be required to cool the gas from 550 degrees F to 285 degrees F. Total additional water use will cost $58,867 per year.

Additional offsite environmental impacts will result from the production of and transportation of the microfine lime reagent to the Hagerstown facility.

5.4.2 Energy analysis

Additional electricity will be required for the conditioning tower, the microfine lime injection system, the increased fan capacity for the increased pressure drop across the conditioning tower and baghouse. The cost for this additional electricity will be $179,711, and does not account for any increased costs associated with increased energy use by the existing ID fan or from a replacement ID fan if it is determined that the existing fan is not adequate.

5.4.3 Economic analysis

The determination of the economic impact from implementation of the microfine lime injection system involved an assessment of the capital and annual operations and maintenance costs for a unit designed for between 40% and 51% removal. The sum of the annualized costs is used to determine cost-effectiveness for the control device. The calculation of the component costs and the cost-effectiveness is described below and summarized in Tables 5.11 and 5.12.

The purchased equipment cost for the conditioning tower and microfine lime injection system were obtained from Envirocare, the vendor for these systems. The cost for a new baghouse was added to the quote from Envirocare. The capital cost for the baghouse was approximated by using a quotation for a baghouse retrofit for the Holcim-Clarksville facility and adjusting by a ratio of the air flow for the two kilns and then adding a cost for the baghouse housing, which was not included in the Clarksville quotation. These costs, added to estimates for additional out of scope items, instrumentation, sales tax and freight, and other direct installation (not included with the scrubber,) constitutes the DC, which is $10,747,242. These costs do not account for the possibility that the new kiln ID fan, which was installed in 2007, may not be adequate for the addition of a baghouse. That determination would require the development of a site-specific baghouse design based upon a final design of the microfine lime injection system.

The IC includes engineering, construction and field expenses, contractor fees, start up fees, and contingencies amounting to $2,236,588. These values were calculated based on guidance found in EPA's *New Source Review Workshop Manual – Draft, 1990*[16] and the EPA *Air Pollution Control Cost Manual, 2002* (recent installation costs are running 200% or more of the purchase cost the EPA manual is out of date for this).[17]

The Total Capital Cost is the sum of the DC and IC. A total capital investment of $12,983,830 is projected. This is capitalized over a period of 15 years with a capital recovery factor of 7.7%, which results in an annualized capital cost estimate of

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[16] Reference 10.

[17] Reference 11.

approximately $1,489,245. The DAC includes operating and maintenance labor and supervision, utilities, and scrubber sludge treatment and disposal. The DAC is driven by maintenance materials, reagent, power, water, and sludge disposal. The IAC includes overhead, taxes, and insurance costs. The annual operating cost is the sum of the DAC and IAC, and is estimated to be between $3,413,620 and $3,427,172 for 40% and 51% removal efficiency, respectively. Note that microfine lime is slightly less expensive than hydrated lime per ton.

The average cost-effectiveness (total annualized costs of control divided by annual emission reductions) was determined using the above information. ACE is calculated as described below.

Annualized Cost for Microfine Lime Injection

The total annualized cost (direct and indirect) for the microfine lime injection system is between $3,413,620 and $3,427,172 at 40% to 51% control efficiency respectively. The projected actual SO_2 emission rate as calculated in Section 3.2 is 795 tons per year. This value is multiplied by the maximum projected control efficiency of either 40% or 51% to get the projected tons SO_2 removed of tons. Projected tons removed are between 318 and 405 tons SO_2.

The average cost-effectiveness for a microfine lime injection system is calculated to be between of $10,735 and $8,453 per ton of SO_2 removed.

Table 5.11 Cost-Effectiveness Evaluations – Microfine Lime Injection 40%

Capital Cost Elements		
Direct Costs		
Purchased Equipment Costs (PEC):		***$5,809,320***
	Microfine Lime system w/ Conditioning tower	$1,600,000
	Baghouse Replacement	$3,290,000
	Instrumentation (10%)	$489,000
	Sales Tax (3%)	$161,370
	Freight (5%)	$268,950
Direct Installation Costs (DIC) 85% of PEC:		***$4,937,922***
	Foundation and Supports (12% of PEC)	$697,118
	Handling and Erection (40% of PEC)	$2,323,728
	Electrical (1% of PEC)	$58,093
	Piping (30% of PEC)	$1,742,796
	Insulation for Ductwork (1% of PEC)	$58,093
	Painting (1% of PEC)	$58,093
Total Direct Cost (DC) = (PEC) + (DIC)		**$10,747,242**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$2,033,262***
	Engineering (10% of PEC)	$580,932
	Construction/Field Exp. (10% of PEC)	$580,932
	Contractor Fees (10% of PEC)	$580,932
	License	$0
	Start-up (1% of PEC)	$58,093
	Performance Test (1% of PEC)	$58,093
	Contingencies (3% of PEC)	$174,280
Site Preparation and Building (SPB) 10% of IIC:		**$203,326**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$2,236,588**
Total Capital Investment (TCI) = (DC) + (IC)		**$12,983,830**

