United States Environmental Protection Agency | Office of Water (4303) | EPA-821-B-00-008 December 2000

EPA

Economic, Environmental, and Benefits Analysis of the Proposed Metal Products and Machinery Rule

Economic, Environmental, and Benefits Analysis of the Proposed Metal Products and Machinery Rule

U.S. Environmental Protection Agency
Office of Science and Technology
Engineering and Analysis Division

Washington, DC 20460
December 2000

This document was prepared by the Office of Water staff. Abt Associates provided assistance and support in performing the underlying analysis supporting the conclusions detailed in this report.

Table of Contents

Chapter 7: Government and Community Impact Analysis

Chapter 8: Foreign Trade Impacts

Chapter 9: Firm Level, New Source and Industry Impacts

Chapter 10: Regulatory Flexibility Analysis/SBREFA

Chapter 11: Social Costs

Part III: Benefits

Chapter 12: Benefit Overview

Chapter 13: Human Health Benefits

Chapter 14: Lead-Related Benefits

Chapter 15: Recreational Benefits

Chapter 16: POTW Benefits

Chapter 17: Environmental Justice Analysis and Protection of Children

PART IV: COMPARISON OF COSTS AND BENEFITS

Chapter 18: MP&M Benefit/Cost Comparison

Chapter 19: Social Costs and Benefits of Regulatory Alternatives

PART V: OHIO CASE STUDY

Chapter 20: Baseline Conditions in Ohio

Chapter 21: Modeling Recreational Benefits in Ohio with a RUM Model

Chapter 22: MP&M Benefit-Cost Analysis in Ohio

APPENDICES

Appendix A: Detailed Economic Impact Analysis Information

Appendix B: MP&M Sector Cost Pass-Through Potential

Appendix C: POTW Administrative Costs

Appendix D: Baseline and Post-Compliance Pollutant Loads

Appendix E: Environmental Assessment

Appendix F: Differential Sample Weighting Technique

Appendix G: Fate and Transport Model for DW and Ohio Analyses

Appendix H: Spacial Distribution of Benefiting Reaches, MP&M Facilities, and Benefiting Populations

Appendix I: Selecting WTP Values for Benefits Transfer

Executive Summary

Introduction

EPA is proposing effluent limitations guidelines and standards for the Metal Products and Machinery (MP&M) industry. This document presents EPA's economic and environmental analyses supporting the proposed rule. The Executive Summary provides an overview of the costs and benefits of the regulation.

Overall, EPA finds that the proposed rule provides significant benefits that are likely to outweigh the social costs of the rule. Moreover, the rule has modest economic impacts. The Agency is continuing to develop and refine its methodologies for estimating the benefits of improved water quality resulting from effluent guidelines, and has used new approaches in some cases in the benefits analyses presented in these reports. EPA recognizes that estimates of both costs and benefits are uncertain, and therefore conducted a number of checks on the reasonableness of the analysis results. In particular, EPA undertook the Ohio case study to perform more detailed and complete benefits analyses than were feasible for the nation as a whole. The Agency is seeking comment on the methodologies and results of both the national analyses and the Ohio case study. Additional information on issues associated with extrapolation of the benefit results can be found in Section E.4.

Detailed descriptions of the analytic methodologies and results are presented in the Economic, Environmental, and Benefit Assessment (EEBA). In addition, the EEBA presents costs, benefits, and economic impacts for alternatives to the proposed rule that were considered by EPA.

Executive Summary Contents:

ES.1 Overview of the MP&M Industry and its Effluent Discharges

The proposed regulation will apply to process wastewater discharges from MP&M facilities performing manufacturing, rebuilding, or maintenance on a metal part, product, or machine using an MP&M operation and discharging process wastewater either directly or indirectly to surface waters. These potentially-regulated MP&M facilities represent only a portion of all facilities in the relevant industrial sectors, since some facilities do not generate or discharge process wastewater.

Department of Commerce data indicate that there are more than 1.3 million establishments operating in potential MP&M sectors. The MP&M survey results indicate that there are approximately 89,000 MP&M facilities that manufacture, rebuild, or repair metal machines, parts, products, or equipment using processes covered by the proposed rule. Of these 89,000, approximately 26,000 do not use or discharge water or use a contract hauler for their wastewater. Only 62,752 facilities, or 71 percent of the MP&M facilities, are water-discharging facilities that could be potentially subject to the MP&M regulation. These 62,752 water-discharging facilities include 57,948 indirect dischargers (i.e., facilities discharging effluent to a publicly-owned sewage treatment works or POTWs) and 4,804 direct dischargers (i.e., facilities discharging effluent directly to a waterway under a NPDES permit).

Table ES.1 shows the estimated number of MP&M facilities (water dischargers and zero dischargers) and total discharge flow (prior to implementation of the proposed rule) by type of facility. The largest number of sites, approximately 44,000, perform "rebuilding/maintenance only" and account for approximately 9 percent of the total estimated discharge flow for the industry. "Manufacturing only" represents the next largest number of facilities (27,000) and represents the largest percentage of the total estimated discharge flow for the industry (75 percent).

Table ES.1: Number of MP&M Facilities (Water-Discharging and Zero-Discharge) and Total Discharge Flow by Type of Facility

Type of Facility	Number of Facilities	Total Estimated Discharge Flow (million gal.yr)	Percent of Facilities	Percent of Total Discharge Flow
Manufacturing & Rebuilding/Maintenance	7,400	11,200	8.3%	9.1%
Manufacturing Only	27,000	91,700	30.4%	75.2%
Rebuilding/Maintenance Only	44,000	11,100	49.5%	9.1%
Unknown/others	10,500	8,100	11.8%	6.6%
Total	89,000	122,000	100.0%	100.0%

Source: U.S. EPA analysis. See Technical Development Document *for the proposed rule.*

Table ES.2 compares the number of potentially-regulated facilities with the number that are actually subject to requirements under the proposed rule. Of the 62,752 water discharging facilities, 3,766 are predicted to close in the baseline, leaving 58,986 facilities operating in the baseline that EPA estimates could be regulated. The proposed rule would regulate 9,839 of these facilities, including 5,186 indirect discharging facilities and 4,653 direct dischargers.

The estimated 9,839 water-discharging facilities that are regulated under the preferred option represent less than 0.8 percent of all facilities in the MP&M industries, and 17 percent of those that are potentially regulated. Over 90 percent of the potentially-regulated indirect dischargers will not be subject to requirements under the proposed rule, whereas the proposed rule will regulate all of the direct dischargers operating in the baseline.

Table ES.2: Number of MP&M Facilities Potentially-Regulated and Subject to Requirements under the Proposed Rule

	All Water-Discharging MP&M Facilities	Operating in the Baseline	Regulated under the Proposed Rule	Percent of Facilities Operating in the Baseline that are Regulated
Direct	4,804	4,653	4,653	100%
Indirect	57,948	54,333	5,186	10%
Total	62,752	58,986	9,839	17%

Source: U.S. EPA analysis.

The following are important characteristics of the MP&M industries as a whole and of the portion of those industries potentially-regulated under the proposed rule.

Many potentially-regulated MP&M facilities produce goods and services that serve multiple market sectors. It is not possible to associate regulatory costs and benefits to particular sectors, because EPA is not able to link regulated processes to specific sectors for facilities operating in multiple sectors. The results of EPA's cost and economic impact analyses are disaggregated by type of facility but not by sector.

Establishments in the relevant MP&M industries are located in every state, with a particular concentration in the heavy industrial regions along the Gulf Coast, both East and West Coasts and the Great Lakes Region. Moreover, MP&M facilities are frequently located in highly populated regions. Based on survey information, 24% of facilities receiving detailed MP&M questionnaires are located in counties with populations of at least 1 million people, and 42% of facilities sampled are located in counties with populations of at least 500 thousand people.[1]

EPA is regulating the MP&M industry because the industry releases substantial quantities of pollutants, including toxic pollutant compounds (priority and nonconventional metals and organics) and conventional pollutants such as total suspended solids (TSS) and oil and grease (O&G). These MP&M industry pollutants are generally controlled by straightforward and widely-used treatment system technologies such as chemical precipitation and clarification (frequently referred to as the lime and settle process).

Discharges of these pollutants to surface waters and POTWs have a number of adverse effects, including degradation of aquatic habitats, reduced survivability and diversity of native aquatic life, and increased human health risk through the consumption of contaminated fish and water. In addition, many of these pollutants volatilize into the air, disrupt biological wastewater treatment systems, and contaminate sewage sludge.

ES.2 Description of the Proposed Rule

EPA grouped facilities into subcategories as a basis for the proposed regulation. The subcategories differ in part based on the type of wastewater that facilities discharge, including:

- facilities that discharge wastewaters with high metals content, with or without oil and grease (O&G); and
- facilities that discharge wastewaters containing mainly O&G, with limited metals and associated other organic constituents.

The subcategories identified by EPA in each group are:

Metal-bearing (with or without O&G):

- Non Chromium Anodizing: facilities that perform aluminum anodizing without the use of chromic acid or dichromate sealants;
- Metal Finishing Job Shops: facilities that perform one or more of six metal finishing operations and that own no more than 50 percent of the materials undergoing metal finishing;
- Printed Wiring Board: facilities manufacture, maintain, and repair printed wiring boards (i.e., circuit boards), not including job shops;
- Steel Forming & Finishing: facilities that perform MP&M operations or cold forming operations on steel wire, rod, bar, pipe, or tube;
- General Metals: MP&M facilities that discharge metal-bearing wastewater, with or without oil-bearing wastewater, that do not fit into one of the other metal-bearing subcategories described above.

Oil-bearing only:

- Shipbuilding Dry Docks: MP&M process wastewater generated in or around dry docks and similar structures, such as graving docks, building ways, marine railways, and lift barges at shipbuilding facilities. These structures include sumps or containment systems that enable shipyards to control the discharge of pollutants to the surface water.
- Railroad Line Maintenance: facilities that perform routine cleaning and light maintenance on railroad engines, cars, car-wheel trucks, and similar parts or machines, and discharge only from oily operations and/or washing of the final product.
- Oily Wastes: MP&M facilities that discharge only oil-bearing wastewater from a specified list of unit operations and that are not Shipbuilding Dry Dock or Railroad Line Maintenance facilities.

EPA evaluated ten technology options that might be used to treat wastewaters from the MP&M facilities. Table ES.3 lists these technology options:

[1] EPA is not able to characterize the location characteristics of all potentially-regulated MP&M facilities at the national level precisely, because the MP&M survey design was not intended to provide national results by location characteristics.

Table ES.3: Technology Options

Option #	Description
For metal-bearing wastes	
1	segregation of wastewaters, preliminary treatment (including oil-water separation), chemical precipitation, and sedimentation using a clarifier (chemical precipitation with gravity clarification)
2	in-process flow control and pollution prevention + option 1
3	segregation of wastewaters, preliminary treatment (including oil removal by ultrafiltration), chemical precipitation, and solids separation using a microfilter
4	in-process flow control and pollution prevention + option 3
For oil-bearing wastes	
5	oil-water separation by chemical emulsion breaking
6	in-process flow control and pollution prevention + option 5
7	oil-water separation by ultrafiltration
8	in-process flow control and pollution prevention + option 7
9	oil-water separation by dissolved air flotation (DAF)
10	in-process flow control and pollution prevention + option 9

EPA defined specific effluent limitations based on a statistical analysis of the performance of these technologies. The even-numbered options add in-process flow controls and pollution prevention (i.e., pollution prevention, recycling, and water conservation to allow recovery and reuse of materials) to the treatment technologies specified in the odd-numbered options. In all cases, options with in-process flow control and pollution prevention cost less and remove more pollutants than do the comparable options without pollution prevention. The EEBA, therefore, did not analyze options without flow control and pollution prevention.

The Agency considered a range of low flow exclusions for indirect dischargers, to reduce burdens on permitting officials and reduce the economic impacts of the rule. Evaluation of the low flow cutoffs considered the amount of pollutant discharged by each subcategory and flow size category.

Table ES.4 shows the technology options and exclusions that EPA is proposing for each subcategory. This table also defines two regulatory alternatives for which EPA evaluated costs, benefits, economic impacts and cost-effectiveness. These include:

- Option 2/6/10, which applies the same technologies for each subcategory, and eliminates the low flow and subcategory exclusions of the proposed rule, and

- Option 4/8, which applies more stringent technology requirements for all subcategories and does not include low flow exclusions.

Table ES.4: Summary of Proposed Rule and Regulatory Alternatives for Existing Sources

Subcategory	Proposed rule	Option 2/6/10	Option 4/8
General Metals	Technology option 2; 1 mgy flow cutoff for indirect dischargers	Technology option 2	Technology option 4
Metal Finishing Job Shop	Technology option 2	Technology option 2	Technology option 4
Non-Chromium Anodizing	Technology option 2; no PSES for indirect dischargers	Technology option 2	Technology option 4
Oily Wastes	Technology option 6; 2 mgy flow cutoff for indirect dischargers	Technology option 6	Technology option 8
Printed Wiring Board	Technology option 2	Technology option 2	Technology option 4
Railroad Line Maintenance	Technology option 10; no PSES for indirect dischargers	Technology option 10	Technology option 8
Shipbuilding Dry Dock	Technology option 10; no PSES for indirect dischargers	Technology option 10	Technology option 8
Steel Forming & Finishing	Technology option 2	Technology option 2	Technology option 4

Note: PSES = Pretreatment Standards for Existing Sources. The standards for different classes of dischargers are discussed in Chapter 4 of the EEBA.

ES.3 Economic Impacts and Social Costs of the Proposed Rule

EPA assessed the economic impacts and social costs associated with the proposed rule using detailed financial and technical data from a series of surveys of MP&M facilities. Engineering analyses of these facilities identified the pollution prevention and treatment systems needed to comply with the proposed rule and other regulatory alternatives. The estimated capital and annual operating and maintenance costs of these systems, incremental to the costs of systems already in place, represent the compliance costs of the rule.[2] EPA analyzed the financial performance of potentially-regulated facilities under the current conditions (the baseline) and subject to the proposed regulatory requirements. The Agency used a variety of measures to assess the economic impacts resulting from the proposed rule, both for the regulated MP&M facilities and for the firms and governments that own the facilities. The economic impact analysis also considered impacts for small entities in particular, and impacts on employment, foreign trade and communities. The results of the analyses for sample facilities were extrapolated using survey sample weights for each facility, to provide national-level results.

ES.3.1 Economic Impacts

Overall, EPA found the economic impacts of the proposed rule to be very modest. The following are EPA's findings for different categories of impacts.

a. Facility impacts

The facility impact analysis assesses how facilities will be affected financially by the proposed rule. Key outputs of the facility impact analysis include expected facility closures in the MP&M industries, associated losses in employment, and the number of facilities experiencing financial stress short of closure ("moderate impacts"). EPA performed economic impact analyses for three categories of facilities, using different methodologies to evaluate each of the groups. The three groups are:

- Private MP&M Facilities. This group includes privately-owned facilities that do not perform railroad line maintenance and are not owned by governments. This major category includes private businesses in a wide range of sectors or industries, including facilities that manufacture and rebuild railroad equipment. Only facilities that repair railroad track and equipment along the railroad line are not included.

- Railroad line maintenance facilities maintain and repair railroad track, equipment and vehicles.

- Government-owned facilities include MP&M facilities operated by municipalities, State agencies and other public sector entities such as State

[2] The annual equivalent of capital and other one-time costs is calculated by annualizing costs at a seven percent discount rate over an estimated 15 year equipment life. Annual compliance costs are annualized capital costs plus annual operating and maintenance (O&M) costs.

universities. Many of these facilities repair, rebuild, and maintain buses, trucks, cars, utility vehicles (e.g., snow plows and street cleaners), and light machinery.

The specific methodology used to assess impacts differed for each of the three types of MP&M facilities. For private MP&M facilities, EPA established thresholds for measures of financial performance and compared the facilities' performance before and after compliance with each regulatory option with these thresholds. Impacts were measured at the operating company level for railroad line maintenance facilities, since firms are unlikely to keep track of financial performance at the facility level for these sites. For governments, EPA compared compliance costs with facilities' baseline costs of service, and assessed the impact of the compliance costs on the government's taxpayers and on its ability to finance compliance costs by issuing debt.

EPA identified facilities that are financially weak and might be expected to close under baseline conditions. Of the estimated 62,752 discharging facilities, 6.1 percent or 3,829 facilities were assessed as baseline closures. The 3,829 baseline closures include 3,678 indirect dischargers, or 6.3 percent of indirect dischargers, and 151 direct dischargers, or 3.1 percent of direct dischargers. These facilities were excluded from the post-compliance analysis of regulatory impacts.

Table ES.5 provides an overview of the facility-level economic impacts for the proposed rule. This table shows that less than one-half of one percent of facilities are projected to close due to the rule, and approximately one percent are expected to experience moderate financial stress short of closure. The proposed rule excludes over 90 percent of the indirect discharging facilities from any requirements.

Table ES.5: Regulatory Impacts for All Facilities, Proposed Rule, National Estimates

	Total	Direct	Indirect
Number of facilities operating in the baseline: total	58,922	4,653	54,270
private MP&M and railroad line maintenance	*54,590*	*3,999*	*50592*
government-owned	*4,332*	*654*	*3678*
Number of regulatory closures	199	20	179
Percent of facilities operating in the baseline that are regulatory closures	0.3%	0.4%	0.3%
Number of facilities operating post-regulation	58,787[a]	4,633	54,154[a]
Number of facilities below low flow cutoffs	48,256[a]		48,256[a]
Number of facilities with subcategory exclusions	955		955
Percent of facilities operating in the baseline excluded or below cutoffs	83.5%		90.6%
Number of facilities operating subject to regulatory requirements	9,576	4,633	4,943
Number of facilities experiencing moderate impacts	616	41	575
Percent of facilities operating in the baseline that experience moderate impacts	1.0%	0.9%	1.1%

a. Includes 64 avoided baseline closures -- general metals indirect dischargers below the low flow cutoffs that are projected to close in the baseline but that remain open under the proposed rule.
Source: U.S. EPA analysis.

Table ES.6 shows the results of the analysis by subcategory and discharge status. The table shows that substantial portions of the General Metals and Oily Waste indirect dischargers are excluded by the low flow cutoffs. Metal Finishing Job Shops account for the largest number of closures among indirect dischargers under the proposed rule, and Printed Wiring Board and Metal Finishing Job Shop facilities together account for the largest portion of moderate impacts. Most of the direct discharger impacts (closures and moderate impacts) are in the General Metals subcategory, although the closures and moderately-impacted facilities represent a small percentage of the General Metals direct discharging facilities as a whole.

Table ES.6: Regulatory Impacts by Subcategory, Proposed Rule, National Estimates

Subcategory	# Facilities Operating in Baseline	Regulatory Closures	% Closures	# Exempted	% Exempted	# with Moderate Impacts	% Moderate Impacts
Indirect Dischargers							
General Metals	23,140	24	0.1%	20,164[a]	87%	153	0.7%
Metal Finishing Job Shop	1,231	128	10.4%			117	9.5%
Non-Chromium Anodizing	150	0	0%	150	100%	0	0%
Printed Wiring Board	620	7	1.1%			301	48.7%
Steel Forming & Finishing	105	6	5.7%			4	3.8%
Oily Waste	28,219	14	<.0.1%	28,092	99.5%	-	-
Railroad Line Maintenance	799	0	0%	799	100%	0	0%
Shipbuilding Dry Dock	6	0	0%	6	100%	0	0%
All Indirect Dischargers	54,270	179	0.3%	49,211[a]	91%	575	1.1%
Direct Dischargers							
General Metals	3,636	20	0.6%			34	0.9%
Metal Finishing Job Shop	12	0	0%			0	0%
Non-Chromium Anodizing	0						
Printed Wiring Board	11	0	0%			0	0%
Steel Forming & Finishing	43	0	0%			7	16.3%
Oily Waste	911	0	0%			0	0%
Railroad Line Maintenance	34	0	0%			0	0%
Shipbuilding Dry Dock	6	0	0%			0	0%
All Direct Dischargers	4,653	20	0.4%			41	0.9%

a. Includes 64 avoided closures -- general metals indirect dischargers that are projected to close in the baseline but which operate under the proposed rule and are eligible for the low flow cutoff.
Note: may not sum to totals due to independent rounding.
Source: U.S. EPA analysis.

Table ES.7 summarizes impacts for government-owned facilities in particular. Under the proposed rule, 83 percent of the government-owned facilities would be excluded from requirements because they fall below the low flow cutoff proposed for indirect dischargers. The compliance costs of the proposed rule do not result in significant budgetary impacts for any of the governments that operate the facilities.

Table ES.7: Regulatory Impacts for Government-Owned Facilities, Proposed Rule, National Estimates	
Number of government-owned facilities operating in the baseline & post-regulation	4,332
Number of facilities below low flow cutoffs	3,603
Percent of facilities operating in the baseline below cutoffs	83.2%
Number of facilities operating subject to regulatory requirements	729
Number of facilities experiencing impacts	0
Percent of facilities operating in the baseline that experience significant budgetary impacts	0%

Source: U.S. EPA analysis.

b. Firm level impacts

EPA examined the impacts of the proposed rule on firms that own MP&M facilities, as well as on the financial condition of the facilities themselves. A firm that owns multiple MP&M facilities could experience adverse financial impacts at the firm level if its facilities are among those that incur significant impacts at the facility level. The firm-level analysis is also used to compare impacts on small versus large firms, as required by the Regulatory Flexibility Act and the Small Business Regulatory Enforcement Fairness Act.

EPA compared compliance costs with revenue at the firm level as a measure of the relative burden of compliance costs. EPA applied this analysis only to MP&M facilities owned by private entities. EPA estimated firm-level compliance costs by summing costs for all facilities owned by the same firm that responded to the survey plus estimated compliance costs for additional facilities for which respondents submitted voluntary information. The Agency was not able to estimate the national numbers of firms that own MP&M facilities precisely, because the sample weights based on the survey design represent numbers of facilities rather than firms. Most MP&M facilities (43,118 of 54,590, or 80 percent) are single-facility firms, however. These firms can be analyzed using the survey weights. In addition, there are 289 firms that own more than one sample facility. These firms are included in the analysis with a sample weight of one, since it is not known how many firms these 289 sample firms represent.

Table ES.8 shows the results of the firm-level analysis. The results represent a total of 43,407 MP&M firms (43,118 + 289), owning 54,590 facilities (43,118 owned by single-facility firms + 11,473 owned by multi-facility firms).

Table ES.8: Firm Level Before-Tax Annual Compliance Costs as a Percent of Annual Revenues

Number of Firms in the Analysis[a]	Number and Percent with Before-Tax Annual Compliance Costs/Annual Revenues Equal to:					
	Less than 1%		1-3%		Over 3%	
	Number	%	Number	%	Number	%
43,407	41,236	95%	1,070	2.5%	1,101	2.5%

a. Firms whose only MP&M facilities close in the baseline are excluded.

A small percentage (2.5 percent) of the firms in the analysis incur before-tax compliance costs equal to 3 percent or more of annual revenues. Ninety-five percent incur compliance costs less than 1 percent of annual revenues, and the remaining 2.5 percent incur costs between 1 and 3 percent of revenues. Of 2,171 firms in the analysis that incur costs greater than 1 percent of revenues, 636 are single-facility small firms that were reported in the facility impact analysis to close (161 firms) or experience moderate impacts (475 firms) due to the rule.

This analysis is likely to overstate costs at the firm level for two reasons. First, it includes compliance costs for facilities that are projected to close due to the rule. The estimated compliance costs for these facilities are higher than the true cost to the firm of shutting down the facility, as illustrated by the detailed facility impact analysis that projects closures. Second, the analysis does not take account of actions a multi-facility firm might take to reduce its compliance costs under the proposed rule. These include transferring functions among facilities to consolidate wet processes and take advantage of scale economies in wastewater treatment.

c. Employment effects

Changes in employment due to the rule include both job losses that occur when facilities close and job gains associated with facilities' compliance activities. EPA estimated that a total of 5,916 jobs would be lost at the 199 facilities projected to close under the proposed rule. At the same time, EPA estimated that manufacturing and installing compliance equipment would lead to 4,488 full-time equivalent (FTE) positions, and that operating and maintaining compliance systems would result in another 286 FTEs per year. EPA projects a net loss in employment in the initial years following promulgation of the proposed rule, with net increased employment in later years due to the continuing compliance requirements. Net impacts on unemployment depend on how long workers displaced from closing facilities remain unemployed. Assuming conservatively that unemployed workers are out of work for one year on average, the proposed rule would result in a net gain of 2,575 years of employment (FTE-years) (−5,916 FTEs lost × 1 year + 4,488 one-time compliance FTEs + 296 continuing compliance FTEs × 15 years), or an average of 172 FTEs per year over 15 years. This estimate of employment impacts is likely to understate the net increase, because it ignores the fact that some production and employment lost at closing plants is likely to result in increased production and employment at other MP&M facilities.

d. Community impacts

EPA also considered the potential impacts of changes in employment due to the proposed rule on the communities where MP&M facilities are located. Given the projected overall increase in employment due to the proposed rule, EPA does not expect the rule to have significant impacts at the community level.

e. Foreign trade impacts

Facility closures caused by the proposed rule may reduce U.S. production of MP&M goods and services. EPA assessed the potential impact of these production changes on the U.S. balance of trade using information provided by the MP&M surveys on the source of competition in domestic and foreign markets. The analysis allocates the value of changes in output for each facility that is projected to close due to the rule to exports, imports or domestic sales, based on the predominant source of competition in each market reported in the surveys.

Table ES.9 shows the results of this analysis. The table compares the projected changes in exports, imports and balance of trade (expressed in $1999) to baseline 1999 values for both the MP&M industries and for the U.S. balance of trade in commodities as a whole. The projected changes in trade under the proposed rule have a very small impact on the balance of trade. The total U.S. balance of trade in commodities would decline by less than 0.01 percent and the balance of trade in the MP&M industries would decline by 0.01 percent.

Table ES.9: Potential Impacts of Proposed Rule on U.S. Foreign Commodity Trade (millions of 1999 dollars)

	1999 Exports [a]	1999 Imports	Trade Balance
Baseline	$695,797	$1,024,618	($328,821)
Change due to the rule	0	$21.1	($21.1)
Post-compliance	$695,797	$1,024,235	($328,438)
% Change from baseline	0%	<0.01%	(<0.01%)

a. Only 3 regulatory closures reported exports, totaling $16,613. These facilities reported no foreign competition in the international market.
Source: Bureau of Census and U.S. EPA analysis.

e. Impacts on new facilities

EPA assessed the impacts of the proposed rule on new facilities based on the characteristics of a model facility in each subcategory and (in some cases) discharge category (direct and indirect). Engineering estimates of compliance costs for Option 2/6/10 and Option 4/8 for a representative facility reflect the typical flow size and other technical characteristics of facilities in each category. In the absence of the MP&M rule, new sources in the Metal Finishing Job Shop and Printed Wiring Board subcategories would comply with 40 CFR 433 new source requirements, and Steel Forming & Finishing new sources would comply with 40 CFR 420 new source requirements. Therefore, the analysis considers only the incremental costs of proposed MP&M new source requirements beyond those baseline requirements.

Table ES.10 shows the results of the new source analysis. New sources in all but the Metal Finishing Job Shop direct discharger subcategory incur costs that are below one percent of post-regulation revenues. Cost increases of this magnitude are unlikely to place new facilities at a competitive disadvantage relative to existing sources. Moreover, costs as a percentage of revenues are generally comparable for new sources and existing sources with which they will compete.

Table ES.10: Impacts on New Sources

Subcategory	Discharge Status	Proposed Technology Option	Annualized Compliance Costs (ACC) ($1999)	Facility Revenue ($1999)	New Source ACC as % of Revenue
General Metals	I	4	$393,220	$417,071,318	0.09%
General Metals	D	4	$167,342	$398,818,659	0.04%
Metal Finishing Job Shops	I	4	$65,369	$1,428,443	4.58%
Metal Finishing Job Shops	D	4	$70,735	$5,089,823	1.39%
Non-Chromium Anodizing*	D	2	$97,108	$24,201,166	0.40%
Oily Waste	I	6	$355,874	$474,228,616	0.08%
Oily Waste	D	6	$37,815	$116,772,943	0.03%
Printed Wiring Board	I	4	$70,563	$35,030,097	0.20%
Printed Wiring Board	D	4	$160,184	$1,029,783,596	0.02%
Railroad Line Maintenance*	D	10	$184,261	N/A	N/A
Shipbuilding Dry Dock*	D	10	$220,492	$192,018,827	0.11%
Steel Forming & Finishing	I	4	$114,851	$69,640,244	0.16%
Steel Forming & Finishing	D	4	$46,945	$32,759,295	0.14%

* EPA is not proposing Pretreatment Standards for New Sources in these subcategories.
Source: U.S. EPA analysis.

Railroad line maintenance facilities do not have revenue reported at the facility level, and it is therefore not possible to compare costs as a percent of facility revenue for new and existing facilities in this subcategory. The representative new source railroad line maintenance facility would incur annualized costs ($184,261) that are somewhat higher than those incurred by existing facilities in this subcategory (which range from zero to $122,042.)

f. Impacts on small entities

Table ES.11 shows the total number of facilities operating in the baseline and the number owned by small entities. Overall, approximately 80 percent of all MP&M facilities are owned by small entities. However, it should be noted that the low flow exclusions in the proposed rule will exclude approximately 85 percent of the facilities owned by small entities.

Table ES.11: Number and Percent of MP&M Facilities Owned by Small Entities

Type of Facility	Number of Facilities of all Sizes Operating in the Baseline	Number of Facilities Owned by Small Entities	Percent of Facilities Owned by Small Entities
Private MP&M[a]	54,591	44,773	82%
Government-Owned	4,332	2,672	62%
Total[a]	58,923	47,445	81%

a. Excludes baseline closures
Source: U.S. EPA analysis.

EPA assessed impacts on small entities by comparing compliance costs to revenues for the small entities at the firm level and by analyzing the facility impact analysis results for facilities owned by small firms. These analyses indicate that 941, or 2.2% of small entities may incur costs equal to 3 percent or more of annual revenues.

Approximately 85 percent of small entities are not projected to incur any costs to comply with the proposed rule because they are among the facilities covered by the low flow exclusions. More than 95 percent of small entities incur either no costs or compliance costs less than 1 percent of annual revenues. An estimated 181 facilities owned by small entities might close as a result of the proposed rule, and 492 facilities owned by small entities are likely to experience moderate financial impacts. The181 small entity facility closures represent less than one-half of one percent of the facilities owned by small entities that are operating in the baseline.

Tables ES.12 and ES.13 present the results of the firm- and facility-level analyses, respectively, for small firms. The Agency was not able to estimate national numbers of firms that own MP&M facilities precisely, because the sample weights based on the survey design represent numbers of facilities rather than firms. The results in Table ES.12 are reasonable approximations, however, in that 95 percent of the facilities owned by small firms are single-facility firms, for which sample weights could be used.

Table ES.12: Firm Level Before-Tax Annual Compliance Costs as a Percent of Annual Revenues for Private Small Businesses

Number of Small Firms in the Analysis*	Number and Percent with Before-Tax Annual Compliance Costs/Annual Revenues Equal to:					
	Less than 1%		1-3%		Over 3%	
	Number	%	Number	%	Number	%
42,509	40,560	95.4%	1,008	2.4%	941	2.2%

*Firms whose only MP&M facilities close in the baseline are excluded.
Source: U.S. EPA analysis.

Table ES.13: Closures and Moderate Impacts for Facilities Owned by Small Entities, Proposed Rule	
Number of facilities operating in the baseline	47,445
Number of facilities excluded	40,825
Percent excluded	85%
Number of closures	181
Percent closing	0.4%
Number of facilities with moderate impacts	492
Percent with moderate impacts	1.0%

Source: U.S. EPA analysis

EPA estimates that there are 2,672 facilities owned by small governments (those with populations less than 50,000). The low flow exclusion in today's proposed rule will exclude 2,262 of these small government-owned MP&M facilities. Thus, the proposed rule covers 410 small government-owned facilities. Of these facilities, only 270 incur costs, and the average cost per facility is less than $10,000. The total compliance cost for all the small government-owned facilities incurring costs under today's proposed rule is $2.7 million. Only 140 of the 270 facilities have costs greater than 1 percent of baseline cost of service (measured as total facility costs and expenditures, including operating, overhead and debt service costs and expenses). EPA estimated no significant impacts for any of these facilities, based on the combined impacts on the site cost of service, impacts on taxpayers, and impact on government debt levels.

ES.3.2 Social Costs

The social costs of the proposed rule represent the value of society's resources used to comply with and administer the rule. EPA estimated three categories of social cost for the proposed regulation:

- the cost of society's economic resources used to comply with the proposed regulation,
- the cost to governments of administering the proposed regulation, and
- the social costs of unemployment resulting from the regulation.

Summing across the categories of social cost results in a total social cost estimate of $2,033 to $2,113 million annually (1999$) (see Table ES.14). The social costs of the rule are dominated by the resource costs of compliance, which account for 95 to over 99 percent of total social costs. The midpoint value of total social costs (the simple average of the high and low values) is $2,073.3 million (1999$).

Table ES.14: Total Social Cost: Proposed Rule (million 1999$)

Social Cost Categories	**Low Value**	**High Value**
Resource cost of compliance expenditures	$2,033.7	
Costs to POTWs of administering the rule	$0.115	$0.912
Social costs of unemployment	$0.0	$77.9
Total Social Cost	$2,033.9	$2,112.6

Source: U.S. EPA analysis

a. Resource costs of compliance

Resource costs of compliance are the value of society's productive resources — including labor, equipment, and materials — expended to achieve the reductions in effluent discharges required by the proposed rule. The social costs of these resources are higher than the costs incurred by facilities because facilities are able to deduct the costs from their taxable income. The costs to society, however, are the full value of the resources used, whether they are paid for by the regulated facilities or by all taxpayers in the form of lost tax revenues.

EPA did not include any costs for facilities that were predicted to close in the baseline, but did include costs for facilities that were projected to close due to the proposed rule, equal to the compliance cost they would incur if they continued to operate. This represents the value to society of the resources that would be used to comply with the proposed rule if all facilities continued to operate rather than some closing due to the rule. This estimate represents an upper-bound social value of the compliance resources associated with the proposed rule. The total social costs of these compliance resources is $2,034 million per year.

b. Administrative costs

The main component of this cost category is the cost of resources used to write permits under the proposed rule, and for compliance monitoring and enforcement activities. POTWs will incur costs to permit additional facilities, convert some permits from concentration-based to mass-based, and repermit some facilities earlier than would otherwise be required. While EPA expects that the proposed rule will also result in cost savings to permit writers, EPA did not include any such savings in the estimate of social costs.

EPA estimated the low and high estimates of permitting cost per facility, and took account of the need to repermit indirect dischargers with existing permits within the three year compliance period rather than on the normal five year permitting schedule. Total estimated government administration costs for the proposed rule range from $0.1 to $0.9 million (1999$) annually.

c. Social cost of unemployment

EPA considered two components of the social cost of unemployment that may result from the proposed rule:

- The cost of worker dislocation (exclusive of cash benefits) to unemployed individuals, as measured by their willingness to pay to avoid unemployment; and
- The additional cost to governments to administer unemployment benefits programs.

An estimated 5,916 jobs may be lost at facilities that close due to the proposed rule. EPA estimates that the annualized social costs associated with these job losses range from $59.1 million to $77.9 million (1999$). This estimate includes:

- $59.0 to $77.8 million (1999$) in the social cost of involuntary unemployment, based on high and low estimates of workers willingness to pay to avoid an episode of unemployment; and
- $0.1 million (1999$) in the cost to governments of administering additional unemployment claims.

The rule will also result in increased employment due to the need to manufacture, install, operate and maintain compliance equipment. The additional demand for labor in complying facilities may exceed the job losses estimated to occur in closing facilities. As a result, the net costs associated with unemployment as a result of the regulation may be negative. In this analysis, EPA used a range of zero to $77.9 million (1999$) as the estimated social cost of unemployment cost resulting from the proposed rule. To be conservative in the analysis, EPA limited the lower value of this range to zero. That is, EPA did not include the possible savings in unemployment-related costs as a negative cost (a benefit) of the proposed rule.

ES.4 Benefits of the Proposed Rule

The proposed regulation will reduce MP&M industry pollutant discharges with a number of consequent benefits to society, including:

- improved quality of freshwater, estuarine, and marine ecosystems;
- increased survivability and diversity of aquatic and terrestrial wildlife;
- reduced risks to human health through consumption of fish or water taken from affected waterways; and
- reduced cost of disposal or use of municipal sewage sludge affected by MP&M pollutant discharges.

EPA estimates that the proposed rule would substantially reduce pollutant discharges to U.S. waters, as shown by the loadings estimates in Table ES.14. Loadings are shown both in pounds of pollutant and in toxic-weighted pound equivalents. The latter measure reflects the relative toxicity of the various toxic pollutants. The regulation would result in a 89 percent reduction in total toxic-weighted pollutant lbs. equivalent per year. The estimated toxic weighted pollutant reductions range from 99% for cyanide to 30% for nonconventional organics. Reductions in pounds of pollutants (not toxic-weighted) range from 99% for cyanide to 51% for priority organics. The proposed rule achieves very significant reductions for toxic metals, cyanide and conventional pollutants (oil and grease, total suspended solids, and chemical oxygen demand).

