September 2010

Regulatory Impact Analysis: Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Sewage Sludge Incineration Units

Draft Report

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CONTENTS

Appendixes

LIST OF FIGURES

Number **Page**

LIST OF TABLES

SECTION 1
INTRODUCTION

Section 129 of the Clean Air Act (CAA) requires that performance standards for new units and emission guidelines (EG) for existing units be established for each category of solid waste incineration units. In previous actions, the U.S. Environmental Protection Agency (EPA) has promulgated rules and EG for hospital medical and infectious waste incinerators (HMIWI), commercial and industrial solid waste incinerators (CISWI), and other solid waste incineration (OSWI) units. These actions did not apply to sewage sludge incinerators (SSI). EPA is proposing new source performance standards (NSPS) and EG for SSI units. As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA). The RIA includes an economic impact analysis (EIA) and a small entity impacts analysis and documents the RIA methods and results.

1.1 Executive Summary

The key results of the RIA are as follows:

- **Options Analyzed:** EPA analyzed the following options and selected Option 2:
  - Option 1 is the MACT floor level of control for the two subcategories developed for existing sewage sludge incineration (SSI) units, multiple hearth (MH) units, and fluidized bed (FB) units.
  - Option 2 is the same as Option 1, with the addition of activated carbon injection for additional mercury (Hg) emissions reduction from MH units.
  - Option 3 is the same as Option 2, with the addition of an afterburner on all MH units for additional carbon monoxide (CO) emissions reduction.
- **Engineering Cost Analysis:** EPA estimates the proposed rule's total annualized costs will be $92 million (2008$).
- **Social Cost Analysis:** Because the proposed regulatory option affects governmental entities (96 of the 97 owners are governmental entities) providing services not provided in a market, the Office of Air Quality Planning and Standards (OAQPS) has used the direct compliance cost method as a measure of social costs. The social cost is approximately $92 million (2008$).
- **Small Entity Analyses:** EPA performed a screening analysis for impacts for 18 small government entities by comparing compliance costs to revenues (e.g., revenue tests). EPA's analysis found the tests were below 1% for small entities.
- **Benefits Analysis:** In the year of full implementation (2015), EPA estimates the monetized $PM_{2.5}$ benefits of the proposed NSPS and EG are $130 million to $320 million and $120 million to $290 million, at 3% and 7% discount rates, respectively.

All estimates are in 2008$ for the year 2015. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates fall between these estimates. The benefits from reducing other air pollutants have not been monetized in this analysis, including reducing 2,900 tons of CO, 96 tons of HCl, 3.0 tons of Pb, 1.6 tons of Cd, 5,500 pounds of mercury (Hg), and 90 grams of total dioxins/furans (CDD/CDF) each year. In addition, ecosystem benefits and visibility benefits have not been monetized in this analysis.

- **Net Benefits:** The net benefits for the NSPS and EG are $37 million to $220 million and $26 million to $190 million, at 3% and 7% discount rates, respectively (Table 1-1). All estimates are in 2008$ for the year 2015.

1.2 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA:

- Section 2 describes the SSI process, alternative disposal methods, and affected entities.
- Section 3 describes the engineering cost analysis.
- Section 4 describes the economic impact and small entity analyses.
- Section 5 presents the benefits estimates.

Table 1-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the SSI NSPS and EG in 2015 (millions of 2008$)[a]

	3% Discount Rate			7% Discount Rate		
Proposed: Option 2						
Total Monetized Benefits[b]	$130	to	$320	$120	to	$290
Total Social Costs[c]		$92			$92	
Net Benefits	$37	to	$220	$26	to	$190
Non-monetized Benefits	26,000 tons of carbon monoxide 96 tons of HCl 5,500 pounds of mercury 1.6 tons of cadmium 3.0 tons of lead 90 grams of dioxins/furans Health effects from NO_2 and SO_2 exposure Ecosystem effects Visibility impairment					
Option 1						
Total Monetized Benefits[b]	$130	to	$320	$120	to	$290
Total Social Costs[c]		$63			$63	
Net Benefits	$66	to	$250	$55	to	$220
Non-monetized Benefits	2,900 tons of carbon monoxide 96tons of HCl 820 pounds of mercury 1.6 tons of cadmium 3.0 tons of lead 74 grams of dioxins/furans Health effects from NO_2 and SO_2 exposure Ecosystem effects Visibility impairment					
Option 3						
Total Monetized Benefits[b]	$130	to	$310	$120	to	$290
Total Social Costs[c]		$132			$132	
Net Benefits	-$5.4	to	$180	-$14	to	$150
Non-monetized Benefits	26,000 tons of carbon monoxide 96 tons of HCl 5,500 pounds of mercury 1.6 tons of cadmium 3.0 tons of lead 90 grams of dioxins/furans Health effects from NO_2 and SO_2 exposure Ecosystem effects Visibility impairment					

[a] All estimates are for the implementation year (2015), and are rounded to two significant figures. These results include 2 new FB incinerators anticipated to come online by 2015 and the large entities comply and small entities landfill assumption.

[b] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as NO_x and SO_2. It is important to note that the monetized benefits include many but not all health effects associated with $PM_{2.5}$ exposure. Benefits are shown as a range from Pope et al. (2002) to Laden et al. (2006). These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because there is no clear scientific evidence that would support the development of differential effects estimates by particle type. These estimates include energy disbenefits valued at $0.5 million at a 3% discount rate from CO_2 emissions.

[c] The annual compliances costs serve as a proxy for the annual social costs of this rule given the lack of difference between the two.

SECTION 2
DESCRIPTION OF SEWAGE SLUDGE INCINERATION[1]

Sewage sludge incinerators combust the organic and inorganic solids and dissolved materials resulting from the wastewater treatment process. Incineration greatly reduces the sludge volume, and post-incineration sludge ash can be disposed of more easily. Sludge ash is generally disposed of in landfills but can also be used in construction materials. In addition to disposal functions, some facilities capture the heat from sewage sludge incineration operations and use the heat as an energy source.

The incineration process releases several pollutants, some of which were present in the sewage sludge and some of which are created as a result of combustion. Pollutants emitted from SSI include particulate matter (PM), hydrocarbons, CO, nitrogen oxides, sulfur dioxide, hydrogen chloride, dioxins and dibenzofurans, and a number of metals. The amount of these pollutants released during incineration depends on the content of the sludge, the type of incinerator used, and the level of PM control.

The majority of incineration facilities (163, or 75%) are multiple hearth (MH) incinerators. These incinerators consist of a cylinder around a series of hearths with a rotating shaft through the center. Rabble arms with teeth in each hearth rake the sludge while air is ducted into the shaft and circulated. The incinerator consists of the upper drying zone, the middle sludge combustion zone, and the lower cooling zone.

Although MH incinerators have been in use since the 1930s and remain in the majority, fluidized bed (FB) incinerators have begun to replace them.[2] Of the 218 incineration units in operation 55 (25%) are FB incinerators. In a FB incinerator, a steel shell holds a refractory-lined grid beneath a bed of sand. Air is injected into the incinerator, fluidizing the sand and sludge. FB incinerators work efficiently to transfer heat from the sand to the sludge, using less excess air than MH incinerators. Emissions for most pollutants are, therefore, lower for FB incinerators.

2.1 Relation to Publicly Owned Treatment Works (POTWs)

Publicly owned treatment works (POTWs) are wastewater treatment systems owned by states, municipalities, or other public entities. POTWs receive sewage from homes and

[1]Portions of this section rely on information provided by EPA (2007 and 2009).
[2]Other types of sewage sludge incinerators, such as electric arc furnaces, are no longer used in the United States.

businesses, runoff, and sometimes industrial wastewater. After the wastewater treatment process, POTWs are responsible for disposing of the sewage sludge.

POTWs treat sewage in three steps: primary, secondary, and tertiary treatment. In the primary stage, heavy solids settle to the bottom while oil and light solids are skimmed from the top. The sludge removed during this step is known as primary sludge. During secondary treatment, biological treatment creates secondary sludge. Some plants may continue with a tertiary treatment of chemical disinfection, which produces a tertiary or chemical sludge (EPA, 2009). The three sludge types are then generally combined and disposed of or sent for further treatment.

2.2 Alternative Disposal Options

Incineration continues to be utilized to dispose of sewage sludge but is increasingly becoming less common. Additional pollution controls will increase costs for facilities that continue to use the incineration disposal method. If the additional costs are high enough, many POTWs may choose to adopt alternative disposals methods (e.g., surface disposal in landfills or other beneficial land applications). However, the use of alternative disposal methods may be of limited in some areas because of landfill capacity constraints, local geography, or other legal or economic constraints.

2.2.1 Surface Disposal: Landfills

Landfilling, in some cases, provides a simple and low-cost option for sewage sludge disposal. Sewage sludge may be placed in landfills used for other municipal solid waste or in landfills constructed specifically for sewage sludge. The landfill disposal option is attractive for low-volume incinerators; landfill capacity constraints limit disposal opportunities for large sludge volumes.

Sewage sludge may also be useful for landfills. For example, sludge can be used in place of a daily soil cover for odor and blowing litter control or as a final cover for closed landfills to aid growth of a vegetative layer. The sewage sludge’s high organic content also helps break down other landfill waste.

2.2.2 Other Land Application

Sewage sludge that has undergone treatment to make it safe for use on other land application (e.g., fertilizer) is commonly referred to as biosolids. Biosolids can be sold to agricultural or landscaping entities for land application, so the organic material in biosolids is reused to contribute to crop production. Land application has also been used in mine reclamation to reestablish vegetation.

Biosolids must meet federal and state regulations to ensure their safety; meeting these standards may make other land applications a less attractive disposal option. In addition, land application may not be suitable in some areas, based on factors such as proximity of water sources and slope. Rules vary based on the quality of the biosolid: Class A biosolids meet strict standards, while Class B biosolids are treated but still contain detectable pathogen levels and face greater restrictions on usage (EPA, 2007). Actions must also be taken to reduce the vector attraction of biosolids, either through additional treatment or by preventing contact with vectors.

2.3 Ownership

Sewage sludge incinerators can be operated by municipalities or other entities. There is no specific North American Industry Classification System (NAICS) code for these units. Applicable NAICS codes include 562213 (solid waste combustors and incinerators) and 221320 (sewage treatment facilities). Most sludge incinerators are located in the eastern United States.

The United States has 97 operators that own 112 facilities with a total of 218 affected incinerator units; the typical (e.g., median) operator owns one facility. Almost all operators are towns, cities, and their utility authorities; the exception is one operator that is a large publicly owned company. Among owner municipalities whose exact population is known, the average (median) population is 336,305 (108,213). Out of the 94 owners with population information available, 18 (or 19%) are small entities that serve a population under 50,000.

SECTION 3
ENGINEERING COST ANALYSIS

This section documents the calculation of costs and emissions reductions associated with existing and new sources complying with the MACT floor level of control, the selection of control options more stringent than the MACT floor level of control, and summarizes cost and emissions reductions of each control option. The costs and emission reductions of each option are then used in the economic analysis (Section 4) and human health benefits analysis (Section 5). Costs and emissions reductions were calculated for two scenarios:

- Control options were applied to all SSI units, and
- Control options were applied to only larger entities. Larger entities mean wastewater treatment facilities that are owned by municipalities or authorities with more than 50,000 people. Entities with fewer than 50,000 people are likely to dispose of sewage sludge by landfilling rather than continuing to operate their incineration unit.

3.1 Calculation of Costs and Emissions Reductions of the Maximum Achievable Control Technology (MACT) Floor

A significant portion of the total cost for industry compliance comes from the cost of installing new pollution control devices or improving existing pollution control devices for units not currently meeting the proposed limits. In order to determine the control costs, it was necessary to evaluate, for each SSI unit, how much improvement for each pollutant would be needed to meet the proposed emissions limits.

The average pollutant concentration values used to calculate baseline annual emissions (Estimation of Baseline Emissions, 2010) for each unit were compared with the proposed emissions limits, and percentages were calculated to quantify the amount of improvement needed for the unit to meet the proposed limits. Tables C-1a and C-1b in Appendix C contain the baseline pollutant concentration values used for each unit in each subcategory and the percentage improvement required to meet the proposed emissions limits for each unit for each pollutant. The existing SSI units are subcategorized into two main groups: multiple hearth (MH) units and fluidized bed (FB) units. The pollutant- and subcategory-specific limits are shown in each header row of these tables.

Control methods and cost algorithms utilized in a recent rulemaking for another waste combustion source category, Hospital, Medical and Infectious Waste Incinerators (HMIWI) were updated and utilized generally for the SSI source category, since most of these algorithms can be tailored to the combustion units found in the SSI source category with slight modifications.

Based on these required improvements, pollutant-specific control methods were chosen as follows for units requiring more than 10 percent improvement to meet the proposed limits. It was assumed that units within 10 percent of the limit would be able to meet the limit by making minor adjustments to the unit and/or controls already in place.

Metals (cadmium and lead) and PM: Adding fabric filters (FF).

Mercury and dioxins/furans (CDD/CDF): Adding activated carbon injection (ACI) and adjusting the carbon addition rate to meet the amount of reduction required.

Hydrogen chloride (HCl): Adding packed bed scrubbers (PBS).

Carbon monoxide (CO): No further improvement was needed for units to meet the MACT floor limit. However, the beyond-the-floor limit required the use of afterburner retrofits for units not already having similar control. The costs and emission reductions associated with the proposed CO limit are discussed in the memorandum "Analysis of Beyond the Maximum Achievable Control Technology (MACT) Floor Controls for Existing SSI Units."[2]

Nitrogen oxides (NO_x): No more than 10 percent improvement in NO_x control was needed for any units. Minor adjustments were considered sufficient for those needing improvement to meet the NO_x limit.

Sulfur dioxide (SO_2): Adding packed bed scrubbers.

Further descriptions of these controls and their associated costs are listed below in Section 3.1.1.

3.1.1 Compliance Costs

This section presents the methodology used to estimate costs for existing SSI for (A) the emission controls used to comply with the proposed limits; (B) the monitoring, testing, recordkeeping, and reporting activities used to demonstrate compliance; and (C) the alternatives to compliance.

3.1.1.1 Emission Control Costs

Emission control technologies and other control measures that can be used to comply with the MACT floor options for existing SSI units include PBS, FF, and activated ACI. This section presents the costs that were estimated for each of these control measures.

The retrofit factors for the capital costs were assumed to be 40 percent for packed bed scrubbers, fabric filters, and 20 percent for and ACI.[5, 6] Downtime costs for the retrofits were assumed to be negligible. Most SSI are expected to have adequate space to install an emission control system without shutting down the incinerator for an extended period. It was also expected that connecting the ductwork could be performed during a scheduled downtime for maintenance, thereby minimizing expected downtime.[7]

The capital and annual costs for the emission controls were estimated in units of dollars ($) and $/flow. The $/flow costs were calculated by dividing the capital/annual control cost estimate for each unit by the average gas flow rate assigned to that unit.

Costs are on a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables C-2a to C-2c in Appendix C present a summary of the parameters and equations used in the cost algorithms for each emission control and alternative to compliance where applicable. Table C-3 in Appendix C lists of the unit-specific inputs used in the algorithms (e.g., incinerator charge rate, stack gas flow rate, incinerator operating hours, and concentrations)

a. Adding a fabric filter.

Fabric filters can be installed either alone or with other add-on controls. The cost algorithm for installing a fabric filter is presented in Table C-2a in Appendix C and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.[6] The fabric filter capital costs range from approximately $893,000 to $4.2 million, and annualized costs range from approximately $209,000/yr to $1.2 million/yr. Sources for specific cost data are noted below Table C-2a in Appendix C.

b. Adding a packed bed scrubber.

Wet scrubbers can be installed alone or after a dry scrubber/fabric filter. The cost algorithm for installing a packed-bed wet scrubber is presented in Table C-2b of Appendix C and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.[8] The packed-bed wet scrubber capital costs range from approximately $366,000 to $8.7 million, and annualized costs range from approximately $103,000/yr to $1.8 million/yr. Sources for specific cost data are noted below Table C-2b in Appendix C.

c. Adding an activated carbon injection (ACI) system.

Injecting activated carbon before the fabric filter has been demonstrated to improve the removal efficiency of both Hg and CDD/CDF from SSI. The cost algorithm for installing an ACI system is presented in Table C-2c in Appendix C and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.[8] Adjustments to the carbon injection rate were made to account for how much reduction was required to meet the proposed limit, and whether a packed-bed scrubber was being added, since those may also assist in reducing Hg emissions. The packed-bed scrubber adjustment is a ten percent Hg reduction, and is based on input from the boiler NESHAP development. The ACI factor compares the carbon grain loading originally assumed to achieve 90 percent control of mercury or 98 percent control of CDD/CDF to the amount of reduction the unit will need to meet the proposed emission limits. The highest factor (Hg or CDD/CDF) is then used to adjust the carbon injection rate calculation of the algorithm. ACI capital costs range from approximately $8,400 to $37,000, and annualized costs range from approximately $9,300/yr to $210,000/yr. Sources for specific cost data are noted below Table C-2c in Appendix C.

d. Additional Control Options.

Minor adjustments, such as air handling and distribution adjustments in the firebox, can be made to certain units to improve NO_x control. It was assumed these adjustments could be made at no additional cost.

3.1.1.2 Stack Testing, Monitoring, and Recordkeeping Costs

Monitoring Costs. Initial and continuous compliance provisions for SSI units were selected to be as consistent as possible with proposed commercial and industrial solid waste incinerator (CISWI) and current HMIWI provisions. This section presents the costs that were estimated for each of these requirements.

The total capital cost for stack testing, monitoring, and recordkeeping and reporting for all subcategories is estimated at approximately $14.9 million, and the total annualized cost is about $16.9 million per year. Cost estimates were based on algorithms recently utilized in the HMIWI regulatory development. Costs were updated to a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables C-4a to C-4e in Appendix C present a summary of the parameters and equations used in the cost algorithms for each monitoring component, where applicable.

Inspections. Consistent with HMIWI regulations, it was assumed that annual control device inspections will be required for any units having control devices in place or requiring further controls to meet the proposed emission limits. In this context, control devices include fabric filters, afterburners, wet scrubbers, or ACI systems. The cost was estimated at a flat rate of $1000 per year. See Table C-4a in Appendix C for further details and sources.

Parameter monitors. Monitoring of operating parameters can be used to indicate whether air pollution control equipment and practices are functioning properly to minimize air pollution. Based on the existing CISWI regulations and HMIWI regulations, it was assumed that parameter monitoring will be mandatory for all units required to add fabric filters, packed bed scrubbers, or ACI systems. Costs for each monitoring system were estimated as follows:

- For a fabric filter bag leak detection system, capital cost was estimated at $25,500 and annualized cost at $9,700/yr.
- For a wet scrubber monitoring system, capital cost was estimated at $24,300 and annualized cost at $5,600/yr.
- The cost for ACI monitoring depends on a unit's annual operational hours. There are no capital costs for ACI monitoring. Annual costs ranged from $500 to $9,800.

For default parameters and equations used for monitoring costs, see Table C-4b. Sources for specific cost data are noted below the table.

a. Testing Costs

1. *Initial Stack Testing.* It was assumed that initial stack testing will be required for each pollutant that the ICR testing showed did not meet the proposed emission limit. Any unit having no test data for certain pollutants will also be required to perform an initial emissions test for those pollutants. Costs for each required stack test were summed and multiplied by 2/3 to adjust for economies of scale when multiple pollutant tests were being performed on a unit. The annualized costs were calculated assuming a capital recovery factor of 0.10979 (15 years at 7 percent). The basis of these cost estimates for each stack test is summarized in Table C-4c in Appendix C.
2. *Annual Stack Testing.* It was assumed that all units, to some extent, will be required to demonstrate ongoing compliance with the emissions limits for all pollutants. It was assumed that all units will be required to conduct annual stack tests for all pollutants. The cost for this annual testing was estimated to be approximately $61,000/yr. The basis of these cost estimates for each stack test is summarized in Table C-4c in Appendix C.
3. *Visible emissions testing.* All SSI units will likely have ash handling operations. Therefore, these units would be required to demonstrate compliance to a 5 percent visible emissions limit for fugitive emissions generated during ash handling (similar to HMIWI). We are proposing that units will be required to conduct annual performance tests for fugitive emissions from ash handling using EPA Method 22. Costs for this annual test include a capital cost of $250 and an annual cost of $200, based on the *Revised Compliance Costs and Economic Inputs for Existing HMIWI*

memo.[8] Further details regarding this cost estimate are included in Table C-4d in Appendix C.

b. Recordkeeping and Reporting Costs

For all units, a flat rate of $2,989 per year was estimated as the annual cost for recordkeeping and reporting. Further details regarding this cost estimate, including hourly labor assumptions, labor rates, and associated sources, are included in Table C-4e in Appendix C.

3.1.1.3 Alternative Disposal Costs

Certain SSI units may have waste disposal alternatives other than combustion available to them, and these alternatives may prove to be less costly than the controls and monitoring required for compliance with the proposed SSI standards. To determine if landfilling would be an affordable option for facilities even in the absence of the proposed standards, both the annual cost to landfill and the annual unit operating cost were estimated. Then, the overall cost for the landfilling option was calculated using the following equation:

Annual Cost for Landfilling Option = Annual Cost to Landfill – Annual Cost to Operate SSI Unit

The methodology for determining annual landfilling costs and annual unit operational costs is described below.

a. Cost to Haul to Landfill

The cost to haul waste to a landfill is the sum of additional sludge storage costs, landfill tipping fees, and transportation costs, which depend on the amount of waste to be hauled and the distance traveled per haul.

If choosing to landfill, it was assumed that a facility would need adequate storage capacity to store a minimum of 2 to 4 days worth of dried sludge, to account for occasional multi-day landfill closures (e.g. weekends and holidays). Facilities may already have such storage on-site to account for non-continuous operation of the incineration unit. For this analysis, to provide a conservative estimate of costs of the landfilling option, a cost for storing dewatered sludge was calculated. It was assumed that a concrete pad with metal railing would be sufficient for storage of dried or dewatered sludge at small entities. The smaller entities have a lower average dry sludge capacity than large entities. Sewage sludge incineration capacity was known for 4 of the 21 units owned by small entities. An average capacity of 1.90 dry tons per hour was applied to the other 17 units, and these capacities were used to estimate the maximum volume of dry sludge that would accumulate over 4 days. Costs were then estimated for the concrete and aluminum required to accommodate these volumes. Table C-5c in Appendix C presents these costs estimates by unit. For large entities, a different type of storage would likely be required (such as a concrete basin capable of storing large quantities of sludge); storage costs for these facilities were not estimated because it was assumed large entities would comply rather than shut down their units and landfill.

Tipping fees used in the analysis were specific to each state where state data were available[9]; where state data were not available, landfill tipping fees were based on regional tipping fees.[10] All fees were in units of $/ton waste and were converted to 2008 dollars. The annual tonnage of waste being diverted was calculated based on the dry sludge feed rate of each unit and the number of hours it operates per year. Operational hours and sludge feed rates are discussed in further detail in the SSI inventory and baseline emissions memos. Discussion with landfill experts indicated that landfills may accept wet sewage sludge as well. However, because landfills might have a wet sludge capacity limit and SSI units are already dewatering their sludge, it's likely they would continue to do this. The cost analysis therefore focuses on landfilling dry sludge rather than wet sludge.

Transportation costs were based on an estimated $0.266 per ton-mile[11]. It was assumed that a landfill could be found within 50 miles of each facility, yielding a roundtrip distance of 100 miles. However, a review of state regulations for states where small entities are located revealed that Connecticut and New Jersey do not allow sewage sludge to be landfilled. To adjust for this, round trip distances for facilities in these states were increased to 200 miles, assuming a landfill could be found in another state within 100 miles from the facility.

Annual landfilling costs varied widely, ranging from $13,000/yr to $5.1 million/yr. Table C-5a in Appendix C summarizes the parameters and equations used to calculate the annual cost for each facility to landfill the waste it would otherwise incinerate in an SSI.

b. Cost to Operate Incinerator

Annual incinerator operational costs were based on data provided from the ICR survey and known unit capacities. The survey specifically requested that respondents provide annual costs to operate each incinerator in 2006, 2007 and 2008. Costs were then confirmed or revised based on follow-up contact with the survey recipients. Several steps were taken and assumptions made to standardize the data: (1) total costs provided were assumed to be for operating *only* the incinerator (i.e. did not include dewatering or other aspects of plant operation); (2) total costs listed for multiple units were divided evenly among each unit; and (3) individual cost components (e.g. electricity, labor, fuel) were summed if a total cost was not explicitly provided.

Because cost information was only available for the 9 surveyed entities, an annual cost factor, in $/dry ton, was developed using the available data and multiplied by the average capacities of all other units. Both an average factor ($113.80/dry ton for FB units and $329.22/dry ton for MH units) and a minimum factor ($55.50/dry ton for FB units and $79.43/dry ton for MH units) were calculated and applied. The minimum factor is the most conservative estimate (i.e. would yield the lowest unit operational cost and thus the highest net cost for the landfilling option) and was used for the economic analysis.[12]

Table C-5b in Appendix C summarizes the information provided, assumptions made, and cost factors used to estimate costs for all units not having cost data.

3.1.2 Emission Reductions

Emissions reductions were calculated for each of the nine pollutants for two scenarios: (1) assuming each existing unit complied with the proposed emissions limits; and (2) assuming that all large entities would comply with the proposed emission limits and small entities would cease using their incinerators and landfill the dewatered sludge instead. Emission reductions were calculated by estimating the emissions resulting from each scenario and subtracting the baseline emissions previously calculated. Baseline emission calculations are discussed in a separate memorandum.[3] The baseline memorandum indicates that emissions and flow rate information was collected from only 25 of the 218 SSI units. Sludge capacity information was collected from 105 of 218 units. As described in the baseline memorandum, default factors for emissions, flow rate, and sludge capacity were developed and applied to units without data.

3.1.2.1 Emission Reductions if All Entities Comply With MACT Floor Limits

Emission reductions were calculated using the following equation:

Reduction = Baseline – MACT Floor Emission

The calculation of baseline emissions are described in detail in a separate memo.[3] The MACT floor emission values, resulting from all entities meeting the proposed limits, were calculated as follows:

a. Units already meeting the proposed limits.

If a unit was already meeting the MACT floor for a given pollutant, then the MACT floor emission value was assumed to equal the baseline value (i.e., no backsliding or emissions increases would occur), yielding zero reduction.

b. Units not currently meeting the proposed limits.

For units not already meeting the MACT floor for a given pollutant, it was assumed that with the proposed limits in place the unit would reduce its pollutant concentration to at least that of the floor. Thus, the reduction would be the difference between the baseline and the proposed limit.

3.1.2.2 Emission Reductions if Large Entities Comply With MACT Floor Limits and Small Entities Landfill

For large entities, reductions are calculated as described in Section 4.1. For small entities, however, the emissions resulting from hauling the diverted waste, landfilling the waste, and flaring the landfill gas generated from the waste need to be considered. Emission reductions for small entities were calculated using the following equations:

Reduction = Baseline – (MACT Floor Emission + Emissions from Landfilling)

Emissions from Landfilling = Vehicle Emissions + Direct Landfill Emissions + Flare Emissions

a. Vehicle Emissions

To determine the vehicle emissions resulting from the trucks that would haul the dewatered sewage sludge to a nearby landfill, assumptions regarding sludge density, truck capacity, and vehicle emission factors were made:

1. A dewatered sludge density of 1,215 pounds per cubic yard[13] was used in conjunction with each unit's capacity to determine the approximate volume of sludge to be hauled.
2. It was assumed that, since most facilities would need to move at least 50 cubic yards per day, a maximum capacity hauling vehicle (36 yd^3) would be the most likely vehicle used.[14]
3. The following emission factors for CO, NO_x, Filterable PM, $PM_{2.5}$, and SO_2 were derived from EPA's Office of Transportation and Air Quality (OTAQ) Motor Vehicle Emission Simulator (MOVES),[15] using national defaults for parameters and refuse trucks as the source type :

CO	2.99 grams emitted per mile
NO_x	10.8 grams emitted per mile
Filterable PM	0.65 grams emitted per mile
$PM_{2.5}$	0.56 grams emitted per mile
SO_2	0.03 grams emitted per mile

Table C-6a shows the inputs and resulting emissions calculated for each unit choosing the landfill option.

b. Direct Landfill Emissions

Landfill gas generated by the decomposition of waste is a source of Hg, HCl, and SO_2. Emissions of these three criteria pollutants due to landfilled, dewatered sewage sludge, were estimated using EPA's LandGEM[16] model in conjunction with default landfill gas sulfur and chlorine concentrations, as reported in the AP-42.[17] As a conservative estimate, it was assumed that landfill gas collection systems would collect 50 percent of the landfill gas generated. Unit capacities and operational hours were used to determine the amount of waste diverted annually from all units. Instead of running LandGEM for each individual unit, a total estimate of landfill gas generated by running the model once using the total annual waste diverted for all units. Unit-specific estimates for landfill emissions were not calculated. Raw LandGEM outputs and default assumptions are presented in Table C-6b in Appendix C. Resulting total emissions over 20 years for these three pollutants are presented in Table C-6c in Appendix C. These values were divided by 20 to obtain annual emissions directly emitted from landfills as a result of landfilling dewatered sewage sludge.

c. Emissions from Landfill Gas Flaring

Additional emissions of PM, NO_x, and CO will result from flaring landfill gas generated by the landfilling of dewatered sewage sludge. A landfill gas collection efficiency of 50 percent was assumed, meaning that 50 percent of the landfill gas generated from landfilled sewage sludge would be collected and combusted. AP-42 emission factors, representing the mass of pollutant emitted per volume of methane combusted, were applied in conjunction with the methane output calculated in the LandGEM model. Again, LandGEM outputs are presented in Table C-6b in Appendix C, and resulting total emissions over 20 years for these three pollutants are presented in Table C-6c in Appendix C. Values were divided by 20 to obtain annual emissions resulting from landfill gas flaring.

3.2 Analysis of Beyond the MACT Floor Controls for Existing SSI Units

The MACT floor analysis for existing sources results in emission levels that each existing SSI unit is required to meet. The costs and emission reductions of the MACT floor requirements were estimated using the following assumptions: (1) units that needed to meet the MACT floor for Cd, Pb, and PM would add a FF, (2) units that needed to meet the MACT floor for HCl and SO_2 would add a packed bed scrubber (PBS), and (3) units that needed to meet the MACT floor for Hg and CDD/CDF would use activated carbon injection (ACI) (Cost and Emissions Reduction, 2010). All FB and MH units were determined to meet the floor level of control for NO_x and CO, and no additional control was necessary.

Section 3.2.1 discusses the selection of more stringent controls or emission levels than the floor level reviewed for this analysis. Section 3.2.2 discusses the methodology used to estimate costs and emission reductions of the more stringent controls, and Section 3.2.3 summarizes regulatory options selected for the BTF analysis. Baseline emissions and emission reductions of $PM_{2.5}$ were calculated from emissions data collected by EPA and assuming that controls applicable for PM would also reduce $PM_{2.5}$.

3.2.1 Selection of More Stringent Controls

The control technologies that were costed to achieve the MACT floor levels for PM, Cd, Pb, HCl, SO_2, Hg, and CDD/CDF are the most effective controls available to reduce these pollutants. Consequently, no additional technologies were considered to control these pollutants for this analysis. Since not every SSI unit was determined to need FF, PBS, or ACI to achieve the MACT floor level of control or operated them currently (i.e., the baseline level of control), more stringent controls to be analyzed for the entire SSI source category would be requiring all units that did not have these controls at baseline or for meeting the MACT floors to add these controls. Consequently, more stringent controls applied to SSI units that were analyzed include adding a FF for all SSI units (if the units did not already have one at baseline or to meet the MACT floor) to control PM, Cd, and Pb; adding a PBS for all SSI units (if the units did not already have one at baseline or to meet the MACT floor) to control HCl and SO_2; and adding ACI (if the units did not already have one at baseline or to meet the MACT floor) to control Hg and CDD/CDF. Emission reductions of $PM_{2.5}$ were calculated assuming that controls applicable for PM would also reduce $PM_{2.5}$.

Potential add-on control technologies that achieve NO_x reduction at other combustion sources are selective catalytic reduction (SCR), selective noncatalytic reduction (SNCR), and flue gas recirculation (FGR). However, none of these technologies were evaluated to be appropriate for SSI units. SSI units do not use SCR or SNCR (Inventory Database, 2010). Additionally, there are no successful applications of SCR technology to waste-combustion units possibly because of the difficulties operating SCRs in operations where there is significant PM or sulfur loading in the gas stream. Application of SNCR also may not be technically feasible considering the combustion mechanisms of MH and FB units (U.S. EPA, 2003). Application of SNCR requires installation of a reagent injection system that is unlikely to work for existing SSI units. Additionally, SNCR is optimal for combustion units with high residence time and exit incinerator temperature, and less effective for lower uncontrolled NO_x pollutant loadings (e.g., less than 200 ppm). Existing SSI units are not good matches for these considerations. FGR has been used on combustion devices to reduce NO_x emissions. However, the amount of NO_x reduced varies widely, ranging from 20% to 80%, and site-specific factors often affect the performance. To support regulations for SSI units, EPA collected emissions information on the nine Section 129 pollutants. One unit providing emission test data operates a MH unit with FGR. However, its emission levels are similar to units without FGR. Therefore, no conclusion could be made on FGR performance. Additionally, no FB units use any add-on NO_x control because FB units can achieve low NO_x emission levels, below 100 ppmv and many achieve below 70 ppmv.

For control of CO, an add-on combustion device, such as an afterburner or thermal oxidizer, was analyzed as a more stringent control device that could be applied to SSI units. CO emissions data were collected from nine MH SSI units as part of the data collection efforts supporting the development of emission standards for SSI units. Table 3-1 summarizes the average CO concentration levels from these units (Facility, Unit, and Emissions Test Database, 2010). The table is grouped into three classes of SSIs: (1) units that do not use any combustion controls, (2) units that use an on-hearth afterburner, and (3) units that use either a detached afterburner or thermal oxidizer or use FGR in combination with an on-hearth afterburner.

Afterburner, or secondary chamber, retrofits include retrofitting an incinerator with a larger secondary chamber (with a longer gas residence time, for example, 2 seconds) and operating it at a higher temperature (e.g., 1,800°F). On-hearth afterburners are the top hearth of a MH unit that has been redesigned so that sludge is rerouted to the second hearth. Retrofitting the MH unit with an on-hearth afterburner may require modifications to downstream air pollution control systems because of higher temperatures and larger volumes of exhaust gases (Dangtran, Mullen, and Mayrose, 2000). Although there will be reductions in CO and total hydrocarbon (THC) emissions, the reductions may be limited because of low temperature and limited residence time of the gas in the afterburner stage. The use of FGR in combination with an on-hearth afterburner shows significantly lower emissions levels than just using an on-hearth

Table 3-1. Summary of Average CO Emissions Collected from MH Units

Classes	Facility	Location	Unit ID	Average CO Emission Level (ppmvd @ 7% O_2)
Uncontrolled	Boat Harbor	VA	1	3,761
On-hearth afterburner	Seneca	MN	1	1,323
			2	853
	Central Contra Costa	CA	1	905
			2	752
Detached afterburner, thermal oxidizer, or on-hearth afterburner with flue gas recirculation	Columbia Metro	SC	1	63
	Mountain View	NJ	2	39
	Upper Blackstone	MA	1	28
			3	59

afterburner. However, this may be a generalization because only one data point for this control combination was reviewed. Additionally, performance of FGR is often influenced by site-specific parameters that may not be generalized to the entire subcategory.

Table 3-1 shows that MH units using an add-on afterburner or thermal oxidizer can achieve CO emission levels less than 100 ppmv. The Clean Water Acts "503 Rule" [40CFR Part 503] limits sewage sludge incinerators to 100 ppm THC as propane, dry basis, corrected to 7% oxygen, averaged for 30 days. The 503 Rule allows substitution of 100 ppm CO dry basis, corrected to 7% oxygen for the THC originally required. This allows the use of a lower cost, easier to maintain CO monitor in place of the THC monitor, which is difficult to keep online. To be consistent with the 503 regulations for disposal of sewage sludge, a value of 100 ppmv was used as the emission level that a MH unit with an afterburner could achieve. Because CO levels for FB units are below 100 ppmv, no afterburners were costed for this subcategory.

3.2.2 Methodology Used to Estimate Cost and Emission Reductions

The methodology used to calculate costs and emission reductions from applying the more stringent controls followed the procedures discussed in Section 3.1 and in the SSI cost memorandum (Cost and Emissions Reduction, 2010). As described above, if a unit already had a FF or needed one to meet the MACT floor limits, no additional costs for FF were calculated. Otherwise, a FF was costed out for the unit. Similar procedures were followed for PBS and ACI. The cost algorithms; inputs to the algorithms; and testing, monitoring, recordkeeping, and reporting costs calculations are the same as conducted for the MACT floor and are discussed in detail in the MACT floor cost and emission reductions memorandum.

Emission reductions from applying the controls relative to the MACT floor limits were calculated using the following procedure. First, the reduction efficiency of the control for each pollutant was applied to the uncontrolled concentration to determine the total reduction the control would achieve. The reduction from uncontrolled levels to the MACT floor limits was previously calculated for the MACT floor cost and emission reduction analysis discussed in Section 3.1 and in a supporting memorandum (Cost and Emissions Reduction, 2010). For each pollutant, the incremental reduction between the more stringent control application and the MACT floor was calculated by subtracting the MACT floor concentration from the reduction achieved by the more stringent control. Reduction of $PM_{2.5}$ was calculated assuming that controls applicable for PM would also reduce $PM_{2.5}$.

3.2.3 Selection of Regulatory Options

Tables 3-2 and 3-3 summarize the costs, emission reductions, and incremental cost effectiveness of the controls analyzed in the BTF analysis, for the case where all entities comply (Table 3-2) and the case where small entities choose to landfill (Table 3-3). Tables 3-4 and 3-5 present the results from Tables 3-2 and 3-3 on a per unit basis. The number of Fluidized Bed units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 41 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 7 units; and ACI, 51 units. The number of Multiple Hearth units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 25 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 11 units; and ACI, 2 units. The total number of SSIs requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 66 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 18 units; and ACI, 53 units. The per unit values were calculated by dividing the costs and emissions reduction for each option by the number of SSI units that would require control for the option. The tables indicate that except for the afterburner, all of the controls applied result in a high incremental cost-effectiveness, greater than $70,000/ton. Consequently, these controls, with the exception of activation carbon injection for Hg control, were considered infeasible. Activated carbon injection was determined to provide significant reduction in Hg emissions at MH units. Therefore, the following control options were selected for further analysis:

- Option 1 is the MACT floor level of control for the two subcategories developed for existing SSI units, MH units and FB units.

- Option 2 is the same as Option 1, with the addition of activated carbon injection for additional Hg emissions reduction from MH units.

- Option 3 is the same as Option 2, with the addition of an afterburner on all MH units for additional CO emissions reduction.

