CHAPTER NINE

COST AND ECONOMIC IMPACTS OF ALTERNATIVES TO CURRENT CKD DISPOSAL PRACTICES

9.0 INTRODUCTION

Section 8002(o)(5) of RCRA requires EPA to analyze "alternatives to current disposal methods" for cement kiln dust (CKD) waste, while Section 8002(o)(6) requires the Agency to analyze "the costs of such alternatives" and Section 8002(o)(7) directs EPA to address "the impact of those alternatives on the use of natural resources." This chapter presents EPA's analysis of the cost and potential economic impacts of adopting a wide variety of alternative practices for managing CKD, including the use of emerging technologies. This analysis draws on the information presented in preceding chapters addressing current management practices (Chapter 4) and potential management alternatives (Chapter 8). The results of this analysis contributed to the formulation of a range of regulatory status options, which are presented for public review and comment in Chapter 10.

This chapter consists of three sections. The first describes the approach and methods used to develop the cost and impact estimates. The second presents and discusses the costs of managing CKD under a variety of different management practices. The final section explores potential impacts on the cement industry and its markets and relates these impacts to a general discussion of regulatory management options.

9.1 APPROACH AND METHODS

This section describes how EPA conducted its cost analysis. A short section on the conceptual framework used for the analysis is followed by a description of the methodology used to estimate facility costs and a discussion of data sources and limitations. Details on the Agency's approach, methods, and results are provided in a Cost Background Document[1] prepared in support of this report, which may be found in the RCRA docket (No. F-93-RCKA-FFFFF).

RCRA requires EPA to analyze alternatives to current CKD disposal methods and their costs. "Alternatives" can be thought of in two distinct ways: alternative regulatory frameworks that EPA might select, and alternative management practices that individual cement kiln operators might adopt *in response to* regulatory changes. To avoid confusing these two ideas, this report will refer to the choices to be made by EPA as regulatory scenarios, and the choices made by cement kiln operators in response to changing regulations as CKD management alternatives or responses. This report first provides estimates of the costs of CKD management alternatives for the case study plants, and then uses these cost estimates to address the broader question of the potential industry-wide costs and impacts associated with these practices, as described in Section 9.3.

In EPA's basic analytical framework, the costs imposed by an alternative management practice are measured as the difference in cost between the current management practice (referred to hereafter as the "baseline") and the (generally different) alternative practice.

9.1.1 Data Sources

Detailed site-specific data on cement plant operation and CKD generation and waste management practices form the basis for the analyses presented in this chapter. The more important data were drawn primarily from the 1991 Portland Cement Association (PCA) Survey responses, supplemented by EPA observations made during the 1992 field sampling visits to

---

[1] ICF Incorporated, 1993. *Technical Background Document: Cost and Economic Impacts of Alternatives to Current CKD Disposal Practices.*

the 10 cement plants addressed in this analysis and referenced in earlier chapters. Data on emerging CKD management technologies were obtained from both published and primary sources, including detailed discussion and correspondence with the developers of these technologies. Most of the industry and market data upon which EPA has based its assessment of the economic conditions facing the cement industry were obtained from documents published by PCA and the U.S. Bureau of Mines (BOM). PCA's U.S. and Canadian Portland Cement Industry, Plant Information Summary, December 31, 1991, and BOM's Cement (1990) were particularly useful, as were documents published by the U.S. International Trade Administration, International Trade Commission, and Bureau of the Census.

9.1.2 Approach to Estimating Costs and Impacts of CKD Management Alternatives

EPA's basic approach to analyzing the costs of CKD management alternatives in this report is to estimate the financial costs of each alternative as they would be experienced by a sample of 10 selected cement manufacturing plants. These estimates were made by applying cost-estimating functions to the specific conditions found at the facilities in the sample. This approach may be contrasted with an exhaustive analysis of the costs at every facility in the country, for which sufficient data were unavailable, and a model facility approach, which may have lacked realism for specific facilities. A disadvantage of this approach is that in order to extrapolate the results of the cost analysis at specific facilities to estimates of nationwide costs, one must assume that the sample is representative of the industry as a whole. To address this issue, EPA has taken care to select plants that encompass much of the range of conditions found across the industry.

Case Study Plants

EPA selected a sample of 10 plants for detailed analysis and discussion. The 10 plants examined were drawn from 15 plants at which EPA conducted CKD sampling during February and March, 1992. Of these 15 facilities, the 10 selected as the sample for the costing analysis are those plants for which EPA's knowledge of existing operational and waste management practices is most complete. These 10 plants are identified in Exhibit 9-1, which also presents some of the key data on plant operations, CKD generation, and CKD management that are used in the analyses. As discussed in Chapter 1, the Agency has assembled this sample so as to reflect, to the extent possible, the full range of cement kiln technology types, geographic regions of the U.S., and types of fuel used. Accordingly, EPA believes that the 10 facilities examined in this chapter are adequately representative of the population of active CKD-generating plants in the U.S. to support general conclusions regarding the cost and economic impacts of adopting alternative CKD management practices.

To verify that the sample is representative of the population, EPA conducted t-test comparisons of the average gross and net CKD generation rates of the sample of 10 and the remaining 69 cement plants for which data are available. These variables were selected because they have a strong bearing on the costs of adopting various CKD management methods. The mean gross and net CKD generation rates of these two groups cannot be distinguished at a 95 percent confidence level, suggesting that they are drawn from the same overall population and

Exhibit 9-1

Facilities Included in the Cost Analysis

Company	**Location**	**Kiln Type**	**Hazardous Waste Burner** (Yes/No)	**Gross CKD Generation Rate** (Metric Tons/Yr.)	**Net CKD Generation Rate** (Metric Tons/Yr.)	**CKD Disposed** (Metric Tons/Yr.)	**CKD Sold** (Metric Tons/Yr.)
Ash Grove Cement	Chanute, Kansas	Wet	Yes	80,244	77,372	59,963	17,409
Dixie (Southdown)	Knoxville, Tennessee	Dry Ph/Pc	Yes	27,431	16,506	4,386	12,120
Essroc Materials	Speed, Indiana	Dry Ph/Pc	No	172,249	28,274	25,008	3,266
Holnam	Clarksville, Missouri	Wet	Yes	344,700	227,000	214,753	12,247
Holnam	Tijeras, New Mexico	Dry Ph/Pc	No	58,659	25,755	25,755	0
Independent Cement	Catskill, New York	Wet	No	57,299	57,293	36,025	21,268
Kaiser Cement	Cupertino, California	Dry Ph/Pc	No	162,388	545[a]	454	91
LaFarge	Fredonia, Kansas	Wet	Yes	71,372	67,446	67,446	0
Rinker Portland Cement	Miami, Florida	Wet	No	95,246	900	900	0
River Cement	Festus, Missouri	Dry Long	Yes	69,054	53,784	53,784	0

Source: Responses to 1991 Portland Cement Association (PCA) Survey.

[a] Although the operator of this plant reported a net CKD generation rate of 545 metric tons/yr. for 1990, EPA determined during its 1992 site sampling visit that the plant currently recycles 100 percent of the gross CKD generated. Accordingly, in the remainder of this chapter, EPA assumes that net CKD generation by this plant is zero.

therefore, that the sample adequately represents the larger group of cement plants for which EPA has data, and by inference, the industry as a whole.

Methods for Estimating Facility Costs

To calculate the costs of managing CKD in various ways for the 10 plants, EPA developed and applied cost-estimating functions, based on an engineering analysis of each alternative and its component operations and activities. These functions were developed to express CKD management costs as a function of waste generation rate and other plant-specific operating variables.

In EPA's cost estimating analysis, the first step was to estimate the costs and benefits[2] of waste management activities and their distribution over time. The second step was to discount all future costs to the present and then calculate the equivalent annualized compliance cost or benefit. The annualized compliance cost or benefit is the average annual cost or benefit

[2] In this analysis, EPA has considered both the operating savings and the income generated through the sale of new byproducts and services associated with certain CKD management methods. These savings and income streams are referred to throughout this chapter as "benefits."

(i.e., annuity), over the assumed operating life of the facility, that has the same total present value as the sum of the actual expenses incurred and revenues received at their actual times. This method offers the distinct advantage of allowing comparisons among alternative technologies whose costs and benefits may be incurred at different times.

Cost estimating functions were developed from an engineering analysis of each technology, and were generally based on empirical data regarding each cost element for a given technology. The sum of the costs of these elements equals the total facility cost for a particular CKD management strategy. Similarly, the benefits accruing to the facility operator of adopting a particular CKD management alternative are expressed on an annualized basis; these benefits are in the form of operating savings and additional revenues. In all cases, EPA's cost estimating procedures consider both initial capital investment costs, and annual operating and maintenance (O&M) costs (e.g., materials, labor, and utilities). Results are expressed as annualized total costs, total and annualized capital costs, and unit costs (e.g., cost per unit of waste or product).

For certain CKD management alternatives, e.g., disposal of CKD in a secured landfill under RCRA Subtitle C, two additional categories of costs may be incurred. In one category are the capital costs for disposal facility closure and annual costs of post-closure care and maintenance, which are simply capital and O&M costs that are incurred beginning at facility closure. In the other category are the costs associated with potential corrective actions for solid waste management units that release hazardous constituents to the environment; these costs would apply only to cement plants that are newly regulated under RCRA Subtitle C. EPA has not explicitly included the costs of corrective action in the final impact analysis due to the wide range of uncertainty associated with these cost estimates. Nonetheless, some estimates of possible plant-level corrective action costs for typical facilities are presented in Section 9.2 for illustrative purposes.

Methods for Extrapolating from the Case Study Sample to the Industry

Having estimated the costs of various CKD management methods for a representative sample of plants in the cement industry, the Agency performed an analysis of the economic impacts of regulatory scenarios. This analysis is presented in Section 9.3.

As part of this exercise, EPA extrapolated the estimates obtained for the sample of 10 plants to the industry as a whole, to gauge the potential nationwide impacts of the scenarios considered. EPA estimated nationwide impacts of general regulatory management options in two steps.

Cost impacts were first scaled up from the 10 case study plants to the larger 79 facility sample for which the Agency has CKD generation rate data from the PCA Survey. Next, cost impacts were scaled up from these 79 plants to all plants in the domestic industry. To scale the cost from the 10 sample plants to the 79 plants, EPA multiplied total costs estimated for the 10 plants by the ratio of (1) total net CKD for the 79 plants to (2) total net CKD for the 10 plants. To estimate total costs for the additional 36 plants (for which CKD generation data were not available), the Agency extrapolated costs from the 79 survey plants based on relative cement production rather than CKD. To estimate nationwide costs, EPA thus scaled up the total cost for the 79 survey respondents by the ratio of (1) total U.S. cement production capacity to (2) estimated cement production capacity of the 79 plants.

For waste management alternatives that might affect only the 35 plants currently burning or projected to burn hazardous waste, the analysis was conducted in the same manner except that costs for the five hazardous waste burning plants in the sample were first scaled up to the 17 hazardous waste burning plants represented among the 79, and then to the 35 hazardous waste burning plants nationwide.

9.1.3 Cost Accounting Assumptions

Costs of regulations can be viewed in two contexts, economic and financial. The two perspectives consider regulatory costs in two very different ways for different purposes. The economic context considers impacts on resource allocation for the economy as a whole, while the financial context evaluates private sector effects on facilities, firms, and other discrete entities. For this report, EPA has focused on the financial context (i.e., impacts on facilities and the industry), in keeping with the statutory directives articulated at RCRA §8002(o), by evaluating the costs of alternative management practices and their effects on the industry.

Consequently, in conducting this analysis, EPA has employed data and cost accounting assumptions that reflect the viewpoint of cement producers. For example, the Agency has employed a discount rate (9.49 percent) that approximates the likely cost of obtaining financing for regulatory compliance-related expenditures, rather than a "social" discount rate, or cost to society. This discount rate is based on an estimate of the weighted average cost of capital to U.S. industrial firms.[3] Similarly, costs and benefits have been calculated on an after-tax basis, to better reflect the actual financial impacts of prospective regulatory requirements.

In estimating the costs of applying specific waste management technologies, the Agency made a number of additional assumptions, as described in the Cost Background Document.

9.1.4 Limitations of the Analysis

The analytical results presented below are based upon the application of simple cost engineering models to a sample of 10 cement plants that EPA has assumed are representative of the industry as a whole. To the extent that this assumption is not valid (i.e., there are important operational practices or technologies being used to generate and manage CKD that are not known to the Agency), the results of this analysis may yield biased conclusions. Given, however, the scope and depth of EPA's information collection process (e.g., site visits to nearly 20 percent and detailed survey results from nearly 70 percent of the plants in the industry), the Agency believes it unlikely that any important CKD management technologies or site-specific CKD management practices have been overlooked.

There are important limitations in EPA's understanding of the technical aspects and costs of direct CKD recycling. While virtually all cement plants directly recycle some portion of the CKD collected, the Agency has only a limited understanding of the extent to which facility operators currently attempt to maximize the quantity recycled (or control the trace metal or dioxin concentrations), the engineering and operational constraints on this practice, and the economic trade-offs between the incremental costs of increasing recycling rates and the benefits of recovering the resource value contained in the CKD. Because increasing direct CKD recycling is perhaps the simplest and most effective means of eliminating CKD disposal and its associated impacts, the Agency views this as a key information gap.

Finally, EPA's knowledge and understanding of certain market and technical issues limits the Agency's ability to offer definitive conclusions regarding the feasibility of certain CKD management options. For example, while it is clear that alkali content of the cement product can be a controlling factor in the extent of CKD recycling in some parts of the country, EPA does not have sufficient information on the regional variability in cement product markets (which are often driven by state transportation department specifications) and raw material composition to determine which plants are or may be constrained by the 0.6 percent alkali limit established by ASTM and which are not.[4] Similarly, the feasibility of raw material substitution as a means of increasing CKD recycling rates broadly across the industry cannot be determined based upon current information. The Agency does, however, view this option as a promising, low-cost alternative to land disposal of CKD, at least for some plants.