Annualized Costs		
Direct Annual Costs		
Utilities:		
	Fuel	$0
	Power ($0.11/kWh)	$179,711
	Water($1.00/1000 gallon)	$58,867
Raw Materials/Chemicals:		
	Lime ($132/ton)	$364,119
Operating Labor:		
	Operator Labor (0.5 hr/shift @ $31.50/hr)	$17,246
	Supervising Labor (15% of Operator)	$2,587
Maintenance:		
	Maintenance Labor (0.5 hr/shift @ $31.50/hr)	$17,246
	Maint. Supervision (15% of Maintenance)	$2,587
	Maintenance Materials (100% of Labor)	$17,246

Table 5.11 Cost-Effectiveness Evaluations – Microfine Lime Injection 40% (continued)

Replacement Parts (5% of PEC):		$290,466
Waste Treatment and Disposal:		
	Sludge disposal ($80/ton)	$245,318
Compliance Costs:		**$60,000**
	Performance Tests	$40,000
	Recordkeeping and Reporting	$20,000
Total Direct Annual Costs (DAC)		**$1,255,394**
Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$34,148
	Insurance (1% of TCI)	$129,838
	Administrative Charges (2% of TCI)	$259,677
	Capital Recovery	$1,489,245
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$2,158,226**
Total Annualized Costs (DAC + IAC)		**$3,413,620**
Potential Emissions	Tons per year SO_2	795
Potential Emission Reduction		
	Percent Control	40
	SO_2 Tons per Year Controlled	318
Cost Effectiveness	$ per Ton SO_2 Reduced	**$10,735**

Table 5.12 Cost-Effectiveness Evaluations -Microfine Lime Injection 51%

Capital Cost Elements		
Direct Costs		
Purchased Equipment Costs (PEC):		***$5,809,320***
	Microfine Lime system w/ Conditioning tower	$1,600,000
	Baghouse Replacement	$3,290,000
	Instrumentation (10%)	$489,000
	Sales Tax (3%)	$161,370
	Freight (5%)	$268,950
Direct Installation Costs (DIC) 85% of PEC:		***$4,937,922***
	Foundation and Supports (12% of PEC)	$697,118
	Handling and Erection (40% of PEC)	$2,323,728
	Electrical (1% of PEC)	$58,093
	Piping (30% of PEC)	$1,742,796
	Insulation for Ductwork (1% of PEC)	$58,093
	Painting (1% of PEC)	$58,093
Total Direct Cost (DC) = (PEC) + (DIC)		**$10,747,242**

Table 5.12 Cost-Effectiveness Evaluations -Microfine Lime Injection 51% (continued)

Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$2,033,262***
	Engineering (10% of PEC)	$580,932
	Construction/Field Exp. (10% of PEC)	$580,932
	Contractor Fees (10% of PEC)	$580,932
	License	$0
	Start-up (1% of PEC)	$58,093
	Performance Test (1% of PEC)	$58,093
	Contingencies (3% of PEC)	$174,280
Site Preparation and Building (SPB) 10% of IIC:		**$203,326**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$2,236,588**
Total Capital Investment (TCI) = (DC) + (IC)		**$12,983,830**
Annualized Costs		
Direct Annual Costs		
Utilities:		
	Fuel	$0
	Power ($0.11/kWh)	$179,711
	Water($1.00/1000 gallon)	$58,867
Raw Materials/Chemicals:		
	Lime ($132/ton)	$364,119
Operating Labor:		
	Operator Labor (0.5 hr/shift @ $31.50/hr)	$17,246
	Supervising Labor (15% of Operator)	$2,587
Maintenance:		
	Maintenance Labor (0.5 hr/shift @ $31.50/hr)	$17,246
	Maint. Supervision (15% of Maintenance)	$2,587
	Maintenance Materials (100% of Labor)	$17,246
Replacement Parts (5% of PEC):		$290,466
Waste Treatment and Disposal:		
	Sludge disposal ($80/ton)	$252,094
Compliance Costs:		**$60,000**
	Performance Tests	$40,000
	Recordkeeping and Reporting	$20,000
Total Direct Annual Costs (DAC)		**$1,262,170**