Table ES.14: Summary of Discharges by Pollutant Type for Potentially-Regulated MP&M Facilities[a]

Pollutant Category	Current Releases		Releases under The Proposed Rule		Percent Reduction due to the Proposed Rule	
	Pounds	Pounds Eq.	Pounds	Pounds Eq.	Pounds	Pounds Eq.
Priority Pollutants						
Metals	34,527,668	16,476,843	2,018,185	1,500,230	94%	91%
Organics	2,095,832	323,410	1,024,636	156,560	51%	52%
Cyanide (CN)	4,718,247	5,190,072	35,881	39,469	99%	99%
Nonconventional Pollutants						
Metals	120,756,930	7,201,034	23,723,669	1,265,904	80%	82%
Organics	50,468,179	210,501	9,411,727	146,873	81%	30%
Conventional Pollutants						
COD	2,445,579,193		601,888,710		75%	
O&G	220,782,391		20,953,718		91%	
TSS	231,466,565		27,404,519		88%	
Total		29,401,860		3,109,036		89%

[a] Includes all water-discharging facilities that continue to operate in the baseline, including facilities that are not subject to requirements under the proposed rule. Discharges discussed in this table are facility discharges and do not account for POTW removals. EPA believes it is appropriate to analyze wastewater discharges disregarding the POTW removals because indirect discharges present environmental risks that are not fully addressed by POTW treatment. The MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 hazardous air pollutants (HAPs) that may present a threat to human health or the environment. Other MP&M pollutants released by the industry are found in POTW sludge. Only eight of these pollutants have land application pollutant criteria that limit the uses of sludge.
Source: U.S. EPA analysis.

EPA assessed the benefits from the expected pollutant loading reductions in three broad classes: human health, ecological, and economic productivity benefits. EPA was able to assess benefits within these three classes with varying degrees of completeness and rigor. Where possible, EPA quantified the expected effects and estimated monetary values. Some benefit categories could not be monetized due to data limitations and a limited understanding of how society values certain water quality changes. EPA also conducted a more detailed case study of the regulation's expected benefits for the State of Ohio. The case study addresses some of the limitations inherent in the national analysis.

The national benefits estimates for the proposed rule presented in this report range from $1.3 billion to $3.8 billion per year. In contrast, the preamble to the proposed rule presents benefits estimates ranging from $0.4 billion to $1.1 billion. The estimates in the preamble include human health benefits (reductions in cancer and lead exposure), recreational fishing benefits, non-use benefits, and improved POTW sludge quality. This report includes monetized estimates for additional benefits categories, specifically recreational boating and near-water recreation, and higher estimates for non-use benefits based on these additional recreational benefits.

EPA traditionally estimates national benefits and costs from proposed effluent limitations guidelines by extrapolating the benefits and costs assessment results for the sample facilities to the entire population of facilities nationwide. The analysis assumes that facilities represented by the sample facility have the same technical, economic/financial and benefit characteristics, including:

Technical characteristics that affect costs and discharges:

- type of discharger (i.e., zero, direct, indirect);
- type and number of processes;
- number and types of metals;
- wastewater characteristics;
- treatment in place;
- flow size; and
- costs.

Economic and financial characteristics that affect financial impacts:

- markets, including domestic and foreign sales;
- competition, including domestic competition and imports;
- baseline financial position;
- cash flow;
- ability to borrow money; and
- liquidation values and closure costs.

Environmental and geographic characteristics that affect benefits:

- size of the receiving POTW,
- waterbody type,
- stream flow characteristics,
- populations residing near the waterbody, and
- the number of potential recreational users affected.

Extrapolation from the sample facilities to the entire population of facilities uses sample facility weights developed as part of the sampling plan. The sample weights are based on the stratification of the facility population using variables such as facility size and SIC code or industry sector. Sometimes stratification is done on the two previously mentioned variables alone, while other times EPA uses a database with considerably more information for stratification. Stratification generally does not include variables related to non-facility characteristics that may influence occurrence and magnitude of the expected benefits due to paucity of the relevant data concerning these variables at the time of sample plan design.

Not accounting for distribution of non-facility characteristics in the sample frame may occasionally cause extrapolation anomalies in benefits analyses and lead to a larger than desired level of uncertainty. Despite this extrapolation procedure shortfall, the resulting national estimates are unbiased (i.e., they are not expected to consistently overestimate or underestimate the parameters estimated).

Because EPA has not yet resolved some possible anomalies in the extrapolation of this analysis to the national level, the monetized benefits for the new categories of benefits are not included in the summary of benefits for the proposed rule that appears in the preamble. They are included in this report, however, to present the methodologies and their results as applied to the MP&M rule for public comment, concurrent with seeking peer review of these methodologies. Based on the results obtained using only sample facility locations and the case study results, EPA believes that the benefits of the MP&M regulation exceed the costs. EPA is not equally certain of the absolute level of benefits. The Agency is currently working on post-stratification of the MP&M facility sample to address this issue, and expects to have the process completed prior to the final regulation.

ES.4.1 Reduced Human Health Risk

EPA analyzed the following measures of health-related benefits: reduced cancer risk from fish and water consumption; reduced risk of non-cancer toxic effects from fish and water consumption; lead-related health effects to children and adults; and reduced occurrence of in-waterway pollutant concentrations in excess of levels of concern. The levels of concern include human health-based ambient water quality criteria (AWQC) or documented toxic effect levels for those chemicals not covered by water quality criteria. Although some health effects are relatively well understood and can be quantified and monetized in a benefits analysis (e.g., cancer), others are less well understood, and may not be assessed with the same rigor or at all (e.g., systemic health effects). The Agency therefore monetized only two of these health benefits: (1) changes in the incidence of cancer from fish and water consumption, and (2) changes in adverse health effects in children and adults from reduced lead exposure.

a. Benefits from reduced incidence of cancer cases

EPA estimated aggregate cancer risk from contaminated drinking water for populations served by drinking water intakes on waterbodies to which MP&M facilities discharge. This analysis is based on seven carcinogenic pollutants for which no published drinking water criteria are currently available. This analysis excludes six carcinogens for which drinking water criteria are available. EPA assumed that public drinking water treatment systems will remove these pollutants from the public water supply.

Calculated in-stream concentrations serve as a basis for estimating changes in cancer risk for populations served by affected drinking water intakes. EPA estimates that the proposed regulation would eliminate 2.24 cancer cases associated with consumption of contaminated drinking water, or 44 percent of the cancer cases associated with baseline MP&M discharges, annually.

EPA valued the reduced cancer cases using estimated willingness-to-pay (WTP) values for avoiding premature mortality. EPA estimates the mean value of avoiding one statistical death to be $5.8 million (1997$), based on cancer's association with both mortality and the hardships (e.g., psychic and other costs) from a prolonged period of morbidity prior to death. The Agency assumed that an individual would be willing to pay to avoid the disease at its start. This action may significantly precede the cancer-related death itself, if death occurs. The estimated monetary value of benefits from reduced incidence of cancer associated with drinking water is $17.7 million per year (1997$), based on the above assumptions.

EPA also estimated the aggregate cancer risk to recreational and subsistence anglers and their families from consuming contaminated fish. This analysis is based on thirteen carcinogenic pollutants found in MP&M effluent discharges. Estimated contaminants in fish tissue reflect predicted in-stream pollutant concentrations and biological uptake factors. EPA used data on numbers of licensed anglers by State and county, presence of fish consumption advisories, fishing activity rates, and average household size to estimate the affected population of recreational and subsistence anglers and their families. The analysis uses different fish consumption rates for recreational and subsistence anglers to estimate the change in cancer risk within these populations.

The proposed rule eliminates an estimated 0.05 cancer cases per year for combined recreational and subsistence angler populations, representing a reduction of about 36 percent from a baseline of about 0.13cases. This change translates into $0.36 million (1997$) in annual benefits due to reduced cancer risk from consumption of contaminated fish by these populations.

Total benefits from reduced incidence of cancer cases, including both drinking water and fish exposures, are $18.08 million (1997$) annually (see Table ES.15).

Table ES.15: Estimated Annual Benefits from Avoided Cancer Cases from Fish and Drinking Water Consumption

Regulatory Status	Drinking Water		Fish Consumption		Total	
	Annual Cancer Cases	Benefit Value (million 1999$)	Annual Cancer Cases	Benefit Value (million 1999$)	Annual Cancer Cases	Benefit Value (million 1997$)
Baseline	5.10	N/A[1]	0.126	N/A	5.23	N/A
Proposed Option	2.86	$17.70	0.081	$0.36	2.94	$18.08
Percent Reduction	43.9%	N/A	35.7%	N/A	43.9%	N/A

[1] Not Applicable
Source: U.S. Environmental Protection Agency

b. Reductions in systemic health effects

EPA estimates that the proposed rule would result in the removal of 142 million pounds of 77 pollutants related to a wide range of non-cancer human health effects (e.g., systemic effects, reproductive toxicity, and developmental toxicity). Reducing human exposure to these pollutants via fish and water consumption, relative to pollutant-specific health effects thresholds, yields an additional measure of the human health benefits likely to result from the proposed regulation. EPA compared estimated in-stream pollutant concentrations for 77 systemic toxicants with risk reference doses to calculate the hazard score distributions for populations consuming drinking water and fish. The Agency's comparison of baseline and post-compliance exposures shows population movement from higher to lower risk values for both the fish and drinking water analyses. Both analyses also show substantial increases in the percentage of the exposed populations that would not be exposed to any risk of systemic health hazards.

c. Benefits from reduced exposure to lead

EPA performed a separate analysis of benefits from reduced exposure to lead from consumption of contaminated fish tissue. The analysis addressed three population groups:

- preschool age children,
- pregnant women, and
- adult men and women.

Unlike the analysis of systemic health risk from exposure to other MP&M pollutants, this analysis is based on dose-response functions tied to specific health endpoints to which monetary values can be applied. Using blood-lead levels as a biomarker of lead exposure, EPA estimated baseline and post-compliance blood lead levels in the exposed populations and then used changes in these levels to estimate benefits in the form of avoided health damages.

EPA assessed neurobehavioral effects on children based on a dose-response relationship for IQ decrements. The Agency expressed avoided neurological and cognitive damages as changes in overall IQ levels, including reduced incidence of extremely low IQ scores (<70, or two standard deviations below the mean) and reduced incidence of blood-lead levels above 20 mg/dL. The analysis valued the avoided neurological and cognitive damages by using:

- the value of compensatory education that an individual would otherwise need, and
- the impact of an additional IQ point on individuals' future earnings.

EPA estimated that implementing the proposed rule would result in avoided IQ loss of 489 points across all exposed children. The estimated monetary value of avoided IQ loss is $4.9 million (1999$). In addition, reduced occurrences of extremely low IQ scores (<70) and reduced incidence of blood-lead levels above 20 mg/dL would result in a $0.1 million (1999$) decrease in the annual cost of compensatory education for children with learning disabilities.

Prenatal exposure to lead is an important exposure route. Fetal exposure to lead in utero due to maternal blood-lead levels may result in several adverse health effects, including decreased gestational age, reduced birth weight, late fetal death, neurobehavioral deficits in infants, and increased infant mortality. EPA assessed benefits to pregnant women by relating changes in the risk of infant mortality to changes in maternal blood-lead levels during pregnancy. This analysis estimated the monetary benefit of reduced neonatal mortality risk to be $12.7 million (1997$), based on the estimated WTP to avoid a mortality.

Adults also suffer form adverse health effects due to lead exposure. The adult health effects that EPA was able to quantify all relate to lead's effects on blood pressure. Quantified health effects include increased incidence of hypertension (estimated for males only), initial coronary heart disease (CHD), strokes (initial cerebrovascular accidents (CBA) and atherothrombotic brain infarctions (BI)), and premature mortality. This analysis does not include other health effects associated with elevated blood pressure, or other adult health effects of lead (e.g., nervous system disorders in adults, anemia, and possible cancer effects). EPA used cost of illness estimates (i.e., medical costs and lost work time) to estimate the monetary value of reduced incidence of hypertension, initial CHD, and strokes. EPA then used the value of a statistical life saved to estimate changes in the risk of premature mortality. The estimated monetary value of health benefits to adults is $18.0 million (see Table ES.16).

Total benefits from reduced exposure to lead, including both children and adults, are $35.8 million (1999$) annually under the proposed option.

Table ES.16: National Adult Lead Benefits (Millions of 1999$ per Year)

Category	Proposed Option	
	Reduced Cases	Monetary Value
Men		
Hypertension	959.85	$1.00
CHD	1.24	$0.09
CBA	0.52	$0.14
BI	0.29	$0.08
Mortality[a]	1.7	$13.41
Women		
CHD	0.39	$0.03
CBA	0.17	$0.03
BI	0.10	$0.02
Mortality[a]	0.41	$3.24
Total Benefits		**$18.04**

a. Unlike other benefits in this table, the value of avoided mortality is expressed in 1997$.

National Level Exposed Population:

- Hypertension: 428,363 men ages 20 to 74;
- Coronary heart disease, cerebrovascular accidents, brain infarction, and mortality: 173,386 men and 192,091 women ages 45-74.

d. Exceedances of Human Health-Based AWQC

EPA also estimated the effect of MP&M facility discharges by comparing the estimated baseline and post-compliance in-stream concentrations of 18 pollutants in affected waterways to human health AWQC through two consumption routes:

- water and organisms, and
- organisms alone.

Pollutant concentrations in excess of these values indicate potential human health risks.

❖ ***Consumption of water and organisms***
EPA estimates that 10,310 receiving reaches nationwide have baseline in-stream concentrations exceeding human health AWQC for consumption of water and organisms. The proposed rule eliminates these excess concentrations on 1,105 of those reaches.

Results also show that 382 receiving reaches will experience partial water quality improvements from reduced occurrence of some pollutant concentrations in excess of AWQC limits for consumption of water and organisms.

❖ ***Consumption of organisms alone***
EPA estimates that 192 receiving reaches nationwide have baseline in-stream concentrations exceeding human health AWQC for consumption of organisms alone. The proposed rule eliminates these excess concentrations on 121 of those reaches.

ES.4.2 Ecological, Recreational, and Nonuser Benefits

EPA expects the proposed regulation to provide ecological benefits by improving the habitats or ecosystems (aquatic and terrestrial) affected by MP&M discharges. Benefits associated with changes in aquatic life include:

- restoring sensitive species,
- recovering diseased species,
- reducing taste-and odor-producing algae populations,
- increasing dissolved oxygen (DO), and
- increasing the assimilative capacity of affected waterways.

These improvements enhance the quality and value of water-based recreation, such as fishing, swimming, wildlife viewing, camping, waterfowl hunting, and boating. The benefits from improved water-based recreation include the increased value that participants derive from a day of recreation, or the increased number of days that consumers of water-based recreation choose to visit the cleaner waterways. This analysis measures the economic benefit to society based on the increased monetary value of recreational opportunities resulting from water quality improvements.

a. Reduced aquatic life impacts
EPA estimated the cases in which in-waterway pollutant concentrations resulting from baseline MP&M facility discharges on affected waterways exceed recommended acute and chronic AWQC protecting aquatic life. Pollutant concentrations in excess of these AWQC values indicate potential impacts to aquatic life.

The analysis compared baseline and post-compliance exceedances of aquatic life AWQC to determine the effects of the rule. Results show that baseline pollutant concentrations exceed acute AWQC in 878 reaches and chronic AWQC in 2,466 reaches nationally at baseline discharge levels. EPA estimates that the proposed option eliminates concentrations in excess of acute and chronic criteria in 775 and 1,029 reaches, respectively. Results also show that an additional 903 receiving reaches will experience partial water quality improvements from reduced occurrence of some pollutant concentrations in excess of acute and/or chronic AWQC limits for protection of aquatic life.

b. Recreational benefits
EPA assessed the recreational benefits from reduced occurrence of pollutant concentrations exceeding aquatic life and/or human health AWQC values. Combining its findings from both the aquatic life and human health AWQC exceedance analyses, EPA found 10,443 stream reaches exceeding chronic or acute aquatic life AWQC and/or human health AWQC values at baseline discharge levels. The Agency estimates that the proposed rule will eliminate exceedances on 1,185 of these discharge reaches, leaving 9,258 reaches with concentrations of one or more pollutants exceeding AWQC limits. Of these 9,258 reaches, 1,837 reaches will experience partial water quality improvements from reduced occurrence of some pollutant concentrations in excess of AWQC limits.

EPA attached a monetary value to reduced exceedances based on increased values for three water-based recreation activities (fishing, wildlife viewing, and boating) and on nonuser values. EPA applied a benefits transfer approach to estimate the total WTP, including both use and nonuse values, for improvements in surface water quality. This approach builds upon a review and analysis of the surface water valuation literature.

EPA first estimated the baseline value of water-based recreation for benefiting reaches, based on per-reach estimates of:

- annual person-days of water-based recreation, and
- per-day values of water-based recreation.

EPA based baseline per-day values of water-based recreation on studies by Walsh et. al (1992) and Bergstrom and Cordell (1991). The studies provide values per recreation day for a wide range of water-based activities, including fishing, boating, wildlife viewing, waterfowl hunting, camping, and picnicking. The mean values per recreation day used in this analysis are $39.62, $24.72, and $45.44 (1999$) for fishing, near-water recreation, and boating, respectively.

EPA then applied the percentage change in the recreational value of water resources implied by surface water valuation studies to estimate changes in values for all MP&M reaches in which the regulation eliminates AWQC exceedences by one or more MP&M pollutants. The Agency selected eight of the most comparable studies and calculated the changes in recreation values from water quality improvements (as a percentage of the baseline) implied by those studies. Sources of estimates included Lyke (1993), Jakus et al. (1997), Montgomery and Needleman (1997), Paneuf et al. (1998), Desvousges et al. (1987), Lant and Roberts (1990), Farber and Griner (2000), and Tudor et al. (2000). EPA took a simple mean of point estimates from all applicable studies to derive a central tendency value for percentage changes in the water resource values due to water quality improvements. These studies yielded estimates of increased recreational value from water quality improvements expected from reduced MP&M discharges of 12.7, 20.2, and 12.4 percent for fishing, wildlife viewing, and boating, respectively. Table ES.17 provides the estimated national recreational benefits of the proposed rule (1999$).

EPA also estimated non-market nonuser benefits. These benefits are not associated with current use of the affected ecosystem or habitat; instead, they arise from the value that society places on improved water quality independent of planned uses or based on expected future use. Past studies have shown that nonuser values are a sizable component of the total economic value of water resources. EPA estimated average changes in nonuser value to equal one-half of the recreational use benefits. The estimated increase in nonuser value is $760.3 million (1999$).

Table ES.17: Estimated Recreational Benefits from Reduced MP&M Discharges (Proposed Option)

Recreational Activity	Low	Mid	High
Fishing	$196	$365	$627
Boating	$265	$446	$672
Wildlife Viewing and Near-Water Recreation	$500	$710	$920
Total Recreational Use Benefits (Fishing + Boating + Wildlife Viewing)	$961	$1,521	$2,219
Nonuser Benefits (1/4, ½, and 2/3 of Total Recreational Use)	$240	$760	$1,464
Total Recreational Benefits (million 1999$)	**$1,201**	**$2,281**	**$3,683**

Source: U.S. EPA analysis.

The recreational trips corresponding to the three activities considered in this analysis are stochastically independent; EPA calculated the total value of enhanced water-based recreation opportunities by summing the three recreation categories and nonuser value. The resulting increase in the value of water resources to consumers of water-based recreation and nonusers is 2,281 million (1999$) annually.

ES.4.3 Reduced POTW Impacts

EPA evaluated two productivity measures associated with MP&M pollutants. The first measure was the pollutant interference at publicly-owned treatment works (POTWs), which was quantified but not monetized. The second measure was the pass-through of pollutants into the sludge, which limits options for its disposal.

MP&M pollutants may impair POTW treatment effectiveness by inhibiting the biological activity of activated sludge. EPA estimated inhibition of POTW operations by comparing predicted POTW influent concentrations with available inhibition levels for 89 pollutants. POTW inhibition values come from guidance published by EPA and other sources. At baseline discharge levels, EPA estimates that concentrations of 18 pollutants discharged from MP&M facilities exceed biological inhibition criteria at 515 POTWs nationwide. The proposed regulation would eliminate potential inhibition problems at 306 POTWs and reduce the occurrence of pollutant concentrations in excess of inhibition criteria at 82 POTWs. POTWs may impose local limits to prevent inhibitions. If local limits are in place, the estimated reduction in potential inhibition problems at the affected POTWs is overstated. In this case, however, the estimated social cost of the MP&M regulation is also overstated.

EPA also quantified the reduced costs for managing and disposing of sewage sludge. This analysis relied on data from 147 POTW surveys. POTWs provided information on sewage sludge use and disposal costs and practices, total metal loadings to the POTW, percentage of total metal loadings contributed by MP&M facilities, and the number of known MP&M dischargers to the POTW. The survey also provided information on the percentage of qualifying sludge that is not land applied, and reasons for not land applying qualifying sludge.

EPA estimated baseline and post-compliance sludge concentrations of eight metals for POTWs receiving discharges from the sample MP&M facilities. EPA compared these concentrations with the relevant metal concentration limits for land application and surface disposal. EPA estimated that concentrations of one or more metals at 6,953 POTWs would fail the land application limits in the baseline. EPA estimated that 62 POTWs will be able to select the lower-cost land application disposal based on estimated reductions in sludge contamination. An estimated 1.7 million dry metric tons (DMT) of sewage sludge would newly qualify for land application annually. EPA also estimated that 21 POTWs that previously met only the land application pollutant limit would, as a result of regulation, meet the more stringent land application concentration limits. EPA expects these POTWs to benefit through reduced recordkeeping requirements and exemption from certain sludge management practices. The annual estimated cost savings for the POTWs expected to upgrade their sludge disposal practices are $61.3 million (1999$).

This analysis includes an adjustment to the estimate of national sludge use/disposal cost benefits for POTWs located at cost-prohibitive distances from agricultural, forest, or disturbed lands suitable for sludge application. EPA assumed that 46 percent of sludge generated in the United States is generated by POTWs located too far from sites suitable for sewage sludge application to make these practices economical.

ES.4.4 Total Estimated Benefits of the Proposed MP&M Rule

EPA estimates that total benefits for the five categories for which monetary estimates were possible are $2.396 billion (1999$) annually. EPA characterized uncertainty inherent in the benefits analysis by bounding benefit estimates. The annual lower- and upper-bound benefit estimates of the proposed option are $1,284 and $3,833 billion (1999$), respectively. The monetized benefits of the rule underestimate its total benefits because they omit numerous sources of benefits to society from reduced MP&M effluent discharges. Examples of benefit categories not reflected in this estimate include: non-cancer health benefits other than benefits from reduced exposure to lead; other water-dependent recreational benefits, such as swimming and waterskiing; reduced cost of drinking water treatment for the pollutants with drinking water criteria; and benefits to wildlife and endangered species.

ES.5 Comparing Estimated Costs and Benefits

EPA cannot perform a complete cost-benefit comparison because not all of the benefits resulting from the proposed regulatory alternative can be valued in dollar terms. Table ES.18 shows that combining the estimates of social benefits and social costs yields an estimate of net monetizable benefits ranging from negative $809 million to positive $1,752 million annually (1999$) at the national level. Comparing the midpoint estimate of social costs with the midpoint estimate of monetized benefits results in a net benefit of $311 million. The lack of a comprehensive benefits valuation limits this assessment of the relationship between costs and benefits of the proposed rule.

Table ES.18: Comparison of National Annual Monetizable Benefits to Social Costs: Proposed Rule (millions of 1999$)

Benefit and Cost Categories	Low	Midpoint	High
Benefit Categories			
Reduced Cancer Risk from Fish Consumption[a]	$0.3	$0.3	$0.3
Reduced Cancer Risk from Water Consumption[a]	$13.0	$13.0	$13.0
Reduced Risk from Exposure to Lead	$28.0	$28.0	$28.0
Enhanced Water-Based Recreation	$960.6	$1,520.7	$2,218.7
Nonuse Benefits	$240.2	$760.3	$1,464.3
Avoided Sewage Sludge Disposal Costs	$61.1	$61.3	$61.5
Total Monetized Benefits	**$1,303.2**	**$2,383.6**	**$3,785.8**
Cost Categories			
Resource Costs of Compliance	$2,033.7	$2,033.7	$2,033.7
Costs of Administering the Proposed Regulation	$0.1	$0.3	$0.9
Social Costs of Unemployment	$0	$39.0	$78.0
Total Monetized Costs	$2,033.9	$2,073.0	$2,112.6
Net Monetized Benefits (Benefits Minus Costs)[b]	**($809.4)**	**$310.6**	**$1,751.9**

a. The monetary value of benefits from reduced incidence of cancer is based on 1997$.
b. EPA calculated the low net benefit value by subtracting the high value of costs from the low value of benefits, and calculated the high net benefit value by subtracting the low value of costs from the high value of benefits. The midpoint net benefit is based on the midpoint values for costs and benefits.
Source: U.S. EPA analysis.

As previously mentioned, extrapolating from sample facility results to national results can introduce uncertainty into the analysis for both the cost and the benefits estimates. EPA therefore also compared costs and benefits for the sample facilities alone, basing the sample results on known facility and benefit pathway characteristics. Table ES.19 presents the results of this analysis. EPA found that the relationship between benefits and costs for sample facilities alone (i.e., those facilities whose receiving stream characteristics are known) are similar to that found in the national analysis. Specifically, in both analyses the low estimate for net benefits is negative while the midpoint and high estimates for net benefits are positive. This similarity in the relationship between benefits and costs in the two analyses significantly increases EPA's confidence that the benefits of the regulation exceed the costs, even when the estimated total value of national benefits has some uncertainties associated with it.

Table ES.19: Comparison of Annual Monetizable Benefits to Social Costs for Sample Facilities: Proposed Rule (thousands of 1999$)

Benefit and Cost Categories	Low	Midpoint	High
Reduced Cancer Risk from Fish Consumption [a]	$17.4	$17.4	$17.4
Reduced Cancer Risk from Water Consumption [a]	$1,057.1	$1,057.1	$1,057.1
Reduced Risk from Exposure to Lead	$2,585.0	$2,585.0	$2,585.0
Enhanced Water-Based Recreation	$68,990.4	$108,803.9	$158,121.1
Nonuse Benefits	$17,247.6	$54,402.0	$104,359.9
Avoided Sewage Sludge Disposal Costs	$7,532.1	$7,532.4	$7,532.7
Total Monetized Benefits	**$97,429.6**	**$174,397.8**	**$273,673.2**
Total Monetized Costs[b]	**$121,392.9**	**$121,392.9**	**$121,392.9**
Net Monetized Benefits (Benefits Minus Costs)[c]	**($23,963.3)**	**$53,004.9**	**$152,280.3**

a. The monetary value of benefits from reduced incidence of cancer is based on 1997$.
b. Total monetized costs represent the resource cost of compliance only. This analysis does not include the cost of administering the proposed regulation and the social cost of unemployment. Excluding these costs does not affect the conclusions of their analysis because these costs are very small relative to the resource cost of compliance.
c. EPA calculated the low net benefit value by subtracting the high value of costs from the low value of benefits, and calculated the high net benefit value by subtracting the low value of costs from the high value of benefits. The middle net benefit is based on the midpoint values for costs and benefits.
Source: U.S. EPA analysis.

ES.6 Ohio Case Study

The Ohio case study assesses the costs and benefits of the proposed rule for the state's facilities and waterbodies. Ohio is among the ten states with the largest numbers of MP&M facilities. Ohio has a diverse water resource base and a more extensive water quality ecological database than many other states. EPA gathered data on MP&M facilities and on Ohio's baseline water quality conditions and water-based recreation activities to support the case study analysis. These data characterize current water quality conditions, water quality changes expected from the regulation, and the expected welfare changes from water quality improvements at waterbodies affected by MP&M discharges. The case study also estimates the social costs of the proposed rule for facilities in Ohio, and compares estimated social costs and benefits for the State.

The case study analysis supplements the national level analysis performed for the proposed MP&M regulation in two important ways:

- the analysis used improved data and methods to determine MP&M pollutant discharges from both MP&M facilities and other sources. In particular, EPA oversampled Ohio with 1,600 screener questionnaires to augment information on the State's MP&M facilities. The Agency also used information from the sampled MP&M facilities to estimate discharge characteristics of non-sampled MP&M facilities, as described in Appendix G of the EEBA.
- the analysis used an original travel cost (TC) study to value four recreational uses of water resources affected by the regulation: swimming, fishing, boating, and near-water activities.

The added detail provides a more complete and reliable analysis of water quality changes from reduced MP&M discharges. The study provides more complete estimates of changes in human welfare resulting from reduced health risk, enhanced recreational opportunities, and improved economic productivity.

The case study analysis of recreational benefits combines water quality modeling with a random utility model (RUM) to assess how changes in water quality from the regulation will affect consumers' valuation of water resources. The RUM analysis addresses a wide range of pollutant types and effects, including water quality measures not often addressed in past recreational benefits studies. In particular, the model supports a more complete analysis of recreational benefits from reductions in nutrients and toxic pollutants (i.e., priority pollutants and nonconventional pollutants with toxic effects).

ES.6.1 Benefits

The use of an original RUM model allows the Agency to address limitations inherent in benefits transfer used in the analysis of recreational benefits at the national level. The use of benefits transfer often requires additional assumptions because water quality changes evaluated in the available recreation demand studies are only roughly comparable with the water quality measures evaluated for a particular rule.

The RUM model estimates the effects of the specific water quality characteristics analyzed for the proposed MP&M regulation, such as the presence of AWQC exceedances and concentrations of the nonconventional nutrient Total Kjeldahl Nitrogen (TKN). This direct link between the water quality characteristics analyzed for the rule and the characteristics valued in the RUM analysis reduces uncertainty in benefit estimates and makes the analysis of recreational benefits more robust.

In addition to conventional pollutants and TKN, the proposed MP&M regulation affects a broad range of pollutants, many of which are toxic to human and aquatic life but are not directly observable (i.e., priority and non-conventional pollutants). These unobservable toxic pollutants degrade aquatic habitats, decrease the size and abundance of fish and other aquatic species, increase fish deformities, and change watershed species composition. Changes in toxic pollutant concentrations may therefore affect recreationists' valuation of water resources, even if consumers are unaware of changes in ambient pollutant concentrations.

The study used data from the 1993 National Demand Survey for Water-Based Recreation (NDS), conducted by EPA and the National Forest Service, to examine the effects of in-stream pollutant concentrations on consumers' decisions to visit a particular waterbody. The analysis estimated baseline and post-compliance water quality at recreation sites actually visited by the surveyed consumers and at all other sites within the consumers' choice set, visited or not. The RUM analysis of consumer behavior then estimated the effect of ambient water quality and other site characteristics on the total number of trips taken for different water-based recreation activities and the allocation of these trips among particular recreational sites. The RUM analysis is a TC model, in which the cost to travel to a particular recreational site represents the "price" of a visit.

EPA modeled two consumer decisions:

- how many water-based recreational trips to take during the recreational season (the trip participation model), and
- which recreation site to choose (the site choice model).

Combining the trip participation model's prediction of trips under the baseline and post-compliance scenarios and the site choice model's per-trip welfare measure provides a measure of total welfare. EPA calculated each individual's seasonal welfare gain for each recreation activity from post-compliance water quality changes, and then used Census data to aggregate the estimated welfare change to the State level. The sum of estimated welfare changes over the four recreation activities yielded estimates of total welfare gain.

EPA estimated other components of benefits in Ohio using similar methodologies to those used for the national-level analysis. In addition to the RUM study of recreational benefits, other analytical improvements included use of the following:

- more detailed data on MP&M facilities, obtained from the 1,600 additional surveys;
- data on non-MP&M discharges to estimate current baseline conditions in the state; and
- a first-order decay model to estimate in-stream concentrations in the Ohio waterbodies in the baseline and post-compliance.

The Agency believes that the added level of detail results in more robust benefit estimates.

Summing the monetary values over all benefit categories yields total monetized benefits of $181.8 to $298.7 million (1999$) annually for the proposed option, as shown in Table ES.20. The midpoint estimate of monetized benefits for the proposed option is $244.0 million (1999$). Although more comprehensive than the national benefits analysis, the case study benefit estimates still omit some mechanisms by which society is likely to benefit from the proposed rule. Examples of benefit categories not reflected in the monetized benefits include non-lead related non-cancer health benefits and reduced costs of drinking water treatment.

Table ES.20: Annual Benefits from Reduced MP&M Discharges in Ohio: Proposed Option (1999$)

Benefit Category	Low	Midpoint	High
1. Reduced Cancer Risk[a]			
Fish Consumption	$57	$182	$313
Water Consumption	$77,401	$244,587	$421,062
2. Reduced Risk from Exposure to Lead:			
Children	$32,509	$63,856	$96,944
Adults	$25,982	$70,661	$117,822
3. Enhanced Water-Based Recreation	$145,365,723	$162,449,204	$179,532,685
4. Nonuse Benefits	$36,341,431	$81,224,602	$118,492,572
5. Avoided Sewage Sludge Disposal Costs	$10,000	$10,000	$10,000
Total Monetized Benefits	**$181,853,103**	**$244,126,948**	**$298,768,342**

a. The monetary value of benefits from reduced incidence of cancer is based on 1997$.
Source: U.S. EPA analysis.

ES.6.2 Social Costs

EPA also estimated the social costs of the proposed rule for MP&M facilities in Ohio. Predicting the number of regulatory closures is necessary to estimate the costs and impacts of the regulation on industry and water quality. Facilities that are baseline closures will not be affected by the proposed MP&M regulation.

The screener data collected for Ohio facilities did not provide financial data to perform an after-tax cash flow or net present value test, as done in the national analysis. EPA therefore used data from the national analysis to estimate the percentage of facilities that would close in the baseline and post-compliance. EPA assumed that the ratio of facilities that close in the national analysis would be comparable to that for Ohio facilities with the same discharge status, subcategory, and flow category. For example, eight percent of indirect General Metals facilities discharging more than 6.25 million gallons per year close in the baseline in the national data set; this same percent distribution is assumed for Ohio screener indirect dischargers in that flow size category.

EPA developed engineering estimates of compliance costs for each Ohio facility, and annualized costs using a seven percent discount rate over a 15-year period. As in the national social cost analysis, EPA included compliance costs for facilities that close due to the rule, as well as costs for facilities that continue to operate subject to the proposed regulation. Including costs for regulatory closures in effect calculates the social costs of compliance that would be incurred if every facility continued to operate post-regulation. In fact, some facilities find it more economic to close. For this reason, calculating costs as if all facilities continue operating provides an upper-bound estimate of social costs.

EPA used the same methods as used in the national social cost analysis to estimate other components of social costs for the Ohio case study. Table ES.21 shows the total estimated social costs of the proposed rule for Ohio facilities.

Table ES.21: Annual Social Costs for Ohio Facilities: Proposed Option (millions 1999$, costs annualized at 7%)

Component of Social Costs	Lower bound	Midpoint	Upper bound
Resource value of compliance costs		$141.7	
Government administrative costs	$0.011	$0.025	$0.083
Social cost of unemployment	$.007	$3.673	$7.338
Total Social Cost	$141.7	$145.4	$149.1

ES.6.3 Comparing Monetized Benefits and Costs

The social cost of the proposed rule in Ohio is estimated at $141.7 to $149.1 million annually (1999$). The sum total of benefits that can be valued in dollar terms ranges from $181.8 million to $298.7 million annually (1999$). Combining the estimates of social benefits and social costs yields a net monetizable benefit ranging from $32.7 million to $157.0 million annually. Comparing the midpoint estimate of social costs ($145.4 million) with the midpoint estimate of monetizable benefits ($244.1 million) results in a net social benefit of $98.7 million. This represents a partial cost-benefit comparison because not all of the benefits resulting from the proposed rule can be valued in dollar terms. The Ohio case study shows substantial net positive benefits even for the lower-bound estimate of benefits.

The Ohio case study is more robust than most analyses that EPA usually performs for the following reasons:

- the study provides more detailed data on MP&M facilities than is possible at the national level;
- better water quality data were available for this state than is usually available;
- the 1600 Screeners provided information on locations of MP&M facilities in Ohio allowing the Agency to take more accurate account of joint discharges to the same reach;
- it includes data on non-MP&M discharges in the baseline and post compliance;
- it includes the affect of MP&M discharges of nutrients such as TKN;
- it uses a first-order decay model to estimate in-stream concentrations in downstream waterbodies; and
- it includes an additional recreational benefit category (swimming) in the analysis.

In addition, the RUM model used to estimate recreational benefits allows EPA to estimate the effects of specific water quality characteristics analyzed for the proposed MP&M regulation, (i.e., the presence of AWQC exceedances.) This direct link between the water quality characteristics analyzed for the rule and the characteristics valued in the RUM analysis reduces uncertainty in benefit estimates and makes the analysis of recreational benefits more robust.

Chapter 1: Introduction

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is proposing effluent limitations guidelines and standards for the Metal Products and Machinery (MP&M) Industry, under Sections 301, 304, 306, 307 and 501 of the Clean Water Act. EPA has determined that the proposed rule is likely to result in aggregate costs to the economy that exceed $100 million annually. The Agency therefore found that the proposed regulation is a "significant regulatory action" as defined by Executive Order 12866 [58 Federal Register 51, 735 (October 4, 1993)] and has prepared an analysis of the benefits and costs to society of the proposed rule, as required by the Executive Order.

CHAPTER CONTENTS:

1.1 PURPOSE

This report presents the results of EPA's economic analyses for the proposed rule. These analyses support EPA's compliance with the requirements of the following statutes and other rule-making provisions:

- Executive Order 12866 "Regulatory Planning and Review", which requires analysis of costs, benefits, and economic impacts of the proposed rule and regulatory alternatives;
- Unfunded Mandates Reform Act (UMRA), which requires evaluation of impacts on governments, among other requirements;
- Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (RFA/SBREFA), which requires consideration of the rule's impact on small firms and governments;
- Executive Order 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations";
- Executive Order 13084 " Protection of Children from Environmental Health Risks and Safety Risks";
- Executive Order 13158 "Marine Protected Areas"; and
- Coastal Zone Act Reauthorization Amendments (CZARA).

1.2 ORGANIZATION

This report is organized in five major parts, 22 chapters, and nine appendices, as follows:

Part I "Introduction and Background Information" (Chapters 1 though 4) describes the need for the regulation, provides a profile of the MP&M industry, and describes the proposed rule and other regulatory options considered by the Agency.