---

[3] ICF Incorporated, 1990. *Regulatory Impact Analysis for the Proposed Rulemaking on Corrective Action for Solid Waste Management Units (Draft)*. Prepared for Economic Analysis Staff, Office of Solid Waste, U.S. EPA. June 25, 1990.

[4] The reader is referred to Section 8.1.2 of this report for background information on this topic.

9.2 DESCRIPTIONS AND COSTS OF BASELINE AND ALTERNATIVE CKD MANAGEMENT METHODS

The waste management practices discussed in this report reflect the range of practices that are currently employed to manage CKD, as well as alternative management techniques that the Agency believes could be employed by facility operators in response to new regulatory requirements. These practices fall into four basic categories: (1) current practices; (2) alternative land disposal practices; (3) alternative recycling and recovery; and (4) other operating practices.

At present, at least some operators of U.S. cement kilns are using most of these practices, and many use combinations of several. As shown in Chapter 3 of this report and in Exhibit 9-1, cement plant operators most often directly recycle some fraction of their gross CKD, many sell some portion of their net CKD for off-site use, and most dispose the remainder in on-site waste management units. In only a few cases is CKD treatment and recovery practiced, and in no instance, to EPA's knowledge, is CKD currently managed as a RCRA Subtitle C hazardous waste.

As discussed in Chapters 4 and 8, based upon extensive research and evaluation, EPA believes that certain trends in CKD management are apparent, and that at least some of these trends may continue regardless of the Agency's ultimate decision concerning the regulatory status of CKD. The most important trend observed is the move away from disposal and toward waste reduction, recovery, or productive use. For example, some operators have been successful in increasing direct CKD recycling, either by reconfiguring dust handling systems or modifying their raw material mix; in at least a few cases, net CKD generation rates have been cut to zero in the process. At the same time, sales of CKD for off-site use have been increasing,[5] as cement companies have more aggressively promoted the sale and use of this material for stabilizing wastes, amending agricultural soils, and other applications. Finally, the historical interest in recovering and reusing CKD to produce cement clinker (described in Chapter 8) is resulting in the limited application of several CKD recycling technologies. Based upon a preliminary evaluation (described more fully below), EPA believes that several of these technologies may find more widespread application in the cement industry during the next few years. The level of interest in this type of CKD management approach is evidenced by the large number of additional site-specific engineering evaluations that have been requested of and conducted by the developers of these technologies.[6]

As described in Section 9.1, EPA has developed cost estimating equations to calculate baseline costs reflecting the current waste management practices employed by nine of the 10 facilities in the sample (the tenth generates no net waste), as well as the costs under various alternative management practices. EPA's current and alternative land disposal cost estimates reflect the assumption that disposal costs are a function of several variables:

- Quantities of CKD generated, recycled, and disposed;
- Physical and chemical characteristics of CKD;
- Depth to ground water;
- Current ground-water and surface water monitoring practices;
- Location characteristics of the facility;
- Characteristics of CKD waste management units; and
- Remaining useful life of existing CKD waste management units.

---

[5] Recent information suggests, however, that the operators of a number of hazardous waste-burning cement plants have suspended sales of CKD, pending the outcome of EPA's decision-making process regarding the RCRA status of this material.

[6] For example, a principal of Passamaquoddy Technology has reported conducting 35 such evaluations for his technology. Personal communication with Garrett Morrison, Passamaquoddy Technology, Inc., July 2, 1993.

Differences in these variables across facilities explain, in large part, differences in results among facilities that may have comparable CKD generation rates. Similarly, the Agency's costing functions for CKD treatment and recovery technologies are based upon waste generation rates, the chemical composition of the CKD entering the recovery process, and in some cases, cement kiln technology type and local climatic conditions.

9.2.1 Current Practices

The major current practices that are applied to CKD fall into three basic categories, which are discussed below: 1) direct recycling; 2) off-site beneficial use; and 3) on-site land disposal. Each of these three approaches to dust management confers economic benefit to or imposes costs on the facility operators that employ it. EPA's evaluation of alternative CKD management methods and their costs builds upon an understanding of the current, or baseline, practices for CKD management that are described in this section.

Direct Recycling of Collected Dust

Direct recycling, as described in Chapters 3 and 8, is practiced at a majority of the operating cement plants in the U.S., at least to some degree. In brief, direct recycling involves returning CKD to the cement kiln (or raw material storage) directly as an input, without any treatment or reclamation. Approximately 18 percent of cement plants, or 20 plants nationwide, recycle all of their CKD.[7]

As a general matter, as stated in Chapter 8, it is in the facility operator's interest to remove as little CKD from the kiln system as possible. Nonetheless, there are wide disparities across the industry in both the quantities and the percentages of gross CKD generated that are directly returned to the kiln (or raw feed) system. In general, operators of dry kilns tend to recycle a greater percentage of their gross CKD than operators of wet process systems, and operators of hazardous waste-burning kilns recycle a lower percentage of their CKD than operators of kilns not burning hazardous wastes. CKD that is recycled is typically pneumatically conveyed, or "insufflated" to the flame end of the kiln, where it is reintroduced through or adjacent to the burner pipe. Alternatively, the collected CKD may be conveyed to raw material storage (silos or tanks, for dry and wet process kilns, respectively).

One approach to decreasing the amount of CKD removed from the system (and therefore, destined for disposal) is to reduce the total amount of dust leaving the kiln (i.e., decrease the gross CKD generation rate). As discussed in Chapter 8, however, facility operators are already motivated by process efficiency and cost considerations to limit the quantities of dust that exit the kiln; most kilns are equipped with chain sections and most operators limit air flow velocities to reduce turbulence, in order to control excessive dust production. Accordingly, opportunities for reductions in gross CKD, or total collected dust, in cement kiln systems appear to be quite limited.

Options for returning the material collected, however, are more numerous. CKD has significant value as a raw material in cement making, particularly because it has already been quarried, crushed, ground, blended, and partially calcined. One industry source has indicated that this material (net CKD) has a value to the cement producer of $4-12 per short ton;[8] this range is consistent with estimates obtained from other industry sources.

In performing this analysis of the impacts of CKD management alternatives, EPA has not explicitly calculated the baseline cost savings at plants that already recycle their CKD or the industry-wide benefits of increasing recycling rates, because of data limitations. As stated

---

[7] Based on 18 percent of the sample of 79 plants in the Portland Cement Association survey and 115 plants total in the U.S.

[8] Morrison, G.L., 1993. *Passamaquoddy Technology Recovery Scrubber Operations Update and Forecast.* July. pg. 7.

above, however, the Agency believes that the average reductions in variable operating costs of increased recycling are on the order of $9 per metric ton (range of about $4.50 to $13.50 per metric ton) of CKD recycled, less handling costs. These estimates do not consider the capital and operating costs associated with installing direct CKD recycling equipment (e.g., for insufflation), nor do they reflect any off-setting credits associated with the avoided costs of CKD disposal.

Off-Site Beneficial Use

As discussed above in Chapters 4 and 8, CKD may be used for a number of off-site beneficial purposes, including stabilizing wastes, fertilizing farmland, and neutralizing waste acids. In 1990, off-site utilization accounted for approximately 943,000 metric tons of CKD, which was about 6 percent of the gross CKD and 20 percent of the net (non-recycled) CKD generated in the U.S., according to PCA Survey data. Approximately 70 percent of the total quantity of CKD going to off-site beneficial use was used for waste stabilization, including dewatering and stabilizing municipal sewage sludge and oil sludge. Twelve percent of the CKD used off site was applied as a combination fertilizer and agricultural liming agent, due to its potassium content and its alkalinity (which is beneficial where acidic soils are prominent).

EPA has extremely limited data on the prices obtained for CKD destined for off-site use.[9] Only one actual price quote is currently available: Keystone Cement in Bath, Pennsylvania reportedly sells its CKD for about $10.00 per metric ton plus transportation costs.[10] Based upon observations made during field visits, EPA believes that the operators of other cement plants sell CKD for a few dollars per metric ton, or give it away. In this chapter and supporting analyses, the Agency has assumed that cement plants receive a nominal price for their CKD ($5 per metric ton), because of the availability of low-cost competing materials in many areas. The net revenues received from CKD sales are assumed to be equal to the sale price (f.o.b.) because of the minimal handling or processing required for typical off-site uses.

Current Land Disposal Practices

Most CKD that is removed from the kiln system (i.e., is not directly recycled to the kiln) and is not used off site in a beneficial application is disposed of on land. EPA believes that, in the absence of new regulatory controls, this would continue to be an important waste management practice across the industry. Of the 81 facilities responding to the 1991 PCA survey, 77 percent dispose of some CKD on site. The remaining 23 percent recycle all of their CKD, or sell all of their non-recycled, or net, CKD. No off-site disposal of CKD has been reported. Extrapolating from data provided by the PCA Survey respondents to the entire industry, an estimated 3.8 million metric tons of CKD were land-disposed nationwide in 1990. A full description of current land disposal practices is provided above in Chapter 4.

Facilities relying on on-site disposal typically dump CKD into an unlined, retired portion of the limestone quarry associated with the cement plant. Alternatively, they may dump CKD in large unlined piles at other on-site locations. Only one respondent to the PCA Survey reported use of a pond, in which the CKD disposal area collects and retains water that covers the CKD. About one-fourth of the plants reportedly co-dispose CKD with other waste materials, such as furnace brick, concrete debris, and tires; typically, the co-disposed wastes amount to less than one percent of the quantity of CKD disposed. In addition, quarry overburden (the earth and rock removed to reach unmined deposits of limestone and other raw materials) is co-disposed with CKD at some plants. Across all plants represented in the PCA Survey data, total quantities of overburden co-disposed with CKD nearly equalled the amount of CKD disposed in 1990.

---

[9] Although EPA has received information on off-site use in response to its 1992 RCRA §3007 request indicating that the operators of at least 35 plants sold CKD in 1990, and that an additional 31 plant operators either sold or gave away CKD during that year, none of these responses provided CKD pricing data.

[10] Personal communication with Doug Glasford, Keystone Cement, November 24, 1992.

Increasingly, on-site CKD management practices are being affected by non-RCRA federal environmental control regulations and standards developed and applied at the state level. As discussed in Chapter 7, national controls on stormwater run-off have been developed under the Clean Water Act, and plants in many states are subject to limitations on fugitive dust emissions from operating and waste management units, including CKD piles. In some instances, state government agencies have required special controls on CKD management units, to limit contaminant releases to the environment.

EPA's cost estimates for current baseline CKD land disposal practices for the case study plants include costs for land, land clearing, heavy equipment, operator labor, utilities, and, as appropriate, environmental control measures such as dust suppression and run-on/run-off controls. The bulk of these costs are associated with equipment to convey CKD from the cement plant to the disposal site and place it in the desired location. For consistency, the Agency has assumed throughout that CKD disposal would be performed with dedicated equipment, and that certain more or less fixed costs would be incurred by the operator, irrespective of the CKD quantity disposed.

Of the nine facilities in the sample used in EPA's cost analysis that rely on on-site CKD disposal, estimated costs for land disposal ranged from about $83,000 to just under $400,000 per year; the median cost is about $3.50 per metric ton of CKD. In part because of EPA's simplifying assumptions, facilities disposing the least CKD have the highest estimated unit disposal costs.

9.2.2 Alternative Land Disposal Practices

In the event of a change in the RCRA regulatory status of CKD, it is likely that changes in existing management practices would be required at most plants for regulatory compliance. These modifications would likely be driven by specific regulatory requirements, which cannot be precisely defined at this time. EPA has prepared an analysis of the costs of several different approaches to more stringent regulation of the land disposal of CKD, which are described in this section. The regulatory framework for these approaches is Subtitle C of RCRA, which provides for a comprehensive system for the management of hazardous wastes. This section presents descriptions of and costs associated with three different approaches to land disposal of CKD within the context of Subtitle C: (1) a conventional Subtitle C scenario in which all existing program elements are applied; (2) a modified Subtitle C scenario that incorporates the flexibility in establishing site-specific requirements provided by §3004(x) of RCRA; and (3) a much more limited approach that might be implemented to control CKD contaminant releases to environmental media.

Conventional Subtitle C Technology and Administrative Standards

EPA regulations promulgated pursuant to RCRA Subtitle C define stringent "cradle to grave" management practices that must be applied to hazardous wastes generated and managed in the United States. Under these regulations, only carefully defined approaches to hazardous waste management are permissible, and all of these approaches are adapted to the conditions found at individual hazardous waste management sites through permits. As an inorganic solid material, only a very few options are available for the permanent disposal of CKD as a hazardous waste. CKD could be managed for short periods of time in a waste pile, but long term disposal would require the use of a landfill meeting EPA-specified minimum technology standards. Accordingly, EPA has identified and categorized all requirements under Subtitle C that might have cost implications for the management of CKD in a hazardous waste landfill, including requirements related to notification, permitting, technical standards for land disposal, monitoring, closure, post-closure care, financial responsibility, and corrective action for continuing releases due to past practices; possible Land Disposal Restrictions program requirements have not been included, due to uncertainties regarding appropriate pre-disposal treatment for this material. More detailed requirements are described in the Background Document.

Subtitle C Costs (Exclusive of Corrective Action Costs)

Assuming Subtitle C landfill disposal, annualized costs for eight of the nine facilities with non-zero net CKD generation range from about $2.4 million to more than $14 million over and above baseline waste management costs, and average about $6.3 million per facility. The ninth plant, facility G, generates a relatively small amount of net CKD; its annualized incremental costs are much lower -- about $140,000 per year. For the eight facilities with significant net waste generation rates, capital costs comprise 50 to 77 percent of the annualized costs. Total capital costs for each facility range from about $7.8 million to $74 million, except for facility G, which has an estimated capital cost of only $20,000 because its operator is assumed to send the CKD off site for disposal, and requires only a temporary storage area. Overall, average capital costs are $25.8 million for the case study plants. The relative importance of capital costs is a reflection of the major capital expenditures that would be required to construct on-site Subtitle C secured landfills for managing CKD.[11] Estimated Subtitle C disposal costs for each facility are shown in Exhibit 9-2.