Tables 3-6 and 3-7 summarize the costs, total emission reductions, and incremental cost-effectiveness of the three options. Detailed costs and emission reductions for each SSI unit for the each option are presented in supporting memoranda

Table 3-2. Emissions Reductions and Costs If All Units Comply

Fluidized Bed Incinerators		# of units requiring additional control	Cost (2008$)[f] Total Capital Investment ($)	Cost (2008$)[f] Total Annualized Cost ($/yr)	Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
					Baseline Emissions and Incremental Emission Reductions (tons/year)												
Baseline Emissions			-	-	0.0103	119.6	2.99	0.0531	0.0758	327.4	56.60	54.22	134.1	0.000082	0.0000068	-	-
MACT Floor Total Cost and Emission Reductions[a]		51	$86,696,269	$32,313,699	0.0010	0	1.53	0.0053	0.0579	0	41.00	38.88	59.7	0.000079	0.0000065	141.1	-
BTF Costs and Emission Reductions by Control	Fabric Filter	14	$32,663,593	$8,402,116	0.0066	0	0	0.0343	0	0	0.00	0.00	0	0	0	0.041	$205,482,746
	Afterburner Retrofit[b]	52	$31,532,870	$10,384,276	0	0	0	0	0	0	0	0	0	0	0	0.000	-
	Packed Bed Scrubber	46	$48,701,933	$10,854,865	0	0	1.01	0	0	0	0	0	54.2	0	0	55.240	$196,505
	Activated Carbon Injection[c]	0	$0	$0	0	0	0	0	0.0074	0	0	0	0	0.000001	0.0000002	0.007	$0

Multiple Hearth Incinerators		# of units requiring additional control	Cost (2008$)[f] Total Capital Investment ($)	Cost (2008$)[f] Total Annualized Cost ($/yr)	Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
					Baseline Emissions and Incremental Emission Reductions (tons/year)												
Baseline Emissions			-	-	2.83	29024	122.59	6.0595	3.0536	7358.5	1101.46	666.13	3078.8	0.000020	0.0000013	-	-
MACT Floor Total Cost and Emission Reductions[a]		41	$131,764,712	$40,327,113	1.41	0	91.51	2.6237	0.0315	4.3051	277.90	167.21	2132.6	0.000000	0.0000000	2,677.5	$15,061
BTF Costs and Emission Reductions by Control	Fabric Filter	138	$478,373,914	$115,254,825	1.15	0	0	2.8750	0	0	614.00	372.00	0	0	0	990.0	$116,416
	Afterburner Retrofit	128	$145,514,140	$43,193,966	0	25691	0	0	0	0	0	0	0	0	0	25,691	$1,681
	Packed Bed Scrubber	148	$258,596,495	$54,863,534	0	0	19.60	0	0	0	0	0	659.2	0	0	678.8	$80,820
	Activated Carbon Injection	161	$6,230,844	$32,335,212	0	0	0	0	2.6235	0	0	0	0	0.000020	0.0000013	2.624	$12,324,974[d]

All Incinerators		# of units requiring additional control	Cost (2008$)[f] Total Capital Investment ($)	Cost (2008$)[f] Total Annualized Cost ($/yr)	Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
					Baseline Emissions and Incremental Emission Reductions (tons/year)												
Baseline Emissions			-	-	2.84	29144	125.58	6.1126	3.1294	7685.9	1158.05	720.36	3212.9	0.000102	0.0000081	-	-
MACT Floor Total Cost and Emission Reductions[a]		92	$218,460,981	$72,640,812	1.41	0	93.04	2.6291	0.0894	4.3051	318.90	206.09	2192.2	0.000079	0.0000065	2,818.7	$25,771
BTF Costs and Emission Reductions by Control	Fabric Filter	152	$511,037,506	$123,656,941	1.16	0	0	2.9093	0	0	614.00	372.00	0	0	0	990.1	$124,897
	Afterburner Retrofit	180	$177,047,010	$53,578,242	0	25691	0	0	0	0	0	0	0	0	0	25,691	$2,086
	Packed Bed Scrubber	194	$307,298,429	$65,718,399	0	0	20.61	0	0	0	0	0	713.5	0	0	734.1	$89,525
	Activated Carbon Injection	161	$6,230,844	$32,335,212	0	0	0	0	2.6310	0	0	0	0	0.000021	0.0000015	2.631	$12,290,076[e]

a. The number of Fluidized Bed units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 41 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 7 units; and ACI, 51 units.
The number of Multiple Hearth units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 25 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 11 units; and ACI, 2 units.
The total number of SSIs requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 66 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 18 units; and ACI, 53 units.

b. Emission reductions of zero are an artifact of the methodology used to conservatively estimate reductions, which was kept consistent for all pollutant controls. For other pollutants, reductions resulted from the installation of controls where improvement was needed in order to meet the proposed limit. For any case where the unit already met a pollutant limit, that MACT pollutant concentration was set equal to the baseline, based on the assumption that the unit would be able to at least achieve the limit. For CO, all FB units already met the limit, yielding a calculated reduction of zero for each unit.

c. Although no additional ACI is required for beyond-the-floor control for FB units (hence no incremental cost), small reductions are calculated because for the BTF scenario, the maximum control efficiency (98%) was assumed. For the MACT floor scenario, only the percent reduction required to meet the floor limits were incorporated as the control efficiencies.

d. The cost-effectiveness of ACI control for MH units is equivalent to $6,160 per pound of Hg reduced.

e. The cost-effectiveness of ACI control for all units is equivalent to $6,150 per pound of Hg reduced.

f. Costs were annualized using a discount rate of 7 percent

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Table 3-3. Emissions Reductions and Costs If Small Entities Landfill

Fluidized Bed Incinerators		# of units requiring additional control	Cost (2008$)[a] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
					Baseline Emissions and Incremental Emission Reductions (tons/year)[b]												
Baseline Emissions			-	-	0.01032	119.6	2.99	0.0531	0.0758	327.4	56.60	54.22	134.1	0.000082	0.0000068	-	-
MACT Floor Total Cost and Emission Reductions[c]		46	$69,952,757	$26,163,050	0.00282	18.89	1.81	0.0147	0.0612	53.05	43.47	41.23	76.8	0.000080	0.0000065	235.3	$111,194
Additional Costs and Emission Reductions by Control	Fabric Filter	13	$30,642,201	$7,926,815	0.00524	0	0	0.0271	0	0	0.00	0.00	0	0	0	0.032	$245,034,357
	Afterburner Retrofit[d]	43	$26,571,102	$8,659,394	0	0	0	0	0	0	0	0	0	0	0	0.000	-
	Packed Bed Scrubber	39	$41,683,343	$9,277,850	0	0	0.80	0	0	0	0	0	40.6	0	0	41.437	$223,903
	Activated Carbon Injection[e]	0	$0	$0	0	0	0	0	0.0060	0	0	0	0	0.000001	0.0000001	0.006	$0

Multiple Hearth Incinerators		# of units requiring additional control	Cost (2008$)[a] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
					Baseline Emissions and Incremental Emission Reductions (tons/year)[b]												
Baseline Emissions			-	-	2.82779	29024.5	122.59	6.0595	3.0536	7358.5	1101.46	666.13	3078.8	0.000020	0.0000013	-	-
MACT Floor Total Cost and Emission Reductions[c]		38	$125,327,287	$33,647,893	1.54590	3080.16	94.72	2.9497	0.3536	793.81	348.85	210.41	2221.0	0.000002	0.0000001	6,753.8	$4,982
Additional Costs and Emission Reductions by Control	Fabric Filter	127	$440,670,924	$105,196,529	1.04710	0	0	2.6084	0	0	469.00	284.00	0	0	0	756.655	$139,028
	Afterburner Retrofit	122	$137,648,283	$40,428,804	0	22971.28	0	0	0	0	0	0	0	0	0	22,971.284	$1,760
	Packed Bed Scrubber	137	$237,426,572	$50,085,972	0	0	17.62	0	0	0	0	0	601.5	0	0	619.149	$80,895
	Activated Carbon Injection	149	$5,744,514	$28,913,350	0	0	0	0	2.3440	0	0	0	0	0.000017	0.0000012	2.344	$12,334,707[f]

All Incinerators		# of units requiring additional control	Cost (2008$)[a] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
					Baseline Emissions and Incremental Emission Reductions (tons/year)[b]												
Baseline Emissions			-	-	2.83811	29144.0	125.58	6.1126	3.1294	7685.9	1158.05	720.36	3212.9	0.000102	0.0000081	-	-
MACT Floor Total Cost and Emission Reductions[c]		84	$195,280,044	$59,810,943	1.54872	3099.05	96.53	2.9644	0.4147	846.86	392.32	251.64	2297.8	0.000082	0.0000067	6,989.1	$8,558
Additional Costs and Emission Reductions by Control	Fabric Filter	140	$471,313,125	$113,123,344	1.05234	0	0	2.6355	0	0	469.00	284.00	0	0	0	756.688	$149,498
	Afterburner Retrofit	165	$164,219,385	$49,088,198	0	22971.28	0	0	0	0	0	0	0	0	0	22,971.284	$2,137
	Packed Bed Scrubber	176	$279,109,916	$59,363,822	0	0	18.43	0	0	0	0	0	642.2	0	0	660.586	$89,865
	Activated Carbon Injection	149	$5,744,514	$28,913,350	0	0	0	0	2.3500	0	0	0	0	0.000019	0.0000013	2.350	$12,303,406[g]

a. Costs were annualized using a discount rate of 7 percent.
b. Emissions from landfilling activities are not included in this table.
c. The number of Fluidized Bed units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 33 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 5 units; and ACI, 46 units.
   The number of Multiple Hearth units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 24 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 10 units; and ACI, 2 units.
   The total number of SSIs requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 57 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 15 units; and ACI, 48 units.
d. Emission reductions of zero are an artifact of the methodology used to conservatively estimate reductions, which was kept consistent for all pollutant controls. For other pollutants, reductions resulted from the installation of controls where improvement was needed in order to meet the proposed limit. For any case where the unit already met a pollutant limit, that MACT pollutant concentration was set equal to the baseline, based on the assumption that the unit would be able to at least achieve the limit. For CO, all FB units already met the limit, yielding a calculated reduction of zero for each unit.
e. Although no additional ACI is required for beyond-the-floor control for FB units (hence no incremental cost), small reductions are calculated because for the BTF scenario, the maximum control efficiency (98%) was assumed. For the MACT floor scenario, only the percent reduction required to meet the floor limits were incorporated as the control efficiencies.
f. The cost-effectiveness of ACI control for MH units is equivalent to $6,170 per pound of Hg reduced.
g. The cost-effectiveness of ACI control for all units is equivalent to $6,150 per pound of Hg reduced.

Table 3-4. Emissions Reductions and Costs If All Units Comply – Per Unit Basis

Fluidized Bed Incinerators		# of units requiring additional control	Cost (2008$)[b] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year) Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
Baseline Emissions			-	-	0.0002	2.2	0.05	0.0010	0.0014	6.0	1.03	0.99	2.4	0.000001	0.0000001	-	-
MACT Floor Total Cost and Emission Reductions[a]		51	$1,699,927	$633,602	0.0000	0	0.03	0.0001	0.0011	0	0.80	0.76	1.2	0.000002	0.0000001	2.8	$228,934
BTF Costs and Emission Reductions by Control	Fabric Filter	14	$2,333,114	$600,151	0.0005	0	0	0.0024	0	0	0.00	0.00	0	0	0	0.003	$205,482,746
	Afterburner Retrofit	52	$606,401	$199,698	0	0	0	0	0	0	0	0	0	0	0	0.000	-
	Packed Bed Scrubber	46	$1,058,738	$235,975	0	0	0.02	0	0	0	0	0	1.2	0	0	1.201	$196,505
	Activated Carbon Injection	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Multiple Hearth Incinerators		# of units requiring additional control	Cost (2008$)[b] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year) Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
Baseline Emissions			-	-	0.02	178	0.75	0.0372	0.0187	45.1	6.76	4.09	18.9	0.000000	0.0000000	-	-
MACT Floor Total Cost and Emission Reductions[a]		41	$3,213,773	$983,588	0.03	0	2.23	0.0640	0.0008	0.105	6.78	4.08	52.0	0.000000	0.0000000	65.3	$15,061
Additional Costs and Emission Reductions by Control	Fabric Filter	138	$3,466,478	$835,180	0.01	0	0	0.0208	0	0	4.45	2.70	0	0	0	7.2	$116,416
	Afterburner Retrofit	128	$1,136,829	$337,453	0	201	0	0	0	0	0	0	0	0	0	201	$1,681
	Packed Bed Scrubber	148	$1,747,274	$370,700	0	0	0.13	0	0	0	0	0	4.5	0	0	4.6	$80,820
	Activated Carbon Injection	161	$38,701	$200,840	0	0	0	0	0.0163	0	0	0	0	0.000000	0.0000000	0.016	$12,324,974

All Incinerators		# of units requiring additional control	Cost (2008$)[b] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year) Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
Baseline Emissions			-	-	0.02	180	0.81	0.0381	0.0201	51.1	7.79	5.07	21.3	0.000002	0.0000001	-	-
MACT Floor Total Cost and Emission Reductions[a]		92	$4,913,700	$1,617,190	0.03	0	2.26	0.0641	0.0019	0.105	7.58	4.84	53.2	0.000002	0.0000001	30.6	$52,784
Additional Costs and Emission Reductions by Control	Fabric Filter	152	$5,799,591	$1,435,331	0.01	0	0	0.0233	0	0	4.45	2.70	0	0	0	6.5	$220,359
	Afterburner Retrofit	180	$1,743,231	$537,150	0	201	0	0	0	0	0	0	0	0	0	143	$3,763
	Packed Bed Scrubber	194	$2,806,011	$606,675	0	0	0.15	0	0	0	0	0	5.6	0	0	3.8	$160,330
	Activated Carbon Injection	161	$38,701	$200,840	0	0	0	0	0.0163	0	0	0	0	0.000000	0.0000000	0.016	$12,290,076

a. The number of Fluidized Bed units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 41 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 7 units; and ACI, 51 units.
The number of Multiple Hearth units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 25 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 11 units; and ACI, 2 units.
The total number of SSIs requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 66 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 18 units; and ACI, 53 units.

b. Costs were annualized using a discount rate of 7 percent.

Table 3-5. Emissions Reductions and Costs If Small Entities Landfill – Per Unit Basis

Fluidized Bed Incinerators		# of units requiring additional control	Cost (2008$)[a] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year)[b] Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
Baseline Emissions			-	-	0.00019	2.2	0.05	0.0010	0.0014	6.0	1.03	0.99	2.4	0.000001	0.0000001	-	-
MACT Floor Total Cost and Emission Reductions[c]		46	$1,520,712	$568,762	0.00006	0.41	0.04	0.0003	0.0013	1.15	0.95	0.90	1.7	0.000002	0.0000001	5.1	$111,194
Additional Costs and Emission Reductions by Control	Fabric Filter	13	$2,357,092	$609,755	0.00040	0	0	0.0021	0	0	0.00	0.00	0	0	0	0.002	$245,034,357
	Afterburner Retrofit[d]	43	$617,933	$201,381	0	0	0	0	0	0	0	0	0	0	0	0.000	-
	Packed Bed Scrubber	39	$1,068,804	$237,894	0	0	0.02	0	0	0	0	0	1.0	0	0	1.062	$223,903
	Activated Carbon Injection[e]	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Multiple Hearth Incinerators		# of units requiring additional control	Cost (2008$)[a] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year)[b] Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
Baseline Emissions			-	-	0.01735	178.1	0.75	0.0372	0.0187	45.1	6.76	4.09	18.9	0.000000	0.0000000	-	-
MACT Floor Total Cost and Emission Reductions[c]		38	$3,298,086	$885,471	0.04068	81.06	2.49	0.0776	0.0093	20.89	9.18	5.54	58.4	0.000000	0.0000000	177.7	$4,982
Additional Costs and Emission Reductions by Control	Fabric Filter	127	$3,469,850	$828,319	0.00824	0	0	0.0205	0	0	3.69	2.24	0	0	0	5.958	$139,028
	Afterburner Retrofit	122	$1,128,265	$331,384	0	188.2892	0	0	0	0	0	0	0	0	0	188.289	$1,760
	Packed Bed Scrubber	137	$1,733,041	$365,591	0	0	0.13	0	0	0	0	0	4.4	0	0	4.519	$80,895
	Activated Carbon Injection	149	$38,554	$194,049	0	0	0	0	0.0157	0	0	0	0	0.000000	0.0000000	0.016	$12,334,707

All Incinerators		# of units requiring additional control	Cost (2008$)[a] Total Capital Investment ($)	Total Annualized Cost ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year)[b] Cd	CO	HCl	Pb	Hg	NOx	PM Filt	PM 2.5	SO2	D/F Total	D/F TEQ	Total Emission Reductions (tons/yr)	Incremental Cost-effectiveness ($/ton)
Baseline Emissions			-	-	0.01754	180.2	0.81	0.0381	0.0201	51.1	7.79	5.07	21.3	0.000002	0.0000001	-	-
MACT Floor Total Cost and Emission Reductions[c]		84	$4,818,799	$1,454,233	0.04074	81.47	2.53	0.0779	0.0106	22.04	10.13	6.43	60.1	0.000002	0.0000001	182.8	$7,953
Additional Costs and Emission Reductions by Control	Fabric Filter	140	$5,826,942	$1,438,074	0.00865	0	0	0.0226	0	0	3.69	2.24	0	0	0	5.960	$241,271
	Afterburner Retrofit	165	$1,746,197	$532,765	0	188.2892	0	0	0	0	0	0	0	0	0	188.289	$2,830
	Packed Bed Scrubber	176	$2,801,844	$603,485	0	0	0.15	0	0	0	0	0	5.4	0	0	5.582	$108,116
	Activated Carbon Injection	149	$38,554	$194,049	0	0	0	0	0.0157	0	0	0	0	0.000000	0.0000000	0.016	$12,334,707

a. Costs were annualized using a discount rate of 7 percent.
b. Emissions from landfilling activities are not included in this table.
c. The number of Fluidized Bed units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 33 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 5 units; and ACI, 46 units.
   The number of Multiple Hearth units requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 24 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 10 units; and ACI, 2 units.
   The total number of SSIs requiring some sort of control to meet the MACT floors can be broken down as follows: Fabric Filter, 57 units; Afterburner Retrofit, 0 units; Packed Bed Scrubber, 15 units; and ACI, 48 units.
d. Emission reductions of zero are an artifact of the methodology used to conservatively estimate reductions, which was kept consistent for all pollutant controls. For other pollutants, reductions resulted from the installation of controls where improvement was needed in order to meet the proposed limit. For any case where the unit already met a pollutant limit, that MACT pollutant concentration was set equal to the baseline, based on the assumption that the unit would be able to at least achieve the limit. For CO, all FB units already met the limit, yielding a calculated reduction of zero for each unit.
e. Although no additional ACI is required for beyond-the-floor control for FB units (hence no incremental cost), small reductions are calculated because for the BTF scenario, the maximum control efficiency (98%) was assumed. For the MACT floor scenario, only the percent reduction required to meet the floor limits were incorporated as the control efficiencies.

Table 3-6. Emissions Reductions and Costs If All Units Comply[a]

Option		Cost (2008$)		Baseline Emissions and Incremental Emission Reductions (tons/year)											Total Emission Reductions of 129 Pollutants
		Total Capital Investment ($million)	Total Annualized Cost ($million/yr)	Cd	CO	HCl	Pb	Hg	NO_x	PM Filt	$PM_{2.5}$	SO_2	D/F Total	D/F TEQ	
Baseline Emissions		—	—	2.84	29,100	126	6.11	3.13	7,700	1,160	720	3,210	0.000102	0.0000081	—
Costs and Emission Reductions	Option 1 (MACT Floor)	$220	$73	1.41	0	93.0	2.63	0.09	4.31	319	206	2,190	0.000079	0.0000065	2,819
	Option 2 (MACT Floor + Activated carbon injection for MH units)	$225	$105	1.41	0	93.0	2.63	2.71	4.31	319	206	2,190	0.000098	0.0000078	2,821
	Option 3 (Option 2 + Afterburners for MH Units)	$370	$148	1.41	25,700	93.0	2.63	2.71	4.31	319	206	2,190	0.000098	0.0000078	28,500

Table 3-7. Emissions Reductions and Costs If Large Entities Comply and Small Entities Landfill[a]

Option		Cost (2008$)		Baseline Emissions and Incremental Emission Reductions (tons/year)											Total Emission Reductions of 129 Pollutants
		Total Capital Investment ($million)	Total Annualized Cost ($million/yr)	Cd	CO	HCl	Pb	Hg	NO_x	PM Filt	$PM_{2.5}$	SO_2	D/F Total	D/F TEQ	
Baseline Emissions		—	—	2.84	29,100	126	6.11	3.13	7,700	1,160	720	3,210	0.000102	0.0000081	—
Costs and Emission Reductions	Option 1 (MACT Floor)	$195	$59.8	1.55	2,850	96.2	2.96	0.41	823	390	251	2,300	0.000082	0.0000067	6,714
	Option 2 (MACT Floor + Activated carbon injection for MH units)	$201	$89	1.55	2,850	96.2	2.96	2.76	823	390	251	2,300	0.000099	0.0000078	6,717
	Option 3 (Option 2 + Afterburner for MH Units)	$338	$129	1.55	25,800	96.2	2.96	2.76	823	390	251	2,300	0.000099	0.0000078	29,690

[a]Annualized costs were calculated using a discount rate of 7 percent.

3.3 Estimation of Impacts for New Units Constructed within 5 Years After Promulgation of the SSI NSPS

3.3.1 Estimation of New Sources

Several significant changes have occurred to SSI units in the past 20 years. EPA's Office of Water (OW) set emission and discharge standards for sewage sludge disposal methods (including incineration) in 1993 (40 CFR part 503). As a result of the CWA part 503 Rule, many wastewater treatment facilities chose to use alternative methods for disposing of sewage sludge, such as landfilling or land application, rather than try to meet the incineration requirements. Many of the closed incinerators had been operated by municipalities or agencies serving smaller populations (i.e., fewer than 50,000 people) (Summary of Telephone Contacts, 2010).

The general trend has also been for facilities still incinerating sewage sludge to replace older MH units with newer FB units because of better emissions performance, savings in fuel cost, and flexibility in operation. Since 1988, over 40 new FB systems have been installed, with 11 replacing existing MH units (Dangtran, Mullen, and Mayrose, 2000). Discussions with the National Association of Clean Water Agencies (NACWA), the industry trade group, indicated that only FB units are likely to be constructed in the future (U.S. EPA, 2009b). Consequently, it was assumed that any new units that would be built after promulgation of the NSPS would be a FB design.

To estimate the number of new sources that might be constructed in the 5 years following promulgation of the NSPS, the number of sources being constructed 5 years prior to proposal of the rule was reviewed to determine if there was a trend. Under EPA's New Source Review (NSR) program, if a company is planning to build a new plant or modify an existing plant such that air pollution emissions will increase by a large amount, then the company must obtain an NSR permit. The NSR permit is a construction permit that requires the company to minimize air pollution emissions by changing the process to prevent air pollution and/or installing air pollution control equipment. The NSR program defines control levels based on the type of program the source is subject to: reasonably available control technology (RACT), best available control technology (BACT), or lowest achievable emissions reduction (LAER). Information from the EPA's RACT/BACT/LAER database contains case-specific information on the "best available" air pollution technologies that have been required to reduce the emission of air pollutants from stationary sources. This information has been provided by state and local permitting agencies. The database was searched for SSI units permitted or constructed since 2005. The search results showed two FB units at the R.L. Sutton Water Reclamation facility in Georgia were permitted in 2005, and completed construction in 2008 and are currently in operation. Additional information collected from state environmental agencies and permits indicated an additional three units at the Mill Creek Wastewater Treatment Plant in Ohio were expected to finish construction and be in operation in 2010 (Oommen and Allen, 2010a). All of these new FB units were replacements for MH units.

Based on the data collected and assuming the trend in construction continues, five additional FB units will be permitted to be constructed in 5 years after the NSPS is proposed. However, given the time necessary to review and assess the requirements of the NSPS and plan, permit, and construct incineration units, it is unlikely that all five would be in operation in the 5 years. For this analysis, it was assumed at least two new FB units would be constructed and in operation in this time period.

3.3.2 Methodology Used to Estimate Cost and Emission Reductions of the MACT Floor Level of Control

Cost and emission reductions for new units complying with the NSPS were calculated by (1) determining the controls that these units would most likely apply if the NSPS were not in place (referred to as the baseline level of control), (2) calculating the cost of complying with the NSPS emission levels, and (3) estimating the emissions reduction from complying with the NSPS emissions levels. Each of these steps is discussed in more detail.

3.3.2.1 Determining Baseline Controls

The baseline level of control that new units would likely implement (in the absence of the NSPS) was determined from reviewing the most common controls used at existing FB units, as shown in the SSI inventory memorandum (Inventory Database, 2010). Table 3-8 shows the distribution of controls. Based on this information, the baseline controls assumed for the new units are a combination of venturi scrubbers and impingement scrubbers. Data gathered on the controls currently used at FB units indicate that few FB units operate an afterburner, because their CO emissions are already low. However, to meet the new source floor limit, the analysis costs out an afterburner to reach the limit. In reality, new FB units that are constructed are likely to be designed to meet the CO level. Costing an afterburner provides a conservative estimate of costs.

3.3.2.2 Calculating Baseline Emissions

The SSI baseline emissions memorandum (Estimation of Baseline Emissions, 2010) documents the calculation of baseline emissions from existing FB SSI units. Baseline emissions were calculated on a mass basis by multiplying the concentration of the pollutant in the emission stream, flow rate of the emission stream, and the hours of operation of the SSI unit. For units

Table 3-8. Control Device Distribution for Fluidized Bed Incinerators[a]

Existing Control Devices	Number of Units	Percent
Distribution of Individual Controls		
Venturi scrubber (vs, vs(ad))	49	89
Impingement scrubber (imp)	38	69
Wet ESP (wesp)	14	25
Cyclone separator (cs)	4	7
Activated carbon (ac inject or ac polish)	4	7
Afterburner (abo or abd)	4	7
Packed bed scrubber (ccpt, pbs, pbt)	2	4
Distribution of Control Combinations		
abd – mc – vs – imp	2	3.64
abd – vs – imp – hss – cs	1	1.82
abo – imp – wesp	1	1.82
ac inject. – vs(ad) – wesp	3	5.45
ccpt	1	1.82
cs – vs – pbt	2	3.64
unknown	4	7.27
vs	5	9.09
vs – cs	1	1.82
vs – imp	25	45.45
vs – imp – wesp	8	14.55
vs – imp – wesp – ac polish.	1	1.82
vs(ad) – wesp	1	1.82
Total	55	100.00

[a] Dominak, Robert, Co−Chair NACWA Biosolids Management Committee, e-mail to Amy Hambrick, U.S. EPA. August 5, 2009. "SSI Inventory Updated Information."

where no emissions test data were collected, baseline emissions were estimated using an average uncontrolled concentration and applying reduction efficiencies associated with the control devices located at each SSI unit for each pollutant.

An average flue gas flow rate factor was also developed for FB units relating the flue gas flow rate to the dry sludge feed rate from units providing emission test data. For units where sludge feed rates were not collected, unit capacities were multiplied by a capacity utilization factor of 75%, which was the median of the capacity utilizations reported in the ICR survey responses. More information about how unit capacity values were obtained can be found in the SSI inventory database memorandum (Inventory Database, 2010). The flow rate of the flue gas stream was calculated by multiplying the dry sludge feed rate by the average flue gas flow rate factor.

Based on the information gathered from RACT/BACT/LAER and permits, it is likely that new FB units constructed will be replacements for existing units. However, it cannot be determined how many units will be replaced at a facility or the total number of units that will be in operation at a facility. For this analysis, the simplest and most conservative assumption was used—that only one FB unit would be constructed replacing one older MH unit. The operating hours for facilities operating one unit were assumed to be 8,400 hours per year (incorporating two weeks' downtime).

Table 3-9 shows the average concentration factors, average dry sludge capacity, and operating hours, as well as other default parameters necessary for the costs. These factors were applied to each new unit estimated to be constructed within the next 5 years. Table 3-10 shows the estimated baseline concentrations for new units.

Calculating Costs and Emission Reductions

Costs were calculated using the procedures and algorithms discussed in the memorandum "Cost and Emissions Reduction of Complying with the MACT Floor for Existing SSI Units" (Oommen and Allen, 2010b). Control devices costed out were those that would be necessary to meet the MACT floor level of control for new sources. It is possible for some units with wet scrubbers to comply with the NSPS limits for SO_2 by adding caustic. However, it is uncertain if all units could do this. Therefore, this analysis assumed a PBS would be used, which would provide a more conservative estimate of costs. Similarly, wet electrostatic precipitators can be used for PM control; a FF was costed in this analysis to provide a conservative estimate of costs.

Table 3-11 shows the comparison of baseline emissions levels to MACT floor levels to determine the amount of pollutant reduction needed and the types of control devices that would be used to meet the levels. Emission reductions from applying the MACT floor requirements to the baseline emission levels are presented in Table 3-10. The inputs to the cost algorithm are presented in Table 3-9. For this analysis, it was assumed that controls applicable for PM would also reduce $PM_{2.5}$.

Table 3-9. Cost and Emission Reduction Calculation Inputs

Parameter	Default (Average of known data for FB subcategory)
Capacity (dtph)	2.26
Capacity (dry lb/hr)	4,516.36
Sludge feed rate (dry tons/hr)	1.69
Sludge feed rate (dry lb/hr)	3,387.27
Operating hours (hr/yr)[a]	8,400
Stack gas flow rate (dscfm)	9,239.97
Stack gas temperature (°F)[b]	1,050
ACI adjustment factor[c]	1.03
Sludge heating value (BTU/lb)[d]	7740
NO_X, lb/MMBTU	0.07
PM (gr/dscf)	0.0054
HCl (ppmvd)	0.124

[a] Conservatively assumed new unit would operate 350 days per year (2 weeks' downtime).

[b] Assumed average gas temperature used for commercial and industrial solid waste incinerators (CISWI).

[c] ACI algorithm is based on 90% Hg reduction efficiency and 98% CDD/CDF reduction efficiency. This adjustment factor will be used to adjust total annual costs to the estimated reduction efficiency needed to meet the floor.

[d] Converted to BTU/lb from 18 MJ/kg dried, undigested sludge (http://www.aseanenvironment.info/Abstract/41015799.pdf).

Table 3-10. Summary of Emission Reductions for New SSI Units

Pollutant	Concentration Units	Additional Control Needed for MACT	Baseline Concentration	NSPS Limit	MACT Emission Concentration	Emission Reduction (concentration)	Emission Reduction (tpy)	Annual Emission Reductions: Year 5 (Assuming 2 new units come online in 5 years)
Cadmium (Cd)	mg/dscm	Add FF	0.002	0.00051	0.00051	0.002	2.36E-04	4.73E-04
Carbon monoxide (CO)	ppmvd	Add ABD	16.331	7.4	7.4	8.931	1.51E+00	3.02E+00
Hydrogen chloride (HCl)	ppmvd	none[a]	0.124	0.13	0.050	0.074	1.64E-02	3.27E-02
Lead (Pb)	mg/dscm	Add FF	0.011	0.00053	0.00053	0.011	1.53E-03	3.06E-03
Mercury (Hg)	mg/dscm	Add ACI	0.014	0.001	0.001	0.013	1.82E-03	3.64E-03
Nitrogen oxides (NO_x)	ppmvd	none[b]	27.926	26	26	1.926	5.35E-01	1.07E+00
Particulate matter (filterable)	mg/dscm	Add FF	12.443	4.1	4.1	8.343	1.21E+00	2.43E+00
Particulate matter ($PM_{2.5}$)	mg/dscm	Add FF	11.801	2.3	2.3	9.501	1.38E+00	2.76E+00
Sulfur dioxide (SO_2)	ppmvd	Add PBS	3.303	2.0	2.0	1.303	5.04E-01	1.01E+00
Total dioxin/furans	ng/dscm	Add ACI	15.962	0.94	0.94	15.022	2.18E-06	4.37E-06
Total dioxin/furans (TEQ)	ng/dscm	Add ACI	1.312	0.023	0.023	1.289	1.87E-07	3.75E-07

[a] Assumed scrubber (installed for SO_2 control) has 98% efficiency for HCl control.

[b] Assumed units could meet limit by making minor adjustments rather than installing add-on control.

Table 3-11 shows the estimated total capital investment (TCI) and total annual costs (TAC) calculated for a single unit using the cost algorithms previously discussed. The table also shows the monitoring, testing, reporting, and recordkeeping costs. The table shows the TCI and TAC for the two new FB units that are assumed to be constructed and in operation in the 5 years after proposal of the NSPS.

Table 3-11. MACT Costs Associated with Model FB Unit

	Parameter	TCI	TAC
Controls	Add FF	$1,995,892	$580,670
	Add PBS	$1,013,167	$233,832
	Add ACI	$25,786	$163,338
	Add ABD	$625,106	$233,589
	Subtotal:	**$3,659,952**	**$1,211,429**
Monitoring, Testing, Reporting and Recordkeeping	Initial Stack Test	$61,000	
	Annual Stack Test		$61,000
	Bag Leak Detection System	$25,500	$9,700
	Wet Scrubber Monitoring	$24,300	$5,600
	ACI Monitoring	$0	$9,800
	Annual Control Device Inspection		$1,000
	CO CEMS	$134,000	$41,400
	Annual Visual Emissions Test of Ash Handling	$250	$740
	Reporting and Recordkeeping		$2,989
	Subtotal:	**$245,050**	**$132,229**
TOTAL:		**$3,905,002**	**$1,343,657**

3.3.3 Analysis of Beyond the Floor Options

The control technologies costed to achieve the MACT floor levels are generally the most effective controls available: FFs for PM, Cd, Pb; ACI for Hg and CDD/CDF; afterburners for CO; and PBSs for HCl and SO_2. In addition, incremental additions of activated carbon have not been proven to achieve further reductions above the projected flue gas concentration estimated to achieve the limits for new sources. Data gathered do not indicate that any FB units operate NO_x controls, such as SNCR, SCR, or flue gas recirculation because the NO_x emissions are already low. Therefore, no BTF options were analyzed for this analysis because we are not aware of any technologies or methods to achieve emission limits more stringent than the MACT floor limits for new units, which are based on the lowest emitting FB units.

SECTION 4
ECONOMIC IMPACT ANALYSIS

EPA has prepared an EIA to provide decision makers with a measure of the social costs of using resources to comply with the proposed greenhouse gas (GHG) reporting requirements. As noted in EPA's (2000) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus). Because the proposed regulatory option affects governmental entities (96 of the 97 owners are governmental entities) providing services not provided in a market, the Office of Air Quality Planning and Standards (OAQPS) has used the direct compliance cost method as a measure of social costs. Since no market impacts are anticipated, the economic analysis focused on the comparison of control cost to total governmental revenue.

The EIA evaluates three options discussed in Section 3:

- Option 1 is the MACT floor level of control for the two subcategories developed for existing SSI units, MH units and FB units.
- Option 2 is the same as Option 1, with the addition of activated carbon injection for additional Hg emissions reduction from MH units.
- Option 3 is the same as Option 2, with the addition of an afterburner on all MH units for additional CO emissions reduction.

Within each option, EPA presents the results of the cost analysis using two assumptions:

- Large government entities comply and incinerate while small government entities choose to landfill. EPA anticipates this is the *most likely* response to the regulation based on analysis of landfilling costs and interviews with a sample of small government entities.
- All government entities (small and large) comply and incinerate. EPA anticipates this assumption significantly overstates the rule's costs because it assumes small entities do not consider other disposal options.

4.1 Social Cost Estimates

EPA has estimated compliance costs for all existing units to add the necessary controls, monitoring equipment, inspections, and recordkeeping and reporting requirements to comply with the proposed SSI standards. Based on the engineering cost analysis, we anticipate the overall total annual social cost to be approximately $92 million. The lowest cost option is the MACT floor where large entities comply and small entities landfill ($63 million). The highest cost option is the MACT floor with afterburners and fabric filters for MH units and all entities comply ($151 million). All cost options are displayed in Table 4-1.

Table 4-1. Annual Social Cost Estimates by Option and Disposal Choices ($ million, 2008$)

	Large Entities Comply and Small Entities Landfill	All Units Comply
Existing Sources		
Option 1 (MACT Floor)	**$60**	$73
Option 2 (MACT Floor + Afterburner for MH Units)	**$89**	$105
Option 3 (Option 2 + Fabric Filters for MH Units)	**$129**	$148
New Sources (Fluidized Bed)[a]	**$3**	$3

[a] Two new FB units that are assumed to be constructed and in operation in the 5 years after proposal of the NSPS.

4.2 Small Entity Analysis

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a *significant* economic impact on a *substantial* number of small entities (SISNOSE). The first step in this assessment was to determine whether the rule will have SISNOSE. To make this determination, EPA used a screening analysis to indicate whether EPA can certify the rule as not having a SISNOSE. The elements of this analysis included

- identifying affected small entities,
- selecting and describing the measures and economic impact thresholds used in the analysis, and
- completing the assessment and determining the SISNOSE certification category.

4.2.1 *Identify Affected Small Entities*

For the purposes of assessing the impacts of the proposed rule on small entities, small entity is defined as (1) a small business as defined by the Small Business Administration's regulations at 13 CFR 121.20; (2) a small governmental jurisdiction that is a government of a city, county, town, school district, or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise that is independently owned and operated and is not dominant in its field. As reported in Section 2, EPA has identified 18 small entities that have a population of fewer than 50,000. There are no small businesses or organizations affected by the proposed rule.

4.2.2 *Screening Analysis: Revenue Test*

In the next step of the analysis, EPA compared each regulatory option's control costs to total government revenues (i.e., a "revenue" test). To estimate government revenues, we collected U.S. Census financial information for municipal governments by population ranges, computed average per capita revenues for each population range, and multiplied the per capita revenue figure by the population served by small and large government entities (Table 4-2).

Table 4-2. Calculated Municipal and Township Per Capita Revenues by Population Size

	Population Size			
	Fewer than 10K	**10 to 25K**	**25 to 50K**	**>50K**
Number of municipalities/townships	16,745	1,436	643	605
Population	28,750,200	22,588,957	22,576,240	100,966,557
Revenue (thousand 2002$)	34,944,647	32,010,988	31,630,676	238,846,095
Per capita (2002$)	$1,215	$1,417	$1,401	$2,366
Per capita (2008$)	$1,455	$1,696	$1,677	$2,831

Source: U.S. Census. 2005. Finances of Municipal and Township Governments: 2002. Table 13, accessed June 8, 2010 at http://www.census.gov/prod/2005pubs/gc024x4.pdf.

Each option's screening results under two disposal assumptions are presented in Tables 4-3 through Table 4-8. As noted above, EPA anticipates small government entities will most likely switch from incineration to landfilling (Tables 4-4, 4-6, and 4-8). EPA has also presented small entity results where small entities comply and incinerate (Tables 4-3, 4-5, and 4-7). However, EPA anticipates this assumption would significantly overstate the rule's small entity impacts because it assumes small entities continue to incinerate and do not consider other less expensive disposal options.

Based on the engineering cost analysis, EPA anticipates the overall total annualized cost for the selection option will be $92 million (Option 2: MACT floor with activated carbon injection for MH, large entities comply and small entities landfill); under this option and set of disposal choices, all small entities are affected at less than 1% revenues (Table 4-6).

For the lowest cost Option 1, the MACT floor where large entities comply and small entities landfill (total annualized costs = $63 million), all small entities are affected at less than 1% revenue (Table 4-4).

For the highest cost Option 3, the MACT floor with activated carbon injection and afterburners for MH units and small entities landfill (total annualized cost = $132 million). All small entities are still affected at less than 1% revenue (Table 4-8).

Table 4-3. Option 1 Revenue Tests for Government Entities: All Entities Comply

Sample Statistic	Small	Large
Cost-Revenue-Ratios		
Mean	1.1%	0.1%
Median	0.9%	0.1%
Minimum	0.1%	0.0%
Maximum	3.4%	1.0%
Number of Entities	18	69
Number of Entities > 1%	9	0
Number of Entities > 3%	2	0

Table 4-4. Option 1 Revenue Tests for Government Entities: Large Entities Comply and Small Entities Landfill

Sample Statistic	Small	Large
Cost-Revenue-Ratios		
Mean	−0.6%	0.1%
Median	−0.2%	0.1%
Minimum	−2.6%	0.0%
Maximum	0.7%	1.0%
Number of Entities	18	69
Number of Entities > 1%	0	0
Number of Entities > 3%	0	0

Table 4-5. Option 2 Revenue Tests for Government Entities: All Entities Comply

Sample Statistic	Small	Large
Cost-Revenue-Ratios		
Mean	1.6%	0.2%
Median	1.2%	0.1%
Minimum	0.5%	0.0%
Maximum	4.4%	1.2%
Number of Entities	18	69
Number of Entities > 1%	13	2
Number of Entities > 3%	2	0

Table 4-6. Option 2 Revenue Tests for Government Entities: Large Entities Comply and Small Entities Landfill

Sample Statistic	Small	Large
Cost-Revenue-Ratios		
Mean	−0.6%	0.2%
Median	−0.2%	0.1%
Minimum	−2.6%	0.0%
Maximum	0.7%	1.2%
Number of Entities	18	69
Number of Entities > 1%	0	2
Number of Entities > 3%	0	0

Table 4-7. Option 3 Revenue Tests for Government Entities: All Entities Comply

Sample Statistic	Small	Large
Cost-Revenue-Ratios		
Mean	1.9%	0.3%
Median	1.3%	0.2%
Minimum	0.6%	0.0%
Maximum	6.0%	1.2%
Number of Entities	18	69
Number of Entities > 1%	16	2
Number of Entities > 3%	3	0

Table 4-8. Option 3 Revenue Tests for Government Entities: Large Entities Comply and Small Entities Landfill

Sample Statistic	Small	Large
Cost-Revenue-Ratios		
Mean	−0.6%	0.3%
Median	−0.2%	0.2%
Minimum	−2.6%	0.0%
Maximum	0.7%	1.2%
Number of Entities	18	69
Number of Entities > 1%	0	2
Number of Entities > 3%	0	0

SECTION 5
HUMAN HEALTH BENEFITS OF EMISSIONS REDUCTIONS

5.1 Synopsis

In this section, we provide an estimate of the monetized benefits associated with reducing particulate matter (PM) for the proposed Sewage Sludge Incinerator (SSI) New Source Performance Standard (NSPS) and Emissions Guidelines (EG). For this rule, the PM reductions are the result of emission limits on PM, emission limits on $PM_{2.5}$ precursors such as NO_x and SO_2, as well as emission limits on other pollutants. The total $PM_{2.5}$ reductions are the consequence of the technologies installed or waste diversion to meet these multiple limits. These estimates reflect the monetized human health benefits of reducing cases of morbidity and premature mortality among populations exposed to the $PM_{2.5}$ precursors reduced by this rulemaking. Using a 3% discount rate, we estimate the total monetized benefits including energy disbenefits of the proposed SSI NSPS and EG to be $130 million to $320 million in the implementation year (2015). Using a 7% discount rate, we estimate the total monetized benefits including energy disbenefits of the proposed SSI NSPS and EG to be $120 million to $290 million in the implementation year. All estimates are in 2008$.

These estimates reflect EPA's most current interpretation of the scientific literature. Higher or lower estimates of benefits are possible using other assumptions; examples of this are provided in Figure 5-2. Data, resource, and methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including benefits from reducing hazardous air pollutants, ecosystem effects, and visibility impairment. The benefits from reducing other air pollutants have not been monetized in this analysis, including reducing 2,900 tons of CO, 96 tons of HCl, 3.0 tons of Pb, 1.6 tons of Cd, 5,500 pounds of mercury (Hg), and 90 grams of total dioxins/furans (CDD/CDF) each year.

5.2 Calculation of $PM_{2.5}$ Human Health Benefits

This rulemaking would reduce emissions of $PM_{2.5}$, SO_2, and NO_2. Because SO_x and NO_2 are also precursors to $PM_{2.5}$, reducing these emissions would also reduce $PM_{2.5}$ formation, human exposure, and the incidence of $PM_{2.5}$-related health effects. For this rule, the PM reductions are the result of emission limits on PM, emission limits on $PM_{2.5}$ precursors such as NO_x and SO_2, as well as emission limits on other pollutants. The total $PM_{2.5}$ reductions are the consequence of the technologies installed or waste diversion to meet these multiple limits. Due to analytical limitations, it was not possible to provide a comprehensive estimate of $PM_{2.5}$-related benefits. Instead, we used the "benefit-per-ton" approach to estimate these benefits based on the methodology described in Fann, Fulcher, and Hubbell (2009). The key assumptions are described in detail below. These $PM_{2.5}$ benefit-per-ton estimates provide the total monetized human health benefits (the sum of premature mortality and premature morbidity) of reducing one ton of $PM_{2.5}$ from a specified source. EPA has used the benefit per-ton technique in several previous RIAs, including the recent NO_2 NAAQS RIA (U.S. EPA, 2010b). Table 5-1 shows the quantified and unquantified benefits captured in those benefit-per-ton estimates.