Table 5.12 Cost-Effectiveness Evaluations -Microfine Lime Injection 51% (continued)

Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$34,148
	Insurance (1% of TCI)	$129,838
	Administrative Charges (2% of TCI)	$259,677
	Capital Recovery	$1,489,245
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$2,165,002**
Total Annualized Costs (DAC + IAC)		**$3,427,172**
Potential Emissions	Tons per year SO_2	795
Potential Emission Reduction		
	Percent Control	51
	SO_2 Tons per Year Controlled	405
Cost Effectiveness	$ per Ton SO_2 Reduced	**$8,453**

5.5 Wet Scrubbing Control Technology

The wet lime scrubbing (WLS) process involves mixing the flue gas with a sprayed aqueous suspension of $Ca(OH)_2$ or $CaCO_3$ (limestone) after the ESP. As with the DLS, the existing ESP would continue to be operated to collect and segregate the CKD to reduce the amount of CKD wasted and to return as much of the CKD as possible, given the alkali content, to the kiln feed to reduce CO_2 emissions per ton cement product. The SO_2 reacts with the scrubbing reagent to form $CaSO_3$ or $CaSO_4$, which is retained in the aqueous suspension as sludge. The sludge is dewatered and either disposed of in a landfill or, in some cases, reused in the process. Due to handling problems and strict product quality considerations, it has been assumed that the sludge would not be reused in the finish mills. No costs for facility modifications to utilize the sludge on-site have been included in this evaluation. Wastewater from the WLS would likely have to be treated prior to discharge. Costs for equipment for this treatment have not been included in the cost effectiveness calculations but would be expected to be in excess of an additional $300,000. The WLS process has a control efficiency between 80% and 95%.

Holcim contacted the wet scrubber vendor and discussed the impact of the reduction in SO_2 inlet concentration seen since the last kiln modification in February 2008. At an inlet concentration of 100 ppm, which reflects the concentrations that have been experienced since the last kiln modifications in February 2008, the vendor would not warranty an exit emission rate below 10-12 ppm. As a result, calculation for the wet scrubber system was completed at 90% efficiency instead of 95% efficiency (100 ppm SO_2 currently experienced when reduced to 10 ppm is 90%). A 95% efficiency with an inlet concentration of 100 ppm results in an outlet concentration of 5 ppm, which is below what the vendor will warranty.

Note that in the early years of operation the wet scrubbers at Holcim's Midlothian kilns had efficiencies between 65% and 78%. Therefore, an efficiency of 90% may not be achievable on a continuous basis.

An adequate supply of water for the WLS system and the disposal or treatment of WLS sludge and wastewater may present technical problems. Additional drawbacks include high energy requirements. Despite the identified drawbacks, WLS at 80-90% removal efficiency is considered a BACT control option. Further analysis is conducted, therefore, considering environmental, energy, and economic impacts.

5.5.1 Environmental Analysis

Adverse environmental impacts associated with the WLS system include sludge and wastewater generation, treatment, and disposal. The WLS system is estimated to produce more than 2,129 tons of sludge annually. The sludge will require treatment prior to disposal or utilization in the process. While the sludge might be recycled into the process, treatment costs associated with its reuse are expected to be equivalent to those for disposal. The corresponding cost for reuse/treatment/disposal is estimated to be in excess of $170,299.

Wastewater from the WLS would likely have to be treated prior to discharge. This cost is not quantified, but it could be significant. Use of a wet scrubber generates new waste streams and incurs significant costs for the management of these wastes. There is concern that metals may be transferred from the exhaust to the new wastewater streams creating a need for treatment before discharge. Additional off-site environmental impacts will result from the production of and transportation of the lime reagent to the Hagerstown facility.

5.5.2 Energy Analysis

The use of a WLS system will significantly increase electricity consumption. It is estimated that 1,248 kW/h will be used by the facility for operation of the WLS system. At current utility rates, this usage corresponds to an estimated annual electricity cost of over $1,202,573. This cost may fluctuate with seasonal utility rates. In addition, deregulation of the utility industry in some areas has resulted in substantial increases in the usage costs for electricity. The direct cost for the facility does not take into account the additional power generation needed to meet the demand at the power supplier. Also not included in the cost are any increased costs associated with increased energy use by the existing ID fan or from a replacement ID fan if it is determined that the existing fan is not adequate.