The highest cost per metric ton of net CKD for Subtitle C disposal is more than $153 per metric ton for Facility G, which is assumed to send its waste off site because that would be less costly than constructing an on-site unit, given this plant's low net waste generation rate and scale economies. Most of the remaining facilities also have costs of more than $100 per metric ton of CKD. Even at these relatively high unit costs, however, construction of on-site disposal units is the most cost-effective response for most of the operators of the plants in the sample, because of scale economies.

Potential Subtitle C Corrective Action Costs

One potentially important and very costly component of regulating CKD under RCRA Subtitle C is corrective action requirements. Section 3004(u) of the Hazardous and Solid Waste Amendments of 1984 (HSWA) to RCRA requires permitted Subtitle C facilities to undertake corrective action for toxic releases to all media, from all solid waste management units (SWMUs) located on their premises. These requirements would affect all newly-permitted cement plants under the Subtitle C requirements if (1) they manage (store or dispose) newly generated CKD on site and (2) they have prior releases from solid waste management units (SWMUs) requiring cleanup. The following classes of facilities would not be affected by this Subtitle C requirement:

(1) Facilities that presently burn hazardous waste fuels and are already subject to Subtitle C permit requirements, because cement plants burning hazardous waste fuels are already subject to facility-wide corrective action requirements (if they release hazardous constituents to the environment);

(2) Facilities that send all newly generated waste off site for disposal; and

[11] Major line item costs include those of procuring and installing one clay, two sand, and two synthetic liners, leachate collection systems, and run-on/run-off controls, as well as site preparation and excavation costs.

Exhibit 9-2

Subtitle C Disposal Costs

Facility	Estimated Current Waste Management Cost ($000/YR)	Subtitle C Costs Incremental to Current Practices					
		Loss of Revenue From CKD Sales ($000/YR)	Annualized Cost ($000/YR)	Total Capital Cost ($000)	Annualized Capital Cost ($000/YR)	Annualized Cost per MT CKD ($/MT)	Annualized Cost per MT Cement ($/MT)
A	214	87	10,613	52,595	7,848	137.2	27.9
B	104	18	3,182	11,637	1,736	112.5	3.0
C	396	61	14,382	74,383	11,099	63.4	11.6
D	148	0	2,996	10,863	1,621	116.3	9.3
E	128	106	8,569	40,749	6,080	149.6	17.8
F	140	0	4,095	17,571	2,622	60.7	14.0
G	83	0	138	21	3	153.3	0.4
H	118	0	3,958	16,736	2,497	73.6	3.7
I	80	61	2,379	7,809	1,165	144.1	4.7
SAMPLE TOTAL	1,411.0000	333	50,312.0000	232,364	34,671.000	1,010.700	92.400
MINIMUM	80	0	138	20	3	60.7	0.4
MAXIMUM	396	106	14,382	74,382	11,098	153.3	27.9
AVERAGE	157	37	5,590	25,818	3,852	112.3	10.3

Note: Current waste management cost is calculated from the quantity of CKD currently being wasted. Regulatory cost increments to current waste management costs are calculated from the net waste generation rate, which includes both the quantity of CKD currently sold and the quantity wasted.

(3) Facilities that generate and manage CKD on site but do not have toxic releases to ground water, soil, air, or surface waters warranting mandated cleanup or control.

Note that facilities in category (2) would not be affected even if they have SWMUs on site that release hazardous constituents, because such facilities could avoid being brought into the Subtitle C regulatory system for hazardous waste treatment, storage, or disposal facilities (TSDFs) in the first instance. For this analysis, EPA has calculated and presented potential corrective action costs for all nine CKD-generating facilities in the sample for illustrative purposes; as stated above, the five hazardous waste-burning plants in the sample are already subject to facility-wide corrective action requirements. In addition, the Agency has assumed that all historically disposed wastes at each site would require a corrective action response; this worst-case assumption obviously produces higher estimated costs than likely actual costs if CKD were to be newly regulated as a hazardous waste. The purview of this analysis includes both active and inactive SWMUs at active CKD-generating facilities.[12]

[12] Releases from SWMUs at inactive cement plants would be controlled under Superfund.

Based upon data on corrective action strategies and costs for remediating contaminated media at cement plants and analogous industrial facilities, EPA developed two basic conceptual approaches to prospective corrective actions at CKD-generating facilities:

(1) Excavation, treatment, and secured disposal of wastes in a waste management unit (on- or off-site), referred to as Remedial Strategy 1 in this analysis; and

(2) Capping, cap maintenance, and future use restrictions, referred to as Remedial Strategy 2.

Because of the nature of the waste and contaminants in question, and the philosophy of EPA's corrective action program, the emphasis in developing these two strategies is on contaminant source control. Depending upon the severity and areal extent of contamination at individual facilities, additional steps (e.g., ground-water pumping and treatment) might be required at some facilities. EPA has not, however, included the costs of such actions in this analysis.

Estimated annualized upper bound corrective action costs at the nine sample plants range from $108,000 to almost $15 million for Strategy 1, and from $450,000 to $775,000 for Strategy 2. The wide disparity in estimated costs under Strategy 1 reflects the great differences among the sample plants with respect to existing CKD (and other waste) quantities (12,900 to 1.8 million cubic meters). If Remedial Strategy 1 is required at sites in the sample of nine, the annualized costs of regulatory compliance under Subtitle C could increase by as much as 470 percent over and above general facility and waste disposal costs; costs at all but one facility could increase by at least 30 percent. In contrast, if Strategy 2 (involving capping) were to be adopted, upper bound Subtitle C costs would increase by only 5.2 to 15.2 percent. The Technical Background Document provides a detailed description of the methods used in this analysis, and presents the site-specific potential corrective action costs developed under Strategies 1 and 2.

The results of the analysis suggest that corrective action requirements could, at some facilities, add significantly to the costs of Subtitle C disposal and, at certain plants, exceed all other costs related to Subtitle C land disposal of future CKD generation. EPA notes that plants having low net CKD generation rates, and correspondingly low on-site CKD disposal costs, could have high corrective action (and total compliance) costs, and vice versa, because of the variability in 1) the quantities of CKD and other wastes historically accumulated at each site, and 2) the environmental conditions that drive corrective action costs.

With respect to corrective action, it should be noted that the 35 or so cement plants already permitted (or in the process of being permitted) as hazardous waste burners will already be subject to facility-wide corrective action, if needed, under Subtitle C of RCRA. Thus, additional corrective action responsibilities could accrue only to the 85 plants not permitted as hazardous waste burners. How many of these plants, if any, might require corrective action would remain to be determined by site-specific studies.

Alternative Subtitle C Costs Under RCRA §3004(x)

The Agency has also examined a less costly disposal option that would represent somewhat less stringent disposal practice requirements under a modified form of Subtitle C. RCRA Section 3004(x) allows for flexible Subtitle C regulation for hazardous CKD waste, as well as several other special waste categories, under certain conditions. Under this provision, many significant RCRA requirements[13] may be modified at the Administrator's discretion

> "...to take into account the special characteristics of such wastes, the practical difficulties associated with implementation of such requirements, and site-specific characteristics ... so long as such

[13] Specifically, RCRA sections 3004(c) through (g) (land disposal restrictions), (o) (minimum technology standards), (u) corrective action for continuing releases), and 3005(j) (permitting of interim status treatment, storage, and disposal surface impoundments) are covered by this provision.

modified requirements assure protection of human health and the environment."

Accordingly, EPA has estimated costs for a "Subtitle C-Minus" alternative, assuming that on-site CKD disposal would need to meet less stringent technology requirements than under full Subtitle C, due to site-specific variability in potential risk to ground water. Plants located in areas with deep ground water and relatively impermeable soils (low risk sites) would be allowed to continue using their current landfills, while plants located in areas with more vulnerable ground water would be required to construct new landfills with liners (clay for moderate risk sites, composite for high risk sites) and leachate collection systems. These less stringent liner and leachate collection system requirements result in capital cost savings of several million dollars at most of the case study plants. All plants would, however, still be required to conduct ground-water monitoring and many other activities mandated by existing standards.

Based upon the case study risk assessments presented in Chapter 6, two of the nine sample plants considered in this analysis are classified as "high" risk facilities. Annualized compliance costs for one of these two facilities are about 18 percent less than under full Subtitle C. The second high risk facility (Facility G), has a very low waste generation rate, and its operator would face the same land disposal costs under Subtitle C-Minus as it would under Subtitle C, because it relies on off-site disposal.

Six of the remaining facilities have moderate risk levels, and their costs are about 50 percent (range of 37 to 60 percent) lower than under full Subtitle C.

The difference is even more dramatic for the only low risk plant (facility D), which has compliance costs that are 78 percent lower. Overall, EPA estimates that disposal costs could average about 42 percent lower for Subtitle C-Minus than for full Subtitle C disposal. Estimated costs for the nine case study facilities under Subtitle C-Minus are shown in Exhibit 9-3.

Additional detail regarding the manner in which EPA has computed the costs for the land disposal alternatives is provided in the Technical Background Document.

Exhibit 9-3

Subtitle C-Minus Disposal Costs

Facility	Risk Level[a]	Estimated Current Waste Management Cost ($000/YR)	Subtitle C-Minus Costs Incremental to Current Practices					
			Loss of Revenue From CKD Sales ($000/YR)	Annualized Cost ($000/YR)	Total Capital Cost ($000)	Annualized Capital Cost ($000/YR)	Annualized Cost Per MT CKD ($/MT)	Annualized Cost Per MT Cement ($/MT)
A	Moderate	214	87	4,763	19,438	2,900	61.6	12.5
B	Moderate	104	18	1,993	4,988	744	70.5	1.9
C	High	396	61	11,817	59,834	8,928	52.1	9.6
D	Low	148	0	671	662	99	26.1	2.1
E	Moderate	128	106	4,096	15,438	2,308	71.5	8.5
F	Moderate	140	0	2,185	6,822	1,018	32.4	7.5
G	High	83	0	138	21	3	152.5	0.4
H	Moderate	118	0	2,251	7,142	1,065	41.9	2.1
I	Moderate	80	61	1,536	3,117	465	93.1	3.1
SAMPLE TOTAL		1,411	333	29,450	117,462	17,530	602	48
MINIMUM		80	0	138	21	3	26.1	0.4
MAXIMUM		396	106	11,817	59,834	8,928	152.5	12.5
AVERAGE		157	37	3,272	13,051	1,947	66.9	5.3

Note: Current waste management cost is calculated from the quantity of CKD currently being wasted. Regulatory cost increments to current waste management costs are calculated from the net waste generation rate, which includes both the quantity of CKD currently sold and the quantity wasted.

[a] As documented in the site-specific hazard potential analyses presented in Chapter 6.

Tailored Contaminant Release Controls

A less stringent alternative to the very complex and costly technical and administrative requirements associated with even a flexible Subtitle C approach could consist of tailored upgrades to existing land disposal units. Under this approach, the objective would be to employ site-specific contaminant release controls to ensure that CKD and its constituents were not released to adjacent environmental media, and hence, would not migrate to potential environmental and human receptors.

Based upon the results of the risk analysis presented in Chapter 6 of this report, the primary potential risk pathways of concern for most plants are fugitive dust that might result in CKD deposition on crop and grazing land, and human health and ecological risk from stormwater run-off releases to fields and surface waters from disposal piles. Though perhaps of less frequent concern, there is also the possibility of ground-water contamination associated with the disposal of CKD in sub-grade units in areas of shallow ground water or under fractured-flow conditions.

EPA thus estimated costs for upgrading existing active land management units at the case study facilities examined in this chapter. Many possible types and degrees of upgrading could be considered under various future regulatory scenarios. For purposes of providing an illustrative example, however, the Agency estimated costs for just one set of typical upgraded practices, consisting of the following set of contaminant release control elements:

- Fugitive dust emission controls;
- Run-on/run-off controls;
- Ground-water monitoring;
- Waste pile capping at unit closure;
- Post-closure care; and
- Costs related to engineering studies and permitting.

Fugitive dust emission controls consist of water lines that are installed around the perimeter of a waste management unit; these lines are equipped with spray nozzles that are used to wet the material inside the unit on a periodic basis. Run-on/run-off controls are comprised of drainage ditches and culverts that are installed around the perimeter of the unit, and pipes and pumping that are employed to convey stormwater away from the unit. Ground-water monitoring systems involve single wells, placed at 200 foot intervals, around one-half (i.e., a down-gradient edge) of the perimeter of the unit. The screen depth is the midpoint of the aquifer. Ground-water sampling and analysis are conducted quarterly from all wells in the system. Waste pile capping involves regrading the deposited material, as necessary, then installing a two foot thick soil cap and planting grass to stabilize the cover material.[14] Post-closure care under this alternative consists of continued ground-water monitoring, maintenance of run-on/run-off controls and the integrity of the soil cap (through mowing and fertilizing the grass), and site security. Finally, costs related to engineering studies and permitting are assumed by EPA to be $250,000, all of which is incurred in Year 1.

These controls are scaled to the predicted size of a facility's waste management unit, as determined through EPA's estimates of current waste management costs. Facilities that currently employ one or more of these practices would bear no additional cost for the corresponding program element. For example, plants that currently monitor ground-water quality would experience no additional costs for this requirement. The resulting cost estimates for this type of tailored approach are presented in Exhibits 9-4 and 9-5 for the nine relevant case study cement plants.

[14] Waste management unit capping at facilities in arid areas (e.g., New Mexico) involves placement of a rock cap rather than a soil cap.

