United States
Environmental Protection
Agency

Office Of Water
(4303)

EPA 821-R-95-025
April 1995

EPA

Cost-Effectiveness Analysis Of Proposed Effluent Limitations Guidelines And Standards For The Metal Products And Machinery Industry (Phase 1)

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ACKNOWLEDGEMENTS

Credit must be given to Bill Cleary and the whole MP&M team for their professional manner, conscientious effort, and contributions.

Credit must also be given to Abt Associates for their assistance and support in performing the underlying analysis supporting the conclusions detailed in this report. Their study was performed under Contracts 68-C0-0080, 68-C3-0302, and 68-C4-0060.

Additional information used in this document was provided by Radian under Contract 68-C4-0024, and Versar under Contract 68-D3-0013.

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Section 1
Introduction

This cost-effectiveness analysis supports the proposed effluent limitations guidelines and standards for the Metal Products and Machinery Industry (MP&M) Phase I Industry.[1] The report assesses the cost-effectiveness of five regulatory options for indirect dischargers, which discharge effluent to publicly-owned treatment works (POTWs), and three options for direct dischargers, which discharge effluent directly to a waterway.

Cost-effectiveness analysis is used in the development of effluent limitations guidelines to evaluate the relative efficiency of a proposed regulation to the efficiency of previous regulations. Cost-effectiveness is defined as the incremental annual cost (in 1981 constant dollars) per incremental toxic-weighted pound of pollutant removed. This definition includes the following concepts:

Toxic-Weighted Removals — Because pollutants differ in their toxicity, the reductions in pollutant discharges, or pollutant removals, are adjusted for toxicity by multiplying the estimated removal quantity for each pollutant by a normalizing weight, called a *Toxic Weighting Factor (TWF)*. The TWF for each pollutant measures its toxicity relative to copper, with more toxic pollutants having higher TWFs.

Annual Costs — The cost-effectiveness analysis uses the estimated annual costs of complying with the alternative regulatory options. The annual costs include annual expenses for operating and maintaining compliance equipment and for meeting monitoring requirements, and an annual allowance for the capital outlays for pollution prevention and treatment systems needed for compliance. These costs are calculated on a pre-tax basis (i.e., without any adjustment for tax treatment of capital outlays and operating expenses). In addition, the annual allowance for capital outlays is calculated using an assumed

[1]See the *Economic Impact Analysis of Effluent Limitations Guidelines for the MP&M Industry (Phase I)*.

opportunity cost of capital to society of 7 percent. Finally, the compliance costs are calculated in 1981 dollars to facilitate the comparison of cost-effectiveness values for regulations developed at different times for different industries.

Incremental Calculations

The incremental values that are calculated for a given option are the change in total annual compliance costs and change in removals from the next less stringent option, or the baseline if there is no less stringent option, where regulatory options are ranked by increasing levels of toxic-weighted removals. Thus, the cost-effectiveness values for a given option are relative to another option, or, for the least stringent option, to the baseline.

The result of the cost-effectiveness calculation represents the unit cost of removing the next pound-equivalent of pollutants. Cost-effectiveness is strictly a relative measure used for comparative purposes. This analysis does not provided an absolute scale by which a particular cost-effectiveness value can be assigned a qualitative judgment. Because cost-effectiveness values are expressed in 1981 dollars per pound-equivalent removed, cost-effectiveness values for a given option may be compared with those of other options being considered for a given regulation and also with those calculated for other industries or past regulations.

Although not required by the Clean Water Act, cost-effectiveness analysis is a useful tool for evaluating options for the removal of toxic pollutants. It is not intended to analyze the removal of conventional pollutants, however, such as oil and grease, biological oxygen demand and total suspended solids, and removals of these pollutant are not included in the cost-effectiveness calculation.

The remaining parts of this report are organized as follows. Section 2 of the report defines cost-effectiveness, discusses the cost-effectiveness methodology, and describes the relevant regulatory options. Section 3 presents the findings of the separate analyses for direct dischargers and for indirect dischargers. Section 4 compares the cost-effectiveness of the proposed regulation with the cost-effectiveness values calculated for previously promulgated rules. In addition, the reports includes six appendixes. Appendix A lists the pollutants of concern and their CAS numbers while Appendix B gives the Toxic Weighting Factor (TWF) for each pollutant. Appendix C contains the Publicly Owned Treatment Work (POTW) removal efficiencies used in this analysis. These removal efficiences are the the percentage of each pollutant that a typical POTW is expected to remove from indirect facility discharges. Appendix D contains an alternative set of weighting factors, *Pollutant Weighting Factors* (PWFs), for normalizing pollutant removals according to toxicity. The PWFs are based on a different analytic convention than the TWFs. The results of the cost-effectiveness analysis using the PWFs are contained in Appendix E. Finally, Appendix F contains cost-effectiveness analysis results that are calculated on a different cost basis: these costs are the after-tax annual costs to industry using estimated after-tax costs of capital to annualize the cost of capital equipment.

Section 2

Methodology

2.1 Overview

This section defines cost-effectiveness, describes the steps taken in the cost-effectiveness analysis, and characterizes the regulatory options considered in the analysis.

Cost-effectiveness calculations are used in setting effluent limitations guidelines to compare the efficiency of one regulatory option in removing pollutants to another regulatory option. Cost-effectiveness is defined as the incremental annual cost of a pollution control option in an industry or industry subcategory per incremental pollutant removal. The increments considered are relative to another option or to a benchmark, such as existing treatment. Pollutant removals are measured in copper-based "pounds-equivalent." The cost-effectiveness value, therefore, represents the unit cost of removing the next pound-equivalent of pollutant. While not required by the Clean Water Act, cost-effectiveness analysis is a useful tool for evaluating regulatory options for the removal of toxic pollutants. Cost-effectiveness analysis is not intended to analyze the removal of conventional pollutants (oil and grease, biological oxygen demand, and total suspended solids). The removal of conventional pollutants is therefore not addressed in this report.

Three factors are of particular importance in cost-effectiveness calculations: (1) the normalization of pounds of pollutant removed to copper-based pounds-equivalent; (2) the incremental nature of cost-effectiveness, and (3) the fact that cost-effectiveness results are used for comparison purposes rather than on an absolute basis. First, the analysis is based on removals of pounds-equivalent - a term used to describe a pound of pollutant weighted by its toxicity relative to copper. These weights are known as toxic weighting factors. Copper is used as the standard pollutant for developing toxic weighting factors because it is a toxic metal commonly released in industrial effluent and removed from that effluent. The use of pounds-equivalent reflects the fact that some pollutants are more toxic than others. By expressing removals in common terms, the removals can be summed across pollutants to give a meaningful basis for comparing cost-effectiveness results among alternative regulatory options or different regulations.

Second, cost-effectiveness analysis is done on an incremental basis to compare the incremental or marginal cost and removals of one control option to another control option or to existing treatment.

The third point is that no absolute scales exist for judging cost-effectiveness values. The values are considered high or low only within a given context, such as similar discharge status or compared to effluent limitations guidelines for other industries.

Cost-effectiveness analysis involves a number of steps, which may be summarized as follows:

- Determine the relevant wastewater pollutants;
- Estimate the relative toxic weights of priority and other pollutants;
- Define the pollution control approaches;
- Calculate pollutant removals for each control option;
- Determine the annualized cost of each control option;
- Rank the control options by increasing stringency and cost;
- Calculate incremental cost-effectiveness values; and
- Compare cost-effectiveness values.