Part II "Costs and Economic Impacts" (Chapters 5 through 11) presents EPA's analysis of the economic impacts and social costs of the proposed rule. Chapter 5 presents the basic analysis of costs and impacts at the facility level. Chapters 6 through 9 present analyses of other types of economic impacts that derive from the basic facility-level analysis, including impacts on employment, governments (supporting EPA's compliance with UMRA), communities, foreign trade, firms, and new facilities. Chapter 10 provides an analysis of impacts on small firms and governments, as required by RFA/SBREFA. Finally, Chapter 11 presents the social costs of the proposed rule.

Part III "Benefits" (Chapters 12 through 17) provides EPA's analysis of the environmental impacts and benefits of the proposed rule. Chapter 12 provides an overview of the benefits expected from the rule. Chapters 13 through 16 present EPA's analyses of different components of the benefits analysis. These include human health benefits (except for lead-related) (Chapter 13), lead-related benefits (Chapter 14), recreational benefits (Chapter 15), and benefits to POTWs (Chapter 16). Chapter 17 presents an analysis of the environmental justice effects of the proposed rule, as required by Executive Order 12898.

Part IV "Comparison of Costs and Benefits" (Chapters 18 and 19) compares the social costs and benefits for the proposed rule (Chapter 18) and for other regulatory alternatives considered by the Agency (Chapter 19).

Part V " Ohio Case Study" (Chapters 20 through 22) provides a detailed case study of the proposed rule's costs and benefits for the State of Ohio. This case study includes a more detailed and complete analysis of benefits, based on more complete information on the number and location of MP&M facilities and the characteristics of affected waters than was available for the national analyses. The case study also includes an original travel cost study to value recreational uses affected by the proposed rule. EPA believes that the case study provides more robust results because it avoids the uncertainties that result from the need to extrapolate sample facility results to the national level. The results of the case study generally confirm the overall results of the national analysis.

Appendices to this report provide additional material in support of the analyses described in the chapters, including the following:

- Appendix A: supporting material for the profile of the MP&M industries in Chapter 3;
- Appendix B: description of the cost pass-through analysis;
- Appendix C: description of the methodology used to estimate POTW administrative costs;
- Appendix D: summary of MP&M facility pollutant loadings in the baseline, and after compliance with the proposed rule;
- Appendix E: discussion of methodologies and results of the environmental assessment analysis;
- Appendix F:summary of the method used to extrapolate sample facility results to the national level;
- Appendix G: description of the fate and transport model of pollutant releases used in the drinking water and Ohio analyses;
- Appendix H: analyses of spatial distribution of benefitting reaches in relation to MP&M facility location and benefitting population; and
- Appendix I: description of the surface water valuation studies and specific values selected for assessing recreational benefits from the proposed regulation.

Docket W-99-23 for the proposed rule, located at U.S. EPA Headquarters, provides additional supporting, including:

- copies of the literature cited in the report;
- documentation of the financial and economic portions of the MP&M Section 308 surveys; and
- datasets, spreadsheets, and programs used to perform the analyses.

A companion to this document, *Cost-Effectiveness Analysis of Proposed Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Industry* (EPA-821-B-007), presents a cost-effectiveness analysis for the proposed rule compared with other regulatory alternatives.

1.3 Readers Aids

Each chapter includes a chapter-specific table of contents. A list of references is provided at the end of each chapter. Glossaries and lists of acronyms are also provided at the end of the chapters, and the first usage of items listed in them are denoted in the text with the following formats:

- ***Glossary*** indicates that a term is defined in the chapter glossary, and
- **Acronym** indicates that the acronym is included in the chapter list of acronyms.

The glossary and acronym indicators in the text are linked to the chapter glossary and acronym sections in the .pdf versions of the report, and can be clicked to access the definitions.

Chapter 2: The MP&M Industry and the Need for Regulation

Introduction

The Metal Products and Machinery **(MP&M)** regulation will apply to eight industrial subcategories based on the production processes used and the wastes they generate. MP&M subcategories include: general metals, metal finishing job shops, non-chromium anodizing, printed wiring board, steel forming & finishing, oily waste, railroad line maintenance, and shipbuilding dry docks.

The facilities regulated under this rule produce, manufacture, rebuild, or maintain metal parts, products, or machines that are used in seventeen different markets. These market sectors include: hardware, aircraft, aerospace, ordnance, electronic equipment, stationary industrial equipment, mobile industrial equipment, buses and trucks, motor vehicles, household equipment, instruments, office machines, railroads, ships and boats, precious and non-precious metals, and other metal products. Most of the subcategories above serve multiple markets.

This chapter provides an overview of the MP&M industry and focuses on the pollutant discharges from MP&M facilities potentially subject to regulation. The chapter also reviews additional reasons why EPA is proposing to regulate the industry's effluent discharges. This section discusses: the need to reduce pollutant discharges from the MP&M industry, the issue of addressing market imperfections, the need to achieve a more coherent regulatory framework for the industry, and requirements that stem from the ***Clean Water Act* (CWA)** and litigation.

Chapter Contents:

2.1 Overview of the Facilities Potentially Subject to Regulation

The proposed regulation will apply to process wastewater discharges from MP&M sites performing manufacturing, rebuilding, or maintenance on a metal part, product, or machine to be used in the industrial sectors listed above. The rule does not cover non-process wastewater, MP&M operations that are ancillary activities at facilities outside the industrial sectors, or MP&M operations when performed at gasoline stations or vehicle rental facilities.[1] The proposed regulatory requirements are specified for the eight subcategories noted above, which are defined based on the unit operations performed and the nature of the waste generated.

"MP&M facilities" are facilities that produce metal parts, products or machines for use in one of the market sectors, using operations covered by one of the eight industrial subcategories, that discharge process wastewater, either directly or indirectly, to surface waters. Subcategory facilities frequently produce products for multiple sectors. It is important to note that "MP&M facilities", as defined here, represent only a portion of all facilities in the industrial sectors, since some facilities may perform operations that are not covered by one of the subcategories (i.e., part assembly or plastic molding) and some may not generate or discharge process wastewater.

[1] Section III of the preamble accompanying the proposed rule provides a more detailed discussion of the scope of the rule.

Department of Commerce data indicate that there are more than 1.3 million establishments operating in potential MP&M industries. These establishments are defined by approximately 200 SIC codes.[2] The MP&M survey results indicate that there are approximately 85,000 MP&M facilities that manufacture, rebuild, or repair metal machines, parts, products, or equipment using processes covered by the proposed subcategories. Of these 85,000, approximately 22,000 do not use or discharge water or use a contract hauler for their wastewater. Only 62,752 facilities, or 74.8 percent, are water-discharging facilities that could be potentially subject to the MP&M regulation. These 62,752 water-discharging facilities include 57,948 indirect dischargers (i.e., facilities discharging effluent to a ***publicly-owned sewage treatment works*** or **POTW**s) that would be subject to Pretreatment Standards for Existing Sources (PSES). The remaining 4,804 facilities are direct dischargers (i.e., they discharge effluent directly to a waterway under a National Pollutant Discharge Elimination System **(NPDES)** permit) and would thus be subject to ***Best Available Technology Economically Achievable*** **(BAT)** and ***Best Practicable Control Technology Currently Available*** **(BPT)** requirements.

Of the 62,752 water discharging facilities, 3,766[3] are predicted to close in the baseline, leaving 58,986 existing facilities that EPA estimates could be regulated.[4] The proposed rule would regulate 9,839 of these facilities, including 5,186 indirect discharging facilities and 4,653 direct dischargers. The estimated 9,839 water-discharging facilities that are regulated under the preferred option represent less than 0.8 percent of all facilities in the MP&M industries, and 15.7 percent of those that are potentially regulated. Table 2.1 summarizes important information on the total number of MP&M facilities that could potentially be regulated, and the number that would be regulated under the proposed rule.

Table 2.1 shows that a substantial portion (52,762 or 91 percent) of the potentially-regulated indirect dischargers will not be subject to requirements under the proposed rule. EPA proposes to exclude indirect dischargers below certain low thresholds in the General Metals and Oily Waste subcategories (20,164 and 28,092, respectively). The Agency also proposes to exclude indirect dischargers in three subcategories whose effluents are not expected to present significant environmental harm when discharged through POTWs (150 Non-Chromium Anodizing, 799 Railroad Line Maintenance, and 6 Shipbuilding Dry Dock facilities).[5] The proposed rule will regulate 4,653 direct dischargers -- all of the direct discharging MP&M facilities that continue to operate in the baseline.

2.2 MP&M Discharges and the Need for Regulation

EPA is regulating the MP&M industry because the industry releases substantial quantities of pollutants, including toxic pollutant compounds (priority and nonconventional metals and organics) and ***conventional pollutants*** such as ***total suspended solids*** **(TSS)** and ***oil and grease*** **(O&G)**. These MP&M industry pollutants are generally controlled by straightforward and widely-used treatment system technologies such as chemical precipitation and clarification (frequently referred to as the lime and settle process).[6]

Discharges of these pollutants to surface waters and POTWs have a number of adverse effects, including degradation of aquatic habitats, reduced survivability and diversity of native aquatic life, and increased human health risk through the consumption of contaminated fish and water. In addition, many of these pollutants volatilize into the air, disrupt biological wastewater treatment systems, and contaminate sewage sludge.

---

[2] Appendix A provides a list of the SIC codes in each industry sector.

[3] This figure excludes an estimated 64 facilities that EPA predicts would close in the baseline but that are expected to continue operations under the proposed rule. Chapter 5 explains the impact of potential revenue increases resulting from market adjustments to the rule that may result in such "avoided closures."

[4] These are facilities that are predicted to close due to weak financial performance under baseline conditions, i.e., in the absence of the proposed rule. EPA does not attribute the costs or the reduced discharges resulting from these baseline closures to the proposed rule, and therefore excludes these facilities from its analyses of the rule's impacts. Baseline closures account for differences between the universe of facilities discussed in this report and the universe discussed in Section IV of the preamble and the *Technical Development Document.*

[5] Also excluded are 3,614 (out of the 57,948) indirect dischargers EPA predicts will close in the baseline, and an additional 151 direct dischargers predicted to close in the baseline.

[6] See Chapter 12 and Appendix E for more detailed information on the pollutants of concern in the MP&M industry.

Table 2.1: Summary of MP&M Facilities Potentially and Actually Regulated Under the Proposed Rule

Subcategory	Indirect Dischargers: Water Dischargers (# of facilities)	Indirect Dischargers: Regulated under Proposed Rule (# of facilities)	Direct Dischargers: Water Dischargers (# of facilities)	Direct Dischargers: Regulated under Proposed Rule (# of facilities)
General Metals	26,191	3,103	3,784	3,636
Metal Finishing Job Shop	1,514	1,231	15	12
Non-Chromium Anodizing	190	0	0	0
Printed Wiring Board	624	621	11	11
Steel Forming & Finishing	110	105	43	43
Oily Waste	28,514	126	911	911
Railroad Line Maintenance	799	0	34	34
Shipbuilding Dry Dock	6	0	6	6
All Categories	57,948	5,186	4,804	4,653

Source: U.S. EPA analysis.

Metal constituents are of particular concern because of the large amounts present in MP&M effluents. Unlike some organic compounds and other wastes that are metabolized in activated sludge systems to relatively innocuous constituents, metals are elements and cannot be eliminated. Moreover, in solution, some metals have a high affinity for biological uptake. Depending on site-specific conditions, metals form insoluble inorganic and organic complexes that partition to sewage sludge at POTWs or underlying sediment in aquatic ecosystems. The accumulated metal constituents can return to a ***bioavailable*** form upon land application of sewage sludge; dredging and resuspension of sediment; or as a result of seasonal, natural, or induced alteration of sediment chemistry.

Benefits of reducing metal and other pollutant loads to the environment from MP&M facilities include reduced risk of cancer and systemic human health risks, improved recreation opportunities (e.g., fishing , swimming, boating, and other near-water recreational activities), improved aquatic and benthic habitats, and less costly sewage sludge disposal and increased beneficial use of the sludge.[7]

The goal of the MP&M regulation is to reduce pollutant discharges and to eliminate or reduce the level of risk and harm caused by them. These pollutant discharges and their harmful consequences are the ***externalities*** that the MP&M regulation addresses, as discussed in Section 2.3.

2.2.1 Baseline MP&M Discharges

Tables 2.2 and 2.3 provide an overview of the discharges from MP&M facilities that are potentially regulated under the proposed rule. Loadings are defined as ***toxic-weighted*** loadings. This measure weights quantities of different pollutants in effluents by a measure of their relative toxicity. Toxic-weighted loadings measures the relative toxic effects of discharges containing different mixtures of pollutants. MP&M discharges also contain conventional pollutants with little or no toxic effects that nonetheless can have adverse environmental impacts, such as O&G and some components of TSS. Tables 2.2 and 2.3 present discharges at baseline and under the proposed rule — not the *effect* of the pollutants.

[7] Sewage sludge is also called biosolids.

Table 2.2: Toxic-Weighted Discharges for Potentially Regulated MP&M Facilities and Those Regulated under the Proposed Rule
Indirect Dischargers[a] (Pounds Equivalent)

Subcategory	Baseline Discharges	# Facilities in the Baseline	Average Baseline Loadings per Facility	Remaining Discharges Under Proposed Rule
General Metals	28,370,265	23,204	1,223	20,550,241
Metal Finishing Job Shop	6,352,993	1,231	5,161	1,978,438
Non-Chromium Anodizing	54,517	150	363	54,517
Printed Wiring Board	409,588	621	6,595	2,563,010
Steel Forming & Finishing	656,688	105	6,254	427,646
Oily Waste	377,567	28,219	13	348,803
Railroad Line Maintenance	1,757	799	2	1,757
Shipbuilding Dry Dock	831	6	139	831
All Categories	39,910,106	54,333	735	25,925,243

[a] Excludes dischargers from facilities that are projected to close in the baseline (5,312,613 lbs-equiv., or an average of 1,470 lbs-equiv. per closing facility). Discharges discussed in this table are total discharges from the facility, and do not reflect POTW pollutant removals. EPA believes it is appropriate to analyze wastewater discharges disregarding the POTW removals because indirect discharges present environmental risks that are not fully addressed by POTW treatment. The MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 hazardous air pollutants (HAPs) that may present a threat to human health or the environment. Other MP&M pollutants are found POTW in sludge. Only eight of these pollutants have land application pollutant criteria that limit the uses of sludge.
Source: U.S. EPA analysis.

The large number of General Metals facilities account for over 71 percent of total toxic-weighted baseline loadings from facilities that continue to operate in the baseline, followed by Metal Finishing Job Shop facilities (16 percent), and Printed Wiring Board facilities (10 percent). On a per-facility basis, however, the largest toxic-weighted discharges come from Printed Wiring Board, Steel Forming & Finishing and Metal Finishing Job Shop facilities. These facilities discharge an average of 5,000 to over 6,000 lbs equivalent each, compared with an average per facility discharge of 735 lbs equivalent for the potentially regulated MP&M facilities as a whole.

Table 2.3 provides the same information for direct discharging facilities. The large number of General Metals direct dischargers again account for the majority (64 percent) of total toxic-weighted discharges in the baseline.

Table 2.3: Toxic-Weighted Discharges for Potentially Regulated MP&M Facilities and Those Regulated under the Proposed Rule
Direct Dischargers[a] (Pounds Equivalent)

Subcategory	Baseline Discharges	# Facilities in the Baseline	Average Baseline Loadings per Facility	Remaining Discharges Under Proposed Rule
General Metals	1,486,108	3,636	409	586,837
Metal Finishing Job Shop	22,496	12	1,875	8,301
Non-Chromium Anodizing				
Printed Wiring Board	142,535	11	12,958	77,962
Steel Forming & Finishing	626,274	43	14,565	28,126
Oily Waste	40,634	911	45	24,564
Railroad Line Maintenance	1,267	34	37	1,093
Shipbuilding Dry Dock	2,667	6	445	2,556
All Categories	2,321,981	4,653	499	988,439

[a] Excludes dischargers from facilities that are projected to close in the baseline (1,780,229 lbs-equiv., or an average of 5,167 lbs-equiv. per closing facility). Discharges discussed in this table are total discharges from the facility, and do not account for POTW pollutant removals. EPA believes it is appropriate to analyze wastewater discharges disregarding the POTW removals because indirect discharges present environmental risks that are not fully addressed by POTW treatment. The MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 hazardous air pollutants (HAPs) that may present a threat to human health or the environment. Other MP&M pollutants released by the industry are found in POTW sludge. Only eight of these pollutants have land application pollutant criteria that limit the uses of sludge.
Source: U.S. EPA analysis.

2.2.2 Discharges under the MP&M Regulation

Tables 2.2 and 2.3 also show the toxic loadings that would remain after implementation of the proposed rule, for indirect and direct dischargers respectively. These reductions result from increased treatment of effluents and pollution prevention at facilities that continue to operate subject to the regulation, and from the elimination of discharges at facilities that close as a result of the rule. The proposed rule would eliminate 35 percent of the baseline toxic-weighted discharges from indirect dischargers and 57 percent of the baseline loadings from direct dischargers. Additional information on the environmental effects of the proposed rule and two other options can be found in *Part III: Environmental Impacts and Benefits* of this report, and in Appendix E.

Table 2.4 shows baseline and post-regulation loadings by type of pollutant, both as unweighted pounds and on a toxic-weighted basis, for facilities that are regulated under the proposed rule. The facilities that are regulated account for 70 percent of the baseline toxic-weighted releases from all potentially-regulated facilities. The proposed rule eliminates 89 percent of the baseline toxic-weighted loadings from the facilities that are regulated, including 92 percent of the ***priority pollutants*** (91 percent of the metals, 52 percent of the organics, and 99 percent of the cyanide) and 81 percent of the ***nonconventional pollutants*** (82 percent of the metals and 30 percent of the organics). The proposed rule also eliminates substantial portions of the baseline discharges of conventional pollutants from the regulated facilities, including 75 percent of the ***chemical oxygen demand (COD)***, 90 percent of the O&G, and 88 percent of the TSS.[8]

[8] It is not possible to provide an overall estimate of total pollutant pounds removed, because overlap among some of the pollutant categories would result in double-counting if the categories were summed. For example, TSS may include some of the priority pollutant and nonconventional metals discharges. Use of the toxic-weighted loadings avoids this double-counting, but does not include conventional pollutants.

Table 2.4: Summary of Discharges by Pollutant Type for Facilities Regulated under the Proposed Rule[a]

Pollutant Category	Current Releases		Releases under The Proposed Rule		Proposed Rule Reductions	
	Pounds	Pounds Eq.	Pounds	Pounds Eq.	Pounds	Pounds Eq.
Priority Pollutants						
Metals	34,527,668	16,476,843	2,018,185	1,500,230	32,509,483	14,976,613
Organics	2,095,832	323,410	1,024,636	156,560	1,071,196	166,850
Cyanide (CN)	4,718,247	5,190,072	35,881	39,469	4,682,366	5,150,603
Nonconventional Pollutants						
Metals	120,756,930	7,201,034	23,723,669	1,265,904	97,033,261	5,935,130
Organics	50,468,179	210,501	9,411,727	146,873	41,056,452	63,628
Conventional Pollutants						
COD	2,445,579,193		601,888,710		1,843,690,483	
O&G	220,782,391		20,953,718		199,828,673	
TSS	231,466,565		27,404,519		204,062,046	

[a] Discharges discussed in this table are facility discharges and do not account for POTW removals. EPA believes it is appropriate to analyze wastewater discharges disregarding the POTW removals because indirect discharges present environmental risks that are not fully addressed by POTW treatment. The MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 hazardous air pollutants (HAPs) that may present a threat to human health or the environment. Other MP&M pollutants released by the industry are found in POTW sludge. Only eight of these pollutants have land application pollutant criteria that limit the uses of sludge.
Source: U.S. EPA analysis.

2.3 Addressing Market Imperfections

Environmental legislation in general, and the CWA and the MP&M regulation in particular, seek to correct imperfections — ***uncompensated*** environmental externalities — in the functioning of the market economy. In manufacturing, rebuilding, and repairing metal products and machinery, MP&M facilities release pollutants that increase risks to human health and aquatic life and cause other environmental harm without accounting for the consequences of these actions on other parties (sometimes referred to as ***third parties***) who do not directly participate in the business transactions of the business entities.

These costs are not borne by the responsible entities and are therefore *external* to the production and pricing decisions of the responsible entity.

A profit-maximizing firm or a cost-minimizing government-owned facility will ignore these costs when deciding how much to produce and how to produce it. In addition, the externality is uncompensated because no party is compensated for the adverse consequences of the pollution releases.

When these external costs are not accounted for in the production and pricing decisions of the responsible entities, their decisions will yield a mix and quantity of goods and services in the economy, and an allocation of economic resources to production activities, that are less than optimal. In particular, the quantity of pollution and related environmental harm caused by the activities of the responsible entities will, in general, exceed ***socially optimal levels***. As a result, society will not maximize total social welfare.

In addition, adverse ***distributional effects*** may accompany the uncompensated environmental externalities. If the distribution of pollution and environmental harm is not random among the U.S. population, but instead is concentrated among certain population subgroups based on socio-economic or other demographic characteristics, then the uncompensated environmental externalities may produce undesirable transfers of economic welfare among subgroups of the population. See *Chapter 17: Environmental Justice and Protection of Children* for more information.

The goal of environmental legislation and implementing regulations, including the proposed MP&M rule that is the subject of this EEBA, is to correct these environmental externalities by requiring businesses and other polluting entities to reduce their pollution and environmental harm. Congress, in enacting the authorizing legislation, and EPA, in promulgating the implementing regulations, act on behalf of society to achieve a mix of goods and services and a level of pollution that more nearly approximates socially optimal levels. As a result, the mix and quantity of goods and services provided by the economy, the allocation of economic resources to those activities, and *the quantity of pollution and environmental harm accompanying those activities* will yield higher net economic welfare to society.

Requiring polluting entities to reduce levels of pollution and environmental harm is one approach to addressing the problem of environmental externalities. This approach imposes costs on the polluting entities in the form of compliance costs incurred to reduce pollution to allowed levels. A polluting entity will either incur the costs of meeting the regulatory limits or will determine that compliance is not in its best financial interest and will cease the pollution-generating activities. This approach to addressing the problem of environmental externalities will generally result in improved economic efficiency and net welfare gains for society if the cost of reducing the pollution and environmental harm activities is less than the value of benefits to society from the reduced pollution and environmental harm.

It is theoretically possible to correct the market imperfection by means other than direct regulation. For example, negotiation and/or litigation could achieve an optimal allocation of economic resources and mix of production activities within the economy. However, the transaction costs of assembling the affected parties and involving them in the negotiation/litigation process, as well as the public goods character of the improvement sought by negotiation or litigation, make this approach impractical.

2.4 Achieving a More Complete and Coherent Regulatory Framework for the Metals Industries

The MP&M regulation will help to achieve a more coherent regulatory framework for the effluent discharge limitations that apply to the MP&M industry and other metals industries whose operations may overlap with the MP&M industry.

EPA has previously promulgated effluent guidelines regulations for thirteen metals-related industries. In some instances, these industries may perform operations that are found in MP&M facilities. These effluent guidelines are:

- Electroplating (40 CFR Part 413),
- Iron & Steel Manufacturing (40 CFR Part 420),
- Nonferrous Metals Manufacturing (40 CFR Part 421),
- Ferroalloy Manufacturing (40 CFR Part 424),
- Metal Finishing (40 CFR Part 433),
- Battery Manufacturing (40 CFR Part 461),
- Metal Molding & Casting (40 CFR Part 464),
- Coil Coating (40 CFR Part 465),
- Porcelain Enameling (40 CFR Part 466),
- Aluminum Forming (40 CFR Part 467),
- Copper Forming (40 CFR Part 468),
- Electrical & Electronic Components (40 CFR Part 469), and
- Nonferrous Metals Forming & Metal Powders (40 CFR Part 471).

In 1986, the Agency reviewed coverage of these regulations and identified a significant number of metals processing facilities discharging wastewater that these 13 regulations did not cover. Based on this review, EPA performed a more detailed analysis of these unregulated sites and identified the discharge of significant amounts of pollutants. This analysis resulted in the formation of the "Machinery Manufacturing and Rebuilding" **(MM&R)** point source category. In 1992, EPA changed the name of the category to "Metal Products and Machinery" (MP&M) to clarify coverage of the category (57 FR 19748).

EPA recognizes that in some cases unit operations performed in industries covered by the existing effluent guidelines are the same as unit operations performed at MP&M facilities. In general, where unit operations and their associated wastewater discharges are already covered by an existing effluent guideline, they will remain covered under that effluent guideline. (See 40 CFR438.1(b)). However, some facilities currently regulated under the existing Electroplating (40 CFR 413) and Metal Finishing (40 CFR 433) effluent guidelines will be covered by the MP&M regulation instead. EPA is proposing to replace the existing Electroplating (40 CFR 413) and Metal Finishing (40 CFR 433) effluent guidelines with the MP&M regulations for all facilities in the Printed Wiring Board subcategory and the Metal Finishing Job Shops subcategories (see Table 2.5).

When a facility covered by an existing metals effluent guideline (other than Electroplating or Metal Finishing) discharges wastewater from unit operations not covered under that existing metals guideline but covered under MP&M, it will need to comply with both regulations (see 40 CFR 438.1(c)). In those cases, the permit writer or control authority (e.g., Publicly Owned Treatment Works) will combine the limitations using an approach that proportions the limitations based on the different in-scope production levels (for production-based standards) or wastewater flows. POTWs refer to this approach as the "combined wastestream formula" (40 CFR 403.6(e)), while NPDES permit writers refer to it as the "building block approach". Permit writers and local control authorities currently issue permits and control mechanisms for many facilities in other effluent guidelines categories where overlaps with more than one effluent limitation guidelines regulation occur (e.g., Organic Chemicals, Plastics, and Synthetic Fibers; Pesticide Manufacturing; Pesticide Formulating, Packaging, and Repackaging; and Pharmaceutical Manufacturing).

EPA does not intend the preceding table to be exhaustive, but rather to provide a general overview of the proposed applicability of the Electroplating, Metal Finishing, and Metal Products & Machinery effluent guidelines.

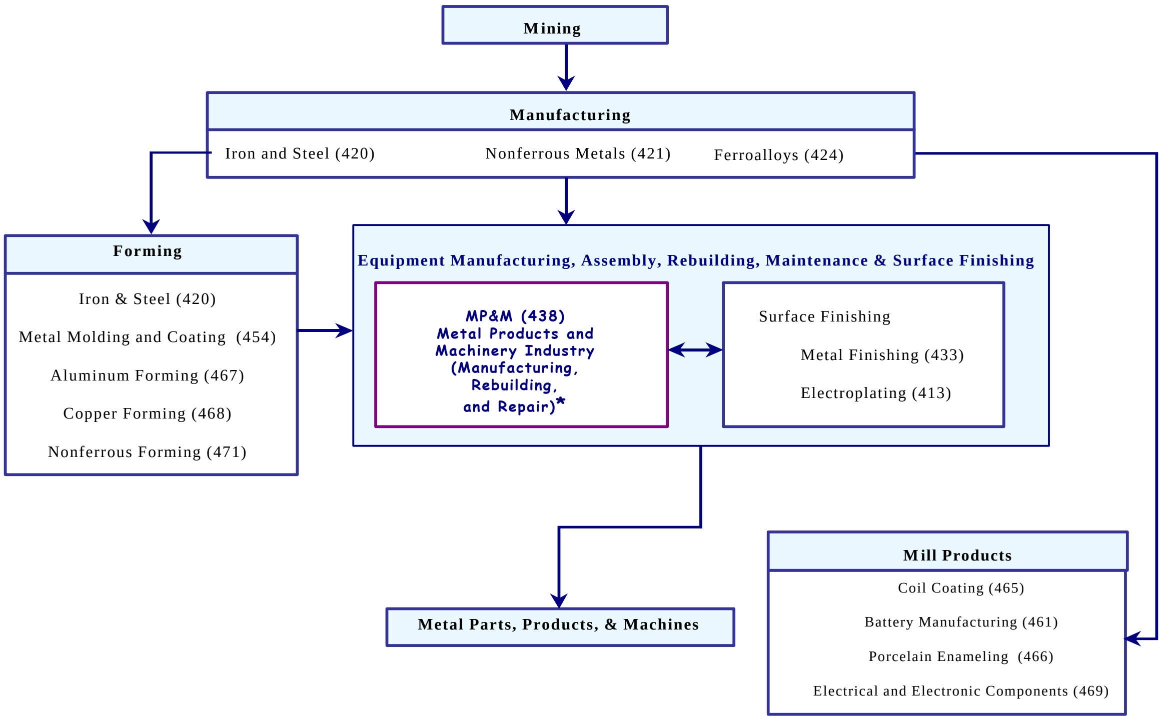
Figure 2.1 illustrates the relationship among the various metals industries effluent guidelines.

Table 2.5: Proposed Coverage by MP&M Subcategory

Subcategory	Proposing to Continue Coverage under 40 CFR Part 413 (Electroplating)	Proposing to Continue Coverage under 40 CFR Part 433 (Metal Finishing)	Proposing Coverage under 40 CFR Part 438 (Metal Products & Machinery)
General Metals	none	Existing facilities that are currently covered (or new facilities that would be covered) by 433 AND are indirect dischargers that introduce less than or equal to 1 million gallons per year into POTW.	All new and existing direct dischargers in this subcategory regardless of annual wastewater discharge volume and all new and existing indirect dischargers in this subcategory with annual wastewater discharges greater than 1 million gallons per year.
Metal Finishing Job Shops	none (see non-chromium anodizing)	none (see non-chromium anodizing)	All new and existing direct and indirect dischargers under this subcategory. These facilities would no longer be covered by 413 or 433.
Non-Chromium Anodizing[a]	Existing indirect dischargers that are currently covered by 413 AND that only perform non-chromium anodizing (or do not commingle their non-chromium anodizing wastewater with other process wastewater for discharge).	New and existing indirect dischargers (not covered by 413) that only perform non-chromium anodizing (or do not commingle their non-chromium anodizing wastewater with other process wastewater for discharge).	Existing and new direct dischargers that only perform non-chromium anodizing (or do not commingle their non-chromium anodizing wastewater with other process wastewater for discharge).
Printed Wiring Board (Printed Circuit Board)	none	none	All new and existing direct and indirect dischargers under this subcategory. These facilities would no longer be covered by 413 or 433.
Steel Forming & Finishing [b]	N/A	N/A	All new and existing direct and indirect discharges under this subcategory as described.
Oily Waste	N/A	N/A	All new and existing direct and indirect dischargers under this subcategory as described. This subcategory excludes new and existing indirect dischargers that introduce less than or equal to 2 MGY into a POTW. Facilities under the cutoff are not and will not be covered by national categorical regulations.
Railroad Line Maintenance	N/A	N/A	All new and existing direct dischargers under this subcategory as described. There are no national categorical pretreatment standards for these facilities.
Shipbuilding Dry Docks	N/A	N/A	All new and existing direct dischargers under this subcategory as described. There are no national categorical pretreatment standards for these facilities.

[a] Facilities that perform anodizing with chromium or with dichromate sealants (or commingle their non-chromium anodizing process wastewater with wastewater from other MP&M subcategories) all fall under the Metal Finishing Job Shop subcategory and will only be covered by 438.
[b] Includes cold forming of steel wire, bars, rods, pipes, and tubes.
Source: U.S. EPA analysis.

Figure 2.1: Metals Industries Effluent Guidelines Covered Under 40CFR



* Includes cold forming of steel wire, bars, rods, pipes, and tubes.

Source: U.S. EPA analysis.

2.5 Meeting Legislative and Litigation-Based Requirements

EPA is proposing effluent limitations guidelines and standards for the MP&M industry under authority of the CWA, Sections 301, 304, 306, 307, and 501. These CWA sections require the EPA Administrator to publish limitations and guidelines for controlling industrial effluent discharges consistent with the overall CWA objective to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." EPA's proposal of the MP&M industry regulation responds to these requirements.

In addition, the proposed MP&M regulation responds to the requirements of a consent decree entered by the Agency as a result of litigation. Section 304(m) of the CWA (33 U.S.C. 1314(m)), added by the Water Quality Act of 1987, required EPA to establish schedules for (i) reviewing and revising existing effluent limitations guidelines and standards, and (ii) promulgating new effluent guidelines. On January 2, 1990, EPA published an Effluent Guidelines Plan (55 FR 80), in which schedules were established for developing new and revised effluent guidelines for several industry categories. One of the industries for which the Agency established a schedule was the Machinery Manufacturing and Rebuilding Category (MM&R).[9]

The Natural Resources Defense Council, Inc. **(NRDC)** and Public Citizen, Inc. challenged the Effluent Guidelines Plan in a suit filed in U.S. District Court for the District of Columbia (NRDC et al v. Reilly, Civ. No. 89-2980). The plaintiffs charged that EPA's plan did not meet the requirements of Section 304(m). A Consent Decree in this litigation was entered by the Court on January 31, 1992. This plan required, among other things, that EPA propose effluent guidelines for the MP&M category by November, 1994 and take final action on these effluent guidelines by May, 1996. EPA filed a motion with the Court on September 28, 1994, requesting an extension until March 31, 1995, for the EPA Administrator to sign the proposed regulation and a subsequent four month extension for signature of the final regulation in September 1996. EPA

[9] The name was changed to Metal Products and Machinery (MP&M) in 1992 to avoid confusion over what was covered by the rule.

published a proposal entitled, "Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Metal Products and Machinery" (60 FR 28210) on May 30, 1995.

EPA initially divided the industry into two phases based on industrial sector, as the Agency believed that would make the regulation more manageable. The Phase I proposal included the following industry sectors: Aerospace; Aircraft; Electronic Equipment; Hardware; Mobile Industrial Equipment; Ordnance; and Stationary Industrial Equipment. At that time, EPA planned to propose a rule for the Phase II sectors approximately three years after the MP&M Phase I proposal.

EPA received over 4,000 pages of public comment on the Phase I proposal. One area where commenters from all stakeholder groups (i.e., industry, environmental groups, and regulators) were in agreement was that EPA should not divide the industry into two separate regulations. Commenters raised concerns regarding the regulation of similar facilities with different compliance schedules and potentially different limitations for similar processes based solely on whether the facilities were in a Phase I or Phase II MP&M industrial sector. Furthermore, a large number of facilities performed work in multiple sectors. In such cases, permit writers and control authorities (e.g., POTWs) would need to decide which MP&M rule (Phase I or 2) applied to a facility.

Based on these comments, EPA decided to combine the two phases of the regulation into one proposal. The proposal addressed by this report completely replaces the 1995 proposal. Under the 304(m) decree as amended, these MP&M rules are to be promulgated in December 2002.

GLOSSARY

Best Available Technology Economically Achievable: Effluent limitations for direct dischargers, addressing priority and non-conventional pollutants. BAT is based on the best existing economically achievable performance of plants in the industrial subcategory or category. Factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the processes employed, engineering aspects of the control technology, potential process changes, non-water quality environmental impacts (including energy requirements), economic achievability, and such factors as the Administrator deems appropriate. The Agency may base BAT limitations upon effluent reductions attainable through changes in a facility's processes and operations. Where existing performance is uniformly inadequate, EPA may base BAT upon technology transferred from a different subcategory within an industry or from another industrial category.

Best Practicable Control Technology Currently Available: Effluent limitations for direct discharging facilities, addressing conventional, toxic, and non-conventional pollutants. In specifying BPT, EPA considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of the equipment and facilities, the processes employed and any required process changes, engineering aspects of the control technologies, non-water quality environmental impacts (including energy requirements), and such other factors as the Agency deems appropriate. Limitations are traditionally based on the average of the best performances of facilities within the industry of various ages, sizes, processes, or other common characteristics. Where existing performance is uniformly inadequate, EPA may require higher levels of control than currently in place in an industrial category if the Agency determines that the technology can be practically applied.

bioavailable: Degree of ability to be absorbed and ready to interact in organism metabolism. (http://www.epa.gov/OCEPAterms)

chemical oxygen demand: A measure of the oxygen required to oxidize all compounds, both organic and inorganic, in water. (http://www.epa.gov/OCEPAterms/cterms.htm)

Clean Water Act: Act passed by the U.S. Congress to control water pollution. Formerly referred to as the Federal Water Pollution Control Act of 1972 or Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), 33 U.S.C. 1251 et. seq., as amended by: Public Law 96-483; Public Law 97-117; Public Laws 95-217, 97-117, 97-440, and 100-04.

conventional pollutants: Statutorily listed pollutants understood well by scientists. These may be in the form of organic waste, sediment, acid, bacteria, viruses, nutrients, oil and grease, or heat. (http://www.epa.gov/OCEPAterms)

distributional effects: Occurs when the distribution of pollution and environmental harm is not random among the U.S. population, but instead is concentrated among certain population subgroups based on socio-economic or other demographic characteristics, then the uncompensated environmental externalities may produce undesirable transfers of economic welfare among subgroups of the population.

externalities: Costs or benefits of market transactions that are not reflected in the prices buyers and sellers use to make their decisions. An externality is a by-product of the production or consumption of a good or service that affects someone not immediately involved in the transaction. (http://www.enmu.edu/users/biced/home/glossary.html) A type of market failure that causes inefficiency. (http://www.amosweb.com/cgi-bin/gls_dsp.pl?term=externalities)

nonconventional pollutants: Any pollutant not statutorily listed or which is poorly understood by the scientific community. (http://www.epa.gov/OCEPAterms)

oil and gas (O&G): These organic substances may include hydrocarbons, fats, oils, waxes and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

Pretreatment Standards for Existing Sources (PSES): Categorical pretreatment standards for existing indirect dischargers, designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Standards are technology-based and analogous to BAT effluent limitations guidelines.

priority pollutants: 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater or soil samples.

publicly-owned treatment works: A treatment works for municipal sewage or liquid industrial wastes that is owned by a State or municipality.

socially optimal level: Situation in which it is impossible to make any individual better off without making someone else worse off. Also referred to as Pareto optimal.

social welfare: The sum of the welfare of all participants in the society; measured by the sum of consumer surplus -- the value consumers derive from goods and services less the price they have to pay for the goods and services -- and producers' surplus -- the revenue received by producers of goods and services less their costs of producing the goods and services.

third parties: Those affected by a by-product of the production or consumption of a good or service that are not immediately involved in the transaction.

total suspended solids: A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids." (http://www.epa.gov/OCEPAterms/tterms.html).

toxic-weighted pollutants: This measure weights quantities of different pollutants in effluents by a measure of their relative toxicity. Toxic-weighted loadings measures the relative toxic effects of discharges containing different mixtures of pollutants.

uncompensated: Where parties damaged by externalities receive no compensation for accepting the damage.