Exhibit 9-4

Tailored Contaminant Release Controls Costs: Continued Sales of CKD for Off-Site Use

Facility	Estimated Current Waste Management Cost ($000/YR)	Loss of Revenue From CKD Sales ($000/YR)	Costs Incremental to Current Practices				
			Total Capital Cost ($000)	Annualized Capital Cost ($000/YR)	Annualized Capital and O&M Costs ($000/YR)	Annualized Cost Per MT CKD ($/MT)	Annualized Cost Per MT Cement ($/MT)
A	214	0	301	45	97	1.6	0.26
B	104	0	319	48	85	3.4	0.08
C	396	0	370	55	157	0.7	0.13
D	148	0	271	40	59	2.3	0.18
E	128	0	287	43	83	2.3	0.17
F	140	0	314	47	100	1.5	0.34
G	83	0	263	39	51	56.7	0.13
H	118	0	2,032	303	364	6.8	0.34
I	80	0	427	64	83	18.9	0.17
SAMPLE TOTAL	1,411	0	4,584	684	1,079	--	--
MINIMUM	80	0	263	39	51	0.7	0.08
MAXIMUM	396	0	2,032	303	364	56.7	0.34
AVERAGE	157	0	509	76	120	10.5	0.20

Exhibit 9-5

Tailored Contaminant Release Controls Costs: Curtailed Sales of CKD for Off-Site Use

Facility	Estimated Current Waste Management Cost ($000/YR)	Loss of Revenue From CKD Sales ($000/YR)	Costs Incremental to Current Practices				
			Total Capital Cost ($000)	Annualized Capital Cost ($000/YR)	Annualized Capital and O&M Costs ($000/YR)	Annualized Cost Per MT CKD ($/MT)	Annualized Cost Per MT Cement ($/MT)
A	214	87	308	46	104	1.34	0.27
B	104	18	322	48	87	3.07	0.08
C	396	61	373	56	160	0.70	0.13
D	148	0	271	40	59	2.28	0.18
E	128	106	296	44	94	1.65	0.20
F	140	0	314	47	100	1.48	0.34
G	83	0	263	39	51	53.38	0.13
H	118	0	2,032	303	364	6.78	0.34
I	80	61	529	79	110	6.70	0.22
SAMPLE TOTAL	1,411	333	4,707	702	1,125	--	--
MINIMUM	80	0	263	39	51	0.70	0.08
MAXIMUM	396	106	2,032	303	364	53.38	0.34
AVERAGE	157	37	523	78	125	8.60	0.21

Under this set of improvements to current land disposal practices and assuming continued sale of CKD for off-site use at current levels, annualized CKD management costs increase by 40 to 300 percent, ranging from $51,000 to more than $360,000 per year. For the majority of plants, annualized CKD land management costs would increase by 40 to 80 percent. Capital costs for installing these release controls would generally fall in the $200,000 to $400,000 range, though one facility (H) would face new capital requirements of over $2.0 million because of its location in a flood plain. On a unit basis, incremental costs average about $10 per metric ton of CKD (within a range of about $1.00 to $53) and about $0.20 per metric ton of cement, ranging from $0.08 to $0.34 per ton of cement.

Using an alternative (extreme) assumption that all sales of CKD for off-site use would be curtailed (e.g., due to regulatory changes), costs for these controls increase somewhat for the five cement plants in the sample that reportedly sell CKD (Exhibit 9-5). Cost increases are due both to the loss of revenue from CKD sales and to the need to dispose of larger CKD quantities. The range of annualized costs under this variant remains the same as in the previous case, but the average impact increases from $120,000 to just under $125,000 per year. Effects on capital requirements are relatively modest, and unit impacts, expressed as the annualized cost per metric ton of CKD, are negligible for most of the plants studied.

In the event that the continued use of the existing CKD management unit(s) resulted in release of contaminants to ground water (as determined by the quarterly ground-water sampling and analysis required under this alternative), corrective action would be necessary. As shown in the Subtitle C corrective action cost analysis presented above, the most cost-effective means of controlling releases to ground water is generally waste management unit capping with an impermeable cover to control further leachate formation within the unit. These costs would be incurred during a single year, and represent the expense of engineering and installing a composite liner and top soil layer on the entire CKD waste pile at its predicted maximum size (i.e., assuming 15 years of waste accumulation).[15]

Based on this approach, the estimated corrective action cost for any of the case study plants that might require corrective action range from just over $100,000 to about $2.2 million. The average per-facility cost is about $1.36 million assuming continued sales of CKD for off-site use at 1990 levels, or about $1.45 million if CKD sales were curtailed. Six of the nine case study plants fall within the range of $1.35 million to $1.8 million.

The Agency assumes that only a relatively small number of plants would face new to corrective action responsibilities under this scenario (and, as previously noted, these responsibilities would apply only to currently active land placement units). Only the 50 or so plants currenly generating net waste and managing it on site (and that are also not hazardous waste burners already subject to corrective action) could have new corrective action responsibilities under this costing scenario. In addition, of these 50 plants, only a fraction would be likely to have ground water contaminant releases requiring correction (based on results of the ground water risk pathway analyses reported in Chapter 6). At $1.4 million per plant, if 10 to 20 plants out of the 50, for example, were to require such corrective action, total capital costs would be on the order of $14 to $28 million for the industry as a whole.

Overall, even with corrective action for ground-water releases, this tailored upgrading of existing units is far less costly than either the full Subtitle C or the Subtitle C-Minus land management standards.

9.2.3 Alternative On-Site CKD Recycling and Recovery Techniques

There are several available alternatives to the on-site disposal of CKD. Some build upon practices that are already in widespread use, while others rely upon unconventional methods to chemically treat CKD so that it may be converted into useful products. The more prominent of these alternative approaches are discussed below.

Increasing Direct CKD Recycling

Despite the clear economic incentive to recycle as much of the collected (gross) CKD as possible, there are several factors that can limit the ability of the kiln operator to directly reuse this material. The primary limitation appears to be buildup of alkalis (sodium and potassium) and sulfur in the recirculating dust load and in the clinker. As discussed at length in Chapters 3 and 8, a large percentage of plants in the U.S. must meet the ASTM standard of 0.6 percent or less alkali in most or all of their product.[16] The conventional method for complying with this limitation has been to periodically remove ("bleed") CKD from the system as a waste or by-product. An emerging alternative is to selectively reformulate raw materials input combinations to yield total alkali concentrations within acceptable product limits, despite continuous recycling of CKD. EPA's research indicates that at least some facilities have been able to recycle all of their CKD on a continuous basis in this manner through the selective use of high purity raw materials, often purchased from off-site sources.[17] At present, however, there is insufficient

---

[15] Unlike typical Subtitle C corrective action provisions, EPA has assumed here that corrective action would affect <u>only</u> the units being employed to manage currently generated and disposed CKD. Other SWMUs at a cement plant would be unaffected.

[16] Types I and II Portland cement (which must comply with the 0.6 percent alkali limit) comprise the vast majority of Portland cement, and Portland cement comprises the vast majority of hydraulic cement, produced and used in the U.S.

[17] For example, Calaveras Cement Company is able to continuously recycle all of the CKD generated at its Tehachapi, CA plant through the use of a low-alkali ("sweetener") sand purchased

information either to assess the extent to which the alkali limit actually influences CKD generation across the industry, or to evaluate the national potential of raw material substitution as a feasible low-cost means of reducing or eliminating net CKD generation or its constituent levels.

Other in-plant factors that may limit direct CKD recycling can include reliance by the facility operator on CKD return methods (e.g., insufflation) that cannot accommodate the entire CKD stream generated by the facility, or on mechanical systems that are incapable of accommodating fluctuations in CKD generation rates, i.e., have no surge capacity. For example, cement plants with relatively high total dust collection rates may not be able to recycle all of this CKD through insufflation without reducing the kiln flame temperature beyond limits that would adversely affect product (clinker) quality. The operator of one of the facilities visited during EPA's 1992 CKD sampling program reportedly disposes of about 50 percent of its total collected CKD solely for this reason.[18] EPA has not been able to determine the extent to which such considerations currently limit CKD recycling across the domestic cement industry, and therefore is not in a position to predict trends or the magnitude of waste reduction opportunities associated with overcoming these types of engineering problems.

Innovative CKD Recovery Technologies

As an alternative to the predominant CKD management practices currently in use, several technologies have been developed for recovering the values contained within this material. In general, these techniques both recover the lime, silica, and other components that are used to produce cement clinker, and produce a residue containing relatively high concentrations of alkali salts that may have value as a fertilizer. The Agency has identified at least three innovative technologies for treating and recovering CKD that would otherwise be wasted. These technologies are examined here in detail because they appear to be promising from the standpoint of both technical and economic feasibility and pollution prevention potential. The three technologies are as follows:

1. Alkali leaching;
2. Fluid bed recovery (Fuller process); and
3. Recovery scrubbing (Passamaquoddy Technology process).

Each of these processes is based upon the premise that by removing some or most of the alkali salts contained in CKD, the treated CKD can either be returned to the clinker production process or manufactured into clinker directly. The alkali salts (primarily potassium sulfate), in turn, can then be sold (with or without further purification) for their fertilizer value. Each technology employs a different approach for separating the alkalis from the CKD, and each produces a somewhat different primary treatment residue (by-product). One of the technologies, the Passamaquoddy Technology recovery scrubber, also reportedly confers a number of other process cost savings and new revenue streams.

Using information collected from the published literature, site visits, and extensive interviews with the principals involved in developing these technologies, the Agency has developed costing equations covering the major capital equipment and O&M cost items, as well as the operating savings and by-product revenues, associated with implementing each of the

from an off-site, local source; this low alkali sand counterbalances the relatively high alkali content in the native limestone. (Source: Personal communication with Lars Oberg, Calaveras Cement Company, Tehachapi, CA, May 20, 1993.)

[18] Personal communication with Brian Graf, ESSROC Materials, Inc. (Logansport, IN), March 17, 1992.

three technologies. These equations and the assumptions upon which they are based are presented in the Technical Background Document.[19]

Because these technologies are not in widespread use and because of the variability in potential input and by-product market conditions across the country, EPA has constructed both "high value" and "low value" cases. In the high value case, all potential savings and by-product revenues are received by the facility operator, while in the low value case, only the most certain benefits of installing the technology are realized; other, more market-driven benefits are assumed to be zero or negative (i.e., impose costs). As a result, the Agency's predicted overall costs (benefits) of installing and operating these innovative technologies should be interpreted as ranges rather than point estimates.

In addition, to assess the cost-effectiveness of larger versus smaller CKD feed rates the Agency estimated costs twice for each technology, once with units sized for the reported gross CKD generation rate, and once using the units sized for net CKD generation rate. Despite reported scale economies associated with the technologies, EPA's analysis suggests that in general, these recovery processes are most economically applied using the net CKD generation rate as the input.[20] Another assumption made in this analysis is that the facility operators would find it more cost-effective to feed CKD that is currently being sold for off-site use to these alternative recovery technologies. That is, EPA assumed that the benefits of recovering the raw mix values (at $9 per metric ton) coupled with the possible additional benefits from by-product revenues would outweigh the lost revenues associated with CKD sales (at $5 per metric ton) and the additional costs of scaling up the CKD processing equipment to handle the larger material volume.

EPA made a number of additional assumptions. The more important ones are as follows: 1) the three technologies are readily available, that is, they would be freely licensed and/or installed by their developers, i.e., would be available to all domestic cement plant operators;[21] 2) CKD that is treated and returned to the kiln system has a value of $9/metric ton in all cases; 3) water used, saved, or recovered has a value of $1/1000 gallons; and 4) CKD recovery processes are operated 24 hours per day, 330 days per year.

Other important costing assumptions apply differently to the high value and low value cases. For the high value case, the following additional assumptions have been applied: 1) potassium sulfate has a value of approximately $220/metric ton; 2) by-products containing significant concentrations of potassium sulfate have a value that is directly proportional to their potassium sulfate concentration; and 3) by-products are marketable throughout the region surrounding each cement plant, i.e., the entire quantities produced can be sold at the estimated price. For the low value cases, EPA has assumed that between two to 10 percent of the incoming CKD that is removed must be disposed and is sent to secure disposal at an <u>off-site</u> commercial landfill (either for non-hazardous solid wastes or for RCRA Subtitle C hazardous

---

[19] ICF Incorporated, op cit.

[20] One key reason for this outcome is that in EPA's analysis, CKD that is currently recycled confers no incremental raw material value, because this value has already been captured by the facility operator. Consequently, the facility operator choosing to treat the gross CKD stream receives new raw material credits <u>only</u> for the net portion of this stream, even though the equipment and operating expenses are scaled up to process the entire gross CKD quantity. Using this set of assumptions, the operator would choose to treat the gross stream only if the incremental by-product credits were sufficient to offset the additional capital and O&M costs or if the net CKD stream was of an insufficient quantity to support a particular technology.

[21] It should also be noted that EPA has no information on the likely licensing and/or royalty arrangements and fees that would be required to install these technologies. Accordingly, costs associated with these arrangements have <u>not</u> been included in this analysis, even though they might be non-trivial.

wastes), at a cost of about $50 and $277 per metric ton (including transportation), respectively.[22] Moreover, other sources of revenue related to additional by-products or services that apply to particular processes are assumed to be unavailable to the plant operator.

Finally, it is worthy of note that two of the technologies, the alkali leaching system and the Passamaquoddy Technology recovery scrubber, have to date been applied only to wet process kiln systems. In this analysis, EPA has assumed that with additional expenditures (e.g., for a rotary dryer and ancillary equipment), operators of dry process kilns would be able to adapt these two technologies to their own operations without significant technical difficulties. Accordingly, the Agency has calculated and presented data from the application of each technology to each plant in the analysis, irrespective of kiln type, and has included, where appropriate, the incremental capital and O&M costs associated with the necessary additional equipment.

Other basic design conditions for the application of the three technologies to our sample of nine net CKD-generating cement plants are summarized in Exhibit 9-6.