These steps are discussed below.

Pollutant Discharges Considered in the Cost-Effectiveness Analysis

Some of the factors considered in selecting pollutants for regulation include toxicity, frequency of occurrence, and amount of pollutant in the waste stream. The cost-effectiveness analysis of the proposed Metal Products and Machinery (MP&M) Phase I effluent limitations guidelines is based on 67 pollutants, listed in Appendix A.

Relative Toxic Weights of Pollutants

Cost-effectiveness analyses account for differences in toxicity among the regulated pollutants by using toxic weighting factors (TWFs). Relatively more toxic pollutants have higher TWFs. These factors are necessary because different pollutants have different potential effects on human and aquatic life. For example, a pound of nickel (TWF=0.036) in an effluent stream has significantly less potential effect than a pound of cadmium (TWF=5.16). The toxic weighting factors are used to calculate the *toxic pound-equivalent* unit — a standardized measure of toxicity.

In the majority of cases, toxic weighting factors are derived from both chronic freshwater aquatic criteria (or toxic effect levels) and human health criteria (or toxic effect levels) established for the consumption of fish. These factors are then standardized by relating them to copper. The resulting toxic weighting factors for each pollutant are provided in Appendix B. Table 2-1 shows some examples of the effects of different aquatic and human health criteria on weighting factors.

Table 2-1 Weighting Factors Based on Copper Freshwater Chronic Criteria				
Pollutant	**Human Health Criteria* (µg/l)**	**Aquatic Chronic Criteria (µg/l)**	**Weighting Calculation**	**Toxic Weighting Factor**
Copper**	--	12.0	5.6/12.0	0.467
Hexavalent Chromium	3,400	11.0	5.6/3,400 + 5.6/11	0.511
Nickel	4,600	160.0	5.6/4,600 + 5.6/160	0.036
Cadmium	170	1.1	5.6/170 + 5.6/1.1	5.120
Benzene	12	265.0	5.6/12 + 5.6/265	0.488

Criteria are maximum contamination thresholds. Using the above calculation, the greater the values for the criteria used, the lower the toxic weighting factor. Units for criteria are micrograms of pollutant per liter of water.

* Based on ingestion of 6.5 grams of fish per day.

** While the water quality criterion for copper has been revised (to 12.0 µg/l), the cost-effectiveness analysis uses the old criterion (5.6 µg/l) to facilitate comparisons with cost-effectiveness values for other effluent limitations guidelines. The revised higher criteria for copper results in a toxic weighting factor for copper not equal to 1.0 but equal to 0.467.

Source: Environmental Protection Agency

As indicated in Table 2-1, the toxic weighting factor is the sum of two criteria-weighted ratios: the "old" copper criterion divided by the human health criterion for the particular pollutant, and the "old" copper criterion divided by the aquatic chronic criterion. For example, using the values reported in Table 2-1, 10.96 pounds of copper pose the same relative hazard in surface waters as one pound of cadmium, since cadmium has a toxic weight 10.96 times (5.12/0.467 = 10.96) as large as the toxic weight of copper.

2.2 Pollution Control Options

This section summarizes the three BAT/BPT and four PSES options that EPA considered. The BAT/BPT options would apply to direct dischargers, while PSES options would apply to indirect dischargers.

2.2.1 BAT/BPT Technology Options

1. Option 1: Lime and Settle Treatment. Option 1 consists of preliminary treatment for specific pollutants and end-of-pipe treatment with chemical precipitation (usually accomplished by raising the pH with an alkaline chemical such as lime or caustic to produce insoluble metal hydroxides) followed by clarification.

This treatment, which is also commonly referred to as lime and settle treatment, has been widely used throughout the metals industry and is well documented to be effective for removing metal pollutants. As with a number of previously promulgated regulations, EPA established these options on the basis that all process wastewaters, except solvent bearing wastewaters, would be treated through lime and settle end-of-pipe treatment.

All of the regulatory options considered for the MP&M category were based on a commingled treatment of process wastewaters through lime and settle with preliminary treatment when needed for specific waste streams. Preliminary treatment is performed to remove oil and grease through emulsion breaking and oil skimming; to destroy cyanide using sodium hypochlorite; to reduce hexavalent chromium to the trivalent form of chromium which can subsequently be precipitated as chromium hydroxide; or to break metal complexes by chemical reduction. EPA also included the contract hauling of any wastewaters associated with organic solvent degreasing as part of the Option 1 technology.

Through sampling episodes and site visits, EPA determined that some wastewaters, usually alkaline cleaning wastewaters and water-based metal working fluids (e.g., machining and grinding coolants, deformation lubricants), may contain significant amounts of oil and grease. These wastewaters require preliminary treatment to remove oil and grease and organic pollutants. Chemical emulsion breaking followed by either skimming or coalescing is an effective technology for removing these pollutants.

EPA also identified MP&M wastewaters that may contain significant amounts of cyanide, such as plating and cleaning wastewaters. These wastewaters require preliminary treatment to destroy the cyanide, which is typically performed using alkaline chlorination with sodium hypochlorite or chlorine gas. EPA has also identified hexavalent chromium-bearing wastewaters, usually generated by anodizing, conversion coating, acid treatment, and electroplating operations and rinses. These wastewaters require chemical reduction of the hexavalent chromium to trivalent chromium. Sodium metabisulfite or gaseous sulphur dioxide are typically used as reducing agents. Several surface treatment wastewaters typically contain significant amounts of chelated metals. These chelated metals require chemical reduction to break down the chelated metals prior to lime and settle. Sodium borohydride, hydrazine, and sodium hydrosulfite can be used as reducing agents. These preliminary treatment technologies are more effective and less costly on segregated wastewaters, prior to adding wastewaters that do not contain the pollutants being treated with the preliminary treatment technologies. Thus, EPA includes these preliminary treatment steps whenever it refers to lime and settle treatment.

2. Option 2: In-process Flow Control, Pollution Prevention, and Lime and Settle Treatment. Option 2 builds on Option 1 by adding in-process pollution prevention, recycling, and water conservation methods that allow for recovery and reuse of materials. These techniques or technologies can save money for companies by allowing materials to be used over a longer period before they need to be disposed. They can also can be used to recover metal or metal treatment solutions. Using these techniques along with water conservation leads to the generation of less pollution and results in more effective treatment of the wastewater that is generated. As has been demonstrated by numerous industrial treatment systems, the treatment of metal bearing wastewaters is relatively independent of influent concentration. In fact, since the treatment system is a physical/chemical system, and will generally function to certain physical/chemical properties, within a broad range, the more highly concentrated wastewater influent will result in better pollutant removals and less mass of pollutant in the discharge. In addition, the cost of a treatment system largely depends on the size which in turn largely depends on flow, thus the lower the flow of water to the treatment system the less costly the system. The in-process technologies included in Option 2 include:

- Flow reduction using flow restrictors, conductivity meters, and/or timed rinses, for all flowing rinses, plus countercurrent cascade rinsing for all flowing rinses;
- Flow reduction using bath maintenance for all other process water-discharging operations;
- Centrifugation and 100 percent recycling of painting water curtains;
- Centrifugation and pasteurization to extend the life of water-soluble machining coolants reducing discharge volume by 80 percent; and
- In-process metals recovery using ion exchange followed by electrolytic recovery of the cation regenerant for selected electroplating rinses. This includes first-stage drag-out rinsing with electrolytic metal recovery.