5.5.3 Economic Analysis

The determination of the economic impact for implementation of a WLS involved an assessment of the capital and annual operations and maintenance costs for a unit designed for 90% removal. The sum of the annualized costs is used to determine the cost-effectiveness of the control device. The calculation of the component costs and the cost-effectiveness is described below and summarized in Table 5.13.

A purchased equipment capital cost was obtained from a vendor capable of providing the WLS system to Holcim-Hagerstown. The cost for a wet scrubber system for the dry kiln was $10,692,000. The scrubber cost, added to estimates for additional out of scope items, instrumentation, sales tax and freight, and other direct installation (not included with the scrubber), constitutes the DC, which is $19,780,200.

The IC includes engineering, construction and field expenses, contractor fees, start up fees, and contingencies amounting to $4,429,920. These values were calculated based on guidance found in EPA's *New Source Review Workshop Manual – Draft, 1990*[18] and the EPA *Air Pollution Control Cost Manual, 2002* (recent installation cost are running 200% or more of the purchase cost the EPA manual is out of date for this).[19]

The Total Capital Cost is the sum of the DC and IC. A total capital investment of $24,210,120 is projected. This is capitalized over a period of 15 years with a capital

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[18] Reference 10.

[19] Reference 11.

recovery factor of 7.7%, which results in an annualized capital cost estimate of approximately $2,776,859.

The DAC includes operating and maintenance labor and supervision, utilities, and scrubber sludge treatment and disposal. The DAC is driven by maintenance materials, electricity needs and sludge treatment and disposal. The IAC includes overhead, taxes and insurance costs. The annual operating cost is the sum of the DAC and IAC, and is estimated to be $12,924,933.

The average cost-effectiveness (total annualized costs of control divided by annual emission reductions) was determined using the above information. ACE is calculated as described below.

The total annualized cost (direct and indirect) for the wet scrubber system is $12,924,933. The scrubber system was designed to remove 90% of the SO_2 emissions with an uptime of 95% based upon Holcim-Hagerstown's operating experience at their Midlothian, TX facility. The projected actual SO_2 emission rate as calculated in Section 3.2 is 795 tons per year. This value is multiplied by the control efficiency of 90% to get the projected tons SO_2 removed equal to 716 tons.

The average cost-effectiveness, therefore, for a wet scrubber is calculated to be $18,064 per ton of SO_2 removed. These costs do not account for the possibility that the new kiln ID fan, which was installed in 2007, may not be adequate for the addition of a wet scrubber.

Table 5.13 Cost-Effectiveness Evaluations – Wet Scrubbing 90%

Capital Cost Elements		
Direct Costs		
Purchased Equipment Costs (PEC):		***$10,692,000***
	Control Device	$6,000,000
	Auxiliary Equipment	$3,000,000
	Instrumentation (10%)	$900,000
	Sales Tax (3%)	$297,000
	Freight (5%)	$495,000
Direct Installation Costs (DIC) 85% of PEC:		***$9,088,200***
	Foundation and Supports (12% of PEC)	$1,283,040
	Handling and Erection (40% of PEC)	$4,276,800
	Electrical (1% of PEC)	$106,920
	Piping (30% of PEC)	$3,207,600
	Insulation for Ductwork (1% of PEC)	$106,920
	Painting (1% of PEC)	$106,920
Total Direct Cost (DC) = (PEC) + (DIC)		**$19,780,200**
Indirect Costs		
Indirect Installation Costs (IIC) 35% of PEC:		***$4,027,200***
	Engineering (10% of PEC)	$1,069,200
	Construction/Field Exp. (10% of PEC)	$1,069,200
	Contractor Fees (10% of PEC)	$1,069,200
	License	$285,000
	Start-up (1% of PEC)	$106,920
	Performance Test (1% of PEC)	$106,920
	Contingencies (3% of PEC)	$320,760
Site Preparation and Building (SPB) 10% of IIC:		**$402,720**
Total Indirect Costs (IC) = (IIC) + (SPB)		**$4,429,920**
Total Capital Investment (TCI) = (DC) + (IC)		**$24,210,120**
Annualized Costs		
Direct Annual Costs		
Utilities:		
	Cost to reheat stack gas	$5,974,957
	Power ($0.11/kWh)	$1,202,573
	Water($1.00/1000 gallon)	$83,045
Raw Materials/Chemicals:		
	Hydrated Lime ($156/ton)	$129,097
Operating Labor:		
	Operator Labor ($80K/man)	$240,000
	Supervising Labor (15% of Operator)	$36,000
Maintenance:		
	Maintenance Labor ($80K/man)	$240,000
	Maint. Supervision (15% of Maintenance)	$36,000
	Maintenance Materials (100% of Labor)	$240,000