Alkali Leaching

The alkali leaching process is the simplest of the three technologies considered in this section; the process involves combining CKD with water at a ratio of about 1:5, agitating the mixture, allowing the leached CKD solids to settle, then recycling this slurry (muds) to the process and removing the liquid fraction for concentration and eventual sale as a liquid fertilizer. When installed at dry process kilns or plants, muds from the leaching process must be dried and stored in a raw feed silo, for return to the kiln to produce clinker. In wet process kilns the underflow

[22] For purposes of discussion in this chapter, only the results for Subtitle C disposal of the recovery residues are presented. The intermediate case results may be found in the Technical Background Document.

Exhibit 9-6

Key Design Conditions for the Nine Case Study Cement Plants

Sample Plant	Process Type	Net Annual Evaporation Rate (Inches/Yr.)	Estimated Clinker Capacity (Metric Tons)	Clinker Capacity Utilization (Percent)	Estimated Annual Clinker Production (Metric Tons/Yr.)	Percent K_2O in CKD[a]
A	Wet	15	449,922	80.4	361,737	3.2
B	Dry	<0	1,026,384	97.4	999,698	4.7
C	Wet	<0	1,179,230	99.8	1,176,872	4.7
D	Dry	50	430,873	71.6	308,505	1.3
E	Wet	<0	533,375	86.1	459,236	4.7
F	Wet	15	346,868	80.4	278,882	4.7
G	Wet	<0	511,604	71.4	365,286	4.7
H	Dry	<0	1,023,209	99.8	1,021,162	2.9
I	Dry	<0	544,260	87.6	476,772	4.7

[a] Facility-specific average calculated from data provided in response to EPA's 1992 RCRA §3007 request for plants A, D, and H; for the other plants, industry average calculated from all available responses.

slurry is either mixed with the feed slurry or pumped into the kiln through a pipe, parallel to the kiln feed. In the high value case, the liquid (potash) fertilizer solution is sold at a price of $15 per metric ton, while in the low value case, this material is not saleable and must be evaporated to the point at which it can be handled as a dry sludge, then disposed in a landfill (both Subtitle C and non-hazardous waste landfills are considered). In any event, about 90 percent of the original CKD is returned to the process as kiln feed, and the remaining 10 percent is either sold or disposed.

The leaching process technology has been in use for at least 20 years; two cement plants (at Inkom, ID and Dundee, MI) currently use the technology, which has enabled the operators of these two facilities to eliminate on-site CKD disposal. As discussed in Chapter 8, the operator of the Inkom facility (Ash Grove Cement) has been operating its leaching process for many years and has been selling its potash solution to a local agri-chemicals dealer throughout this period.[23]

The cost estimation for the alkali leaching process considers (1) the annual quantity of CKD fed to the process, (2) the facility's baseline waste management costs, (3) the K_2O concentration of the CKD, (4) whether the plant uses the wet or a dry process, and (5) the annual evaporation rate where the plant is located. The capital expenditures required for alkali leaching include the costs of procuring and installing the following equipment:

- A dust elevator, a leaching tank with a slow-moving agitator, pumps, and piping (all facilities);
- Either a mechanical evaporator or an evaporation pond (if the annual site-specific evaporation rate is high enough); and

[23] Personal communication with Craig Southworth, Ash Grove Cement Company, May 20, 1993.

- For dry process kilns only, a leached slurry (muds) dewatering system to dry the recovered dust prior to reentry to the kiln.
- Under the low value case, where the potash solution cannot be sold as a fertilizer, an additional evaporator and dewatering system are required to concentrate the potash solution to a sludge for disposal.

Capital costs are annualized and added to annual operating and maintenance expenses for an estimate of total costs. Annual savings are estimated for (1) the amount of raw feed for the kiln that is replaced by recycled CKD, and (2) the elimination of disposal costs for CKD that is no longer land disposed. In the high value case, annual income also is estimated for fertilizer (potash solution) sales. Estimated annual costs, savings, and income (if any) are combined to obtain an estimate of the annual net cost or net benefits from utilizing the process. For each facility, estimates based on processing both gross CKD and net CKD are compared; and the facility is assumed to select the volume with the lower net costs (or, the higher net income). The results of this exercise are presented in Exhibit 9-7, which displays EPA's costing results using the high value and low value cases. Detailed results of these cases, as well as the intermediate case, are presented in the Background Document.

Under the high value case where the operator can find markets for the potash solutions, the alkali leaching system yields benefits to five of the nine plants. The estimated annualized benefit for these five plants ranges from about $68,000 to more than $1.6 million, and averages $563,000 per year. The remaining four plants are predicted to experience net costs of $150,000 to just over $200,000 annually. For most plants, the better point of application of this technology appears to be to the net CKD stream, as estimated net benefits are higher for net CKD than for gross CKD at all but one of the sample facilities, and the difference for this plant is small (less than four percent), given the level of resolution of this analysis. For the five plants experiencing economic gain, these results suggest an average net benefit of almost $20 per ton of CKD and close to $1.00 per ton of cement product. The impacts on the four plants predicted to experience increased costs range from about $3.75 to $10.50 per ton of CKD processed, or from $0.15 to $0.46 per ton of finished cement.

Using more pessimistic assumptions about the marketability and regulatory status of the by-product potassium sulfate solution from alkali leaching, the predicted economic benefits are reduced substantially. If the by-product solution is not marketable and instead must be concentrated to a sludge, dewatered, and disposed in an off-site Subtitle C landfill (e.g., if the material exhibited characteristics of hazardous waste or if the Subtitle C derived-from rule were to apply), the technology is profitable for only one of the nine plants in the sample. For the other eight, estimated cost increases exceed $3.5 million annually at one facility, $1 million annually at four, and $500,000 at two others. Costs per ton of CKD at these eight plants range from about $16 per metric ton to more than $38 per metric ton, while costs per metric ton of cement range from $0.85 to $4.19.

Exhibit 9-7

Estimated Incremental Net Costs for the Alkali Leaching System

Case	**Sample Facility**	**Burns Hazardous Waste**	**Total Capital Costs** ($000)	**Total Annual O&M and Annualized Capital Costs** ($000/Yr.)	**Total Annual Savings and Income** ($000/Yr.)	**Annual Net Cost** ($000/Yr.)	**Net Cost/ Metric Ton of CKD** ($/MT)	**Net Cost/ Metric Ton of Cement** ($/MT)
High Value	A	Yes	769	406	822	-416	-5.38	-1.10
	B	No	1,642	492	337	155	5.49	0.15
	C	Yes	2,384	1,109	2,754	-1,645	-4.77	-1.33
	D	No	1,558	455	304	150	5.83	0.46
	E	No	639	359	633	-274	-4.78	-0.57
	F	Yes	732	332	747	-414	-5.81	-1.41
	G	No	51	23	91	-68	-75.08	-0.18
	H	Yes	2,353	697	496	201	3.74	0.19
	I	Yes	1,215	390	216	175	10.57	0.35
	Wtd. Avg., Haz. Waste Burners		1,491	587	1,007	-420	-3.72	-0.60
	Wtd. Avg., All Facilities		1,260	474	711	-237	-3.16	-0.37
Low Value (Subtitle C Disposal of Residual Alkalies)	A	Yes	1,664	2,036	661	1,375	17.77	3.62
	B	No	2,161	1,142	251	891	31.51	0.85
	C	Yes	3,495	5,371	1,706	3,665	16.16	2.97
	D	No	2,052	1,052	282	770	29.90	2.38
	E	No	1,399	1,594	459	1,135	19.81	2.35
	F	Yes	1,537	1,756	530	1,226	18.18	4.19
	G	No	132	62	88	-27	-29.38	-0.07
	H	Yes	3,089	1,862	398	1,465	27.23	1.37
	I	Yes	1,604	794	166	628	38.03	1.25
	Wtd. Avg., Haz. Waste Burners		2,278	2,364	692	1,672	18.92	2.40
	Wtd. Avg., All Facilities		1,904	1,741	505	1,237	20.08	1.95

Because the alkali leaching technology is the least complex of the three alternatives examined, it has the lowest capital costs for equipment and installation. Total capital investment costs range from less than $1 million to about $2.4 million in the high value case, even at dry process plants, which require substantially more equipment than wet process plants to adopt this technology. The average annualized capital cost for the sample of nine plants is just over $181,000 in the high value case. Under the low value cases, where additional equipment is required to concentrate the potash solution and dry the sludge adequately for land disposal, total and annualized capital investment requirements more than double at several plants and on average increase by about 50 percent.

For the five plants at which this technology yields a positive return under the high value case, annual return on total investment ranges from 54 percent to 133 percent. The average net annual return across the nine case study plants is 18.8 percent under the high value case.

Fluid Bed Dust Recovery

The Fuller Company's fluid bed pocess does not remove alkalis from CKD to prepare it for reintroduction to the kiln, but instead thermally treats the dust to produce clinker directly from the CKD, while concentrating the alkalis into a by-product stream for sale as a fertilizer or disposal as a processing residue. The fluid bed process can be designed to thermally treat either gross or net CKD. In the fluid bed process, CKD is pelletized and calcined into clinker on a fluid bed instead of in a typical rotary kiln; clinker yields are on the order of 60 percent of the CKD treated. The fluid bed process also produces a by-product material representing about 10 percent of the original input CKD volume. The remaining 30 percent of the incoming CKD is removed in the form of exhaust gases (ignition loss).[24] The fluid bed process has been demonstrated only on a pilot scale, though several evaluations are underway worldwide. A detailed description of the fluid bed process may be found in Chapter 8.

In addition to the initial purchase and installation costs of the fluid bed reactor itself, the required capital expenditures include the costs of procuring and installing feed tanks, a pug mill, pelletizers, a rotary dryer, a roll crusher, a screen, dust collectors, a surge bin, a heat exchanger, a fluid bed cooler, a spray tower, fans, piping, and pumps. Because this technology produces cement clinker directly rather than a treated CKD slurry, there is no difference in required equipment or cost when applied to dry versus wet process kilns. Annual savings are estimated for the elimination of disposal costs for CKD that is no longer land-disposed, and annual income is estimated for the sale of clinker that is produced by the process. Under the high value case, the operator receives additional revenue from the sale of the by-product (fertilizer) dust. Under the low value case, this material is disposed in an off-site landfill (as a Subtitle C-regulated waste). Costing results for the high value and low value cases are displayed in turn in Exhibit 9-8.

Under the high value case, application of the fluid bed CKD recovery system yields substantial economic benefits for one of the nine facilities. The most cost-effective level of application is the net CKD stream, though two plants produce too little net CKD to use net CKD as the input, based on minimum fluid-bed technology sizing requirements. Because application of the technology to the gross CKD stream would impart net costs rather than benefits and because other available technologies could impart net benefits at these plants, EPA has assumed that the operators of plants G and I would choose not to install the fluid bed reactor system. For the

[24] Ignition loss represents the thermal decomposition of hydrates and carbonates in untreated CKD to form solid oxides (e.g., CaO, MgO) that comprise the clinker and CKD, and H_2O and CO_2 that are emitted as stack exhaust gases.

Exhibit 9-8

Estimated Incremental Net Costs for the Fuller Fluidized Bed System

Case	Sample Facility[a]	Burns Hazardous Waste	Operating Days Per Year	Total Capital Costs ($000)	Total Annual O&M and Annualized Capital Costs ($000/Yr.)	Total Annual Savings and Income ($000/Yr.)	Annual Net Cost ($000/ Yr.)	Net Cost/ Metric Ton of CKD ($/MT)	Net Cost/ Metric Ton of Cement[b] ($/MT)
High Value	A	Yes	330	9,641	2,630	2,454	176	2.27	0.46
	B	No	253	5,090	1,163	748	415	14.67	0.40
	C	Yes	330	24,307	6,529	6,962	-434	-1.91	-0.35
	D	No	231	5,090	1,094	685	409	15.90	1.26
	E	No	330	7,446	2,058	1,787	270	4.72	0.56
	F	Yes	330	8,567	2,287	2,093	194	2.87	0.66
	H	Yes	330	7,052	1,883	1,676	207	3.85	0.19
	Wtd. Avg., Haz. Waste Burners		330	12,392	3,332	3,293	36	0.34	0.05
	Wtd. Avg., All Facilities		305	9,599	2,520	2,344	177	2.31	0.26
Low Value (Subtitle C Disposal of Residual Alkalies)	A	Yes	330	9,641	4,039	1,806	2,234	28.87	5.88
	B	No	253	5,090	1,569	569	1,000	35.37	0.95
	C	Yes	330	24,307	10,661	5,063	5,597	24.68	4.53
	D	No	231	5,090	1,430	535	895	34.75	2.76
	E	No	330	7,446	3,100	1,307	1,793	31.29	3.72
	F	Yes	330	8,567	3,515	1,528	1,987	29.46	6.79
	H	Yes	330	7,052	2,861	1,225	1,635	30.41	1.53
	Wtd. Avg., Haz. Waste Burners		330	12,392	5,269	2,406	2,863	26.93	3.84
	Wtd. Avg., All Facilities		305	9,599	3,882	1,719	2,163	28.21	3.13

[a] Facilities G and I do not generate sufficient quantities of net CKD to meet the minimum practical scale for a commercial scale fluid bed system.

[b] Includes incremental cement clinker production arising from operation of the fluidized bed system.

plant at which application of the fluid bed recovery technology confers estimated benefits, cost savings amount to about $434,000 annually, or 35 cents per metric ton of cement. Net costs for the remaining six plants are in the $175,000 to $410,000 range, suggesting a unit cost of $2.25 to almost $16 per metric ton of CKD processed, and $0.19 to $0.66 per metric ton of cement.

Under the low value case, the process would not produce net savings for any plant in the sample. Because of the relatively large quantity of by-product generated by this process (10 percent of the incoming CKD quantity), Subtitle C regulation of the process residue would increase net costs dramatically. Typical and average plant costs would increase by about 10 times (to more than $2.1 million annually), and unit costs would approach or exceed $4 per metric ton of cement at half of the plants in the sample.

Estimated total capital costs average almost $9.6 million. Under the high value case, total and annualized capital costs are on average almost eight times higher for the fluid bed reactor system than for the alkali leaching system. Under the low value case, this gap narrows to a factor of five, because in contrast to the alkali leaching system, no additional equipment would be required for the fluid bed system if the by-product had to be disposed. At the one plant for which the estimated net benefit of installing this technology is positive, the net annualized return on total invested capital is 1.8 percent.