ACRONYMS

BAT: Best Available Technology Economically Achievable
BPT: Best Practicable Control Technology Currently Available
COD: chemical oxygen demand
CWA: Clean Water Act
MM&R: Machinery Manufacturing and Rebuilding
MP&M: Metal Products and Machinery
NPDES: National Pollutant Discharge Elimination System
NRDC: Natural Resources Defense Council
O&G: oil and grease
POTW: publicly-owned treatment works
PSES: Pretreatment Standards for Existing Sources
TSS: total suspended solids

Chapter 3: Profile of the MP&M Industries

INTRODUCTION

The proposed MP&M rule would apply to facilities that manufacture, rebuild, or maintain metal parts, products or machines to be used in a large number of industrial sectors. ***Manufacturing*** is the series of unit operations necessary to produce metal products, and is generally performed in a production environment. ***Rebuilding/maintenance*** is the series of unit operations necessary to disassemble used metal products into components, replace the components or subassemblies or restore them to original function, and reassemble the metal product. These operations are intended to keep metal products in operating condition and can be performed in either a production or a non-production environment. Manufacturing and rebuilding/maintenance activities often occur at the same facilities.

The MP&M industry encompasses a large number of industries that manufacture intermediate and final goods, support transportation and other vehicle services, and repair and maintain products and equipment. The health of the MP&M industries is generally tied to the overall economic performance of the economy. The MP&M industry includes manufacturing and non-manufacturing industries defined by 224 4-digit ***Standard Industrial Classification*** (***SIC***) codes, which are grouped into nineteen sectors.[1] Of the 224 SIC codes, 174 are manufacturing (SICs 20 through 39) and 50 are non-manufacturing. All nineteen sectors include manufacturing industries, and eleven include non-manufacturing industries as well.

This chapter provides a profile of the sectors potentially affected by the proposed MP&M rule. The profile focuses on the economic characteristics of these sectors, and the regulated facilities within these sectors, which may affect the financial and economic impacts of the proposed rule.

CHAPTER CONTENTS:

3.1 DATA SOURCES

This profile presents data from the *Economic Censuses, Statistics of U.S. Businesses* (SUSB), and *Annual Survey of Manufactures* (ASM), the *U.S. Industry and Trade Outlook*, EPA's Sector Notebooks, and other sources, to characterize the MP&M sectors as a whole, including both dischargers and non-dischargers.

This profile relies on industries defined by SICs, both because data collection for the MP&M sectors was defined by SICs and to allow for use of historical data. The Census Bureau switched to use of the new North American Industry Classification System (NAICS) codes starting with the 1997 Economic Censuses. Lack of a one-to-one correspondence between an SIC and a NAICS code prevented the Agency

[1] Appendix A lists the nineteen sectors and their associated 4-digit SIC codes.

from matching the 1997 to earlier years' data for a number of sectors. This profile therefore relies primarily on the 1992 Censuses and, for manufacturing sectors, the 1996 Annual Survey of Manufactures.

The Agency used survey data to characterize the facilities within the MP&M sectors that are potentially subject to the proposed rule because they discharge process wastewater from MP&M operations. The survey provides data such as discharge type, small business status, sources of revenues, and financial performance.

The survey requested information on the sectors from which each facility derives its revenues. Many facilities derive revenues from more than one sector. It is therefore difficult to link facility characteristics to a specific sector. Data on the potentially-regulated facilities are therefore summarized by the proposed regulatory subcategories rather than by sectors.

3.2 Overview of the MP&M Industry and Industry Trends

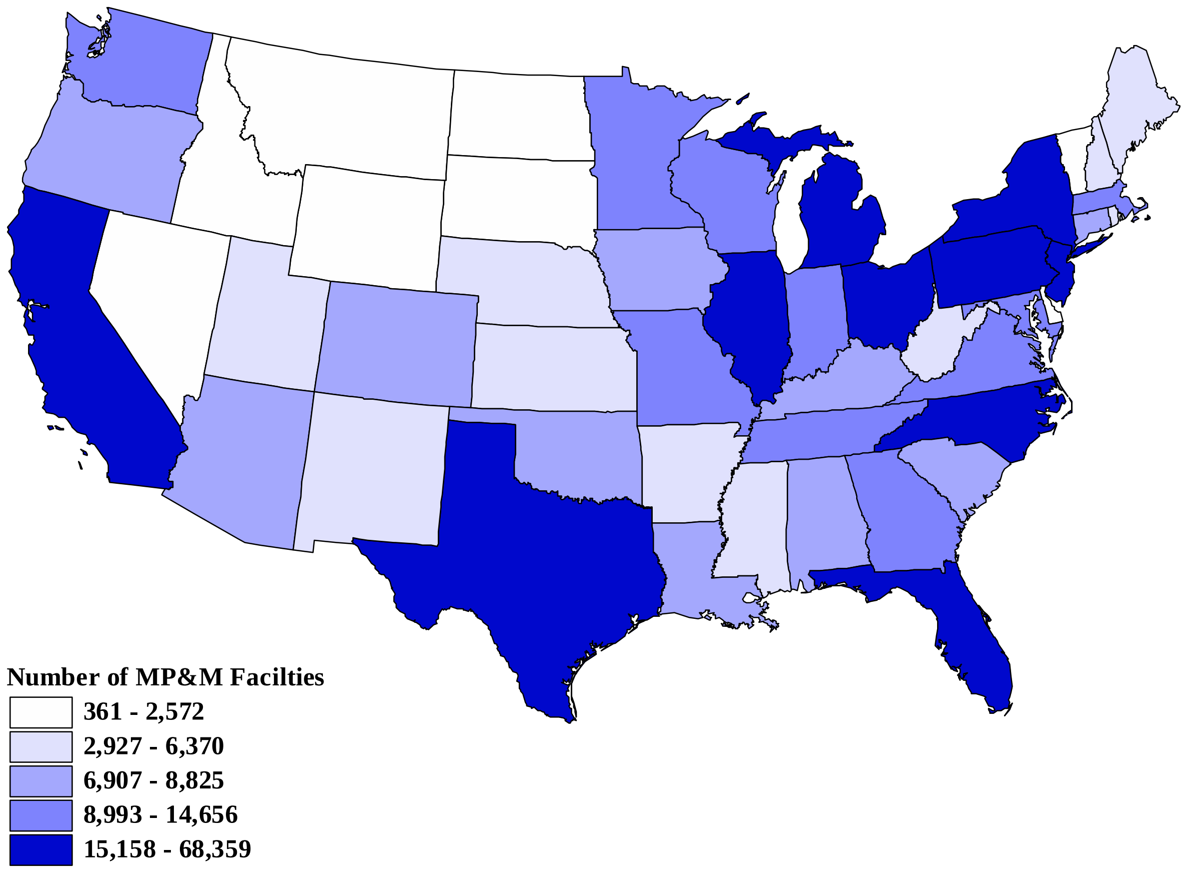
Table 3.1 lists the MP&M sectors and provides a brief description of the products and services produced by each. Appendix A provides a more detailed list of the 4-digit SIC codes in each sector.

Table 3.1: MP&M Sector Definitions

Sector	Sector Description
Aerospace	Metal parts or products such as missiles, space vehicles, satellites and associated launching equipment.
Aircraft	Metal parts or products including all types of aircraft for public, private or commercial use. Includes aircraft parts and equipment as well as aircraft maintenance activities.
Bus and Truck	Metal parts or products including freight trucks and trailers as well as public, private and commercial buses. Includes all associated equipment including equipment specific to truck and bus terminals. Includes bus and truck maintenance activities.
Electronic Equipment	Metal parts or products including general electronic components such as tubes, capacitors, and transformers, as well as finished electronic equipment such as television, radio, and telephone.
Hardware	Metal parts or products such as tools, cutlery, valves and tubing, dies, springs, sheet metal, drums, and heat treating equipment.
Household Equipment	Metal parts or products including appliances such as refrigerators, laundry equipment, lighting equipment, cooking equipment, and vacuum cleaners. Non-communication type radios and televisions are included in this sector.
Iron and Steel	Sites engaged in iron or steel manufacturing, forming and finishing.
Instruments	Metal parts or products such as laboratory and medical equipment, measuring devices, environmental and process controls, optical equipment, surgical and dental equipment, and pens.
Metal Finishing Job Shop	Facilities with more than 50 percent of their revenues coming from work on products not owned by the site. While there are SIC codes associated with some Metal Finishing Job Shops, they sell to a variety of markets and are not a market in and of themselves.
Mobile Industrial Equipment	Metal parts or products including tractors and other farm equipment, construction machinery and equipment, mining machinery and equipment, industrial cranes and hoists, and tracked military vehicles.
Motor Vehicle	Metal parts or products including private passenger vehicles and associated parts and accessories such as automobiles, motorcycles, utility trailers and recreational vehicles, and mobile homes.
Office Machines	Metal parts or products including office computer equipment, storage devices, printers, photocopiers and associated parts and accessories.
Ordnance	Metal parts or products including all small arms, artillery, and ammunition with the exception of missiles (aerospace). Does not include the chemical processing or the manufacture of explosives.
Other Metal Products	Metal parts or products including products and machinery not categorized into the other sectors (e.g., sporting goods, musical instruments).
Precious Metals and Jewelry	Metal parts or products including jewelry, silverware, trophies, and clocks as well as all associated parts and accessories.
Printed Wiring Boards	Metal parts or products including printed wiring boards and printed wiring boards.
Railroad	Metal parts or products including railcars, locomotives and associated parts and accessories as well as track, switching and terminal stations.
Ships and Boats	Metal parts or products including ships and boats for military, freight, and private recreation. Includes submarines, ferries, tug boats, barges, yachts, and other recreational boats as well as all parts and accessories. Also includes rebuilding and maintenance activities performed at marinas, dry docks, and other on shore activities specifically related to ships and boats.
Stationary Industrial Equipment	Metal parts or products including all industrial machinery, such as turbines, oil field machinery, elevators and moving stairways, conveying equipment, chemical process industry equipment, pumps, compressors, blowers, industrial ovens, vending machines, commercial laundry equipment, commercial refrigeration and heating equipment, welding apparatus, motors, and generators.

Figure 3.1 shows that there MP&M facilities are located in every state. A few MP&M sectors such as shipbuilding are concentrated geographically, and transportation-related MP&M facilities are found throughout the country. Overall, however, MP&M facilities are most concentrated in the heavy industrial regions along the Gulf Coast, both East and West Coasts, and the Great Lakes Region (New York, Pennsylvania, Ohio, Indiana, Illinois, and Michigan).

Figure 3.1: Number of MP&M Facilities by State



Source: Department of Commerce, Bureau of the Census, Census of Manufactures, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1992.

Table 3.2 shows output by sector for manufactures, non-manufactures, and sector total. In 1992, MP&M facilities accounted for more than $1.9 trillion in output. Manufacturing accounted for 60 percent of the total MP&M output. Motor vehicles are the largest single MP&M sector, accounting for almost 40 percent of all MP&M output.

While MP&M non-manufacturers outnumbered MP&M manufacturers by more than two to one in 1996, manufacturers' revenues were nearly $400 billion larger than MP&M non-manufacturers' revenues.

Table 3.2: MP&M Output and Share (millions, $1992)						
Sector	Manufacturers		Non-Manufacturers		Sector Total	
	Output [a]	Share	Output [a]	Share	Output [a]	Share
Aerospace	27,073.9	2.3%			27,073.9	1.4%
Aircraft	104,783.9	8.9%	6,167.6	0.8%	110,951.5	5.7%
Bus & Truck	8,140.2	0.7%	143,806.1	18.6%	151,946.3	7.8%
Electronic Equipment	81,380.7	6.9%			81,380.7	4.2%
Hardware	127,769.0	10.8%			127,769.0	6.6%
Household Equipment	75,552.4	6.4%	2,193.1	0.3%	77,745.5	4.0%
Instruments	111,908.9	9.5%	6,648.1	0.9%	118,557.0	6.1%
Iron and Steel	14,967.3	1.3%			14,967.3	0.8%
Job Shop [b]	9,886.4	0.8%			9,886.4	0.5%
Mobile Industrial Equipment	35,494.9	3.0%			35,494.9	1.8%
Motor Vehicle	265,433.9	22.5%	506,487.4	65.7%	771,921.3	39.6%
Office Machine	66,746.7	5.7%	13,029.6	1.7%	79,776.3	4.1%
Ordnance	6,995.2	0.6%			6,995.2	0.4%
Other Metal Products	51,958.6	4.4%	16,487.9	2.1%	68,446.5	3.5%
Precious Metals and Jewelry	7,986.7	0.7%	274.7	0.0%	8,261.4	0.4%
Printed Wiring Boards	7,311.8	0.6%			7,311.8	0.4%
Railroad	4,588.8	0.4%	28,348.9	3.7%	32,937.7	1.7%
Ships and Boats	15,207.6	1.3%	29,207.2	3.8%	44,414.8	2.3%
Stationary Industrial Equipment	154,689.7	13.1%	18,668.6	2.4%	173,358.3	8.9%
Total MP&M	**1,177,876.6**	**100.0%**	**771,319.2**	**100.0%**	**1,949,195.8**	**100.0%**
Percent of total	*60.4%*		*39.6%*		*100.0%*	

a. Value of shipments for manufacturing industries; total sales for retail and wholesale trade; total receipts for service industries; total revenue for transportation.
b. Includes facilities in two SICs that are defined specifically as job shops (SICs 3471 and 3479.) Facilities reporting in other sectors may also operate as job shops, so these data are likely to understate the true output of MP&M job shops.
Source: Department of Commerce, Bureau of the Census, Census of Manufactures, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1992.

The following sections describe the MP&M sectors and briefly discusses recent industry trends in each sector. The discussion is based on *U.S. Industry and Trade Outlook 2000* (DRI-McGraw Hill), EPA's Sector Notebooks, and other sources.

3.2.1 Aerospace

The aerospace industry includes original equipment manufacturers (OEM) and facilities that rebuild and repair aerospace equipment. The industry serves both military and commercial end-uses such as space vehicles for commercial communication satellites, although military applications dominate. Products include guided missiles and space vehicles, and associated propulsion units and parts. The assembly of aerospace products draws on numerous other industries, including plastics, rubber, fabricated metals, metal casing, glass, textile, and electronic components.

Aerospace products are typically produced by a prime contractor and several tiers of subcontractors. Final assembly is performed by relatively few facilities compared with the numerous subassembly and parts manufacturers.

There has been substantial consolidation in recent years in the U.S. aerospace industry, due to declines in defense spending. The number of facilities and firms as well as sector value of shipments decreased from 1992 to 1996 in the U.S., but value of shipments have rebounded to levels comparable to the 1992 production levels in recent years. This is partially due to replenishing of stocks depleted during the bombing in Kosovo.

Growth in the industry is expected to come from lower cost air-to-air missiles, with strong focus on increasing efficiency in production by reducing costs. There has also been growth in consumer demand for direct-to-home television, voice and data transmission, and other satellite services which has increased the commercial demand for space vehicles needed to launch satellites.

The aerospace industry exports a substantial share of its output. Many North American and European governments with large defense budgets have been seeking to reduce their military budgets, while governments in South America (with smaller budgets) have been maintaining or increasing their defense spending. There has been substantial consolidation in the European aerospace industry, which has become more competitive with U.S. companies (U.S. EPA 1997; DRI/McGraw Hill 2000).

3.2.2 Aircraft

Trends in the aircraft sector are heavily influenced by changes in industry structure and in the international political-economic arena. There has been substantial restructuring through mergers and consolidation in the aircraft manufacturing industry, including producers of both aircraft and aircraft parts nationally and internationally. Firms are focused on improving efficiency through cost cutting efforts such as reduced staffing. Although there were significant production increases of new aircraft in 1998 and 1999, growth in production is now expected to level off as producers shift their focus to improving the efficiency of existing aircraft.

Global competition in the airline industry may also reduce the demand for U.S. aircraft products in the future. Trade agreements in the European Union (E.U.) are expected to limit the sale of U.S. engines and engine parts. In addition, there is a growing trend for U.S. producers to outsource many aircraft parts to firms in other nations, in order to bring down costs and compete internationally.

In addition to aircraft manufacturing, this sector includes rebuilding and repair of aircraft at manufacturers' facilities or at airports.[2] Maintenance and repair of aircraft has been influenced by strong growth in both passenger and commercial air traffic and by the maintenance requirements of older aircraft.

3.2.3 Electronic Equipment

The electronic equipment sector can be divided into two general groups of industries: microelectronics manufacturers and telecommunications equipment.

[2] EPA is proposing to cover wastewater generated from washing vehicles only when it occurs as a preparatory step prior to performing an MP&M unit operation (e.g., prior to disassembly to perform engine maintenance or rebuilding). The proposed rule does not cover the washing of cars, aircraft, or other vehicles when it is performed only for aesthetic/cosmetic purposes.

Microelectronics industries manufacture a wide range of products from electronic connectors to integrated circuit panels. These products are used as material inputs in many industries such as automotive, telecommunications, aerospace, computer, and medical equipment. The telecommunications industry also covers a range of industries. These industries are focused on the production of equipment used in network equipment, fiber optics, and wireless communication equipment.

While the microelectronics industry covers a diverse array of products, producers, and end-uses, there have been a number of general trends in the industry. The electronics sectors have shown very rapid growth over the last two decades. The U.S. is a major producer of electronic products, although Japan is the leading producer of consumer electronics. With a strong increase in the use of microelectronic products in industries throughout the economy, this has been a rapidly growing industry. U.S. firms face strong international competition for cutting edge technological advances in their products. Due to the high skill level necessary in the development of products, there is considerable competition for skilled labor. The recent growth in industry shipments is expected to continue, partially due to the Information Technology Agreement, which seeks to eliminate import duties on information technology products by 2000.

The telecommunications industries have also experienced considerable growth in the past few years. Much of the growth in the industry has come from the growing use of fiber optics and wireless end-user devices. Growth is expected to continue, due in part to the World Trade Organization's Agreement on Basic Telecommunications in 1998, which opened overseas markets to U.S. firms competing to develop telecommunications networks.

3.2.4 Hardware

The hardware sector consists of many different industries, which can be generally classified into three groups: building hardware, conventional hardware, and tooling hardware.

Building hardware consists of a group of industries that manufacture metal building products, including fabricated structural metal, sheet metal work, and architectural metalwork. This group of industries has been growing rapidly throughout the 1990's. The building products industry as a whole saw record sales in 1998 and again in 1999. Much of this growth is attributed to large highway projects funded by the Transportation Efficiency Act for the 21st Century.

Conventional hardware includes products such as screws, industrial fasteners, and valves and hose fittings. The products produced in this industry are used in the production of manufactured goods. Trends in this industry, therefore, generally reflect trends in other manufacturing industries. A primary industry influencing conventional hardware is the auto industry. Hardware producers have experienced pressures from end users such as auto makers to reduce costs.

The industry faces a continued trend of consolidation of firms and increasing global pressure from countries with low labor costs. Domestic producers of screws and industrial fasteners saw growth in the real value of shipments due to the strong U.S. economy.

The tooling hardware sector also contains a variety of different industries that produce various types of tools for different uses. Because these industries also face continued globalization, many of them are impacted by changes in the global economy. The decline in Asian markets in 1998 and 1999 resulted in a sharp decline in the value of shipments for the machine tooling industries. Prior to the 1998 financial crisis, value of shipments were increasing annually. The market for the power-driven segment of hand tools has increased, however, despite troubled overseas markets.

3.2.5 Household Equipment

There are three general groups of industries included in this sector: household furniture, household appliances, and plumbing equipment. Generally speaking, factors that affect this sector are consistent across these three groups. Low interest rates, low unemployment, and increased disposable income have stimulated growth in each of these industries. Higher interest rates due to intervention from the Federal Reserve and higher consumer prices for energy could result in a leveling off in this industry. Furthermore, all three industries face international competition as imports account for a substantial share of domestic consumption.

Metal furniture accounts for 20 percent of the household furniture industry. Metal components are increasingly being added to non-metal furniture. For example, there is a trend to increase the functionality of non-metal furniture by equipping recliners with heat and massage. This could increase the industry's reliance on metal parts. The industry has integrated vertically, as large manufacturers have begun to open their own retail stores in an effort to differentiate their products.

There are two groups of household appliance manufacturers. Major appliances such as washing machines and refrigerators are produced by relatively few firms. Smaller appliances are characterized by little product differentiation but considerable price competition and are manufactured by a larger number of companies.

Finally, a significant characteristic of the plumbing equipment market is the extent of U.S. dependence on foreign imports. While the U.S. construction market has grown at a record pace in the past few years, increasing demand for plumbing equipment, much of the demand has been served by imports and this industry has a trade deficit.

3.2.6 Instruments

The instruments sector is characterized by a diverse array of technologically advanced products and intense global competition among many firms of varying sizes. The sector can be generally divided into industrial measuring and testing instruments, and medical instruments.

In the industrial measuring industry, producers of laboratory instruments are typically integrated firms who have consolidated and reduced costs in response to pressures from medical and pharmaceutical customers. Producers of measuring devices are also facing pressures to consolidate. These firms have been hurt by low commodity prices during the past few years, which have led to reduced investment in measuring equipment by fuel and grain producers. Sales should rebound, however, if Asian economies and fuel prices continue to grow. Small companies still dominate the electronic test equipment industry, which is characterized by a high degree of product differentiation. Most of these firms are not large enough to export products.

Sales for medical devices increased steadily throughout the 1990's, while employment remained relatively constant. The industry has historically been characterized by many small to mid-size firms and intense competition for technological innovation. Efforts to bring down health care costs is one of the primary challenges facing this industry. Pressure to reduce costs has reduced insurance companies' willingness to pay for new equipment. As the population ages, however, demand for medical services and devices is expected to grow. The industry should continue to grow through 2004 at a rate of 8 to 10 percent, which is somewhat less than growth in recent years.

3.2.7 Iron and Steel

The basic iron and steel industry is regulated under 40 CFR 420, and primary iron and steel works, blast furnaces and rolling mills are not affected by the proposed MP&M rule. The proposed MP&M rule will regulate facilities that perform MP&M operations or cold forming operations on steel wire, rod, bar, pipe, or tube. This subcategory does not include facilities that perform those operations on base materials other than steel, nor does it include wastewater generated from performing any hot steel forming operations or wastewater from cold forming, electroplating or continuous hot dip coating of steel sheet, strip, or plates.

Events in the global steel industry in the past few years have had significant and possibly far reaching impacts on domestic producers. In 1998, the industry experienced a global steel crisis. This crisis was caused in part by the

Asian financial crisis, which triggered a sharp decline in imports of steel by major steel importing countries of Asia. This led to a flood of steel imports into U.S., and U.S. steel imports rose 33 percent in 1998. The situation was made worse by global overcapacity largely derived from producers in Russia and Latin America.

This flood of steel into the U.S. and Europe led to rapidly declining steel prices in both regions. The "unfair" trading prices resulted in over 20 nations taking formal trade protection actions such as import duties and price floors. Excess inventories that accrued during the surge of imports hurt domestic producers. These inventories were expected to be exhausted by 2000. The steel industry is projected to grow along with the economy at a rate of 1 to 2 percent per year through 2004.

3.2.8 Job Shops

MP&M metal finishing job shops are defined as those facilities with more than 50 percent of their revenues coming from products not owned by the site. While there are specific SIC codes associated with some Metal Finishing Job Shops, they sell to a variety of markets and are not a market in and of themselves.

3.2.9 Motor Vehicle and Bus & Truck

The major trend in these industries is the continual consolidation of firms into globalized manufacturers. Motor vehicle manufacturers are no longer constrained within national boundaries, as mergers and joint ventures include some of the largest firms from different countries. Many foreign owned manufacturers have facilities located in the U.S., and relative production costs and exchange rates play a greater role in determining the location of production facilities than the national identity of parent companies.

Manufacturers have increasingly standardized the design of motor vehicles and their parts. These changes have resulted in much less product differentiation among manufacturers, but also in greater product quality. However, greater product quality has resulted in a consistently sharp increase in price over the past three decades. This price increase may have reached its pinnacle as prices have declined in 1998 and 1999. The real value of shipments for automobiles increased 1.3 percent between 1996 and 2000.

3.2.10 Mobile Industrial Equipment

Mobile industrial equipment is divided among a number of different industry segments that produce machinery for different sets of end-users. Growth in the construction equipment industry is typically tied to economic factors such as housing starts, employment, and consumer confidence. Shipments of construction equipment have risen steadily during much of the 1990's. However, they have begun to level off in 1999 and 2000. This is partially due to a decline in demand caused by the Asian crisis, but may also reflect a slowdown in the residential construction market. This decline in demand may be offset by new spending from Federal, State, and local governments in response to the 1998 Transportation Equity Act for the 21st Century.

The farm and mining machinery industries both have been suffering from low commodity prices. Both industries experienced growth in shipments throughout much of the 1990's, but were hit in1999 by low prices. Farm equipment was hit hardest as the real value of shipments fell by 38 percent in 1999. Output is expected to continue to decrease until grain surpluses decline and agricultural prices rise. Declining world prices is only one of a number of trends impacting the industry for agricultural production equipment. The consolidation of farms has also had a significant in impact on this industry. With the increase in farm size, there is growing dependence upon mechanization to farm more acres per farm.

3.2.11 Office Machine

The office machine sector is a rapidly growing and dynamic global market. The industry has experienced 7.8 percent growth in the real value of shipments between 1996 and 2000. While this growth was accomplished with only a 1.3 percent increase in total employment, production employment increased by 5.4 percent. The relative difference between total and production employment can be attributed to increasing reliance on the Internet for sales, thereby reducing the need for non-production employment. The industry has undergone mergers and acquisitions to bring down costs in order to compete. Firms also rely on joint venturing agreements. Firms are forming alliances with past competitors to produce complementary components of new technologies. Consolidation also allows firms to diversify, providing a range of products such as PCs, software, and information technology to protect against the strong competition in the market for any one product. Firms have also increasingly outsourced production to electronics manufacturers more equipped to increase production and take advantage of economies of size, while the original firms utilize their resources for research and development of new technologies to stay competitive.

Globalization is an important trend in this industry as machine components are produced in different countries. Despite the trend toward a globalized market, the U.S. has held a negative trade balance for over a decade. In recent years, this has partially been due to the Asian financial crisis. As Asian economies continue to recover the trade balance is expected to improve for the U.S.

3.2.12 Precious Metals and Jewelry

Domestic production in this industry is dominated by many small firms, mostly concentrated in the northeast U.S., and is impacted by trends in consumer behavior and the retail market. Global competition has a significant impact on the competitiveness of domestic firms. These factors have provided both favorable and unfavorable conditions to the industry.

Strong consumer spending on precious metals and costume jewelry has been fueled by increased disposable income. Devaluation in the price of gold due to declining world prices has also benefitted the industry because it reduces the cost of making jewelry.

Increases in spending have not necessarily translated into gains for domestic producers. The lowering of tariffs has resulted in a steady increase in imports of costume jewelry, as labor-intensive production is often less expensive in developing countries. Domestic producers are also hurt by the strong U.S. dollar, which makes U.S. exports more expensive. Another challenge comes from the retail market, which has put strong pressure on producers to bring down prices in order to compete. These challenges include consolidation of retailers, giving them greater purchasing power, increased Internet and television home shopping, and a decrease in the number of wholesalers. The *U.S. Industry & Trade Outlook 2000* projects minimal growth in the precious metals industry of 1 percent through 2004 and a decline in costume jewelry of 2 percent.

3.2.13 Printed Wiring Boards

Printed wiring boards (also referred to as printed wiring boards) are the physical structures on which electronic components such as semiconductor and capacitors are mounted. Computers and communications are the largest uses for printed wiring boards. In addition, printed wiring boards are used in a wide array of other products, including toys, radios, television sets, electronic wiring in cars, guided-missile and airborne electronic equipment, biotechnology, medical devices, digital imaging equipment, and industrial control equipment.

While some producers of PWBs produce them for their own use, most manufacturers are independent firms that sell PWBs to the open market. The majority of PWB manufacturers are small firms.

The domestic industry has experienced considerable growth throughout the 1990's. There is growing international pressure to bring down costs, however, in order to compete in the global economy. The real value of shipments grew nine percent from 1996 to 2000. Growth has been spurred by continual growth in end-use markets. In addition to the increase value of shipments, U.S. firms have seen a 5.6 percent increase in average hourly earnings and a 16.3 percent increase in capital expenditures. High costs inhibit the competitiveness of U.S. firms as they are already facing tight competition from Asian producers. Consequently, many of the larger firms are looking to relocate offshore.

3.2.14 Railroad

Railroad service consists of both freight and passenger service. In the past few years, railroad companies have been focusing on improving the efficiency of their lines and services. There has been a continued trend toward consolidation of major freight railroads. Consequently, companies have reduced the number of lines and focused attention on increasing the capacity of fewer lines.

Since the 1980's railroad traffic increased by 50 percent, while the line network decreased by 39 percent. This was accomplished by increasing capital expenditures for equipment such as new locomotives with greater horsepower, installation of double tracks, and increases in the capacity of non-railroad owned freight cars. Consequently, freight service saw the first increase in operating revenue since 1984, although this was coupled with sharp decreases in employment. Passenger service has undergone similar changes to increase efficiency by adding new locomotives and beginning a transition to high speed train service.

3.2.15 Ships and Boats

Ship manufacturing has experienced continual declines throughout the 1990's. Despite efforts by the Federal Government to stimulate investment in converting the industry from production of military ships to merchant ships, the U.S. Navy remains the primary customer of shipbuilders. The U.S. Navy has dramatically reduced its orders for new vessels since the end of the Cold War, and decommissioned many ships and submarines. The Navy decreased its fleet by 208 ships from 1985 to 1998. Although the Navy plans to add 66 new ships through construction and conversion from 2000 through 2004, this represents a decline of over 60 percent in the procurement of new ships since the 1980's. The ship building industry should be helped, however, by the Oil Pollution Act of 1990, which requires all oil tankers entering U.S. ports to have double hulls.

This sector also manufactures boats, with sales that reflect overall trends in recreational expenditures. The U.S. boat building business is the world’s leading supplier of recreational craft. Rapid growth in the market for smaller personal water craft (e.g., jet skis) has led to an increase in imports of boats.

3.2.16 Stationary Industrial Equipment

The stationary industrial equipment sector includes machinery used in a number of industries, as well as machinery parts. These industries produce machinery used for oil, paper, and food production, printing and packaging, as well as heaters and air conditioners, electric generating equipment, and motor generators. These industries also produce large metal-working machines used in making parts for other industries.

The industries supplying oil and gas production, paper production, and printing machinery were impacted by similar global factors, and consequently followed similar trends. Oil production was impacted by low petroleum prices in 1998. Gas production has also been influenced by low oil prices, which puts pressure on the gas industry to reduce costs in order to compete. These factors led to a decline of 38 percent in the real value of shipments in 1998 and 1999, although the price of petroleum has increased in 1999 and 2000 and machinery shipments grew 9.2 percent.

Paper manufacturing equipment has also suffered from events overseas. Although the U.S. has seen a decline in the production of paper throughout the latter half of the 1990's, the U.S. remains the largest producer of paper manufacturing machinery. The industry therefore relies heavily on exports to sustain growth. With struggling economies overseas, the industry saw a decline in the annual value of shipments from 1996 to 2000. The printing industry was also impacted by the Asian economy. Printing machinery manufacturers realized strong growth during the first half of the 1990's due to increased demand for new digital presses, but a decline in exports resulted in slower growth for the later half of the decade. Global events did not have such an impact on manufacturers of packaging machinery, as the U.S. is not only the leading producer of this equipment but also its leading end-user.

A variety of industries manufacture equipment used to produce energy or to power equipment. Refrigeration, air conditioning, and heating equipment sales tend to follow growth in housing starts and construction of new office buildings. A number of factors contributed to strong growth in this industry throughout the 1990's including record housing starts, record heat in the summer of 1999, replacement of chlorofluorocarbon (CFC) air conditioning units, and a large percentage of new homes being built with central air conditioning. With 66 percent of the existing air conditioners containing CFC technology still in operation, replacement of these machines provides an opportunity for growth in this industry in the future. However, with rising interest rates in the past few years, housing starts are expected to slow, which should moderate growth.

Turbines, transformers, and switchboards are all used for the production of electricity, which saw considerable growth from 1990 to 1998 as the domestic economy grew. This growth was also impacted by the financial crisis in Asia, however. A number of advanced technologies have been developed to meet the demands of a deregulated industry. These technologies are capable of producing electricity from smaller facilities at competitive costs. Implementation of these technologies is not expected to take place for a few years, however, as the effects of deregulation become clearer. Consequently, growth is expected to be slow through 2004.

3.3 Characteristics of MP&M Manufacturing Sectors

The analyses presented in this section cover a nine year period from 1988 to 1996. The data come primarily from the 1992 *Economic Censuses* and from the *Annual Survey of Manufactures* for other years. Data are presented over nine years rather than ten because data are incomplete in the *Annual Survey of Manufactures* for many SIC codes in 1987. OMB reclassified a number of 4-digit SIC industries in 1987 which made it difficult to compare SIC codes before and after this reclassification.

Trends in dollar values are shown in real terms, using the ***Producer Price Index*** **(PPI)** for industrial commodities. The PPI is family of indexes that measure price changes from the perspective of the seller. This profile uses the PPI to inflate nominal monetary values to constant dollars. The PPI for industrial commodities increased slightly every year between 1987 and 1996. Table 3.3 shows the index values for the relevant years.

Table 3.3: Producer Price Index for Industrial Commodities

Year	Producer Price Index (PPI)	Percent Change
1987	102.6	n/a
1988	106.3	3.6%
1989	111.6	5.0%
1990	115.8	3.8%
1991	116.5	0.6%
1992	117.4	0.8%
1993	119	1.4%
1994	120.7	1.4%
1995	125.5	4.0%
1996	127.3	1.4%

Source: Bureau of Labor Statistics, Producer Price Index.

3.3.1 Domestic Production

a. Output

The two most common measures of manufacturing output are ***value of shipments*** (VOS) and ***value added*** (VA). Historical trends in these measures provide insight into the overall economic health of an industry. Value of shipments is the sum of the receipts a manufacturer earns from the sale of its outputs. It is an indicator of the overall size of a market or the size of a firm in relation to its market or competitors. Value added is used to measure the value of production activity in a particular industry. It is the difference between the value of shipments and the value of purchased non-labor inputs used to make the products sold.

Table 3.4 presents the trend in value of shipments and value added by MP&M sector during the period 1988 to 1996.

The aerospace and ordnance industries experienced a significant decline in VOS and VA over this period. Aerospace value of shipments had a negative average annual growth rate of 7.6 percent, due to the decreased military spending during the last. Aerospace VOS has risen in recent years, however, due in part to replenishing of stocks depleted during the bombing in Kosovo. Railroad equipment manufacturers enjoyed an average annual growth of 7.6 percent in VOS, after some years of decline. Electronic equipment experienced the next largest average growth, with annual growth in VOS averaging 5.1 percent, due primarily to the rapid growth in the use of microelectronics in industries throughout the economy. Ship and boat manufacture experienced continual declines throughout the 1990's. The U.S. Navy remains the primary customer of shipbuilders and the Navy has reduced its fleet since the end of the Cold War.

Table 3.4: Real Value of Shipments and Value Added: MP&M Manufacturing Sectors (millions, $1996)

Sector	Value of Industry Shipments			Value Added by Manufacture		
	1988	1996	Average Annual Growth Rate	1988	1996	Average Annual Growth Rate
Aerospace	33,763	17,928	-7.6%	22,671	9,986	-9.7%
Aircraft	95,268	83,394	-1.7%	48,492	45,220	-0.9%
Bus & Truck	9,234	13,473	4.8%	3,398	5,172	5.4%
Electronic Equipment	80,206	119,464	5.1%	45,837	62,919	4.0%
Hardware	143,151	169,567	2.1%	77,528	92,566	2.2%
Household Equipment	82,331	92,649	1.5%	39,958	42,731	0.8%
Instruments	110,998	127,935	1.8%	73,322	83,540	1.6%
Iron and Steel	18,195	18,727	0.4%	6,781	6,663	-0.2%
Job Shops	11,007	14,003	3.1%	6,536	7,793	2.2%
Mobile Industrial Equipment	42,355	52,683	2.8%	20,034	22,798	1.6%
Motor Vehicle	296,102	363,557	2.6%	100,400	122,541	2.5%
Office Machine	81,007	103,270	3.1%	40,346	41,135	0.2%
Ordnance	9,607	5,222	-7.3%	6,221	3,528	-6.8%
Other Metal Products	55,169	60,034	1.1%	33,808	35,114	0.5%
Precious Metals and Jewelry	10,122	8,670	-1.9%	4,707	4,130	-1.6%
Printed Wiring Boards	9,533	10,702	1.5%	5,560	6,564	2.1%
Railroad	3,935	7,067	7.6%	1,776	2,590	4.8%
Ships and Boats	17,638	15,634	-1.5%	9,462	7,903	-2.2%
Stationary Industrial Equipment	166,007	221,591	3.7%	91,360	117,678	3.2%
Total	**1,275,628**	**1,505,570**	**2.1%**	**638,197**	**720,571**	**1.5%**

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

b. Number of facilities and firms

Table 3.5 shows the number of facilities between 1989 and 1996 and the number of firms between 1990 and 1996. The aerospace industry is the only MP&M manufacturing sector experiencing significant downsizing, with the numbers of firms and facilities decreasing annually by 4.1 and 4.2 percent, respectively. The iron and steel industry experienced a modest decrease in number of firms and facilities.