The flow reduction practices included in Option 2 are widely used by MP&M sites and are also included as part of the regulatory basis for a number of effluent guidelines regulations in the metals industry.

3. Option 3: Advanced End-of-Pipe Treatment. Option 3 includes all of the Option 2 technologies plus advanced end-of-pipe treatment. Advanced end-of-pipe treatment could be either reverse osmosis or ion exchange to remove suspended and dissolved solids yielding a treated wastewater that can be partially recycled as process water. This technology is not widely used but has been demonstrated by some MP&M sites, particularly in instances where the water supply is contaminated and requires clean-up before it can be used. For the purposes of modelling the cost of compliance and resulting pollutant removals, Option 3 technology is expected to achieve a treated wastewater that is sufficiently clean for 90 percent of the treated wastewater to be recycled back to the facility for reuse in industrial operations.

2.2.2 PSES Technology Options

Indirect discharging MP&M sites generate wastewaters with similar pollutant characteristics to direct discharging facilities. Hence, the same treatment technologies and regulatory options - Option 1, Option 2, and Option 3 - discussed previously for BPT and BAT were considered applicable to PSES. However, as described below, EPA developed and analyzed two additional options for indirect dischargers that apply the requirements of Option 1 or Option 2 based on the annual discharge volume of the indirect discharging facility.

The Agency originally considered the following three options in developing PSES for MP&M Phase I indirect dischargers. These options parallel those for direct dischargers.

Option 1: Under this option, EPA would establish PSES on the basis of the application of **lime and settle treatment** without any pollution prevention and flow controls imposed. In implementing Option 1, Control Authorities would likely impose concentration-based standards on facilities.

Option 2: Option 2, as in the BPT selection, adds **in-process flow reduction to lime and settle treatment.** This option would establish PSES such that all facilities should comply with mass-based standards based on the proposed concentration standards and an appropriate flow that should reflect good pollution prevention and water conservation practices. Thus, Option 2 embodies a requirement for pollution prevention and water conservation in conjunction with lime and settle treatment. The flow basis would be determined by the relevant Control Authority, using site specific factors and flow guidance.

Option 3: As in the BPT selection, Option 3 includes all of the **Option 2 technologies plus advanced end-of-pipe treatment.** Advanced end-of-pipe treatment would remove significant amounts of suspended and dissolved solids and yield a treated wastewater that can be recycled as process water.

EPA initially selected Option 2, In-Process Flow Reduction and Pollution Prevention and Lime and Settle Treatment, as the preferred PSES regulatory option Option 2 was associated with relatively small economic impacts. In addition, Option 2 achieved considerably more pollutant removals than Option 1, while costing less than Option 3. However, as discussed in Chapter 1 of the Economic Impact Analysis Report, additional analyses of Option 2 identified several issues that weighed against proposing Option 2 as the basis for PSES effluent guidelines. As a result, EPA defined and analyzed two additional PSES options for indirect discharging facilities as follows:

Option 1a: This option would establish a **tiered PSES requirement depending on the annual discharge volume** at a given MP&M facility. For "low" flow facilities, defined as discharging less than 1,000,000 gallons per year (gpy), PSES would require that they comply with the **concentration standards** of Option 1. For "large" flow facilities, with discharge volumes of 1,000,000 gpy or greater, PSES would require that the **mass-based standards** of Option 2 be imposed, based on the proposed concentration standards and an appropriate flow volume that should reflect good pollution prevention and water conservation practices.

Option 2a: To further reduce the regulatory burden associated with smaller facilities, EPA developed an option based on **in-process reduction and pollution prevention and lime and settle treatment for large flow sites.** This option would establish the same PSES requirements as specified in Option 2, but applied to only large flow facilities (with annual discharge volumes of at least 1 million gallons). Facilities with discharge volumes of less than 1 million gallons per year would not be subject to PSES requirements.

2.3 Calculation of Pollutant Removals

EPA calculated the reductions in pollutant loadings to the receiving water body for each control option. *At-stream* and *end-of-pipe* pollutant removals may differ because a portion of the end-of-pipe loadings for indirect dischargers may be removed by a POTW. As a result, the at-stream removal of pollutants due to PSES regulations are considered to be less than end-of-pipe removals. The cost-effectiveness analysis is based upon removals *at-stream.*

For example, if a facility discharges 100 pounds of cadmium in its waste water to a POTW and the POTW has a removal efficiency for cadmium of 40 percent, then the POTW removes 40 pounds of cadmium, and the cadmium discharged to surface waters is only 60 pounds. If a regulation results in a reduction of cadmium in the facility's waste water to 30 pounds, then the POTW removes 12 of the 30 pounds it receives from the facility, and the amount discharged to surface waters is 18 pounds. As a result, the reduction in discharges to surface waters is 42 pounds, although the reduction in facility discharges to the POTW is 70 pounds. In general, at-stream loadings for facilities that discharge to a POTW are calculated by multiplying end-of-pipe loadings by (1 - POTW removal efficiency). Cost-effectiveness calculations reflect the fact that the actual reduction of pollutant discharge to surface waters is not 30 pounds (the change in the amount discharged to the POTW), but 42 pounds (= 60 - 18), the change in the amount ultimately discharged to surface waters.

2.4 Annualized Costs for Each Control Option

Full details of the methods by which the costs of complying with the regulatory options were estimated can be found in the Technical Development Document and the Economic Impact Analysis Report. A brief summary of the compliance cost analysis is provided below.

Two categories of compliance costs were included in the cost-effectiveness analysis: (1) capital costs, and (2) operating, maintenance, and monitoring costs. Although operating, maintenance, and monitoring costs occur annually, capital costs are one-time "lump sum" costs. To express the capital costs on a annual basis, capital costs were annualized over the expected useful life of the capital equipment, 15 years, at an opportunity cost of capital to society of 7 percent. Total annualized costs are the sum of annualized capital costs and the annual operating, maintenance and monitoring costs. The cost-effectiveness analysis presented in the main body of this report uses pre-tax costs as the basis for its calculations. Thus, these costs may be interpreted as the cost to society of the facility-level actions for compliance with MP&M regulatory options. Appendix F presents an alternative analysis using the after-tax compliance costs expected to be incurred by MP&M facilities.

Compliance costs were originally calculated in dollars of the year 1989, the base year of the MP&M industry regulation analysis. For comparing cost-effectiveness values of the options under review to those of other promulgated rules, the compliance costs used in the cost-effectiveness analysis were deflated from to 1981 dollars using Engineering News Record's Construction Cost Index (CCI). This adjustment factor is:

$$Adjustment\ factor = \frac{1981\ CCI}{1989\ CCI} = \frac{3535}{4615} = 0.766$$

2.5 Stringency and Cost Ranking

The regulatory options were ranked to determine relative cost-effectiveness. Options were first ranked in increasing order of stringency, where stringency is aggregate pollutant removals, measured in pounds-equivalent. If two or more options remove equal amounts of pollutants, these options were then ranked in increasing order of cost. For example, if two or more options specify zero discharge, the removals under each option would be equal. The options would then be ranked from least expensive to most expensive.