Table 5-1. Human Health and Welfare Effects of $PM_{2.5}$

Pollutant / Effect	Quantified and Monetized in Primary Estimates	Unquantified Effects Changes in:
$PM_{2.5}$	Adult premature mortality Bronchitis: chronic and acute Hospital admissions: respiratory and cardiovascular Emergency room visits for asthma Nonfatal heart attacks (myocardial infarction) Lower and upper respiratory illness Minor restricted-activity days Work loss days Asthma exacerbations (asthmatic population) Infant mortality	Subchronic bronchitis cases Low birth weight Pulmonary function Chronic respiratory diseases other than chronic bronchitis Non-asthma respiratory emergency room visits Visibility Household soiling

Consistent with the Portland Cement NESHAP (U.S. EPA, 2009a), the $PM_{2.5}$ benefits estimates utilize the concentration-response functions as reported in the epidemiology literature, as well as the 12 functions obtained in EPA's expert elicitation study as a sensitivity analysis.

- One estimate is based on the concentration-response (C-R) function developed from the extended analysis of American Cancer Society (ACS) cohort, as reported in Pope et al. (2002), a study that EPA has previously used to generate its primary benefits estimate. When calculating the estimate, EPA applied the effect coefficient as reported in the study without an adjustment for assumed concentration threshold of 10 $\mu g/m^3$ as was done in recent (2006-2009) Office of Air and Radiation RIAs.

- One estimate is based on the C-R function developed from the extended analysis of the Harvard Six Cities cohort, as reported by Laden et al. (2006). This study, published after the completion of the Staff Paper for the 2006 $PM_{2.5}$ NAAQS, has been used as an alternative estimate in the $PM_{2.5}$ NAAQS RIA and $PM_{2.5}$ benefits estimates in RIAs completed since the $PM_{2.5}$ NAAQS. When calculating the estimate, EPA applied the effect coefficient as reported in the study without an adjustment for assumed concentration threshold of 10 $\mu g/m^3$ as was done in recent (2006-2009) RIAs.

- Twelve estimates are based on the C-R functions from EPA's expert elicitation study (IEc, 2006; Roman et al., 2008) on the $PM_{2.5}$ -mortality relationship and interpreted for benefits analysis in EPA's final RIA for the $PM_{2.5}$ NAAQS. For that study, twelve experts (labeled A through L) provided independent estimates of the $PM_{2.5}$ -mortality concentration-response function. EPA practice has been to develop independent estimates of $PM_{2.5}$ -mortality estimates corresponding to the concentration-response function provided by each of the twelve experts, to better characterize the degree of variability in the expert responses.

The effect coefficients are drawn from epidemiology studies examining two large population cohorts: the American Cancer Society cohort (Pope et al., 2002) and the Harvard Six Cities cohort (Laden et al., 2006).[1] These are logical choices for anchor points in our presentation because, while both studies are well designed and peer reviewed, there are strengths and weaknesses inherent in each, which we believe argues for using both studies to generate benefits estimates. Previously, EPA had calculated benefits based on these two empirical studies, but derived the range of benefits, including the minimum and maximum results, from an expert elicitation of the relationship between exposure to $PM_{2.5}$ and premature mortality (Roman et al., 2008).[2] Within this assessment, we include the benefits estimates derived from the concentration-response function provided by each of the twelve experts to better characterize the uncertainty in the concentration-response function for mortality and the degree of variability in the expert responses. Because the experts used these cohort studies to inform their concentration-response functions, benefits estimates using these functions generally fall between results using these epidemiology studies (see Figure 5-2). In general, the expert elicitation results support the conclusion that the benefits of $PM_{2.5}$ control are very likely to be substantial.

Readers interested in reviewing the general methodology for creating the benefit-per-ton estimates used in this analysis should consult Fann, Fulcher, and Hubbell (2009). As described in Fann, Fulcher, and Hubbell (2009), benefit-per-ton estimates are developed for selected pollutant/source category combinations. The per-ton values calculated therefore apply only to tons reduced from those specific pollutant/source combinations (e.g., SO_2 emitted from electric generating units; NO_2 emitted from mobile sources). In this analysis, we apply the national average benefit-per-ton estimate for a 2015 analysis year and multiply it by the corresponding emission reductions of directly emitted $PM_{2.5,}$ $SO_{2,}$ and NOx to quantify the benefits of this rule. The benefit-per-ton estimates found in Fann, Fulcher, and Hubbell (2009) reflect a specifc set of key assumptions and input data. As we update these underlying assumptions to reflect the

[1]These two studies specify multi-pollutant models that control for SO_2, among other pollutants.
[2]Please see the Section 5.2 of the Portland Cement proposal RIA in Appendix 5A for more information regarding the change in the presentation of benefits estimates.

scientific literature, we re-estimate the benefit-per-ton estimates and post the updated estimates at http://www.epa.gov/air/benmap/bpt.html. In addition, we adjust these estimates to match the currency year for the costs in this analysis.

These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because there is no clear scientific evidence that would support the development of differential effects estimates by particle type. Directly emitted PM, SO_2, and NOx are the primary $PM_{2.5}$ precursors affected by this rule. Even though we assume that all fine particles have equivalent health effects, the benefit-per-ton estimates vary between precursors because each ton of precursor reduced has a different propensity to form $PM_{2.5}$. For example, NO_X has a lower benefit-per-ton estimate than direct $PM_{2.5}$ because it does not form as much $PM_{2.5}$, thus the exposure would be lower, and the monetized health co-benefits would be lower.

The benefit-per-ton coefficients in this analysis were derived using modified versions of the health impact functions used in the PM NAAQS Regulatory Impact Analysis. Specifically, this analysis uses the benefit-per-ton method first applied in the Portland Cement NESHAP RIA (U.S. EPA, 2009a), which incorporated three updates: a new population dataset, an expanded geographic scope of the benefit-per-ton calculation, and the functions directly from the epidemiology studies without an adjustment for an assumed threshold.[3] Removing the threshold assumption is a key difference between the method used in this analysis of PM benefits and the methods used in RIAs prior to Portland Cement, and we now calculate incremental benefits down to the lowest modeled $PM_{2.5}$ air quality levels.

EPA strives to use the best available science to support our benefits analyses, and we recognize that interpretation of the science regarding air pollution and health is dynamic and evolving. Based on our review of the current body of scientific literature, EPA now estimates PM-related mortality without applying an assumed concentration threshold. EPA's Integrated Science Assessment for Particulate Matter (U.S. EPA, 2009b), which was recently reviewed by EPA's Clean Air Scientific Advisory Committee (U.S. EPA-SAB, 2009a; U.S. EPA-SAB, 2009b), concluded that the scientific literature consistently finds that a no-threshold log-linear model most adequately portrays the PM-mortality concentration-response relationship while recognizing potential uncertainty about the exact shape of the concentration-response function. Since then, the Health Effects Subcommittee (U.S. EPA-SAB, 2010) of EPA's Council

[3]The benefit-per-ton estimates have also been updated since the Cement RIA to incorporate a revised VSL, as discussed on the next page.

concluded, “The HES fully supports EPA’s decision to use a no-threshold model to estimate mortality reductions. This decision is supported by the data, which are quite consistent in showing effects down to the lowest measured levels. Analyses of cohorts using data from more recent years, during which time PM concentrations have fallen, continue to report strong associations with mortality. Therefore, there is no evidence to support a truncation of the CRF.” In conjunction with the underlying scientific literature, this document provided a basis for reconsidering the application of thresholds in $PM_{2.5}$ concentration-response functions used in EPA’s RIAs. For a summary of these scientific review statements and the panel members commenting on thresholds since 2002, please consult the Technical Support Document (TSD) Summary of Expert Opinions on the Existence of a Threshold (U.S. EPA, 2010c), which is provided as an appendix to this RIA.

Consistent with this recent scientific advice, we are replacing the previous threshold sensitivity analysis with a new “Lowest Measured Level” (LML) assessment. This information allows readers to determine the portion of population exposed to annual mean $PM_{2.5}$ levels at or above the LML of each study; in general, our confidence in the estimated PM mortality decreases as we consider air quality levels further below the LML in major cohort studies that estimate PM-related mortality. While an LML assessment provides some insight into the level of uncertainty in the estimated PM mortality benefits, EPA does not view the LML as a threshold and continues to quantify PM-related mortality impacts using a full range of modeled air quality concentrations. It is important to emphasize that we have high confidence in $PM_{2.5}$-related effects down to the lowest LML of the major cohort studies. Just because we have greater confidence in the benefits above the LML, this does not mean that we have no confidence that benefits occur below the LML.

For this analysis, policy-specific air quality data is not available due to time or resource limitations. For these rules, we are unable to estimate the percentage of premature mortality associated with this specific rule’s emission reductions at each $PM_{2.5}$ level. However, we believe that it is still important to characterize the distribution of exposure to baseline air quality levels. As a surrogate measure of mortality impacts, we provide the percentage of the population exposed at each $PM_{2.5}$ level using the most recent modeling available from the recently proposed Transport Rule (U.S. EPA, 2010e). It is important to note that baseline exposure is only one parameter in the health impact function, along with baseline incidence rates population, and change in air quality. In other words, the percentage of the population exposed to air pollution below the LML is not the same as the percentage of the population experiencing health impacts as a result of a specific emission reduction policy. The most important aspect, which we are unable to quantify for rules without air quality modeling, is the shift in exposure associated with this specific rule. Therefore, caution is warranted when interpreting the LML assessment. For more information on the data and conclusions in the LML assessment for rules without policy-specific air quality modeling, please consult the LML TSD (U.S. EPA, 2010d), which is provided as an appendix to this RIA. The results of this analysis are provided in Section 5.4.

As is the nature of Regulatory Impact Analyses (RIAs), the assumptions and methods used to estimate air quality benefits evolve over time to reflect the Agency's most current interpretation of the scientific and economic literature. For a period of time (2004–2008), the Office of Air and Radiation (OAR) valued mortality risk reductions using a value of statistical life (VSL) estimate derived from a limited analysis of some of the available studies. OAR arrived at a VSL using a range of $1 million to $10 million (2000$) consistent with two meta-analyses of the wage-risk literature. The $1 million value represented the lower end of the interquartile range from the Mrozek and Taylor (2002) meta-analysis of 33 studies. The $10 million value represented the upper end of the interquartile range from the Viscusi and Aldy (2003) meta-analysis of 43 studies. The mean estimate of $5.5 million (2000$)[4] was also consistent with the mean VSL of $5.4 million estimated in the Kochi et al. (2006) meta-analysis. However, the Agency neither changed its official guidance on the use of VSL in rule-makings nor subjected the interim estimate to a scientific peer-review process through the Science Advisory Board (SAB) or other peer-review group.

During this time, the Agency continued work to update its guidance on valuing mortality risk reductions, including commissioning a report from meta-analytic experts to evaluate methodological questions raised by EPA and the SAB on combining estimates from the various data sources. In addition, the Agency consulted several times with the Science Advisory Board Environmental Economics Advisory Committee (SAB-EEAC) on the issue. With input from the meta-analytic experts, the SAB-EEAC advised the Agency to update its guidance using specific, appropriate meta-analytic techniques to combine estimates from unique data sources and different studies, including those using different methodologies (i.e., wage-risk and stated preference) (U.S. EPA-SAB, 2007).

Until updated guidance is available, the Agency determined that a single, peer-reviewed estimate applied consistently best reflects the SAB-EEAC advice it has received. Therefore, the Agency has decided to apply the VSL that was vetted and endorsed by the SAB in the Guidelines

[4] After adjusting the VSL to account for a different currency year (2008$) and to account for income growth to 2015, the $5.5 million VSL is $7.9 million.

for Preparing Economic Analyses (U.S. EPA, 2000)[5] while the Agency continues its efforts to update its guidance on this issue. This approach calculates a mean value across VSL estimates derived from 26 labor market and contingent valuation studies published between 1974 and 1991. The mean VSL across these studies is $6.3 million (2000$).[6] The Agency is committed to using scientifically sound, appropriately reviewed evidence in valuing mortality risk reductions and has made significant progress in responding to the SAB-EEAC's specific recommendations.

Figure 5-1 illustrates the relative breakdown of the monetized $PM_{2.5}$ health benefits.

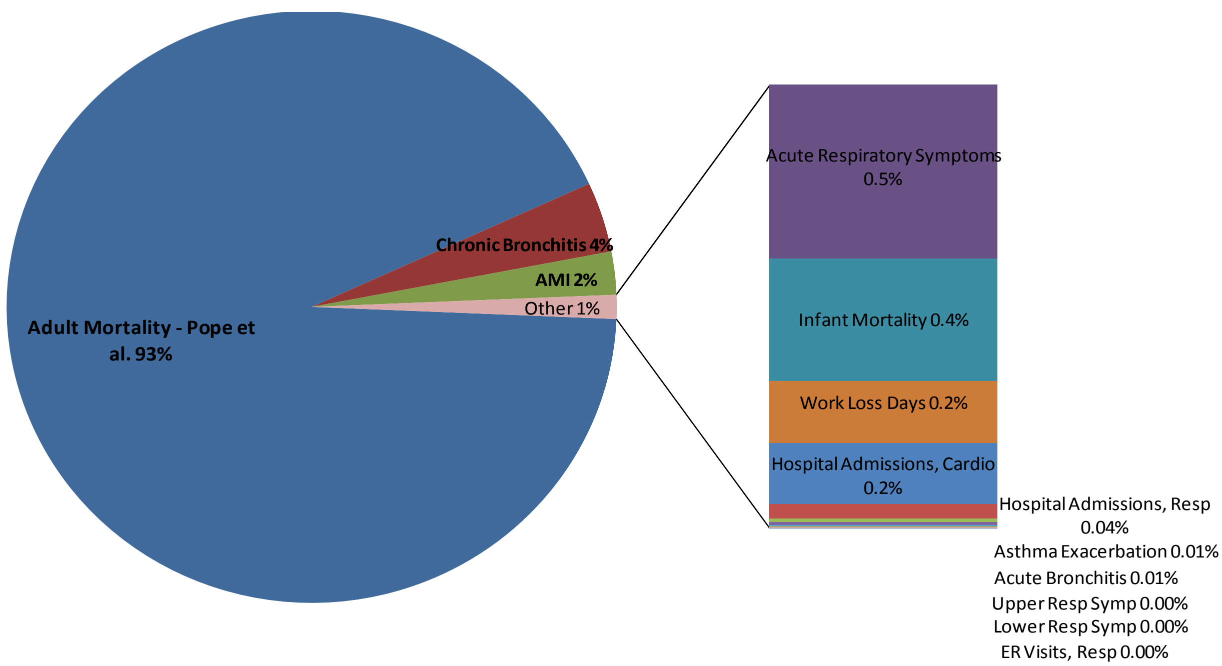

Figure 5-1. Breakdown of Monetized $PM_{2.5}$ Health Benefits using Mortality Function from Pope et al. (2002)[a]

[a] This pie chart breakdown is illustrative, using the results based on Pope et al. (2002) as an example. Using the Laden et al. (2006) function for premature mortality, the percentage of total monetized benefits due to adult mortality would be 97%. This chart shows the breakdown using a 3% discount rate, and the results would be similar if a 7% discount rate was used.

Tables 5-2 and 5-3 provide a general summary of the all units comply assumption and large entities comply and small entities landfill assumption results by pollutant, including the

[5] In the (draft) update of the Economic Guidelines (U.S. EPA, 2008), EPA retained the VSL endorsed by the SAB with the understanding that further updates to the mortality risk valuation guidance would be forthcoming in the near future. Therefore, this report does not represent final agency policy.

[6] In this analysis, we adjust the VSL to account for a different currency year (2008$) and to account for income growth to 2015. After applying these adjustments to the $6.3 million value, the VSL is $9.1 million.

emission reductions and monetized benefits-per-ton at discount rates of 3% and 7%.[7] Table 5-4 provides a summary of the reductions in health incidences as a result of the pollution reductions for the large entities comply and small entities landfill results. In Table 5-5, we provide the benefits using our anchor points of Pope et al. and Laden et al. as well as the results from the expert

Table 5-2. Summary of Monetized Benefits Estimates for Proposed SSI NSPS and EG in 2015 (2008$) (large entities comply and small entities landfill)[a]

	Pollutant	Emissions Reductions (tons)	Benefit per ton (Pope, 3%)	Benefit per ton (Laden, 3%)	Benefit per ton (Pope, 7%)	Benefit per ton (Laden, 7%)	Total Monetized Benefits (millions 2008$ at 3%)	Total Monetized Benefits (millions 2008$ at 7%)
Option 1	Direct $PM_{2.5}$	254	$230,000	$560,000	$210,000	$500,000	$58 to $140	$52 to $130
	$PM_{2.5}$ Precursors							
	SO_2	2,298	$29,000	$72,000	$27,000	$65,000	$68 to $170	$61 to $150
	NO_2	824	$4,900	$12,000	$4,400	$11,000	$4.0 to $9.8	$3.6 to $8.8
						Total	**$130 to $320**	**$120 to $290**
Proposed: Option 2	Direct $PM_{2.5}$	254	$230,000	$560,000	$210,000	$500,000	$58 to $140	$52 to $130
	$PM_{2.5}$ Precursors							
	SO_2	2,298	$29,000	$72,000	$27,000	$65,000	$68 to $170	$61 to $150
	NO_2	824	$4,900	$12,000	$4,400	$11,000	$4.0 to $9.8	$3.6 to $8.8
						Total	**$130 to $320**	**$120 to $290**
Option 3	Direct $PM_{2.5}$	254	$230,000	$560,000	$210,000	$500,000	$58 to $140	$52 to $130
	$PM_{2.5}$ Precursors							
	SO_2	2,298	$29,000	$72,000	$27,000	$65,000	$68 to $170	$61 to $150
	NO_2	824	$4,900	$12,000	$4,400	$11,000	$4.0 to $9.8	$3.6 to $8.8
						Total	**$130 to $320**	**$120 to $290**

[7] To comply with Circular A-4, EPA provides monetized benefits using discount rates of 3% and 7% (OMB, 2003). These benefits are estimated for a specific analysis year (i.e., 2015), and most of the PM benefits occur within that year with two exceptions: acute myocardial infarctions (AMIs) and premature mortality. For AMIs, we assume 5 years of follow-up medical costs and lost wages. For premature mortality, we assume that there is a "cessation" lag between PM exposures and the total realization of changes in health effects. Although the structure of the lag is uncertain, EPA follows the advice of the SAB-HES to assume a segmented lag structure characterized by 30% of mortality reductions in the first year, 50% over years 2 to 5, and 20% over the years 6 to 20 after the reduction in $PM_{2.5}$ (U.S. EPA-SAB, 2004). Changes in the lag assumptions do not change the total number of estimated deaths but rather the timing of those deaths. Therefore, discounting only affects the AMI costs after the analysis year and the valuation of premature mortalities that occur after the analysis year. As such, the monetized benefits using a 7% discount rate are only approximately 10% less than the monetized benefits using a 3% discount rate.

[a] All estimates are for the implementation year (2015), and are rounded to two significant figures so numbers may not sum across columns. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary because each ton of precursor reduced has a different propensity to form $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. These results include 2 new FB incinerators anticipated to come online by 2015. These estimates do not include energy disbenefits valued at \$0.5 million at a 3% discount rate for CO_2 emissions.

elicitation on PM mortality. Figures 5-2 through 5-4 provide a visual representation of the range of benefits estimates and the pollutant breakdown of the monetized benefits.

Table 5-3. Summary of Monetized Benefits Estimates for Proposed SSI NSPS and EG in 2015 (2008$) (all units comply)[a]

	Pollutant	Emissions Reductions (tons)	Benefit per ton (Pope, 3%)	Benefit per ton (Laden, 3%)	Benefit per ton (Pope, 7%)	Benefit per ton (Laden, 7%)	Total Monetized Benefits (millions 2008$ at 3%)	Total Monetized Benefits (millions 2008$ at 7%)
Option 1	Direct $PM_{2.5}$	209	$230,000	$560,000	$210,000	$500,000	$48.0 to $120.0	$43.0 to $110.0
	$PM_{2.5}$ Precursors							
	SO_2	2,193	$29,000	$72,000	$27,000	$65,000	$65 to $160	$59 to $140
	NO_2	5	$4,900	$12,000	$4,400	$11,000	$.02 to $.06	$.02 to $.05
						Total	**$110 to $270**	**$100 to $250**
Proposed: Option 2	Direct $PM_{2.5}$	209	$230,000	$560,000	$210,000	$500,000	$48.0 to $120.0	$43.0 to $110.0
	$PM_{2.5}$ Precursors							
	SO_2	2,193	$29,000	$72,000	$27,000	$65,000	$65 to $160	$59 to $140
	NO_2	5	$4,900	$12,000	$4,400	$11,000	$.02 to $.06	$.02 to $.05
						Total	**$110 to $270**	**$100 to $250**
Option 3	Direct $PM_{2.5}$	209	$230,000	$560,000	$210,000	$500,000	$48 to $120	$43 to $110
	$PM_{2.5}$ Precursors							
	SO_2	2,193	$29,000	$72,000	$27,000	$65,000	$65 to $160	$59 to $140
	NO_2	5	$4,900	$12,000	$4,400	$11,000	$.02 to $.06	$.02 to $.05
						Total	**$110 to $270**	**$100 to $250**

[a] All estimates are for the implementation year (2015), and are rounded to two significant figures so numbers may not sum across columns. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary because each ton of precursor reduced has a different propensity to form $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. These results include 2 new FB incinerators anticipated to come online by 2015. These estimates do not include energy disbenefits valued at $0.5 million at a 3% discount rate for CO_2 emissions.

Table 5-4. Summary of Reductions in Health Incidences from $PM_{2.5}$ Benefits for the Proposed SSI NSPS and EG in 2015[a]

	Option 1	Proposed: Option 2	Option 3
Avoided Premature Mortality			
Pope et al.	14	14	14
Laden et al.	36	36	36
Avoided Morbidity			
Chronic Bronchitis	10	10	10
Acute Myocardial Infarction	23	23	23
Hospital Admissions, Respiratory	3	3	3
Hospital Admissions, Cardiovascular	7	7	7
Emergency Room Visits, Respiratory	14	14	14
Acute Bronchitis	23	23	23
Work Loss Days	1,900	1,900	1,900
Asthma Exacerbation	250	250	250
Minor Respiratory Symptoms	11,000	11,000	11,000
Lower Respiratory Symptoms	270	270	270
Upper Respiratory Symptoms	210	210	210

[a] All estimates are for the analysis year (2015) and are rounded to whole numbers with two significant figures. All fine particles are assumed to have equivalent health effects, but each $PM_{2.5}$ precursor pollutant has a different propensity to form $PM_{2.5}$. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology. These results include 2 new FB incinerators anticipated to come online by 2015 and the large entities comply and small entities landfill assumption.

Table 5-5. All $PM_{2.5}$ Benefits Estimates for the Proposed SSI NSPS and EG at Discount Rates of 3% and 7% in 2015 (in millions of 2008$)[a]

	Option 1		Proposed: Option 2		Option 3	
	3%	7%	3%	7%	3%	7%
Benefit-per-ton Coefficients derived from Epidemiology Literature						
Pope et al.	$130	$120	$130	$120	$130	$120
Laden et al.	$320	$290	$320	$290	$320	$290
Benefit-per-ton Coefficients Derived from Expert Elicitation						
Expert A	$340	$300	$340	$300	$340	$300
Expert B	$260	$230	$260	$230	$260	$230
Expert C	$260	$230	$260	$230	$260	$230
Expert D	$180	$160	$180	$160	$180	$160
Expert E	$420	$380	$420	$380	$420	$380
Expert F	$230	$210	$230	$210	$230	$210
Expert G	$150	$140	$150	$140	$153	$139
Expert H	$190	$170	$190	$170	$190	$170
Expert I	$250	$230	$250	$230	$250	$230
Expert J	$210	$190	$210	$190	$210	$190
Expert K	$51	$46	$51	$46	$51	$46
Expert L	$190	$170	$190	$170	$190	$170

[a] All estimates are rounded to two significant figures. Estimates do not include confidence intervals because they were derived through the benefit-per-ton technique described above. The benefits estimates from the Expert Elicitation are provided as a reasonable characterization of the uncertainty in the mortality estimates associated with the concentration-response function. These results include 2 new FB incinerators anticipated to come online by 2015 and the large entities comply and small entities landfill assumption. These estimates do not include energy disbenefits valued at $0.5 million at a 3% discount rate for CO_2 emissions.

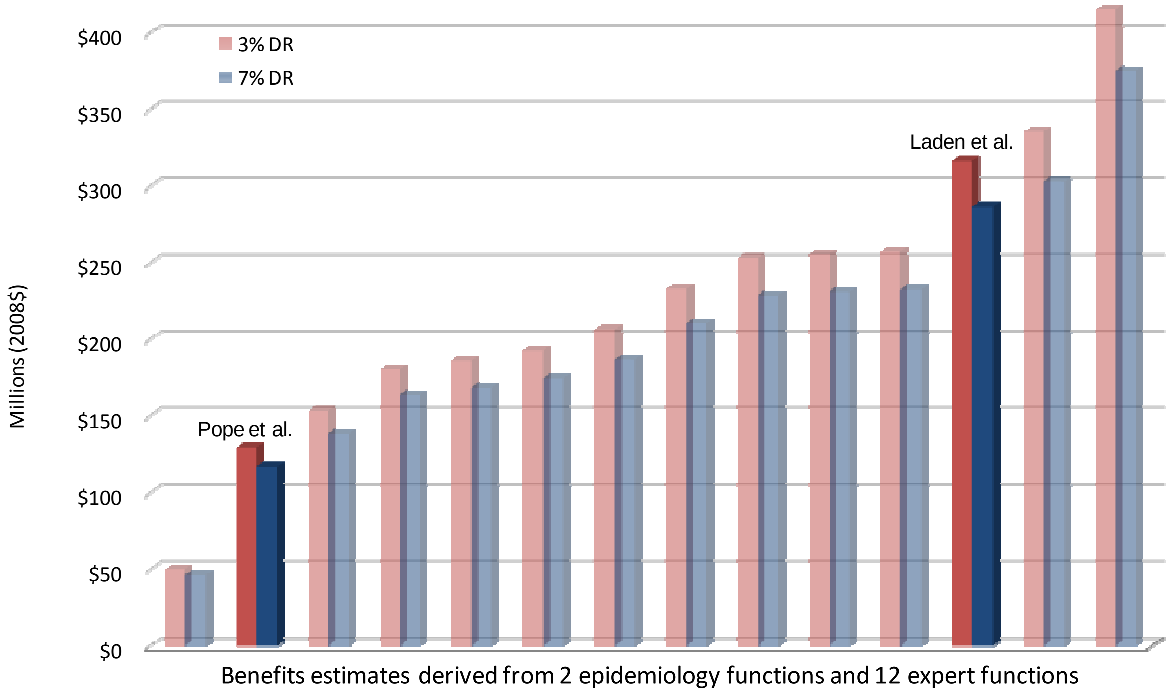

Figure 5-2. Total Monetized $PM_{2.5}$ Benefits for the Proposed SSI NSPS and EG in 2015

[a] This graph shows the estimated benefits at discount rates of 3% and 7% using effect coefficients derived from the Pope et al. study and the Laden et al study, as well as 12 effect coefficients derived from EPA's expert elicitation on PM mortality. The results shown are not the direct results from the studies or expert elicitation; rather, the estimates are based in part on the concentration-response function provided in those studies. These results include 2 new FB incinerators anticipated to come online by 2015 and the large entities comply and small entities landfill assumption. These estimates do not include energy disbenefits valued at $0.5 million at a 3% discount rate for CO_2 emissions.

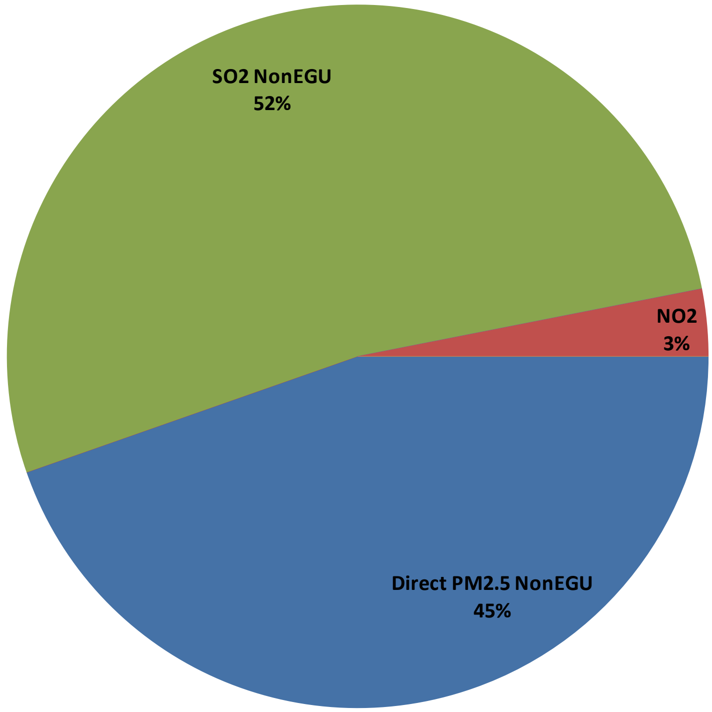

Figure 5-3. Breakdown of Monetized Benefits for the Proposed SSI NSPS and EG by $PM_{2.5}$ Precursor Pollutant and Source

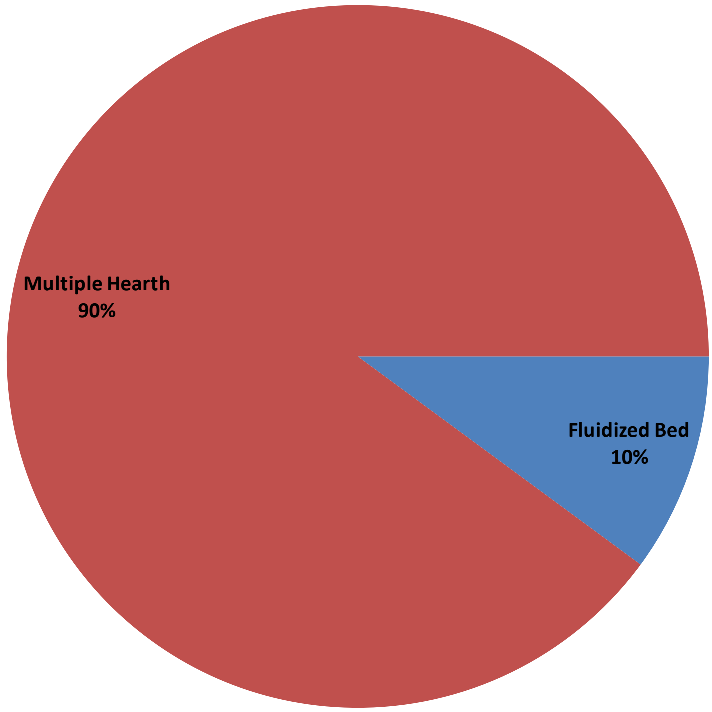

Figure 5-4. Breakdown of Monetized Benefits for the Proposed SSI NSPS and EG by Subcategory

5.3 Energy Disbenefits

Electricity usage associated with the operation of control devices is anticipated to increase emissions of pollutants from utility boilers that supply electricity to the sewage sludge incinerators. For example, increased scrubber pump horsepower and sorbent injection controls may cause slight increases in electricity consumption. We estimate that the increased electricity consumption associated with the proposed option would be 12 million kWh if all entities comply, and 12 million kWh if the small entities landfill. Using national emission factors from eGRID for electrical generating units (EGUs), we estimate the increased emissions to be 19,000 tpy of CO_2 for the proposed option assuming that small entities landfill.[8] Since NOx and SO_2 are covered by capped emissions trading programs, we are only estimating the CO_2 emission increases from the increased electricity demand. The methodology used to calculate these

[8] Option 3 has additional energy disbenefits associated with the supplemental fuel required to run the afterburners, which results in additional emissions of CO_2, CO, and NOx. The CO_2 energy disbenefits for Option 3 are shown in Tables 5-7 and 5-8. The additional NOx disbenefits (as a precursor to $PM_{2.5}$ using the methodolology described in Section 5.2) for Option 3 are $0.4 million to $0.9 million, which do not affect the rounded benefits results.

emission increases is described "Secondary Impacts of Control Options for the Sewage Sludge Incineration Source Category", which is available in the docket.

5.3.1 Social Cost of Carbon and Greenhouse Gas Disbenefits

EPA has assigned a dollar value to reductions in carbon dioxide (CO_2) emissions using recent estimates of the "social cost of carbon" (SCC). The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. The SCC estimates used in this analysis were developed through an interagency process that included EPA and other executive branch entities, and concluded in February 2010. EPA first used these SCC estimates in the benefits analysis for the final joint EPA/DOT Rulemaking to establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; see the rule's preamble for discussion about application of SCC (75 FR 25324; 5/7/10). The SCC Technical Support Document (SCC TSD) provides a complete discussion of the methods used to develop these SCC estimates.[9]

The interagency group selected four SCC values for use in regulatory analyses, which we have applied in this analysis: \$5, \$21, \$35, and \$65 per metric ton of CO_2 emissions[10] in 2010, in 2007 dollars. The first three values are based on the average SCC from three integrated assessment models, at discount rates of 2.5, 3, and 5 percent, respectively. SCCs at several discount rates are included because the literature shows that the SCC is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context. The fourth value is the 95th percentile of the SCC from all three models at a 3 percent discount rate. It is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. Low probability, high impact events are incorporated into all of the SCC values through explicit consideration of their effects in two of the three models as well as the use of a probability density function for

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[9] Docket ID EPA-HQ-OAR-2009-0472-114577, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury (February 2010). Also available at http://www.epa.gov/otaq/climate/regulations.htm

[10] The interagency group decided that these estimates apply only to CO_2 emissions. Given that warming profiles and impacts other than temperature change (e.g. ocean acidification) vary across GHGs, the group concluded "transforming gases into CO_2-equivalents using GWP, and then multiplying the carbon-equivalents by the SCC, would not result in accurate estimates of the social costs of non-CO_2 gases" (SCC TSD, pg 13).

equilibrium climate sensitivity. Treating climate sensitivity probabilistically results in more high temperature outcomes, which in turn lead to higher projections of damages.

The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. Note that the interagency group estimated the growth rate of the SCC directly using the three integrated assessment models rather than assuming a constant annual growth rate. This helps to ensure that the estimates are internally consistent with other modeling assumptions. The SCC estimates for the analysis years of 2015, in 2008$ are provided in Table 5-6.

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Academies of Science (NRC, 2008) points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

The interagency group noted a number of limitations to the SCC analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. The limited amount of research linking climate impacts to economic damages makes the interagency modeling exercise even more difficult. The interagency group hopes that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling. Additional details on these limitations are discussed in the SCC TSD.

In light of these limitations, the interagency group has committed to updating the current estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, the interagency group has set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area.

Applying the global SCC estimates to the estimated increases in CO_2 emissions for the range of policy scenarios, we estimate the dollar value of the climate-related disbenefits captured by the models for each analysis year. For internal consistency, the annual disbenefits are discounted back to NPV terms using the same discount rate as each SCC estimate (i.e. 5%, 3%, and 2.5%) rather than 3% and 7%.[11] These estimates are provided in Tables 5-7 and 5-8.

Table 5-6. Social Cost of Carbon (SCC) Estimates (per tonne of CO_2) for 2015 [a]

Discount Rate and Statistic	SCC estimate (2008$)
5% Average	$5.9
3% Average	$24.7
2.5% Average	$39.9
3% 95%ile	$75.6

[a] The SCC values are dollar-year and emissions-year specific. SCC values represent only a partial accounting of climate impacts.

Table 5-7. Monetized SCC-derived Disbenefits of CO_2 Emission Increases in 2015 (all units comply, millions of 2008$)[a]

Discount Rate and Statistic	Option 1	Proposed: Option 2	Option 3
	24,900 tpy CO_2	24,900 tpy CO_2	126,000 tpy CO_2
5% Average	$0.1	$0.1	$0.7
3% Average	$0.6	$0.6	$3.1
2.5% Average	$1.0	$1.0	$5.0
3% 95%ile	$1.9	$1.9	$9.5

[a] The SCC values are dollar-year and emissions-year specific. SCC values represent only a partial accounting of climate impacts. These results include 2 new FB incinerators anticipated to come online by 2015.

Table 5-8. Monetized SCC-derived Disbenefits of CO_2 Emission Increases in 2015 (large entities comply and small entities landfill, millions of 2008$)[a]

Discount Rate and Statistic	Option 1	Proposed: Option 2	Option 3
	21,782 tpy CO_2	21,782 tpy CO_2	114,784tpy CO_2
5% Average	$0.1	$0.1	$0.7
3% Average	$0.5	$0.5	$2.8
2.5% Average	$0.9	$0.9	$4.6

[11] It is possible that other benefits or costs of proposed regulations unrelated to CO_2 emissions will be discounted at rates that differ from those used to develop the SCC estimates.

3% 95%ile	$1.6	$1.6	$8.7

[a] The SCC values are dollar-year and emissions-year specific. SCC values represent only a partial accounting of climate impacts. These results include 2 new FB incinerators anticipated to come online by 2015.

5.4 Unquantified Benefits

The monetized benefits estimated in this RIA only reflect the portion of benefits attributable to the health effect reductions associated with ambient fine particles. Data, resource, and methodological limitations prevented EPA from quantifying or monetizing the benefits from several important benefit categories, including benefits from reducing toxic emissions, ecosystem effects, and visibility impairment. The health benefits from reducing hazardous air pollutants (HAPs) and carbon monoxide have not been monetized in this analysis. In addition to being a $PM_{2.5}$ precursor, SO_2 emissions also contribute to adverse effects from acidic deposition in aquatic and terrestrial ecosystems, increased mercury methylation, as well as visibility impairment. The benefits from reducing other air pollutants that have not been monetized in this analysis including 2,900 tons of carbon monoxide, 96 tons of HCl, 3.0 tons of lead, 1.6 tons of cadmium, 5,500 pounds of mercury, and 90 grams of total dioxins/furans each year.

5.4.1 Carbon Monoxide Benefits

Carbon monoxide (CO) exposure is associated with a variety of health effects. Without knowing the location of the emission reductions and the resulting ambient concentrations using fine-scale air quality modeling, we were unable to estimate the exposure to CO for nearby populations. Due to data, resource, and methodological limitations, we were unable to estimate the benefits associated with the reductions of CO emissions that would occur as a result of this rule.

Carbon monoxide in ambient air is formed primarily by the incomplete combustion of carbon-containing fuels and photochemical reactions in the atmosphere. The amount of CO emitted from these reactions, relative to carbon dioxide (CO_2), is sensitive to conditions in the combustion zone, such as fuel oxygen content, burn temperature, or mixing time. Upon inhalation, CO diffuses through the respiratory system to the blood, which can cause hypoxia (reduced oxygen availability). Carbon monoxide can elicit a broad range of effects in multiple tissues and organ systems that are dependent upon concentration and duration of exposure.

The Integrated Science Assessment for Carbon Monoxide (U.S. EPA, 2010a) concluded that short-term exposure to CO is "likely to have a causal relationship" with cardiovascular morbidity, particularly in individuals with coronary heart disease. Epidemiologic studies associate short-term CO exposure with increased risk of emergency department visits and hospital admissions. Coronary heart disease includes those who have angina pectoris (cardiac chest pain), as well as those who have experienced a heart attack. Other subpopulations potentially at risk include individuals with diseases such as chronic obstructive pulmonary disease (COPD), anemia, or diabetes, and individuals in very early or late life stages, such as older adults or the developing young. The evidence is suggestive of a causal relationship between short-term exposure to CO and respiratory morbidity and mortality. The evidence is also suggestive of a causal relationship for birth outcomes and developmental effects following long-term exposure to CO, and for central nervous system effects linked to short- and long-term exposure to CO.

5.4.2 Other SO_2 Benefits

In addition to being a precursor to $PM_{2.5}$, SO_2 emissions are also associated with a variety of respiratory health effects. Unfortunately, we were unable to estimate the health benefits associated with reduced SO_2 exposure in this analysis because we do not have air quality modeling data available. Without knowing the location of the emission reductions and the resulting ambient concentrations, we were unable to estimate the exposure to SO_2 for nearby populations. Therefore, this analysis only quantifies and monetizes the $PM_{2.5}$ benefits associated with the reductions in SO_2 emissions.

Following an extensive evaluation of health evidence from epidemiologic and laboratory studies, the U.S. EPA has concluded that there is a causal relationship between respiratory health effects and short-term exposure to SO_2 (U.S. EPA, 2008). According to summary of the ISA in EPA's risk and exposure assessment (REA) for the SO_2 NAAQS, "the immediate effect of SO_2 on the respiratory system in humans is bronchoconstriction" (U.S. EPA, 2009c). In addition, the REA summarized from the ISA that "asthmatics are more sensitive to the effects of SO_2 likely resulting from preexisting inflammation associated with this disease." A clear concentration-response relationship has been demonstrated in laboratory studies following exposures to SO_2 at concentrations between 20 and 100 ppb, both in terms of increasing severity of effect and percentage of asthmatics adversely affected (U.S. EPA, 2009c). Based on our review of this information, we identified four short-term morbidity endpoints that the SO_2 ISA identified as a "causal relationship": asthma exacerbation, respiratory-related emergency department visits, and respiratory-related hospitalizations. The differing evidence and associated strength of the evidence for these different effects is described in detail in the SO_2 ISA. The SO_2 ISA also concluded that the relationship between short-term SO_2 exposure and premature mortality was "suggestive of a causal relationship" because it is difficult to attribute the mortality risk effects to SO_2 alone. Although the SO_2 ISA stated that studies are generally consistent in reporting a relationship between SO_2 exposure and mortality, there was a lack of robustness of the observed associations to adjustment for pollutants.