Table 3.5: Number of Firms and Facilities: MP&M Manufacturing Sectors

Sector	Number of Firms			Number of Facilities		
	1990	1996	Average Annual Growth Rate	1989	1996	Average Annual Growth Rate
Aerospace	109	85	-4.1%	143	106	-4.2%
Aircraft	1,428	1,486	0.7%	1,633	1,691	0.5%
Bus & Truck	889	953	1.2%	1,016	1,040	0.3%
Electronic Equipment	5,649	6,180	1.5%	6,396	6,693	0.7%
Hardware	34,984	37,832	1.3%	37,861	40,044	0.8%
Household Equipment	6,787	7,563	1.8%	7,914	8,303	0.7%
Instruments	7,963	9,730	3.4%	8,959	10,552	2.4%
Iron and Steel	597	583	-0.4%	784	770	-0.3%
Job Shop	4,798	5,280	1.6%	5,104	5,549	1.2%
Mobile Industrial Equipment	3,318	3,341	0.1%	3,606	3,591	-0.1%
Motor Vehicle	4,991	6,044	3.2%	5,977	7,024	2.3%
Office Machine	1,828	2,002	1.5%	2,050	2,087	0.3%
Ordnance	340	421	3.6%	385	442	2.0%
Other Metal Products	11,517	13,819	3.1%	12,069	14,198	2.3%
Precious Metals and Jewelry	3,719	3,867	0.7%	3,870	3,892	0.1%
Printed Wiring Boards	1,034	1,452	5.8%	1,046	1,530	5.6%
Railroad	147	152	0.6%	180	215	2.6%
Ships and Boats	2,511	3,195	4.1%	2,708	3,310	2.9%
Stationary Industrial Equipment	35,231	40,618	2.4%	37,261	42,317	1.8%
Total	**127,840**	**144,603**	**2.1%**	**138,962**	**153,354**	**1.4%**

Source: Small Business Administration, Statistics of U.S. Businesses.

c. Employment

Employment is a measure of the level and trend of activity in an industry. While employment growth generally signals economic strength in an industry, strong productivity growth and scale economies can yield growth in revenues that exceeds growth in employment.

Table 3.6 shows that employment in the MP&M manufacturing sectors as a whole decreased modestly between 1988 and 1997, declining at an average rate of 0.7 percent annually. The aerospace, ordnance, and aircraft sectors experienced the largest decreases in employment from 1988 to 1996. The electronic equipment sector showed the most growth in output but had less than 0.01 percent increase in employment, reflecting an increase in real productivity.

Table 3.6: Employment: MP&M Manufacturing Sectors

Sector	Number of Employees		
	1988	**1996**	**Average Annual Growth Rate**
Aerospace	223,700	81,000	-11.9%
Aircraft	596,600	376,800	-5.6%
Bus & Truck	63,900	67,700	0.7%
Electronic Equipment	602,500	604,800	0.0%
Hardware	1,246,200	1,307,600	0.6%
Household Equipment	584,900	570,600	-0.3%
Instruments	886,500	753,800	-2.0%
Iron and Steel	65,500	67,900	0.5%
Job Shops	123,300	129,200	0.6%
Mobile Industrial Equipment	232,400	232,600	0.0%
Motor Vehicle	928,000	974,000	0.6%
Office Machine	329,800	259,100	-3.0%
Ordnance	86,500	40,200	-9.1%
Other Metal Products	368,100	361,400	-0.2%
Precious Metals and Jewelry	87,100	65,800	-3.4%
Printed Wiring Boards	80,900	88,300	1.1%
Railroad	25,900	30,600	2.1%
Ships and Boats	182,900	141,300	-3.2%
Stationary Industrial Equipment	1,269,800	1,396,900	1.2%
Total	**7,984,500**	**7,549,600**	**-0.7%**

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

d. Capital expenditures

New capital expenditures are needed to modernize, expand, and replace existing capacity to meet growing demand. Table 3.7 presents new capital expenditures by sector. In general, the MP&M industries increased their capital expenditures by 4.3 percent annually. The only sectors that had a decline in spending on new capital were aerospace, aircraft, ordnance, and ships and boats.

Table 3.7: New Capital Expenditures: MP&M Manufacturing Sectors (millions, $1996)

Sector	1988	1996	Average Annual Growth Rate
Aerospace	1,229	490	-10.9%
Aircraft	2,828	2,023	-4.1%
Bus & Truck	151	200	3.6%
Electronic Equipment	2,925	4,205	4.6%
Hardware	3,299	5,276	6.0%
Household Equipment	2,017	2,454	2.5%
Instruments	3,754	4,533	2.4%
Iron and Steel	394	584	5.0%
Job Shops	331	724	10.3%
Mobile Industrial Equipment	1,052	1,052	0.0%
Motor Vehicle	5,344	12,045	10.7%
Office Machine	2,856	2,917	0.3%
Ordnance	184	85	-9.2%
Other Metal Products	1,659	1,875	1.5%
Precious Metals and Jewelry	87	146	6.7%
Printed Wiring Boards	403	585	4.8%
Railroad	73	97	3.6%
Ships and Boats	453	351	-3.1%
Stationary Industrial Equipment	4,065	6,775	6.6%
Total	**33,104**	**46,417**	**4.3%**

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

3.3.2 Industry Structure and Competitiveness

This profile shows facility and firm size and data on foreign trade as measures of industry structure and competitiveness in MP&M manufacturing.

a. Facility size

In general, the MP&M industries are characterized by a large number of small businesses. Table 3.8 shows that approximately 98 percent of all MP&M facilities employ 500 employees or less. However, those facilities only account for 39 percent of the value of shipments. Hardware and stationary industrial equipment represent 55 percent of the facilities employing 19 people or less.

Table 3.8: Number of Facilities and Value of Shipments by Facility Employment Size Category: MP&M Manufacturing Sectors

Sector	Number of Facilities					Value of Shipments (millions, $1992)				
	1 to 19	20 to 99	100 to 499	500 to 2,499	2,500 or more	1 to 19	20 to 99	100 to 499	500 to 2,499	2,500 or more
Aerospace	39	23	35	24	19	207	70	1,045	5,601	20,151
Aircraft	900	466	257	85	37	551	2,208	7,053	26,194	68,778
Bus & Truck	557	313	128	17	0	411	1,636	3,854	2,240	0
Electronic Equipment	3,898	2,207	934	154	17	2,316	10,483	24,378	37,418	6,786
Hardware	26,790	10,866	2,247	151	1	15,861	47,999	49,569	14,341	0
Household Equipment	5,160	2,165	1,050	171	8	2,950	10,215	31,278	29,064	2,044
Instruments	6,295	2,490	1,152	296	31	3,901	12,778	32,448	44,457	18,324
Iron and Steel	297	278	182	15	0	397	3,469	8,147	2,956	0
Job Shop	3,651	794	144	2	0	1,725	3,580	3,262	0	0
Mobile Industrial Equipment	2,362	927	326	63	8	1,578	5,009	10,815	18,093	0
Motor Vehicle	3,604	1,625	1,002	235	72	2,714	9,256	34,923	105,710	112,831
Office Machine	1,370	526	232	83	16	1,197	4,714	11,994	27,405	21,437
Ordnance	264	77	58	26	4	94	281	1,769	4,851	0
Other Metal Products	10,483	2,207	558	59	4	4,384	9,139	14,960	23,475	0
Precious Metals and Jewelry	3,251	528	120	11	0	1,643	2,370	3,731	243	0
Printed Wiring Boards	735	423	149	16	1	367	1,614	2,510	2,821	0
Railroad	83	81	30	10	2	92	596	1,102	2,799	0
Ships and Boats	2,373	467	182	25	6	851	1,822	3,947	2,222	6,366
Stationary Industrial Equipment	29,234	7,799	2,101	294	10	13,950	33,892	59,180	43,331	4,337
Total	**101,346**	**34,262**	**10,887**	**1,737**	**236**	**55,188**	**161,132**	**305,963**	**393,220**	**261,054**

Source: Department of Commerce, Bureau of the Census, Census of Manufactures, 1992.

b. Firm size

The Small Business Administration (SBA) defines small businesses according to the firms' number of employees. Table 3.9 shows that 141,048 (92 percent) of all MP&M manufacturing facilities are owned by firms that employ 500 or fewer workers and would therefore be considered small businesses. The remaining 12,306 facilities are owned by firms that employ more than 500 workers and account for 72 percent of total estimated receipts.

Table 3.9: Number of Firms, Facilities, and Estimated Receipts by Firm Employment Size Category, 1996: MP&M Manufacturing Sectors

Sector	Firms			Facilities			Estimated Receipts (millions, $1996)		
	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more
Aerospace	51	2	32	51	2	53	0	0	17,851
Aircraft	1,209	135	142	1,212	158	321	2,301	2,664	88,050
Bus & Truck	805	92	56	810	107	123	2,129	2,475	6,287
Electronic Equipment	4,936	681	563	4,977	786	930	11,404	16,279	76,563
Hardware	34,162	2,345	1,325	34,398	2,968	2,678	62,437	39,927	57,501
Household Equipment	6,408	665	490	6,455	791	1,057	12,007	16,334	62,299
Instruments	8,273	727	730	8,320	842	1,390	16,180	15,238	90,897
Iron and Steel	362	108	113	368	153	249	1,890	4,152	11,949
Job Shops	4,945	240	95	5,001	338	210	6,714	3,271	2,905
Mobile Industrial Equipment	2,875	263	203	2,898	319	374	6,255	5,930	30,140
Motor Vehicle	4,950	614	480	4,987	724	1,313	10,614	20,053	343,942
Office Machine	1,662	167	173	1,668	180	239	5,040	7,069	60,436
Ordnance	358	25	38	358	28	56	309	425	3,952
Other Metal Products	13,097	492	230	13,152	602	444	12,728	10,073	28,778
Precious Metals and Jewelry	3,747	86	34	3,753	89	50	3,339	1,894	2,015
Printed Wiring Boards	1,250	137	65	1,258	150	122	2,093	2,253	5,412
Railroad	99	24	29	101	30	84	306	465	5,883
Ships and Boats	3,003	137	55	3,012	165	133	2,532	2,771	10,789
Stationary Industrial Equipment	37,669	1,691	1,258	37,835	2,002	2,480	49,438	33,418	111,831
Total	**129,861**	**8,631**	**6,111**	**130,614**	**10,434**	**12,306**	**207,715**	**184,691**	**1,017,479**

Source: Small Business Administration, Statistics of U.S. Businesses, 1996.

c. Foreign trade

This profile uses two measures of foreign competitiveness: ***export dependence*** and ***import penetration***. Export dependence is the share of value of shipments that is exported. Import penetration is the share of domestic consumption met by imports. For both measures, a high value indicates a relatively high dependence on foreign markets.

Table 3.10 shows that in the U.S., the four industries with the highest level of domestic consumption were motor vehicles, stationary industrial equipment, hardware, and electronic equipment. Of these four industries, stationary industrial equipment is the only industry with positive net exports (exports minus imports) in 1999. Overall, the U.S. was a net importer of MP&M manufactured goods. The table also shows that there is global competition in many of the MP&M industries, which is illustrated by the number of industries that have both large export dependence and import penetration. For example, roughly 89 percent of U.S. consumption of precious metals is met by imports, while almost 70 percent of U.S. production is sold as exports.

Table 3.10: Trade Statistics, 1999: MP&M Manufacturing Sectors

Sector	Value of Imports (millions, 1999$)	Value of Exports (millions, 1999$)	Value of Shipments (millions, 1999$)	Implied Domestic Consumption[a]	Import Penetration[b]	Export Dependence[c]
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Aerospace	250	276	17,816	17,789	1.4%	1.6%
Aircraft	23,725	60,749	82,870	45,846	51.7%	73.3%
Bus & Truck	740	691	13,388	13,437	5.5%	5.2%
Electronic Equipment	61,944	37,355	118,714	143,303	43.2%	31.5%
Hardware	30,221	21,850	168,502	176,873	17.1%	13.0%
Household Equipment	50,530	14,664	92,066	127,933	39.5%	15.9%
Instruments	24,404	36,421	127,131	115,114	21.2%	28.6%
Iron and Steel	1,070	341	18,609	19,338	5.5%	1.8%
Job Shops[d]			13,915			
Mobile Industrial Equipment	13,473	14,222	52,352	51,604	26.1%	27.2%
Motor Vehicle	161,632	64,800	361,272	458,104	35.3%	17.9%
Office Machine	63,717	47,637	102,621	118,701	53.7%	46.4%
Ordnance	717	2,147	5,189	3,758	19.1%	41.4%
Other Metal Products	27,573	10,415	59,657	76,815	35.9%	17.5%
Precious Metals and Jewelry	20,444	6,007	8,616	23,053	88.7%	69.7%
Printed Wiring Boards	2,265	2,570	10,634	10,330	21.9%	24.2%
Railroad	2,056	1,238	7,023	7,840	26.2%	17.6%
Ships and Boats	1,062	1,612	15,536	14,987	7.1%	10.4%
Stationary Industrial Equipment	48,319	57,313	220,198	211,204	22.9%	26.0%
Total	**534,141**	**380,305**	**1,496,107**	**1,649,943**	**32.4%**	**25.4%**

a. Implied domestic consumption based on value of shipments, imports, and exports [column d + column b - column c].
b. Import penetration based on implied domestic consumption and imports [column b / column e].
c. Export dependence based on value of shipments and exports [column c / column d].
d. As explained in the text, job shops include only two SICs specific to job shops, and not facilities in other SICs that may be operating as job shops.
Note: components may not sum to totals due to rounding.
Source: Department of Commerce, Bureau of the Census.

Table 3.11 shows the change in the value of exports and imports from 1996 to 1999. In 1996 the U.S. had negative net exports from MP&M industries, reflecting a trade deficit of $70.6 million. That trade deficit increased in 1999 by roughly $83.2 million to about $153.8 million. As is discussed in greater detail in Section 3.4, exports for a number of the MP&M industries grew slower from 1996 to 1999 than in previous years due to financial crises in Asia and Latin America, while the strong domestic economy and low commodity prices resulted in increased growth in imports.

Table 3.11: Exports and Imports: MP&M Manufacturing Sectors

Sector	Value of Imports (millions, 1999$)			Value of Exports (millions, 1999$)		
	1996	1999	Average Annual Growth Rate	1996	1999	Average Annual Growth Rate
Aerospace	133	250	23.4%	133	276	27.6%
Aircraft	13,065	23,725	22.0%	38,479	60,749	16.4%
Bus & Truck	382	740	24.7%	406	691	19.4%
Electronic Equipment	29,344	61,944	28.3%	28,539	37,355	9.4%
Hardware	24,939	30,221	6.6%	19,166	21,850	4.5%
Household Equipment	37,938	50,530	10.0%	15,669	14,664	-2.2%
Instruments	17,702	24,404	11.3%	29,329	36,421	7.5%
Iron and Steel	874	1,070	7.0%	245	341	11.7%
Job Shops						
Mobile Industrial Equipment	10,044	13,473	10.3%	15,506	14,222	-2.8%
Motor Vehicle	115,783	161,632	11.8%	56,878	64,800	4.4%
Office Machine	62,534	63,717	0.6%	44,543	47,637	2.3%
Ordnance	604	717	5.9%	2,603	2,147	-6.2%
Other Metal Products	23,568	27,573	5.4%	10,481	10,415	-0.2%
Precious Metals and Jewelry	14,765	20,444	11.5%	4,295	6,007	11.8%
Printed Wiring Boards	2,486	2,265	-3.1%	1,815	2,570	12.3%
Railroad	1,126	2,056	22.2%	720	1,238	19.8%
Ships and Boats	1,008	1,062	1.8%	1,007	1,612	17.0%
Stationary Industrial Equipment	36,178	48,319	10.1%	52,049	57,313	3.3%
Total	**392,473**	**534,142**	**10.8%**	**321,863**	**380,308**	**5.7%**

Source: Department of Commerce, Bureau of the Census.

3.3.3 Financial Condition and Performance

Operating margin is a partial measure of industry financial performance. Operating margin is defined as VOS less annual payroll and cost of materials as a percent of VOS. This is a partial measure of profitability, as it does not take into account costs associated with capital expenditures or energy.

Table 3.12 presents the operating margins for each industry for the years 1988 and 1996, as well as the change in operating margin between the two years. Table 3.12 shows that ten MP&M manufacturing sectors experienced increases in their operating margins during the time period, while nine industries experienced decreases. The greatest increases in operating margin occurred in the aircraft, motor vehicles, and bus & truck industries, and the greatest decreases occurred in the aerospace, office machine, and other metal products industries. Ten industries had increases greater than 1 percentage point, and four had operating margins that decreased by more than 1 percentage point.

Table 3.12: Operating Margin: MP&M Manufacturing Sectors (millions, $1996)

Sector	1988	1996	Change in Operating Margin
Aerospace	32.4%	28.9%	-3.5%
Aircraft	20.6%	26.7%	6.1%
Bus & Truck	18.5%	24.4%	5.9%
Electronic Equipment	32.0%	33.8%	1.8%
Hardware	27.5%	29.7%	2.2%
Household Equipment	29.7%	29.5%	-0.2%
Instruments	37.1%	41.1%	4.0%
Iron and Steel	23.2%	22.9%	-0.3%
Job Shops	31.8%	30.8%	-1.0%
Mobile Industrial Equipment	27.9%	28.2%	0.3%
Motor Vehicle	20.9%	22.4%	1.5%
Office Machine	31.7%	30.2%	-1.5%
Ordnance	34.3%	39.6%	5.3%
Other Metal Products	41.9%	40.4%	-1.5%
Precious Metals and Jewelry	27.9%	28.2%	0.3%
Printed Wiring Boards	37.2%	36.8%	-0.4%
Railroad	22.4%	22.1%	-0.3%
Ships and Boats	23.2%	22.5%	-0.7%
Stationary Industrial Equipment	29.4%	31.5%	2.1%

Operating Margin is calculated as (value of shipments - cost of materials - payroll)/value of shipments
Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufactures.

3.4 Characteristics of MP&M Non-Manufacturing Sectors

Eleven of the 18 MP&M sectors include non-manufacturing industries. The non-manufacturing activities are defined by 50 4-digit SIC codes: 26 transportation SIC codes, 18 service SIC codes, five retail trade SIC codes, and one wholesale trade SIC code. MP&M facilities may perform both manufacturing and non-manufacturing activities.

The analyses presented in this section cover 1992 only, because the Census does not collect data annually for non-manufacturing SICs as it does for manufacturers in the Annual Survey of Manufacturers. The profile is based on data from the 1992 Censuses of Transportation, Communications, and Utilities; Service Industries; Retail Trade; and Wholesale Trade.

3.4.1 Domestic Production

a. Output

Table 3.13 shows sales or receipts by sector for the MP&M non-manufacturing SIC codes. Motor vehicles repair and maintenance accounts for almost 66 percent of the total MP&M non-manufacturing sales and receipts.

Table 3.13: Sales/Receipts: MP&M Non-Manufacturing Sectors (millions, $1992)

Sector	Output [a]	Share
Aircraft	6,168	0.8%
Bus & Truck	143,806	18.6%
Household Equipment	2,193	0.3%
Instruments	6,648	0.9%
Motor Vehicle	506,487	65.7%
Office Machine	13,030	1.7%
Other Metal Products	16,488	2.1%
Precious Metals and Jewelry	275	0.0%
Railroad	28,349	3.7%
Ships and Boats	29,207	3.8%
Stationary Industrial Equipment	18,669	2.4%
Total	**771,319**	**100.0%**

a. Total sales for retail and wholesale trade, total receipts for service industries, total revenue for transportation.
Source: Department of Commerce, Bureau of the Census, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1992.

b. Number of facilities and firms

Table 3.14 shows the number of facilities and firms in the MP&M non-manufacturing sectors, with average annual growth rates. There was a positive growth rate from 1989 to 1996 in all of the industries. Office machines, aircraft, bus and truck, and ships and boats were the fastest growing over the time period. The number of office machine facilities grew by approximately 20 percent annually.

Table 3.14: Number of Firms and Facilities: MP&M Non-Manufacturing Sectors

Sector	Number of Firms			Number of Facilities		
	1990	1996	Average Annual Growth Rate	1989	1996	Average Annual Growth Rate
Aircraft	2,024	3,281	8.4%	2,463	4,062	7.4%
Bus & Truck	74,719	113,840	7.3%	88,128	127,675	5.4%
Household Equipment	3,234	3,706	2.3%	3,367	3,935	2.3%
Instruments	7,214	7,444	0.5%	8,365	9,185	1.3%
Motor Vehicle	183,986	213,355	2.5%	203,592	234,542	2.0%
Office Machine	9,206	32,916	23.7%	9,714	35,150	20.2%
Other Metal Products	32,865	36,290	1.7%	34,683	37,902	1.3%
Precious Metals and Jewelry	1,379	1,625	2.8%	1,535	1,838	2.6%
Ships and Boats	5,739	8,290	6.3%	6,561	9,262	5.0%
Stationary Industrial Equipment	14,672	15,075	0.5%	20,880	21,791	0.6%
Total	**335,038**	**435,822**	**4.5%**	**379,288**	**485,342**	**3.6%**

Source: Small Business Administration, Statistics of U.S. Businesses.

c. Employment

Table 3.15 shows employment in each non-manufacturing MP&M sector in 1992. The bus and truck and motor vehicle sectors employ nearly 77 percent of all the non-manufacturing MP&M employment.

Table 3.15: Employment, 1992: MP&M Non-Manufacturing Sectors

Sector	Employment	Share
Aircraft	79,953	1.7%
Bus & Truck	1,683,432	35.9%
Household Equipment	23,681	0.5%
Instruments	108,761	2.3%
Motor Vehicle	1,910,701	40.8%
Office Machine	120,804	2.6%
Other Metal Products	213,242	4.6%
Precious Metals and Jewelry	5,141	0.1%
Railroad	197,421	4.2%
Ships and Boats	171,314	3.7%
Stationary Industrial Equipment	168,850	3.6%
Total	**4,683,300**	**100.0%**

Source: Department of Commerce, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1992.

3.4.2 Industry Structure and Competitiveness

a. Facility size

The non-manufacturing facilities tend to be smaller than manufacturing facilities. There are 204,586 facilities (54.3 percent) that employ 4 employees or less. These facilities account for 7 percent of sales or receipts in the non-manufacturing MP&M sectors.

Table 3.16: Number of Facilities and Sales/Receipts by Facility Employment Size Category: MP&M Non-Manufacturing Sectors

Sector	Number of Facilities					Sales/Receipts (millions, $1992)				
	0 to 4	5 to 9	10 to 19	20 to 99	100 or more	0 to 4	5 to 9	10 to 19	20 to 99	100 or more
Aircraft	1,148	552	455	539	152	240	291	494	1,937	3,067
Bus & Truck	45,917	17,414	14,524	15,750	629	11,432	11,385	18,211	90,748	8,006
Household Equipment	2,078	737	387	181	10	381	406	511	670	170
Instruments	5,942	2,037	1,128	806	195	949	993	1,155	2,011	1,377
Motor Vehicle	106,478	44,749	21,773	19,314	1,647	33,379	36,659	53,593	278,225	92,389
Office Machine	7,113	1,691	1,147	974	168	1,579	1,191	1,653	4,084	3,981
Other Metal Products	22,509	6,851	3,239	1,709	3	3,642	3,099	3,316	5,755	30
Precious Metals and Jewelry	1,163	231	46	17	0	138	60	29	34	0
Ships and Boats	3,077	1,313	877	963	270	1,694	1,808	1,928	8,561	12,776
Stationary Industrial Equipment	9,161	5,511	2,644	1,438	94	2,671	3,540	3,747	5,651	2,411
Total	**204,586**	**81,086**	**46,220**	**41,691**	**3,168**	**56,104**	**59,432**	**84,635**	**397,676**	**124,208**

Source: Department of Commerce, Bureau of the Census, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1992.

b. Firm size

For most of the non-manufacturing SIC codes, SBA defines small businesses according to the firms' total revenue. Therefore, examining a firms employment size is somewhat meaningless for non-manufacturers. Approximately 438,800 facilities, or 90 percent, are owned by firms employing 99 workers or less.

Table 3.17: Number of Firms, Facilities, and Estimated Receipts by Firm Employment Size Category, 1996: MP&M Non-Manufacturing Sectors

Sector	Firms			Facilities			Estimated Receipts (millions, $1996)		
	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more
Aircraft	3,124	80	77	3,189	139	734	2,549	1,186	5,695
Bus & Truck	111,038	2,001	801	112,751	4,334	10,590	74,421	22,461	62,021
Household Equipment	3,669	19	18	3,700	23	212	1,906	258	819
Instruments	7,277	76	91	7,536	206	1,443	2,926	527	3,485
Motor Vehicle	209,814	3,010	531	216,707	7,119	10,716	437,146	174,565	81,721
Office Machine	32,428	290	198	32,745	759	1,646	13,872	4,503	9,911
Other Metal Products	35,788	284	218	36,205	567	1,130	15,712	2,165	4,325
Precious Metals and Jewelry	1,615	6	4	1,661	105	72	252	0	0
Ships and Boats	7,833	243	214	8,000	519	743	8,525	5,743	19,225
Stationary Industrial Equipment	14,587	302	186	16,331	1,359	4,101	14,467	4,321	7,260
Total	**427,173**	**6,311**	**2,338**	**438,825**	**15,130**	**31,387**	**571,776**	**215,729**	**194,463**

Source: Small Business Administration, Statistics of U.S. Businesses.

3.5 Characteristics of Potentially-Regulated MP&M Facilities

The Agency is not using industrial sectors to subcategorize the regulations for the MP&M industry. EPA has determined that the industrial sectors are too broad for the purposes of subcategorization, and many facilities perform operations covered by multiple sectors. Instead, EPA is proposing to define subcategories based on unit operations performed and the nature of the waste generated. EPA has determined that a basis exists for dividing the MP&M category into the following subcategories for the proposed rule: General Metals, Non-Chromium Anodizing, Metal Finishing Job Shops, Printed Wiring Boards, Steel Forming and Finishing, Oily Wastes, Railroad Line Maintenance, and Shipbuilding Dry Dock.

Table 3.18 shows the national number of MP&M facilities that sell products to different combinations of sectors. The table shows that many MP&M facilities operate in multiple market sectors. There is an overlap for almost every combination of sectors, and some MP&M facilities report revenues from three or more sectors.

Table 3.18: Overlap of Sectors

Sectors	Aerospace	Aircraft	Bus and Truck	Electronic Equipment	Hardware	Household Equipment	Instrument	Mobile Industrial Equipment	Motor Vehicle	Office Machine	Ordnance	Other Metal Products	Precious/Non-Precious Metals	Railroad	Ship and Boat	Stationary Industrial Equip.	Unknown
Aerospace	141																
Aircraft	0	189															
Bus and Truck	117	126	1,191														
Electronic Equipment	129	145	141	225													
Hardware	141	165	153	177	324												
Household Equipment	72	72	84	107	143	500											
Instrument	84	108	93	123	150	153	297										
Mobile Industrial Equipment	24	44	53	47	59	47	56	158									
Motor Vehicle	93	102	122	117	229	186	144	83	518								
Office Machine	84	120	81	100	119	96	120	44	56	156							
Ordnance	12	12	12	12	12	12	12	12	12	12	12						
Other Metal Products	81	102	98	93	204	150	132	102	289	56	12	714					
Precious and Non-Precious Metals	24	36	0	24	36	12	36	12	24	36	0	35	113				
Railroad	0	0	23	12	57	12	12	21	57	12	0	45	0	174			
Ship and Boat	60	0	86	84	96	72	93	41	65	81	0	33	12	22	129		
Stationary Industrial Equipment	24	40	44	63	102	71	82	113	90	52	12	135	12	22	46	216	
Unknown																	12

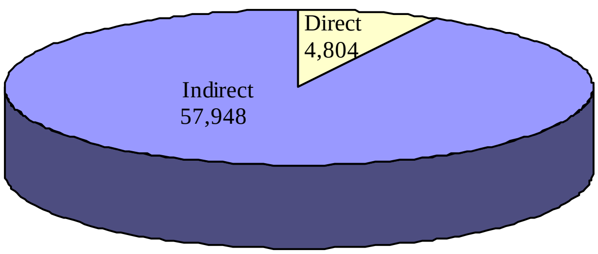
Source: U.S. EPA analysis.

The rest of this profile characterizes MP&M facilities that are expected to incur compliance costs under the proposed effluent guidelines.

Out of a total population of 638,696 MP&M facilities reported in the *Statistics of U.S. Businesses* for 1996, effluent dischargers identified by the MP&M surveys number an estimated 62,752 (10 percent).

Figure 3.2 shows the breakdown of MP&M facilities by discharge type. Of the 62,752 effluent dischargers, 57,948 (92 percent) are indirect dischargers, while the remaining 4,804 (8 percent) are direct dischargers.

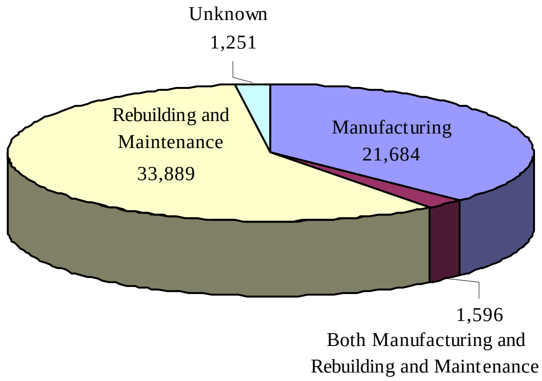
Figure 3.2: Facilities by Discharge Type



Source: U.S. EPA analysis.

Figure 3.3 shows facilities by revenue source, such as manufacturing, rebuilding and maintenance, or government. There are 35,485 facilities (61 percent) that perform rebuilding and maintenance and 23,280 facilities (40 percent) that do manufacturing.

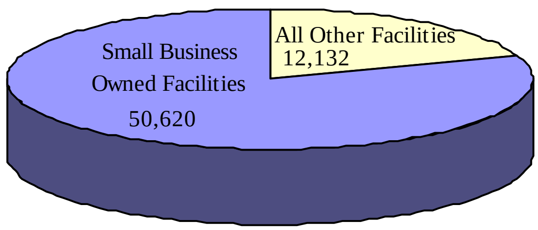
Figure 3.3: Number of Private Facilities by Revenue Source



Source: U.S. EPA analysis.

Small Business Administration (SBA) thresholds for small businesses were applied to each facility to estimate the number of facilities that are likely to be owned by small businesses, as defined by the SBA. By using the methodology detailed in Regulatory Flexibility Analysis (see Chapter 10), EPA determined that 50,620 facilities (81 percent) are owned by small entities.

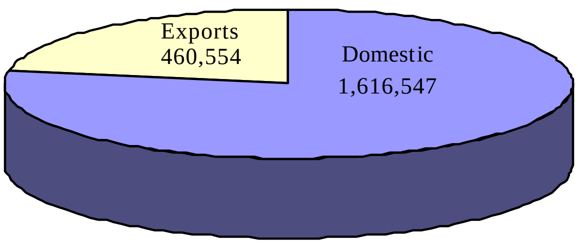
Figure 3.4: Facilities by Small Business Status



Source: U.S. EPA analysis.

Figure 3.5 indicates that MP&M facilities derive approximately 22 percent of their revenues from export sales. Almost 78 percent of MP&M revenues come from domestic non-government sources. Governments account for a very small share of MP&M revenues overall.

Figure 3.5: Facility Revenues by Market Type (millions, 1999$)



Export data were not available for Iron and Steel surveys.

Source: U.S. EPA analysis.

The ***Pre-Tax Return on Assets*** (***PTRA***) is a useful measure of industry profitability. It is well-defined, commonly used, and can be calculated from data reported in the facility surveys. Profits compensate investors not only for the use of their capital, but also for the riskiness of their investment. One firm might have a higher PTRA than another but not be more profitable in economic terms, because it is riskier.

Table 3.19 shows that the steel forming and finishing subcategory has the highest median PTRA (15.9 percent) of all the subcategories. The MP&M facilities may not be typical of the Iron and Steel industry as a whole since they produce only selected finished products. The shipbuilding drydock subcategory has the lowest PTRA (2.5 percent).

Table 3.19: Financial Performance

Subcategory	Median Pre-Tax Return on Assets (PTRA)
Shipbuilding Drydock	2.5%
General Metals	13.5%
Steel Forming & Finishing	15.9%
MF Job Shop	6.8%
Non-Chromium Anodizer	9.0%
Oily Wastes	12.9%
Printed Wiring Boards	14.6%
Railroad Line Maintenance	n/a

Source: U.S. EPA analysis.

GLOSSARY

capital expenditures: expenditures for permanent additions and major alterations to facilities and equipment, as well as replacements and additions to capacity, which are ordinarily depreciated. Reported capital expenditures include work done on contract and expenditures for assets leased from other concerns through capital leases. Expenditures for land and cost of maintenance and repairs charged as current operating expenses are excluded

employment: total number of full-time equivalent employees, including production workers and non-production workers.

export dependence: the share of shipments by domestic producers that is exported; calculated by dividing the value of exports by the value of domestic shipments.

import penetration: the share of all consumption in the U.S. that is provided by imports; calculated by dividing imports by reported or apparent domestic consumption (the latter calculated as domestic value of shipments minus exports plus imports).

manufacturing: series of unit operations necessary to produce metal products; generally performed in a production environment.

North American Industry Classification System: classification system adopted beginning in 1997 to replace SIC codes. NAICS codes will be used throughout North American and allow for greater comparability with the International Standard Industrial Classification System (ISIC), which is developed and maintained by the United Nations. The new system also better reflects the structure of today's economy, including the growth of the service sectors and new technologies.

nominal values: dollar values expressed in current dollars.

operating margin: measure of the relationship between input costs and the value of production, as an indicator of financial performance and condition. Everything else being equal, industries and firms with lower operating margins will generally have less flexibility to absorb the costs associated with a regulation than those with higher operating margins. Operating margins were calculated in this profile by subtracting the cost of materials and total payroll from the value of shipments. Operating margin is only an approximate measure of profitability, since it does not consider capital costs and other costs. It is used to examine trends in revenues compared with production costs within an industry; it should not be used for cross-industry comparisons of financial performance.

pre-tax return on assets (PTRA): the ratio of cash operating income (net income plus depreciation) to the book value of total assets. This ratio is a measure of facility profitability.

primary product shipments: an establishment's shipments of products that are considered primary to its 4-digit SIC code. An establishment is classified in a particular4-digit SIC code if its shipments of the primary products of that industry exceed in value its shipments of the products of any other single industry.

producer price index (PPI): a family of indexes that measures the average change over time in selling prices received by domestic producers of goods and services (Bureau of Labor Statistics, PPI Overview). Used in this profile to convert nominal values into real dollar values.

real values: nominal values normalized using a price index to express values in a single year's dollars. Removes the effects of price inflation when evaluating trends in dollar measures.

rebuilding/maintenance: unit operations necessary to disassemble used metal products into components, replace the components or subassemblies or restore them to original function, and reassemble the metal product. These operations are intended to keep metal products in operating condition and can be performed in either a production or a non-production environment.

Standard Industrial Classification: classification system used for all establishment-based Federal economic statistics classified by industry. Each establishment is assigned a 4-digit SIC code based on its principal product, or service. Last revised in 1987 and currently being replaced by the NAICS.

value added: measure of manufacturing activity, derived by subtracting the cost of purchased inputs (materials, supplies, containers, fuel, purchased electricity, contract work, and contract labor) from the value of shipments (products manufactured plus receipts for services rendered), and adjusted by the addition of value added by merchandising operations (i.e., the difference between the sales value and the cost of merchandise sold without further manufacture, processing, or assembly) plus the net change in finished goods and work-in-process between the beginning-and end-of-year inventories. Value added avoids the duplication in value of shipments as a measure of economic activity that results from the use of products of some establishments as materials by others. Value added is considered to be the best value measure available for comparing the relative economic importance of manufacturing among industries and geographic areas.

value of shipments: net selling values of all products shipped as well as miscellaneous receipts. Includes all items made by or for an establishment from materials owned by it, whether sold, transferred to other plants of the same company, or shipped on consignment. Value of shipments is a measure of the dollar value of production, and is often used as a proxy for revenues. This profile uses value of shipments to indicate the size of a market and how the size differs from year to year, and to calculate operating margins.

ACRONYMS

SIC: Standard Industrial Classification
NAICS: North American Industry Classification System
VOS: value of shipments
VA: value added
PPI: producer price index
PTRA: pre-tax return on assets

REFERENCES

DRI/McGraw-Hill and U.S. Department of Commerce, International Trade Administration. 2000. *U.S. Industry and Trade Outlook.*

U.S. Bureau of Labor Statistics. 2000. *Producer Price Index*.

U.S. Department of Commerce. 1992. Bureau of the Census. *Census of Manufactures, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries*.

U.S. Department of Commerce. 1996. Bureau of the Census. *Annual Survey of Manufactures*.

U.S. Department of Commerce. 2000. Bureau of the Census. *Foreign Trade Data*.

U.S. Environmental Protection Agency. 1995a. *Profile of the Electronics and Computer Industry*. EPA Office of Compliance Sector Notebook Project. EPA 310-R-95-002. http://es.epa.gov/oeca/sector/index.html

U.S. Environmental Protection Agency. 1995b. *Profile of the Fabricated Metal Products Industry*. EPA Office of Compliance Sector Notebook Project. EPA 310-R-95-007. http://es.epa.gov/oeca/sector/index.html

U.S. Environmental Protection Agency. 1995c. *Profile of the Iron and Steel Industry.* EPA Office of Compliance Sector Notebook Project. EPA 310-R-95-005. http://es.epa.gov/oeca/sector/index.html

U.S. Environmental Protection Agency. 1995d. *Profile of the Motor Vehicle Assembly Industry*. EPA Office of Compliance Sector Notebook Project. EPA 310-R-95-009. http://es.epa.gov/oeca/sector/index.html

U.S. Environmental Protection Agency. 1995e. *Printed Wiring Board Industry and Use Cluster Profile.* Design for the Environment Printed Wiring Board Project. EPA 744-R-95-005. http://www.epa.gov/opptintr/dfe/pwb/techreports/usecluster

U.S. Environmental Protection Agency. 1997. *Profile of the Shipbuilding and Repair Industry*. EPA Office of Compliance Sector Notebook Project. EPA 310-R-97-008. http://es.epa.gov/oeca/sector/index.html

U.S. Environmental Protection Agency. 1998. *Profile of the Aerospace Industry*. EPA Office of Compliance Sector Notebook Project. EPA 310-R-98-001. http://es.epa.gov/oeca/sector/index.html

U.S. Small Business Administration. *Statistics of U.S. Businesses*. http://www.sba.gov/advo/stats/int_data.html

Chapter 4: Regulatory Options

Introduction

The preamble accompanying the proposed rule describes the regulatory options considered by EPA for the proposed MP&M effluent guidelines. This chapter provides a brief summary of the individual technology options and the regulatory options.