2.6 Calculation of Incremental Cost-Effectiveness Values

After the options have been ranked by stringency and cost, incremental cost-effectiveness values are calculated. Cost-effectiveness values were calculated separately for indirect and direct dischargers. For each discharger category, the cost-effectiveness value of a particular option is calculated as the incremental annual cost of that option divided by the incremental pounds-equivalent removed by that option. Algebraically, this equation is:

$$CE_k = \frac{ATC_k - ATC_{k-1}}{PE_k - PE_{k-1}}$$

where:

CE_k	=	Cost-effectiveness of Option k;
ATC_k	=	Total annualized compliance cost under Option k; and
PE_k	=	Removals in pounds-equivalent under Option k.

The numerator of the equation is the incremental cost in moving from Option k-1 to Option k. Similarly, the denominator is the incremental removals associated with the move from Option k-1 to Option k. Thus, cost-effectiveness values are measured in dollars per pound-equivalent of pollutant removed. When k corresponds to the least stringent option (k = 1), the incremental costs and removals are the increments in moving from the baseline case to Option k.

2.7 Comparisons of Cost-Effectiveness Values

Two types of comparisons are typically done using cost-effectiveness values. First, the cost-effectiveness values for the alternative regulatory options and technologies under consideration may be compared among themselves to identify which options offer relatively higher or lower cost-effectiveness in achieving pollutant reductions. Second, the cost-effectiveness of regulatory options incremental to the baseline scenario can be used to assess the cost-effectiveness of controls relative to previously promulgated effluent limitations guidelines for other industries.

Section 3

Cost-Effectiveness Results

3.1 Cost-Effectiveness Analysis for Indirect Dischargers

Tables 3-1 and 3-2 summarize the cost-effectiveness analysis results for the PSES regulatory options applicable to indirect dischargers. Annual compliance costs are shown in 1989 dollars, as reported in the EIA, and in 1981 dollars. Pollutant removals are reported on both an unweighted and toxic-weighted basis. The regulatory options are listed in order of increasing stringency on the basis of the estimated toxic-weighted pollutant removals.

Table 3-1
National Estimates of MP&M Annualized Costs and Pollutant Removals
Indirect Dischargers (PSES)

Regulatory Option	Annualized Cost, $millions		Pollutant Removals, thousands	
	1989 dollars	*1981 dollars*	*Raw Pounds*	*Pounds-Equivalent*
Option 2a	146.1	111.9	12,769.7	881.3
Option 1	231.3	177.2	14,611.7	988.9
Option 1A	221.9	170.0	14,872.7	1,011.0
Option 2	228.3	174.9	14,878.8	1,011.6
Option 3	668.8	512.3	15,612.1	1,105.4

Source: US Environmental Protection Agency

Table 3-2
National Estimates of MP&M Incremental Costs, Removals and Cost-Effectiveness
Indirect Dischargers (PSES)

Regulatory Option	Incremental Cost *($ millions, 1981)*	Incremental Removals *(lbs-eq, thousands)*	Cost-Effectiveness *($/lb-eq)*
Option 2a	111.9	881.3	127
Option 1	65.3	107.6	607
Option 1A	(7.2)	22.1	(327)
Option 2	4.9	0.6	8,537
Option 3	337.4	93.8	3,596

Source: US Environmental Protection Agency

As shown in Tables 3-1 and 3-2, Option 2a achieves approximately 12.8 million pounds of toxic pollutant removals, on an unweighted basis and 881,300 pounds-equivalent on a toxic-weighted basis, at a cost of $112 million ($1981). Since Option 2a is the least stringent option, in terms of pollutant removals, the cost-effectiveness of this option is the same as its average cost per pound-equivalent removed, $127. EPA considers this value to be acceptable when compared to values calculated for previous regulations.

The next more stringent option, Option 1, is estimated to achieve approximately 14.6 million pounds of toxic pollutant removals on an unweighted basis and 988,900 pounds-equivalent on a toxic-weighted basis, which is a 107,100 pounds-equivalent increment over Option 2a/2. With an estimated annual compliance cost of $137 million ($1981), or $65 million more than Option 2a/2, the calculated cost effectiveness for Option 1's removals is $607 per pound-equivalent of pollutant removed. This cost-effectiveness value is higher than the values calculated for other industrial discharge limitations previously promulgated by EPA.

In moving from Option 1 to Option 1a, toxic-weighted pollutant removals increase by 22,100 pounds-equivalent while costs decrease by $7.2 million. Thus, the cost effectiveness of Option 1a relative to Option 1 is a negative $327 per pound-equivalent of additional pollutant removed. Because Option 1a is estimated to impose lower cost on industry and society than Option 1 while, at the same time, achieving greater toxic-weighted removals, Option 1a may be said to dominate Option 1 from an economic efficiency perspective. That is, within the context of the cost-effectiveness analysis, society would always be better off by choosing the more stringent Option 1a over Option 1 because a greater quantity of toxic-weighted pollutant removals would be achieved by Option 1a but at a lower total pre-tax cost of compliance.

Stepping beyond Option 1a to Option 2 is clearly not cost effective for existing indirect dischargers in comparison to values calculated for previous regulations. Stepping from Option 1a to Option 2 yields very little additional toxic-weighted pollutant removals, 600 pounds-equivalent, at an additional estimated cost of $4.9 million. Because the increase in removals is so small, the cost-effectiveness value for moving from Option 1a to Option 2 is extremely high at $8,537 per pound-equivalent of additional pollutant removed. The only difference between Option 1a and Option 2 is that Option 2 applies the mass-based limitations of Option 2 to low-flow indirect dischargers while Option 1a applies the somewhat less stringent, concentration-based limitations of Option 1 to these facilities. Thus, the high cost-effectiveness value of $8,537 stems entirely from the increased stringency of regulatory requirements for these low-flow indirect discharging facilities and demonstrates the poor cost effectiveness of applying the Option 2 requirements to this class of facilities. As discussed in Chapter 1 of the Economic Impact Analysis Report, the finding of such a high cost-effectiveness value for Option 2 for low-flow indirect discharging facilities was an important factor in EPA's decision to define and evaluate alternatives to Option 2 for these facilities.

Moving from Option 2 to Option 3 was also found to yield a high cost-effectiveness value. Although the incremental removals for this step are relatively substantial at 93,800 pounds-equivalent, the large increase in cost of $337.4 million yields a cost-effectiveness value of $3,596 per pound-equivalent of additional pollutant removed, thus rendering this option unacceptable from the standpoint of cost effectiveness.

On the basis of this analysis, EPA determined that the proposed option, Option 2a, is cost effective. The cost-effectiveness analysis supports the choice of Option 2a as the proposed PSES regulatory option for indirect dischargers.

3.2 Cost-Effectiveness Analysis for Direct Dischargers

Tables 3-3 and 3-4 summarize the cost-effectiveness for the BPT/BAT regulatory options applicable to direct dischargers. As with indirect dischargers, annual compliance costs are shown in both 1989 and 1981 dollars, and pollutant removals are reported in both unweighted and toxic-weighted pounds. The regulatory options are listed in order of increasing stringency, measured by toxic-weighed pollutant removals.

Table 3-3 shows that Option 1 achieves 1.153 million pounds of removals on an unweighted basis and 58,200 pounds-equivalent of removals on a toxic-weighted basis, at a cost of $11.9 million (1981 dollars). Since Option 1 is the least stringent option, it is compared to the baseline, and the incremental costs and removals shown in Table 3-4 for this option are the same as the total costs and removals. The resulting cost-effectiveness is $204 per pound-equivalent.