SO_2 emissions also contribute to adverse welfare effects from acidic deposition, visibility impairment, and enhanced mercury methylation. Deposition of sulfur causes acidification, which can cause a loss of biodiversity of fishes, zooplankton, and macro invertebrates in aquatic ecosystems, as well as a decline in sensitive tree species, such as red spruce (*Picea rubens*) and sugar maple (*Acer saccharum*) in terrestrial ecosystems. In the northeastern United States, the surface waters affected by acidification are a source of food for some recreational and subsistence fishermen and for other consumers and support several cultural services, including aesthetic and educational services and recreational fishing. Biological effects of acidification in terrestrial ecosystems are generally linked to aluminum toxicity, which can cause reduced root growth, which restricts the ability of the plant to take up water and nutrients. These direct effects can, in turn, increase the sensitivity of these plants to stresses, such as droughts, cold temperatures, insect pests, and disease leading to increased mortality of canopy trees. Terrestrial acidification affects several important ecological services, including declines in habitat for threatened and endangered species (cultural), declines in forest aesthetics (cultural), declines in forest productivity (provisioning), and increases in forest soil erosion and reductions in water retention (cultural and regulating) (U.S. EPA, 2008d).

Reducing SO_2 emissions and the secondary formation of $PM_{2.5}$ would improve the level of visibility throughout the United States. Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon, and soil (Sisler, 1996). These suspended particles and gases degrade visibility by scattering and absorbing light. Higher visibility impairment levels in the East are due to generally higher concentrations of fine particles, particularly sulfates, and higher average relative humidity levels. In fact, particulate sulfate is the largest contributor to regional haze in the eastern U.S. (i.e., 40% or more annually and 75% during summer). In the western U.S., particulate sulfate contributes to 20-50% of regional haze (U.S. EPA, 2009c). Visibility has direct significance to people's enjoyment of daily activities and their overall sense of wellbeing. Good visibility increases the quality of life where individuals live and work, and where they engage in recreational activities.

5.4.3 HAP Benefits

Due to data, resource, and methodology limitations, we were unable to estimate the benefits associated with the hazardous air pollutants that would be reduced as a result of this rule. Available emissions data show that several different HAPs are emitted from SSI. This rule is anticipated to reduce 96 tons of HCl, 3.0 tons of lead, 1.6 tons of cadmium, 5,500 pounds of mercury, and 90 grams of total dioxins/furans each year. In the absence of air quality modeling and/or concentration-response functions, we are unable to quantify the magnitude of the reduction in human exposure to these pollutants associated with the emission reductions from this rule.

5.4.3.1 Mercury

Mercury is a highly neurotoxic contaminant that enters the food web as a methylated compound, methylmercury (U.S. EPA, 2008d). The contaminant is concentrated in higher trophic levels, including fish eaten by humans. Experimental evidence has established that only inconsequential amounts of methylmercury can be produced in the absence of sulfate (U.S. EPA, 2008d). Current evidence indicates that in watersheds where mercury is present, increased sulfate deposition very likely results in methylmercury accumulation in fish (Drevnick et al., 2007; Munthe et al, 2007). The SO_2 ISA concluded that evidence is sufficient to infer a casual relationship between sulfur deposition and increased mercury methylation in wetlands and aquatic environments (U.S. EPA, 2008d).

In addition to the role of sulfate deposition on methylation, this proposed rule would also reduce mercury emissions. Mercury is emitted to the air from various man-made and natural sources. These emissions transport through the atmosphere and eventually deposit to land or water bodies. This deposition can occur locally, regionally, or globally, depending on the form of mercury emitted and other factors such as the weather. The form of mercury emitted varies depending on the source type and other factors. Available data indicate that the mercury emissions from these sources are a mixture of gaseous elemental mercury, inorganic ionic mercury, and particulate bound mercury. Gaseous elemental mercury can be transported very long distances, even globally, to regions far from the emissions source (becoming part of the global “pool”) before deposition occurs. Inorganic ionic and particulate bound mercury have a shorter atmospheric lifetime and can deposit to land or water bodies closer to the emissions source. Furthermore, elemental mercury in the atmosphere can undergo transformation into ionic mercury, providing a significant pathway for deposition of emitted elemental mercury.

This source category emitted about 3.1 tons of mercury in the air in 2008 in the U.S. Based on the EPA’s National Emission Inventory, about 103 tons of mercury were emitted from all anthropogenic sources in the U.S. in 2005. Moreover, the United Nations has estimated that about 2,100 tons of mercury were emitted worldwide by anthropogenic sources in 2005. We believe that total mercury emissions in the U.S. and globally in 2008 were about the same magnitude in 2005. Therefore, we estimate that in 2008, these sources emitted about 3% of the total anthropogenic mercury emissions in the U.S. and about 0.15% of the global emissions. Overall, this rule would reduce mercury emissions by about 5,500 pounds per year from current levels, and therefore, contribute to reductions in mercury exposures and health effects. Due to time and resource limitations, we were unable to model mercury dispersion, deposition, methylation, bioaccumulation in fish tissue, and human consumption of mercury-contaminated fish that would be needed in order to estimate the human health benefits from reducing mercury emissions.

Potential exposure routes to mercury emissions include both direct inhalation and consumption of fish containing methylmercury. In the U.S., the primary route of human exposure to mercury emissions from industrial sources is generally indirectly through the consumption of fish containing methylmercury. As described above, mercury that has been emitted to the air eventually settles into water bodies or onto land where it can either move directly or be leached into waterbodies. Once deposited, certain microorganisms can change it into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish. Consumption of fish and shellfish are the main sources of methylmercury exposure to humans. Methylmercury builds up more in some types of fish and shellfish than in others. The levels of methylmercury in fish and shellfish vary widely depending on what they eat, how long they live, and how high they are in the food chain. Most fish, including ocean species and local freshwater fish, contain some methylmercury. For example, in recent studies by EPA and the U.S. Geological Survey (USGS) of fish tissues, every fish sampled from 291 streams across the country contained some methylmercury (Scudder, 2009).

The majority of fish consumed in the U.S. are ocean species. The methylmercury concentrations in ocean fish species are primarily influenced by the global mercury pool. However, the methylmercury found in local fish can be due, at least partly, to mercury emissions from local sources. Research shows that most people’s fish consumption does not cause a mercury-related health concern. However, certain people may be at higher risk because of their routinely high consumption of fish (e.g., tribal and other subsistence fishers and their families who rely heavily on fish for a substantial part of their diet). It has been demonstrated that high levels of methylmercury in the bloodstream of unborn babies and young children may harm the developing nervous system, making the child less able to think and learn. Moreover, mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages.

Several studies suggest that the methylmercury content of fish may reduce these cardio-protective effects of fish consumption. Some of these studies also suggest that methylmercury may cause adverse effects to the cardiovascular system. For example, the NRC (2000) review of the literature concerning methylmercury health effects took note of two epidemiological studies that found an association between dietary exposure to methylmercury and adverse cardiovascular effects.[12] Moreover, in a study of 1,833 males in Finland aged 42 to 60 years, Solonen et al. (1995) observed a relationship between methylmercury exposure via fish consumption and acute myocardial infarction (AMI or heart attacks), coronary heart disease, cardiovascular disease, and all-cause mortality.[13] The NRC also noted a study of 917 seven year old children in the Faroe Islands, whose initial exposure to methylmercury was *in utero* although post natal exposures may have occurred as well. At seven years of age, these children exhibited an increase in blood pressure and a decrease in heart rate variability.[14] Based on these and other studies, NRC concluded in 2000 that, while "the data base is not as extensive for cardiovascular effects as it is for other end points (i.e. neurologic effects) the cardiovascular system appears to be a target for methylmercury toxicity."[15]

Since publication of the NRC report there have been some 30 published papers presenting the findings of studies that have examined the possible cardiovascular effects of methylmercury exposure. These studies include epidemiological, toxicological, and toxicokinetic investigations. Over a dozen review papers have also been published. If there is a causal relationship between methylmercury exposure and adverse cardiovascular effects, then reducing exposure to methylmercury would result in public health benefits from reduced cardiovascular effects.

In early 2010, EPA sponsored a workshop in which a group of experts were asked to assess the plausibility of a causal relationship between methylmercury exposure and cardiovascular health effects and to advise EPA on methodologies for estimating population

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[12] National Research Council (NRC). 2000. Toxicological Effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology. National Academies Press. Washington, DC. pp. 168-173.

[13] Salonen, J.T., Seppanen, K. Nyyssonen et al. 1995. "Intake of mercury from fish lipid peroxidation, and the risk of myocardial infarction and coronary, cardiovascular and any death in Eastern Finnish men." Circulation, 91 (3):645-655.

[14] Sorensen, N, K. Murata, E. Budtz-Jorgensen, P. Weihe, and Grandjean, P., 1999. "Prenatal Methylmercury Exposure As A Cardiovascular Risk Factor At Seven Years of Age", Epidemiology, pp370-375.

[15] National Research Council (NRC). 2000. Toxicological Effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology. National Academies Press. Washington, DC. p. 229.

level cardiovascular health impacts of reduced methylmercury exposure. The report from that workshop is in preparation.

5.4.3.2 Cadmium

Breathing air with very high levels of cadmium can severely damage the lungs and may cause death. In the United States, where proper industrial hygiene is generally practiced, inhaling very high levels of cadmium at work is expected to be rare and accidental. Breathing air with lower levels of cadmium over long periods of time (for years) results in a build-up of cadmium in the kidney, and if sufficiently high, may result in kidney disease. Lung cancer has been found in some studies of workers exposed to cadmium in the air and studies of rats that breathed in cadmium. The U.S. Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds are known human carcinogens. The International Agency for Research on Cancer (IARC) has determined that cadmium is carcinogenic to humans. The EPA has determined that cadmium is a probable human carcinogen.[16]

5.4.3.3 Lead

The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults to lead at work has resulted in decreased performance in some tests that measure functions of the nervous system. Lead exposure may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people. Lead exposure may also cause anemia. At high levels of exposure, lead can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production.

We have no conclusive proof that lead causes cancer (is carcinogenic) in humans. Kidney tumors have developed in rats and mice that had been given large doses of some kind of lead compounds. The Department of Health and Human Services (DHHS) has determined that lead and lead compounds are reasonably anticipated to be human carcinogens based on limited evidence from studies in humans and sufficient evidence from animal studies, and the EPA has determined that lead is a probable human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic lead is probably carcinogenic to humans. IARC determined that organic lead compounds are not classifiable as to their carcinogenicity in humans based on inadequate evidence from studies in humans and in animals.

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[16] Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Public Health Statement for Cadmium. CAS# 1306-19-0. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=46&tid=15>.

Children are more sensitive to the health effects of lead than adults. No safe blood lead level in children has been determined. Lead affects children in different ways depending on how much lead a child swallows. A child who swallows large amounts of lead may develop anemia, kidney damage, colic (severe "stomach ache"), muscle weakness, and brain damage, which ultimately can kill the child. In some cases, the amount of lead in the child's body can be lowered by giving the child certain drugs that help eliminate lead from the body. If a child swallows smaller amounts of lead, such as dust containing lead from paint, much less severe but still important effects on blood, development, and behavior may occur. In this case, recovery is likely once the child is removed from the source of lead exposure, but there is no guarantee that the child will completely avoid all long-term consequences of lead exposure. At still lower levels of exposure, lead can affect a child's mental and physical growth. Fetuses exposed to lead in the womb, because their mothers had a lot of lead in their bodies, may be born prematurely and have lower weights at birth. Exposure in the womb, in infancy, or in early childhood also may slow mental development and cause lower intelligence later in childhood. There is evidence that these effects may persist beyond childhood.[17]

5.4.3.4 Hydrogen Chloride (HCl)

Hydrogen chloride gas is intensely irritating to the mucous membranes of the nose, throat, and respiratory tract. Brief exposure to 35 ppm causes throat irritation, and levels of 50 to 100 ppm are barely tolerable for 1 hour. The greatest impact is on the upper respiratory tract; exposure to high concentrations can rapidly lead to swelling and spasm of the throat and suffocation. Most seriously exposed persons have immediate onset of rapid breathing, blue coloring of the skin, and narrowing of the bronchioles. Patients who have massive exposures may develop an accumulation of fluid in the lungs. Exposure to hydrogen chloride can lead to Reactive Airway Dysfunction Syndrome (RADS), a chemically- or irritant-induced type of asthma. Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways. Children may also be more vulnerable to gas exposure because of increased minute ventilation per kg and failure to evacuate an area promptly when exposed. Hydrogen chloride has not been classified for carcinogenic effects.[18]

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[17] Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Public Health Statement for Lead. CAS#: 7439-92-1. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at < http://www.atsdr.cdc.gov/ToxProfiles/phs13.html>.

[18] Agency for Toxic Substances and Disease Registry (ATSDR). Medical Management Guidelines for Hydrogen Chloride (HCl). CAS#: 7647-01-0. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/Mhmi/mmg173.html>.

5.4.3.5 Dioxins (Chlorinated dibenzodioxins (CDDs)

A number of effects have been observed in people exposed to 2,3,7,8-TCDD levels that are at least 10 times higher than background levels. The most obvious health effect in people exposure to relatively large amounts of 2,3,7,8-TCDD is chloracne. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Other skin effects noted in people exposed to high doses of 2,3,7,8-TCDD include skin rashes, discoloration, and excessive body hair. Changes in blood and urine that may indicate liver damage also are seen in people. Alterations in the ability of the liver to metabolize (or breakdown) hemoglobin, lipids, sugar, and protein have been reported in people exposed to relatively high concentrations of 2,3,7,8-TCDD. Most of the effects are considered mild and were reversible. However, in some people these effects may last for many years. Slight increases in the risk of diabetes and abnormal glucose tolerance have been observed in some studies of people exposed to 2,3,7,8-TCDD. We do not have enough information to know if exposure to 2,3,7,8-TCDD would result in reproductive or developmental effects in people, but animal studies suggest that this is a potential health concern.

In certain animal species, 2,3,7,8-TCDD is especially harmful and can cause death after a single exposure. Exposure to lower levels can cause a variety of effects in animals, such as weight loss, liver damage, and disruption of the endocrine system. In many species of animals, 2,3,7,8-TCDD weakens the immune system and causes a decrease in the system's ability to fight bacteria and viruses at relatively low levels (approximately 10 times higher than human background body burdens). In other animal studies, exposure to 2,3,7,8-TCDD has caused reproductive damage and birth defects. Some animal species exposed to CDDs during pregnancy had miscarriages and the offspring of animals exposed to 2,3,7,8-TCDD during pregnancy often had severe birth defects including skeletal deformities, kidney defects, and weakened immune responses. In some studies, effects were observed at body burdens 10 times higher than human background levels.[19]

5.4.3.6 Furans (Chlorinated dibenzofurans (CDFs))

Most of the information on the adverse health effects comes from studies in people who were accidentally exposed to food contaminated with CDFs. The amounts that these people were exposed to were much higher than are likely from environmental exposures or from a normal diet. Skin and eye irritations, especially severe acne, darkened skin color, and swollen eyelids

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[19] Agency for Toxic Substances and Disease Registry (ATSDR). 1999. ToxFAQs for Chlorinated Dibenzo-p-dioxins (CDDs) (CAS#: 2,3,7,8-TCDD 1746-01-6). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at http://www.atsdr.cdc.gov/tfacts104.html.

with discharge, were the most obvious health effects of the CDF poisoning. CDF poisoning also caused vomiting and diarrhea, anemia, more frequent lung infections, numbness, effects on the nervous system, and mild changes in the liver. Children born to exposed mothers had skin irritation and more difficulty learning, but it is unknown if this effect was permanent or caused by CDFs alone or CDFs and polychlorinated biphenyls in combination.

Many of the same effects that occurred in people accidentally exposed also occurred in laboratory animals that ate CDFs. Animals also had severe weight loss, and their stomachs, livers, kidneys, and immune systems were seriously injured. Some animals had birth defects and testicular damage, and in severe cases, some animals died. These effects in animals were seen when they were fed large amounts of CDFs over a short time, or small amounts over several weeks or months. Nothing is known about the possible health effects in animals from eating CDFs over a lifetime.[20]

5.5 Characterization of Uncertainty in the Monetized $PM_{2.5}$ Benefits

In any complex analysis, there are likely to be many sources of uncertainty. Many inputs are used to derive the final estimate of economic benefits, including emission inventories, air quality models (with their associated parameters and inputs), epidemiological estimates of concentration-response (C-R) functions, estimates of values, population estimates, income estimates, and estimates of the future state of the world (i.e., regulations, technology, and human behavior). For some parameters or inputs it may be possible to provide a statistical representation of the underlying uncertainty distribution. For other parameters or inputs, the necessary information is not available.

The annual benefit estimates presented in this analysis are also inherently variable due to the processes that govern pollutant emissions and ambient air quality in a given year. Factors such as hours of equipment use and weather are constantly variable, regardless of our ability to measure them accurately. As discussed in the $PM_{2.5}$ NAAQS RIA (Table 5-5) (U.S. EPA, 2006), there are a variety of uncertainties associated with these PM benefits. Therefore, the estimates of annual benefits should be viewed as representative of the magnitude of benefits expected, rather than the actual benefits that would occur every year.

It is important to note that the monetized benefit-per-ton estimates used here reflect specific geographic patterns of emissions reductions and specific air quality and benefits

[20] Agency for Toxic Substances and Disease Registry (ATSDR). 1995. ToxFAQs™ for Chlorodibenzofurans (CDFs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/tfacts32.html>.

modeling assumptions. For example, these estimates do not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors. Use of these $/ton values to estimate benefits associated with different emission control programs (e.g., for reducing emissions from large stationary sources like EGUs) may lead to higher or lower benefit estimates than if benefits were calculated based on direct air quality modeling. Great care should be taken in applying these estimates to emission reductions occurring in any specific location, as these are all based on national or broad regional emission reduction programs and therefore represent average benefits-per-ton over the entire United States. The benefits-per-ton for emission reductions in specific locations may be very different than the estimates presented here.

$PM_{2.5}$ mortality benefits are the largest benefit category that we monetized in this analysis. To better characterize the uncertainty associated with mortality impacts that are estimated to occur in areas with low baseline levels of $PM_{2.5}$, we included the LML assessment. Without policy-specific air quality modeling, we are unable to quantify the shift in exposure associated with this specific rule. For this rule, as a surrogate measure of mortality impacts, we provide the percentage of the population exposed at each $PM_{2.5}$ level using the most recent modeling available from the recently proposed Transport Rule (U.S. EPA, 2010e). A very large proportion of the population is exposed at or above the lowest LML of the cohort studies (Figures 5-5 and 5-6), increasing our confidence in the PM mortality analysis. Figure 5-5 shows a bar chart of the percentage of the population exposed to various air quality levels in the pre- and post-policy policy. Figure 5-6 shows a cumulative distribution function of the same data. Both figures identify the LML for each of the major cohort studies. As the policy shifts the distribution of air quality levels, fewer people are exposed to $PM_{2.5}$ levels at or above the LML. Using the Pope et al. (2002) study, the 85% of the population is exposed to annual mean $PM_{2.5}$ levels at or above the LML of 7.5 $\mu g/m^3$. Using the Laden et al. (2006) study, 40% of the population is exposed above the LML of 10 $\mu g/m^3$. As we model mortality impacts among populations exposed to levels of $PM_{2.5}$ that are successively lower than the LML of the lowest cohort study, our confidence in the results diminishes. However, the analysis above confirms that the great majority of the impacts occur at or above the lowest cohort study's LML. It is important to emphasize that we have high confidence in $PM_{2.5}$-related effects down to the lowest LML of the major cohort studies. Just because we have greater confidence in the benefits above the LML, this does not mean that we have no confidence that benefits occur below the LML.

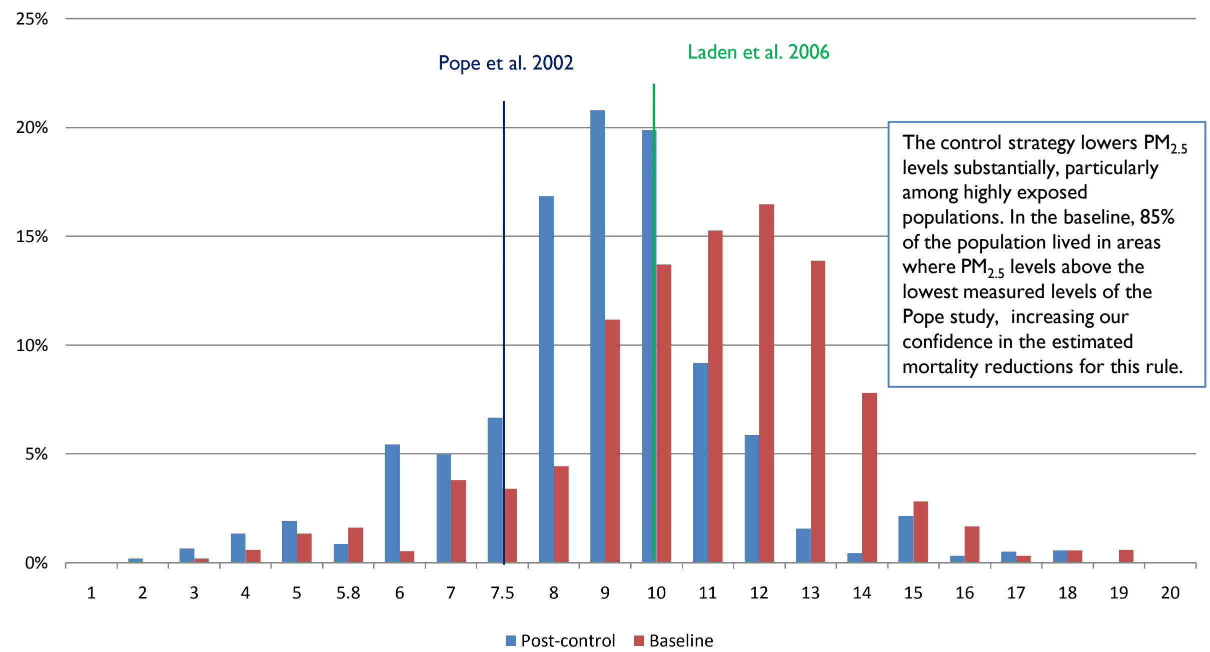

Figure 5-5. Percentage of Adult Population by Annual Mean $PM_{2.5}$ Exposure (pre- and post-policy policy)

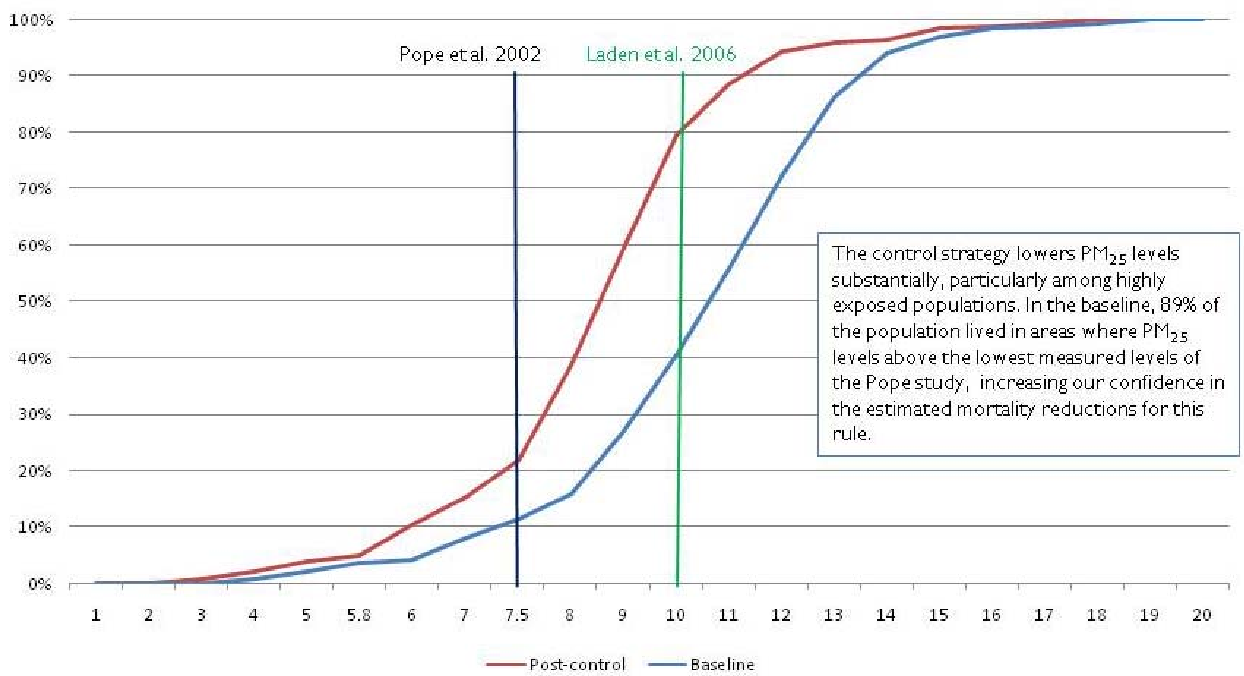

Figure 5-6. Cumulative Distribution of Adult Population at Annual Mean $PM_{2.5}$ levels (pre- and post-policy policy)

Above we present the estimates of the total monetized benefits, based on our interpretation of the best available scientific literature and methods and supported by the SAB-HES and the NAS (NRC, 2002). The benefits estimates are subject to a number of assumptions and uncertainties. For example, for key assumptions underlying the estimates for premature mortality, which typically account for at least 90% of the total monetized benefits, we were able to quantify include the following:

1. $PM_{2.5}$ benefits were derived through benefit per-ton estimates, which do not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual benefits of controlling directly emitted fine particulates.

2. We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because $PM_{2.5}$ produced via transported precursors emitted from EGUs may differ significantly from direct $PM_{2.5}$ released from diesel engines and other industrial sources, but no clear scientific grounds exist for supporting differential effects estimates by particle type.

3. We assume that the health impact function for fine particles is linear down to the lowest air quality levels modeled in this analysis. Thus, the estimates include health benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5,}$ including both regions that are in attainment with fine particle standard and those that do not meet the standard down to the lowest modeled concentrations.

4. To characterize the uncertainty in the relationship between $PM_{2.5}$ and premature mortality (which typically accounts for 85% to 95% of total monetized benefits), we include a set of twelve estimates based on results of the expert elicitation study in addition to our core estimates. Even these multiple characterizations omit the uncertainty in air quality estimates, baseline incidence rates, populations exposed and transferability of the effect estimate to diverse locations. As a result, the reported confidence intervals and range of estimates give an incomplete picture about the overall uncertainty in the $PM_{2.5}$ estimates. This information should be interpreted within the context of the larger uncertainty surrounding the entire analysis. For more information on the uncertainties associated with $PM_{2.5}$ benefits, please consult the $PM_{2.5}$ NAAQS RIA (Table 5-5).

This RIA does not include the type of detailed uncertainty assessment found in the PM NAAQS RIA because we lack the necessary air quality input and monitoring data to run the benefits model. In addition, we have not conducted any air quality modeling for this rule. Moreover, it was not possible to develop benefit-per-ton metrics and associated estimates of uncertainty using the benefits estimates from the PM RIA because of the significant differences between the sources affected in that rule and those regulated here. However, the results of the

Monte Carlo analyses of the health and welfare benefits presented in Chapter 5 of the PM RIA can provide some evidence of the uncertainty surrounding the benefits results presented in this analysis.

5.6 Comparison of Benefits and Costs

Using a 3% discount rate, we estimate the total monetized benefits of the proposed SSI NSPS and EG including energy disbenefits to be $130 million to $320 million in the implementation year (2015). Using a 7% discount rate, we estimate the total monetized benefits of the SSI NSPS and EG including energy disbenefits to be $120 million to $290 million. The annualized costs are $92 million at a 7% interest rate.[21] Thus, net benefits are $37 million to $220 million at a 3% discount rate for the benefits and $26 million to $190 million at a 7% discount rate. All estimates are in 2008$.

Table 5-9 shows a summary of the monetized co-benefits, social costs, and net benefits for the SSI NSPS and EG, respectively. Figures 5-7 and 5-8 show the full range of net benefits estimates (i.e., annual co-benefits minus annualized costs) utilizing the 14 different $PM_{2.5}$ mortality functions at discount rates of 3% and 7%. In addition, the benefits from reducing 2,900 tons of carbon monoxide, 96 tons of HCl, 3.0 tons of lead, 1.6 tons of cadmium, 5,500 pounds of mercury, and 90 grams of total dioxins/furans each year have not been included in these estimates.

[21] For more information on the annualized costs, please refer to Section 4 of this RIA. There are no estimates of costs available at a 3% discount rate.

Table 5-9. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the SSI NSPS and EG in 2015 (millions of 2008$)[a]

	3% Discount Rate			7% Discount Rate		
Proposed: Option 2						
Total Monetized Benefits[b]	$130	to	$320	$120	to	$290
Total Social Costs[c]		$92			$92	
Net Benefits	$37	to	$220	$26	to	$190
Non-monetized Benefits	26,000 tons of carbon monoxide 96 tons of HCl 5,500 pounds of mercury 1.6 tons of cadmium 3.0 tons of lead 90 grams of dioxins/furans Health effects from NO_2 and SO_2 exposure Ecosystem effects Visibility impairment					
Option 1						
Total Monetized Benefits[b]	$130	to	$320	$120	to	$290
Total Social Costs[c]		$63			$63	
Net Benefits	$66	to	$250	$55	to	$220
Non-monetized Benefits	2,900 tons of carbon monoxide 96tons of HCl 820 pounds of mercury 1.6 tons of cadmium 3.0 tons of lead 74 grams of dioxins/furans Health effects from NO_2 and SO_2 exposure Ecosystem effects Visibility impairment					
Option 3						
Total Monetized Benefits[b]	$130	to	$310	$120	to	$290
Total Social Costs[c]		$132			$132	
Net Benefits	-$5.4	to	$180	-$14	to	$150
Non-monetized Benefits	26,000 tons of carbon monoxide 96 tons of HCl 5,500 pounds of mercury 1.6 tons of cadmium 3.0 tons of lead 90 grams of dioxins/furans Health effects from NO_2 and SO_2 exposure Ecosystem effects Visibility impairment					

[a] All estimates are for the implementation year (2015), and are rounded to two significant figures. These results include 2 new FB incinerators anticipated to come online by 2015 and the large entities comply and small entities landfill assumption.

[b] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as NO_x and SO_2. It is important to note that the monetized benefits include many but not all health effects associated with $PM_{2.5}$ exposure. Benefits are shown as a range from Pope et al. (2002) to Laden et al. (2006). These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because there is no clear scientific evidence that would support the development of differential effects estimates by particle type. These estimates include energy disbenefits valued at $0.5 million at a 3% discount rate for CO_2 emissions.

[c] The annual compliances costs serve as a proxy for the annual social costs of this rule given the lack of difference between the two.

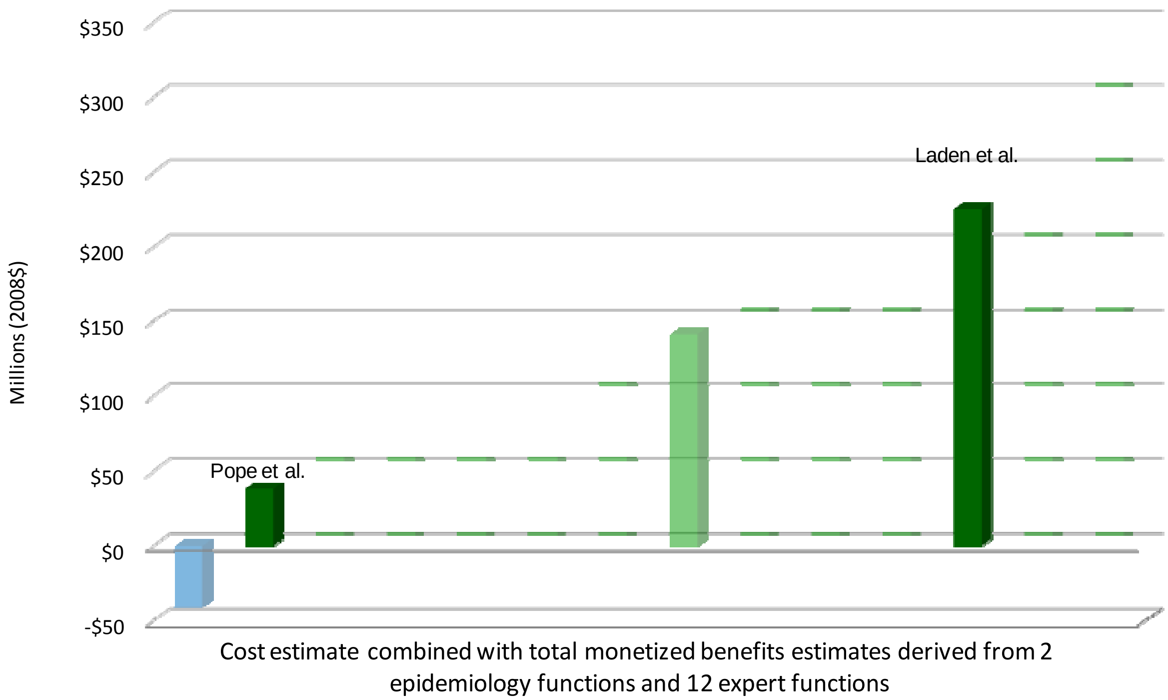

Figure 5-7. Net Benefits for the Proposed SSI NSPS and EG at 3% Discount Rate [a]

[a] Net Benefits are quantified in terms of $PM_{2.5}$ benefits for implementation year (2015). This graph shows 14 benefits estimates combined with the cost estimate. All combinations are treated as independent and equally probable. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. These estimates include energy disbenefits valued at $0.5 million at a 3% discount rate for CO_2 emissions.

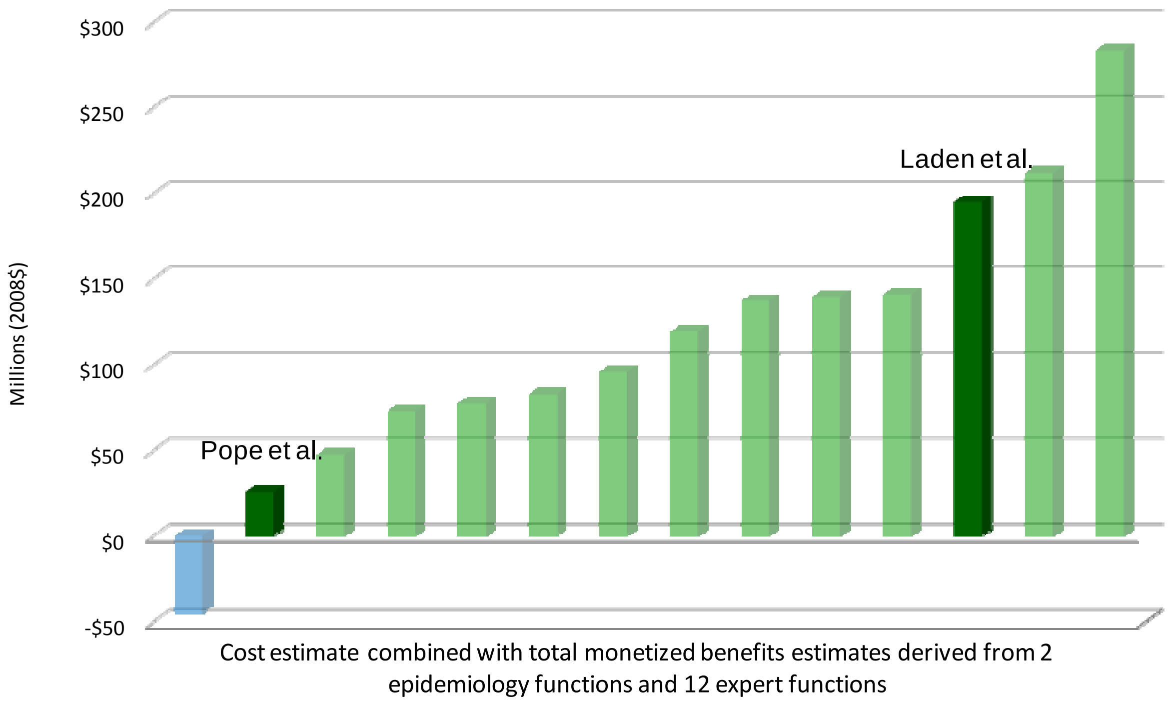

Figure 5-8. Net Benefits for the Proposed SSI NSPS and EG at 7% Discount Rate [a]

[a] Net Benefits are quantified in terms of $PM_{2.5}$ benefits for implementation year (2015). This graph shows 14 benefits estimates combined with the cost estimate. All combinations are treated as independent and equally probable. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. These estimates include energy disbenefits valued at \$0.5 million at a 3% discount rate for CO_2 emissions.

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APPENDIX A

SUMMARY OF EXPERT OPINIONS ON THE EXISTENCE OF A THRESHOLD IN THE CONCENTRATION-RESPONSE FUNCTION FOR $PM_{2.5}$-RELATED MORTALITY

Summary of Expert Opinions on the Existence of a Threshold in the Concentration-Response Function for $PM_{2.5}$-related Mortality

Technical Support Document (TSD)

June 2010

Compiled by:
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Health and Environmental Impact Division
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Contents:

A. HES Comments on 812 Analysis (2010)

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2010. Review of EPA's DRAFT Health Benefits of the Second Section 812 Prospective Study of the Clean Air Act. EPA-COUNCIL-10-001. June. Available on the Internet at <http://yosemite.epa.gov/sab/sabproduct.nsf/0/72D4EFA39E48CDB28525774500738776/$File/EPA-COUNCIL-10-001-unsigned.pdf>.

Pg 2: "The HES generally agrees with other decisions made by the EPA project team with respect to PM, in particular, the PM mortality effect threshold model, the cessation lag model, the inclusion of infant mortality estimation, and differential toxicity of PM."

Pg 2: "Further, the HES fully supports EPA's use of a no-threshold model to estimate the mortality reductions associated with reduced PM exposure."

Pg 6: "The HES also supports the Agency's choice of a no-threshold model for PM-related effects."

Pg 13: "The HES fully supports EPA's decision to use a no-threshold model to estimate mortality reductions. This decision is supported by the data, which are quite consistent in showing effects down to the lowest measured levels. Analyses of cohorts using data from more recent years, during which time PM concentrations have fallen, continue to report strong associations with mortality. Therefore, there is no evidence to support a truncation of the CRF."

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B. Scientific Statement from American Heart Association (2010)

Brook RD, Rajagopalan S, Pope CA 3rd, Brook JR, Bhatnagar A, Diez-Roux AV, Holguin F, Hong Y, Luepker RV, Mittleman MA, Peters A, Siscovick D, Smith SC Jr, Whitsel L, Kaufman JD; on behalf of the American Heart Association Council on Epidemiology and Prevention, Council on the Kidney in Cardiovascular Disease, and Council on Nutrition, Physical Activity and Metabolism. (2010). "Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association." ***Circulation*****. 121: 2331-2378.**

Pg 2338: "Finally, there appeared to be no lower-limit threshold below which PM_{10} was not associated with excess mortality across all regions."

Pg 2350: "There also appears to be a monotonic (e.g., linear or log-linear) concentration-response relationship between $PM_{2.5}$ and mortality risk observed in cohort studies that extends below present-day regulations of 15 $\mu g/m^3$ for mean annual levels, without a discernable "safe" threshold." (cites Pope 2004, Krewski 2009, and Schwartz 2008)

Pg 2364: "The $PM_{2.5}$ concentration– cardiovascular risk relationships for both short- and long-term exposures appear to be monotonic, extending below 15 $\mu g/m^3$ (the 2006 annual NAAQS level) without a discernable "safe" threshold."

Pg 2365: "This updated review by the AHA writing group corroborates and strengthens the conclusions of the initial scientific statement. In this context, we agree with the concept and continue to support measures based on scientific evidence, such as the US EPA NAAQS, that seek to control PM levels to protect the public health. Because the evidence reviewed supports that there is no safe threshold, it appears that public health benefits would accrue from lowering $PM_{2.5}$ concentrations even below present-day annual (15 $\mu g/m^3$) and 24-hour (35 $\mu g/m^3$) NAAQS, if feasible, to optimally protect the most susceptible populations."

Pg 2366: "Although numerous insights have greatly enhanced our understanding of the PM-cardiovascular relationship since the first AHA statement was published, the following list represents broad strategic avenues for future investigation: ... Determine whether any "safe" PM threshold concentration exists that eliminates both acute and chronic cardiovascular effects in healthy and susceptible individuals and at a population level."

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C. Integrated Science Assessment for Particulate Matter (2009)

U.S. Environmental Protection Agency (U.S. EPA). 2009. Integrated Science Assessment for Particulate Matter (Final Report). EPA-600-R-08-139F. National Center for Environmental Assessment – RTP Division. December. Available on the Internet at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546>.

Pg 1-22: "An important consideration in characterizing the public health impacts associated with exposure to a pollutant is whether the concentration-response relationship is linear across the full concentration range encountered, or if nonlinear relationships exist along any part of this range. Of particular interest is the shape of the concentration-response curve at and below the level of the current standards. The shape of the concentration-response curve varies, depending on the type of health outcome, underlying biological mechanisms and dose. At the human population level, however, various sources of variability and uncertainty tend to smooth and "linearize" the concentration-response function (such as the low data density in the lower concentration range, possible influence of measurement error, and individual differences in susceptibility to air pollution health effects). In addition, many chemicals and agents may act by perturbing naturally occurring background processes that lead to disease, which also linearizes population concentration-response relationships (Clewell and Crump, 2005, 156359; Crump et al., 1976, 003192; Hoel, 1980, 156555). These attributes of population dose-response may explain why the available human data at ambient concentrations for some environmental pollutants (e.g., PM, O_3, lead [Pb], ETS, radiation) do not exhibit evident thresholds for health effects, even though likely mechanisms include nonlinear processes for some key events. These attributes of human population dose-response relationships have been extensively discussed in the broader epidemiologic literature (Rothman and Greenland, 1998, 086599)."