Chapter Contents:

4.1 Subcategorization

EPA may divide a point source category into subcategories to address variations in products, raw materials, processes, and other factors that result in distinctly different effluent characteristics. Defining subcategories makes it possible to establish effluent limitations that take into account technological achievability and economic impacts unique to each subcategory. EPA considered the following factors in its evaluation of potential MP&M subcategories:

- unit operation,
- activity,
- raw materials,
- products,
- size of site,
- location,
- age,
- nature of the waste generated,
- economic impacts,
- treatment costs,
- total energy requirements,
- air pollution control methods,
- solid waste generation and disposal, and
- publicly-owned treatment work **(POTW)** burden.

The subcategories differ in part based on the type of wastewater that facilities discharge, including:

- facilities that discharge wastewaters with high metals content, with or without oil and grease **(O&G)**; and
- facilities that discharge wastewaters containing mainly O&G, with limited metals and associated other organic constituents.

The subcategories identified by EPA in each group are:

Metal-bearing (with or without O&G):

- Non Chromium Anodizing,
- Metal Finishing Job Shops,
- Printed Wiring Board,
- Steel Forming & Finishing, and
- General Metals; and

Oil-bearing only:

- Shipbuilding Dry Docks,
- Railroad Line Maintenance, and
- Oily Wastes.

Section VI of the preamble accompanying the proposed rule describes the basis for defining these subcategories. The following are brief summaries of each proposed subcategory:

Non Chromium Anodizing: This subcategory includes facilities that perform aluminum anodizing without the use of chromic acid or dichromate sealants. The wastewater generated at these facilities contains very low levels of metals (except for aluminum) and toxic organic pollutants.

Metal Finishing Job Shops: These facilities must perform one or more of the six operations regulated by the existing Metal Finishing (40 CFR 433) and Electroplating (40 CFR 413) effluent guidelines, and must meet the definition of a "***job shop***." The six metal finishing operations are electroplating, electroless plating, anodizing, coating, chemical etching and milling, and printed circuit board manufacture. A job shop is a facility that owns no more than 50 percent of the materials undergoing metal finishing. EPA proposes to regulate Printed Wiring Board facilities that are job shops under this subcategory, but is seeking comment on this proposal.

Printed Wiring Board: These facilities manufacture, maintain, and repair printed wiring boards (i.e., circuit boards), not including job shops. They perform some unique operations, including applying, developing, and stripping of photoresist; lead/tin soldering; and wave soldering.

Steel Forming & Finishing: This subcategory applies to facilities that perform MP&M operations or cold forming operations on steel wire, rod, bar, pipe, or tube. Other operations on steel, including any hot forming operations for steel, or cold forming, electroplating, or continuous hot dip coating of other steel products, will be regulated under the proposed revisions to the existing Iron and Steel Manufacturing effluent guidelines (40 CFR 420).

General Metals: This subcategory is a catch-all for MP&M facilities that discharge metal-bearing wastewater, with or without oil-bearing wastewater, that do not fit into one of the other metal-bearing subcategories described above. This broad category includes facilities in all MP&M industry sectors except printed wiring boards, and includes facilities operated by states and municipalities.

Shipbuilding Dry Docks: This is one of two specific subcategories that discharge only oil-bearing wastewaters, the other being Railroad Line Maintenance. Other facilities discharging only oil-bearing wastewater are classified in the general Oily Wastes subcategory. This subcategory covers MP&M process wastewater generated in or around dry docks and similar structures, such as graving docks, building ways, marine railways, and lift barges at shipbuilding facilities. These structures include sumps or containment systems that enable shipyards to control the discharge of pollutants to the surface water. Wastewaters generated from other operations at shipyards are not included in this subcategory.

Railroad Line Maintenance: These facilities perform routine cleaning and light maintenance on railroad engines, cars, car-wheel trucks, and similar parts or machines. They must discharge only from MP&M operations that EPA defines as oily operations and/or washing of the final product. This category does not include railroad manufacturing facilities, railroad overhaul, or heavy maintenance facilities.

Oily Wastes: The Oily Wastes subcategory is a catch-all for all MP&M facilities that discharge only oil-bearing wastewater from a specified list of unit operations, and that are not Shipbuilding Dry Dock or Railroad Line Maintenance facilities. Facilities in this subcategory are primarily machine shops or maintenance and repair shops, including state and municipal MP&M facilities. Like the General Metals subcategory, Oily Wastes may include facilities in all of the MP&M industry sectors except printed wiring boards.

4.2 Technology Options

EPA evaluated ten technology options that might be used to treat wastewaters from the MP&M facilities. Table 4.1 lists these technology options:

Table 4.1: Technology Options

Option #	Description
For metal-bearing wastes	
1	segregation of wastewaters, preliminary treatment (including oil-water separation), chemical precipitation, and sedimentation using a clarifier (chemical precipitation with gravity clarification)
2	in-process flow control and pollution prevention + option 1
3	segregation of wastewaters, preliminary treatment (including oil removal by ultrafiltration), chemical precipitation, and solids separation using a microfilter
4	in-process flow control and pollution prevention + option 3
For oil-bearing wastes	
5	oil-water separation by chemical emulsion breaking
6	in-process flow control and pollution prevention + option 5
7	oil-water separation by ultrafiltration
8	in-process flow control and pollution prevention + option 7
9	oil-water separation by dissolved air flotation **(DAF)**
10	in-process flow control and pollution prevention + option 9

Source: U.S. EPA analysis.

The even-numbered options add in-process flow controls and pollution prevention (i.e., pollution prevention, recycling, and water conservation to allow recovery and reuse of materials) to the treatment technologies specified in the odd-numbered options. In all cases, options with in-process flow control and pollution prevention cost less and remove more pollutant than do the comparable options without pollution prevention. This document analyzes only the even-numbered options with flow control and pollution prevention.

EPA defined specific effluent limitations based on a statistical analysis of the performance of these technologies. This analysis is described in the *Technical Development Document* and the *Statistical Support Document.*

4.3 BPT/BAT Options for Direct Dischargers

EPA selected the ***Best Practicable Control Technology Currently Available*** **(BPT)** for direct dischargers in each subcategory based on the average of the best performances within the industry of various ages, sizes, processes, and other characteristics. The Agency considered the cost of these treatment technologies relative to the effluent reductions achieved to assess the cost-reasonableness of these limitations. EPA then considered application of the ***Best Available Technology Economically Achievable*** **(BAT)** for priority and non-conventional pollutants and ***Best Conventional Pollutant Control Technology*** **(BCT)** for conventional pollutants. The Agency is proposing BAT equivalent to BPT for all subcategories except Railroad Line Maintenance and Shipbuilding Dry Docks, for which EPA is not proposing BAT limitations. EPA is also proposing to set BCT equal to BPT for all subcategories.

Table 4.2 shows the technology basis for the proposed option for BPT, BCT and BAT for each subcategory.

Table 4.2: Proposed Options For Direct Dischargers: BPT, BCT and BAT

Subcategory	BPT Technology Option	BCT/BAT
For metal-bearing wastes		
General Metals	2	2
Metal Finishing Job Shop	2	2
Non-Chromium Anodizing	2	2
Printed Wiring Board	2	2
Steel Forming & Finishing	2	2
For oil-bearing wastes		
Oily Wastes	6	6
Railroad Line Maintenance	10	BCT = 10 BAT not proposed
Shipbuilding Dry Dock	10	BCT = 10 BAT not proposed

Source: U.S. EPA analysis.

4.4 PSES Options for Indirect Dischargers

EPA evaluated ***Pretreatment Standards for Existing Sources (PSES)*** for indirect dischargers by evaluating whether pollutants would "***pass through***" POTWs, and whether a combination of POTW treatment and the PSES standards would achieve limitations equivalent to those required for direct dischargers. The *Technical Development Document* discusses the pass-through analysis. The same ten technologies were considered for BPT and for PSES.

The Agency also considered a range of low flow exclusions for indirect dischargers, to reduce burdens on permitting officials and reduce the economic impacts of the rule. Evaluation of the low flow cutoffs also considered the amount of pollutant discharged by each subcategory and flow size category.

Table 4.3 lists the technology options and exclusions proposed for existing indirect dischargers.

Table 4.3: Proposed Options For Indirect Dischargers: PSES

Subcategory	Exclusions	PSES Technology Option
For metal-bearing wastes		
General Metals	1 mgy flow cutoff[a]	2
Metal Finishing Job Shop	none	2
Non-Chromium Anodizing	not proposed	
Printed Wiring Board	none	2
Steel Forming & Finishing	none	2
For oil-bearing wastes		
Oily Wastes	2 mgy flow cutoff	6
Railroad Line Maintenance	not proposed	
Shipbuilding Dry Dock	not proposed	

a. ***Mgy*** = millions of gallons per year.
Source: U.S. EPA analysis.

4.5 NSPS and PSNS Options for New Sources

EPA is proposing ***Pretreatment Standards for New Sources (PSNS)*** for new indirect dischargers and ***New Source Performance Standards (NSPS)*** for new direct dischargers. New facilities have the opportunity to incorporate the best available demonstrated technologies, including process changes, in-plant controls, and end-of-pipe treatment technologies, without the cost of retrofitting. EPA considered the same technologies discussed previously for BPT/BAT and PSES as the basis for new source technology. The Agency strongly considered more advanced treatment options, however, because new sites have the potential to install pollution prevention and pollution control technologies more cost-effectively then existing sources.

Table 4.4 lists the technology options and exclusions being proposed for new direct and indirect dischargers.

Table 4.4: Proposed Options For New Direct Dischargers (NSPS) and Indirect Dischargers (PSNS)

Subcategory	NSPS Technology Option	PSNS Exclusions	PSNS Technology Option
For metal-bearing wastes			
General Metals	4	1 mgy flow cutoff	4
Metal Finishing Job Shop	4	none	4
Non-Chromium Anodizing	2	not proposed	
Printed Wiring Board	4	none	4
Steel Forming & Finishing	4	none	4
For oil-bearing wastes			
Oily Wastes	6	2 mgy flow cutoff	6
Railroad Line Maintenance	10	not proposed	
Shipbuilding Dry Dock	10	not proposed	

Source: U.S. EPA analysis.

4.6 Summary of the Proposed Rule and Regulatory Alternatives

Table 4.5 summarizes the proposed rule for existing sources. This table also describes two regulatory options that EPA considered in the economics analysis:

- Option 2/6/10, which applies the same technologies for each subcategory, and eliminates the low flow and subcategory exclusions of the proposed rule; and
- Option 4/8, which applies more stringent technology requirements for all subcategories and does not include low flow exclusions.

Table 4.5: Summary of Proposed Rule and Regulatory Alternatives for Existing Sources

Subcategory	Proposed rule	Option 2/6/10	Option 4/8
General Metals	Technology option 2; 1 mgy flow cutoff for indirect dischargers	Technology option 2	Technology option 4
Metal Finishing Job Shop	Technology option 2	Technology option 2	Technology option 4
Non-Chromium Anodizing	Technology option 2; no PSES/PSNS for indirect dischargers	Technology option 2	Technology option 4
Oily Waste	Technology option 6; 2 mgy flow cutoff for indirect dischargers	Technology option 6	Technology option 8
Printed Wiring Board	Technology option 2	Technology option 2	Technology option 4
Railroad Line Maintenance	Technology option 10; no PSES/PSNS for indirect dischargers	Technology option 10	Technology option 8
Shipbuilding Dry Dock	Technology option 10; no PSES/PSNS for indirect dischargers	Technology option 10	Technology option 8
Steel Forming & Finishing	Technology option 2	Technology option 2	Technology option 4

Source: U.S. EPA analysis.

GLOSSARY

Best Practicable Control Technology Currently Available (BPT): effluent limitations for direct discharging facilities, addressing conventional, toxic, and non-conventional pollutants. In specifying BPT, EPA considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of the equipment and facilities, the processes employed and any required process changes, engineering aspects of the control technologies, non-water quality environmental impacts (including energy requirements), and such other factors as the Agency deems appropriate. Limitations are traditionally based on the average of the best performances of facilities within the industry of various ages, sizes, processes, or other common characteristics. Where existing performance is uniformly inadequate, EPA may require higher levels of control than currently in place in an industrial category if the Agency determines that the technology can be practically applied.

Best Available Technology Economically Achievable (BAT): effluent limitations for direct dischargers, addressing priority and non-conventional pollutants. BAT is based on the best existing economically achievable performance of plants in the industrial subcategory or category. Factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the processes employed, engineering aspects of the control technology, potential process changes, non-water quality environmental impacts (including energy requirements), economic achievability, and such factors as the Administrator deems appropriate. The Agency may base BAT limitations upon effluent reductions attainable through changes in a facility's processes and operations. Where existing performance is uniformly inadequate, EPA may base BAT upon technology transferred from a different subcategory within an industry or from another industrial category.

Best Conventional Pollutant Control Technology (BCT): effluent limitations for direct discharging facilities, addressing conventional pollutants. Conventional pollutants include biochemical oxygen demand (BOD_5), total suspended solids (TSS), fecal coliform, pH, and O&G. BCT is the equivalent of Best Available Technology (BAT) for control of conventional pollutants. EPA evaluates the reasonableness of BCT candidate technologies by applying a two-part cost test: (1) the POTW test, and (2) the industry cost-effectiveness test. In the POTW test, EPA calculates the cost per pound of conventional pollutant removed by industrial dischargers to upgrade from BPT to a BCT candidate technology, and then compares this cost to the POTW cost per pound for similar pollutant load reductions. The upgrade cost to industry must be less than the POTW benchmark of $0.25 per pound (in 1976 dollars). In the industry cost-effectiveness test, the ratio of the incremental BPT to BCT cost divided by the BPT cost for the industry must be less than 1.29 (i.e., the cost increase must be less than 29 percent).

job shop: a facility that owns no more than 50 percent of the materials undergoing metal finishing.

New Source Performance Standards (NSPS): effluent limitations for new direct dischargers based on the best available demonstrated control technology. NSPS represents the greatest degree of effluent reduction attainable through the application of the best available demonstrated control technology for all pollutants (i.e., conventional, non-conventional, and priority pollutants). In establishing NSPS, EPA considers the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements.

pass-through: pollutants “pass through” a POTW if they are not removed by treatment and are present in the POTW’s discharges to waters of the U.S. EPA compares the percentage of a pollutant removed by well-operated POTWs achieving secondary treatment with the percentage of the pollutant removed by facilities meeting BAT effluent limitations. For purposes of defining PSES and PSNS, a pollutant is determined to pass through if the median percentage removed by a well-operated POTW is less than the median percentage removed under BAT limitations.

Pretreatment Standards for Existing Sources (PSES): categorical pretreatment standards for existing indirect dischargers, designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Standards are technology-based and analogous to BAT effluent limitations guidelines.

Pretreatment Standards for New Sources (PSNS): pretreatment standards for new indirect dischargers, designed to prevent discharges of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Addresses all pollutants (i.e., conventional, non-conventional, and priority pollutants). Based on the same factors as are considered in promulgating NSPS.

ACRONYMS

BAT: best available technology economically achievable
BCT: best conventional pollutant control technology
BPT: best practicable control technology currently available
DAF: dissolved air flotation
MGY: millions of gallons per year
NSPS: new source performance standards
O&G: oil and grease
POTW: publicly-owned treatment works
PSES: pretreatment standards for existing sources
PSNS: pretreatment standards for new sources

Chapter 5: Facility Impact Analysis

INTRODUCTION

The ***facility*** impact analysis assesses whether the proposed MP&M effluent guidelines are likely to impose severe or moderate economic and financial impacts on MP&M facilities. EPA conducted tests of severe economic impacts to assess the rule's economic achievability. ***Severe impacts*** are facility closures and the associated losses in jobs, earnings, and output at facilities that close due to the rule. EPA also evaluated moderate economic impacts to support its evaluation of regulatory options and to understand better the rule's economic impacts. ***Moderate impacts*** are adverse changes in a facility's financial position that are not threatening to its short-term viability.

This regulation will affect three major categories of MP&M facilities: privately-owned, railroad line maintenance, and government-owned facilities. EPA developed separate analytic methodologies for each type of facility:

1. ***Private MP&M facilities***: This group includes all privately-owned facilities that do not perform railroad line maintenance. This major category of facilities operates in various subcategories and includes private businesses in a wide range of sectors or industries, including facilities that manufacture and rebuild railroad equipment. Only facilities that repair railroad track and equipment along the railroad line are excluded. There are 57,587 private MP&M facilities other than railroad line maintenance facilities nationally that may be affected by the rule, representing 91.8 percent of the 62,752 facilities that discharge process wastewater from MP&M activities.

2. ***Railroad line maintenance facilities***: Railroad line maintenance facilities maintain and repair railroad track and vehicles. EPA administered a separate economic and financial survey to these facilities and applied a different impact analysis methodology than that used for other private facilities. This methodology evaluated the aggregate impact of compliance costs for facilities owned by a single railroad company on the profitability and indebtedness of the railroad operating company as a whole. There are 832 railroad line maintenance facilities in the analysis, representing 1.3 percent of all facilities in the analysis.

CHAPTER CONTENTS

3. ***Government-owned facilities***: Government-owned facilities include MP&M facilities operated by municipalities, state agencies and other public sector entities such as state universities. Many of these facilities repair, rebuild, and maintain buses, trucks, cars, utility vehicles (e.g., snow plows and street cleaners), and light machinery. Government-owned facilities operate in two major subcategories: General Metals and Oily Waste. There are 4,332 government-owned facilities in the analysis, representing 6.9 percent of the total.

The specific methodology used to assess impacts differs for each of the three types of MP&M facilities. In each case, EPA established thresholds for measures of financial performance and compared facilities' performance before and after compliance with each regulatory option to these thresholds.

This chapter describes the methodology used to assess facility-level economic impacts for the three types of facilities, and then presents the results of the analyses.

5.1 Data Sources

The economic impact analyses rely on data provided by the financial portion of the detailed questionnaires distributed to MP&M facilities by EPA under the authority of Section 308 of the Clean Water Act. The surveys were conducted in two phases, covering different MP&M industries in each phase. The Phase I survey covered seven industry sectors and reported data for fiscal years 1987 to 1989. The Phase II survey covered an additional ten industry sectors (all remaining MP&M sectors except Steel Forming & Finishing, which was the subject of a separate survey) and reported data for fiscal years 1994 to 1996.[1] EPA administered each survey to a random stratified sample of facilities and assigned each facility a sample weight based on the stratification process and the number of facilities surveyed, so that sample-weighted results would represent all potentially-affected MP&M facilities in the U.S. The results of the impact analyses for the sample facilities were extrapolated to the national level using these facility sample weights.

The survey financial data for private businesses included three years of facility and parent firm income statements and balance sheets and the composition of revenues by MP&M business sector to which the facility's goods and services are sold. Two versions of the Phase II financial survey were used: the long survey, which also requested information on facility ***liquidation*** values, and the short form, which did not request liquidation values.

Data for facilities in the railroad line maintenance subcategory came from a modified version of the Phase II survey administered to railroad operating companies. The questionnaire was modified because railroad operating companies generally do not monitor financial performance or collect financial data at the facility level for their numerous line maintenance facilities. The railroad operating companies reported the number of line maintenance facilities in each operating unit, and provided both operating company and parent firm financial data. They also provided technical data for each line maintenance facility.

Data for facilities in the Steel Forming & Finishing subcategory came from a 1997 Section 308 survey of iron and steel facilities. This survey requested financial data generally similar to that collected by the MP&M surveys, including income statements and balance sheets for fiscal years 1995-1997 for the facility and the parent firm.

Government-owned MP&M facilities provided data in the Phase II Section 308 survey of municipal and other government agency facilities. This survey requested information on fiscal year 1996 sources and amounts of revenue and debt levels for both the government entity and their MP&M facilities, and demographic data for the population served by the government entity.

In addition to the survey data, a number of secondary sources were used to characterize economic and financial conditions in the industries subject to the MP&M effluent guidelines. Secondary sources used in the analyses include:

- Department of Commerce economic census and survey data, including the *Censuses of Manufactures, Annual Surveys of Manufactures,* and international trade data;
- The *Benchmark Input-Output Tables of the United States*, published by the U.S. Department of Commerce's Bureau of Economic Analysis;
- Price index series from the Bureau of Labor Statistics, Department of Labor;
- *U.S. Industry and Trade Outlook*, published by McGraw-Hill and the U.S. Department of Commerce; and
- Industry trade publications.

5.2 Methodology

The facility impact analysis starts with compliance cost estimates from the EPA engineering analysis and then calculates how these compliance costs would affect the financial condition of MP&M facilities. EPA first eliminated from the analysis those facilities showing inadequate financial performance in the baseline, that is, in the absence of the rule. ***Baseline closures*** at these facilities would have occurred with or without the rule. EPA performed a ***cost pass-through analysis*** based on historical input and output price changes for the years 1982 through 1991 to estimate how much prices might rise to help cover the costs of compliance. The Agency then evaluated how the compliance costs would likely affect the financial health of the facility, taking any price changes into account. A facility is identified as a ***regulatory closure*** if it would have operated under baseline conditions but would fall below an acceptable financial performance level when subject to the new regulatory requirements. An ***avoided baseline closure*** occurs if a facility fails the baseline tests but passes the post-compliance tests. An avoided baseline failure is rare but can occur when a facility that is very close to the financial thresholds benefits from industry-wide price

[1] Appendix A.1 provides a detailed description of the surveys and describes how EPA combined data from different surveys.

increases and incurs relatively low regulatory costs compared to its competitors.

EPA also identified private MP&M facilities that would likely incur some moderate impacts from the rule but that are not expected to close as a result of the rule. The test of moderate impacts examined baseline and post-compliance financial ratios. Incremental moderate impacts are attributed to the rule if both financial ratios exceeded threshold values in the baseline (i.e., there were no moderate impacts in the baseline), but at least one financial ratio fell below the threshold value in the post-compliance case.

5.2.1 Converting Engineering Compliance Costs and Financial Data

EPA made three adjustments to the engineering estimates of compliance costs to support the economic impact analyses.[2] First, the costs were converted to 1999 dollars. Second, the costs estimated for privately-owned facilities were adjusted for the effects of taxes. Finally, one-time capital costs were annualized, to provide a total annualized compliance cost for each facility.

EPA used two kinds of deflators to convert dollar values into 1999 constant dollar equivalents. The Agency used the ***Construction Cost Index* (CCI)** to update compliance costs. The CCI is a price index that engineers often use to estimate costs associated with building, installing, and operating waste treatment equipment and facilities. The CCI includes the costs of labor and building materials in 20 major cities. Table 5.1 shows CCI values from 1996 to 1999. Costs increased by 7.8 percent from 1996 to 1999.

Table 5.1: Construction Cost Index

Year	Value	% Change
1996	5620	
1997	5825	3.6%
1998	5920	1.6%
1999	6060	2.4%

Source: Engineering News-Record

EPA used the ***Producer Price Index* (PPI)** to update financial statement data for MP&M facilities. The PPI measures average changes in selling prices that domestic producers receive for their output. EPA used sector-specific PPI averages to update financial data from Phase I survey respondents to 1996, the base year of the analysis. EPA applied an aggregate PPI to update from 1996 to 1999 dollars for both Phase I and Phase II survey data.

Table 5.2 shows aggregate PPI values for all finished goods. Prices increased by 1.3 (133/131.3) percent from 1996 to 1999, and by 26.2 percent from 1987 to 1999 (133/105.4).

Table 5.2: Producer Price Index Industrial Commodities

Year	Value	% Change
1987	102.6	
1988	106.3	3.6%
1989	111.6	5.0%
1990	115.8	3.8%
1991	116.5	0.6%
1992	117.4	0.8%
1993	119.0	1.4%
1994	120.7	1.4%
1995	125.5	4.0%
1996	127.3	1.4%
1997	127.7	0.3%
1998	124.8	-2.3%
1999	126.5	1.4%

Source: Bureau of Labor Statistics

EPA adjusted compliance costs estimated for private sector facilities to take account of the tax deductibility of these costs. A 34 percent marginal income tax rate was used to adjust costs to an after-tax equivalent. This rate is the highest marginal federal corporate income tax rate, and is used as a proxy for the combined effect of federal and state income taxes. This report presents costs either before-tax or after-tax, depending on the purpose of the analysis.

Finally, EPA annualized one-time compliance costs (primarily capital costs) to provide annual costs that could be compared with annual facility revenues. ***Total annual compliance costs* (TACC)** is the sum of annual ***operating and maintenance* (O&M)** costs and the annualized equivalent of one-time costs, calculated over 15 years assuming a seven percent discount rate. The following is the formula used to annualize one-time costs:

$$Annualized\ Cost = PV \times \frac{r \times (1+r)^n}{(1+r)^n - 1} \qquad (5.1)$$

[2] The engineering cost estimates are described in the *Technical Development Document* accompanying this rule.

where:

PV = present value of compliance costs,
r = discount rate (7% in this analysis), and
t = amortization period (15 years).

5.2.2 Market-Level Impacts and Cost Pass-through Analysis

Increased costs associated with the proposed rule can be expected to affect industry level prices and output. Changes in prices and output in turn determine the ultimate distribution of economic impacts among directly- and indirectly-affected industries and their customers and suppliers. The facilities and industries directly affected by the proposed rule might ultimately experience little adverse impact, for example, if they are able to recover most or all of their added costs by raising prices to their customers or lowering the prices paid to their suppliers. Some regulated facilities and companies could even be better off financially as a result of the rule, if they benefit from industry-wide product price increases and incur no or relatively-low compliance costs (e.g., they already have treatment in place). Understanding impacts at the industry level is therefore important to understanding who bears the impacts of the proposed rule.

The MP&M effluent guidelines affect facilities in a very wide range of industries, and some of those industries produce a diverse slate of products that are sold in multiple industrial sectors. Detailed partial equilibrium modeling of product-level market dynamics in each of the affected industries was therefore not feasible. EPA instead used a combination of quantitative and qualitative methods to estimate a proportion of compliance costs that might be recovered through price increases in each MP&M sector. This cost pass-through analysis provided sector-specific coefficients that were applied to total compliance costs in each sector to estimate percentage changes in prices and revenues. EPA then evaluated facility-level impacts assuming that all analyzed facilities in each sector benefit from the same percentage increase in prices and revenues. EPA did not conduct a zero-***cost pass-through analysis***, because results of the Phase I analysis indicated that the complexity of presenting two sets of results were not warranted, given the slight difference in impact results between the two cases.

The estimated cost pass-through potential for each sector reflects an econometric analysis of historical pricing and cost trends in each MP&M industry, coupled with a qualitative market structure analysis. The market structure factors include:

- Market power based on horizontal and vertical integration;
- Extent of competition from foreign suppliers (in both domestic and export markets);
- Barriers to competition, as indicated by above-normal, risk-adjusted profitability; and
- The long-term growth trend in the industry.

EPA developed cost pass-through coefficients that indicate the percentage of compliance costs that EPA expects firms subject to regulation to recover from customers through increased revenues.[3] This approach may either overstate or understate the true changes in revenue for any one particular facility, depending on the diversity of products produced by the facility and the percentage of competitors in each product market that incur compliance costs.

This approach to estimating market-level adjustments is a simplification because it does not simultaneously estimate changes in prices and output. Instead, EPA estimated price changes and then estimated changes in output based on predicted closures, taking into account the effect of the predicted price increases on facilities' financial performance. It is difficult to assess how this simplified approach might affect the estimated economic impacts of the rule. However, EPA does not believe that the overall impact analysis results are highly sensitive to the potential biases introduced by this approach.

5.2.3 Impact Measures for Private Facilities

a. Test of severe impacts

The analysis of severe impacts estimates the number of facilities that could potentially close due to the regulation. EPA predicted that a facility will close if compliance costs cause the facility's overall financial performance to fall below threshold levels. Compliance costs are determined by the type and number of processes that a facility performs, the characteristics of its wastewaters, and the level of treatment performed in the baseline. EPA took the number and type of processes and pollutants produced into account when subcategorizing the industry. However, EPA was not able to link estimated compliance costs to specific products. Nor was EPA able to link facility financial performance to specific products. It was therefore not possible to conduct an impacts analysis at the product level.

In particular, the analysis does not consider output reductions short of closure -- for example, closing one of several production lines/processes or continuing to produce the same products at a reduced level. It is quite possible that a facility with no or relatively low compliance costs for most

[3] Appendix A.2 provides a detailed description of the cost pass-through analysis.

processes could choose to out-source products made using a process that had significant compliance costs associated with it, instead of performing the process in-house. This is particularly true if it is a process that is performed infrequently. It is also possible that firms with multiple facilities could consolidate similar processes at individual facilities to reduce their compliance costs. These situations are not considered in this economic impact analysis. There are likely to be numerous options available to firms and facilities that EPA is unable to model. Because of these unknowns, estimated severe impacts are worst case and are likely to be overstated. In addition, the relationship between the compliance costs associated with the specific processes performed, specific products made from these processes, and the multiple industrial sectors to which these products are sold, is unknown and can not be accounted for in this analysis.

The methodology examines two facility-level financial indicators to estimate closures.

***After-Tax Cash Flow* (ATCF)**: EPA examined ATCF over a three-year period to determine the financial condition of private MP&M facilities. Facilities with negative cash flows were considered candidates for closure, since businesses generally cannot sustain a negative cash flow for long periods of time.

***Net Present Value* (NPV)**: The present value of the expected future cash flows minus the cost. EPA also performed an NPV test for facilities that provided estimates of liquidation values. This test compared the facility liquidation value to the present value of expected future earnings. The conventional model of business management states that businesses can be expected to cease operations when the value of closing (i.e., its liquidation value) exceeds its value as an ongoing business (i.e., the present value of its expected future earnings).

The following sections describe the calculation of these two measures in more detail.

❖ *After-tax cash flow test*

The ATCF test examined whether a facility would lose money on a cash basis over the three years covered by the surveys. If the facility suffers a cash loss on average, then EPA infers that the facility's management is under pressure to change operations or business practices to eliminate future losses. Management might do so by closing the facility. The ATCF test involves calculating each sample facility's average after-tax cash flow over the years for which survey respondents reported income statement data. The calculations are as follows:

1. *Compute after-tax cash flow in 1999 dollars:* EPA averaged income statement data over the years for which survey respondents reported data. For example, if a facility reported income statement data for 1995, 1996, and 1997, then a simple average was calculated for the three reported years and indexed to 1999 values. The ATCF is calculated from survey facility financial data as follows:

$$ATCF = ATI + D \qquad (5.2a)$$

or,

$$\begin{aligned} ATCF &= [REV - (TC+I+D+T)] + D \qquad (5.2b)\\ &= REV - TC - I - T \end{aligned}$$

where:

ATI	=	after-tax income;
D	=	depreciation;
REV	=	revenue;
TC	=	total costs, including operating costs and fixed costs;
I	=	interest; and
T	=	all income taxes.

EPA considered the facility to be a potential baseline closure if it had negative average ATCF before incurring regulatory compliance costs. Baseline closures were excluded from all further analyses.

2. *Compute the average post-regulation after-tax cash flow (ATCF), including regulatory compliance costs and increases in revenue.* EPA then examined the post-compliance cash flow of a facility with non-negative baseline cash flow, to determine both its compliance costs and the benefits from any revenue increases based on the cost pass-through analysis. EPA adjusted the baseline ATCF to reflect the effects of the regulation as follows:

$$\begin{aligned} ATCF_{PC} &= (1-\tau)[(REV+\Delta REV)-(TC+\Delta C)-(I+\Delta I)]\\ &\quad -CC+[\tau(D+\Delta D)] \end{aligned} \qquad (5.3)$$

where:

$ATCF_{pc}$	=	post-compliance after-tax cash flow;
ΔREV	=	post-compliance change in revenue, as calculated in the cost pass-through analysis;
ΔC	=	operating and maintenance costs of compliance;
ΔI	=	change in interest expense after borrowing for compliance investments;
CC	=	annual capital cost of compliance;
ΔD	=	change in depreciation expense after compliance investments; and
τ	=	the marginal corporate income tax rate (0.34).

All other variables are defined as in the baseline ATCF calculation.

The ***operating and maintenance cost*** of compliance **(ΔC)** is the change in costs estimated to result from operating and maintaining pollution controls adopted to comply with effluent guidelines. Operating costs include the costs of monitoring. The annual capital cost of compliance represents a payment on principal for debt-financed compliance investments. Financing costs calculated are based on a 7 percent rate. EPA calculated the change in depreciation (ΔD) for tax purposes as the straight-line depreciation of compliance investment outlays over a 15-year recovery period.

EPA determined that a facility with negative average post-regulation ATCF was subject to severe financial stress under the ATCF test and would be a candidate for post-regulatory closure.

❖ *Net present value test*

EPA applied the NPV test for survey respondents that provided liquidation values, including any post-closure costs or liabilities. Some facilities may have a financial incentive to remain open and comply with the proposed MP&M rule even in the presence of negative cash flows, if they would incur substantial closure costs that exceed the value recovered by selling assets. NPV is the present value of expected future earnings less the liquidation value (including closure and post-closure costs) of the business. A business owner with a negative NPV is financially better off closing and liquidating than keeping the business open. Considering both the ATCF and the NPV tests improves the accuracy of the closure analysis, because it identifies as closures those facilities that would lose money and would not incur substantial costs exceeding assets if they closed.

The NPV test includes these calculations:

1. *Adjust for tax losses or gains on liquidation of facility assets*. EPA compared the facility's liquidation value with a going-concern value based on after-tax cash flow. EPA adjusted the calculated liquidation value for the tax cost (or benefit) resulting from capital gains (or losses). This adjustment involved subtracting asset book values as reported in the facility's balance sheet from the facility's reported asset liquidation values, yielding a capital gain (or loss, if negative) on liquidation. EPA also subtracted any reported extraordinary liability items accompanying liquidation, to yield a net gain (or loss) for tax purposes at facility liquidation. Multiplying this value by the 0.34 tax rate provided a net tax liability (or benefit, if the value was negative) upon liquidation. EPA subtracted this value from the reported liquidation value to give an after-tax liquidation value. The methodology assumes that firms have sufficient income to use all the tax gains due to capital losses.

2. *Calculate* ***total after-tax cash flow (TATCF)*** *available for all capital on an after-tax, total capital basis*. EPA calculated cash flow on an after-tax, total capital basis, to make the cash NPV and liquidation values comparable. The measure of cash flow discounted to calculate NPV includes interest payments, and therefore includes payments available to total capital, i.e., debt and equity. A comparable baseline TATCF is calculated as follows:

$$\begin{aligned} TATCF = {} & REV - (TC + T) \\ & ATCF + I \end{aligned} \qquad (5.4a)$$

which is equivalent to:

$$TATCF = (1-\tau)(REV-TC) + \tau(I + D) \qquad (5.4b)$$

where:

TATCF	=	total after-tax cash flow available for all capital;
REV	=	revenue;
TC	=	total costs, including operating costs and fixed costs;
T	=	all income taxes ($T = \tau \times [REV - TC - I - D]$);
ATCF	=	after-tax cash flow (as defined in the ATCF test above);
I	=	interest;
τ	=	corporate income tax rate; and
D	=	depreciation.

TATCF differs from ATCF in Eq. 5.4a only by the amount of interest payments: ATCF is after-tax cash flow available to equity, while TATCF is after-tax cash flow available to all capital. Interest expense is not adjusted for taxes when it is added back to the ATCF, however, since cash flow is increased by the tax deductibility of interest expenses. The benefit of the tax shield for both depreciation and interest is explicitly shown in Equation 5.4b.[4]

Post-compliance changes in financial parameters are the same as in the ATCF calculation (Equation 5.2).

3. *Calculate the present value of TATCF over 15 years.* EPA estimated the present value of the facility's expected future earnings by discounting TATCF over a 15-year period using a seven percent ***cost of capital***. The Agency elected 15 years as the length of the discounting period because EPA engineers expect compliance-related investments to have a useful life of at least 15 years.

[4] See Brealey and Myers, 1996 for a discussion of this method of cash flow analysis and valuation.

Extending the discounting period beyond 15 years would have had little effect on the NPV test results because discounting progressively reduces the contribution of out-year values to the calculated present value. The PV of TATCF is:

$$PV = \sum_{t=0}^{N} \frac{TATCF_t}{(1 + ACC)^t} \qquad (5.5)$$

where:

PV	=	present value of after-tax cash flows available for all capital i.e., the estimated value of the facility as a ***going concern***;
N	=	the number of years of cash flows analyzed minus one, since the first year's cash flow does not need to be discounted (N=14 in this analysis); and
ACC	=	average cost of capital (7% in this analysis).

4. *Compute the NPV*. The facility's NPV is the present value of its TATCF minus its after-tax, discounted liquidation value.

The NPV test threshold is zero. EPA presumes that the owners of a facility with an NPV less than zero would close the facility and liquidate its assets, if its cash flow is also negative.

❖ ***Severe impacts (closure) criteria***

EPA applied the ATCF alone for facilities that did not provide liquidation values. Facilities with negative baseline ATCF are baseline closures and are not attributed to the rule. Facilities with non-negative ATCF in the baseline case but negative post-compliance ATCF are regulatory closures due to the rule.