Moving from Option 1 to the proposed Option 2 achieves 70,700 pounds-equivalent of toxic-weighted removals, which represents a 12,500 pounds-equivalent increment, at an annual cost of $12.5 million (1981 dollars), which is an increment of $0.6 million over Option 1. Thus the cost-effectiveness of Option 2 is estimated to be $50 per pound-equivalent. EPA considers the cost-effectiveness values of both Option 1 and Option 2 to be acceptable in relation to values calculated for previous regulations.

Table 3-3 National Estimates of MP&M Annualized Costs and Pollutant Removals Direct Dischargers (BAT)				
Regulatory Option	Annualized Cost, $millions		Pollutant Removals, thousands	
	1989 dollars	*1981 dollars*	*Raw Pounds*	*Pounds-Equivalent*
Option 1	15.5	11.9	1,152.5	58.2
Option 2	16.3	12.5	1,232.2	70.7
Option 3	68.7	52.6	1446.7	133.6
Source: Environmental Protection Agency				

Table 3-4 National Estimates of MP&M Incremental Costs, Removals and Cost-Effectiveness Direct Dischargers (BAT)			
Regulatory Option	Incremental Cost *($ millions, 1981)*	Incremental Removals *(lbs-eq, thousands)*	Cost-Effectiveness *($/lb-eq)*
Option 1	11.9	58.2	204
Option 2	0.6	12.5	50
Option 3	40.1	62.9	638
Source: Environmental Protection Agency			

Option 3's cost effectiveness of $638 per pound-equivalent of additional pollutant removed is substantially poorer than the cost effectiveness of Options 1 and 2. Stepping from Option 2 to Option 3 nearly doubles the total toxic-weighted removals with a substantial increase of 62,900 pounds-equivalent. However, Option 3's annual compliance costs are more than four times those estimated for Option 2 and the resulting additional cost of $40.1 million yields the relatively high cost-effectiveness value of $638 per pound-equivalent.

On the basis of this analysis, EPA determines that the proposed Option 2 is cost-effectivene, and that the cost-effectiveness of the various regulatory options supports the choice of Option 2a as the proposed BPT/BAT option for direct dischargers.

3.3 Alternative Toxic Weighting Factors

EPA also performed the cost-effectiveness analysis with an alternative set of toxic weighting factors called Pollutant Weighting Factors. Appendix D lists these weighting factors, and Appendix E presents the results of the additional analysis.

Section 4

Cost-Effectiveness Values for Previous Effluent Guidelines and Standards

Tables 4-1 and 4-2 present, for indirect and direct dischargers, respectively, the baseline and post-compliance pollutant loadings and resulting cost-effectiveness values that were calculated for previous regulations. The values for the proposed MP&M Phase I regulatory options are also listed in these tables. All values are based on Toxic Weighting Factors normalized to copper and the cost-effectiveness values are presented in 1981 dollars.

Table 4-1: Industry Comparison of Cost-Effectiveness Values for Indirect Dischargers Toxic and Nonconventional Pollutants Only, Copper Based Weights (1981 Dollars)*			
Industry	Pounds Equivalent Currently Discharged (To Surface Waters) (000's)	Pounds Equivalent Remaining at Selected Option (To Surface Waters) (000's)	Cost Effectiveness of Selected Option Beyond BPT ($/lb-eq. removed)
Aluminum Forming	1,602	18	155
Battery Manufacturing	1,152	5	15
Can Making	252	5	38
Coal Mining***	N/A	N/A	N/A**
Coil Coating	2,503	10	10
Copper Forming	934	4	10
Centralized Waste Treatment † (co-proposal)			
- Regulatory Option 1	689	330	70
- Regulatory Option 2	689	328	110
Electronics I	75	35	14
Electronics II	260	24	14
Foundries	2,136	18	116
Inorganic Chemicals I	3,971	3,004	9
Inorganic Chemicals II	4,760	6	< 1
Iron & Steel	5,599	1,404	6
Leather Tanning	16,830	1,899	111
Metal Finishing	11,680	755	10
Metal Products & Machinery I †	**1,115**	**234**	**127**
Nonferrous Metals Forming	189	5	90
Nonferrous Metals Mfg I	3,187	19	15
Nonferrous Metals Mfg II	38	0.41	12
Organic Chemicals, Plastics...	5,210	72	34
Pesticide Manufacturing (1993)	257	19	18
Pesticide Formulating, Packaging.. †	33,748	< 1	1
Pharmaceuticals †	340	63	1
Plastic. Molding & Forming	N/A	N/A	N/A
Porcelain Enameling	1,565	96	14
Pulp & Paper	9,539	103	65

* Although toxic weighting factors for priority pollutants varied across these rules, this table reflects the cost-effectiveness at the time of regulation.
** N/A: Pretreatment Standards not promulgated, or no incremental costs will be incurred.
*** Reflects costs and removals of both air and water pollutants
† Proposed rule.

Table 4-2: Industry Comparison of Cost-Effectiveness Values for Direct Dischargers Toxic and Nonconventional Pollutants Only, Copper Based Weights (1981 Dollars)*			
Industry	Pounds Equivalent Currently Discharged (To Surface Waters) (000's)	Pounds Equivalent Remaining at Selected Option (To Surface Waters) (000's)	Cost Effectiveness of Selected Option Beyond BPT ($/lb-eq. removed)
Aluminum Forming	1,340	90	121
Battery Manufacturing	4,126	5	2
Can Making	12	0.2	10
Coal Mining	BAT=BPT	BAT=BPT	BAT=BPT
Coastal Oil and Gas † - Produced Water - Drilling Waste - TWC‡	 5,998 7 2	 506 0 0	 3 292 200
Coil Coating	2,289	9	49
Copper Forming	70	8	27
Centralized Waste Treatment † (co-proposal) - Regulatory Option 1 - Regulatory Option 2	 3,372 3,372	 1,267 1,271	 5 7
Electronics I	9	3	404
Electronics II	NA	NA	NA
Foundries	2,308	39	84
Inorganic Chemicals I	32,503	1,290	< 1
Inorganic Chemicals II	605	27	6
Iron & Steel	40,746	1,040	2
Leather Tanning	259	112	BAT=BPT
Metal Finishing	3,305	3,268	12
Metal Products & Machinery I †	**140**	**70**	**50**
Nonferrous Metals Forming	34	2	69
Nonferrous Metals Mfg I	6,653	313	4
Nonferrous Metals Mfg II	1,004	12	6
Offshore Oil and Gas**†	3,808	2,328	33
Organic Chemicals, Plastics...	54,225	9,735	5
Pesticide Manufacturing (1993)	2,461	371	15
Pharmaceuticals †	208	4	1
Plastics Molding & Forming	44	41	BAT=BPT
Porcelain Enameling	1,086	63	6
Petroleum Refining	BAT=BPT	BAT=BPT	BAT=BPT
Pulp & Paper	61,713	2,628	39
Textile Mills	BAT=BPT	BAT=BPT	BAT=BPT

* Although toxic weighting factors for priority pollutants varied across these rules, this table reflects the cost-effectiveness at the time of regulation.

** Produced water only, for produced sand and drilling fluids and drill cutings, BAT=BPT.

† Proposed rule.