Pg 2-16: "In addition, cardiovascular hospital admission and mortality studies that examined the PM_{10} concentration-response relationship found evidence of a log-linear no-threshold relationship between PM exposure and cardiovascular-related morbidity (Section 6.2) and mortality (Section 6.5)."

Pg 2-25: "2.4.3. PM Concentration-Response Relationship
An important consideration in characterizing the PM-morbidity and mortality association is whether the concentration-response relationship is linear across the full concentration range that is encountered or if there are concentration ranges where there are departures from linearity (i.e., nonlinearity). In this ISA studies have been identified that attempt to characterize the shape of the concentration-response curve along with possible PM "thresholds" (i.e., levels which PM concentrations must exceed in order to elicit a health response). The epidemiologic studies evaluated that examined the shape of the concentration-response curve and the potential presence of a threshold have focused on cardiovascular hospital admissions and ED visits and mortality associated with short-term exposure to PM_{10} and mortality associated with long-term exposure to $PM_{2.5}$.

"A limited number of studies have been identified that examined the shape of the PM cardiovascular hospital admission and ED visit concentration-response relationship. Of these studies, some conducted an exploratory analysis during model selection to determine if a linear curve most adequately represented the concentration-response relationship; whereas, only one study conducted an extensive analysis to examine the shape of the concentration-response curve at different concentrations (Section 6.2.10.10). Overall, the limited evidence from the studies evaluated supports the use of a no-threshold, log-linear model, which is consistent with the observations made in studies that examined the PM-mortality relationship.

"Although multiple studies have previously examined the PM-mortality concentration-response relationship and whether a threshold exists, more complex statistical analyses continue to be developed to analyze this association. Using a variety of methods and models, most of the studies evaluated support the use of a no-threshold, log-linear model; however, one study did observe heterogeneity in the shape of the concentration-response curve across cities (Section 6.5). Overall, the studies evaluated further support the use of a no-threshold log-linear model, but additional issues such as the influence of heterogeneity in estimates between cities, and the effect of seasonal and regional differences in PM on the concentration-response relationship still require further investigation.

"In addition to examining the concentration-response relationship between short-term exposure to PM and mortality, Schwartz et al. (2008, 156963) conducted an analysis of the shape of the concentration-response relationship associated with long-term exposure to PM. Using a variety of statistical methods, the concentration-response curve was found to be indistinguishable from linear, and, therefore, little evidence was observed to suggest that a threshold exists in the association between long-term exposure to $PM_{2.5}$ and the risk of death (Section 7.6)."

Pg 6-75: "6.2.10.10. Concentration Response
The concentration-response relationship has been extensively analyzed primarily through studies that examined the relationship between PM and mortality. These studies, which have focused on short- and long-term exposures to PM have consistently found no evidence for deviations from linearity or a safe threshold (Daniels et al., 2004, 087343; Samoli et al., 2005, 087436; Schwartz, 2004, 078998; Schwartz et al., 2008, 156963) (Sections 6.5.2.7 and 7.1.4). Although on a more limited basis, studies that have examined PM effects on cardiovascular hospital admissions and ED visits have also analyzed the PM concentration-response relationship, and contributed to the overall body of evidence which suggests a log-linear, no-threshold PM concentration-response relationship.

"The results from the three multicity studies discussed above support no-threshold log-linear models, but issues such as the possible influence of exposure error and heterogeneity of shapes across cities remain to be resolved. Also, given the pattern of seasonal and regional differences in PM risk estimates depicted in recent multicity study results (e.g., Peng et al., 2005, 087463), the very concept of a concentration-response relationship estimated across cities and for all-year data may not be very informative."

Pg 6-197: "6.5.2.7. Investigation of Concentration-Response Relationship
The results from large multicity studies reviewed in the 2004 PM AQCD (U.S. EPA, 2004, 056905) suggested that strong evidence did not exist for a clear threshold for PM mortality effects. However, as discussed in the 2004 PM AQCD (U.S. EPA, 2004, 056905), there are

several challenges in determining and interpreting the shape of PM-mortality concentration-response functions and the presence of a threshold, including: (1) limited range of available concentration levels (i.e., sparse data at the low and high end); (2) heterogeneity of susceptible populations; and (3) investigate the PM-mortality concentration-response relationship.

"Daniels et al. (2004, 087343) evaluated three concentration-response models: (1) log-linear models (i.e., the most commonly used approach, from which the majority of risk estimates are derived); (2) spline models that allow data to fit possibly non-linear relationship; and (3) threshold models, using PM_{10} data in 20 cities from the 1987-1994 NMMAPS data. They reported that the spline model, combined across the cities, showed a linear relation without indicating a threshold for the relative risks of death for all-causes and for cardiovascular-respiratory causes in relation to PM_{10}, but "the other cause" deaths (i.e., all cause minus cardiovascular-respiratory) showed an apparent threshold at around 50 $\mu g/m^3$ PM^{10}, as shown in Figure 6-35. For all-cause and cardio-respiratory deaths, based on the Akaike's Information Criterion (AIC), a log-linear model without threshold was preferred to the threshold model and to the spline model.

"The HEI review committee commented that interpretation of these results required caution, because (1) the measurement error could obscure any threshold; (2) the city-specific concentration-response curves exhibited a variety of shapes; and (3) the use of AIC to choose among the models might not be appropriate due to the fact it was not designed to assess scientific theories of etiology. Note, however, that there has been no etiologically credible reason suggested thus far to choose one model over others for aggregate outcomes. Thus, at least statistically, the result of Daniels et al. (2004, 087343) suggests that the log-linear model is appropriate in describing the relationship between PM10 and mortality.

"The Schwartz (2004, 078998) analysis of PM_{10} and mortality in 14 U.S. cities, described in Section 6.5.2.1, also examined the shape of the concentration-response relationship by including indicator variables for days when concentrations were between 15 and 25 $\mu g/m^3$, between 25 and 34 $\mu g/m^3$, between 35 and 44 $\mu g/m^3$, and 45 $\mu g/m^3$ and above. In the model, days with concentrations below 15 $\mu g/m^3$ served as the reference level. This model was fit using the single stage method, combining strata across all cities in the case-crossover design. Figure 6-36 shows the resulting relationship, which does not provide sufficient evidence to suggest that a threshold exists. The authors did not examine city-to-city variation in the concentration-response relationship in this study.

"PM_{10} and mortality in 22 European cities (and BS in 15 of the cities) participating in the APHEA project. In nine of the 22 cities, PM10 levels were estimated using a regression model relating co-located PM10 to BS or TSP. They used regression spline models with two knots (30 and 50 $\mu g/m^3$) and then combined the individual city estimates of the splines across cities. The investigators concluded that the association between PM and mortality in these cities could be adequately estimated using the log-linear model. However, in an ancillary analysis of the concentration-response curves for the largest cities in each of the three distinct geographic areas (western, southern, and eastern European cities): London, England; Athens, Greece; and Cracow, Poland, Samoli et al. (2005, 087436) observed a difference in the shape of the concentration-response curve across cities. Thus, while the combined curves (Figure 6-37) appear to support no-threshold relationships between PM_{10} and mortality, the heterogeneity of the shapes across cities makes it difficult to interpret the biological relevance of the shape of the combined curves.

“The results from the three multicity studies discussed above support no-threshold log-linear models, but issues such as the possible influence of exposure error and heterogeneity of shapes across cities remain to be resolved. Also, given the pattern of seasonal and regional differences in PM risk estimates depicted in recent multicity study results (e.g., Peng et al., 2005, 087463), the very concept of a concentration-response relationship estimated across cities and for all-year data may not be very informative.”

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D. CASAC comments on PM ISA and REA (2009)

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2009. Review of EPA's Integrated Science Assessment for Particulate Matter (First External Review Draft, December 2008). EPA-COUNCIL-09-008. May. Available on the Internet at <http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/73ACCA834AB44A10852575BD0064346B/$File/EPA-CASAC-09-008-unsigned.pdf>.

Pg 9: "There is an appropriate discussion of the time-series studies, but this section needs to have an explicit finding that the evidence supports a relationship between PM and mortality that is seen in these studies. This conclusion should be followed by the discussion of statistical methodology and the identification of any threshold that may exist."

U.S. Environmental Protection Agency Science Advisory Board (U.S. EPA-SAB). 2009. Consultation on EPA's Particulate Matter National Ambient Air Quality Standards: Scope and Methods Plan for Health Risk and Exposure Assessment. EPA-COUNCIL-09-009. May. Available on the Internet at <http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/723FE644C5D758DF852575BD00763A32/$File/EPA-CASAC-09-009-unsigned.pdf>.

Pg 6: "On the issue of cut-points raised on 3-18, the authors should be prepared to offer a scientifically cogent reason for selection of a specific cut-point, and not simply try different cut-points to see what effect this has on the analysis. The draft ISA was clear that there is little evidence for a population threshold in the C-R function."

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2009. Review of *Integrated Science Assessment for Particulate Matter (Second External Review Draft, July 2009)*. EPA-CASAC-10-001. November. Available on the Internet at <http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/151B1F83B023145585257678006836B9/$File/EPA-CASAC-10-001-unsigned.pdf>.

Pg 2: "The paragraph on lines 22-30 of page 2-37 is not clearly written. Twice in succession it states that the use of a no-threshold log-linear model is supported, but then cites other studies that suggest otherwise. It would be good to revise this paragraph to more clearly state – well, I'm not sure what. Probably that more research is needed."

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Mr. Charles Thomas (Tom) Moore, Jr., Air Quality Program Manager, Western Governors' Association, Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, CO

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Dr. Donna Kenski, Data Analysis Director, Lake Michigan Air Directors Consortium, Rosemont, IL

Dr. Kathy Weathers, Senior Scientist, Cary Institute of Ecosystem Studies, Millbrook, NY

E. Krewski et al. (2009)

Krewski, Daniel, Michael Jerrett, Richard T. Burnett, Renjun Ma, Edward Hughes, Yuanli Shi, Michelle C. Turner, C. Arden Pope III, George Thurston, Eugenia E. Calle, and Michael J. Thun with Bernie Beckerman, Pat DeLuca, Norm Finkelstein, Kaz Ito, D.K. Moore, K. Bruce Newbold, Tim Ramsay, Zev Ross, Hwashin Shin, and Barbara Tempalski. (2009). Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. *HEI Research Repor*t, 140, Health Effects Institute, Boston, MA.

Pg 119: [About Pope et al. (2002)] "Each 10-μg/m^3 increase in long-term average ambient $PM_{2.5}$ concentrations was associated with approximately a 4%, 6%, or 8% increase in risk of death from all causes, cardiopulmonary disease, and lung cancer, respectively. There was no evidence of a threshold exposure level within the range of observed $PM_{2.5}$ concentrations."

Krewski (2009). Letter from Dr. Daniel Krewski to HEI's Dr. Kate Adams (dated July 7, 2009) regarding "EPA queries regarding HEI Report 140". Dr. Adams then forwarded the letter on July 10, 2009 to EPA's Beth Hassett-Sipple. (letter placed in docket #EPA-HQ-OAR-2007-0492).

Pg 4: "6. The Health Review Committee commented that the Updated Analysis completed by Pope et al. 2002 reported "no evidence of a threshold exposure level within the range of observed $PM_{2.5}$ concentrations" (p. 119). In the Extended Follow-Up study, did the analyses provide continued support for a no-threshold response or was there evidence of a threshold?

"Response: As noted above, the HEI Health Review Committee commented on the lack of evidence for a threshold exposure level in Pope et al. (2002) with follow-up through the year 1998. The present report, which included follow-up through the year 2000, also does not appear to demonstrate the existence of a threshold in the exposure-response function within the range of observed $PM_{2.5}$ concentrations."

<u>HEI Health Review Committee Members</u>

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Dr. Mark W. Frampton, MD, Professor of Medicine & Environmental Medicine, University of Rochester Medical Center, Rochester, NY

Dr. Stephanie London, MD, PhD, Senior Investigator, Epidemiology Branch, National Institute of Environmental Health Sciences

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Dr. Lianne Sheppard, PhD, Professor, Department of Biostatistics, University of Washington

F. Schwartz et al. (2008)

Schwartz J, Coull B, Laden F. (2008). The Effect of Dose and Timing of Dose on the Association between Airborne Particles and Survival. *Environmental Health Perspectives*. 116: 64-69.

Pg 67: "A key finding of this study is that there is little evidence for a threshold in the association between exposure to fine particles and the risk of death on follow-up, which continues well below the U.S. EPA standard of 15 $\mu g/m^3$."

Pg 68: "In conclusion, penalized spline smoothing and model averaging represent reasonable, feasible approaches to addressing questions of the shape of the exposure–response curve, and can provide valuable information to decisionmakers. In this example, both approaches are consistent, and suggest that the association of particles with mortality has no threshold down to close to background levels."

G. Expert Elicitation on PM-Mortality (2006, 2008)

Industrial Economics, Inc., 2006. *Expanded Expert Judgment Assessment of the Concentration-Response Relationship Between $PM_{2.5}$ Exposure and Mortality*. Prepared for the U.S.EPA, Office of Air Quality Planning and Standards, September. Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/Uncertainty/pm_ee_report.pdf>.

Pg v: "Each expert was given the option to integrate their judgments about the likelihood of a causal relationship and/or threshold in the C-R function into his distribution or to provide a distribution "conditional on" one or both of these factors."

Pg vii: "Only one of 12 experts explicitly incorporated a threshold into his C-R function.[3] The rest believed there was a lack of empirical and/or theoretical support for a population threshold. However, three other experts gave differing effect estimate distributions above and below some cut-off concentration. The adjustments these experts made to median estimates and/or uncertainty at lower $PM^{2.5}$ concentrations were modest."

> "[3] Expert K indicated that he was 50 percent sure that a threshold existed. If there were a threshold, he thought that there was an 80 percent chance that it would be less than or equal to 5 $\mu g/m^3$, and a 20 percent chance that it would fall between 5 and 10 $\mu g/m^3$."

Pg ix: "Compared to the pilot study, experts in this study were in general more confident in a causal relationship, less likely to incorporate thresholds, and reported higher mortality effect estimates. The differences in results compared with the pilot appear to reflect the influence of new research on the interpretation of the key epidemiological studies that were the focus of both elicitation studies, more than the influence of changes to the structure of the protocol."

Pg 3-25: "3.1.8 THRESHOLDS
The protocol asked experts for their judgments regarding whether a threshold exists in the $PM_{2.5}$ mortality C-R function. The protocol focused on assessing expert judgments regarding theory and evidential support for a population threshold (i.e., the concentration below which no member of the study population would experience an increased risk of death).[32] If an expert wished to incorporate a threshold in his characterization of the concentration-response relationship, the team then asked the expert to specify the threshold $PM_{2.5}$ concentration probabilistically, incorporating his uncertainty about the true threshold level.

"From a theoretical and conceptual standpoint, all experts generally believed that individuals exhibit thresholds for PM-related mortality. However, 11 of them discounted the idea of a population threshold in the C-R function on a theoretical and/or empirical basis. Seven of these experts noted that theoretically one would be unlikely to observe a population threshold due to the variation in susceptibility at any given time in the study population resulting from combinations of genetic, environmental, and socioeconomic factors.[33] All 11 thought that there was insufficient empirical support for a population threshold in the C-R function. In addition, two experts (E and L) cited analyses of the ACS cohort data in Pope et al. (2002) and another (J) cited Krewski et al. (2000a & b) as supportive of a linear relationship in the study range.

“Seven of the experts favored epidemiological studies as ideally the best means of addressing the population threshold issue, because they are best able to evaluate the full range of susceptible individuals at environmentally relevant exposure levels. However, those who favored epidemiologic studies generally acknowledged that definitive studies addressing thresholds would be difficult or impossible to conduct, because they would need to include a very large and diverse population with wide variation in exposure and a long follow-up period. Furthermore, two experts (B and I) cited studies documenting difficulties in detecting a threshold using epidemiological studies (Cakmak et al. 1999, and Brauer et al., 2002, respectively). The experts generally thought that clinical and toxicological studies are best suited for researching mechanisms and for addressing thresholds in very narrowly defined groups. One expert, B, thought that a better understanding of the detailed biological mechanism is critical to addressing the question of a threshold.

“One expert, K, believed it was possible to make a conceptual argument for a population threshold. He drew an analogy with smoking, indicating that among heavy smokers, only a proportion of them gets lung cancer or demonstrates an accelerated decline in lung function. He thought that the idea that there is no level that is biologically safe is fundamentally at odds with toxicological theory. He did not think that a population threshold was detectable in the currently available epidemiologic studies. He indicated that some of the cohort studies showed greater uncertainty in the shape of the C-R function at lower levels, which could be indicative of a threshold.

“Expert K chose to incorporate a threshold into his C-R function. He indicated that he was 50 percent sure that a threshold existed. If there were a threshold, he thought that there was an 80 percent chance that it would be less than or equal to 5 $\mu g/m^3$, and a 20 percent chance that it would fall between 5 and 10 $\mu g/m^3$.”

Roman, Henry A., Katherine D. Walker, Tyra L. Walsh, Lisa Conner, Harvey M. Richmond, Bryan J. Hubbell, and Patrick L. Kinney. (2008). “Expert Judgment Assessment of the Mortality Impact of Changes in Ambient Fine Particulate Matter in the U.S.” *Environ. Sci. Technol.*, 42(7):2268-2274.

Pg 2271: “Eight experts thought the true C-R function relating mortality to changes in annual average $PM_{2.5}$ was log-linear across the entire study range (ln(mortality)) β × PM). Four experts (B, F, K, and L) specified a “piecewise” log-linear function, with different β coefficients for PM concentrations above and below an expert-specified break point. This approach allowed them to express increased uncertainty in mortality effects seen at lower concentrations in major epidemiological studies. Expert K thought the relationship would be log-linear above a threshold.”

Pg 2271: “Expert K also applied a threshold, T, to his function, which he described probabilistically. He specified $P(T > 0) = 0.5$. Given $T > 0$, he indicated $P(T \leq 5\ \mu g/m^3) = 0.8$ and $P(5\ \mu g/m^3 < T \leq 10\ \mu g/m^3) = 0.2$. Figure 3 does not include the impact of applying expert K’s threshold, as the size of the reduction in benefits will depend on the distribution of baseline PM levels in a benefits analysis.”

Experts:

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Dr. Dan Krewski, University of Ottawa

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Dr. Morton Lippmann, Professor, Nelson Institute of Environmental Medicine, New York University School of Medicine, Tuxedo, NY

Dr. Joe Mauderly, Lovelace Respiratory Research Institute

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Dr. Arden Pope, Professor, Department of Economics, Brigham Young University, Provo, UT

Dr. Richard Schlesinger, Pace University

Dr. Joel Schwartz, Harvard School of Public Health

Dr. George Thurston—Department of Environmental Medicine, NYU, Tuxedo, NY

Dr. Mark Utell, University of Rochester School of Medicine and Dentistry

H. CASAC comments on PM Staff Paper (2005)

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2005. EPA's Review of the National Ambient Air Quality Standards for Particulate Matter (Second Draft PM Staff Paper, January 2005). EPA-SAB-CASAC-05-007. June. Available on the Internet at <http://yosemite.epa.gov/sab/sabproduct.nsf/E523DD36175EB5AD8525701B007332AE/$File/SAB-CASAC-05-007_unsigned.pdf>.

Pg 6: "A second concern is with methodological issues. The issue of the selection of concentration-response (C-R) relationships based on locally-derived coefficients needs more discussion. The Panel did not agree with EPA staff in calculating the burden of associated incidence in their risk assessment using either the predicted background or the lowest measured level (LML) in the utilized epidemiological analysis. The available epidemiological database on daily mortality and morbidity does not establish either the presence or absence of threshold concentrations for adverse health effects. Thus, in order to avoid emphasizing an approach that assumes effects that extend to either predicted background concentrations or LML, and to standardize the approach across cities, for the purpose of estimating public health impacts, the Panel favored the primary use of an assumed threshold of 10 $\mu g/m^3$. The original approach of using background or LML, as well as the other postulated thresholds, could still be used in a sensitivity analysis of threshold assumptions.

"The analyses in this chapter highlight the impact of assumptions regarding thresholds, or lack of threshold, on the estimates of risk. The uncertainty associated with threshold or nonlinear models needs more thorough discussion. A major research need is for more work to determine the existence and level of any thresholds that may exist or the shape of nonlinear concentration-response curves at low levels of exposure that may exist, and to reduce uncertainty in estimated risks at the lowest PM concentrations."

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I. HES Comments on 812 Analysis (2004)

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2004. Advisory on Plans for Health Effects Analysis in the Analytical Plan for EPA's Second Prospective Analysis – Benefits and Costs of the Clean Air Act, 1990-2020. Advisory by the Health Effects Subcommittee of the Advisory Council on Clean Air Compliance Analysis. EPA-SAB-COUNCIL-ADV-04-002. March. Available on the Internet at <http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/08E1155AD24F871C85256E5400433D5D/$File/council_adv_04002.pdf>.

Pg 20: "The Subcommittee agrees that the whole range of uncertainties, such as the questions of causality, shape of C-R functions and thresholds, relative toxicity, years of life lost, cessation lag structure, cause of death, biologic pathways, or susceptibilities may be viewed differently for acute effects versus long-term effects.

"For the studies of long-term exposure, the HES notes that Krewski et al. (2000) have conducted the most careful work on this issue. They report that the associations between $PM_{2.5}$ and both all-cause and cardiopulmonary mortality were near linear within the relevant ranges, with no apparent threshold. Graphical analyses of these studies (Dockery et al., 1993, Figure 3 and Krewski et al., 2000, page 162) also suggest a continuum of effects down to lower levels. Therefore, it is reasonable for EPA to assume a no threshold model down to, at least, the low end of the concentrations reported in the studies."

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J. NRC – Committee on Estimating the Health Risk Reduction Benefits of Proposed Air Pollution Regulations (2002)

National Research Council (NRC). 2002. Estimating the Public Health Benefits of Proposed Air Pollution Regulations. Washington, DC: The National Academies Press.

Pg 109: "**Linearity and Thresholds**

"The shape of the concentration-response functions may influence the overall estimate of benefits. The shape is particularly important for lower ambient air pollution concentrations to which a large portion of the population is exposed. For this reason, the impact of the existence of a threshold may be considerable.

"In epidemiological studies, air pollution concentrations are usually measured and modeled as continuous variables. Thus, it may be feasible to test linearity and the existence of thresholds, depending on the study design. In time-series studies with the large number of repeated measurements, linearity and thresholds have been formally addressed with reasonable statistical power. For pollutants such as PM_{10} and $PM_{2.5}$, there is no evidence for any departure of linearity in the observed range of exposure, nor any indication of a threshold. For example, examination of the mortality effects of short-term exposure to PM_{10} in 88 cities indicates that the concentration-response functions are not due to the high concentrations and that the slopes of these functions do not appear to increase at higher concentrations (Samet et al. 2000). Many other mortality studies have examined the shape of the concentration-response function and indicated that a linear (nonthreshold) model fit the data well (Pope 2000). Furthermore, studies conducted in cities with very low ambient pollution concentrations have similar effects per unit change in concentration as those studies conducted in cities with higher concentrations. Again, this finding suggests a fairly linear concentration-response function over the observed range of exposures.

"Regarding the studies of long-term exposure, Krewski et al. (2000) found that the assumption of a linear concentration-response function for mortality outcomes was not unreasonable. However, the statistical power to assess the shape of these functions is weakest at the upper and lower end of the observed exposure ranges. Most of the studies examining the effects of long-term exposure on morbidity compare subjects living in a small number of communities (Dockery et al. 1996; Ackermmann-Liebrich 1997; Braun-Fahrländer et al. 1997). Because the number of long-term effects studies are few and the number of communities studied is relatively small (8 to 24), the ability to test formally the absence or existence of a no-effect threshold is not feasible. However, even if thresholds exist, they may not be at the same concentration for all health outcomes.

"A review of the time-series and cohort studies may lead to the conclusion that although a threshold is not apparent at commonly observed concentrations, one may exist at lower levels. An important point to acknowledge regarding thresholds is that for health benefits analysis a key threshold is the population threshold (the lowest of the individual thresholds). However, the population threshold would be very difficult to observe empirically through epidemiology, because epidemiology integrates information from very large groups of people (thousands). Air pollution regulations affect even larger groups of people (millions). It is reasonable to assume that among such large groups susceptibility to air pollution health effects varies considerably across individuals and depends on a large set of underlying factors, including genetic makeup, age, exposure measurement error, preexisting disease, and simultaneous exposures from smoking and occupational hazards. This variation in individual susceptibilities and the resulting distribution of individual thresholds underlies the concentration-response function observed in epidemiology. Thus, until biologically based models of the distribution of individual thresholds are developed, it may be productive to assume that the population concentration-response function is continuous and to focus on finding evidence of changes in its slope as one approaches lower concentrations.

EPA's Use of Thresholds

"In EPA's benefits analyses, threshold issues were discussed and interpreted. For the PM and ozone National Ambient Air Quality Standards (NAAQS), EPA investigated the effects of a potential threshold or reference value below which health consequences were assumed to be zero (EPA 1997). Specifically, the high-end benefits estimate assumed a 12-microgram per cubic meter ($\mu g/m^3$) mean threshold for mortality associated with long-term exposure to $PM_{2.5}$. The low-end benefits estimate assumed a 15-$\mu g/m^3$ threshold for all PM-related health effects. The studies, however, included concentrations as low as 7.5 $\mu g/m^3$. For the Tier 2 rule and the HD engine and diesel-fuel rule, no threshold was assumed (EPA 1999, 2000). EPA in these analyses acknowledged that there was no evidence for a threshold for PM.

"Several points should be noted regarding the threshold assumptions. If a threshold is assumed where one was not apparent in the original study, then the data should be refit and a new curve generated with the assumption of a zero slope over a segment of the concentration-response function that was originally found to be positively sloped. The assumption of a zero slope over a portion of the curve will force the slope in the remaining segment of the positively sloped concentration-response function to be greater than was indicated in the original study. A new concentration-response function was not generated for EPA's benefits analysis for the PM and ozone NAAQS for which threshold assumptions were made. The generation of the steeper slope in the remaining portion of the concentration-response function may fully offset the effect of assuming a threshold. These aspects of assuming a threshold in a benefits analysis where one was not indicated in the original study should be conveyed to the reader. The committee notes that the treatment of thresholds should be evaluated in a consistent and transparent framework by using different explicit assumptions in the formal uncertainty analyses (see Chapter 5)."

Pg 117: "Although the assumption of no thresholds in the most recent EPA benefits analyses was appropriate, EPA should evaluate threshold assumptions in a consistent and transparent framework using several alternative assumptions in the formal uncertainty analysis."

Pg 136: "Two additional illustrative examples are thresholds for adverse effects and lag structures.[2] EPA considers implausible any threshold for mortality in the particulate matter (PM) exposure ranges under consideration (EPA 1999a, p. 3-8). Although the agency conducts sensitivity analyses incorporating thresholds, it provides no judgment as to their relative plausibility. In a probabilistic uncertainty analysis, EPA could assign appropriate weights to various threshold models. For PM-related mortality in the Tier 2 analysis, the committee expects that this approach would have resulted in only a slight widening of the probability distribution for avoided mortality and a slight reduction in the mean of that distribution, thus reflecting EPA's views about the implausibility of thresholds. The committee finds that such formal incorporation of EPA's expert judgments about the plausibility of thresholds into its primary analysis would have been an improvement.

"Uncertainty about thresholds is a special aspect of uncertainty about the shape of concentration-response functions. Typically, EPA and authors of epidemiological studies assume that these functions are linear on some scale. Often, the scale is a logarithmic transformation of the risk or rate of the health outcome, but when a rate or risk is low, a linear function on the logarithmic scale is approximately linear on the scale of the rate or risk itself. Increasingly, epidemiological investigators are employing analytic methods that permit the estimation of nonlinear shapes for concentration-response functions (Greenland et al. 1999). As a consequence, EPA will need to be prepared to incorporate nonlinear concentration-response functions from epidemiological studies into the agency's health benefits analyses. Any source of error or bias that can distort an epidemiological association can also distort the shape of an estimated concentration -response function, as can variation in individual susceptibility (Hattis and Burmaster 1994; Hattis et al. 2001)."

Pg 137: "In principle, many components of the health benefits model need realistic probabilistic models (see Table 5-1 for a listing of such components), in addition to concentration-response thresholds and time lags between exposure and response. For example, additional features of the concentration-response function—such as projection of the results from the study population to the target populations (which may have etiologically relevant characteristics outside the range seen in the study population) and the projection of baseline frequencies of morbidity and mortality into the future—must be characterized probabilistically. Other uncertainties that might affect the probability distributions are the estimations of population exposure (or even concentration) from emissions, estimates of emissions themselves, and the relative toxicity of various classes of particles. Similarly, many aspects of the analysis of the impact of regulation on ambient concentrations and on population exposure involve considerable uncertainty and, therefore, may be beneficially modeled in this way. Depending on the analytic approach used, joint probability distributions will have to be specified to incorporate correlations between model components that are structurally dependent upon each other, or the analysis will have to be conducted in a sequential fashion that follows the model for the data-generating process.

"EPA should explore alternative options for incorporating expert judgment into its probabilistic uncertainty analyses. The agency possesses considerable internal expertise, which should be employed as fully as possible. Outside experts should also be consulted as needed, individually or in panels. In all cases, when expert judgment is used in the construction of a model component, the experts should be identified and the rationales and empirical bases for their judgments should be made available."

NRC members

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APPENDIX B

LOWEST MEASURED LEVEL (LML) ASSESSMENT FOR RULES WITHOUT POLICY-SPECIFIC AIR QUALITY DATA AVAILABLE: TECHNICAL SUPPORT DOCUMENT (TSD)

Lowest Measured Level (LML) Assessment for Rules without Policy-Specific Air Quality Data Available

Technical Support Document (TSD)

June 2010

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Health and Environmental Impact Division
Air Benefit-Cost Group
Research Triangle Park, North Carolina

Inherent in any complex Regulatory Impact Analysis (RIA) are multiple sources of uncertainty. Health benefits analysis relies on an array of data inputs—including air quality modeling, health impact functions and valuation estimates among others—which are themselves subject to uncertainty and may also in turn contribute to the overall uncertainty in this analysis. There are a variety of methods to characterizing the uncertainty associated with the human health benefits of air pollution, including quantitative and qualitative methods. When evaluated within the context of these uncertainties, the health impact and monetized benefits estimates in an RIA can provide useful information regarding the magnitude of the public health impacts attributable to reducing air pollution.

Reductions in premature mortality typically dominate the size of the overall monetized benefits. Therefore, most of the uncertainty characterization generally focuses on the mortality-related benefits. Typically, EPA employs two primary techniques for quantifying this uncertainty. First, because this characterization of random statistical error may omit important sources of uncertainty, we employ the results of an expert elicitation on the relationship between premature mortality and ambient $PM_{2.5}$ concentration (Roman et al., 2008); this provides additional insight into the likelihood of different outcomes and about the state of knowledge regarding the benefits estimates. Second, when we have air quality modeling specific to the policy we are evaluating and it can be used as an input to the health impact and economic analysis, we use Monte Carlo methods for characterizing random sampling error associated with the concentration response functions from epidemiological studies and economic valuation functions.[1] Both approaches have different strengths and weaknesses, which are fully described in Chapter 5 of the PM NAAQS RIA (U.S. EPA, 2006).

In addition, some RIAs, including the PM NAAQS RIA (2006d) and Ozone NAAQS RIA (2008a), also contain a suite of sensitivity analyses that evaluate the sensitivity of the monetized benefits to the specification of alternate mortality cessation lags and income growth adjustment factors. Cessation lags and income growth adjustments are simply multipliers applied to the valuation function, which generally affect monetized benefits estimates in the same manner. Thus, it is possible for readers to infer the sensitivity of these parameters by referring to those previous analyses.[2] Other RIAs contain unique sensitivity analyses that are specific to the

[1] Currently, we are unable to characterize the random sampling error from the underlying studies when applying national average benefit-per-ton estimates.

[2] For example, in the PM NAAQS RIA, the use of an alternate lag structure would change the $PM_{2.5}$-related mortality benefits discounted at 3% discounted by between 10.4% and –27%; when discounted at 7%, these

input parameters of that analysis, such as blood lead level (U.S. EPA, 2008b) or rollback method (U.S. EPA, 2010a). Other sources of uncertainty, including the projection of atmospheric conditions and source-level emissions, the projection of baseline morbidity rates, incomes and technological development are typically unquantified in our RIAs. For these sources, we typically provide a qualitative uncertainty characterization associated with these input parameters.

One particular aspect of uncertainty has received extensive quantitative and qualitative attention in recent RIAs: the existence of a threshold in the concentration-response function for $PM_{2.5}$-related mortality. A threshold is a specific type of discontinuity in the concentration-response function where there are no benefits associated with reducing $PM_{2.5}$ levels in areas where the baseline air quality is less than the threshold. Previously, EPA had included a sensitivity analysis with an arbitrary assumed threshold at 10 $\mu g/m^3$ in the PM-mortality health impact function in the RIA to illustrate that the fraction of benefits that occur at lower air pollution concentration levels are inherently more uncertain. A threshold of 10 $\mu g/m^3$ does not necessarily have any stronger technical basis than any other threshold, and we could have instead assumed a threshold at 4, 7.5, or 12 $\mu g/m^3$ for the sensitivity analysis. In addition to identifying the most support for a non-threshold model, the underlying scientific evidence does not support any specific "bright line".

Based on our review of the current body of scientific literature, EPA now estimates PM-related mortality without applying an assumed concentration threshold. EPA's Integrated Science Assessment for Particulate Matter (U.S. EPA, 2009b), which was recently reviewed by EPA's Clean Air Scientific Advisory Committee (U.S. EPA-SAB, 2009a; U.S. EPA-SAB, 2009b), concluded that the scientific literature consistently finds that a no-threshold log-linear model most adequately portrays the PM-mortality concentration-response relationship while recognizing potential uncertainty about the exact shape of the concentration-response function.[1] Since then, the Health Effects Subcommittee (U.S. EPA-SAB, 2010) of EPA's Council concluded, "The HES fully supports EPA's decision to use a no-threshold model to estimate mortality reductions. This decision is supported by the data, which are quite consistent in

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benefits change by between 31% and -49%. When applying higher and lower income growth adjustments, the monetary value of $PM_{2.5}$ and ozone-related premature changes between 30% and -10%; the value of chronic endpoints change between 5% and -2% and the value of acute endpoints change between 6% and -7%. (U.S. EPA, 2006)

[1]It is important to note that uncertainty regarding the shape of the concentration-response function is conceptually distinct from an assumed threshold. An assumed threshold (below which there are no health effects) is a discontinuity, which is a specific example of non-linearity.

showing effects down to the lowest measured levels. Analyses of cohorts using data from more recent years, during which time PM concentrations have fallen, continue to report strong associations with mortality. Therefore, there is no evidence to support a truncation of the CRF." For a summary of these scientific review statements and the panel members please consult the Technical Support Document (TSD) Summary of Expert Opinions on the Existence of a Threshold (U.S. EPA, 2010c).

Consistent with this finding, we have conformed the previous threshold sensitivity analysis to the current state of the PM science by incorporating a new "Lowest Measured Level" (LML) assessment. While an LML assessment provides some insight into the level of uncertainty in the estimated PM mortality benefits, EPA does not view the LML as a threshold and continues to quantify PM-related mortality impacts using a full range of modeled air quality concentrations. Unlike an assumed threshold, which is a modeling assumption that reduces the magnitude of the estimated health impacts, the LML is a characterization of the fraction of benefits that are more uncertain. It is important to emphasize that just because we have greater confidence in the benefits above the LML, this does not mean that we have no confidence that benefits occur below the LML.

While the LML of each study is important to consider when characterizing and interpreting the overall level PM-related benefits, EPA believes that large cohort-based mortality estimates are suitable for use in air pollution health impact analyses. When estimating PM mortality impacts using risk coefficients drawn from the Harvard Six Cities and the American Cancer Society cohorts there are innumerable other attributes that may affect the size of the reported risk estimates—including differences in population demographics, the size of the cohort, activity patterns and particle composition among others. The LML assessment provides a limited representation of one key difference between the two studies. For the purpose of estimating the benefits associated with reducing $PM_{2.5}$ levels, we utilize the effect coefficients from Pope et al. (2002) for the American Cancer Society cohort and from Laden et al. (2006) for the Harvard Six Cities cohort.

Analyses of these cohorts using data from more recent years, during which time PM concentrations have fallen, continue to report strong associations with mortality. For example, the Krewski et al. (2009) follow-up study of the American Cancer Society cohort had an LML of 5.8 $\mu g/m^3$. As we model mortality impacts among populations exposed to levels of $PM_{2.5}$ that are successively lower than the LML of each study, our confidence in the results diminishes. As air pollution emissions continue to decrease over time, there will be more people in areas where we do not have published epidemiology studies. However, each successive cohort study has shown evidence of effects at successively lower levels of $PM_{2.5}$. As more large cohort studies follow populations over time, we will likely have more studies with lower LML as air quality levels continue to improve. Even in the absence of a definable threshold, we have more confidence in the benefits estimates above the LML of the large cohort studies. To account for the uncertainty in each of the studies that we base our mortality estimates on, we provide the LML for each of the cohort studies. However, the finding of effects at the lowest LML from the recent Krewski et al (2009) study indicates that confidence in $PM_{2.5}$-related mortality effects down to at least 5.8 $\mu g/m^3$ is high.

In the recently proposed Transport Rule RIA (U.S. EPA, 2010b), we included the new LML assessment in which we binned the estimated number of avoided $PM_{2.5}$-related premature mortalities resulting from the implementation of the Transport Rule according to the projected 2014 baseline $PM_{2.5}$ air quality levels. This presentation is consistent with our approach to applying $PM_{2.5}$ mortality risk coefficients that have not been adjusted to incorporate an assumed threshold. A very large proportion of the avoided PM-related impacts occurred among populations initially exposed at or above the LML of each study, which gave us a high level of confidence in the PM mortality estimates. This assessment summarized the distribution of avoided PM mortality impacts according to the baseline $PM_{2.5}$ levels experienced by the population receiving the $PM_{2.5}$ mortality benefit. Approximately 80% of the avoided impacts occurred at or above a baseline annual mean $PM_{2.5}$ level of 10 $\mu g/m^3$ (the LML of the Laden et al. 2006 study); about 97% occur at or above an annual mean $PM_{2.5}$ level of 7.5 $\mu g/m^3$ (the LML of the Pope et al. 2002 study). This assessment confirmed that the great majority of the impacts associated with the Transport Rule occurred at or above each study's LML.

For the Transport Rule, policy-specific air quality modeling data for the year 2014 was available as an input into the benefits analysis. For some rules, especially New Source Performance Standards (NSPS) or National Emissions Standards for Hazardous Air Pollutant (NESHAP) rules, policy-specific air quality data is not available due to time or resource limitations. For these rules, we provide the following LML assessment as a characterization of the baseline exposure to $PM_{2.5}$ levels in the U.S. Many of the upcoming NSPS and NESHAP rules have compliance dates between 2013 and 2016 and represent marginal improvements in air quality levels. Although it the data is not a perfect match, we believe that the air quality data from the Transport Rule is a reasonable approximation of the baseline exposure in the U.S. for upcoming NSPS and NESHAP rules.[1]

For rules without air quality modeling, we generally estimate the monetized benefits and health impacts using benefit-per-ton estimates (Fann, Fulcher and Hubbell, 2009). Using this method, we are unable to estimate the percentage of premature mortality associated with the specific rules' emission reductions at each $PM_{2.5}$ level. However, we believe that it is still important to characterize the uncertainty associated with the distribution of the baseline air quality. As a surrogate measure of mortality impacts, we provide the percentage of baseline exposure at each $PM_{2.5}$ level. If air quality levels in the baseline are above the LML, the marginal changes anticipated from these rules would likely also lead to post-policy air quality levels above the LML. Therefore, we have high confidence that the magnitude of the benefits estimated for these rules, as the marginal changes would also be above the LML.

It is important to note that baseline exposure is only one parameter in the health impact function, along with baseline incidence rates population, and change in air quality. In other words, the percentage of the population exposed to air pollution below the LML is not the same as the percentage of the population experiencing health impacts as a result of a specific emission reduction policy. The most important aspect, which we are unable to quantify for rules without air quality modeling, is the shift in exposure associated with the specific rule. Therefore, caution is warranted when interpreting the following assessment.

A very large proportion of the population is exposed at or above the lowest LML of the cohort studies (Figures 1 and 2), increasing our confidence in the PM mortality analysis. Figure 1 shows a bar chart of the percentage of the population exposed to various air quality levels in the pre- and post-policy policy. Figure 2 shows a cumulative distribution function of the same data. In addition, Figure 2 also demonstrates that policy had a greater impact on reducing exposure to the portion of the population in areas with high $PM_{2.5}$ levels relative to the portion of the population at low $PM_{2.5}$ levels. Both figures identify the LML for each of the major cohort studies. As the policy shifts the distribution of air quality levels, fewer people are exposed to $PM_{2.5}$ levels above the LML. Under baseline conditions, about 96 percent of the population is

[1] Because the Transport Rule is not yet promulgated, the baseline exposure obtained from this modeling data would slightly overestimate the fraction of the population exposed to air quality levels below the LML. As additional rules continue to reduce the ambient $PM_{2.5}$ levels over time, a larger fraction of the population would be exposed to air quality levels below the LML. However, the emission reductions anticipated from the rules without air quality modeling available are comparatively small and represent marginal changes. We intend to update this LML assessment as necessary to correspond with the successively lower baseline air quality levels anticipated as the result of promulgating significant upcoming rules.

exposed to annual mean $PM_{2.5}$ levels of at least 5.8 µg/m^3, which is the lowest air quality level considered in the most recent study of the American Cancer Society cohort by Krewski et al. (2009). Using the Pope et al. (2002) study, the 85% of the population is exposed at or above the LML of 7.5 µg/m^3. Using the Laden et al. (2006) study, 40% of the population is exposed above the LML of 10 µg/m^3. As we model mortality impacts among populations exposed to levels of $PM_{2.5}$ that are successively lower than the LML of the lowest cohort study, our confidence in the results diminishes. However, the analysis above confirms that the great majority of the impacts occur at or above the lowest cohort study's LML. It is important to emphasize that we have high confidence in $PM_{2.5}$-related effects down to the lowest LML of the major cohort studies, which is 5.8 µg/m^3. Just because we have greater confidence in the benefits above the LML, this does not mean that we have no confidence that benefits occur below the LML.