EPA applied both the ATCF and NPV tests to respondents that provided liquidation values. Facilities that fail both tests under baseline conditions are baseline closures. Facilities that pass at least one of the two tests in the baseline case but then fail both tests post-compliance are regulatory closures attributable to the rule.

Employment losses due to regulatory closures are equal to the employment numbers that each facility reported in its survey response. Output losses equal the total revenue at regulatory closures. Avoided baseline closures result in corresponding employment and output gains. EPA estimated national results by multiplying facility results by facility sample weights.

b. Test of moderate impacts

EPA also conducted an analysis of financial stress short of closure to identify moderate impacts due to the rule. Facilities experiencing moderate impacts are not projected to close due to the MP&M effluent guidelines. The rule might reduce their financial performance to the point where they might have somewhat more difficulty obtaining financing for future investments, however.

The analysis of moderate impacts examined two financial indicators:

Pre-Tax Return on Assets (PTRA): The ratio of cash operating income to assets. This ratio measures facility profitability.

Interest Coverage Ratio (ICR): The ratio of cash operating income to interest expenses. This ratio measures the facility's ability to service its debt and borrow for capital investments.

Creditors and equity investors review the above two measures as criteria to determine whether and under what terms they will finance a business. The PTRA and ICR also provide insight into a firm's ability to generate funds for compliance investments from internally-generated equity, i.e., from after-tax cash flow. The measures are defined as follows:

PTRA (net operating income divided by total assets) is a measure of the return earned on a firm's capital assets, independent of the effects of tax and financial structure. PTRA is a comprehensive measure of a firm's economic and financial performance. If a firm cannot sustain a competitive PTRA on a post-compliance basis, it may have difficulty financing the treatment investment, whether financing is to be obtained as debt, equity, or, more likely, a blend of the two.

$$PTRA = \frac{COI}{TA} \qquad (5.6)$$

where:

PTRA	=	pre-tax return on assets,
COI	=	cash operating income, and
TA	=	total assets.

Since COI = REV - TC,

$$PTRA = \frac{REV - TC}{TA} \qquad (5.7)$$

where:

PTRA	=	pre-tax return on assets,
REV	=	revenue,

TC = total costs, and
TA = total assets.

ICR [*pre-tax and pre-interest income* (cash operating income) divided by interest expense] is a measure of a firm's ability to service its contractual financial obligations on the basis of current, ongoing financial performance. Investors and creditors will be concerned about a firm whose operating cash flow does not comfortably exceed its contractual payment obligations. The greater the ICR, the greater the firm's ability to meet interest payments, and, generally speaking, the greater the firm's credit-carrying ability. ICR also provides a measure of the amount of cash flow available for equity after interest payments.

$$ICR = \frac{COI}{I} \qquad (5.8)$$

where:
ICR = interest coverage ratio,
COI = cash income from operations, and
I = interest expense.

COI = REV - TC, therefore:

$$ICR = \frac{REV - TC}{I} \qquad (5.9)$$

where:
ICR = interest coverage ratio,
REV = revenue,
TC = total costs, and
I = interest expense.

Adjusting for the effects of MP&M compliance costs, post-compliance PTRA and ICR are:

$$PTRA_{pc} = \frac{[(REV + \Delta REV) - (TC + \Delta TC)]}{(TA + TI)} \qquad (5.10)$$

$$ICR_{pc} = \frac{[(REV + \Delta REV) - (TC + \Delta TC + \Delta I)]}{(I + \Delta I)} \qquad (5.11)$$

where:
$PTRA_{pc}$ = pre-tax return on assets, post-compliance,
ICR_{pc} = interest coverage ratio, post-compliance,
Δ TC = change in total cost due to compliance, including an annual capital cost,
TI = treatment investment (assuming all of the front-end outlay would be capitalized and reported as an addition to assets on the balance sheet),
Δ = the change in the value for all variables due to compliance, and

all other variables are defined as before.

The incremental values for revenues, expenses, and interest are the same as described in the ATCF test discussion.

EPA compared baseline and post-compliance PTRA to an 8 percent threshold and baseline and post-compliance ICR to a threshold of 4 in this analysis. Both measures are important to financial success and firms' ability to attract capital. EPA assumed that firms with acceptable PTRA and ICR would not be subject to financial distress. Firms that do not fall below either threshold in the baseline but that do fall below one or both of the thresholds as a result of the rule are judged to experience moderate impacts short of closure attributable to the rule.

5.2.4 Impact Measures for Railroad Line Maintenance Facilities

The MP&M rule could potentially apply to some railroad facilities that maintain and repair railroad track and that perform similar operations on railroad and other vehicles. Railroad representatives indicated during data collection that the industry does not collect or monitor significant financial data at the facility level. These discussions led EPA to administer a modified version of the survey to railroad operating units and to perform the primary economic impact analysis at the operating unit level.

The analysis of impacts for railroad line maintenance facilities uses the same measures of impact as for other private MP&M facilities, but applies these measures for the railroad operating unit as a whole. Compliance costs for each railroad are the sum of compliance costs at each MP&M railroad line maintenance facility identified by the operating company.

5.2.5 Impact Measures for Government-Owned Facilities

Government-owned MP&M facilities include all facilities owned by government entities that discharge process wastewater from MP&M activities. Most government-owned facilities that fall under the MP&M rule provide or support transportation services. These facilities repair, rebuild, and maintain buses, trucks, cars, utility vehicles (e.g., snow-plows and street cleaners), and light machinery. The MP&M profile describes government-owned facilities in detail.

Each government subject to the MP&M effluent guidelines at its facilities has a number of choices, which include:

Contracting out the service to a private provider or other governmental agency,
Discontinuing these services altogether, or
Paying for compliance and continuing operations.

The impact analysis does not predict how the government will respond. The analysis evaluates only whether a community incurring compliance costs and continuing operations under the rule would incur a severe burden. A government may choose a different option and avoid some of the budgetary impacts estimated here.

EPA evaluated impacts for government-owned facilities by using three tests. A government that fails all three tests is likely to suffer severe adverse impacts as a result of the rule. The first test is applied at the facility level, and the other two tests are applied at the government level.

a. Impacts on site-level cost of service test

The impacts on site-level cost of service test considers whether a government-owned facility's compliance costs exceed one percent or more of its total baseline cost of service. This test is similar to the test used to assess impacts on private facilities and firms, which compares costs to post-compliance revenues. The facility will likely absorb compliance costs within its current budget if those costs do not exceed one percent of the total. Compliance costs in this scenario will not significantly impact the municipal budget. Costs in excess of one percent do not, in and of itself, indicate that a budgetary impact will occur, but only that additional analysis should be performed to determine if there is an impact.

EPA calculated the ratio of compliance costs to cost of service, R_C, for each government-owned facility as follows:

$$R_C = \frac{TACC}{C_{Baseline}} \qquad (5.12)$$

where:

R_C	=	ratio of compliance costs to cost of service,
TACC	=	total annualized compliance cost for the facility, and
$C_{Baseline}$	=	total baseline cost of service at the facility.

A facility whose R_C is equal to or greater than one percent fails this test.

b. Impacts on taxpayers test

The impacts on taxpayers test evaluates the significance of compliance costs to the people served by the government. A government will fail this test if the ratio of total annualized pollution control costs per household to median household income exceeds one percent, post-compliance. Post-compliance pollution control costs include all pollution control costs (for whatever purpose) reported by the government in the baseline plus the sum of MP&M effluent guideline compliance costs at all MP&M facilities owned by the government. This test closely follows the methodology developed for EPA's Water Quality Standards Workbook (EPA, 1995).

The survey requests information about current municipal expenditures on pollution control. TACC for each government-owned facility is the sum of costs and an amortized capital cost. The sum of TACC at all MP&M facilities for each government, plus baseline municipal expenditures on pollution control, yields a post-compliance total annualized pollution control cost. EPA divided total annualized pollution control costs by the number of households to calculate an average cost per household. The questionnaire also asks for median household income in the geographic area served by the responding government.

EPA calculated a ratio of compliance costs to median household income, R_H, for each government as follows:

$$R_H = \frac{C_{BPB} + \sum_i TACC_i}{MHI} \qquad (5.13)$$

where:

R_H	=	ratio of total annualized pollution control cost to median household income,
C_{BPC}	=	total baseline municipal expenditures on pollution control, and
$TACC_i$	=	total annualized compliance cost for government-owned facility *i*,
MHI	=	median household income for the government jurisdiction.

Governments that incur compliance costs that cause this ratio to exceed one percent fail this test. Governments that fail this test in the baseline as well as post-compliance are not judged to experience major budgetary impacts attributable to the rule. If the rule causes an increase in this ratio to above one percent, then EPA concludes that the rule might present a burden to the taxpayers that support the affected government. The calculation is a conservative estimate of the impact on taxpayers because it does not take into account the fact that non-residential taxpayers (businesses) will bear some of the tax burden or that some costs might be recovered in fees.

This test is used in EPA's *Economic Guidance for Water Quality Standards*. This guidance is used by States and EPA Regions to assess economic factors in setting or revising water quality standards. The guidance includes as a screening measure of economic impact, average total pollution control cost per household divided by median household income. A value less than one percent indicates that a community would incur "little economic impact".[5]

c. Impacts on government debt test

The impacts on government debt test assesses the government's ability to finance compliance with the rule by issuing debt. A government must be able to finance capital compliance costs in addition to meeting ongoing compliance costs. Governments often finance capital compliance costs by issuing debt. This criterion tests each government's capacity to issue debt by examining the ratio of post-compliance debt service costs to the government's total revenue. This measure is analogous to the interest coverage ratio for private firms.

The ratio of debt service costs to revenue , R_D, for each government is:

$$R_D = \frac{D_B + C_k}{TR_B} \tag{5.14}$$

where:

R_D	=	debt-to-revenue ratio;
D_B	=	baseline municipal debt service costs (principal payments and interest);
C_k	=	annualized capital cost of compliance, summed over all government-owned facilities in each government; and
TR_B	=	baseline municipal revenue.

EPA judged that debt service costs above 25 percent of revenues might impede a government's ability to issue debt in the future and present a burden on the budget.

This criterion is used in EPA's MUNIPAY model. This model is used in enforcement cases to assess whether municipalities (e.g., towns, villages, cities, counties, and public utilities) can afford to pay a specific level of compliance costs, Superfund cleanup contributions, or penalties. The model's affordability assessment limits the amount of debt that can finance these costs, capping the debt service ratio at 25 percent.[6] A higher ratio "may reduce the confidence of creditors that the municipality can repay its debt on time." The MUNIPAY manual states that this value slightly exceeds the "warning marks" found in the public finance and management literature.

5.3 RESULTS

This section presents the results of the facility impacts analyses. The first section presents the results of the baseline closure analysis. Section 5.3.2 covers the price increases predicted for the proposed rule, and subsequent sections report the results of the analyses for the proposed rule and the two other regulatory options that EPA analyzed. Section 5.3.3 presents an overview of impacts for all MP&M facilities, and then results are provided for indirect dischargers (Section 5.3.4), direct dischargers (Section 5.3.5), private facilities (Section 5.3.6), and government-owned facilities (Section 5.3.7). Section 5.3.8 provides results by subcategory.

5.3.1 Baseline Closures

Table 5.3 shows the results of the baseline closure analysis by subcategory. A total of 3,829 facilities have negative average After-Tax Cash Flow (ATCF) and (where calculated) a negative Net Present Value (NPV) in the baseline. These facilities are projected to close in the baseline and are not considered in the analysis of impacts attributable to the proposed rule.

Appendix A provides information on typical average closure rates in the MP&M industries. Census data show that over 10,000 facilities, or almost eight percent of all facilities in these industries, close annually. The number of baseline closures predicted in this analysis is consistent with this typical closure rate, and may even slightly understate baseline closures.

[5] Source: EPA's *Economic Guidance for Water Quality Standards: Workbook* (1995) (Chapter 2 "Evaluating Substantial Impacts: Public Sector Entities"). Values between one and two percent indicate potential "mid-range economic impact". Governments with values above one percent are subject to further analysis to determine whether a significant economic impact would in fact occur.

[6] Source: EPA Office of Compliance and Enforcement Assurance, *MUNIPAY User's Manual,* September 1999, p. 4-14.

Table 5.3: Summary of Baseline Closures

Subcategory	Total Number of Dischargers	Number of Baseline Closures	Percent Closing in the Baseline	Number Operating in the Baseline
General Metals	29,975	3,199	10.7%	26,776*
Metal Finishing Job Shop	1,530	286	18.7%	1,244
Non-Chromium Anodizing	190	40	21.1%	150
Printed Wiring Board	635	3	0.5%	632
Steel Forming & Finishing	153	6	3.9%	147
Oily Waste	29,425	295	1.0%	29,130
Railroad Line Maintenance	832	0	0.0%	832
Shipbuilding Dry Dock	11	0	0.0%	11
All Categories	62,752	3,829	6.1%	58,922*

* Excludes 64 facilities projected to close in the baseline that remain open under the proposed rule.
Source: U.S. EPA analysis

5.3.2 Price Increases

The price increases predicted for the proposed rule are shown in Table 5.4. The percentage price increases are small, falling well below one percent for most sectors and less than two percent in all cases.

Table 5.4: Cost Pass-Through Analysis: Percentage Price Increases under the Proposed Rule by Sector

Sector	Percent Price Increase
Aerospace	0.02%
Aircraft	0.03%
Bus and Truck	0.15%
Electronic Equipment	0.07%
Hardware	0.49%
Household Equipment	0.01%
Instrument	0.30%
Iron and Steel	0.81%
Job Shop	1.91%
Mobile Industrial Equipment	0.19%
Motor Vehicle	0.10%
Office Machine	0.06%
Ordnance	0.38%
Other Metal Products	0.03%
Precious and Non-Precious Metals	0.24%
Printed Circuit Board	1.59%
Railroad	0.05%
Ships and Boats	0.02%
Stationary Industrial Equipment	0.17%

5.3.3 Overview of Impacts

Table 5.5 provides an overview of the numbers of facilities closing and experiencing moderate economic impacts, by regulatory option. These national estimates include all types of dischargers (direct and indirect) and types of facilities (private MP&M, railroad line maintenance, and government-owned facilities.)

Table 5.5: Regulatory Impacts for All Facilities by Option, National Estimates

	Proposed Rule	Option 2/6/10	Option 4/8
Number of facilities operating in the baseline: total	58,922	58,922	58,922
private MP&M and railroad line maintenance	*54,590*	*54,590*	*54,590*
government-owned	*4,332*	*4,332*	*4,332*
Number of regulatory closures	199	1,282	2,963
Percent of facilities operating in the baseline that are regulatory closures	0.3%	2.2%	5.0%
Number of facilities operating post-regulation	58,787[a]	57,640	55,959
Number of facilities below low flow cutoffs	48,256[a]		
Number of facilities with subcategory exclusions	955		
Percent of facilities operating in the baseline excluded or below cutoffs	83.5%		
Number of facilities operating subject to regulatory requirements	9,576	57,640	55,959
Number of facilities experiencing moderate impacts	616	2,216	2,309
Percent of facilities operating in the baseline that experience moderate impacts	1.0%	3.8%	3.9%

a. Includes 64 avoided baseline closures -- general metals indirect dischargers below the low flow cutoffs that are projected to close in the baseline but that remain open under the proposed rule.

Source: U.S. EPA analysis.

Table 5.5 shows that the proposed rule substantially reduces facility-level impacts, compared to the alternative options considered by EPA. Only 199 (0.3 percent) of the facilities that continue to operate in the baseline close due to the proposed rule. Another 83 percent of facilities that continue to operate in the baseline are excluded from requirements, due to either the low flow cutoff for indirect dischargers or the exclusion of indirect dischargers in the Non-Chromium Anodizing, Shipbuilding Dry Dock and Railroad Line Maintenance subcategories. Significantly larger numbers of facilities are projected to close under Option 2/6/10 and Option 4/8 (1,282 and 2,963 respectively). See Chapter 4 for a discussion of the options, low flow cutoffs, and subcategory exclusions.

All facilities that are not exempted and that do not close are subject to requirements under these options. Of the 9,577 facilities that are subject to requirements and continue operating post-compliance, 616 facilities experience moderate impacts. These 616 facilities represent approximately one percent of all facilities that continue to operate in the baseline. Of the facilities with 616 moderate impacts under the proposed rule, the rule caused 137 to fall below the pre-tax return on assets threshold only, 38 to fall below the interest coverage ratio threshold only, and 441 to fall below both thresholds. Substantially more facilities experience moderate impacts under the other two regulatory options than under the Proposed Rule (2,216 for Option 2/6/10 and 2,309 for Option 4/8.)

Table 5.6 shows facility compliance costs by option, discharge status, and subcategory. These compliance costs are adjusted for the effect of taxes for privately-owned facilities, and therefore represent costs as experienced by the regulated facilities.

Table 5.6: Total Annualized Facility[a] Compliance Costs by Subcategory, Discharge Status, and Regulatory Option (after-tax, million 1999$)

Subcategory	Proposed Rule		Option 2/6/10		Option 4/8	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
General Metals	$132.3	$969.9	$132.3	$1,295.8	$195.1	$1,885.5
Metal Finishing Job Shop	$0.8	$80.1	$0.8	$80.1	$1.5	$112.1
Non-Chromium Anodizing		$0.0		$17.5		$26.0
Printed Wiring Board	$1.7	$93.4	$1.7	$93.4	$3.0	$141.2
Steel Forming & Finishing	$20.9	$14.0	$20.9	$14.0	$22.7	$21.8
Oily Waste	$9.3	$4.3	$9.3	$143.8	$50.0	$457.4
Railroad Line Maintenance	$0.8	$0.0	$0.8	$0.2	$0.9	$0.4
Shipbuilding Dry Dock	$1.4	$0.0	$1.4	$0.1	$0.4	$0.1
All Categories: Annual Costs	$167.2	$1,161.7	$167.2	$1,644.9	$273.6	$2,644.5
All Categories: Number of Facilities Operating Post-Compliance	4,633	54,154	4,633	53,008	4,615	51,344
All Categories: Number of Facilities Operating Post-Compliance Subject to Requirements	4,633	4,944	4,633	53,008	4,615	51,344
Total Costs to Industry by Option, Directs + Indirects	$1,328.9		$1,812.1		$2,918.1	

a. This table includes facility compliance costs only. Chapter 11 discusses the social costs of the proposed rule and other options. The estimates in this table exclude baseline and regulatory closures, and are post- or after-tax.

Source: U.S. EPA analysis.

The large number of General Metals indirect dischargers account for 73 percent of total compliance costs under the proposed rule. Total compliance costs incurred by facilities that continue to operate post-compliance are 36 percent higher under Option 2/6/10 than under the proposed rule, and 120 percent higher under Option 4/8 than under the proposed rule.

5.3.4 Results for Indirect Dischargers

Table 5.7 summarizes the results of the facility impact analysis for indirect dischargers, including both private businesses and government-owned facilities.

Table 5.7: Regulatory Impacts for Indirect Dischargers by Option, National Estimates

	Proposed Rule	Option 2/6/10	Option 4/8
Number of facilities operating in the baseline: total	54,270	54,270	54,270
private MP&M and railroad line maintenance	*50,592*	*50,592*	*50,592*
government-owned	*3,678*	*3,678*	*3,678*
Number of regulatory closures	179	1,262	2,925
Percent of facilities operating in the baseline that are regulatory closures	0.3%	2.3%	5.4%
Number of facilities operating post-regulation	54,154[a]	53,008	51,345
Number of facilities below low flow cutoffs	48,256[a]		
Number of facilities with subcategory exclusions	955		
Percent of facilities operating in the baseline excluded or below cutoffs	90.6%		
Number of facilities operating subject to regulatory requirements	4,943	53,008	51,345
Number of facilities experiencing moderate impacts	575	2,175	2,199
Percent of facilities operating in the baseline that experience moderate impacts	1.1%	4.0%	4.1%

a. Includes 64 avoided baseline closures -- general metals indirect dischargers below the low flow cutoffs that are projected to close in the baseline but that remain open under the proposed rule.
Source: U.S. EPA analysis.

Since indirect dischargers account for 92 percent of all facilities that continue to operate in the baseline, these results are similar to those shown in Table 5.5 for MP&M facilities as a whole. Over 90 percent of the indirect dischargers operating post-regulation are excluded from requirements by the low flow cutoffs and the subcategory exclusions for Non-Chromium Anodizing, Shipbuilding Dry Dock and Railroad Line Maintenance facilities under the proposed rule.

5.3.5 Results for Direct Dischargers

The analysis of facility impacts reflects the combined effects of small increases in revenues due to price increases and increased compliance costs for some facilities. Impacts on a specific facility depend on how its costs increase relative to its competitors', since all facilities benefit from the industry-wide price increases. Some facilities can even be better off financially under the proposed rule, for example, if they do not have costs due to flow and subcategory exclusions, or already have treatment in place and therefore incur minimal costs. The analysis indicated that 64 indirect discharging facilities would close under baseline conditions, but would continue operating under the proposed rule. All 64 facilities are in the general metals subcategory and below the low flow cutoff. The combination of small revenue increases and no compliance costs improves the financial performance of these facilities sufficiently to avoid the projected closures. Given the small number of these avoided closures (64 facilities out of almost 63,000 discharging facilities), EPA ignores these positive outcomes in the following discussions of facility impacts.

Table 5.8 summarizes the facility impact results for direct dischargers. Direct dischargers represent 8 percent of all facilities that continue to operate in the baseline. Table 5.8 shows that most direct dischargers operate subject to requirements under the proposed rule. Only 0.4 percent of direct dischargers are projected to close due to the rule. All of the MP&M facilities that discharge directly to surface waters either close or continue to operate under the proposed rule subject to the effluent guidelines. Impacts under the proposed rule are the same as Option 2/6/10 impacts, since the proposed rule does not include exclusions or low flow cutoffs for direct dischargers.

Table 5.8: Regulatory Impacts on Direct Dischargers by Option, National Estimates

	Proposed Rule	Option 2/6/10	Option 4/8
Number of facilities operating in the baseline	4,653	4,653	4,653
private MP&M and railroad line maintenance	*3,999*	*3,999*	*3,999*
government-owned	*654*	*654*	*654*
Number of regulatory closures	20	20	37
Percent of facilities operating in the baseline that are regulatory closures	0.4%	0.4%	0.8%
Number of facilities operating post-regulation subject to requirements	4,633	4,633	4,616
Number of facilities experiencing moderate impacts	41	41	110
Percent of facilities operating in the baseline that experience moderate impacts	0.9%	0.9%	2.4%

Source: U.S. EPA analysis.

5.3.6 Results for Private Facilities

Table 5.9 provides the facility impact analysis results for privately-owned facilities, including Railroad Line Maintenance facilities. Again, because privately-owned facilities account for 93 percent of all MP&M facilities that continue to operate in the baseline, these results are similar to the results reported for all MP&M facilities in Table 5.5. Almost 84 percent of facilities operating post-compliance are excluded from requirements under the proposed rule, either by the low flow cutoffs for indirect dischargers or by the exclusion for the three subcategories of indirect dischargers.

Table 5.9: Regulatory Impacts for Private Facilities by Option, National Estimates

	Proposed Rule	Option 2/6/10	Option 4/8
Number of privately-owned facilities operating in the baseline	54,591	54,591	54,591
Number of regulatory closures	199	1,282	2,963
Percent of facilities operating in the baseline that are regulatory closures	0.4%	2.3%	5.4%
Number of facilities operating post-regulation	54,456[a]	53,309	51,628
Number of facilities below low flow cutoffs	44,654[a]		
Number of facilities with subcategory exclusions	955		
Percent of facilities operating in the baseline excluded or below cutoffs	83.5%		
Number of facilities operating subject to regulatory requirements	8,848	53,309	51,628
Number of facilities experiencing moderate impacts	616	2,216	2,309
Percent of facilities operating in the baseline that experience moderate impacts	1.1%	4.1%	4.2%

a. Includes 64 avoided baseline closures -- general metals indirect dischargers below the low flow cutoffs that are projected to close in the baseline but that remain open under the proposed rule.
Source: U.S. EPA analysis.

5.3.7 Results for Government-Owned Facilities

Table 5.10 provides facility impact analysis results for government-owned facilities. The 4,332 government-owned facilities that continue to operate in the baseline represent 8 percent of all MP&M facilities operating in the baseline. The facility impact analysis does not include a methodology for predicting closures for government-owned facilities, and therefore assumes that all government-owned facilities continue operating post-compliance. EPA estimated major budgetary impacts for these facilities and the governments that own them instead. The analysis considers impacts at both the facility and at the government level.

Under the proposed rule, 83 percent of the government-owned facilities would be excluded from requirements because they fall below the low flow cutoff proposed for indirect dischargers. All government-owned facilities would be subject to requirements under Option 2/6/10 and Option 4/8. None of the options impose compliance costs for government-owned facilities that would result in significant budgetary impacts for the governments that operate the facilities.

Table 5.10: Regulatory Impacts for Government-Owned Facilities by Option, National Estimates

	Proposed Rule	Option 2/6/10	Option 4/8
Number of government-owned facilities operating in the baseline & post-regulation	4,332	4,332	4,332
Number of facilities below low flow cutoffs	3,603		
Number of facilities with subcategory exclusions			
Percent of facilities operating in the baseline excluded or below cutoffs	83.2%		
Number of facilities operating subject to regulatory requirements	729	4,332	4,332
Number of facilities experiencing impacts	0	0	0
Percent of facilities operating in the baseline that experience significant budgetary impacts	0%	0%	0%

Source: U.S. EPA analysis.

Tables 5.11 and 5.12 provide more detail on the results of the facility impact analysis for government-owned facilities. Table 5.11 shows the number of government-owned facilities by type and size of government, and the number that fall below relevant flow cutoffs under the proposed rule.

Table 5.11: Number of Government-Owned Facilities by Type and Size of Government Entity

	Municipal Government	State Government	County Government	Regional Governmental Authority	Total
Large Governments (population> 50,000)					
# of government entities > flow cutoff	60	183	77	0	319
# of government entities < flow cutoff	512	183	610	36	1,341
Small Governments (population <= 50,000)					
# of government entities > flow cutoff	410				410
# of government entities < flow cutoff	1,781		481		2,262
All Governments					
# of government entities > flow cutoff	470	183	77	0	729
# of government entities < flow cutoff	2,293	183	1,091	36	3,603
Total	2,763	366	1,167	36	4,332

Source: U.S. EPA analysis of Municipal Survey.

Table 5.12 provides additional detailed information on the results of the three tests performed in the government impact analysis. The table shows that 215 facilities incur costs exceeding one percent of their baseline costs of service. EPA assumes that facilities whose compliance costs fall below that threshold are likely to be able to absorb the costs within their current budgets. Governments that own MP&M facilities with compliance costs above that threshold do not necessarily experience government-level budgetary impacts, but should be evaluated further. The government-level analyses consider the sum of compliance costs incurred by each government for all its affected MP&M facilities. The test of impacts on households also considers the baseline pollution control costs paid by governments, and the test of impacts on government debt also considers the baseline debt service costs of the affected government. None of the governments analyzed incurred compliance costs under the proposed rule that would result in their failing either of the government-level impacts tests (impacts on households or impacts on government debt).

Table 5.12: Impacts on Governments of MP&M Facility Compliance Costs by Size of Government

	Owned by Small Governments		Owned by Large Governments		All Government-Owned Facilities	
Number of government-owned MP&M facilities affected	2,672		1,660		4,332	
	number	**percent**	**number**	**percent**	**number**	**percent**
Number and percent of governments failing all three budgetary impact criteria	0	0%	0	0%	0	0%
Individual Test Results: number and percent of failures						
Compliance costs > one percent of baseline cost of service test	140	5.2%	75	4.5%	215	5.0%
Impacts on taxpayers test	0	0%	0	0%	0	0%
Impacts on government debt test	0	0%	0	0%	0	0%

Source: U.S. EPA analysis.

The fact that no governments incur budgetary impacts at the government level is not surprising. The MP&M activities regulated under the proposed rule typically represent a very small portion of governments' budgets. Even a significant percentage increase in the cost of MP&M activities (as measured by the comparison of post-regulation costs to baseline costs) is unlikely to present any serious burden on the budgets of the affected governments.

Moreover, the costs to government-owned facilities are quite low. The large majority (3,603 or 83 percent) of the 4,332 government-owned facilities are excluded by the proposed low flow cutoffs for Oily Waste and General Metals subcategories, and therefore incur no costs. (All government-owned facilities fall into one of these two subcategories.) The facilities that are regulated include 212 facilities that incur no costs, and 517 that incur annualized costs of $27,360 on average.

5.3.8 Results by Subcategory

Table 5.13 provides a summary of facility-level impacts by subcategory, for indirect and direct dischargers separately. This table shows that substantial portions of the General Metals and Oily Waste indirect dischargers are exempted by the low flow exemptions.

Metal Finishing Job Shops account for the largest number of closures among indirect dischargers in the proposed rule, and Printed Wiring Board and Metal Finishing Job Shop facilities together account for the largest portion of moderate impacts. Most of the direct discharger impacts (closures and moderate impacts) are in the General Metals subcategory, although the closures and moderately-impacted facilities represent a small percentage of the General Metals direct discharging facilities as a whole. See the regulatory flexibility / SBREFA analysis in Chapter 10 for more information on the Metal Finishing Job Shop and Printed Wiring Board subcategories.

Table 5.13: Regulatory Impacts by Subcategory, Proposed Rule, National Estimates

Subcategory	# Facilities Operating in Baseline	Regulatory Closures	% Closures	# Exempted	% Exempted	# with Moderate Impacts	% Moderate Impacts
Indirect Dischargers							
General Metals	23,140	24	0.1%	20,164[a]	87%	153	0.7%
Metal Finishing Job Shop	1,231	128	10.4%	0	0%	117	9.5%
Non-Chromium Anodizing	150			150	100%		
Printed Wiring Board	620	7	1.1%	0	0%	301	48.7%
Steel Forming & Finishing	105	6	5.7%	0%	0%	4	3.8%
Oily Waste	28,219	14	<.0.1%	28,092	99.5%	0	0%
Railroad Line Maintenance	799			799	100%		
Shipbuilding Dry Dock	6			6	100%		
All Indirect Dischargers	54,270	179	0.3%	49,211[a]	91%	575	1.1%
Direct Dischargers							
General Metals	3,636	20	0.6%	0	0%	34	0.9%
Metal Finishing Job Shop	12	0	0%	0	0%	0	0%
Non-Chromium Anodizing							
Printed Wiring Board	11	0	0%	0	0%	0	0%
Steel Forming & Finishing	43	0	0%	0	0%	7	16.3%
Oily Waste	911	0	0%	0	0%	0	0%
Railroad Line Maintenance	34	0	0%	0	0%	0	0%
Shipbuilding Dry Dock	6	0	0%	0	0%	0	0%
All Direct Dischargers	4,653	20	0.4%	0	0%	41	0.9%

a. Includes 64 avoided closures -- general metals indirect dischargers that are projected to close in the baseline but which operate under the proposed rule and are eligible for the low flow cutoff.
Note: may not sum to totals due to independent rounding.
Source: U.S. EPA analysis.

GLOSSARY

after-tax cash flow (ATCF): after-tax cash flow available to equity.

avoided baseline closure: occurs if a facility fails the baseline tests but passes the post-compliance tests.

baseline closure: facilities showing inadequate financial performance in the baseline, that is, in the absence of the rule. These facilities closures would have occurred with or without the rule.

Construction Cost Index (CCI): measures how much it cost to purchase a hypothetical package of goods and services compared to what is was in the base year. It applies to general construction costs. The CCI can be used where labor costs are a high proportion of total costs. The CCI uses 200 hours of common labor, multiplied by the 20-city average rate for wages and fringe benefits. (http://www.enr.com/cost/costfaq.asp)

cost pass-through analysis: calculates the percentage of compliance costs that EPA expects firms subject to regulation to recover from customers through increased revenues.

facility: a contiguous set of buildings or machinery on a piece of land under common ownership.

government-owned facility: includes facilities operated by municipalities, state agencies and other public sector entities such as state universities.

interest coverage ratio (ICR): ratio of cash operating income to interest expenses. This ratio measures the facility's ability to service its debt and borrow for capital investments.

liquidation value: net amount that could be realized by selling the assets of a firm after paying the debt. (http://www.duke.edu/~charvey/Classes/wpg)

moderate impacts: adverse changes in a facility's financial position that are not threatening to its short-term viability.

net present value (NPV): present value of the expected future cash flows minus the cost. (http://www.duke.edu/~charvey/Classes/wpg)

operating and maintenance (O&M): costs estimated to result from operating and maintaining pollution controls adopted to comply with effluent guidelines. Operating costs include the costs of monitoring.

pre-tax return on assets (PTRA): ratio of cash operating income to assets. This ratio measures facility profitability.

private MP&M facility: includes all privately-owned facilities that do not perform railroad line maintenance.

Producer Price Index (PPI): a family of indexes that measures the average change over time in the selling prices received by domestic producers of goods and services. PPI's measure price change from the perspective of the seller. This contrasts with other measures, such as the Consumer Price Index (CPI), that measure price change from the purchaser's perspective. Sellers' and purchasers' prices may differ due to government subsidies, sales and excise taxes, and distribution costs. (http://stats.bls.gov/ppifaq.htm#1)

railroad line maintenance facility: facilities that maintain and repair railroad track and other vehicles.

regulatory closure: a facility that is predicted to close because it can not afford the costs of complying with the rule.

severe impacts: facility closures and the associated losses in jobs, earnings, and output at facilities that close due to the rule.

total after-tax cash flow (TATCF): after-tax cash flow available to all capital.

total annualized compliance cost (TACC): sum of annual operating and maintenance costs and the annualized equivalent of one-time costs, calculated over 15 years assuming a seven percent discount rate.

ACRONYMS

ATCF: after-tax cash flow
CCI: construction cost index
ICR: interest coverage ratio
O&M: operation and maintenance
NPV: net present value
PPI: producer price index
PTRA: pre-tax return on assets
TACC: total annualized compliance cost
TATCF: total after-tax cash flow

REFERENCES

Brealey, Richard A. and Stewart C. Myers. 1996. *Principles of Corporate Finance,* 5th edition. New York: McGraw-Hill.

U.S. Bureau of Labor Statistics, Producer Price Index Revision-Current Series. On-line database at http://stats.bls.gov/ppihome.htm

U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures. On-line database at http://www.census.gov/prod/www/abs/industry.html

U.S. Environmental Protection Agency. 1995. *Interim Economic Guidance for Water Quality Standards Workbook.* Office of Water, Economics and Statistical Analysis Branch. March.

U.S. Environmental Protection Agency. 2000. *Technical Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products & Machinery Point Source Category*. EPA 821-B-00-005. December.

Chapter 6: Employment Effects

INTRODUCTION

The proposed MP&M rule may generate both positive and negative impacts on employment. Facility closures induced by the rule will result in reduced demand for labor and compliance activities at facilities that close, but will also increase employment requirements in facilities that remain open and continue to operate. The regulation will also create a demand for compliance-related equipment and installation, which will also generate new employment requirements.

EPA assumed that all projected facility closures would result in the loss of ***full-time equivalents*** **(FTEs)**.

The MP&M rule may affect overall employment in three ways.

- ***Direct labor requirements***. Direct labor requirements are job losses associated with closures and job gains associated with manufacturing, installing, and operating compliance-related equipment. Direct labor requirements also include labor required to implement pollution prevention activities associated with the rule.[1]

- ***Indirect labor requirements***. Compliance expenditures may increase employment in industries doing business with waste treatment providers. Economists refer to these as ***linked industries***. For example, a firm that manufactures a treatment system will purchase pumps, pipes, and other intermediate goods and services from other firms and sectors of the economy. Employment in these linked industries increases when treatment equipment manufacturers purchase goods and services from them. Closures of MP&M facilities can also lead to reduced requirements for inputs to MP&M industry products, and therefore indirect job losses in the supplier industries.

- ***Induced labor requirements***. Increased employment in the waste treatment industry increases spending on consumer-oriented service and retail businesses. Economists refer to the additional labor demand in the businesses patronized by people working in the waste treatment industry as "induced" labor requirements. Conversely, people who are laid off from MP&M facilities that close due to the rule may spend less, resulting in induced reductions in employment in sectors providing consumer services and products.

CHAPTER CONTENTS:

EPA estimates that the MP&M regulation may cause the short-term loss of 5,916 direct full-time equivalent (FTE) jobs due to facility closures, and a short-term gain in direct employment of 4,488 FTEs for individuals necessary to manufacture and install compliance equipment. The regulation will also cause a continuing direct requirement for 286 FTEs per year to operate and maintain the compliance equipment.

The net effect on direct employment of the proposed rule is an estimated 2,575 increase in ***FTE-years***, a measure that reflects both the number and the duration of jobs lost and gained. This number represents an average gain of 172 FTEs per year over the 15 year analysis period.

The analysis assumes that workers losing their jobs due to closures are out of work for an average of one year. If they were out of work less time than that, the gain would be higher.

The net gain in employment represents a very small percentage of the total employment in the MP&M industries. Given the small magnitude of the job gains and job losses compared to overall employment in these industries, EPA did not estimate indirect and induced employment gains and losses due to the rule. EPA also did not estimate employment gains in engineering and consulting services associated with the compliance requirements.

[1] See the *Technical Development Document* for more information on compliance costs.

The rest of this chapter explains how EPA estimated the effects of the proposed MP&M rule on employment. The first section discusses the impact of facility closures, and the second section discusses the new employment associated with the proposed rule. The final section discusses net impacts on employment.

6.1 Job Losses Due to Closures

EPA projects that 199 facilities will close rather than continue operating under the proposed rule, as discussed in Chapter 5. EPA assumed that all employees working at facilities that are projected to close will lose their jobs. The §308 surveys provide the number of employees at each facility, expressed in FTEs. The job losses attributable to the proposed rule are simply the sum of employment at the plants projected to close. EPA did not analyze the job losses that would occur if facilities cut back on production or ceased production of products that required certain processes instead of closing. The projected closure of 199 facilities results in a loss of 5,916 FTEs.