‡ Treatment, workover, and completion fluids.

References

U.S. EPA (1995). *Development Document for Proposed Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Phase I Point Source Category.* Office of Water.

U.S. EPA (1995). *Economic Impact Analysis of Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Industry (Phase I).* Office of Water.

Appendix A

MP&M Pollutants of Concern

Name	CASNO
CONVENTIONAL POLLUTANTS	
Acidity	None
Alkalinity	None
Ammonia As N	7664417
Chemical Oxygen Demand (COD)	None
Chloride	16887006
Cyanide	57125
Fluoride	16984488
Oil And Grease	None
Sulfate	14808798
Total Dissolved Solids	None
Total Kjeldahl Nitrogen	None
Total Phosphorus	7723140
Total Recoverable Phenolics	None
Total Suspended Solids	None
METALS	
Aluminum	7429905
Antimony	7440360
Arsenic	7440382
Barium	7440393
Boron	7440428
Cadmium	7440439
Calcium	7440702
Chromium	7440473
Cobalt	7440484
Copper	7440508
Iron	7439896
Lead	7439921
Magnesium	7439954
Manganese	7439965
Molybdenum	7439987
Nickel	7440020
Selenium	7782492
Silver	7440224

Name	CASNO
Sodium	7440235
Thallium	7440280
Tin	7440315
Titanium	7440326
Vanadium	7440622
Zinc	7440666
ORGANIC POLLUTANTS	
1,1,1-Trichloroethane	71556
1,1-Dichloroethane	75343
2-Butanone	78933
2-Methylnaphthalene	91576
2-Nitrophenol	88755
2-Propanone	67641
4-Chloro-3-Methylphenol	59507
Alpha-Terpineol	98555
Benzoic Acid	65850
Benzyl Alcohol	100516
Bis(2-Ethylhexyl)Phthalate	117817
Di-N-Butyl Phthalate	84742
Ethylbenzene	100414
Hexanoic Acid	142621
Methylene Chloride	75092
N-Decane	124185
N-Docosane	629970
N-Dodecane	112403
N-Eicosane	112958
N-Hexacosane	630013
N-Hexadecane	544763
N-Octacosane	630024
N-Octadecane	593453
N-Tetracosane	646311
N-Tetradecane	629594
N-Triacontane	638686
Naphthalene	91203
Phenanthrene	85018
Phenol	108952
Tetrachloroethene	127184
Toluene	108883

* Acidity and alkalinity were not included in the cost-effectiveness analysis.

Appendix B

Toxic Weighting Factors

Name	Toxic Weighting Factor
CONVENTIONAL POLLUTANTS	
Ammonia As N	0.00450
Chemical Oxygen Demand (COD)	0.00000
Chloride	0.00000
Cyanide	1.07695
Fluoride	0.03500
Oil And Grease	0.00000
Sulfate	0.00000
Total Dissolved Solids	0.00000
Total Kjeldahl Nitrogen	0.00000
Total Phosphorus	0.05600
Total Recoverable Phenolics	0.00000
Total Suspended Solids	0.00000
METALS	
Aluminum	0.06437
Antimony	0.18797
Arsenic	4.03347
Barium	0.00199
Boron	0.17722
Cadmium	5.15747
Calcium	0.00000
Chromium	0.02668
Cobalt	0.11429
Copper	0.46667
Iron	0.00560
Lead	1.75000
Magnesium	0.00000
Manganese	0.01443
Molybdenum	0.20144
Nickel	0.03622
Selenium	1.12050
Silver	46.66672
Sodium	0.00000
Thallium	0.14000
Tin	0.30108

Name	Toxic Weighting Factor
Titanium	0.02932
Vanadium	0.62222
Zinc	0.05099
ORGANIC POLLUTANTS	
1,1,1-Trichloroethane	0.00431
1,1-Dichloroethane	0.00039
2-Butanone	0.00003
2-Methylnaphthalene	0.01812
2-Nitrophenol	0.00162
2-Propanone	0.00001
4-Chloro-3-Methylphenol	0.00431
Alpha-Terpineol	0.00102
Benzoic Acid	0.00033
Benzyl Alcohol	0.00561
Bis(2-Ethylhexyl)Phthalate	0.11020
Di-N-Butyl Phthalate	0.01166
Ethylbenzene	0.00141
Hexanoic Acid	0.00034
Methylene Chloride	0.00042
N-Decane	0.00431
N-Docosane	0.00008
N-Dodecane	0.00431
N-Eicosane	0.00431
N-Hexacosane	0.00008
N-Hexadecane	0.00431
N-Octacosane	0.00008
N-Octadecane	0.00431
N-Tetracosane	0.00008
N-Tetradecane	0.00431
N-Triacontane	0.00008
Naphthalene	0.01527
Phenanthrene	18.89532
Phenol	0.02800
Tetrachloroethene	0.07426
Toluene	0.00563

Appendix C

POTW Pollutant Removal Efficiencies

Name	**POTW Removal Efficiency %**
CONVENTIONAL POLLUTANTS	
Ammonia As N	8.14
Chemical Oxygen Demand (COD)	2.54
Chloride	0.00
Cyanide	70.44
Fluoride	61.35
Oil And Grease	97.14
Sulfate	0:00
Total Dissolved Solids	0.00
Total Kjeldahl Nitrogen	0.00
Total Phosphorus	0.00
Total Recoverable Phenolics	0.00
Total Suspended Solids	0.11
METALS	
Aluminum	16.81
Antimony	71.13
Arsenic	90.89
Barium	90.20
Boron	70.28
Cadmium	90.05
Calcium	55.19
Chromium	91.25
Cobalt	4.81
Copper	84.11
Iron	83.00
Lead	91.83
Magnesium	31.83
Manganese	40.60
Molybdenum	52.17
Nickel	51.44
Selenium	34.33
Silver	92.42
Sodium	55.19
Thallium	53.80

Name	POTW Removal Efficiency %
Tin	65.20
Titanium	68.77
Vanadium	42.28
Zinc	77.97
ORGANIC POLLUTANTS	
1,1,1-Trichloroethane	90.45
1,1-Dichloroethane	70.00
2-Butanone	91.83
2-Methylnaphthalene	28.00
2-Nitrophenol	26.83
2-Propanone	83.75
4-Chloro-3-Methylphenol	63.00
Alpha-Terpineol	94.60
Benzoic Acid	80.50
Benzyl Alcohol	78.00
Bis(2-Ethylhexyl)Phthalate	59.78
Di-N-Butyl Phthalate	79.31
Ethylbenzene	93.79
Hexanoic Acid	84.00
Methylene Chloride	54.28
N-Decane	9.00
N-Docosane	88.00
N-Dodecane	95.05
N-Eicosane	92.40
N-Hexacosane	71.11
N-Hexadecane	71.11
N-Octacosane	71.11
N-Octadecane	71.11
N-Tetracosane	71.11
N-Tetradecane	71.11
N-Triacontane	71.11
Naphthalene	94.69
Phenanthrene	94.89
Phenol	95.25
Tetrachloroethene	84.61
Toluene	96.18