Figure 1: Percentage of Adult Population by Annual Mean $PM_{2.5}$ Exposure (pre- and post- policy)

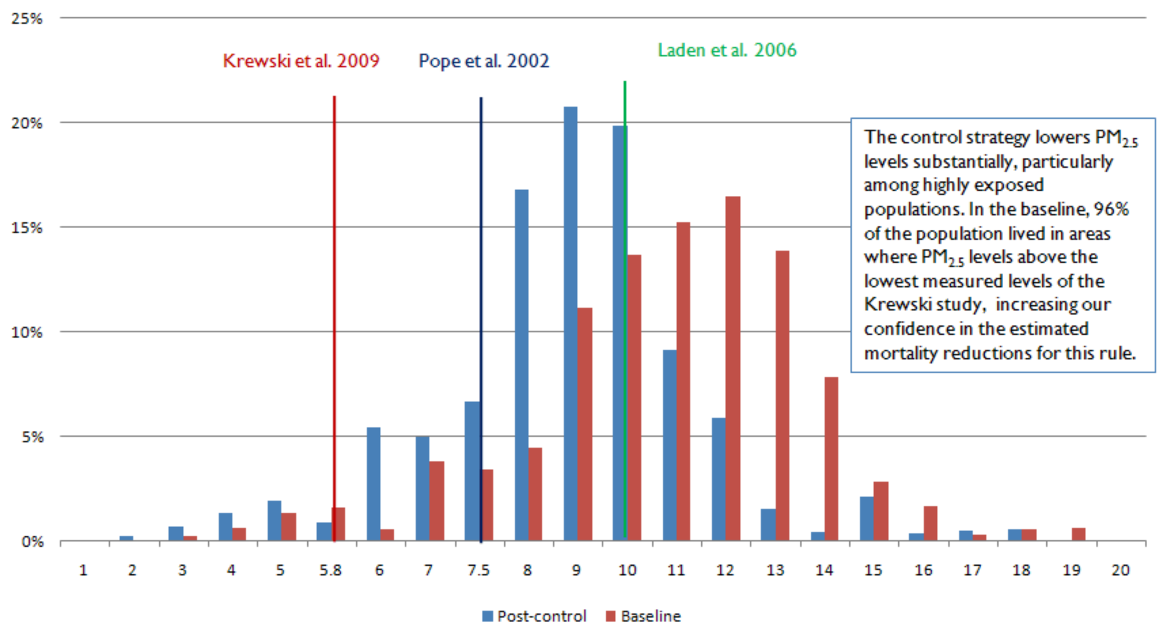
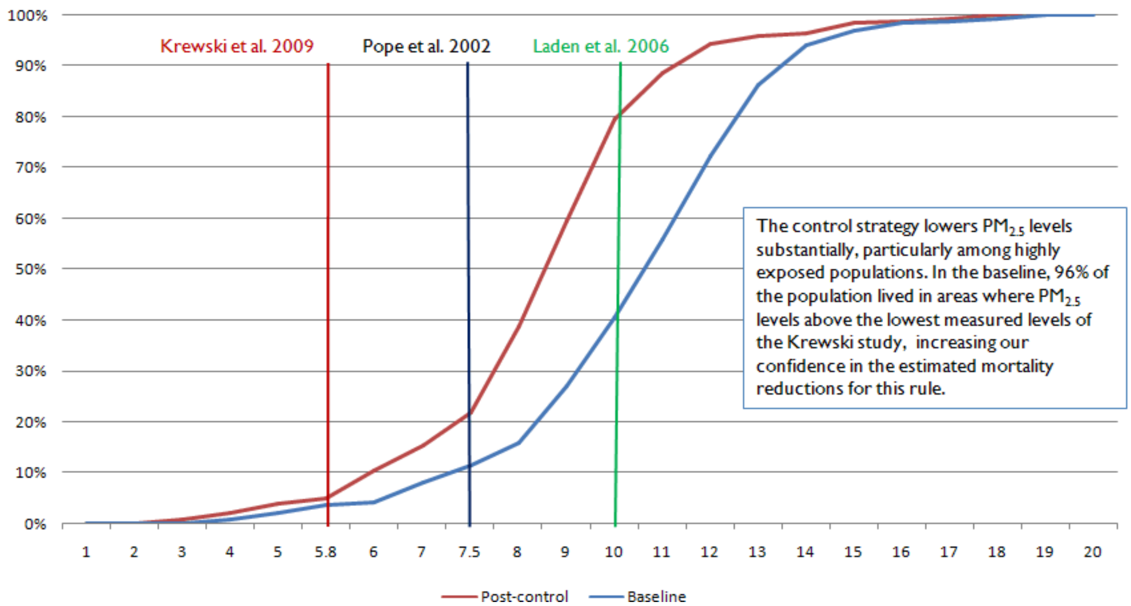


Figure 2: Cumulative Distribution of Adult Population at Annual Mean $PM_{2.5}$ levels (pre- and post-policy)



There are several important differences between the assessment conducted for the Transport Rule and the assessment presented here. If you compare the graphics in the Transport Rule to those provided here, you will notice that these graphs show a larger percentage of the population below the LML. It is imperative to point out that the Transport Rule graphics represented mortality impacts attributable to the Transport Rule, whereas these graphics represent exposure. Mortality impacts are the result of the incremental change in exposure between the baseline and control. However, the baseline population exposure at lower air quality levels is so much larger than the impacts among these same populations. In other words, the population exposed to lower $PM_{2.5}$ levels are not receiving very much of the air quality benefit between the base and the control case.

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APPENDIX C

ADDITIONAL ENGINEERING COST ANALYSIS DATA

Table C-1a. Percent Improvement Needed to Meet MACT floor and Additional Controls Required: Fluidized Bed Incinerators

Part 1 Red cells indicate where additional control is needed

Facility ID	Unit ID	Existing Control Devices	Cadmium (Cd) EG Limit (mg/dscm): 0.0019		Carbon Monoxide (CO) EG Limit (ppmvd): 56		Hydrogen Chloride (HCl) EG Limit (ppmvd): 0.49		Lead (Pb) EG Limit (mg/dscm): 0.0098		Mercury (Hg) EG Limit (mg/dscm): 0.0033		WS or PB Adjustment[1]	ACI Performance Adjustment Factor[2] (Hg Basis)
			Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	% Improve-ment Needed	
AKJuneau	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
CTMattabassett	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
CTSynagroWaterbury	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
CTWestHaven	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
GANoondayCreek	1	unknown	0.00214	11	16.33	-243	2.478	80	0.01105	11	0.01504	78	68	0.76
IADubuque	1	cs - vs - pbt	0.00214	11	16.33	-243	0.050	-889	0.01105	11	0.01354	76	66	0.73
IADubuque	2	cs - vs - pbt	0.00214	11	16.33	-243	0.050	-889	0.01105	11	0.01354	76	66	0.73
KSKawPoint	1	vs	0.00214	11	16.33	-243	2.478	80	0.01105	11	0.01504	78	68	0.76
KSKawPoint	2	vs	0.00214	11	16.33	-243	2.478	80	0.01105	11	0.01504	78	68	0.76
LANewOrleansEastBank	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
MALynnRegional	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
MALynnRegional	2	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
MIYpsilanti	EU-FBSSI	vs- imp - wesp - ac polish.	0.00047	-308	2.64	-2020	0.282	-73	0.00618	-59	0.00057	-482	-492	-5.47
MNStPaulMetro	FBR1	ac inject. - bag - vs(ad) - wesp	0.00043	-344	23.46	-139	0.167	-193	0.00288	-241	0.00170	-95	-95	-1.06
MNStPaulMetro	FBR2	ac inject. - bag - vs(ad) - wesp	0.00075	-154	23.71	-136	0.156	-215	0.00262	-273	0.00089	-271	-271	-3.01
MNStPaulMetro	FBR3	ac inject. - bag - vs(ad) - wesp	0.00069	-174	20.46	-174	0.200	-144	0.00240	-309	0.00039	-753	-753	-8.37
MOLittleBlueValley	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
MORockCreek	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NCBuncombeAshville	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NCTZOsborne	ES-1	abd - vs - imp - hss - cs	0.00017	-988	11.39	-392	0.044	-1008	0.00031	-3028	0.04113	92	82	0.91
NHManchester	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NJBayshoreRegional	1	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
NJBayshoreRegional	2	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
NJCamden	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NJGloucester	1	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
NJGloucester	2	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
NJNorthwestBergen	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73

Facility ID	Unit ID	Existing Control Devices	Cadmium (Cd) EG Limit (mg/dscm): 0.0019 Average (mg/dscm)	Cadmium (Cd) % Improve-ment Needed	Carbon Monoxide (CO) EG Limit (ppmvd): 56 Average (ppmvd)	Carbon Monoxide (CO) % Improve-ment Needed	Hydrogen Chloride (HCl) EG Limit (ppmvd): 0.49 Average (ppmvd)	Hydrogen Chloride (HCl) % Improve-ment Needed	Lead (Pb) EG Limit (mg/dscm): 0.0098 Average (mg/dscm)	Lead (Pb) % Improve-ment Needed	Mercury (Hg) EG Limit (mg/dscm): 0.0033 Average (mg/dscm)	Mercury (Hg) % Improve-ment Needed	WS or PB Adjustment[1] % Improve-ment Needed	ACI Performance Adjustment Factor[2] (Hg Basis)
NJNorthwestBergen	2	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NJPequannockLincolnFairfield	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NJPequannockLincolnFairfield	2	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
NJSomersetRaritan	1	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
NJSomersetRaritan	2	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
NYArlington	1	unknown	0.00214	11	16.33	-243	2.478	80	0.01105	11	0.01504	78	68	0.76
NYErieCounty	1	vs	0.00214	11	16.33	-243	2.478	80	0.01105	11	0.01504	78	68	0.76
NYErieCounty	2	vs	0.00214	11	16.33	-243	2.478	80	0.01105	11	0.01504	78	68	0.76
NYGlensFalls	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NYOneidaCounty	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NYOneidaCounty	2	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NYOneidaCounty	3	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NYPortChester	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NYPortChester	2	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
NYSaratogaCounty	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
OHLittleMiami	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
OHNEORSDEasterly	1	abo - imp - wesp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
PAAlleghenyCounty	001	abd - mc - vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
PAAlleghenyCounty	002	abd - mc - vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
PAWyomingValley	1	vs - imp - wesp	0.00085	-122	16.33	-243	0.124	-295	0.00442	-122	0.01354	76	66	0.73
PRPuertoNuevo	1	vs(ad) - wesp	0.00085	-122	16.33	-243	0.050	-889	0.00442	-122	0.01354	76	76	0.84
SCFelixCDavis	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
VABlacksburg	1	unknown	0.00214	11	16.33	-243	2.478	80	0.01105	11	0.01504	78	68	0.76
VAHLMooney	2	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
WAAnacortes	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
WAEdmonds	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
WALynnwood	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73
WAWestside	1	vs - imp	0.00214	11	16.33	-243	0.124	-295	0.01105	11	0.01354	76	66	0.73

Table C-1a. Percent Improvement Needed to Meet MACT floor and Additional Controls Required: Fluidized Bed Incinerators

Part 2 Red cells indicate where additional control is needed

Facility ID	Unit ID	Existing Control Devices	Nitrogen Oxides (NOx)		Particulate Matter (filterable)		Particulate Matter (PM 2.5)		Sulfur Dioxide (SO2)		Total Dioxin/Furans		ACI Performance Adjustment Factor[2] (CDD/CDF TMB basis)	Total Dioxin/Furans (TEQ)	
			EG Limit (ppmvd): 63		EG Limit (mg/dscm): 12		EG Limit (mg/dscm): 11		EG Limit (ppmvd): 22		EG Limit (ng/dscm): 0.61			EG Limit (ng/dscm): 0.056	
			Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve ment Needed	Average (ng/dscm)	% Improve ment Needed		Average (ng/dscm)	% Improve-ment Needed
AKJuneau	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
CTMattabassett	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
CTSynagroWaterbury	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
CTWestHaven	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
GANoondayCreek	1	unknown	27.93	-126	12.44	4	11.80	7	66.05	67	15.9621	96	0.98	1.3121	96
IADubuque	1	cs - vs - pbt	27.93	-126	12.44	4	11.80	7	1.32	-1565	15.9621	96	0.98	1.3121	96
IADubuque	2	cs - vs - pbt	27.93	-126	12.44	4	11.80	7	1.32	-1565	15.9621	96	0.98	1.3121	96
KSKawPoint	1	vs	27.93	-126	12.44	4	11.80	7	66.05	67	15.9621	96	0.98	1.3121	96
KSKawPoint	2	vs	27.93	-126	12.44	4	11.80	7	66.05	67	15.9621	96	0.98	1.3121	96
LANewOrleansEastBank	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
MALynnRegional	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
MALynnRegional	2	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
MIYpsilanti	EU-FBS SI	vs- imp - wesp - ac polish.	29.76	-112	2.87	-317	4.83	-128	3.30	-566	0.1469	-315	-3.21	0.0064	-772
MNStPaulMetro	FBR 1	ac inject. - bag - vs(ad) - wesp	31.00	-103	2.26	-432	1.72	-538	0.62	-3468	0.4048	-51	-0.52	0.0356	-57
MNStPaulMetro	FBR 2	ac inject. - bag - vs(ad) - wesp	41.44	-52	1.41	-750	1.57	-601	1.65	-1235	0.4060	-50	-0.51	0.0367	-52
MNStPaulMetro	FBR 3	ac inject. - bag - vs(ad) - wesp	22.53	-180	5.38	-123	1.45	-659	1.13	-1843	0.4054	-50	-0.51	0.0362	-55
MOLittleBlueValley	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
MORockCreek	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NCBuncombeAshville	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NCTZOsborne	ES-1	abd - vs - imp - hss - cs	14.90	-323	2.58	-366	11.16	1	7.64	-188	15.9621	96	0.98	1.3121	96
NHManchester	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NJBayshoreRegional	1	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
NJBayshoreRegional	2	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
NJCamden	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NJGloucester	1	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
NJGloucester	2	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
NJNorthwestBergen	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NJNorthwestBergen	2	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96

Facility ID	Unit ID	Existing Control Devices	Nitrogen Oxides (NOx)		Particulate Matter (filterable)		Particulate Matter (PM 2.5)		Sulfur Dioxide (SO2)		Total Dioxin/Furans		ACI Performance Adjustment Factor[2] (CDD/CDF TMB basis)	Total Dioxin/Furans (TEQ)	
			EG Limit (ppmvd): 63		EG Limit (mg/dscm): 12		EG Limit (mg/dscm): 11		EG Limit (ppmvd): 22		EG Limit (ng/dscm): 0.61			EG Limit (ng/dscm): 0.056	
			Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve ment Needed	Average (ng/dscm)	% Improve ment Needed		Average (ng/dscm)	% Improve-ment Needed
NJPequannockLincolnFairfield	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NJPequannockLincolnFairfield	2	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
NJSomersetRaritan	1	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
NJSomersetRaritan	2	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
NYArlington	1	unknown	27.93	-126	12.44	4	11.80	7	66.05	67	15.9621	96	0.98	1.3121	96
NYErieCounty	1	vs	27.93	-126	12.44	4	11.80	7	66.05	67	15.9621	96	0.98	1.3121	96
NYErieCounty	2	vs	27.93	-126	12.44	4	11.80	7	66.05	67	15.9621	96	0.98	1.3121	96
NYGlensFalls	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NYOneidaCounty	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NYOneidaCounty	2	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NYOneidaCounty	3	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NYPortChester	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NYPortChester	2	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
NYSaratogaCounty	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
OHLittleMiami	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
OHNEORSDEasterly	1	abo - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
PAAlleghenyCounty	001	abd - mc - vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
PAAlleghenyCounty	002	abd - mc - vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
PAWyomingValley	1	vs - imp - wesp	27.93	-126	2.49	-382	2.36	-366	3.30	-566	15.9621	96	0.98	1.3121	96
PRPuertoNuevo	1	vs(ad) - wesp	27.93	-126	2.49	-382	2.36	-366	1.32	-1565	15.9621	96	0.98	1.3121	96
SCFelixCDavis	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
VABlacksburg	1	unknown	27.93	-126	12.44	4	11.80	7	66.05	67	15.9621	96	0.98	1.3121	96
VAHLMooney	2	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
WAAnacortes	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
WAEdmonds	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
WALynnwood	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96
WAWestside	1	vs - imp	27.93	-126	12.44	4	11.80	7	3.30	-566	15.9621	96	0.98	1.3121	96

Table C-1a. Percent Improvement Needed to Meet MACT floor and Additional Controls Required: Fluidized Bed Incinerators

Part 3 Red cells indicate where additional control is needed

Facility ID	Unit ID	Existing Control Devices	ACI Performance Adjustment Factor[2] (CDD/CDF TEQ basis)	Max ACI Adjustment Factor	MACT Floor Control Needs (if % improvement >10, add control)		
					FF	Scrubber	ACI
AKJuneau	1	vs - imp	0.98	0.98	add FF		add ACI
CTMattabassett	1	vs - imp	0.98	0.98	add FF		add ACI
CTSynagroWaterbury	1	vs - imp	0.98	0.98	add FF		add ACI
CTWestHaven	1	vs - imp	0.98	0.98	add FF		add ACI
GANoondayCreek	1	unknown	0.98	0.98	add FF	add PBS	add ACI
IADubuque	1	cs - vs - pbt	0.98	0.98	add FF		add ACI
IADubuque	2	cs - vs - pbt	0.98	0.98	add FF		add ACI
KSKawPoint	1	vs	0.98	0.98	add FF	add PBS	add ACI
KSKawPoint	2	vs	0.98	0.98	add FF	add PBS	add ACI
LANewOrleansEastBank	1	vs - imp	0.98	0.98	add FF		add ACI
MALynnRegional	1	vs - imp	0.98	0.98	add FF		add ACI
MALynnRegional	2	vs - imp	0.98	0.98	add FF		add ACI
MIYpsilanti	EU-FBSSI	vs- imp - wesp - ac polish.	-7.88	-3.21			
MNStPaulMetro	FBR1	ac inject. - bag - vs(ad) - wesp	-0.58	-0.52			
MNStPaulMetro	FBR2	ac inject. - bag - vs(ad) - wesp	-0.53	-0.51			
MNStPaulMetro	FBR3	ac inject. - bag - vs(ad) - wesp	-0.56	-0.51			
MOLittleBlueValley	1	vs - imp	0.98	0.98	add FF		add ACI
MORockCreek	1	vs - imp	0.98	0.98	add FF		add ACI
NCBuncombeAshville	1	vs - imp	0.98	0.98	add FF		add ACI
NCTZOsborne	ES-1	abd - vs - imp - hss - cs	0.98	0.98			add ACI
NHManchester	1	vs - imp	0.98	0.98	add FF		add ACI
NJBayshoreRegional	1	vs - imp - wesp	0.98	0.98			add ACI
NJBayshoreRegional	2	vs - imp - wesp	0.98	0.98			add ACI
NJCamden	1	vs - imp	0.98	0.98	add FF		add ACI
NJGloucester	1	vs - imp - wesp	0.98	0.98			add ACI
NJGloucester	2	vs - imp - wesp	0.98	0.98			add ACI
NJNorthwestBergen	1	vs - imp	0.98	0.98	add FF		add ACI
NJNorthwestBergen	2	vs - imp	0.98	0.98	add FF		add ACI
NJPequannockLincolnFairfield	1	vs - imp	0.98	0.98	add FF		add ACI
NJPequannockLincolnFairfield	2	vs - imp - wesp	0.98	0.98			add ACI
NJSomersetRaritan	1	vs - imp - wesp	0.98	0.98			add ACI
NJSomersetRaritan	2	vs - imp - wesp	0.98	0.98			add ACI
NYArlington	1	unknown	0.98	0.98	add FF	add PBS	add ACI
NYErieCounty	1	vs	0.98	0.98	add FF	add PBS	add ACI

Facility ID	Unit ID	Existing Control Devices	ACI Performance Adjustment Factor[2] (CDD/CDF TEQ basis)	Max ACI Adjustment Factor	MACT Floor Control Needs (if % improvement >10, add control)		
					FF	Scrubber	ACI
NYErieCounty	2	vs	0.98	0.98	add FF	add PBS	add ACI
NYGlensFalls	1	vs - imp	0.98	0.98	add FF		add ACI
NYOneidaCounty	1	vs - imp	0.98	0.98	add FF		add ACI
NYOneidaCounty	2	vs - imp	0.98	0.98	add FF		add ACI
NYOneidaCounty	3	vs - imp	0.98	0.98	add FF		add ACI
NYPortChester	1	vs - imp	0.98	0.98	add FF		add ACI
NYPortChester	2	vs - imp	0.98	0.98	add FF		add ACI
NYSaratogaCounty	1	vs - imp	0.98	0.98	add FF		add ACI
OHLittleMiami	1	vs - imp	0.98	0.98	add FF		add ACI
OHNEORSDEasterly	1	abo - imp - wesp	0.98	0.98	add FF		add ACI
PAAlleghenyCounty	001	abd - mc - vs - imp	0.98	0.98	add FF		add ACI
PAAlleghenyCounty	002	abd - mc - vs - imp	0.98	0.98	add FF		add ACI
PAWyomingValley	1	vs - imp - wesp	0.98	0.98			add ACI
PRPuertoNuevo	1	vs(ad) - wesp	0.98	0.98			add ACI
SCFelixCDavis	1	vs - imp	0.98	0.98	add FF		add ACI
VABlacksburg	1	unknown	0.98	0.98	add FF	add PBS	add ACI
VAHLMooney	2	vs - imp	0.98	0.98	add FF		add ACI
WAAnacortes	1	vs - imp	0.98	0.98	add FF		add ACI
WAEdmonds	1	vs - imp	0.98	0.98	add FF		add ACI
WALynnwood	1	vs - imp	0.98	0.98	add FF		add ACI
WAWestside	1	vs - imp	0.98	0.98	add FF		add ACI

NOTE: Data gaps in pollutant concentrations were filled using values found for similar units or using the average concentration over the entire subcategory. For Dioxin/Furan TEQ concentrations, no data was available for the subcategory, so TEQ concentrations were assumed to be 57% of the TMB values.

1. Assumes that units with a packed bed scrubber or installing a packed bed scrubber will get a 10% Hg reduction.
2. ACI algorithm is based on 90% Hg reduction efficiency and 98% CDD/CDF reduction efficiency. This adjustment factor will be used to adjust total annual costs to the estimated reduction efficiency needed to meet the floor.

Table C-1b. Percent Improvement Needed to Meet MACT floor and Additional Controls Required: Multiple Hearth Incinerators

Part 1 Red cells indicate where additional control is needed

Facility ID	Unit ID	Existing Control Devices	Cadmium (Cd) EG Limit (mg/dscm): 0.095		Carbon Monoxide (CO) EG Limit (ppmvd): 3900		Hydrogen Chloride (HCl) EG Limit (ppmvd): 1.0		Lead (Pb) EG Limit (mg/dscm): 0.30		Mercury (Hg) EG Limit (mg/dscm): 0.17		WS or PB Adjustment[1]	ACI Performance Adjustment Factor[2] (Hg Basis)	Nitrogen Oxides (NOx) EG Limit (ppmvd): 210	
			Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	% Improve-ment Needed		Average (ppmvd)	% Improve -ment Needed
AKJohnMAsplund	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
CACentralContraCosta	MHF 1	abo - cs - vs - imp	0.0150	-534	836.4	-366	0.79	-26	0.060	-398	0.051	-231	-241	-2.68	127.7	-64
CACentralContraCosta	MHF 2	abo - cs - vs - imp	0.0176	-439	752.1	-419	0.79	-26	0.036	-740	0.065	-160	-170	-1.89	172.3	-22
CAPaloAlto	1	vs(ad)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
CAPaloAlto	2	vs(ad)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
CTHartford	001	abo - fgr - vs - imp	0.0053	-1701	853.9	-357	0.65	-53	0.015	-1873	0.124	-37	-47	-0.52	106.6	-97
CTHartford	002	abo - fgr - vs - imp	0.0062	-1422	853.9	-357	0.65	-53	0.024	-1144	0.118	-44	-54	-0.60	106.6	-97
CTHartford	3	abo - fgr - vs - imp	0.0058	-1550	853.9	-357	0.65	-53	0.020	-1426	0.121	-40	-50	-0.56	106.6	-97
CTNaugatuck	1	abo - imp - wesp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
CTNaugatuck	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
CTSynagroNewHaven	1	vs - imp - wesp - rto	0.0178	-433	853.9	-357	0.65	-53	0.038	-684	0.103	-65	-75	-0.83	133.3	-58
GAPresidentStreet	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
GAPresidentStreet	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
GARLSutton	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
GARLSutton	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
GARMClayton	1	imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
GARMClayton	2	imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
GAUtoyCreek	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
GAUtoyCreek	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
GAWeyerhaeuser	1	unknown	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
IACedarRapids	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
INBelmontNorth	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.113	-50	-60	-0.67	133.3	-58
INBelmontNorth	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.104	-63	-73	-0.81	133.3	-58
INBelmontNorth	3	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.091	-86	-96	-1.07	133.3	-58
INBelmontNorth	4	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.106	-60	-70	-0.78	133.3	-58
INBelmontNorth	5	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.104	-64	-74	-0.82	133.3	-58
INBelmontNorth	6	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.104	-64	-74	-0.82	133.3	-58
INBelmontNorth	7	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.104	-64	-74	-0.82	133.3	-58

Facility ID	Unit ID	Existing Control Devices	Cadmium (Cd) EG Limit (mg/dscm): 0.095		Carbon Monoxide (CO) EG Limit (ppmvd): 3900		Hydrogen Chloride (HCl) EG Limit (ppmvd): 1.0		Lead (Pb) EG Limit (mg/dscm): 0.30		Mercury (Hg) EG Limit (mg/dscm): 0.17		WS or PB Adjustment [1]	ACI Performance Adjustment Factor[2] (Hg Basis)	Nitrogen Oxides (NOx) EG Limit (ppmvd): 210	
			Average (mg/dscm)	% Improvement Needed	Average (ppmvd)	% Improvement Needed	Average (ppmvd)	% Improvement Needed	Average (mg/dscm)	% Improvement Needed	Average (mg/dscm)	% Improvement Needed	% Improvement Needed		Average (ppmvd)	% Improvement Needed
INBelmontNorth	8	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.104	-64	-74	-0.82	133.3	-58
LANewOrleansEastBank	2	unknown	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
MAFitchburgEast	1	vs - wesp - rto	0.0178	-433	853.9	-357	13.09	92	0.038	-684	0.114	-49	-59	-0.66	133.3	-58
MAUpperBlackstone	1	agr - vs - imp - wesp - rto	0.0042	-2153	27.6	-14042	0.34	-196	0.002	-14243	0.090	-89	-99	-1.10	76.4	-175
MAUpperBlackstone	Incinerator 3	agr - vs - imp - wesp - rto	0.0041	-2231	59.4	-6470	0.31	-218	0.005	-5870	0.065	-160	-170	-1.89	68.5	-206
MDWesternBranch	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MDWesternBranch	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIAnnArbor	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIBattleCreek	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIBattleCreek	2	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex1	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex1	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex1	3	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex1	4	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex1	5	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex1	6	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	1	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	2	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	3	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	4	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	5	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	6	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	7	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIDetroitComplex2	8	hjs - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIFlint	1	abd - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIFlint	2	abd - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIFlint	3	abd - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIFlint	4	abd - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MIPontiacAuburn	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MIWarren	1	imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
MNSeneca	Incinerator 1	abo - vs	0.2509	62	1323.3	-195	0.42	-136	0.072	-318	0.301	43	43	0.48	219.3	4
MNSeneca	Incinerator 2	abo - vs	0.2509	62	823.7	-373	0.42	-136	0.072	-318	0.301	43	43	0.48	219.3	4
MOBigBlueRiver	1	abo - vs	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
MOBigBlueRiver	2	abo - vs	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
MOBigBlueRiver	3	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOBissellPoint	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58

Facility ID	Unit ID	Existing Control Devices	Cadmium (Cd)		Carbon Monoxide (CO)		Hydrogen Chloride (HCl)		Lead (Pb)		Mercury (Hg)		WS or PB Adjustment [1]	ACI Performance Adjustment Factor[2] (Hg Basis)	Nitrogen Oxides (NOx)	
			EG Limit (mg/dscm): 0.095		EG Limit (ppmvd): 3900		EG Limit (ppmvd): 1.0		EG Limit (mg/dscm): 0.30		EG Limit (mg/dscm): 0.17				EG Limit (ppmvd): 210	
			Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	% Improve-ment Needed		Average (ppmvd)	% Improve-ment Needed
MOBissellPoint	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOBissellPoint	3	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOBissellPoint	4	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOBissellPoint	5	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOBissellPoint	6	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOLemay	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOLemay	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOLemay	3	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
MOLemay	4	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NCRockyRiver	1	abd - vs - imp - wesp	0.0178	-433	853.9	-357	0.65	-53	0.038	-684	0.103	-65	-75	-0.83	133.3	-58
NJAtlanticCounty	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NJAtlanticCounty	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NJMountainView	#1	vs - imp - wesp - rto	0.0003	-28547	38.6	-9995	0.86	-16	0.001	-30629	0.099	-72	-82	-0.91	142.0	-48
NJMountainView	#2	vs - imp - wesp - rto	0.0003	-28547	38.6	-9995	0.86	-16	0.001	-30629	0.099	-72	-82	-0.91	142.0	-48
NJParsippanyTroyHills	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NJParsippanyTroyHills	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NJStonyBrook	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NJStonyBrook	2	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYAlbanyCountyNorth	1	vs(ad)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
NYAlbanyCountyNorth	2	vs(ad)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
NYAlbanyCountySouth	1	vs(ad)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
NYAlbanyCountySouth	2	vs(ad)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
NYAuburn	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYBirdIsland	1	abd - vs	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
NYBirdIsland	2	abd - vs	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
NYBirdIsland	3	abd - vs	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
NYFrankEVanLare	1	abo - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
NYFrankEVanLare	2	abo - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
NYFrankEVanLare	3	abo - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
NYNewRochelle	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYNewRochelle	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYNorthwestQuadrant	1	abo - imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58

			Cadmium (Cd)		Carbon Monoxide (CO)		Hydrogen Chloride (HCl)		Lead (Pb)		Mercury (Hg)		WS or PB Adjustment [1]		Nitrogen Oxides (NOx)	
			EG Limit (mg/dscm): 0.095		EG Limit (ppmvd): 3900		EG Limit (ppmvd): 1.0		EG Limit (mg/dscm): 0.30		EG Limit (mg/dscm): 0.17				EG Limit (ppmvd): 210	
Facility ID	**Unit ID**	**Existing Control Devices**	Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	% Improve-ment Needed	**ACI Performance Adjustment Factor[2] (Hg Basis)**	Average (ppmvd)	% Improve-ment Needed
NYOrangetown	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYOssining	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYOssining	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYSchenectady	1	imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58
NYSouthwestBergen Point	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYSouthwestBergen Point	2	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
NYTonawanda	1	unknown	0.0446	-113	853.9	-357	13.09	92	0.096	-213	0.114	-49	-59	-0.66	133.3	-58
OHCanton	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHCanton	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHColumbusSoutherly	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHColumbusSoutherly	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHColumbusSoutherly	3	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHColumbusSoutherly	4	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHEuclid	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHEuclid	2	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHJacksonPike	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHJacksonPike	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHMillCreek	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHMillCreek	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHMillCreek	3	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHMillCreek	4	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHMillCreek	5	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHMillCreek	6	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHNEORSDSoutherly	1	abo - imp - wesp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHNEORSDSoutherly	2	abo - imp - wesp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHNEORSDSoutherly	3	abo - imp - wesp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHNEORSDSoutherly	4	abo - imp - wesp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHNEORSDWesterly	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHNEORSDWesterly	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHWilloughbyEastlake	1	imp	0.4456	79	853.9	-357	0.65	-53	0.957	69	0.103	-65	-75	-0.83	133.3	-58

Facility ID	Unit ID	Existing Control Devices	Cadmium (Cd)		Carbon Monoxide (CO)		Hydrogen Chloride (HCl)		Lead (Pb)		Mercury (Hg)		WS or PB Adjustment [1]	ACI Performance Adjustment Factor[2] (Hg Basis)	Nitrogen Oxides (NOx)	
			EG Limit (mg/dscm): 0.095		EG Limit (ppmvd): 3900		EG Limit (ppmvd): 1.0		EG Limit (mg/dscm): 0.30		EG Limit (mg/dscm): 0.17				EG Limit (ppmvd): 210	
			Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	% Improve-ment Needed		Average (ppmvd)	% Improve-ment Needed
OHYoungstown	1	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
OHYoungstown	2	abo - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
PADelawareCounty Western	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
PADelawareCounty Western	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
PAEastNorritonPlymouthWhitpain	1	cs - vs(ad)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
PAErie	1	vs - wesp	0.0178	-433	853.9	-357	13.09	92	0.038	-684	0.114	-49	-59	-0.66	133.3	-58
PAErie	2	vs - wesp	0.0178	-433	853.9	-357	13.09	92	0.038	-684	0.114	-49	-59	-0.66	133.3	-58
PAHatfield	1	vs - imp - wesp - rto	0.0178	-433	853.9	-357	0.65	-53	0.038	-684	0.103	-65	-75	-0.83	133.3	-58
PAKiskiValley	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
PAUpperMorelandHatboro	1	vs - imp - rto	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
RICranston	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
RICranston	2	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
RINewEngland	1	vs - imp - wesp	0.0178	-433	853.9	-357	0.65	-53	0.038	-684	0.103	-65	-75	-0.83	133.3	-58
SCColumbiaMetro	1	abo/fgr - pbs - vs - imp	0.0025	-3700	63.5	-6045	0.20	-398	0.004	-7886	0.074	-130	-140	-1.56	84.4	-149
SCColumbiaMetro	2	abo/fgr - pbs - vs - imp	0.0025	-3700	63.5	-6045	0.20	-398	0.004	-7886	0.077	-121	-131	-1.46	84.4	-149
SCPlumIsland	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VAArmyBaseNorfolk	1	ws - vs - imp	0.1122	15	853.9	-357	0.65	-53	0.398	25	0.130	-31	-41	-0.46	133.3	-58
VAArmyBaseNorfolk	2	ws - vs - imp	0.1122	15	853.9	-357	0.65	-53	0.398	25	0.130	-31	-41	-0.46	133.3	-58
VABoatHarbor	1	ws - vs - pbs - vs(ad)	0.0537	-77	3761.0	-4	0.70	-42	0.069	-337	0.107	-59	-59	-0.66	154.5	-36
VABoatHarbor	2	ws - vs - pbs - vs(ad)	0.0537	-77	3761.0	-4	0.70	-42	0.069	-337	0.107	-59	-59	-0.66	154.5	-36
VAChesapeakeElizabeth	1	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VAChesapeakeElizabeth	2	vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VAHopewell	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VANomanCole	1	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VANomanCole	2	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VANomanCole	3	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VANomanCole	4	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VANomanCole	5	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VANomanCole	6	abd - vs - imp	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-75	-0.83	133.3	-58
VAVirginiaInitiative	1	ws - vs - imp	0.0745	-28	853.9	-357	0.65	-53	0.461	35	0.064	-166	-176	-1.96	133.3	-58

Facility ID	Unit ID	Existing Control Devices	Cadmium (Cd) EG Limit (mg/dscm): 0.095		Carbon Monoxide (CO) EG Limit (ppmvd): 3900		Hydrogen Chloride (HCl) EG Limit (ppmvd): 1.0		Lead (Pb) EG Limit (mg/dscm): 0.30		Mercury (Hg) EG Limit (mg/dscm): 0.17		WS or PB Adjustment [1]	ACI Performance Adjustment Factor[2] (Hg Basis)	Nitrogen Oxides (NOx) EG Limit (ppmvd): 210	
			Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	% Improve-ment Needed		Average (ppmvd)	% Improve-ment Needed
VAVirginiaInitiative	2	ws - vs - imp	0.0745	-28	853.9	-357	0.65	-53	0.461	35	0.064	-166	-176	-1.96	133.3	-58
VAWilliamsburg	1	vs - imp	0.0323	-194	853.9	-357	0.65	-53	0.097	-210	0.103	-65	-75	-0.83	133.3	-58
VAWilliamsburg	2	vs - imp	0.0323	-194	853.9	-357	0.65	-53	0.097	-210	0.103	-65	-75	-0.83	133.3	-58
WABellinghamPostPoint	1	vs - imp - wesp	0.0178	-433	853.9	-357	0.65	-53	0.038	-684	0.103	-65	-75	-0.83	133.3	-58
WABellinghamPostPoint	2	vs - imp - wesp	0.0178	-433	853.9	-357	0.65	-53	0.038	-684	0.103	-65	-75	-0.83	133.3	-58
WIGreenBayMetro	1	vs(a)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58
WIGreenBayMetro	2	vs(a)	0.0446	-113	853.9	-357	0.65	-53	0.096	-213	0.103	-65	-65	-0.72	133.3	-58

Table C-1b. Percent Improvement Needed to Meet MACT floor and Additional Controls Required: Multiple Hearth Incinerators

Part 2 Red cells indicate where additional control is needed

Facility ID	Unit ID	Existing Control Devices	Particulate Matter (filterable)		Particulate Matter (PM 2.5)		Sulfur Dioxide (SO2)		Total Dioxin/Furans		ACI Performance Adjustment Factor[2] (CDD/CDF TMB basis)	Total Dioxin/Furans (TEQ)		ACI Performance Adjustment Factor[2] (CDD/CDF TEQ basis)
			EG Limit (mg/dscm): 80		EG Limit (mg/dscm): 58		EG Limit (ppmvd): 26		EG Limit (ng/dscm): 5			EG Limit (ng/dscm): 0.32		
			Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ng/dscm)	% Improvement Needed		Average (ng/dscm)	% Improve-ment Needed	
AKJohnMAsplund	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CACentralContraCosta	MHF 1	abo - cs - vs - imp	31.42	-155	21.07	-175	7.27	-258	0.01	-52670	-537.45	0.001	-33797	-344.87
CACentralContraCosta	MHF 2	abo - cs - vs - imp	25.79	-210	21.07	-175	3.41	-663	0.01	-52670	-537.45	0.001	-33797	-344.87
CAPaloAlto	1	vs(ad)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CAPaloAlto	2	vs(ad)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CTHartford	001	abo - fgr - vs - imp	36.09	-122	8.57	-577	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CTHartford	002	abo - fgr - vs - imp	36.09	-122	13.77	-321	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CTHartford	3	abo - fgr - vs - imp	36.09	-122	11.17	-419	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CTNaugatuck	1	abo - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CTNaugatuck	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
CTSynagroNewHaven	1	vs - imp - wesp - rto	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GAPresidentStreet	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GAPresidentStreet	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GARLSutton	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GARLSutton	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GARMClayton	1	imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GARMClayton	2	imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GAUtoyCreek	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GAUtoyCreek	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
GAWeyerhaeuser	1	unknown	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
IACedarRapids	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
INBelmontNorth	1	abo - vs - imp	39.79	-101	21.97	-164	26.57	2	0.69	-619	-6.32	0.047	-584	-5.96
INBelmontNorth	2	abo - vs - imp	40.31	-98	21.97	-164	23.90	-9	0.69	-619	-6.32	0.047	-584	-5.96
INBelmontNorth	3	abo - vs - imp	33.85	-136	21.97	-164	5.51	-372	0.69	-619	-6.32	0.047	-584	-5.96
INBelmontNorth	4	abo - vs - imp	17.55	-356	21.97	-164	1.75	-1382	0.69	-619	-6.32	0.047	-584	-5.96
INBelmontNorth	5	abo - vs - imp	32.87	-143	21.97	-164	14.43	-80	0.69	-619	-6.32	0.047	-584	-5.96
INBelmontNorth	6	abo - vs - imp	32.87	-143	21.97	-164	14.43	-80	0.69	-619	-6.32	0.047	-584	-5.96
INBelmontNorth	7	abo - vs - imp	32.87	-143	21.97	-164	14.43	-80	0.69	-619	-6.32	0.047	-584	-5.96

Facility ID	Unit ID	Existing Control Devices	Particulate Matter (filterable) EG Limit (mg/dscm): 80 Average (mg/dscm)	Particulate Matter (filterable) % Improve-ment Needed	Particulate Matter (PM 2.5) EG Limit (mg/dscm): 58 Average (mg/dscm)	Particulate Matter (PM 2.5) % Improve-ment Needed	Sulfur Dioxide (SO2) EG Limit (ppmvd): 26 Average (ppmvd)	Sulfur Dioxide (SO2) % Improve-ment Needed	Total Dioxin/Furans EG Limit (ng/dscm): 5 Average (ng/dscm)	Total Dioxin/Furans % Improvement Needed	ACI Performance Adjustment Factor[2] (CDD/CDF TMB basis)	Total Dioxin/Furans (TEQ) EG Limit (ng/dscm): 0.32 Average (ng/dscm)	Total Dioxin/Furans (TEQ) % Improve-ment Needed	ACI Performance Adjustment Factor[2] (CDD/CDF TEQ basis)
INBelmontNorth	8	abo - vs - imp	32.87	-143	21.97	-164	14.43	-80	0.69	-619	-6.32	0.047	-584	-5.96
LANewOrleansEastBank	2	unknown	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
MAFitchburgEast	1	vs - wesp - rto	7.22	-1008	4.39	-1220	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
MAUpperBlackstone	1	agr - vs - imp - wesp - rto	1.75	-4464	2.62	-2111	1.20	-2067	0.12	-4036	-41.18	0.006	-5068	-51.71
MAUpperBlackstone	Incinerator 3	agr - vs - imp - wesp - rto	1.21	-6528	2.62	-2111	2.70	-864	0.12	-4036	-41.18	0.006	-5068	-51.71
MDWesternBranch	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MDWesternBranch	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIAnnArbor	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIBattleCreek	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIBattleCreek	2	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex1	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex1	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex1	3	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex1	4	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex1	5	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex1	6	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	1	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	2	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	3	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	4	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	5	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	6	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	7	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIDetroitComplex2	8	hjs - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIFlint	1	abd - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIFlint	2	abd - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIFlint	3	abd - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIFlint	4	abd - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIPontiacAuburn	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MIWarren	1	imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MNSeneca	Incinerator 1	abo - vs	78.76	-2	51.13	-13	18.23	-43	0.76	-559	-5.70	0.069	-362	-3.69
MNSeneca	Incinerator 2	abo - vs	76.16	-5	51.13	-13	18.23	-43	0.76	-559	-5.70	0.069	-362	-3.69
MOBigBlueRiver	1	abo - vs	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
MOBigBlueRiver	2	abo - vs	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
MOBigBlueRiver	3	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOBissellPoint	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96