EPA's research suggests that the Fuller Company process is unique among the CKD treatment technologies in that it could be constructed as a stand-alone facility to receive CKD from other sources and produce cement clinker and by-product fertilizer. Such an arrangement would not require capital investment on the part of the cement company and it would not directly affect the production process at the CKD-generating cement plant. EPA has not formally analyzed this possibility because no examples are available to provide the necessary data. Nonetheless, the developer of this technology believes that this concept could be economically viable if applied in a suitable location, and has conducted preliminary evaluations of this idea.[25]

<u>The Passamaquoddy Technology Flue Gas Desulfurization Process</u>

The flue gas desulfurization process, or recovery scrubber, developed by Passamaquoddy Technology, Inc. with support from the U.S. Department of Energy's Clean Coal Technology Program, reportedly enables all CKD to be recycled as kiln feed by removing alkalies, chlorides, and sulfates from the dust. The recovery scrubber produces potassium sulfate fertilizer crystals (at a rate of about two percent of CKD processed, by weight) as well as reusable cement kiln feed (the remaining 98 percent), and reportedly discharges only scrubbed exhaust gases (and internally consumed distilled water). The process also may produce several additional income streams. First, the process can accommodate alkaline ashes of various types as feedstock materials; the operator of a recovery scrubber may be able to earn tipping fees from ash generators. Second, because reported flue gas scrubbing efficiency is on the order of 90-95 percent, the facility may be able to burn higher sulfur coal (at lower cost) than might be permitted otherwise, under SO_2 emissions limits. Moreover, if EPA should expand its SO_2 emission allowance trading program to include industrial facilities as well as public utilities,[26] cement plants equipped with the recovery scrubber could conceivably sell emission allowances on the open market. Because some of these prospective benefits are related to the presence of significant amounts of sulfur in the kiln combustion gases, this technology might not be suitable for application to the small percentage of U.S. cement plants that do not rely upon coal for at least part of their energy needs.[27] A detailed description of the recovery scrubbing process may be found in Chapter 8.

This system has been installed and is operating at the Dragon Products, Inc. cement plant in Thomaston, ME. According to a representative of Passamaquoddy Technology, this plant is recycling all of its newly generated CKD, is producing high-purity potassium sulfate crystals, and has recently signed contracts for receipt of alkaline ash generated off site, which will be fed to the recovery scrubber system in the same manner as the CKD.[28] Dragon Products anticipates receiving a $30 per ton tipping fee for accepting this material.

The Passamaquoddy Technology recovery scrubber is by far the most complex of the recovery technologies examined in this chapter. The capital equipment and associated costs of the technology can be grouped into major functional categories, as follows:

---

[25] Personal communication with Sidney Cohen, The Fuller Company, July 20, 1993.

[26] Keynote Address by Carol Browner, EPA Administrator, at the Clean Air Marketplace 1993. September 9, 1993.

[27] Only 10 of the 81 respondents to the 1991 PCA Survey providing useable data indicated that coal was not used as a primary kiln fuel at their plants.

[28] Personal communication with Garrett Morrison, Passamaquoddy Technology, Inc., July 2, 1993.

- Gas handling equipment (duct work and fan);

- CKD processing equipment (mixing tank, reaction tank, pumps, and piping);

- Fertilizer production equipment (heat exchanger, circulating pump, evaporation tank, condenser, and centrifuge);

- Equipment controls (instrumentation, electrical distribution, and miscellaneous construction - also includes engineering, design, and project management); and

- A dewatering system (for dry process kilns only - pressure filter press, steel filtrate tank, filter cake storage bin, rotary drum dryer, conveyor, pumps, piping, electrical, and instrumentation).

The cost estimation for the recovery scrubber process includes the following elements: (1) the annual quantity of CKD; (2) the process type (wet or dry); (3) the percentage of K_2O in the dust feed; and (4) the facility's baseline waste management costs. For the high value case, EPA also assumes: (1) the scrubber is designed with excess capacity and processes not only currently generated CKD but also CKD from stockpiles and/or alkali ash from off-site sources (at a ratio of 5:2); (2) the facility can sell excess SO_2 allowances for $300 per ton SO_2; (3) the plant switches from low sulfur coal to high sulfur coal, at savings of $2 per ton of coal; (4) the potassium sulfate output is sold as fertilizer at $175 per metric ton; and (5) off-site sources pay the facility $33 per metric ton to receive their alkali ash, which is used as an input to the process. In the low value cases, the recovery scrubber is sized only to accommodate current on-site CKD generation, and none of the additional sources of savings or revenue are assumed to be available to the facility operator. In addition, off-site land disposal of the by-product crystals is required, in either a commercial Subtitle D or Subtitle C landfill. Costing results for the high value and low value (Subtitle C Disposal) cases are displayed in Exhibit 9-9.

Exhibit 9-9

Estimated Incremental Net Costs for the Passamaquoddy Technology Recovery Scrubbing Process

Case	Sample Facility	Burns Hazardous Waste	Total Capital Costs ($)	Total Annual O&M and Annualized Capital Costs ($000/Yr.)	Total Annual Savings and Income ($000/Yr.)	Annual Net Cost ($000/Yr.)	Net Cost/ Metric Ton of CKD ($/MT)	Net Cost/ Metric Ton of Cement ($/MT)
High Value Case	A	Yes	10,552	1,996	2,709	-712	-8.87	-1.87
	B	No	24,742	5,057	5,112	-55	-0.32	-0.05
	C	Yes	22,738	4,247	8,621	-4,375	-19.32	-3.54
	D	No	5,488	1,113	780	333	12.94	1.03
	E	No	9,142	1,716	2,206	-490	-8.55	-1.02
	F	Yes	10,568	1,911	2,695	-784	-10.99	-2.68
	G	No	12,790	2,326	2,736	-410	-4.31	-1.07
	H	Yes	9,751	1,946	1,705	241	4.48	0.22
	I	Yes	5,021	1,006	669	336	20.38	0.67
	Wtd. Avg., Haz. Waste Burners		11,649	2,221	3,280	-1,059	-11.78	-1.52
	Wtd. Avg., All Facilities		12,267	2,369	3,026	-657	-7.40	-1.03
Low Value (Subtitle C Disposal of Residual Alkalies)	A	Yes	6,525	1,586	683	903	11.67	2.38
	B	No	4,895	1,094	263	831	29.39	0.79
	C	Yes	14,402	3,641	1,772	1,870	8.25	1.51
	D	No	3,664	874	293	580	22.53	1.79
	E	No	5,958	1,385	475	909	15.87	1.89
	F	Yes	6,613	1,479	549	930	13.79	3.18
	G	No	430	76	88	-12	-12.85	-0.03
	H	Yes	6,553	1,562	421	1,141	21.21	1.06
	I	Yes	3,516	796	173	623	37.73	1.24
	Wtd. Avg., Haz. Waste Burners		7,522	1,812	720	1093	12.37	1.57
	Wtd. Avg., All Facilities		5,840	1,388	524	864	14.03	1.36

In the high value case, installation of the recovery scrubber yields net benefits for six of the nine facilities with positive net CKD generation rates. The other three have relatively low net CKD generation rates and operate dry process plants, both of which would make the economics of this alternative less favorable than they would be otherwise; the projected cost impacts are on the order of only $240,000 to $340,000 per year. The optimal application point for six of the nine plants is to the net CKD stream rather than the gross CKD quantity. For two of the remaining plants (A and B) the differences are marginal. For the six plants in the sample showing a positive return on investment, net benefits average more than $1.1 million per year, and range from $55,000 to almost $4.4 million annually. On a unit basis, benefits for the plants under this case average about $7.40 per metric ton of CKD and $1.03 per metric ton of cement.

Under the low value case, the recovery scrubber process produces net benefits at only one plant in the sample, and is uniformly most cost-effective when applied to the net CKD generation rate. Under the assumption of hazardous waste disposal of the recovery scrubber residue, the process is predicted to generate a (small) net benefit at only one plant, which has a very low waste generation rate and a relatively high estimated current disposal cost. Unit costs average about $1.35 per ton of cement, and range from about zero to $3.20.

Capital installation costs associated with this technology are comparable to those for the fluid bed technology, and are considerably higher than those for the alkali leaching system. Total capital costs under the high value case average more than $12.2 million, and range up to $24.7 million. Under the low value case, capital costs are actually lower, because in the absence of expected revenues from receipt of alkaline ash from off-site and SO_2 emission allowance sales, the technology would be designed and installed at a significantly (about 50 percent) smaller scale. In these cases, capital installation costs average about $5.8 million and run from $3.5 to about $6.5 million for most of the sample facilities. As with the other technologies, capital costs would be unaffected by whether the process residue is managed in non-hazardous or hazardous waste management units, because all such disposal is assumed to occur at off-site locations, due to scale economies.

Under the high value case, the annualized return on total invested capital for the six plants with estimated net benefits from installing the recovery scrubber ranges from 0.2 to about 19 percent, with four of the facilities falling in the range from 3.2 to 7.4 percent per year. Across the nine case study plants, the average annualized return on capital is 5.4 percent. These rates of return are substantially lower than those associated with the alkali leaching system, even though total net benefits are in all cases higher.

9.2.4 Other Operating Practices

In addition to modifying the chemical characteristics of and/or management practices applied to CKD after it is removed from the kiln system, it may be possible to effect reductions in disposal rates by relaxing some of the constraints that appear to limit CKD recycling or by attempting to modify some of the inputs that may be resulting in increased generation and removal of dust. Two possible approaches are presented and briefly discussed in this section.

Revised Standards for Cement Products

One possible means for overcoming recycling limitations imposed by-product quality concerns would be to modify the ASTM alkali limit, at least for certain applications. The purpose of the ASTM standard is to prevent reactions between the alkalis in cement and the lime and silica in the aggregates used in making concrete. Such reactions are to be avoided because they expand, crack, and weaken the concrete. If the reactions could be reliably prevented by some means other than limiting the alkali content of cement, specifications for the alkali content of cement could be relaxed, and more CKD could be recycled. At least some members of the cement industry favor such an approach, and the Mid-Atlantic Regional Concrete Technical Committee is considering a recommendation favoring relaxed cement alkali standards in combination with concrete aggregate standards (the committee consists of representatives from the cement, aggregate, and concrete industries, state and federal highway agencies, and the U.S. Army Corps of Engineers).[29] At present, however, it is unclear whether any such modifications in product standards will be undertaken. EPA has not been able to evaluate the feasibility of implementing this type of approach to reducing CKD removal and disposal rates.

Curtailing Use of Hazardous Waste Fuels

A second possible means of increasing recycling rates could be to reduce the use of hazardous wastes as fuel. Only a subset of all cement plants and kilns burn hazardous waste. Kilns at twenty-five cement plants are known to burn hazardous waste, while about 10 additional plants have received and/or have applied for approval to do so. These thirty-five plants represent less than a third of all cement plants in the country, and constitute about 25 percent of total industry clinker capacity. PCA Survey data show, however, that the hazardous waste burning plants tend to generate disproportionate quantities of CKD: the Agency projects that almost half of the net CKD generated and land-disposed is associated with hazardous waste-burning cement plants. Because (as stated above) hazardous waste provides about seven percent of the industry's energy inputs and hazardous waste-burning plants constituted 25 percent of the industry (in terms of clinker capacity) it can be estimated that hazardous waste provides about 28 percent of the energy for the subset of kilns that use it.[30]

If the Bevill Exclusion for CKD were to be removed, one potential response of affected cement plant operators could be to suspend hazardous waste burning in their kilns. The costs of this response, per metric ton of cement, are calculated as follows:

(1) the amount of energy derived from hazardous waste fuel per metric ton of cement, multiplied by the sum of

(2a) the revenues received for accepting hazardous waste per unit of energy, plus

(2b) the cost, per unit of energy, of replacing the energy value of the hazardous waste with fossil fuel.

As shown in Exhibit 9-10, EPA estimates that for the five hazardous waste-burning plants in the sample of nine, the average gross benefit from burning hazardous waste amounted to

---

[29] Reardon, Patrick W., Jr., "Low Alkali Cement Requirements for Northeast U.S. Markets," Cement Technology, November 1991, pp. 61-63.

[30] Assuming that energy use per unit of clinker production does not differ on average between the facilities that burn hazardous waste and those that do not, and if hazardous waste burners constitute 25 percent of clinker capacity, then the hazardous waste burners also use 25 percent of all of the fuel used in the industry. If hazardous waste provides seven percent of all energy, it must provide 28 percent (i.e., 7 percent divided by 25 percent) of the energy, on average, at the subset of facilities that burn hazardous waste.

Exhibit 9-10

Economic Benefits from Burning Hazardous Waste Fuels

Sample Plant	**Quantities of Hazardous Waste Fuels Received**		**Gross Benefits from Hazardous Waste Fuel Burning**			
	Solid (Metric Tons)	**Liquid** (Metric Tons)	**Revenues from Receipt of Wastes** ($000)	**Fuel Cost Savings** ($000)	**Total Benefit** ($000/yr.)	**Benefit per Metric Ton of Cement** ($/yr.)
A	11,014	36,638	12,325	1,094	13,419	35.33
C	0	68,438	12,821	1,759	14,581	11.80
F	86	29,644	5,596	772	6,369	21.75
H	0	44,474	8,332	1,176	9,508	8.87
I	548	131	296	13	310	0.62
Average	2,330	35,865	7,874	963	8,837	15.67

approximately $15.70 per metric ton of cement,[31] which includes both revenues from receiving hazardous waste from generators and alternative fuel cost savings.[32] These do not reflect the permitting, engineering, administrative, or operating costs associated with installing a hazardous waste fuel burning operation at a cement plant; they are presented for illustrative purposes only.