Appendix D

Pollutant Weighting Factors

Name	Pollutant Weighting Factor
CONVENTIONAL POLLUTANTS	
Ammonia As N	0.00081
Chemical Oxygen Demand (COD)	0.00000
Chloride	0.00000
Cyanide	0.19231
Fluoride	0.00625
Oil And Grease	0.00000
Sulfate	0.00000
Total Dissolved Solids	0.00000
Total Kjeldahl Nitrogen	0.00000
Total Phosphorus	0.01000
Total Recoverable Phenolics	0.00000
Total Suspended Solids	0.00000
METALS	
Aluminum	0.01149
Antimony	0.07166
Arsenic	57.15000
Barium	0.00100
Boron	0.03165
Cadmium	0.90909
Calcium	0.00000
Chromium	0.00476
Cobalt	0.02041
Copper	0.08333
Iron	0.00100
Lead	0.31250
Magnesium	0.00000
Manganese	0.01000
Molybdenum	0.03597
Nickel	0.00625
Selenium	0.20000
Silver	8.33333
Sodium	0.00000
Thallium	0.02500
Tin	0.05376

Titanium	0.00524
Vanadium	0.11111
Zinc	0.00909
ORGANIC POLLUTANTS	
1,1,1-Trichloroethane	0.00077
1,1-Dichloroethane	0.00027
2-Butanone	0.00057
2-Methylnaphthalene	0.00324
2-Nitrophenol	0.00029
2-Propanone	0.00029
4-Chloro-3-Methylphenol	0.00077
Alpha-Terpineol	0.00018
Benzoic Acid	0.00006
Benzyl Alcohol	0.00100
Bis(2-Ethylhexyl)Phthalate	0.56900
Di-N-Butyl Phthalate	0.00200
Ethylbenzene	0.00032
Hexanoic Acid	0.00006
Methylene Chloride	0.21492
N-Decane	0.00077
N-Docosane	0.00001
N-Dodecane	0.00077
N-Eicosane	0.00077
N-Hexacosane	0.00001
N-Hexadecane	0.00077
N-Octacosane	0.00001
N-Octadecane	0.00077
N-Tetracosane	0.00001
N-Tetradecane	0.00077
N-Triacontane	0.00001
Naphthalene	0.00270
Phenanthrene	357.14285
Phenol	0.00500
Tetrachloroethene	1.25000
Toluene	0.00100

Appendix E

Results of Cost-Effectiveness Analysis Using Pollutant Weighting Factors

E.1 Alternative Toxic Weighting Factors

EPA also performed the cost-effectiveness analysis with an alternative set of toxic weighting factors called *Pollutant Weighting Factors (PWFs)*. Appendix D listed these weighting factors, while this appendix presents the results of the additional analysis.

PWFs are derived from either chronic aquatic life criteria (or toxic effect levels) or human health criteria (or toxic effect levels) established for the consumption of water and fish. For carcinogenic substances, the human health risk level is 10^6, rather than 10^5 in the case of TWFs. In contrast to TWFs, PWFs are not related to a benchmark pollutant. PWFs are derived by taking the reciprocal of the more stringent (smaller value) of the aquatic life or human health criteria or toxic effect levels.

While the cost-effectiveness values calculated with PWFs cannot be compared to cost-effectiveness values calculated with TWFs for previous regulations, they do permit comparisons between options in the current effluent guideline analysis. In this regard, the PWF-based cost-effectiveness analysis supports the findings described in Section 3. Among the options considered for MP&M Phase I effluent guidelines, the cost-effectiveness values for the proposed options for both indirect and direct dischargers are superior to the values calculated for the other options evaluated.

E.2 Cost-Effectiveness Analysis for Indirect Dischargers

Tables E-1 and E-2 summarize the cost-effectiveness analysis results for the PSES regulatory options applicable to indirect dischargers. Annual compliance costs are shown in 1989 dollars, as reported in the EIA, and in 1981 dollars, on a pre-tax basis, with capital costs annualized using a 7 percent opportunity cost of capital. Pollutant removals are reported on both an unweighted and toxic-weighted basis. The regulatory options are listed in order of increasing stringency on the basis of the estimated toxic-weighted pollutant removals.

As shown in Table E-1, EPA estimates that Option 2a, the proposed option, would achieve 12.8 million pounds of pollutant removals, which is the same as shown in the previous analysis using TWFs. The effect of using PWFs instead of TWFs is to reduce the toxic pounds-equivalent of this quantity of removals from 881,300 to 444,100 pounds-equivalent. Since Option 2a is the least stringent option, the incremental removals and costs shown in Table E-2 are the same as the totals, yielding a cost-effectiveness of $252 per pound-equivalent of pollutant removed. The cost-effectiveness values for the other regulatory options are substantially inferior to this value.

Table E-1
National Estimates of MP&M Annualized Costs and Pollutant Removals, Using Pollutant Weighting Factors
Indirect Dischargers (PSES)

Regulatory Option	Annualized Cost, $millions		Pollutant Removals, thousands	
	1989 dollars	*1981 dollars*	*Raw Pounds*	*Pounds-Equivalent*
Option 2a	146.1	111.9	12,769.7	444.1
Option 1	231.3	177.2	14,611.7	528.2
Option 1A	221.9	170.0	14,872.7	538.7
Option 2	228.3	174.9	14,878.8	538.9
Option 3	668.8	512.3	15,612.1	586.2

Source: US Environmental Protection Agency

Table E-2
National Estimates of MP&M Incremental Costs, Removals and Cost-Effectiveness
Using Pollutant Weighting Factors
Indirect Dischargers (PSES)

Regulatory Option	Incremental Cost *($ millions, 1981)*	Incremental Removals *(lbs-eq, thousands)*	Cost-Effectiveness *($/lb-eq)*
Option 2A	111.9	444.1	252
Option 1	65.3	84.1	776
Option 1A	(7.2)	10.4	(686)
Option 2	4.9	0.2	22,854
Option 3	337.4	47.3	7,127

Source: US Environmental Protection Agency

E.3 Cost-Effectiveness Analysis for Direct Dischargers

Tables E-3 and E-4 summarize the cost-effectiveness for the BPT/BAT regulatory options applicable to direct dischargers. As with indirect dischargers, annual compliance costs are shown in both 1989 and 1981 dollars, and pollutant removals are reported in both unweighted and toxic-weighted pounds. The regulatory options are listed in order of increasing stringency, measured by toxic-weighed pollutant removals.

Table E-3 shows that Option 1 achieves 1.153 million pounds of removals on an unweighted basis and 44,200 pounds-equivalent of removals on a toxic-weighted basis, at a cost of $11.9 million (1981 dollars). Since Option 1 is the least stringent option, it is compared to the baseline, and the incremental costs and removals shown in Table E-4 for this option are the same as the total costs and removals. This results in a cost-effectiveness of $269 per pound-equivalent.

Table E-3 National Estimates of MP&M Annualized Costs and Pollutant Removals Direct Dischargers (BAT)				
	Annualized Cost, $millions		**Pollutant Removals, thousands**	
Regulatory Option	*1989 dollars*	*1981 dollars*	*Raw Pounds*	*Pounds-Equivalent*
Option 1	15.5	11.9	1,152.5	44.2
Option 2	16.3	12.5	1,232.2	85.0
Option 3	68.7	52.6	1,446.7	221.5
Source: Environmental Protection Agency				

Table E-4 National Estimates of MP&M Incremental Costs, Removals and Cost-Effectiveness Direct Dischargers (BAT)			
Regulatory Option	**Incremental Cost** *($ millions, 1981)*	**Incremental Removals** *(lbs-eq, thousands)*	**Cost-Effectiveness** *($/lb-eq)*
Option 1	11.9	44.2	269
Option 2	0.6	40.7	147
Option 3	40.1	136.6	238
Source: Environmental Protection Agency			

Moving from Option 1 to the proposed Option 2 achieves 85,000 pounds-equivalent of toxic-weighted removals, which represents a 40,700 pounds-equivalent increment, at an annual cost of $12.5 million (1981 dollars), which is an increment of $0.6 million over Option 1. Thus the cost-effectiveness of Option 2 is estimated to be $147 per pound-equivalent.