Facility ID	Unit ID	Existing Control Devices	Particulate Matter (filterable)		Particulate Matter (PM 2.5)		Sulfur Dioxide (SO2)		Total Dioxin/Furans		ACI Performance Adjustment Factor[2] (CDD/CDF TMB basis)	Total Dioxin/Furans (TEQ)		ACI Performance Adjustment Factor[2] (CDD/CDF TEQ basis)
			EG Limit (mg/dscm): 80		EG Limit (mg/dscm): 58		EG Limit (ppmvd): 26		EG Limit (ng/dscm): 5			EG Limit (ng/dscm): 0.32		
			Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ng/dscm)	% Improv ement Needed		Average (ng/dscm)	% Improve-ment Needed	
MOBissellPoint	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOBissellPoint	3	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOBissellPoint	4	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOBissellPoint	5	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOBissellPoint	6	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOLemay	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOLemay	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOLemay	3	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
MOLemay	4	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NCRockyRiver	1	abd - vs - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NJAtlanticCounty	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NJAtlanticCounty	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NJMountainView	#1	vs - imp - wesp - rto	3.93	-1934	4.83	-1101	9.28	-180	0.22	-2156	-22.00	0.014	-2160	-22.04
NJMountainView	#2	vs - imp - wesp - rto	3.93	-1934	4.83	-1101	9.28	-180	0.22	-2156	-22.00	0.014	-2160	-22.04
NJParsippanyTroyHills	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NJParsippanyTroyHills	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NJStonyBrook	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NJStonyBrook	2	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYAlbanyCountyNorth	1	vs(ad)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYAlbanyCountyNorth	2	vs(ad)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYAlbanyCountySouth	1	vs(ad)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYAlbanyCountySouth	2	vs(ad)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYAuburn	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYBirdIsland	1	abd - vs	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
NYBirdIsland	2	abd - vs	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
NYBirdIsland	3	abd - vs	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
NYFrankEVanLare	1	abo - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYFrankEVanLare	2	abo - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYFrankEVanLare	3	abo - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYNewRochelle	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYNewRochelle	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYNorthwestQuadrant	1	abo - imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYOrangetown	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYOssining	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYOssining	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYSchenectady	1	imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYSouthwestBergenPoint	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96

			Particulate Matter (filterable)		Particulate Matter (PM 2.5)		Sulfur Dioxide (SO2)		Total Dioxin/Furans			Total Dioxin/Furans (TEQ)		
			EG Limit (mg/dscm): 80		EG Limit (mg/dscm): 58		EG Limit (ppmvd): 26		EG Limit (ng/dscm): 5			EG Limit (ng/dscm): 0.32		
Facility ID	**Unit ID**	**Existing Control Devices**	Average (mg/dscm)	% Improve-ment Needed	Average (mg/dscm)	% Improve-ment Needed	Average (ppmvd)	% Improve-ment Needed	Average (ng/dscm)	% Improv ement Needed	**ACI Performance Adjustment Factor[2] (CDD/CDF TMB basis)**	Average (ng/dscm)	% Improve-ment Needed	**ACI Performance Adjustment Factor[2] (CDD/CDF TEQ basis)**
NYSouthwestBergenPoint	2	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
NYTonawanda	1	unknown	36.09	-122	21.97	-164	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
OHCanton	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHCanton	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHColumbusSoutherly	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHColumbusSoutherly	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHColumbusSoutherly	3	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHColumbusSoutherly	4	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHEuclid	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHEuclid	2	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHJacksonPike	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHJacksonPike	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHMillCreek	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHMillCreek	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHMillCreek	3	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHMillCreek	4	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHMillCreek	5	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHMillCreek	6	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHNEORSDSoutherly	1	abo - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHNEORSDSoutherly	2	abo - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHNEORSDSoutherly	3	abo - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHNEORSDSoutherly	4	abo - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHNEORSDWesterly	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHNEORSDWesterly	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHWilloughbyEastlake	1	imp	72.19	-11	43.93	-32	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHYoungstown	1	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
OHYoungstown	2	abo - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
PADelawareCountyWestern	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
PADelawareCountyWestern	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
PAEastNorritonPlymouth Whitpain	1	cs - vs(ad)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
PAErie	1	vs - wesp	7.22	-1008	4.39	-1220	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
PAErie	2	vs - wesp	7.22	-1008	4.39	-1220	186.34	86	0.69	-619	-6.32	0.047	-584	-5.96
PAHatfield	1	vs - imp - wesp - rto	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
PAKiskiValley	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
PAUpperMorelandHatboro	1	vs - imp - rto	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
RICranston	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96

Facility ID	Unit ID	Existing Control Devices	Particulate Matter (filterable)		Particulate Matter (PM 2.5)		Sulfur Dioxide (SO2)		Total Dioxin/Furans		ACI Performance Adjustment Factor[2] (CDD/CDF TMB basis)	Total Dioxin/Furans (TEQ)		ACI Performance Adjustment Factor[2] (CDD/CDF TEQ basis)
			EG Limit (mg/dscm): 80		EG Limit (mg/dscm): 58		EG Limit (ppmvd): 26		EG Limit (ng/dscm): 5			EG Limit (ng/dscm): 0.32		
			Average (mg/dscm)	% Improvement Needed	Average (mg/dscm)	% Improvement Needed	Average (ppmvd)	% Improvement Needed	Average (ng/dscm)	% Improvement Needed		Average (ng/dscm)	% Improvement Needed	
RICranston	2	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
RINewEngland	1	vs - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
SCColumbiaMetro	1	abo/fgr - pbs - vs - imp	11.11	-620	21.97	-164	7.99	-225	2.36	-112	-1.14	0.143	-123	-1.26
SCColumbiaMetro	2	abo/fgr - pbs - vs - imp	14.63	-447	21.97	-164	7.99	-225	2.36	-112	-1.14	0.143	-123	-1.26
SCPlumIsland	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAArmyBaseNorfolk	1	ws - vs - imp	72.18	-11	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAArmyBaseNorfolk	2	ws - vs - imp	72.18	-11	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VABoatHarbor	1	ws - vs - pbs - vs(ad)	57.89	-38	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VABoatHarbor	2	ws - vs - pbs - vs(ad)	57.89	-38	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAChesapeakeElizabeth	1	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAChesapeakeElizabeth	2	vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAHopewell	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VANomanCole	1	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VANomanCole	2	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VANomanCole	3	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VANomanCole	4	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VANomanCole	5	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VANomanCole	6	abd - vs - imp	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAVirginiaInitiative	1	ws - vs - imp	39.44	-103	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAVirginiaInitiative	2	ws - vs - imp	39.44	-103	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAWilliamsburg	1	vs - imp	40.25	-99	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
VAWilliamsburg	2	vs - imp	40.25	-99	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
WABellinghamPostPoint	1	vs - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
WABellinghamPostPoint	2	vs - imp - wesp	7.22	-1008	4.39	-1220	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
WIGreenBayMetro	1	vs(a)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96
WIGreenBayMetro	2	vs(a)	36.09	-122	21.97	-164	9.32	-179	0.69	-619	-6.32	0.047	-584	-5.96

Table C-1b. Percent Improvement Needed to Meet MACT floor and Additional Controls Required: Multiple Hearth Incinerators

Part 3 Red cells indicate where additional control is needed

Facility ID	Unit ID	Existing Control Devices	Max ACI Adjustment Factor	MACT Floor Control Needs (if %improvement >10, add control)		
				FF	Scrubber	ACI
AKJohnMAsplund	1	vs - imp	-0.83			
CACentralContraCosta	MHF 1	abo - cs - vs - imp	-2.68			
CACentralContraCosta	MHF 2	abo - cs - vs - imp	-1.89			
CAPaloAlto	1	vs(ad)	-0.72			
CAPaloAlto	2	vs(ad)	-0.72			
CTHartford	001	abo - fgr - vs - imp	-0.52			
CTHartford	002	abo - fgr - vs - imp	-0.60			
CTHartford	3	abo - fgr - vs - imp	-0.56			
CTNaugatuck	1	abo - imp - wesp	-0.83			
CTNaugatuck	2	vs - imp	-0.83			
CTSynagroNewHaven	1	vs - imp - wesp - rto	-0.83			
GAPresidentStreet	1	vs - imp	-0.83			
GAPresidentStreet	2	vs - imp	-0.83			
GARLSutton	1	abo - vs - imp	-0.83			
GARLSutton	2	abo - vs - imp	-0.83			
GARMClayton	1	imp	-0.83	add FF		
GARMClayton	2	imp	-0.83	add FF		
GAUtoyCreek	1	vs - imp	-0.83			
GAUtoyCreek	2	vs - imp	-0.83			
GAWeyerhaeuser	1	unknown	-0.66		add PBS	
IACedarRapids	1	vs - imp	-0.83			
INBelmontNorth	1	abo - vs - imp	-0.67			
INBelmontNorth	2	abo - vs - imp	-0.81			
INBelmontNorth	3	abo - vs - imp	-1.07			
INBelmontNorth	4	abo - vs - imp	-0.78			
INBelmontNorth	5	abo - vs - imp	-0.82			
INBelmontNorth	6	abo - vs - imp	-0.82			
INBelmontNorth	7	abo - vs - imp	-0.82			
INBelmontNorth	8	abo - vs - imp	-0.82			
LANewOrleansEastBank	2	unknown	-0.66		add PBS	
MAFitchburgEast	1	vs - wesp - rto	-0.66		add PBS	
MAUpperBlackstone	1	agr - vs - imp - wesp - rto	-1.10			
MAUpperBlackstone	Incinerator 3	agr - vs - imp - wesp - rto	-1.89			
MDWesternBranch	1	abo - vs - imp	-0.83			
MDWesternBranch	2	abo - vs - imp	-0.83			
MIAnnArbor	1	abd - vs - imp	-0.83			
MIBattleCreek	1	abd - vs - imp	-0.83			
MIBattleCreek	2	abd - vs - imp	-0.83			
MIDetroitComplex1	1	vs - imp	-0.83			
MIDetroitComplex1	2	vs - imp	-0.83			
MIDetroitComplex1	3	vs - imp	-0.83			
MIDetroitComplex1	4	vs - imp	-0.83			
MIDetroitComplex1	5	vs - imp	-0.83			
MIDetroitComplex1	6	vs - imp	-0.83			
MIDetroitComplex2	1	hjs - imp	-0.83	add FF		
MIDetroitComplex2	2	hjs - imp	-0.83	add FF		
MIDetroitComplex2	3	hjs - imp	-0.83	add FF		
MIDetroitComplex2	4	hjs - imp	-0.83	add FF		
MIDetroitComplex2	5	hjs - imp	-0.83	add FF		
MIDetroitComplex2	6	hjs - imp	-0.83	add FF		
MIDetroitComplex2	7	hjs - imp	-0.83	add FF		
MIDetroitComplex2	8	hjs - imp	-0.83	add FF		
MIFlint	1	abd - imp	-0.83	add FF		

Facility ID	Unit ID	Existing Control Devices	Max ACI Adjustment Factor	MACT Floor Control Needs (if %improvement >10, add control)		
				FF	Scrubber	ACI
MIFlint	2	abd - imp	-0.83	add FF		
MIFlint	3	abd - imp	-0.83	add FF		
MIFlint	4	abd - imp	-0.83	add FF		
MIPontiacAuburn	1	vs - imp	-0.83			
MIWarren	1	imp	-0.83	add FF		
MNSeneca	Incinerator 1	abo - vs	0.48	add FF		add ACI
MNSeneca	Incinerator 2	abo - vs	0.48	add FF		add ACI
MOBigBlueRiver	1	abo - vs	-0.66		add PBS	
MOBigBlueRiver	2	abo - vs	-0.66		add PBS	
MOBigBlueRiver	3	vs - imp	-0.83			
MOBissellPoint	1	abo - vs - imp	-0.83			
MOBissellPoint	2	abo - vs - imp	-0.83			
MOBissellPoint	3	abo - vs - imp	-0.83			
MOBissellPoint	4	abo - vs - imp	-0.83			
MOBissellPoint	5	abo - vs - imp	-0.83			
MOBissellPoint	6	abo - vs - imp	-0.83			
MOLemay	1	abo - vs - imp	-0.83			
MOLemay	2	abo - vs - imp	-0.83			
MOLemay	3	abo - vs - imp	-0.83			
MOLemay	4	abo - vs - imp	-0.83			
NCRockyRiver	1	abd - vs - imp - wesp	-0.83			
NJAtlanticCounty	1	abo - vs - imp	-0.83			
NJAtlanticCounty	2	abo - vs - imp	-0.83			
NJMountainView	#1	vs - imp - wesp - rto	-0.91			
NJMountainView	#2	vs - imp - wesp - rto	-0.91			
NJParsippanyTroyHills	1	vs - imp	-0.83			
NJParsippanyTroyHills	2	vs - imp	-0.83			
NJStonyBrook	1	abd - vs - imp	-0.83			
NJStonyBrook	2	abd - vs - imp	-0.83			
NYAlbanyCountyNorth	1	vs(ad)	-0.72			
NYAlbanyCountyNorth	2	vs(ad)	-0.72			
NYAlbanyCountySouth	1	vs(ad)	-0.72			
NYAlbanyCountySouth	2	vs(ad)	-0.72			
NYAuburn	1	abd - vs - imp	-0.83			
NYBirdIsland	1	abd - vs	-0.66		add PBS	
NYBirdIsland	2	abd - vs	-0.66		add PBS	
NYBirdIsland	3	abd - vs	-0.66		add PBS	
NYFrankEVanLare	1	abo - imp	-0.83	add FF		
NYFrankEVanLare	2	abo - imp	-0.83	add FF		
NYFrankEVanLare	3	abo - imp	-0.83	add FF		
NYNewRochelle	1	abo - vs - imp	-0.83			
NYNewRochelle	2	abo - vs - imp	-0.83			
NYNorthwestQuadrant	1	abo - imp	-0.83	add FF		
NYOrangetown	1	vs - imp	-0.83			
NYOssining	1	vs - imp	-0.83			
NYOssining	2	vs - imp	-0.83			
NYSchenectady	1	imp	-0.83	add FF		
NYSouthwestBergenPoint	1	abd - vs - imp	-0.83			
NYSouthwestBergenPoint	2	abd - vs - imp	-0.83			
NYTonawanda	1	unknown	-0.66		add PBS	
OHCanton	1	vs - imp	-0.83			
OHCanton	2	vs - imp	-0.83			
OHColumbusSoutherly	1	vs - imp	-0.83			
OHColumbusSoutherly	2	vs - imp	-0.83			
OHColumbusSoutherly	3	vs - imp	-0.83			
OHColumbusSoutherly	4	vs - imp	-0.83			
OHEuclid	1	abd - vs - imp	-0.83			
OHEuclid	2	abd - vs - imp	-0.83			
OHJacksonPike	1	vs - imp	-0.83			

Facility ID	Unit ID	Existing Control Devices	Max ACI Adjustment Factor	MACT Floor Control Needs (if %improvement >10, add control)		
				FF	Scrubber	ACI
OHJacksonPike	2	vs - imp	-0.83			
OHMillCreek	1	vs - imp	-0.83			
OHMillCreek	2	vs - imp	-0.83			
OHMillCreek	3	vs - imp	-0.83			
OHMillCreek	4	vs - imp	-0.83			
OHMillCreek	5	vs - imp	-0.83			
OHMillCreek	6	vs - imp	-0.83			
OHNEORSDSoutherly	1	abo - imp - wesp	-0.83			
OHNEORSDSoutherly	2	abo - imp - wesp	-0.83			
OHNEORSDSoutherly	3	abo - imp - wesp	-0.83			
OHNEORSDSoutherly	4	abo - imp - wesp	-0.83			
OHNEORSDWesterly	1	abo - vs - imp	-0.83			
OHNEORSDWesterly	2	abo - vs - imp	-0.83			
OHWilloughbyEastlake	1	imp	-0.83	add FF		
OHYoungstown	1	abo - vs - imp	-0.83			
OHYoungstown	2	abo - vs - imp	-0.83			
PADelawareCountyWestern	1	vs - imp	-0.83			
PADelawareCountyWestern	2	vs - imp	-0.83			
PAEastNorritonPlymouthWhitpain	1	cs - vs(ad)	-0.72			
PAErie	1	vs - wesp	-0.66		add PBS	
PAErie	2	vs - wesp	-0.66		add PBS	
PAHatfield	1	vs - imp - wesp - rto	-0.83			
PAKiskiValley	1	vs - imp	-0.83			
PAUpperMorelandHatboro	1	vs - imp - rto	-0.83			
RICranston	1	abd - vs - imp	-0.83			
RICranston	2	abd - vs - imp	-0.83			
RINewEngland	1	vs - imp - wesp	-0.83			
SCColumbiaMetro	1	abo/fgr - pbs - vs - imp	-1.14			
SCColumbiaMetro	2	abo/fgr - pbs - vs - imp	-1.14			
SCPlumIsland	1	vs - imp	-0.83			
VAArmyBaseNorfolk	1	ws - vs - imp	-0.46	add FF		
VAArmyBaseNorfolk	2	ws - vs - imp	-0.46	add FF		
VABoatHarbor	1	ws - vs - pbs - vs(ad)	-0.66			
VABoatHarbor	2	ws - vs - pbs - vs(ad)	-0.66			
VAChesapeakeElizabeth	1	vs - imp	-0.83			
VAChesapeakeElizabeth	2	vs - imp	-0.83			
VAHopewell	1	abd - vs - imp	-0.83			
VANomanCole	1	abd - vs - imp	-0.83			
VANomanCole	2	abd - vs - imp	-0.83			
VANomanCole	3	abd - vs - imp	-0.83			
VANomanCole	4	abd - vs - imp	-0.83			
VANomanCole	5	abd - vs - imp	-0.83			
VANomanCole	6	abd - vs - imp	-0.83			
VAVirginiaInitiative	1	ws - vs - imp	-1.96			
VAVirginiaInitiative	2	ws - vs - imp	-1.96			
VAWilliamsburg	1	vs - imp	-0.83			
VAWilliamsburg	2	vs - imp	-0.83			
WABellinghamPostPoint	1	vs - imp - wesp	-0.83			
WABellinghamPostPoint	2	vs - imp - wesp	-0.83			
WIGreenBayMetro	1	vs(a)	-0.72			
WIGreenBayMetro	2	vs(a)	-0.72			

NOTE: Data gaps in pollutant concentrations were filled using values found for similar units or using the average concentration over the entire subcategory. For Dioxin/Furan TEQ concentrations, no data was available for the subcategory, so TEQ concentrations were assumed to be 57% of the TMB values.

1. Assumes that units with a packed bed scrubber or installing a packed bed scrubber will get a 10% Hg reduction.
2. ACI algorithm is based on 90% Hg reduction efficiency and 98% CDD/CDF reduction efficiency. This adjustment factor will be used to adjust total annual costs to the estimated reduction efficiency needed to meet the floor.

Table C-2a. Control Costs: Fabric Filter Cost Algorithm

Parameters/Costs	Equation/Defaults
A. Parameters	
1. Incinerator capacity, lb/hr (C)	
2. Annual operating hours, hr/yr (H)	
3. Exhaust gas flow rate, dscfm (Q)	
4. PM concentration, gr/dscf (PM)	
5. Water vapor in gas from incinerator (10% by weight)	
a. lb/min	= Q / (385 ft^3/lb-mol) x (29 lb/lb-mol) x moisture content (0.10)
b. scfm	= (lb/min) / (18 lb/lb-mol) x (385 ft^3/lb-mol)
6. Enthalpy change in quench (1800°F to 300°F)	
a. Dry gas from incinerator, Btu/lb air	= [7.010 x (300°F - 77°F) - 7.554 x (1800°F - 77°F)] / (29 lb/lb-mol)
b. Water vapor from incinerator, Btu/lb water vapor	= [8.154 x (300°F - 77°F) - 9.215 x (1800°F - 77°F)] / (18 lb/lb-mol)
c. Total gas stream, Btu/yr	= [(Btu/lb air) x Q / (385 ft3/lb-mol) x (29 lb/lb-mol) x (60 min/hr) x H] + [(Btu/lb water vapor) x Q x (0.00753 lb water vapor/ft3) x (60 min/hr) x H]
d. Cooling water	
i. Heat of vaporization at 77°F, Btu/lb	1,050
ii. Sensible heat for vapor, Btu/lb	85
iii. Total, Btu/lb water	1,135
7. Cooling water evaporated, lb/yr	
a. lb/yr	= [enthalpy change (total gas stream, Btu/yr)] / [enthalpy change (cooling water, Btu/lb)]
b. scfm	= [cooling water evaporated (lb/yr)] / (18 lb/lb-mol) x (385 ft3/lb-mol) / (H * 60 min/hr)
8. Actual gas flow into fabric filter, acfm (AQ)	= [Q + (water vapor in gas from incinerator, scfm) + (water vapor added in quench, i.e., cooling water evaporated, scfm)] x [(300°F + 460°F)/528°R]
9. Operating labor rate, $/hr (LR)	$34.60
10. Electricity cost, $/kWh (EC)	$0.07
11. Water cost, $/1,000 gal (WC)	$0.20
12. Compressed air cost, $/1,000 ft^3 (CAC)	$0.24
13. Dust disposal cost, $/ton (DDC)	$34.29
14. Capital recovery factors	= $[i \times (1 + i)^a] / [(1 + i)^a - 1]$, where i = interest rate, a = equipment life
a. Bag CRF, 2-yr life, 7% interest	0.55309
b. Cage CRF, 4-yr life, 7% interest	0.29523
c. Equipment CRF, 20-yr life, 7% interest	0.09439
15. Cost index	
a. 2008	575.4
b. 1989	357.5
B. Total Capital Investment	
1. $	= (47.0 x Q + 306,720) x (1.4 retrofit cost factor) x (525.4/357.5)
2. $/dscfm	= $ / Q
C. Direct Annual Operating Costs, $/yr	
1. Electricity	= (0.746 kW/hp) x hp (0.0072 x Q + 3.20) x H x EC
3. Evaporative cooler water	= (0.1007 x Q + 23.1506) gal/min x (60 min/hr) x H x WC

Parameters/Costs	Equation/Defaults
4. Operating labor	= (1 hr/shift) x (1 shift/8 hr) x H x LR
5. Supervisory labor	= 0.15 x (operating labor)
6. Maintenance labor	= (0.5 hr/shift) x (1 shift/8 hr) x H x (LR x 1.1)
7. Maintenance materials	= 0.02 x TCI
8. Compressed air	= AQ x (2 ft^3 air/1,000 ft^3 filtered) x (60 min/hr) x H x CAC
9. Dust disposal	= (PM gr/dscf x Q x 60 min/hr x 1 lb/7,000 gr) x (1 ton/2,000 lb) x H x DDC
10. Bag replacement	
a. Bag cost	= AQ x ($2.5/$ft^2$) x (525.4/317.4) x (1.08 taxes and freight ratio)/(3.5 ft/min G/C ratio)
b. Bag replacement labor cost	= AQ x (0.15 hr/bag)/(18 ft^2 bag area)/(3.5 ft/min G/C ratio) x LR
c. Bag replacement cost	= Bag CRF x [(total bag cost) + (bag replacement labor cost)]
11. Cage replacement	
a. Number of bags	= AQ/(3.5 ft/min G/C ratio)/(18 ft^2 bag area)
b. Cage replacement labor cost	= bag replacement labor cost
c. Cage replacement cost	= Cage CRF x [single-cage cost (4.941+ 0.163 x 18 ft^2 bag area) x (number of bags) x (525.4/317.4) + (cage replacement labor cost)]
D. Indirect Annual Costs, $/yr	
1. Overhead	= 0.6 x (labor + maintenance materials)
2. Property taxes, insurance, and administration	= 0.04 x TCI
3. Capital recovery	= Equipment CRF x (TCI - bag replacement cost - cage replacement cost)
E. Total Annual Cost	
1. $/yr	= Direct Annual Costs + Indirect Annual Costs
2. ($/yr) / dscfm	= ($/yr) / Q

Sources:

1. Cost equations: Hospital/Medical/Infectious Waste Incinerators (HMIWI) [EPA-HQ-OAR-2006-0534] Model Plant Description and Cost Report (II-A-112); and Dry Injection Fabric Filter Cost Memorandum (IV-B-32).
2. Operating labor rate: Bureau of Labor Statistics, Occupational Employment Statistics, May 2008 National Industry-Specific Occupational Employment and Wage Estimates
3. Electricity cost: Energy Information Administration. Average Industrial Retail Price of Electricity: October 2009.
4. Water cost: Air Compliance Advisor, version 7.5.
5. Compressed air cost: P2Pays.org. Energy Tips – Compressed Air. Compressed Air Tip Sheet #1. August 2004.
6. Dust disposal cost: NSWMA's 2005 Tip Fee Survey

Table C-2b. Control Costs: Packed-Bed Scrubber Cost Algorithm

Parameters/Costs	Equations/Defaults
A. Parameters	
1. Incinerator capacity, lb/hr (C)	
2. Temperature into quench, F (T1)	130
3. Temperature out of PB to ID fan, F (T2)	
4. Annual operating hours, hr/yr (H)	
5. Exhaust gas flow rate, dscfm (Qd)	
6. Assumed moisture content in gas entering quench, % (M)	10
7. Exhaust gas flow rate, scfm (Qw)	= (Qd) / (1 - M/100)
8. Water added in quench, scfm (Qh)	= ((7.010 x (T1 - 77°F) - 6.958 x (T2 - 77°F)) x 0.9 + (8.154 x (T1 - 77°F) - 8.064 x (T2 - 77°F)) x 0.1) x (lb-mole/385 scf) x Qw / (1,160 Btu/lb) / (18 lb/lb-mole) x (0.7302 ft^3-atm/lb-mol-°R) x 528°R / 1 atm
9. Actual flow out of PB, acfm (Qa)	= (Qw + Qh) x (460°F + T2)/(528°R)
10. HCl concentration, ppmvd (HCl)	
11. Operating labor rate, $/hr (LR)	$34.60
12. Electricity cost, $/kWh (EC)	$0.07
13. Caustic cost, $/ton (CC)	$357
14. Sewage disposal cost, $/1,000 gal (SDC)	$0.00
15. Water cost, $/1,000 gal (WC)	$0.20
16. Assumed pressure drop through control system, inches of water (ΔP)	15
17. Surface area-to-volume ratio for 1" dia. Ceramic Raschig rings, ft^2/ft^3 (SAV)	58
18. Minimum packing wetting rate, ft^2/hr (WR)	1
19. Water density, lb/ft^3 (Wd)	62.4
20. Water circulation flow rate, lb/hr-ft^2 (Gs)	= SAV x Wd x WR
21. Estimated column cross-sectional area from separate analysis, ft^2 (A)	19.2
22. Water circulation rate, gpm (GPM)	= Gs x A x (1 hr/60 min) x (1 gal/8.33 lb)
23. Water head, ft of water (Head)	
24. Wastewater (blowdown) flow, gpm (B)	= (HCl/1000000) x (Qd) x (lb-mole/385 ft^3) x (1 lb-mole NaCl/1 lb-mole HCl) x (58.2 lb NaCl/lb-mole NaCl) x (1 lb wastewater/0.1 lb NaCl) x (1 gal/8.33 lb)
25. Capital recovery factor, 15-yr equipment life, 7% interest (CRF)	= $[i \times (1 + i)^a] / [(1 + i)^a - 1]$, where i = interest rate, a = equipment life
26. Chemical Engineering plant cost index	
a. 2008	575.4
b. 1989	357.5
B. Total Capital Investment	
1. $	= (27.6 x Qd + 109,603) x (525.4/357.5) x (1.4 retrofit factor)
2. $/dscfm	= $ / Qd
C. Direct Annual Costs, $/yr	
1. Operating labor	= (if Qa < 20,000, then 0, otherwise 0.5 hr/shift) x H x LR
2. Supervisory labor	= 0.15 x (operating labor)
3. Maintenance labor	= (0.5 hr/8-hr shift) x H x (LR x 1.1)
4. Maintenance materials	= 0.02 x TCI
5. Electricity	= (0.000181 x Qa x ΔP x H x EC) + (0.000289 x GPM x Head x H x EC)

Parameters/Costs	Equations/Defaults
6. Caustic	= HCl x (3.117E-9) x Q x H x CC
7. Sewage disposal	= B x (60 min/hr) x H x SDC
8. Makeup water	= (B + Qh x (lb-mole/385 scf) x (18 lb/lb-mole) x (gal/8.33 lb)) x (60 min/hr) x H x WC
D. Indirect Annual Costs, $/yr	
1. Overhead	= 0.6 x (labor + maintenance materials)
2. Property taxes, insurance, and administration	= 0.04 x TCI
3. Capital recovery	= CRF x TCI
E. Total Annual Cost	
1. $/yr	= Direct Annual Costs + Indirect Annual Costs
2. ($/yr) /dscfm	= ($/yr) / Qd

Sources:

1. Cost equations: Hospital/Medical/Infectious Waste Incinerators (HMIWI) [EPA-HQ-OAR-2006-0534]-Model Plant Description and Cost Report (II-A-112); and Wet Scrubber Cost Memorandum (IV-B-30).
2. Operating labor rate: Bureau of Labor Statistics, Occupational Employment Statistics, May 2008 National Industry-Specific Occupational Employment and Wage Estimates.
3. Electricity cost: Energy Information Administration. Average Industrial Retail Price of Electricity: October 2009.
4. Caustic cost: Purchasing.com. Caustic soda price hike is on the horizon. August 29, 2007.

Table C-2c. Control Costs: Activated Carbon Injection (ACI) Cost Algorithm

Parameters/Costs	Equations/Defaults
A. Parameters	
1. Incinerator capacity, lb/hr (C)	
2. Annual operating hours, hr/yr (H)	
3. Exhaust gas flow rate, dscfm (Q)	
4. Operating labor rate, $/hr (LR)	$34.60
5. Activated carbon cost, $/lb (ACC)	$1.38
6. Dust disposal cost, $/ton (DDC)	$34.29
7. Capital recovery factor, 20-yr equipment life, 7% interest (CRF)	= [i x (1 + i)a] / [(1 + i)a - 1], where i = interest rate, a = equipment life
8. Cost index	
a. 2008	575.4
b. 1990	361.3
9. ACI Adjustment Factor (AF)	
B. Total Capital Investment	
1. $	= 4,500 x (Q/1,976)0.6 x (1.2 retrofit factor) x (575.4/361.3)
2. $/dscfm	= $ / Q
C. Direct Annual Costs, $/yr	
1. Operating labor	= (0.25 hr/8-hr shift) x H x LR
2. Supervisory labor	= 0.15 x (operating labor)
3. Maintenance	= 0.2 x TCI
4. Activated carbon	= 0.00127 x Q x H x ACC x AF
5. Dust disposal	= 0.00127 x Q x (1 ton/2,000 lb) x H x DDC x AF
D. Indirect Annual Costs, $/yr	
1. Overhead	= 0.6 x (labor + maintenance materials)
2. Property taxes, insurance, and administration	= 0.04 x TCI
3. Capital recovery	= CRF x TCI
E. Total Annual Cost	
1. $/yr	= Direct Annual Costs + Indirect Annual Costs
2. ($/yr) / dscfm	= ($/yr) / Q

Sources:

1. Cost equations: Hospital/Medical/Infectious Waste Incinerators (HMIWI) [EPA-HQ-OAR-2006-0534] Model Plant Description and Cost Report (II-A-112).
2. Operating labor rate: Bureau of Labor Statistics, Occupational Employment Statistics, May 2007 National Industry-Specific Occupational Employment and Wage Estimates.
3. Activated carbon cost: The Innovation Group. Chemical Profiles: Carbon, Activated. 2002. Assumed 20% price increase based on online information from Norit, an activated carbon vendor.
4. Dust disposal cost: NSWMA's 2005 Tip Fee Survey.

Table C-3. Unit-Specific Inputs Used in Cost Algorithms

Facility ID	Unit ID	Unit Type	Capacity (dtph)	Capacity (dry lb/hr)	Sludge Feed Rate (dry tons/hr)	Sludge Feed Rate (dry lb/hr)	Operating Hours (hr/yr)	Stack Gas Flow Rate (dscfm)	Stack Gas Temp[1] (°F)	ACI Adjustment Factor	Landfill Tipping Fee	PM (gr/dscf)	HCl (ppmvd)
AKJuneau	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	43.02	0.0054	0.12
CTMattabassett	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	80.40	0.0054	0.12
CTSynagroWaterbury	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	80.40	0.0054	0.12
CTWestHaven	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	80.40	0.0054	0.12
GANoondayCreek	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	35.31	0.0054	2.48
IADubuque	1	FB	1.70	3400	1.28	2550	4200	6956	1050	0.98	39.85	0.0054	0.05
IADubuque	2	FB	1.70	3400	1.28	2550	4200	6956	1050	0.98	39.85	0.0054	0.05
KSKawPoint	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	27.51	0.0054	2.48
KSKawPoint	2	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	27.51	0.0054	2.48
LANewOrleansEastBank	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	34.61	0.0054	0.12
MALynnRegional	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	84.53	0.0054	0.12
MALynnRegional	2	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	84.53	0.0054	0.12
MIYpsilanti	EU-FBSSI	FB	3.46	6920	2.85	5692	3240	14465	1050	-1.86	39.85	0.0013	0.28
MNStPaulMetro	FBR1	FB	5.42	10840	4.19	8372	7270	21898	1050	-0.47	39.85	0.0010	0.17
MNStPaulMetro	FBR2	FB	5.42	10840	3.94	7876	7270	20984	1050	-0.49	39.85	0.0006	0.16
MNStPaulMetro	FBR3	FB	5.42	10840	3.76	7523	7270	19859	1050	-0.48	39.85	0.0024	0.20
MOLittleBlueValley	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	39.85	0.0054	0.12
MORockCreek	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	39.85	0.0054	0.12
NCBuncombeAshville	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	37.45	0.0054	0.12
NCTZOzborne	ES-1	FB	3.25	6500	2.42	4840	8400	10281	1050	1.02	37.45	0.0011	0.04
NHManchester	1	FB	2.00	4000	1.50	3000	8400	8184	1050	0.98	80.40	0.0054	0.12
NJBayshoreRegional	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0011	0.12
NJBayshoreRegional	2	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0011	0.12
NJCamden	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	77.04	0.0054	0.12
NJGloucester	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0011	0.12
NJGloucester	2	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0011	0.12
NJNorthwestBergen	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0054	0.12
NJNorthwestBergen	2	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0054	0.12
NJPequannockLincolnFairfield	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0054	0.12
NJPequannockLincolnFairfield	2	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	77.04	0.0011	0.12
NJSomersetRaritan	1	FB	0.65	1300	0.49	975	4200	2660	1050	0.98	77.04	0.0011	0.12
NJSomersetRaritan	2	FB	1.33	2660	1.00	1994	4200	5439	1050	0.98	77.04	0.0011	0.12
NYArlington	1	FB	0.35	700	0.26	525	8400	1432	1050	0.98	59.92	0.0054	2.48
NYErieCounty	1	FB	0.78	1560	0.59	1172	4200	3197	1050	0.98	59.92	0.0054	2.48
NYErieCounty	2	FB	0.78	1560	0.59	1172	4200	3197	1050	0.98	59.92	0.0054	2.48
NYGlensFalls	1	FB	1.54	3080	1.16	2310	8400	6301	1050	0.98	59.92	0.0054	0.12

Facility ID	Unit ID	Unit Type	Capacity (dtph)	Capacity (dry lb/hr)	Sludge Feed Rate (dry tons/hr)	Sludge Feed Rate (dry lb/hr)	Operating Hours (hr/yr)	Stack Gas Flow Rate (dscfm)	Stack Gas Temp[1] (°F)	ACI Adjustment Factor	Landfill Tipping Fee	PM (gr/dscf)	HCl (ppmvd)
NYOneidaCounty	1	FB	0.84	1680	0.63	1253	8400	3417	1050	0.98	59.92	0.0054	0.12
NYOneidaCounty	2	FB	0.84	1680	0.63	1253	8400	3417	1050	0.98	59.92	0.0054	0.12
NYOneidaCounty	3	FB	0.84	1680	0.63	1253	360	3417	1050	0.98	59.92	0.0054	0.12
NYPortChester	1	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	59.92	0.0054	0.12
NYPortChester	2	FB	2.26	4516	1.69	3387	4200	9240	1050	0.98	59.92	0.0054	0.12
NYSaratogaCounty	1	FB	1.44	2880	1.08	2156	8400	5882	1050	0.98	59.92	0.0054	0.12
OHLittleMiami	1	FB	3.00	6000	2.25	4500	8400	12275	1050	0.98	34.24	0.0054	0.12
OHNEORSDEasterly	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	34.24	0.0011	0.12
PAAlleghenyCounty	001	FB	3.25	6500	1.88	3760	8400	10257	1050	0.98	52.77	0.0054	0.12
PAAlleghenyCounty	002	FB	3.25	6500	1.88	3760	8400	10257	1050	0.98	52.77	0.0054	0.12
PAWyomingValley	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	52.77	0.0011	0.12
PRPuertoNuevo	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	36.69	0.0011	0.05
SCFelixCDavis	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	38.52	0.0054	0.12
VABlacksburg	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	52.77	0.0054	2.48
VAHLMooney	2	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	52.77	0.0054	0.12
WAAnacortes	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	48.47	0.0054	0.12
WAEdmonds	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	48.47	0.0054	0.12
WALynnwood	1	FB	2.26	4516	1.69	3387	8400	9240	1050	0.98	48.47	0.0054	0.12
WAWestside	1	FB	2.42	4840	1.81	3625	8400	9888	1050	0.98	48.47	0.0054	0.12
AKJohnMAsplund	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	43.02	0.0158	0.65
CACentralContraCosta	MHF 1	MH	2.50	5000	1.95	3900	4200	23132	1050	-2.61	43.02	0.0137	0.79
CACentralContraCosta	MHF 2	MH	2.50	5000	1.54	3085	4200	22925	1050	-1.78	43.02	0.0113	0.79
CAPaloAlto	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	43.02	0.0158	0.65
CAPaloAlto	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	43.02	0.0158	0.65
CTHartford	001	MH	2.50	5000	2.38	4759	6016	17217	1050	-0.41	80.40	0.0158	0.65
CTHartford	002	MH	2.50	5000	2.30	4603	6016	16360	1050	-0.49	80.40	0.0158	0.65
CTHartford	3	MH	2.50	5000	1.88	3750	360	18080	1050	-0.44	80.40	0.0158	0.65
CTNaugatuck	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	80.40	0.0032	0.65
CTNaugatuck	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	80.40	0.0158	0.65
CTSynagroNewHaven	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	80.40	0.0032	0.65
GAPresidentStreet	1	MH	0.38	760	0.29	576	4200	2777	1050	-0.72	35.31	0.0158	0.65
GAPresidentStreet	2	MH	0.38	760	0.29	576	4200	2777	1050	-0.72	35.31	0.0158	0.65
GARLSutton	1	MH	0.25	500	0.19	375	4200	1808	1050	-0.72	35.31	0.0158	0.65
GARLSutton	2	MH	0.25	500	0.19	375	4200	1808	1050	-0.72	35.31	0.0158	0.65
GARMClayton	1	MH	1.25	2500	0.94	1875	4200	9040	1050	-0.72	35.31	0.0315	0.65
GARMClayton	2	MH	1.25	2500	0.94	1875	4200	9040	1050	-0.72	35.31	0.0315	0.65
GAUtoyCreek	1	MH	1.75	3500	1.31	2625	4200	12656	1050	-0.72	35.31	0.0158	0.65
GAUtoyCreek	2	MH	1.75	3500	1.31	2625	4200	12656	1050	-0.72	35.31	0.0158	0.65
GAWeyerhaeuser	1	MH	3.52	7040	2.64	5279	8400	25454	1050	-0.66	35.31	0.0158	13.09
IACedarRapids	1	MH	3.92	7840	2.94	5880	8400	28349	1050	-0.72	39.85	0.0158	0.65