Table 5.13 Cost-Effectiveness Evaluations – Wet Scrubbing 90% (continued)

Replacement Parts (5% of PEC):		$534,600
Waste Treatment and Disposal:		
	Sludge disposal ($80/ton)	$170,299
Compliance Costs:		**$60,000**
	Performance Tests	$40,000
	Recordkeeping and Reporting	$20,000
Total Direct Annual Costs (DAC)		**$8,946,570**
Indirect Annual Costs		
	Overhead (60% of all labor & maint matls)	$475,200
	Insurance (1% of TCI)	$242,101
	Administrative Charges (2% of TCI)	$484,202
	Capital Recovery	$2,776,859
Capital Recovery Factor (CRF)		0.1147
	Equipment Life (years)	15
	Interest Rate (%)	7.7
Total Indirect Annual Costs (IAC)		**$3,978,362**
Total Annualized Costs (DAC + IAC)		**$12,924,933**
Potential Emissions	Tons per year SO_2	795
Potential Emission Reduction		
	Percent Control	90
	SO_2 Tons per Year Controlled	716
Cost-Effectiveness	$ per Ton SO_2 Reduced	**$18,064**

5.6 Ranking of Control Technologies

Based upon achievable removal of SO_2 emissions, wet scrubbing is the most effective add-on control option; however, IDS can achieve equivalent control.

Table 5.14 Ranking of Control Technologies

Control Rank	Technology	Control Efficiency
1	Inherent Dry Scrubbing	82%-96%
2	Wet Scrubbing	80-90%
3	Microfine Lime Injection	40% - 51%
4	Dry Scrubbing	Up to 40%

5.7 Selection of BACT

Before reaching final conclusions about the effectiveness of the potential BACT control options, it is important to remember that this PSD permit and BACT review is the result of a permitted physical change to the kiln system to implement SIP required NO_x controls. The physical changes under that construction permit began in 2003 and continued through early 2008. None of these physical changes were for the purpose of increased clinker production, nor did they result in increased clinker production. They were all undertaken solely for the purpose of compliance with the NO_X SIP requirements and to resolve the unanticipated increase in SO_2 emissions above PSD significance levels. Holcim has spent approximately $2.1 million for the NO_X control system and additional $3.6 million for the capital and engineering services associated with the attempts to reduce the resulting SO_2 emissions increase. In other words, $5.7 million has already been spent by the facility for SO_2 controls created by the implementation of NO_X controls. The facility has already reduced emissions from a high of 1,448 TPY SO_2 in 2005.

5.7.1 Wet Scrubber

Of the add-on control technologies, the wet lime scrubber (WLS) has the highest potential control efficiency (80-90%). The cost-effectiveness calculations were based upon the maximum control efficiency of 90%. Holcim's experience with WLS leads them to believe that this level of control may not be routinely achievable. Therefore, the cost-effectiveness calculations represent the lowest possible cost per ton SO_2 removed. In addition, the cost per ton of clinker for a wet lime scrubber is an increase of $26.36/ton at 2008 actual production rates and $22.12/ton at the maximum historical production rate. Considering the $18,064/ton SO_2 removed and the increased cost per ton clinker, the wet scrubber has been eliminated as economically feasible. This added cost burden would make the Holcim-Hagerstown plant non-competitive in today's market. In addition, significant negative environmental impacts are associated with the increased energy and water requirements and the treatment and disposal off-site of wastewater and sludge.