The average value taken across the five hazardous waste burners in the sample obscures a high degree of variability in the benefit of this practice among the individual plants. One of the plants in the sample reported burning less than 1,000 metric tons of hazardous waste, which was less than one unit of hazardous waste for every 500 units of cement produced. At the other extreme, another plant operator reported consuming almost 50,000 tons of hazardous waste fuel, or more than one unit of hazardous waste for every 10 units of cement. Consequently, estimated revenues from hazardous waste burning range from less than $0.70 to more than $35 per metric ton of cement.

This wide range of potential financial impacts resulting from curtailment of hazardous waste fuel burning suggests that this alternative might be a cost-effective response to a change

[31] Removal of the one facility with a very low hazardous waste fuel consumption rate raises the average benefit to the remaining four plants to more than $19.40 per metric ton of cement.

[32] According to a recent (May 1993) draft report published by EPA's Office of Waste Programs Enforcement, Estimating Costs for the Economic Benefits of RCRA Non-Compliance, the median value received by cement plants for burning bulk, non-halogenated solvents and organic liquids (the most prevalent hazardous waste fuel) was about $170 per short ton, with a heating value of about 10,000 Btu per pound, which is about $34 per million Kcal. Prices are even higher for halogenated solvents and organic liquids, for wastes in drums, or for solid wastes. EPA estimates that bulk solid hazardous wastes bring a typical price of $450 per short ton. To this value must be added the cost of replacing the hazardous waste with fossil fuel, which EPA estimates to be approximately $4.00 per million Kcal (see Exhibit 2-22 of this report) assuming that bituminous, subbituminous, or lignite coal would be substituted for the hazardous waste.

in the regulatory status of CKD for some operators under certain conditions.[33] This high degree of variability also suggests, however, that the costs of suspending hazardous waste fuel burning at some cement plants would exceed the costs of on-site Subtitle C disposal of CKD.

9.2.5 Summary of the Costs of Alternative CKD Management Methods

From the foregoing, it is clear that the operators of U.S. cement plants have a number of options for managing the CKD that they generate. In most cases, current practices involve on-site land disposal of CKD in unlined, non-engineered piles or portions of quarries. Some operators, however, have been successful in either directly recycling a major portion of the gross CKD that they generate or selling a substantial fraction of the dust that is not recycled, or both. At a few facilities, novel approaches to recovering CKD that would otherwise be disposed have been implemented, though the technical and economic feasibility of some of these technologies have not been demonstrated at a full commercial scale. CKD also could be managed under more stringent controls in accordance with existing or modified RCRA Subtitle C standards. This would involve constructing on-site (because of scale economies) hazardous waste landfills, and disposing waste CKD in these new units. Alternatively, regulations could establish tailored contaminant release controls that would be installed and operated within the facility's existing waste management system. Finally, in the event of a change in the RCRA regulatory status of CKD, there might be incentives for kiln operators that burn hazardous waste fuels to cease this practice in order to avoid regulatory compliance costs.

To facilitate further examination of and comparisons among these disparate approaches to CKD management, the comparative costs of adopting these alternative practices are summarized in Exhibits 9-11 through 9-13. Exhibit 9-11 presents summary statistics on the total estimated cost impacts of adopting these strategies for the nine sample plants and for the subset of five facilities that burn hazardous waste fuels. Exhibits 9-12 and 9-13 display these results in normalized form; Exhibit 9-12 provides estimated facility-level cost impacts per metric ton of CKD, while Exhibit 9-13 provides these results on a per ton of cement product basis. Each exhibit provides impacts incremental to the estimated costs of current practices, and, where applicable, displays both high value and low value results.

Exhibit 9-11 shows that, for the median and average plant results, two of the CKD recovery technologies indicate net benefits (revenues) to the facility operator under the high value case, for both the nine case study plants and the subset of five hazardous waste-burning facilities. Tailored contaminant release controls and the third CKD recovery technology under the high value case have the lowest costs. These alternative approaches would approximately double current management costs, assuming the median and average values in the exhibit. From there, the cost of alternative practices jumps substantially, to typical costs of more than $1 million annually per facility. In this category would fall the three CKD recovery technologies under the low value case, Subtitle C and Subtitle C-Minus land disposal, and cessation of hazardous waste burning. These results are generally consistent between the group of nine and the sub-set of five, with the obvious exception of the alternative of cessation of hazardous waste burning.

---

[33] In addition, if social costs were analyzed, they would include the lost surplus to suppliers of hazardous wastes (i.e., the price each supplier would be willing to pay to be rid of its hazardous waste, minus the price each supplier actually paid). This lost surplus could be a significant loss to society, though it would not be a factor in the decisions of cement kiln operators except to the extent that the price for accepting hazardous waste at kilns that remain in the business of burning hazardous wastes could rise substantially.

Exhibit 9-11

Total Incremental Annualized Costs of CKD Management Alternatives for EPA Case Study Cement Plants

CKD Management Alternative	**All Facilities in Sample** (9 Plants)				**Hazardous Waste Burners in Sample** (5 Plants)			
	Minimum ($000/yr)	**Median** ($000/yr)	**Maximum** ($000/yr)	**Weighted Average** ($000/yr)	**Minimum** ($000/yr)	**Median** ($000/yr)	**Maximum** ($000/yr)	**Weighted Average** ($000/yr)
Recovery Scrubber/ High Value	-4,375	-410	336	-657	-4,375	-712	336	-1,059
Alkali Leaching/High Value	-1,645	-68	201	-237	-1,645	-414	201	-420
Tailored Contaminant Release Controls/Sale of Dust	51	83	364	144	83	100	364	160
Fluidized Bed/High Value	-434	207	415	177	-434	176	207	36
Tailored Contaminant Release Controls/No Sale of Dust	51	100	364	148	100	110	364	164
Recovery Scrubber/Low Value	-12	903	1,870	864	623	930	1,870	1,093
Alkali Leaching/Low Value	-27	1,135	3,665	1,237	628	1,375	3,365	1,672
Fluidized Bed/Low Value	895	1,793	5,597	2,163	1,635	1,987	5,597	2,863
Subtitle C- Landfill	138	2,185	11,817	6,590	1,536	2,251	11,817	7,566
Stop Burning of Hazardous Waste	0	310	14,581	4,910	310	9,508	14,581	8,837
Subtitle C Landfill	138	3,958	14,382	9,511	2,379	4,095	14,382	10,437

* Per plant averages.

Exhibit 9-12

Annualized Incremental Costs of CKD Management Alternatives per Metric Ton of CKD for EPA Case Study Cement Plants

CKD Management Alternative	**All Facilities in Sample** (9 Plants)				**Hazardous Waste Burners in Sample** (5 Plants)			
	Minimum ($/MT)	**Median** ($/MT)	**Maximum** ($/MT)	**Weighted Average** ($/MT)	**Minimum** ($/MT)	**Median** ($/MT)	**Maximum** ($/MT)	**Weighted Average** ($/MT)
Recovery Scrubber/ High Value	-19.32	-4.31	20.38	-7.40	-19.32	-8.87	20.38	-11.78
Alkali Leaching/High Value	-75.08	-4.78	10.57	-0.37	-5.81	-4.77	10.57	-0.60
Fluidized Bed/High Value	-1.91	3.85	15.90	2.31	-1.91	2.27	3.85	0.34
Tailored Contaminant Release Controls/No Sale of Dust	0.70	2.28	53.38	2.03	0.70	1.48	6.78	1.89
Tailored Contaminant Release Controls/Sale of Dust	0.70	2.30	56.70	2.53	0.70	1.60	18.90	2.40
Recovery Scrubber/ Low Value	-12.85	15.87	37.73	14.03	8.25	13.79	37.73	12.37
Alkali Leaching/Low Value	-29.38	27.23	38.03	20.08	16.16	18.18	38.03	18.92
Fluidized Bed/Low Value	24.68	30.41	35.37	28.21	24.68	28.87	30.41	26.93
Subtitle C- Landfill	26.10	61.60	152.48	53.20	32.39	52.10	93.10	51.05
Stop Burning Hazardous Waste	0.00	18.75	176.78	79.74	18.75	94.43	176.78	100.00
Subtitle C Landfill	60.71	116.33	153.30	90.80	60.71	73.59	144.10	80.16

On a cost per unit of waste basis, the results are quite similar, with respect to both the direction and the relative magnitude of cost impacts. As shown in Exhibit 9-12, the recovery scrubber and alkali leaching systems again show net benefits in the central tendency (median and weighted average), high value case, and adoption of the fluidized bed recovery system or tailored contaminant release controls imposes impacts of about the same magnitude as current practices. CKD recovery under the low value case and the Subtitle C landfill alternatives would impose impacts ranging between $14 and $91 per ton CKD, though these values are far lower than the unit cost of commercial off-site Subtitle C disposal, and all but the Subtitle C landfill and cessation of hazardous waste burning alternatives are less costly than typical off-site non-hazardous waste disposal.

Incremental costs per ton of cement product follow much the same pattern. Exhibit 9-13 shows that the alternative practices fall in the same rank on a cost per unit product basis, and that the central tendency measures (median and weighted average) suggest impacts of less than $0.30 per metric ton of cement for five of the alternatives to current practice. CKD recovery under the low value case imposes estimated cost impacts of between about $1.35 and $3.15 per metric ton of cement, or 2.4 to 5.7 percent of the value of sales (about $55 per metric ton). The Subtitle C land disposal and cessation of hazardous waste burning alternatives suggest typical impacts exceeding $5 per metric ton, or more than the typical net margin received by cement producers. In a few extreme cases, estimated impacts approach the typical sales price of cement.

Finally, capital investment requirements for installing these various CKD management alternatives vary widely, as displayed in Exhibit 9-14. The capital costs of cessation of burning hazardous waste are assumed to be negligible given EPA's costing assumptions regarding sunk capital. Installation of contaminant release controls on existing CKD management units would require highly variable investments of capital on the part of the facility operator, due to the variability of existing management controls at CKD-generating plants and site-specific environmental conditions (and associated risk potential). In most cases, however, capital investment requirements for this alternative do not exceed $350,000 per plant. Installation of CKD recovery technologies or Subtitle C landfill disposal alternatives, on the other hand, would require much greater capital resources. Weighted average capital investment costs range from about $1.2 million to almost $50 million. As stated above, the alkali leaching process is the least complex and capital-intensive of the CKD recovery technologies, and occupies the lower end of this cost range. Typical values for the capital costs of the other alternatives are in the $6 million to $12 million range. Not surprisingly, the full Subtitle C land disposal alternative imposes the greatest capital costs, due to the complexity and expense of installing multiple liner and leachate collection systems and other aspects of regulatory compliance.

9.3 POTENTIAL IMPACTS OF ALTERNATIVE MANAGEMENT PRACTICES

Based on the cost estimates described in the preceding section, this section provides the Agency's perspectives on potential impacts from implementing these alternative management practices, first at the level of our typical case study cement plants and then for the industry as a whole.

9.3.1 Individual Plant-Level Impacts

In considering impacts at the individual plant level, the added cost of an alternative dust management practice relative to the market value of cement produced (added cost per dollar of sales) provides a direct measure of relative importance and a first general measure of impact.

Exhibit 9-13

Annualized Incremental Costs of CKD Management Alternatives per Metric Ton of Cement for EPA Case Study Cement Plants

CKD Management Alternative	**All Facilities in Sample** (9 Plants)				**Hazardous Waste Burners in Sample** (5 Plants)			
	Minimum ($/MT)	**Median** ($/MT)	**Maximum** ($/MT)	**Weighted Average** ($/MT)	**Minimum** ($/MT)	**Median** ($/MT)	**Maximum** ($/MT)	**Weighted Average** ($/MT)
Recovery Scrubber/ High Value	-3.54	-1.02	1.03	-1.03	-3.54	-1.87	0.67	-1.52
Alkali Leaching/High Value	-1.41	-0.18	0.46	-0.37	-1.41	-1.10	0.35	-0.60
Fluidized Bed/High Value	-0.35	0.46	1.26	0.26	-0.35	0.19	0.66	0.05
Tailored Contaminant Release Controls/Sale of Dust	0.08	0.17	0.34	0.20	0.13	0.26	0.34	0.21
Tailored Contaminant Release Controls/No Sale of Dust	0.08	0.20	0.34	0.21	0.13	0.27	0.34	0.22
Recovery Scrubber/ Low Value	-0.03	1.51	3.18	1.36	1.06	1.51	3.18	1.57
Alkali Leaching/Low Value	-0.07	2.35	4.19	1.95	1.25	2.97	4.19	2.40
Fluidized Bed/Low Value	0.95	3.72	6.79	3.13	1.53	4.53	6.79	3.84
Subtitle C- Landfill	0.40	3.10	12.50	7.96	2.10	7.50	12.50	8.63
Stop Burning Hazardous Waste	0.00	0.62	35.33	8.71	0.62	11.80	35.33	15.67
Subtitle C Landfill	0.40	9.30	27.90	13.27	3.70	11.60	27.90	13.60

Exhibit 9-14

Capital Investment Requirements for Implementing CKD Management Alternatives for EPA Case Study Cement Plants

CKD Management Alternative	**All Facilities in Sample** (9 Plants)				**Hazardous Waste Burners in Sample** (5 Plants)			
	Minimum ($ 000)	**Median** ($ 000)	**Maximum** ($ 000)	**Weighted Average** ($ 000)	**Minimum** ($ 000)	**Median** ($ 000)	**Maximum** ($ 000)	**Weighted Average** ($ 000)
Stop Burning Hazardous Waste	0	0	0	0	0	0	0	0
Tailored Contaminant Release Controls/Sale of Dust	263	314	2,032	501	301	370	2,032	554
Tailored Contaminant Release Controls/No Sale of Dust	27	167	1,887	507	308	373	2,032	560
Alkali Leaching/High Value	51	1,216	2,384	1,260	732	1,216	2,384	1,491
Alkali Leaching/Low Value	132	1,664	3,495	1,904	1,537	1,664	3,495	2,278
Recovery Scrubber/ Low Value	430	5,958	14,402	5,840	3,516	6,553	14,402	7,522
Fluidized Bed/High Value	5,090	7,446	24,307	9,599	7,052	8,567	24,307	12,392
Fluidized Bed/Low Value	5,090	7,446	24,307	9,599	7,052	8,567	24,307	12,392
Recovery Scrubber/ High Value	5,021	10,552	24,742	12,267	5,021	10,552	22,738	11,649
Subtitle C- Landfill	21	6,823	59,834	30,712	3,117	7,142	59,834	36,149
Subtitle C Landfill	21	16,736	74,383	47,105	7,809	17,571	74,383	52,404

Exhibit 9-15 summarizes the cost-relative-to-sales impacts of the alternative practices for the nine typical cement plants studied in this Report. For this purpose, the cost per ton of cement estimates (from Exhibit 9-13, above) have been compared to a nominal cement price of $55 per metric ton, an approximate national average for recent years. As has been done previously, results are presented both for the entire set of case study plants and, separately, for the five hazardous waste fuel-burning plants. The alternative practices are ranked from highest cost to lowest cost (or net revenue, in the case of high-value dust recovery).