Facility ID	Unit ID	Unit Type	Capacity (dtph)	Capacity (dry lb/hr)	Sludge Feed Rate (dry tons/hr)	Sludge Feed Rate (dry lb/hr)	Operating Hours (hr/yr)	Stack Gas Flow Rate (dscfm)	Stack Gas Temp[1] (°F)	ACI Adjustment Factor	Landfill Tipping Fee	PM (gr/dscf)	HCl (ppmvd)
INBelmontNorth	1	MH	2.60	5200	2.03	4060	4200	7085	1050	-0.67	31.64	0.0174	0.65
INBelmontNorth	2	MH	2.60	5200	2.15	4293	4200	19574	1050	-0.70	31.64	0.0176	0.65
INBelmontNorth	3	MH	2.60	5200	2.12	4233	4200	7888	1050	-0.96	31.64	0.0148	0.65
INBelmontNorth	4	MH	2.60	5200	2.09	4187	4200	20699	1050	-0.67	31.64	0.0077	0.65
INBelmontNorth	5	MH	2.00	4000	1.50	3000	4200	7662	1050	-0.71	31.64	0.0144	0.65
INBelmontNorth	6	MH	2.00	4000	1.50	3000	4200	20410	1050	-0.71	31.64	0.0144	0.65
INBelmontNorth	7	MH	2.00	4000	1.50	3000	4200	7413	1050	-0.71	31.64	0.0144	0.65
INBelmontNorth	8	MH	2.00	4000	1.50	3000	4200	20185	1050	-0.71	31.64	0.0144	0.65
LANewOrleansEastBank	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.66	34.61	0.0158	13.09
MAFitchburgEast	1	MH	2.30	4600	1.72	3443	8400	16597	1050	-0.66	84.53	0.0032	13.09
MAUpperBlackstone	1	MH	3.00	6000	1.79	3587	8544	6271	1050	-0.99	84.53	0.0008	0.34
MAUpperBlackstone	Incinerator 3	MH	3.00	6000	1.96	3921	216	14421	1050	-1.67	84.53	0.0005	0.31
MDWesternBranch	1	MH	1.08	2160	0.81	1620	4200	7810	1050	-0.72	55.64	0.0158	0.65
MDWesternBranch	2	MH	1.08	2160	0.81	1620	4200	7810	1050	-0.72	55.64	0.0158	0.65
MIAnnArbor	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	39.85	0.0158	0.65
MIBattleCreek	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIBattleCreek	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIDetroitComplex1	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIDetroitComplex1	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIDetroitComplex1	3	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIDetroitComplex1	4	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIDetroitComplex1	5	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIDetroitComplex1	6	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MIDetroitComplex2	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIDetroitComplex2	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIDetroitComplex2	3	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIDetroitComplex2	4	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIDetroitComplex2	5	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIDetroitComplex2	6	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIDetroitComplex2	7	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIDetroitComplex2	8	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIFlint	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIFlint	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIFlint	3	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIFlint	4	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0315	0.65
MIPontiacAuburn	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	39.85	0.0158	0.65
MIWarren	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	39.85	0.0315	0.65
MNSeneca	Incinerator 1	MH	1.58	3160	1.34	2676	4000	16607	1050	0.48	39.85	0.0344	0.42

Facility ID	Unit ID	Unit Type	Capacity (dtph)	Capacity (dry lb/hr)	Sludge Feed Rate (dry tons/hr)	Sludge Feed Rate (dry lb/hr)	Operating Hours (hr/yr)	Stack Gas Flow Rate (dscfm)	Stack Gas Temp[1] (°F)	ACI Adjustment Factor	Landfill Tipping Fee	PM (gr/dscf)	HCl (ppmvd)
MNSeneca	Incinerator 2	MH	1.58	3160	1.42	2843	4000	15606	1050	0.37	39.85	0.0333	0.42
MOBigBlueRiver	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.66	39.85	0.0158	13.09
MOBigBlueRiver	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.66	39.85	0.0158	13.09
MOBigBlueRiver	3	MH	2.69	5381	2.02	4036	360	19458	1050	-0.72	39.85	0.0158	0.65
MOBissellPoint	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOBissellPoint	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOBissellPoint	3	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOBissellPoint	4	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOBissellPoint	5	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOBissellPoint	6	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOLemay	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOLemay	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOLemay	3	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
MOLemay	4	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	39.85	0.0158	0.65
NCRockyRiver	1	MH	2.97	5940	2.23	4452	8400	21464	1050	-0.72	37.45	0.0032	0.65
NJAtlanticCounty	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	77.04	0.0158	0.65
NJAtlanticCounty	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	77.04	0.0158	0.65
NJMountainView	#1	MH	0.80	1600	0.80	1597	2715	7698	1050	-0.80	77.04	0.0017	0.86
NJMountainView	#2	MH	0.80	1600	0.80	1597	2715	9267	1050	-0.80	77.04	0.0017	0.86
NJParsippanyTroyHills	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	77.04	0.0158	0.65
NJParsippanyTroyHills	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	77.04	0.0158	0.65
NJStonyBrook	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	77.04	0.0158	0.65
NJStonyBrook	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	77.04	0.0158	0.65
NYAlbanyCountyNorth	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65
NYAlbanyCountyNorth	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65
NYAlbanyCountySouth	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65
NYAlbanyCountySouth	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65
NYAuburn	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	59.92	0.0158	0.65
NYBirdIsland	1	MH	14.04	28080	10.53	21063	8400	101548	1050	-0.66	59.92	0.0158	13.09
NYBirdIsland	2	MH	14.04	28080	10.53	21063	8400	101548	1050	-0.66	59.92	0.0158	13.09
NYBirdIsland	3	MH	14.04	28080	10.53	21063	360	101548	1050	-0.66	59.92	0.0158	13.09
NYFrankEVanLare	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	59.92	0.0315	0.65
NYFrankEVanLare	2	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	59.92	0.0315	0.65
NYFrankEVanLare	3	MH	2.69	5381	2.02	4036	360	19458	1050	-0.72	59.92	0.0315	0.65
NYNewRochelle	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65
NYNewRochelle	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65
NYNorthwestQuadrant	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	59.92	0.0315	0.65
NYOrangetown	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	59.92	0.0158	0.65
NYOssining	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65
NYOssining	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	59.92	0.0158	0.65

Facility ID	Unit ID	Unit Type	Capacity (dtph)	Capacity (dry lb/hr)	Sludge Feed Rate (dry tons/hr)	Sludge Feed Rate (dry lb/hr)	Operating Hours (hr/yr)	Stack Gas Flow Rate (dscfm)	Stack Gas Temp[1] (°F)	ACI Adjustment Factor	Landfill Tipping Fee	PM (gr/dscf)	HCl (ppmvd)
NYSchenectady	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	59.92	0.0315	0.65
NYSouthwestBergenPoint	1	MH	4.92	9840	3.69	7375	4200	35557	1050	-0.72	59.92	0.0158	0.65
NYSouthwestBergenPoint	2	MH	4.92	9840	3.69	7375	4200	35557	1050	-0.72	59.92	0.0158	0.65
NYTonawanda	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.66	59.92	0.0158	13.09
OHCanton	1	MH	1.08	2160	0.81	1620	4200	7810	1050	-0.72	34.24	0.0158	0.65
OHCanton	2	MH	1.08	2160	0.81	1620	4200	7810	1050	-0.72	34.24	0.0158	0.65
OHColumbusSoutherly	1	MH	3.00	6000	2.25	4500	4200	21696	1050	-0.72	34.24	0.0158	0.65
OHColumbusSoutherly	2	MH	3.00	6000	2.25	4500	4200	21696	1050	-0.72	34.24	0.0158	0.65
OHColumbusSoutherly	3	MH	3.00	6000	2.25	4500	4200	21696	1050	-0.72	34.24	0.0158	0.65
OHColumbusSoutherly	4	MH	3.00	6000	2.25	4500	4200	21696	1050	-0.72	34.24	0.0158	0.65
OHEuclid	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	34.24	0.0158	0.65
OHEuclid	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	34.24	0.0158	0.65
OHJacksonPike	1	MH	2.32	4640	1.74	3486	4200	16807	1050	-0.72	34.24	0.0158	0.65
OHJacksonPike	2	MH	2.32	4640	1.74	3486	4200	16807	1050	-0.72	34.24	0.0158	0.65
OHMillCreek	1	MH	4.00	8000	3.00	6000	4200	28928	1050	-0.72	34.24	0.0158	0.65
OHMillCreek	2	MH	4.00	8000	3.00	6000	4200	28928	1050	-0.72	34.24	0.0158	0.65
OHMillCreek	3	MH	4.00	8000	3.00	6000	4200	28928	1050	-0.72	34.24	0.0158	0.65
OHMillCreek	4	MH	4.00	8000	3.00	6000	4200	28928	1050	-0.72	34.24	0.0158	0.65
OHMillCreek	5	MH	4.00	8000	3.00	6000	4200	28928	1050	-0.72	34.24	0.0158	0.65
OHMillCreek	6	MH	4.00	8000	3.00	6000	4200	28928	1050	-0.72	34.24	0.0158	0.65
OHNEORSDSoutherly	1	MH	3.60	7200	2.70	5400	4200	26035	1050	-0.72	34.24	0.0032	0.65
OHNEORSDSoutherly	2	MH	3.60	7200	2.70	5400	4200	26035	1050	-0.72	34.24	0.0032	0.65
OHNEORSDSoutherly	3	MH	3.60	7200	2.70	5400	4200	26035	1050	-0.72	34.24	0.0032	0.65
OHNEORSDSoutherly	4	MH	3.60	7200	2.70	5400	4200	26035	1050	-0.72	34.24	0.0032	0.65
OHNEORSDWesterly	1	MH	1.79	3580	1.34	2685	4200	12945	1050	-0.72	34.24	0.0158	0.65
OHNEORSDWesterly	2	MH	1.79	3580	1.34	2685	4200	12945	1050	-0.72	34.24	0.0158	0.65
OHWilloughbyEastlake	1	MH	3.42	6840	2.57	5130	8400	24733	1050	-0.72	34.24	0.0315	0.65
OHYoungstown	1	MH	2.00	4000	1.50	3000	4200	14464	1050	-0.72	34.24	0.0158	0.65
OHYoungstown	2	MH	2.00	4000	1.50	3000	4200	14464	1050	-0.72	34.24	0.0158	0.65
PADelawareCountyWestern	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	52.77	0.0158	0.65
PADelawareCountyWestern	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	52.77	0.0158	0.65
PAEastNorritonPlymouthWhitpain	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	52.77	0.0158	0.65
PAErie	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.66	52.77	0.0032	13.09
PAErie	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.66	52.77	0.0032	13.09
PAHatfield	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	52.77	0.0032	0.65
PAKiskiValley	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	52.77	0.0158	0.65
PAUpperMorelandHatboro	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	52.77	0.0158	0.65
RICranston	1	MH	0.95	1900	0.71	1424	4200	6863	1050	-0.72	48.48	0.0158	0.65
RICranston	2	MH	1.98	3960	1.48	2968	4200	14311	1050	-0.72	48.48	0.0158	0.65
RINewEngland	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	48.48	0.0032	0.65

Facility ID	Unit ID	Unit Type	Capacity (dtph)	Capacity (dry lb/hr)	Sludge Feed Rate (dry tons/hr)	Sludge Feed Rate (dry lb/hr)	Operating Hours (hr/yr)	Stack Gas Flow Rate (dscfm)	Stack Gas Temp[1] (°F)	ACI Adjustment Factor	Landfill Tipping Fee	PM (gr/dscf)	HCl (ppmvd)
SCColumbiaMetro	1	MH	1.08	2160	0.89	1773	7300	4620	1050	-1.44	38.52	0.0049	0.20
SCColumbiaMetro	2	MH	1.08	2160	0.68	1351	7300	5145	1050	-1.34	38.52	0.0064	0.20
SCPlumIsland	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	38.52	0.0158	0.65
VAArmyBaseNorfolk	1	MH	1.50	3000	0.82	1648	4200	8455	1050	-0.34	52.77	0.0315	0.65
VAArmyBaseNorfolk	2	MH	1.50	3000	1.13	2250	4200	10848	1050	-0.34	52.77	0.0315	0.65
VABoatHarbor	1	MH	1.79	3580	1.64	3278	4200	11399	1050	-0.66	52.77	0.0253	0.70
VABoatHarbor	2	MH	1.79	3580	1.34	2688	4200	12957	1050	-0.66	52.77	0.0253	0.70
VAChesapeakeElizabeth	1	MH	1.50	3000	1.12	2236	4200	7908	1050	-0.72	52.77	0.0158	0.65
VAChesapeakeElizabeth	2	MH	1.50	3000	1.13	2250	4200	10848	1050	-0.72	52.77	0.0158	0.65
VAHopewell	1	MH	2.69	5381	2.02	4036	8400	19458	1050	-0.72	52.77	0.0158	0.65
VANomanCole	1	MH	1.88	3760	1.41	2813	4200	13560	1050	-0.72	52.77	0.0158	0.65
VANomanCole	2	MH	1.88	3760	1.41	2813	4200	13560	1050	-0.72	52.77	0.0158	0.65
VANomanCole	3	MH	3.83	7660	2.88	5750	4200	27722	1050	-0.72	52.77	0.0158	0.65
VANomanCole	4	MH	3.83	7660	2.88	5750	4200	27722	1050	-0.72	52.77	0.0158	0.65
VANomanCole	5	MH	1.58	3160	1.19	2375	4200	11450	1050	-0.72	52.77	0.0158	0.65
VANomanCole	6	MH	1.58	3160	1.19	2375	4200	11450	1050	-0.72	52.77	0.0158	0.65
VAVirginiaInitiative	1	MH	1.88	3760	2.08	4164	4200	16867	1050	-1.84	52.77	0.0172	0.65
VAVirginiaInitiative	2	MH	1.88	3760	1.41	2813	4200	13560	1050	-1.84	52.77	0.0172	0.65
VAWilliamsburg	1	MH	1.96	3920	1.55	3101	4200	6501	1050	-0.72	52.77	0.0176	0.65
VAWilliamsburg	2	MH	1.96	3920	1.47	2938	4200	14162	1050	-0.72	52.77	0.0176	0.65
WABellinghamPostPoint	1	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	48.47	0.0032	0.65
WABellinghamPostPoint	2	MH	2.69	5381	2.02	4036	4200	19458	1050	-0.72	48.47	0.0032	0.65
WIGreenBayMetro	1	MH	1.23	2460	0.92	1848	4200	8910	1050	-0.72	39.59	0.0158	0.65
WIGreenBayMetro	2	MH	1.23	2460	0.92	1848	4200	8910	1050	-0.72	39.59	0.0158	0.65

1. Assumed average gas temperature used for incinerators (CISWI)

Table C-4b. Monitoring Costs

Parameters/Costs	Equation	Based on Default Parameters		Based on Default Parameters and hr/yr
		Bag Leak Detector	Wet Scrubber Monitor	ACI
A. Parameters				
1. Recording lime/carbon flow, min/4-hr period				5
2. Annual operating hours, hr/yr (H)				
3. Cost index				
a. 2008		575.4	575.4	575.4
b. 2006		499.6	499.6	499.6
c. 1997		386.5	386.5	386.5
d. 1993		359.2	359.2	359.2
e. 1992		358.2	358.2	358.2
4. Operating labor wage rate, $/hr (LR)		$34.60	$34.60	$34.60
5. Capital recovery factor, 20-yr equipment life, 7% interest (CRF)	$= [i \times (1 + i)^a] / [(1 + i)^a - 1]$, where i = interest rate, a = equipment life	0.09439	0.09439	0.09439
B. Total Capital Investment, $ (TCI)				
1. Planning		$800	$700	
2. Select type of equipment		$4,500	$400	
3. Provide support facilities		$500	$1,500	
4. Purchased equipment cost (PEC)		$14,100	$19,300	
5. Install and check equipment		$4,800	$1,000	
6. Perf. spec. tests (certif.)		$0	$700	
7. Prepare QA/QC plan		$800	$700	
8. Total capital cost	= Planning + selecting equipment + support facilities + PEC + installation + perf. spec. tests + QA/QC plan	$25,500	$24,300	
C. Annual Costs, $/yr				
1. Operating labor	= (5 min to record lime/carbon flow/4-hr period) x (1 hr/60 min) x H x LR			= (5 min to record lime/carbon flow/4-hr period) x (1 hr/60 min) x H x LR
2. Maintenance materials	= 0.02 x TCI		$500	
3. Operation & maintenance	= Day-to-day activities + annual RATA + CGA + annual QA + O&M review and update	$6,000		
4. Recordkeeping and reporting	= $1,000 x (525.4/386.5)	$200	$1,500	
5. Overhead	= 0.6 x (labor + maintenance materials)		$300	= 0.6 x (labor + maintenance materials)
6. Property taxes, insurance, and administration	= 0.04 x TCI		$1,000	
7. Capital recovery	= CRF x TCI	$3,500	$2,300	
8. Total annual cost	= Operating labor + maintenance materials + recordkeeping and reporting + overhead + property taxes, insurance, and administration + capital recovery	$9,700	$5,600	= Operating labor + maintenance materials + recordkeeping and reporting + overhead + property taxes, insurance, and administration + capital recovery

Notes:
1. Monitoring costs have been rounded to the nearest $100 to be consistent with level of rounding in original costs.

2. Costs to be replaced include: (a) bag leak detector replacing opacity test; (b) CO CEMS replacing CO test and secondary chamber temperature monitor;(c) HCl CEMS replacing HCl test, HCl sorbent monitor (dry scrubbers) and scrubber liquor pH monitor (wet

Sources:
1. Hospital/Medical/Infectious Waste Incinerators (HMIWI) [EPA-HQ-OAR-2006-0534] Testing and Monitoring Options and Costs Memo (IV-B-66).
2. E-mail and attachment from Peter Westlin, EPA, to Mary Johnson, EPA. August 19, 2008. Monitoring Options for SNCR on Medical Waste Incinerators.
3. E-mail from Dan Bivins, EPA, to Mary Johnson, EPA. September 27, 2006. Cost of CO CEMS.
4. E-mail from Dan Bivins, EPA, to Mary Johnson, EPA. July 28, 2006. Some Preliminary Thoughts on the HWI Monitoring.

Table C-4c. Stack Testing Costs

Parameters/Costs	Equation	Values
A. Parameters		
1. Cost index		
a. 2008		575.4
d. 1992		358.2
B. Testing Costs, $		
1. Method 5 (PM)	= $8,000 x (575.4/358.2)	$13,000
2. Method 9 (opacity)	= $1,000 x (575.4/358.2) + $1,500	$3,500
3. Method 10 (CO)	= $4,000 x (575.4/358.2) + $1,000	$7,000
4. Method 26 (HCl)	= $5,000 x (575.4/358.2)	$8,000
5. Method 29 (metals)	= $8,000 x (575.4/358.2) + $2,000	$15,000
6. Method 23 (CDD/CDF)	= $21,000 x (575.4/358.2) - $5,000	$29,000
7. Method 7E (NO_X)	= $5,000 x (575.4/358.2)	$8,000
8. Method 6C (SO_2)	= $5,000 x (575.4/358.2)	$8,000

Annual testing for all:	2/3*sum of costs	**$61,000**
CRF (15 yr, 7%):	(0.07*(1+0.07)^15)/((1+0.07)^15-1)	**0.10979**

Note:
1. Initial testing costs to be annualized over 15 years at 7% interest.
2. Testing costs have been rounded to the nearest $1,000 (except for opacity) to be consistent with level of rounding in original costs; costs also adjusted based on additional information from EPA.
3. Multiple test costs adjusted by 2/3 in nationwide cost estimates to account for travel, accommodations, methods/sampling trains, etc. common to the tests.

Sources:
1. Memorandum from R. Segall, EPA/EMB, to R. Copland, EPA/SDB. October 14, 1992. Medical Waste Incinerator Study: Emission Measurement and Continuous Monitoring. (II-B-89)
2. E-mail from Jason Dewees, EPA, to Peter Westlin, EPA. August 20, 2008. Monitoring Options for SNCR & Test Cost Questions.
3. E-mail from Jason Dewees, EPA, to Mary Johnson, EPA. August 20, 2008. Re: Monitoring Options for SNCR & Test Cost Questions.

Table C-4d. Visible Emissions Testing Costs

Parameters/Costs	Equation	Values
A. Parameters		
1. Operating labor rate, $/hr (LR)		$34.60
2. Capital recovery factor, 5-yr equipment life, 7% interest (CRF)	$= [i \times (1 + i)^a] / [(1 + i)^a - 1]$, where i = interest rate, a = equipment life	0.24389
B. Total Capital Investment, $ (TCI)	= Combination light meter/anemometer ($200) + digital stopwatches (2 each at $25)	$250
C. Direct Annual Costs, $/yr		
1. Operating labor	= (1 hr/reading) x (3 readings/test) x (1 test/yr) x LR	$104
D. Indirect Annual Costs, $/yr		
1. Overhead	= 0.6 x (operating labor)	$62
2. Property taxes, insurance, and administration	= 0.04 x TCI	$10
3. Capital recovery	= CRF x TCI	$61
E. Total Annual Cost, $/yr (rounded)	= Direct Annual Costs + Indirect Annual Costs	$200

Sources:

1. Professional Equipment. 2008. Light Meters Industrial and Professional: Digital Light Meter. Website: http://www.professionalequipment.com.
Accessed July 24, 2008.
2. Cole-Parmer. 2008. Digital Stopwatches -Cole Parmer Instrument Catalog. Website: http://www.coleparmer.com. Accessed July 24, 2008.

Table C-4e. Recordkeeping and Reporting Costs

Burden item	(A) Person-hours per occurrence	(B) Number of occurrences per year	(C) Technical person-hours per year (C = A x B)	(D) Management person-hours per year (D = C x 0.05)	(E) Clerical person-hours per year (E = C x 0.1)	(F) Total person-hours per year (F = C + D + E)	(G) Cost, $
A. Applications	N/A						
B. Surveys and Studies	N/A						
C. Reporting Requirements							
1. Read instructions	1.0	1	1.0	0.05	0.1	1.2	$41
2. Required activities							
a. Perf. spec. tests (certif.) for CMS	17	1	17	0.9	1.7	20	$696
3. Write report							
a. Notification of initial performance test							
i. Pollutants, fugitive ash emissions	2.0	1	2.0	0.1	0.2	2.3	$82
ii. Fugitive ash emissions	1.0	1	1.0	0.05	0.1	1.2	$41
b. Notification of initial CMS demonstration	2.0	1	2.0	0.1	0.2	2.3	$82
c. Report of initial performance test							
i. Pollutants, fugitive ash emissions	8.0	1	8.0	0.4	0.8	9.2	$328
ii. Fugitive ash emissions	2.0	1	2.0	0.1	0.2	2.3	$82
d. Report of initial CMS demonstration	Incl. in C2						
e. Annual report							
i. Results of performance tests conducted during the year	40	1	40	2.0	4.0	46	$1,638
D. Recordkeeping Requirements							
1. Read instructions	Incl. in C1						
2. Plan activities	N/A						
3. Implement activities	N/A						
4. Develop record system	N/A						
5. Time to enter information							
a. Records of initial performance test	Incl. in C3						
b. Records of annual and any subsequent compliance tests	Incl. in C3						
E. Total Labor Burden and Cost			73	3.7	7.3	84	$2,989

Notes:

1. Industry costs are based on the following hourly rates: technical at $34.60, management at $82.23, and clerical at $22.32 (see table below). The composite hourly labor rate is ($34.60/hr) + (0.05 x $82.23/hr) + (0.1 x $22.32/hr) = $40.94/hr. Labor

2. Person-hours per occurrence for CMS performance specification costs are based on the performance specification costs to certify CMS ($700) divided by the composite hourly labor rate ($40.94/hr).
3. Control device inspection cost already accounted for under monitoring costs.
4. Assume 8 hours for each facility to review the report of the initial performance test for pollutants and fugitive ash.
5. Assume 2 hours for each facility to review the report of the initial performance test for fugitive ash.
6. Assume 40 hours to review report of annual PM, CO, and HCl compliance reports.
7. The average recurrent burden and cost in the first 3 years after promulgation for the sources with recurrent burden are equal to the person-hours added down each column for technical, management, and clerical and the sum of the cost column.

Sources:
1. Bureau of Labor Statistics, Occupational Employment Statistics, May 2008 National Industry-Specific Occupational Employment and Wage Estimates.
2. Hospital/Medical/Infectious Waste Incinerators (HMIWI) [EPA-HQ-OAR2006-0534] Testing and Monitoring Options and Costs Memo (IV-B-66).

Labor Rates:

Parameter	Pulp, Paper and Paperboard Mills	Pipeline Transportation	Cement and Concrete Product Manufacturing	Pharma-ceutical & Medicine Manufacturing	Total	Loaded
1. Technical - Stationary Engineers & Boiler Operators	$19.14	$21.11	$18.88	$27.36	$21.62	$34.60
2. Management - Engineering Managers	$41.41	$58.22	$43.90	$62.05	$51.40	$82.23
3. Clerical - Office Clerks, General	$14.21	$14.15	$12.58	$14.85	$13.95	$22.32
4. Composite labor rate						$40.94

Table C-5a. Alternative Disposal Cost Option: Cost to Landfill

Parameters/Costs	Equation
A. Parameters	
1. Incinerator feed rate, lb/hr (C)	
2. Annual operating hours, hr/yr (H)	
3. Landfill tip fee ($/ton)[1]	
B. Annual Costs, $/ton	
50 mile round trip	= $0.266/ton-mile x 50 miles + landfill tip fee
100 mile round trip	= $0.266/ton-mile x 100 miles + landfill tip fee
200 mile round trip	= $0.266/ton-mile x 200 miles + landfill tip fee
C. Annual Costs (with landfill tip fee), $/yr	
50 mile round trip	= Total annual cost x (C x 0.67) x H
100 mile round trip	
200 mile round trip	

Sources:

1. State average tipping fees from BioCycle December 2008, Vol 49, No. 12, P. 22, Table 5.
Where state data unavailable, NSWMA's 2005 Tip Fee Survey regional averages were used.
For Puerto Rico, NSWMA national U.S. average used. All values corrected to 2008 dollars using CPI data from Bureau of Labor Statistics: http://data.bls.gov/cgi-bin/cpicalc.pl
Unit-specific tipping fees are listed in Table 5.

2. Hauling cost: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, Table 3-17: Average Freight Revenue Per Ton-mile.
Assumed 50, 100, or 150 mile/trip to reach nearest landfill.

Table C-5b. Reported Operating Costs and Calculated Cost Factors

Facility ID	Unit ID	Unit Type	Feedrate (dry tons/year)	Total Annual Cost To Operate Unit	Cost Factor ($/dry ton)
MIYpsilanti	EU-FBSSI	FB	9,221.27		
MNStPaulMetro	FBR1	FB	30,433.03	2,633,334.00	86.53
MNStPaulMetro	FBR2	FB	28,630.10	2,633,334.00	91.98
MNStPaulMetro	FBR3	FB	27,346.28	2,633,334.00	96.30
NCTZOsborne	ES-1	FB	20,328.00	1,128,240.75	55.50
PAAlleghenyCounty	001	FB	15,792.00	2,783,333.00	176.25
PAAlleghenyCounty	002	FB	15,792.00	2,783,333.00	176.25
CACentralContraCosta	MHF 1	MH	8,190.00	4,760,351.00	581.24
CACentralContraCosta	MHF 2	MH	6,478.15	4,760,351.00	734.83
CTHartford	001	MH	14,314.07	1,137,000.00	79.43
CTHartford	002	MH	13,844.82	1,137,000.00	82.12
MAUpperBlackstone	1	MH	15,322.20	1,513,370.00	98.77
MNSeneca	Incinerator 1	MH	5,352.73	950,000.00	177.48
MNSeneca	Incinerator 2	MH	5,685.93	950,000.00	167.08
NJMountainView	#1	MH	2,167.48	1,410,554.67	650.78
NJMountainView	#2	MH	2,167.48	1,410,554.67	650.78
SCColumbiaMetro	1	MH	6,472.39	1,116,666.67	172.53
SCColumbiaMetro	2	MH	4,932.37	1,116,666.67	226.40

Cost Factors*

FB	Minimum ($/dry ton)	55.50
	Average ($/dry ton)	113.80
MH	Minimum ($/dry ton)	79.43
	Average ($/dry ton)	329.22

* Cost factors were multiplied with the average feedrates determined for each unit in order to estimate the annual cost to operate it.

Table C-5c. Alternative Disposal Cost Option: Sludge Storage Cost

FacilityID	UnitID	Unit Type	ControlCategory	Capacity (dtph)	Assigned Capacity	Assigned tons/day[a]	Assigned cubic yards/ day[b]	Assigned 4-day Capacity (ft3)	Pad size if 6' deep storage (ft2)	Rail Length[c] (ft)	Aluminum Sheet Area[d] (ft2)	# of 4'x8' sheets required	Rail Cost[e]	Concrete Cost[f] (at $6/ft2)	Total Storage Cost ($)	Annualized Storage Cost[g]
PAKiskiValley	1	MH	vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
NYGlensFalls	1	FB	vs - imp	1.54	1.54	36.96	61	6571	1095	33	794	25	$3,850	$6,571	$10,421	$1,144
WAAnacortes	1	FB	vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
PAHatfield	1	MH	vs - imp - wesp - rto		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
VAHopewell	1	MH	abd - vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
OHWilloughbyEastlake	1	MH	imp	3.42	3.42	82.08	135	14592	2432	49	1184	37	$5,698	$14,592	$20,290	$2,228
NYAuburn	1	MH	abd - vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
NYArlington	1	FB		0.35	0.35	8.4	14	1493	249	16	379	12	$1,848	$1,493	$3,341	$367
AKJuneau	1	FB	vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
CTNaugatuck	1	MH	abo - imp - wesp		1.90	91.32	150	16235	2706	52	1248	40	$6,160	$16,235	$11,197	$1,229
CTNaugatuck	2	MH	vs - imp		1.90										$11,197	$1,229
WALynnwood	1	FB	vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
MAFitchburgEast	1	MH	vs - wesp - rto	2.30	2.30	55.2	91	9813	1636	40	971	31	$4,774	$9,813	$14,587	$1,602
NJPequannockLincolnFairfield	1	FB	vs - imp		1.90	91.32	150	16235	2706	52	1248	40	$6,160	$16,235	$11,197	$1,229
NJPequannockLincolnFairfield	2	FB	vs - imp - wesp		1.90										$11,197	$1,229
WAEdmonds	1	FB	vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
VABlacksburg	1	FB			1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
RINewEngland	1	MH	vs - imp - wesp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
NYOrangetown	1	MH	vs - imp		1.90	45.66	75	8117	1353	37	883	28	$4,312	$8,117	$12,429	$1,365
OHEuclid	1	MH	abd - vs - imp		1.90	91.32	150	16235	2706	52	1248	40	$6,160	$16,235	$11,197	$1,229
OHEuclid	2	MH	abd - vs - imp		1.90										$11,197	$1,229

a. Assumed unit operating 24 hrs per day.
b. Volume based on sludge density of 1215 lbs/yd3 (Pocket Ref (ISBN 1-885071-00-0) page 435).
c. Assumed square concrete pad.
d. Rail height of 6 feet chosen for minimal concrete surface area requirement.
e. Based on cost of $154 per 4' by 8' sheet of flattened aluminum, 0.125 inches thick (Metals Depot: http://www.metalsdepot.com/products/hrsteel2.phtml?page=expanded&LimAcc=$LimAcc)
f. Researched concrete slab costs (including installation, materials, and labor) ranged from $3/ft2 to $10/ft2. For this analysis, an average of $6/ft2 was used.
g. Capital Recovery Factor based on 7% interest and 15 year lifetime.

Table C-6a. Emissions for Landfilling Option: Increased Emissions from Waste-Hauling Vehicles

FacilityID	UnitID	Unit Type	Maximum Charge Rate (ton waste/hr)	Daily waste hauled (tons/day)	Daily waste hauled (cu yd/day)	Operating Hours (hr/yr)	Annual Waste (tpy)	Annual Waste (cu yd/yr)	Number of truck trips per year	Round Trip Miles	mi/yr	CO (tpy)	NOx (tpy)	PM10 (tpy)	PM 2.5 (tpy)	SO2 (tpy)
AKJuneau	1	FB	2.26	54	89	8400	18,969	31,225	867	100	86,735	0.28604	1.03554	0.06187	0.05315	0.00248
NJPequannockLincolnFairfield	1	FB	2.26	54	89	4200	9,484	15,612	434	200	86,731	0.28603	1.03549	0.06187	0.05315	0.00248
NJPequannockLincolnFairfield	2	FB	2.26	54	89	4200	9,484	15,612	434	200	86,731	0.28603	1.03549	0.06187	0.05315	0.00248
NYArlington	1	FB	0.35	8	14	8400	2,940	4,840	134	100	13,443	0.04433	0.16050	0.00959	0.00824	0.00039
NYGlensFalls	1	FB	1.54	37	61	8400	12,936	21,294	591	100	59,150	0.19507	0.70619	0.04219	0.03625	0.00169
VABlacksburg	1	FB	2.26	54	89	8400	18,969	31,225	867	100	86,735	0.28604	1.03554	0.06187	0.05315	0.00248
WAAnacortes	1	FB	2.26	54	89	8400	18,969	31,225	867	100	86,735	0.28604	1.03554	0.06187	0.05315	0.00248
WAEdmonds	1	FB	2.26	54	89	8400	18,969	31,225	867	100	86,735	0.28604	1.03554	0.06187	0.05315	0.00248
WALynnwood	1	FB	2.26	54	89	8400	18,969	31,225	867	100	86,735	0.28604	1.03554	0.06187	0.05315	0.00248
CTNaugatuck	1	MH	2.69	65	106	4200	11,298	18,598	517	200	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
CTNaugatuck	2	MH	2.69	65	106	4200	11,298	18,598	517	200	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
MAFitchburgEast	1	MH	2.30	55	91	8400	19,320	31,802	883	100	88,340	0.29133	1.05471	0.06302	0.05413	0.00253
NYAuburn	1	MH	2.69	65	106	8400	22,596	37,195	1,033	100	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
NYOrangetown	1	MH	2.69	65	106	8400	22,596	37,195	1,033	100	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
OHEuclid	1	MH	2.69	65	106	4200	11,298	18,598	517	100	51,660	0.17037	0.61677	0.03685	0.03166	0.00148
OHEuclid	2	MH	2.69	65	106	4200	11,298	18,598	517	100	51,660	0.17037	0.61677	0.03685	0.03166	0.00148
OHWilloughbyEastlake	1	MH	3.42	82	135	8400	28,728	47,289	1,314	100	131,358	0.43320	1.56830	0.09370	0.08049	0.00376
PAHatfield	1	MH	2.69	65	106	8400	22,596	37,195	1,033	100	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
PAKiskiValley	1	MH	2.69	65	106	8400	22,596	37,195	1,033	100	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
RINewEngland	1	MH	2.69	65	106	8400	22,596	37,195	1,033	100	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
VAHopewell	1	MH	2.69	65	106	8400	22,596	37,195	1,033	100	103,320	0.34073	1.23355	0.07370	0.06331	0.00296
												6.03	**21.84**	**1.30**	**1.12**	**0.05**

Notes:

*assumed density of dewatered sludge is 1215 lbs/yd3 (Pocket Ref (ISBN 1-885071-00-0) page 435)

*assumed maximum capacity of hauling vehicles (36 cu yd) for 50+ cu yd/day. (Land application of biosolids: process design manual. Center for Environmental Research Information (U.S.), 1997. Page 214.)

*emission factors based on national average output from EPA's Office of Transportation and Air Quality (OTAQ) MOtor Vehicle Emission Simulator (MOVES). See factors below:

Pollutant	g/mi	lb/mi
CO	2.99	0.0066
NOx	10.8	0.0239
PM10	0.65	0.0014
PM2.5	0.56	0.0012
SO2	0.03	0.0001

Table C-6b. Emissions for Landfilling Option: LandGEM Output

	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon monoxide			Mercury (total) - HAP		
Year	*(Mg/year)*	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*
2011	325,914	358,505	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	325,914	358,505	325,914	358,505	1.997E+03	1.599E+06	1.074E+02	5.334E+02	7.995E+05	5.372E+01	1.464E+03	7.995E+05	5.372E+01	3.869E-06	4.637E-04	3.116E-08
2013	325,914	358,505	651,827	717,010	3.878E+03	3.105E+06	2.086E+02	1.036E+03	1.553E+06	1.043E+02	2.842E+03	1.553E+06	1.043E+02	7.513E-06	9.005E-04	6.050E-08
2014	325,914	358,505	977,741	1,075,515	5.649E+03	4.523E+06	3.039E+02	1.509E+03	2.262E+06	1.520E+02	4.140E+03	2.262E+06	1.520E+02	1.095E-05	1.312E-03	8.814E-08
2015	325,914	358,505	1,303,655	1,434,020	7.317E+03	5.859E+06	3.937E+02	1.954E+03	2.929E+06	1.968E+02	5.362E+03	2.929E+06	1.968E+02	1.418E-05	1.699E-03	1.142E-07
2016	325,914	358,505	1,629,568	1,792,525	8.888E+03	7.117E+06	4.782E+02	2.374E+03	3.558E+06	2.391E+02	6.514E+03	3.558E+06	2.391E+02	1.722E-05	2.064E-03	1.387E-07
2017	325,914	358,505	1,955,482	2,151,030	1.037E+04	8.301E+06	5.578E+02	2.769E+03	4.151E+06	2.789E+02	7.598E+03	4.151E+06	2.789E+02	2.009E-05	2.407E-03	1.618E-07
2018	325,914	358,505	2,281,395	2,509,535	1.176E+04	9.417E+06	6.327E+02	3.141E+03	4.709E+06	3.164E+02	8.619E+03	4.709E+06	3.164E+02	2.279E-05	2.731E-03	1.835E-07
2019	325,914	358,505	2,607,309	2,868,040	1.307E+04	1.047E+07	7.033E+02	3.492E+03	5.234E+06	3.517E+02	9.581E+03	5.234E+06	3.517E+02	2.533E-05	3.036E-03	2.040E-07
2020	325,914	358,505	2,933,223	3,226,545	1.431E+04	1.146E+07	7.698E+02	3.822E+03	5.729E+06	3.849E+02	1.049E+04	5.729E+06	3.849E+02	2.772E-05	3.323E-03	2.232E-07
2021	325,914	358,505	3,259,136	3,585,050	1.547E+04	1.239E+07	8.324E+02	4.133E+03	6.195E+06	4.162E+02	1.134E+04	6.195E+06	4.162E+02	2.998E-05	3.593E-03	2.414E-07
2022	325,914	358,505	3,585,050	3,943,555	1.657E+04	1.327E+07	8.914E+02	4.425E+03	6.633E+06	4.457E+02	1.214E+04	6.633E+06	4.457E+02	3.210E-05	3.847E-03	2.585E-07
2023	325,914	358,505	3,910,964	4,302,060	1.760E+04	1.409E+07	9.469E+02	4.701E+03	7.047E+06	4.735E+02	1.290E+04	7.047E+06	4.735E+02	3.410E-05	4.087E-03	2.746E-07
2024	325,914	358,505	4,236,877	4,660,565	1.857E+04	1.487E+07	9.992E+02	4.961E+03	7.436E+06	4.996E+02	1.361E+04	7.436E+06	4.996E+02	3.599E-05	4.313E-03	2.898E-07
2025	325,914	358,505	4,562,791	5,019,070	1.949E+04	1.560E+07	1.048E+03	5.205E+03	7.802E+06	5.242E+02	1.428E+04	7.802E+06	5.242E+02	3.776E-05	4.525E-03	3.041E-07
2026	325,914	358,505	4,888,705	5,377,575	2.035E+04	1.629E+07	1.095E+03	5.436E+03	8.147E+06	5.474E+02	1.491E+04	8.147E+06	5.474E+02	3.943E-05	4.726E-03	3.175E-07
2027	325,914	358,505	5,214,618	5,736,080	2.116E+04	1.695E+07	1.139E+03	5.652E+03	8.473E+06	5.693E+02	1.551E+04	8.473E+06	5.693E+02	4.100E-05	4.914E-03	3.302E-07
2028	325,914	358,505	5,540,532	6,094,585	2.193E+04	1.756E+07	1.180E+03	5.857E+03	8.779E+06	5.898E+02	1.607E+04	8.779E+06	5.898E+02	4.248E-05	5.092E-03	3.421E-07
2029	325,914	358,505	5,866,445	6,453,090	2.265E+04	1.813E+07	1.218E+03	6.049E+03	9.067E+06	6.092E+02	1.660E+04	9.067E+06	6.092E+02	4.388E-05	5.259E-03	3.533E-07
2030	325,914	358,505	6,192,359	6,811,595	2.332E+04	1.868E+07	1.255E+03	6.230E+03	9.339E+06	6.275E+02	1.709E+04	9.339E+06	6.275E+02	4.519E-05	5.416E-03	3.639E-07
2031	0	0	6,518,273	7,170,100	2.396E+04	1.919E+07	1.289E+03	6.401E+03	9.594E+06	6.446E+02	1.756E+04	9.594E+06	6.446E+02	4.643E-05	5.565E-03	3.739E-07
									119,434,741	**8,025**			**8,025**			**0.00000465**

Notes:

Values derived from LandGEM V3.02, using the following defaults:

k = 0.06 k value based on default IPCC value for sewage sludge in dry, temperate climate.

Lo = 42 Inventory default Lo for MSW = 100 for conventional climate (dry, temperate); CAA default Lo for MSW = 170 for conventional climate (dry, temperate).

Sewage sludge Lo value calculated based on IPCC equation using default degradable organic carbon (DOC) value of 0.05 for sewage sludge.

IPCC values for other Lo parameters are consistent with inventory defaults, so multplied the result by 1.7 to be consistent with CAA defaults.

Methane in landfill gas = 50%

Table C-6c. Emissions for Landfilling Option: Increased Emissions from Landfill and Flare

Pollutant	Total Tons Emitted Over 20 Years 358,505 tpy basis	Tons per Year
PM	17.92	0.90
HCl	7.62	0.38
SO2	14.94	0.75
CO	4802.91	240.15
NOx	42.16	2.11
CDD/CDF	-	-
Hg	4.65E-06	2.3E-07
Pb	-	-
Cd	-	-

Notes:
PM based on LandGEM methane output and default flare emission factor of 17 lb/MMdscf methane (AP-42 Table 4.2-5)
HCl based on default landfill gas Cl content of 42 ppmv (AP-42 Section 2.4.4.2)
SO2 based on LandGEM gas output and default landfillgas S content of 46.9 ppmv (AP-42 Section 2.4.4.2)
CO based on LandGEM methane output and default flare emission factor of 750 lb/MMdscf methane (AP-42 Table 4.2-5)
NOx based on LandGEM methane output and default flare emission factor of 40 lb/MMdscf methane (AP-42 Table 4.2-5)
Hg based on LandGEM Hg output