5.7.2 Microfine Lime Injection

The next ranked add-on control technology is microfine lime injection (MFL). This technology does not currently exist on any long dry or wet cement kiln and therefore, a pilot study is required to determine the viability of this technology for the Hagerstown kiln. The plant must continue to operate the ESP for segregation of alkali in the CKD. There is no known system where you have an ESP followed by a conditioning tower followed by a baghouse. In addition, it is unclear whether the current ID fan will be adequate for the pressure drop created by the conditioning tower and baghouse. If it is not, a new ID fan will add over $1 million to the capital cost of the system. At this point, it is unknown whether this system would work. Therefore, the proposed control system must be considered as a pilot system. Therefore, it is questionable whether it meets the criteria for BACT. Due to the significantly lower stack gas temperatures at the point of lime injection when compared to modern preheater/precalciner kilns, the potential control efficiency from the use of MFL on a long dry kiln is significantly lower than that potentially achieved on those kiln types. At an estimated control efficiency of between 40% and 51% based on the actual data and vendor estimate, respectively, the cost-effectiveness ranges between $10,735 and $8,453 per ton SO_2 removed. MFL requires an additional capital investment of over $12.9 million above the $3.6 million already spent on SO_2 controls. In addition, MFL has significant negative environmental impacts related to the manufacture and transport of the microfine lime and the transport and landfilling of the sludges generated by the process, as well as the negative impacts from the increased power and water usage. The EPA's RBLC Database does not list MFL as an installed SO_2 control technology. Therefore, MFL has been eliminated from consideration as BACT based on both cost-effectiveness and negative associated environmental impacts.

5.7.3 Dry Lime Scrubbing

The final add-on control evaluated for BACT is dry lime scrubbing (DLS). This technology also does not currently exist on a long dry kiln and is in use on only one long wet kiln in Belgium. The plant must continue to operate the ESP for segregation of alkali in the CKD. There is no known system where you have an ESP followed by a conditioning tower followed by a baghouse. In addition, it is unclear whether the current ID fan will be adequate for the pressure drop created by the conditioning tower and baghouse. If it is not, a new ID fan will add over $1 million to the capital cost of the system. At this point, it is unknown whether this system would work. Therefore, the proposed control system must be considered as a pilot system. It is questionable whether it meets the criteria for BACT. Due to the significantly lower stack gas temperatures at the point of lime injection when compared to modern preheater/precalciner kilns, the potential control efficiency from the use of DLS on a long dry kiln is significantly lower than that potentially achieved on those kiln types. Due to the significant difference in kiln gas characteristics between the long dry kiln and preheater/precalciner, a pilot study is required to determine the viability of this technology for the Hagerstown kiln. A maximum control efficiency of 40% is estimated based on the gas temperature. At this efficiency and a capital cost in excess of $9.8 million, the cost-efficiency is anticipated to be a minimum of $11,401 per ton SO_2 removed. This is in excess of the $3.6 million already spent on SO_2 control. Negative environmental impacts are associated with the manufacture and transport of the hydrated lime reagent and the transport and landfilling of the sludges generated by the DLS. The EPA's RBLC Database does not list DLS as an installed SO_2 control technology. Therefore, DLS has also been eliminated from consideration as BACT.

Table 5.15 Summary of BACT Cost Analysis Information

Control Rank	Technology	Control Efficiency	Cost Per Ton SO_2 Removed	Cost Per Ton Clinker
1	Inherent Dry Scrubbing	82% - 96%	- - -	$5.70*
2	Wet Scrubbing	80% - 90%	$18,064	$26.36
3	Microfine Lime Injection	40% - 51%	$10,735 - $8,453	$6.96 - $6.99
4	Dry Scrubbing	Up to 40%	$11,401	$7.39

* Based on the $3.6 million already spent on SO_2 controls.

5.7.4 Conclusion

All potential add-on SO_2 control technologies have been eliminated based upon cost-effectiveness and negative environmental impacts. Of the potential add-on SO_2 control technologies analyzed here, only wet scrubbing is listed in the EPA's RBLC Database as an installed technology on recently permitted cement manufacturing facilities. Of the potential add-on control technologies considered, wet scrubbing is the least cost effective both in terms of cost per ton of SO_2 removed and in additional production cost in terms of cost per ton of clinker. For comparison, the state of Missouri Department of Natural Resources considers control technologies with a cost greater than $5,000 per ton of pollutant removed to not be cost effective.[20] As can be seen in Table 5.15, the most cost effective add-on control technology would cost over $11,000 per ton of SO_2 removed to implement. This is more than double the threshold of what is considered cost-effective SO_2 removal.

Therefore, the inherent dry scrubbing of the kiln itself combined with the improvements that have already been installed, such as the new kiln ID fan and mixing air system represent BACT for Holcim's Hagerstown kiln.

5.8 References

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