The results presented in Exhibit 9-15 indicate a very wide variation in cost per dollar of sales, both among plants for particular management practices and across the different alternative practices. For Subtitle C land disposal, as an example, the difference between the low cost and the high cost plant ranges from less than one cent to over 50 cents per dollar of sales. As noted in earlier sections of this chapter, this extreme difference across plants is a reflection of the wide variations in waste dust generation rates and other observed plant-specific variables affecting total costs of waste management. Hazardous waste burners would generally face higher management costs for any of the land disposal practices because of their higher waste generation rates. Wide variation in relative costs implies great differences in competitive disadvantage, should plants competing for the same regional market become subject to one of these alternative practices.

The high absolute cost impact of the Subtitle C and C-Minus land management practices is due to the combined effects of a high waste-to-product ratio (about 0.06 tons of net CKD per ton of cement for the median kiln), the high incremental cost of Subtitle C practices and the relatively low value of product (at about $55 per metric ton). Both median and high end cost-to-sales ratios for Subtitle C and C-Minus land management are extremely high by any industry pollution control standard, and generally exceed traditional industry profit rates by a wide margin or multiple.

In contrast, the low cost alternative practices - both the tailored contaminant release control land management and the various dust recovery technologies - suggest relatively affordable approaches at the individual plant level, ranging from less than 1/2 cent per dollar of sales (or possible net profit in some instances) up to a few cents per sales dollar, depending on the particular alternative practice scenario.

9.3.2 Nationwide Cement Industry Impacts

As a first step in projecting nationwide impacts of alternative management practices for waste dust, Exhibit 9-16 presents a hypothetical extrapolation of average plant-level costs for each of the individual alternatives to the maximum relevant universe of affected cement plants. For example, if Subtitle C land management standards were to be employed in the future in place of current land management practices for waste dust, about 85 U.S. cement plants would be affected, given EPA's estimate that about 25 percent of today's kilns recycle all or virtually all of their collected dust. If all 85 plants were to manage all their current net CKD under these Subtitle C standard practices, the required new capital investment cost would amount to about $2.4 billion, and total annualized future dust management costs for the industry as a whole would increase by more than $500 million per year.

By contrast, with respect to the Tailored Contaminant Release Control land management scenario, the Agency estimates that perhaps 15 to 20 percent of the 85 facilities currently land

Exhibit 9-15

Incremental Costs of Alternative CKD Management Practices Relative to Value of Cement Sales (Incremental cost per ton of cement/revenue per ton of cement — cents per dollar of sales)

CKD Management Alternative	All Facilities in Sample (9 Plants)				Hazardous Waste Burners in Sample (5 Plants)			
	Minimum	Median	Maximum	Weighted Average	Minimum	Median	Maximum	Weighted Average
Stop Burning Hazardous Waste	0	1.1	64.2	15.8	1.1	21.5	64.2	28.5
Subtitle C Landfill	0.7	16.9	50.7	24.1	6.7	21.1	50.7	24.7
Subtitle C- Landfill	0.7	5.6	22.7	14.5	3.8	13.6	22.7	15.7
Recovery Low Value C	-0.1	2.8	5.8	2.5	1.9	2.8	5.8	2.9
Tailored Contaminant Release Controls/No Sale of Dust	0.2	0.4	0.6	0.4	0.2	0.5	0.6	0.4
Tailored Contaminant Release Controls/Sale of Dust	0.2	0.3	0.6	0.4	0.2	0.5	0.6	0.4
Recovery High Value	-6.4	-1.9	0.8	-1.9	-6.4	-3.4	1.2	-2.8

Exhibit 9-16

Industry Wide Costs of Alternative Management Practices (Cost in $ Million)

	Industry Wide			35 Hazardous Waste Burners	
	No. of Affected Plants	Total Capital Cost	Total Annual Cost	Total Capital Cost	Total Annual Cost
Subtitle C Standard Landfill	85[a]	1,919	416	1,070	224
Subtitle C-Minus Landfill	85	970	243	610	143
Cease Haz. Waste Burning	35	0	280	0	280
Tailored Contaminant Release Controls - No Sale	70[b]	39	9	23	5
Tailored Contaminant Release Controls - Sale	70	38	9	22	5
Dust Recovery - Low Value	85	912	64	238	35
Dust Recovery - High Value	85	434	-49	369	-34

[a] - Assuming 30 plants with zero or negligible net waste.

[b] - Assuming 15-20% of the 85 plants with net waste are already essentially in compliance.

disposing waste dust may already be employing these or equivalent practices.[34] Hence, under this scenario, only about 70 of the 115 plants, or 60 percent of the industry nationwide might initially incur costs for this particular set of alternative practices. Similarly, aggregate costs or other impacts affecting hazardous waste burning cement plants, viewed as a subset, would relate only to the 35 or so plants expected to be in that category.

It is clear from Exhibit 9-16 that total national costs for the alternative practices, considered independently from one another, vary substantially across the wide variety of management methods evaluated. Within the subset of land management practices alone (including Subtitle C Standards, C-Minus, and Tailored Contaminant Release Control), new capital investment requirements could range from $2 billion down to $38 million, and annualized costs for the industry could range from $416 to $9 million. Under the two most favorable dust recovery technology options, in the two cases considered, capital investment costs for the 85 affected plants would also be quite substantial (on the order of $500 million to over $1 billion for 85 cement plants). But if these emerging technologies should prove universally adaptable and cost-effective, within the range tentatively estimated by the Agency, then total industry-wide costs could be in a quite moderate range between plus or minus 6 percent of sales and with a median close to break-even.

The potential impacts on the industry and its markets could also be expected to vary to an extreme degree across the several technical dust management alternatives. For example, the high-cost Subtitle C practices, with both high initial capital requirements and costs per ton of cement ranging over 30 percent of the value of product, would place an extreme competitive strain on a large segment of the industry. Here, one would expect, with 25 to 30 percent of the

[34] This is a very rough estimate based on land management practices reported in the PCA Survey for 1990. See Chapter 4, Section 4.3, for summary information on practices.

domestic industry as well as potential foreign competition unaffected, that an initial impact would entail a substantial decrease in the number of financially viable domestic cement plants. Since the major portion of surviving plants would be operating under substantially higher long run total costs, economic theory would also project a substantial increase in regional and national average prices of cement necessary to cover the increased costs of waste management. The natural market corollaries of this impact scenario also suggest a decrease in overall domestic demand for cement in relation to other substitute building and construction materials, and a larger relative and absolute market share for imported cements.[35]

The Tailored Contaminant Release Control scenario for continued land management of waste dust represents an alternative with much less potential for adverse industry impacts. Indeed, with median incremental costs at only about one-half of one percent of sales and a high end cost at one percent, there would appear to be little concern regarding industry-wide impacts.

For the industry subgroup of hazardous waste fuel burners, the alternative practice option of ceasing to burn hazardous waste-derived fuels would also, as noted previously, imply rather extreme competitive disruption. With average and median plant-level financial impacts over 20 percent of the average value of cement, many and perhaps most of these plants would not consider this a financially viable alternative under current or future market conditions.

The emerging recovery technologies represent the most interesting as well as the most uncertain set of CKD management alternatives from a potential impacts standpoint.

9.3.3 Conclusions and Relationships to Regulatory Requirements

The preceding discussion has focused primarily on costs and implications of individual CKD management practices as technological alternatives, viewed independently in isolation from one another, and in the absence of any particular regulatory context. In reality, cement companies are not and would not in the future be restricted to just one industry-wide alternative. As demonstrated in this and preceding chapters, plants generally have a choice of several existing and emerging dust control and management options. Subject to existing regulatory constraints, managers can be expected to chose the alternative or combination of alternatives that tend to contribute most to company profitability, by minimizing disposal costs and/or by exploiting CKD by-product use potentials.

In the absence of further state or federal CKD regulation, the principal competitive choices foreseeable in the baseline would appear to include: (1) traditional land disposal; (2) a continued substantial role for various off-site by-product uses (the most profitable option for many plants); (3) further development of the emergent dust recovery technologies; and (4) possible in-plant dust generation reduction and recycling via process adjustments, improved system controls, and raw material or fuel substitutions.

Given the wide variety and the plant-specific nature of the options, it is virtually impossible to predict future baseline CKD management trends with any degree of accuracy. High technology land management practices, of the type required for hazardous waste land placement under Subtitle C of RCRA, would not be considered an economically competitive (or perhaps even an economically feasible) CKD management option by private management in the baseline regulatory context. Most plants might continue to view currently uncontrolled land placement as the optimal practice from the plant's profit-and-loss standpoint. Nonetheless, evidence presented in Chapter 8 and earlier in this chapter suggest that a substantial segment of the industry is looking towards CKD reduction, recovery, and off-site use options as economically superior. EPA's cost analysis suggests that one or more of the currently available or emerging recovery technologies could in fact be economically attractive, under a reasonable

[35] As recently as 1988, about one-fifth of U.S. cement demand was supplied by imports. This has decreased to about 10 percent in 1991, and is expected to decrease further to seven percent by 1992. U.S. Bureau of Mines, Mineral Commodity Summaries, 1993, p. 42.

set of assumptions, particularly for plants with high CKD generation. To the extent that these approaches do prove successful from a private profit-and-loss standpoint, the industry's future baseline trend would be towards increased natural resource conservation and decreased land disposal.

New state or federal regulations directed at controlling traditionally unrestricted on-site land placement could assume many forms and degrees of restriction. Several levels of such controls were simulated by the Agency's engineering cost studies, including two variations of incremental contaminant release controls and two increasingly more severe versions of RCRA Subtitle C technology standards. Essentially, these regulatory approaches would remove low cost land practice options and shift cement plant decisions toward a choice between the (increasingly) higher cost land disposal options and the other CKD reduction and recovery options.

Two main conclusions were drawn regarding the relative costs of these shifting choices. The first is that incremental land management practices, of the type simulated in the tailored contaminant release control scenarios, could be implemented at relatively modest additional cost at most of the 70 or so cement plants not now already in compliance. Although CKD management costs would about double, on average, relative to baseline, the absolute cost increment relative to the market value of cement would average about one-half of one percent of sales. The maximum added cost-to-sales estimate for the EPA case study sample was about one percent.

This cost increment could probably be absorbed without severe industry impact or a substantial number of plant dislocations. There would be some fractional percentage increases in regional cement prices to cover the added dust management costs, but this would not appear sufficient to materially influence international trade flows. At the same time, the alternative non-disposal CKD reduction and recovery options would become incrementally less costly (or more profitable) relative to land disposal. As a result, one would also expect at least a modest shift away from land disposal towards the other options.

The second major conclusion from the cost analysis is that the incremental land disposal costs implied by the RCRA Subtitle C minimum technology and administrative standards would indeed be much higher in both relative and absolute terms than either current typical land practices or the incremental contaminant release scenario described above. The Subtitle C regulatory scenarios projected incremental cost-to-sales ratios for the median affected facility of 5.5 and 17 percent, respectively, for the C-Minus and full Subtitle C versions. (For hazardous waste burners, median and average costs would be even higher than for the industry as a whole due to generally higher net waste generation rates.) High end ratios for the EPA case study sample were estimated at 21 percent and 52 percent.

For the Subtitle C scenarios, any impact assessment becomes inherently uncertain. Under the industry-wide waste listing version, a substantial majority of the Nation's cement plants (about 85 currently managing new CKD in land-based units out of 115 U.S. plants) would be faced with a rather extreme set of dust management options. (Under an alternative regulatory option, where removing the Bevill regulatory exemption would affect only hazardous waste burners, about 35 of the 115 operating cement plants would face the same choice among extreme options.) On the one hand, affected plants would face a very high cost but well known and relatively simple-to-implement land disposal technology. The alternative waste reduction, recycle, and recovery options, though potentially much lower in cost, are likely to be much more technically complex to adopt and operate, and much more uncertain in outcome. Some may not work as promised; some may not be as cost effective as the original prototypes or EPA's preliminary cost estimates might suggest.

The possible outcomes of this potential decision process, viewed in the context of a generally new and developing set of dust reduction and recovery technologies, cover a broad spectrum. Although the Agency's studies of alternative practices and preliminary engineering cost estimates suggest that currently or soon to be available innovative technologies could well play a critical future role in the industry, at this early stage in their development there can be no real guarantees. Under a Subtitle C regulatory scenario, the economic risk is that a significant portion of the industry might be unable to develop or adapt to what would amount to a technological revolution in cement kiln dust generation and management practices. Under this circumstance, a substantial portion of the industry could be forced out of business due to the high costs of land disposal, as described above. On the other side of the equation are the substantial economic benefits, the savings in energy and other natural resources, and the improvements in environmental quality that could potentially accrue from the new recovery technologies, should they prove successful.

CHAPTER NINE

COST AND ECONOMIC IMPACTS OF ALTERNATIVES TO CURRENT CKD DISPOSAL PRACTICES

LIST OF EXHIBITS