Option 3 achieves incremental pollutant removals of 136,600 pounds-equivalent at the incremental cost of $40.1 million, thus yielding a cost-effectiveness value of $238 per pound-equivalent. Notably, Option 3 achieves substantially better cost effectiveness when removals are normalized by using the PWFs than the TWFs. As a result, in the PWF analysis, all three BAT/BPT options for direct dischargers appear to be cost effective.

Appendix F

Results of Cost-Effectiveness Analysis Using After-Tax Costs of Compliance

F.1 Private Compliance Costs

EPA also performed the cost-effectiveness analysis using total annualized costs of compliance after tax adjustments and with capital costs annualized on the basis of facility-specific costs of capital. This analysis differs from that of Section 3 in which annual compliance costs were calculated on a pre-tax basis with capital costs annualized at a 7 percent opportunity cost of capital to society. The after-tax costs used in this appendix may be interpreted as the annual costs of compliance as incurred on a cash basis by MP&M facilities. Because the effect of the tax treatment of operating expenses and capital outlays is to shift to society a share of the compliance costs, the costs presented in this appendix are generally lower than those presented in Section 3.

The after-tax cost-based cost-effectiveness analysis supports the findings described in Section 3. Among the options considered for MP&M Phase I effluent guidelines, the cost-effectiveness values calculated for the proposed options are superior to the values calculated for the other regulatory options analyzed.

F.2 Cost-Effectiveness Analysis for Indirect Dischargers

As shown in Tables F-1 and F-2, Option 2a achieves approximately 12.8 million pounds of toxic pollutant removals, on an unweighted basis and 881,300 pounds-equivalent on a toxic-weighted basis. The total compliance costs for this option is $93.1 million in 1981 constant dollars. Since Option 2a is the least stringent option, in terms of pollutant removals, the cost-effectiveness of this option is the same as its average cost per pounds-equivalent removed, $106.

Option 1 is estimated to achieve approximately 14.6 million pounds of toxic pollutant removals on an unweighted basis and 989,400 pounds-equivalent on a toxic-weighted basis, which is a 107,600 pounds-equivalent increment over Option 2a. With an estimated annual compliance cost of $132 million ($1981), or $39 million more than Option 2a, the calculated cost effectiveness for Option 1's removals is $362 per pound-equivalent of pollutant removed. In moving from Option 1 to Option 1a, toxic-weighted pollutant removals increase by 22,100 pounds-equivalent while costs increase by $4.3 million. Thus, the cost effectiveness of Option 1a is $193 per pound-equivalent of additional pollutant removed, an acceptable cost-effectiveness value.

Moving from Option 1A to Option 2 yields very little additional pollutant removals — 600 pounds-equivalent — at an additional cost of $3.2 million, yielding a high cost-effectiveness value of $5,530 per pound-equivalent. Option 3 has the highest pollutant removals and the highest costs, at 1.105 million pounds-equivalent and $402.4 million (1981 dollars), respectively. Compared to Option 2, this represents a $262.8 million increase in compliance costs, but a proportionately smaller increase in pollutant removals of 93,800 pounds-equivalent. The corresponding cost-effectiveness is $2,801 per pound-equivalent.

Table F-1
National Estimates of MP&M Annualized Costs and Pollutant Removals
Indirect Dischargers (PSES)

Regulatory Option	Annualized Cost, $millions		Pollutant Removals, thousands	
	1989 dollars	*1981 dollars*	*Raw Pounds*	*Pounds-Equivalent*
Option 2a	121.6	93.1	12,769.7	881.3
Option 1	172.5	132.1	14,611.7	988.9
Option 1A	178.1	136.4	14,872.7	1,011.0
Option 2	182.2	139.6	14,878.8	1,011.6
Option 3	525.3	402.4	15,612.1	1,105.4

Source: Environmental Protection Agency

Table F-2
National Estimates of MP&M Incremental Costs, Removals and Cost-Effectiveness
Indirect Dischargers (PSES)

Regulatory Option	Incremental Cost *($ millions, 1981)*	Incremental Removals *(lbs-eq, thousands)*	Cost-Effectiveness *($/lb-eq)*
Option 2a	93.1	881.3	106
Option 1	39.0	107.6	362
Option 1A	4.3	22.1	193
Option 2	3.2	0.6	5,530
Option 3	262.8	93.8	2,801

Source: Environmental Protection Agency

F.3 Cost-Effectiveness Analysis for Direct Dischargers

Tables F-3 and F-4 summarize the cost-effectiveness for the BPT/BAT regulatory options applicable to direct dischargers. As with indirect dischargers, annual compliance costs are shown in both 1989 and 1981 dollars, and pollutant removals are reported in both unweighted and toxic-weighted pounds. The regulatory options are listed in order of increasing stringency, measured by toxic-weighed pollutant removals.

Table F-3 shows that Option 1 achieves 1.153 million pounds of removals on an unweighted basis and 58,200 pounds-equivalent of removals on a toxic-weighted basis, at a cost of $10.7 million (1981 dollars). Since Option 1 is the least stringent option, it is compared to the baseline, and the incremental costs and removals shown in Table F-4 for this option are the same as the total costs and removals. This results in a cost-effectiveness of $183 per pound-equivalent.

Moving from Option 1 to the proposed Option 2 achieves 70,700 pounds-equivalent of toxic-weighted removals, which represents a 12,500 pounds-equivalent increment, at an annual cost of $11.9 million (1981 dollars), which is an increment of $1.2 million over Option 1. Thus the cost-effectiveness of Option 2 is estimated to be $96 per pound-equivalent.

Option 3's cost-effectiveness of $476 is considerably higher than the value calculated for Option 2. Option 3 achieves a substantial increment in pollutant removals of 62,900 pounds-equivalent, but it does so at an incremental cost of $30 million, compared to Option 2.

Table F-3
National Estimates of MP&M Annualized Costs and Pollutant Removals
Direct Dischargers (BAT)

Regulatory Option	Annualized Cost, $millions		Pollutant Removals, thousands	
	1989 dollars	*1981 dollars*	*Raw Pounds*	*Pounds-Equivalent*
Option 1	13.9	10.7	1,152.5	58.2
Option 2	15.5	11.9	1,232.2	70.7
Option 3	54.6	41.8	1403.3	117.5

Source: Environmental Protection Agency

Table F-4
National Estimates of MP&M Incremental Costs, Removals and Cost-Effectiveness
Direct Dischargers (BAT)

Regulatory Option	Incremental Cost *($ millions, 1981)*	Incremental Removals *(lbs-eq, thousands)*	Cost-Effectiveness *($/lb-eq)*
Option 1	10.7	58.2	183
Option 2	1.2	12.5	96
Option 3	30.0	46.8	640

Source: Environmental Protection Agency