Table 6.1: Job Losses by Subcategory

Subcategory	Estimated Job Losses	% of Jobs in Subcategory
General Metals	1,415	0.01%
Metal Finishing Job Shop	2,065	4.0%
Non-Chromium Anodizing	0	0%
Printed Wiring Board	976	0.7%
Steel Forming & Finishing	952	4.2%
Oily Waste	509	0.01%
Railroad Line Maintenance	0	0%
Shipbuilding Dry Dock	0	0%
All Categories	5,916	0.03%

Source: U.S. EPA analysis.

Job losses equal 0.3 percent of employment in all water discharging MP&M facilities, and 0.03 percent of all employment in the industry. These are very small percentages of all facilities operating in the baseline. The subcategories with the greatest job losses are the Metal Finishing Job Shops (8.4 percent of water dischargers in the subcategory), Steel Forming & Finishing (4.2 percent), and Printed Wiring Boards (2.2 percent). The lost jobs represent 4.0 percent, 4.2 percent, and 0.7 percent of the total employment at water discharging facilities in each subcategory respectively

Job losses due to closures in the General Metals subcategory total 1,415. which represent 0.2 percent of water discharging facilities, and 0.01 percent of all employment at water discharging facilities in the subcategory. All other subcategories have job losses that are less than one percent.

6.2 Job Gains Due to Compliance Requirements

6.2.1 Direct Labor Requirements

Direct labor requirements arise from employment necessary to manufacture, install, and operate equipment that MP&M facilities need to comply with the proposed rule, as well as pollution prevention activities undertaken to comply with the regulation. The following sections discuss labor requirements associated with manufacturing compliance equipment, equipment installation, and operation, respectively.

a. Direct labor requirements for manufacturing treatment systems

EPA estimated the direct labor requirements for manufacturing wastewater treatment systems using three steps:

- Calculate the cost of compliance equipment;
- Estimate the share of the cost of compliance equipment due to labor inputs. This estimate shows how much money goes to employees of equipment manufacturers; and
- Convert the dollars spent on manufacturing employees to a full-time employment equivalent (FTE), based on a yearly labor cost.

❖ ***Treatment system equipment cost***

EPA estimated the cost of manufacturing treatment system equipment for each facility estimated to stay open and to comply with the regulation. This information is found in the facility-level impact analysis (Chapter 5).

The national estimate of capital costs for the proposed rule is $1,339.6 million ($1999).[2] This value includes the purchase cost paid to manufacturers of compliance equipment, and the costs of shipping, installation, insurance, engineering, and consultants. Table 6.2 shows the components of total capital costs for the proposed rule.[3] The basic cost of compliance equipment is $632.3 million.

Table 6.2: Components of Proposed Rule Capital Costs (thousand 1999$, before tax)

Cost Component	Cost[a]
a. Direct capital equipment cost	$632,301.7
b. Shipping (27.4% of a)	$181,520.5
c. Installation labor (9.6% of a)	$93,773.5
d. Total installed direct capital costs (a + b + c)	$907,602.7
e. Indirect costs: insurance, engineering & consultants (47.6% of d)	$432,018.9
Total installed capital costs	$1,339,621.6

a. Excludes costs for baseline and regulatory closures.
Source: U.S. EPA analysis.

❖ ***Labor share of treatment system cost***

The Bureau of Economic Analysis (BEA) calculates ***direct requirements coefficients*** that measure how many dollars of each input are purchased to produce a dollar of a given output.[4] EPA used requirements coefficients for BEA Sector 40, the "Heating, Plumbing, and Fabricated Structural Metal Products Industry," for the employment analysis. MP&M project engineers identified BEA Sector 40 as the industrial sector that most nearly matches the businesses that would make, install, and operate waste treatment systems for MP&M facilities complying with the rule. The inputs into Sector 40 production include intermediate goods, materials, and services, as well as labor.

BEA's direct requirements table shows that every dollar of Sector 40 output delivered to final demand requires $0.30632 expended to compensate Sector 40 employees. Multiplying labor's share of output value (30.63 percent) by the value of compliance equipment purchases for the proposed rule ($632.3 million) yields the labor cost of manufacturing treatment system equipment: $193.7 million. EPA assumes that one-third of the equipment purchases and associated labor costs would be incurred in each of the first three years after promulgation of the rule.

❖ ***FTE jobs***

EPA converted the total labor cost to the number of FTE-equivalent jobs by dividing the total labor cost by an estimated yearly labor cost per FTE employee. EPA used the hourly labor rate used in the engineering cost analysis – $29.67 per hour in 1996 dollars. The $29.67 per hour rate includes fringe benefits (e.g., holidays, vacation, and various insurances) and payroll taxes. EPA adjusted this amount to 1999 dollars using the Bureau of Labor Statistics Employment Cost Index for manufacturing of durable goods, to provide an hourly rate in 1999$ of $32.02. The gross 1999$ annual labor cost per FTE position for a 2,000-hour work year is $64,040. EPA estimated that one-time spending on manufacturing treatment system equipment would require 3,024 FTEs. Again, EPA assumed that one third of these FTEs (1,008) would be associated with equipment purchases in each of the first three years after promulgation of the rule.

b. Direct labor requirements for installing treatment systems

EPA's estimate of the direct labor requirements to install treatment system equipment parallels its methodology for analyzing the labor requirements for equipment manufacture.

❖ ***Treatment system equipment installation labor cost***

MP&M project engineers estimate that installation labor costs are seven percent of the total installed direct cost of compliance equipment. The estimated one-time cost of installation labor is $93.8 million for the proposed option. (See Table 6.2.)

❖ ***FTE jobs***

EPA used the loaded hourly labor cost of $32.02 per hour and 2,000 hours per year to convert labor costs to numbers of FTE jobs. Complying facilities will require an estimated 1,464 person-years of full-time employment to install the equipment needed to comply with the proposed rule. This corresponds to 488 FTEs in each of the first three years after promulgation of the rule.

[2] The $1,339.6 million is the sum of one-time outlays for purchasing and installing the capital equipment needed to comply with the proposed rule. This expense is not the annual equivalent of that capital investment. The capital outlay is annualized in the economic impact analysis over a 15-year period. The resulting value, which is part of the total annual cost of compliance, is $112.2 million.

[3] See the *Technical Development Document* for a description of the methods used to estimate capital costs.

[4] See "Benchmark Input-Output Accounts for the U.S. Economy, 1992," in *Survey of Current Business*, July 1997, U.S. Department of Commerce, Bureau of Economic Analysis.

c. Direct labor requirements for operating and maintaining treatment systems

MP&M project engineers estimated that labor costs represent one percent of total compliance operating and maintenance (O&M) costs. For the proposed rule, the labor cost of O&M is $18.3 million per year (1999$), corresponding to 286 FTE positions per year at an hourly rate of $32.02.

d. Total direct labor requirements

The total direct labor requirement for complying with the proposed MP&M rule is the sum of the direct labor requirements of manufacturing, installing, and operating treatment systems. Table 6.3 summarizes the direct labor requirements associated with compliance expenditures under the proposed rule. These requirements include total one-time expenditures to manufacture and install compliance equipment equal to 4,488 FTEs, and continuing requirements for operating and maintenance of 286 FTEs per year.

Table 6.3: Direct Labor Requirements of the Proposed Rule, National Estimates (thousands 1999 Dollars, before tax)

	Total Capital Equipment Cost	Labor Share	Total Labor Cost	FTEs[a]
Year 1				
Manufacturing (1/3 of $632,301)	$210,767	30.63%	$64,558	1,008
Installation labor (1/3 of $93,774)			$31,258	488
1/3 of Annual Operating and Maintenance Cost ($18,288)			$6,095.9	95
Year 1 Total				1,591
Year 2				
Manufacturing (1/3)	$210,767	30.63%	$64,558	1,008
Installation labor (1/3)			$31,258	488
2/3 of Annual Operating and Maintenance Cost			$12,191.9	190
Year 2 Total				1,686
Year 3				
Manufacturing (1/3)	$210,767	30.63%	$64,558	1,008
Installation labor (1/3)			$31,258	488
Annual Operating and Maintenance Cost			$18,287.8	286
Year 3 Total				1,782
Year 4 and Thereafter				
Years 3-15, Total				286

a. Number of jobs calculated on the basis of an average hourly labor cost of $32.02 and 2,000 hours per labor-year.

Source: U.S. EPA analysis, Bureau of Labor Statistics, Bureau of Economic Analysis.

6.2.2 Indirect and Induced Labor Requirements

In addition to direct labor requirements, the proposed MP&M rule may also generate employment through the indirect and induced effects described earlier. Economists use ***multipliers*** to measure indirect and induced input requirements. Multipliers indicate how much a region's economy grows when a dollar is injected into a specific industry at a specific location. When an MP&M facility spends a dollar on treatment equipment, the businesses that make, install, and operate the equipment earn a dollar.

These businesses in turn buy from other suppliers, who in turn buy from still other businesses. In addition, employees in the treatment system industry spend the money they earn on groceries, homes, and other goods and services, thus adding to the impact of that original dollar.

EPA considered a range of multipliers in this analysis to illustrate the possible aggregate employment effects of an MP&M rule. These industry multipliers are averages reflecting both input-intensive activities and activities with relatively few links to other industries. One earlier EPA study used multipliers ranging from 3.5 to 3.9 to estimate employment effects of general water treatment and pollution control activities.[5] A National Utility Contractors Association (NUCA) study of "clean water investments" documented total employment effect multipliers ranging from 2.8 to 4.0.[6] Using the high and low values among multipliers cited in these studies (2.8 to 4.0), EPA estimates that the indirect and induced economic effect of 286 continuing new direct jobs per year would create 801 to 1,144 full-time jobs in the rest of the economy.

EPA is not including a total estimate of indirect and induced job gains and losses at this time, however, because (1) the magnitude of losses and gains is very small at the national level and occur across all states; and (2) the number of job gains during the first three years of the regulation is close to the number of job losses that could occur during the first three years of the regulation. The job gains after the first three years are expected to be approximately 286 jobs per year, without any regulation associated losses. The low magnitude of these gains means that it is highly unlikely that there will be any secondary and induced impacts associated with the proposed regulation.

6.3 NET EFFECTS ON EMPLOYMENT

It is difficult to predict overall impacts of the proposed MP&M rule on employment, because the timing and duration of changes in employment depend on a number of factors. In a full-employment economy, unemployment due to plant closures is likely to be short-lived, and the displaced workers are likely to be employed again quickly in other jobs. In less robust economic times, or in locations with substantial local unemployment, unemployment among those laid off from plants that close due to the rule may persist longer.

The timing of the employment created by the rule is more predictable. The rule will create a short-term demand for labor in the early years of implementation, as facilities are required to purchase and install equipment to comply with the rule. The increased employment needed to operate and maintain compliance systems will persist, presumably for the life of the plant.

Table 6.4 provides an estimate of the level and timing of direct impacts of the proposed rule on employment. This estimate assumes that displaced workers are out of work for one year on average, that facilities come into compliance or close over a three year period, and that the requirements to operate and maintain compliance systems continue for 15 years.

The proposed rule would result in a small net decrease in direct employment in each of the first three years of implementation, and then would require 286 FTEs in each year after that. Summing employment each year over the 15 year analysis period indicates that the proposed rule would result in a net increase of 2,575 "FTE-years" in direct labor requirements. Averaged over the 15 year period, this represents a gain of 172 FTEs a year.

Some of the FTEs required to comply with the rule (the annual operating and maintenance requirements and possibly some of the installation labor) will be hired in the same industry sectors that lose employment due to closures. Other FTEs will be gained in industries that supply pollution control equipment to the MP&M industries. EPA does not have specific information on where these equipment manufacturing jobs will occur, but it is likely that some of them will be within the MP&M industries as well, given the nature of compliance equipment. (Waste treatment equipment is often fabricated metal products and machinery.) While it is difficult to determine what the net effect on specific MP&M sectors will be, comparing the estimated annual average net change in FTEs with total employment in the affected industries provides some measure of the potential overall impact of the net impact on direct employment. The average net gain of 172 FTEs equals a negligible percent of total annual employment in the MP&M facilities potentially subject to the rule (water-discharging facilities) and even less compared with total 1996 employment in the industries (SICs) that make up the MP&M industries.[7]

Facilities that remain open and comply with the MP&M regulations are likely to see an increase in their business from closing facilities, assuming no change in demand. This

[5] U.S. Environmental Protection Agency, 1993.

[6] Apogee Research, Inc. 1992.

[7] Total employment in the potentially regulated MP&M facilities is 20,490,006 FTEs, as reported in the Section 308 surveys.

analysis does not take this potential increased business into account in the estimation of job losses and gains. EPA also did not consider the possible effects of excess capacity or underemployment in the equipment manufacturing and installation industries, and assumed that all compliance requirements would result in proportional changes in employment.

Table 6.4: Estimated Direct Net Impacts on Employment over 15 Years, Proposed Rule (number of FTEs per year and total FTE-years)

Year	One-Time Manufacturing & Installation[a]	Annual O&M[a]	Closures[b]	Net Change in Employment
1	1,496	95	1,972	(381)
2	1,496	190	1,972	(286)
3	1,496	286	1,972	(190)
4		286		286
5		286		286
6		286		286
7		286		286
8		286		286
9		286		286
10		286		286
11		286		286
12		286		286
13		286		286
14		286		286
15		286		286
Total FTE-years over 15 years	4,488	4,003	5,916	2,575

a. Assumes that one-third of facilities come into compliance in each of 3 years/
b. Assumes that one-third of the facilities projected to close do so in each of the first 3 years.
Source: U.S. EPA analysis.

GLOSSARY

direct labor requirements: employment losses resulting from lost MP&M output caused by the rule and employment gains caused by compliance expenditures resulting from the rule in the directly-affected industries.

direct requirements coefficients: Bureau of Economic Analysis measure of the dollar value of specific inputs purchased to produce a dollar of a given output.

full-time equivalent (FTE): hours of employment equivalent to one full-time job

FTE-year: one year of full-time employment

indirect labor requirements: changes in employment in industries that supply directly affected industries resulting from increased purchases or reduced output in the directly affected industries.

induced labor requirements: changes in employment in industries providing goods and services to people whose employment is directly or indirectly affected by the rule.

linked industries: industries that sell goods and services to or purchase output from a directly-affected industry.

multiplier: a measure of the change in some aspect of the size of the economy per unit change in employment or spending; in this report, the total changes in employment resulting from a unit change in direct labor requirements.

ACRONYM

FTE: full-time equivalent

REFERENCES

Apogee Research, Inc. 1992. *A Report on Clean Water Investment and Job Creation*, prepared for National Utility Contractors Association.

U.S. Bureau of Labor Statistics. 2000. *Employment Cost Index - Historical Listing*. July 27. http://stats.bls.gov/ecthome.htm.

U.S. Department of Commerce. 1992 and 1997. Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMSII), Second Edition* and *Third Edition*. Washington, D.C.

U.S. Department of Commerce. 1997. Bureau of Economic Analysis, *The 1992 Benchmark Input-Output Accounts of the United States*.

U.S. Environmental Protection Agency, Office of Water .1993. *Job Creation Fact Sheet*, internal document. February.

Chapter 7: Government and Community Impact Analysis

Introduction

In this chapter, EPA examines how the MP&M rule might affect the economic welfare of communities, where communities are defined as States, counties and metropolitan areas. This chapter also summarizes information on government impacts that supports EPA's compliance with the ***Unfunded Mandates Reform Act*** (**UMRA**).

Communities may suffer adverse impacts from a rule in two ways. First, local governments may incur costs to comply with the rule, if they operate MP&M facilities, or to administer the rule. Second, communities may be affected if MP&M facility closures resulting from the rule affect the health of their local economies.

Chapter Contents

7.1 Impacts on Governments

The proposed MP&M rule may have two effects on governments:

- Government-owned MP&M facilities may be subject to the proposed rule, and therefore incur compliance costs; and

- Municipalities that own ***publicly owned treatment works*** (**POTWs**) that receive influent from MP&M facilities subject to the rule may incur costs to implement the proposed rule. These include costs of permitting MP&M facilities that have not been previously permitted, and repermitting some MP&M facilities with existing permits earlier than would otherwise be required. In addition, POTWs may elect to issue mass-based permits to some MP&M facilities that currently have concentration-based permits, at an additional cost.

7.1.1 Impacts on Governments that Operate MP&M Facilities

Chapter 5 presented EPA's analysis of the proposed rule's impacts on government-owned MP&M facilities and on the governments that own them. The analysis shows that the proposed rule imposes only limited costs on government-owned facilities, because 3,603 (83 percent) of the facilities are exempted under the low flow cutoffs (110 General Metals facilities and 3,492 Oily Wastes facilities.)

An estimated 215 government-owned facilities (5 percent of the total) would incur costs under the proposed rule exceeding one percent of their baseline cost of service. Therefore, 95 percent of the government-owned facilities either incur no costs or are likely to be able to absorb the added costs within their existing budgets. None of the affected governments incur costs that cause them to exceed the thresholds for impacts on taxpayers or for government debt burden. EPA therefore does not expect the proposed rule to impose budgetary burdens on any of the governments that own MP&M facilities.

7.1.2 Government Administrative Costs

State and local governments may incur costs to implement the proposed rule for indirect dischargers. This section describes the administrative activities involved and presents estimates of their costs.

The federal and state governments will implement the requirements for direct dischargers by incorporating the new standards in existing NPDES permits. EPA does not expect governments to incur incremental administrative costs as a result of this rule for direct dischargers, since all direct dischargers must already have NPDES permits.

Publicly owned treatment works (POTWs) will incur costs to implement the proposed rule for indirect dischargers, however. Permitting authorities will have to issue permits for the first time to some indirect discharging facilities and will have to accelerate repermitting for some indirect dischargers that currently hold permits. Communities that own POTWs that must issue permits will therefore incur additional costs as a result of the proposed rule.

EPA is able to estimate total costs to POTWs, but is not able to estimate the costs to any one POTW, since it is not possible to determine what POTWs receive discharges from the regulated MP&M facilities. EPA is also not able to assess budgetary impacts on community-owned POTWs, since available data do not provide estimates of financial characteristics for the specific POTWs receiving effluent affected by this rule. The relatively low POTW permitting costs per facility estimated in this section for the proposed rule suggest, however, that impacts on individual POTWs will be minor.

a. Permitting activities

The General Pretreatment Regulations (40 CFR Part 403) establish procedures, responsibilities, and requirements for EPA, States, local governments, and industry to control pollutant discharges to POTWs. Under the Pretreatment Regulations, POTWs or approved States implement categorical pretreatment standards (i.e., PSES and PSNS).

Discharges from an MP&M facility to a POTW may be permitted in the baseline.[1] For example, industrial users subject to another Categorical Pretreatment Standard would have a discharge permit. Other significant industrial users (SIU) that are typically permitted by POTWs include industrial users that:

discharge an average of 25,000 gallons per day or more of process wastewater to a POTW;

contribute a process waste stream which makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant; or

have a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard.

EPA does not expect the costs of administering the pretreatment program to increase due to the MP&M regulation for facilities that already hold a permit specifying the allowable mass of pollutant discharge to water. Governments will incur additional permitting costs, however, for unpermitted facilities and for any facilities currently with a concentration-based permit that will be issued a mass-based permit under the proposed rule instead.

b. Data sources

EPA collected information from POTWs to support development of the MP&M effluent guideline. Of 150 surveys mailed, EPA received responses to 147, for a 98 percent response rate. The POTW survey asked respondents to provide information on administrative permitting costs, sewage sludge use and disposal costs and practices, and general information (including number of permitted users and number of known MP&M dischargers). The administrative cost information included the number of hours required to complete specific permitting and repermitting, inspection, monitoring, and enforcement activities. Respondents were also asked to provide an average labor cost for all staff involved in permitting activities. EPA used the survey responses on administrative costs to estimate a range of costs incurred by POTWs to permit a single MP&M facility.

c. Methodology

EPA performed the following steps to estimate total POTW administrative costs for the proposed rule and other regulatory alternatives:

❖ ***Determine the number and characteristics of indirect dischargers that will be permitted under the proposed rule.*** The cost of permitting a given MP&M facility varies depending on whether the facility is already permitted. EPA has information from the MP&M facility surveys on baseline permit status. Because costs differ by type of permit (mass-based versus concentration-based), EPA determined how many permits of each type would be issued. All Steel Forming & Finishing facilities will require mass-based permits under the proposed rule. Mass-based permits are not required for the other subcategories. Permit writers can determine what type of permit is appropriate for facilities in subcategories other than Steel Forming & Finishing. EPA is encouraging permit writers and control authorities to issue mass-based permits and control mechanisms, however, where appropriate and feasible. For costing purposes, the analysis of permitting costs assumes that one-third of the new or reissued permits in subcategories other than Steel Forming & Finishing will be mass-based. To the degree that POTWs do not require mass-based permits in subcategories other than Steel

[1] Under the General Pretreatment Program, a facility's discharges may be controlled through a "permit, order or similar means". For simplicity, this report refers to the control mechanism as a permit.

Forming & Finishing, this analysis will overestimate administrative costs.

❖ ***Use the data from the POTW survey to determine a high, middle, and low hourly burden for permitting a single facility.***
EPA defined the low and high estimates of hours such that 90% of the POTW responses fell above the low value and 90% of responses fell below the high value. The median value is used to define the middle hourly burden.

❖ ***Use the data from the POTW survey to determine the average frequency of performing certain administrative functions.***
For administrative functions that are not performed at all facilities, survey data were used to calculate the portion of facilities requiring these functions. For example, the survey data show that on average 38.5% of facilities submit a non-compliance report.

❖ ***Multiply the per-facility burden estimate by the average hourly wage.***
EPA determined a high, middle and low dollar cost of administering the rule for a single facility by multiplying the per-facility hour burden by the average hourly wage. The POTW survey reported an average hourly labor rate of $36.98 (1999$) for staff involved in permitting. This is a fully-loaded cost, including salaries and fringe benefits.

❖ ***Calculate the annualized cost of administering the rule.***
The number of facilities, hourly burden estimate, frequency estimates, and hourly wage estimates are all combined to determine the total cost of administering the rule. The type of administrative activities required varies over time and the total administrative cost is calculated over a 15 year time period. EPA calculated the present value of total costs using a seven percent discount rate, and then annualized the present value using the same seven percent discount rate.

d. Unit costs of permitting activities

EPA estimated unit costs for the following permitting activities:

Permit application and issuance: developing and issuing concentration-based permits at previously unpermitted facilities; developing and issuing mass-based permits at previously unpermitted facilities; developing and issuing mass-based permits at facilities with concentration-based permits; providing technical guidance; and conducting public and evidentiary hearings;

Inspection: inspecting facilities both for the initial permit development and to assess subsequent compliance;

Monitoring: sampling and analyzing permittee's effluent; reviewing and recording permittee's compliance self-monitoring reports; receiving, processing, and acting on a permittee's non-compliance reports; and reviewing a permittee's compliance schedule report for permittees in compliance and permittees not in compliance;

Enforcement: issuing administrative orders and administrative fines; and

Repermitting.

EPA believes that theses functions constitute the bulk of the required administrative activities. There are other relatively minor or infrequent administrative functions (e.g., identifying facilities to be permitted, providing technical guidance to permittees in years other than the first year of the permit, or repermitting a facility in significant non-compliance), but the associated costs are likely to be insignificant compared to the estimated costs for the five major categories outlined above.

Table 7.1 provides a summary of the estimated unit costs for each permitting activity. Appendix C provides a detailed discussion of these unit costs.

Table 7.1: Government Administrative Activities for Indirect Dischargers: Per Facility Hours and Costs

Administrative Activity	Percent of facilities for which activity is required	Frequency of activity	Typical hours and costs		
			Low	Median	High
Develop and issue a concentration-based permit at a previously unpermitted facility	100% of unpermitted facilities being issued a new concentration-based permit (2/3 of new permits)	One time	3.7 hours; $137	9.7 hours; $359	30.7 hours; $1,135
Develop and issue a mass-based permit at a previously unpermitted facility	100% of unpermitted MP&M facilities being issued a new mass-based permit (1/3 of new permits)	One time	4.0 hours; $148	12.0 hours; $444	40.0 hours; $1,479
Develop and issue a mass-based permit at a facility holding a concentration-based permit	All Steel Forming & Finishing facilities with a concentration-based permits and 1/3 of other facilities with a concentration-based permit	One time	2.0 hours; $74	8.0 hours; $296	21.0 hours; $777 year
Provide technical guidance to a permittee on permit compliance	100% of MP&M facilities being issued a new concentration-based permit	One time	1.0 hour; $37	3.3 hours; $122	10.7 hours; $396
	100% of MP&M facilities being issued a new mass-based permit	One time	2.0 hours; $74	3.7 hours; $137	13.0 hours; $481
Conduct a public or evidentiary hearing	3.2% of MP&M facilities being issued a new mass-based or concentration-based permit	One time	2.3 hours; $85	8.0 hours; $296	33.3 hours; $1,231
Permittee inspection for permit development	100% of MP&M facilities being issued a new permit	One Time	2.3 hours; $85	4.7 hours; $174	12.0 hours; $444
Permittee inspection for compliance assessment	100% of MP&M facilities being issued a new permit	Annual	1.8 hours; $67	3.7 hours; $137	10.0 hours; $370
Sample and analyze permittee's effluent	100% of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	3.0 hours; $111	14.0 hours; $518
Review and data entry of permittee's compliance self-monitoring reports	100% of MP&M facilities being issued a new permit	Annual	0.5 hours; $18	1.0 hour; $37	3.5 hours; $129
Receive, process and act on a permittee's non-compliance reports	38.5% of all indirect dischargers receiving a new permit.	5 times per year	1.0 hour; $37	2.0 hours; $74	5.7 hours; $211
Review a compliance schedule report	Meeting milestones: 16.0% of all facilities issued a new permit (94% of the 17% who have compliance milestones).	2 reports per year	0.5 hours; $18	1.0 hour; $37	3.0 hours; $111
	Not meeting milestones: 1% of all facilities issued a new permit (6% of the 17% who have compliance milestones).	2 reports per year	0.8 hours; $30	1.8 hours; $67	6.0 hours; $222
Minor enforcement action e.g., issue an administrative order	7% of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	3.7 hours; $137	13.3 hours; $492
Minor enforcement action, e.g., impose an administrative fine	7% of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	5.3 hours; $196	24.7 hours; $913
Repermit	100% of MP&M facilities being issued a new permit	Every 5 years	1.0 hour; $37	4.0 hours; $148	17.0 hours; $629

Source: U.S. EPA analysis of POTW survey responses.

e. Results

Table 7.2 summarizes the estimated POTW permitting costs for the proposed rule, Option 2/6/10, and Option 4/8. Appendix C presents detailed calculations of permitting costs for these regulatory options. These calculations reflect the incremental number of facilities requiring different types of permitting, inspection, monitoring, enforcement and repermitting in each year multiplied by the unit hours and cost per facility for those activities.

All facilities are assumed to receive a permit within a three-year compliance period. Some facilities with existing permits are repermitted sooner than they otherwise would be on the normal five-year permitting cycle. The cost analysis calculates incremental costs by subtracting the costs of repermitting these facilities on a five-year schedule from the costs of repermitting all such facilities within three years. EPA assumes that the required initial permitting activities will be equally divided over the three-year period. The analysis also calculates the net increase in the number of facilities requiring permitting by subtracting the number of facilities that close due to the rule from the number of facilities that will require new permits under the proposed rule.

Table 7.2: POTW Permitting Costs by Regulatory Option

	Proposed Rule			Option 2/6/10			Option 4/8		
Number of facilities permitted:									
new concentration-based permit	432			16,009			15,119		
new mass-based permit	216			8,004			7,559		
conversion of existing concentration-based to a mass-based permit	223			8,424			8,422		
POTW permitting costs over 15 years (million 1999$):	high	med.	low	high	med.	low	high	med.	low
net present value	$8.3	$2.5	$1.0	$357.7	$107.1	$45.7	$332.6	$99.7	$42.5
annualized (@ 7%)	$0.9	$0.3	$0.1	$39.3	$11.8	$5.0	$36.5	$10.9	$4.7
maximum costs in any one year	$1.6	$0.5	$0.2	$55.9	$17.2	$7.2	$52.3	$16.1	$6.7

Source: U.S. EPA analysis.

EPA estimates that POTWs as a whole will incur incremental average annualized costs over 15 years of between $115,000 and $912,000 under the proposed rule. These costs include issuing new permits to facilities that do not currently have permits, issuing mass-based permits to some facilities that currently have concentration-based permits, and repermitting some facilities sooner than would otherwise be required to meet the three-year compliance schedule. On average, a POTW's costs for the incremental permitting are only $23 to $184 per permitted MP&M indirect discharger under the proposed rule.

EPA expects that these increases in costs will be partially offset by reductions in government administrative costs for facilities that are already permitted under local limits and that will be repermitted under this rule. The technical guidance provided by EPA as a part of this rulemaking may reduce the research required by permit writers in developing Best Professional Judgement (BPJ) permits for industrial dischargers not previously covered by a categorical standard or a water quality standard. Further, the establishment of discharge standards may reduce the frequency of evidentiary hearings. The promulgation of limitations may also enable EPA and the authorized States to cover more facilities under general permits. EPA did not estimate these cost savings to permitting authorities that may result from the rule.

The proposed option requires substantially less permitting by POTWs than the other two options, because a large percentage of facilities that would otherwise have to be permitted are excluded by low-flow cutoffs or subcategory exclusions. Option 2/6/10 results in slightly higher permitting costs than Option 4/8, because more facilities would close under Option 4/8 and therefore not have to be permitted.

7.2 COMMUNITY IMPACTS OF FACILITY CLOSURES

EPA considered the potential impacts of changes in employment due to the proposed rule on the communities where MP&M facilities are located. Changes in employment due to the rule include both job losses that occur when facilities close and job gains associated with facilities' compliance activities. EPA estimated that a total of 5,916 jobs would be lost at the 199 facilities projected to close under the proposed rule. (See Chapter 6.) At the same time, EPA estimated that manufacturing and installing compliance equipment would lead to 4,488 full-time equivalent (FTE) positions, and that operating and maintaining compliance systems would result in another 286 FTEs per year. Over a 15 year analysis period, the net effect of job gains and losses caused by the rule is an increase of 2,575 FTE-years or an average of 172 FTEs per year. This estimate assumes that workers that lose their job are unemployed for an average of one year, and that compliance investments and closures occur evenly over the first three years after promulgation. This estimate of employment impacts is likely to understate the net increase, because it ignores the fact that some production and employment lost at closing plants is likely to result in increased production and employment at other MP&M facilities.

Given the projected overall increase in employment due to the proposed rule, EPA does not expect the rule to have significant impacts at the community level. It is not possible to predict precisely where the job gains and losses will occur. However, facilities that are projected to close due to the rule have employment ranging from 2 to 205 FTEs. MP&M facilities tend to be located in industrialized urban areas, and closures of this size are not likely to have a major impact on a local economy.

GLOSSARY

publicly owned treatment works: a treatment works as defined by section 212 of the Clean Water Act, which is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

Unfunded Mandates Reform Act: Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104-4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and Tribal governments and the private sector. Under §202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "Federal mandates" that may result in expenditures to State, local, and Tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule for which a written statement is needed, §205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule.

Acronyms

POTW: publicly owned treatment works

UMRA: Unfunded Mandates Reform Act

Chapter 8: Foreign Trade Impacts

INTRODUCTION

EPA assessed the proposed rule's likely impacts on foreign trade, as part of its analysis of the rule's effect on the national economy. Changes in the balance of trade have the potential to affect currency exchange rates, money supply, interest rates, inflation, capital flows and labor migration. The MP&M industries include a substantial portion of the nation's economy, and significant impacts on the balance of trade in these industries could have an effect on the overall economy. The trade analysis presented in this chapter indicates that the MP&M rule will not have a significant impact on the balance of trade in commodities, however, either for the MP&M industries or for the economy as a whole.

Chapter 5 estimated price increases and losses in output likely to result from the rule. EPA assessed the impact of these market-level changes on the U.S. balance of trade using information provided by MP&M private facility surveys on the source of competition in domestic and foreign markets. The trade analysis allocates the value of changes in output for each facility that is projected to close due to the rule to exports, imports or domestic sales, based on the predominant source of competition in each market reported in the surveys.

CHAPTER CONTENTS:

8.1 DATA SOURCES

The 199 facility closures identified in Chapter 5 are used to determine foreign trade impacts. Each closed facility's revenues are lost output that can be attributed to the rule.

The analysis uses survey responses to determine whether a closed facility's revenues are more likely to be replaced by either domestic or foreign producers. Question 5 in the Phase I §308 survey asked respondents to identify their "major source of competition" in each of three markets: local/regional, national, and international. Question 8 in the Phase II survey asked respondents to identify their "most significant source of competition" in domestic and international markets.

Respondents selected one of the following possible responses:

- domestic firms,
- foreign firms,
- no competition in this market, and
- do not operate in this market.

During the process of clarifying survey answers with respondents, EPA found that most of those respondents who did not select any of the sources of competition said that they did not participate in the relevant market. Therefore, if a respondent did not answer the question regarding the most important source of competition in the domestic or international markets, EPA classified the facility as not operating in the respective market (domestic or foreign.)

The analysis also uses survey responses to determine revenues from exports. The Phase I §308 survey reported the percentage of revenues earned from domestic customers and from overseas markets. EPA used export share and total revenues for each facility to calculate export and domestic revenues. The Phase II survey asked respondents to report revenues from MP&M exports. EPA then calculated domestic sales by subtracting export revenues from total revenues for each facility.

The Iron & Steel survey did not report comparable information on the source of competition in domestic and foreign markets. EPA relied on published trade statistics for the products produced by facilities in the Steel Forming & Finishing subcategory to assess potential impacts on trade for these facilities.

EPA obtained 1999 import and export data from the Bureau of the Census, Foreign Trade Division for those commodities determined to be MP&M-related. The data included imports and exports by all facilities in relevant industries, including both dischargers and non-dischargers.

8.2 METHODOLOGY

The effect of an increase in domestic production costs on the foreign trade balance is influenced by a variety of factors, including:

- the extent to which domestic producers attempt to raise prices to recover costs,
- the price elasticity of demand in both domestic and export markets,
- the likely pricing and supply response of foreign producers, and
- trends in currency exchange rates.

EPA did not attempt to model changes in prices, output, and sales in domestic and foreign markets simultaneously for all of the products and services involved in the MP&M industries. As in the facility impact analysis described in Chapter 5, the trade analysis relies on a sequential analysis that assesses price increases and then predicts output adjustments based on closures. EPA used the facilities' own assessments of their competitive status relative to foreign producers, as reported in the survey, to assess impacts of these output adjustments on the balance of trade.

EPA expects that foreign firms will replace some but not all of the output from closing facilities. Domestic firms that remain open or enter the market may also win customers that used to buy from the closing facility. Revenues lost by closing facilities are assigned to domestic or foreign producers as follows:

Lost exports: If a closing facility stated that most of its international competition came from foreign firms, then EPA assigned the facility's export revenues to foreign firms. U.S. exports would therefore decline by the amount of the closing facility's exports. If the facility identified domestic businesses as its greatest source of competition in foreign markets, then EPA assigned the closing facility's export revenues to undetermined other domestic firms. Closures of these facilities, which reported relatively low foreign competition for exports, will have no impact on U.S. exports under the expected scenario.

Increased imports: If a closing facility in the domestic sector identified foreign producers as the main source of competition, then EPA assigned the facility's lost domestic revenues to foreign firms. Imports would increase by the same amount. If other domestic businesses posed the strongest competition, then EPA assigned the closing facility's domestic sales to undetermined other U.S. producers, and imports would remain constant.

Six Steel Forming and Finishing facilities are projected to close under the proposed option. These six facilities have revenues in total of only $326,860. This represents an insignificant portion of the total imports, $51.9 billion[1] or less than 0.01 percent. The survey data collected for the Steel Forming and Finishing facilities did not provide export data. EPA assumed that the ratio of exports to value of shipments in the industry as a whole was the same as those closing facilities in our analysis. This assumption results in total lost exports of $28,565 which also represents less than 0.01 percent of total exports in the industry amounting to $937.7 million. Therefore, EPA assumed that the small output lost from closures projected for this sector would have no impact on the balance of trade in finished steel products.

8.3 RESULTS

Chapter 3 provides an overview of exports, imports and the balance of trade in the MP&M industries. U.S. MP&M producers as a group exported products with a value of $380.3 billion in 1999. Imports to the U.S. of the same products in 1999 totaled $534.1 billion, resulting in an overall net MP&M commodity trade deficit of $153.8 billion. Some MP&M sectors contribute to a positive commodity trade balance (e.g. aircraft, with a $37.0 billion positive balance in 1999). In other sectors, substantially more products are imported than exported (e.g. motor vehicles, with a net negative balance of $96.8 billion.)

Table 8.1 shows that the proposed effluent guidelines will have a negligible impact on U.S. imports, exports, and the national trade balance. Projected imports increase by $21.1 million, or less than 0.01 percent of baseline imports, and there is no change in exports post-compliance. The net result is an insignificant less than 0.01 percent decline in the national balance of trade in commodities.

[1] Based on the U.S. Department of Commerce, Bureau of the Census, *Current Industrial Reports* for Steel Mill Products in 1997. Only the relevant products are included: wire products, cold finished bar, and pipes and tubes (except seamless and large diameter pipe).

Table 8.1 Estimated National Impacts on U.S. Foreign Commodity Trade (millions 1999$)

	1999 Exports [a]	1999 Imports	Trade Balance
Baseline	$695,797	$1,024,618	($328,821)
Change due to the rule	0	$21.1	($21.1)
Post-compliance	$695,797	$1,024,235	($328,438)
% Change from baseline	-	<0.01%	(<0.01%)

a. Only 3 regulatory closures reported exports, totaling $16,613. These facilities reported no foreign competition in the international market.
Source: Bureau of Census and U.S. EPA analysis.

Table 8.2 shows regulatory impacts on MP&M-related foreign trade. The projected changes in exports and imports also represent an insignificant percentage of commodity trade in the MP&M industries, resulting in a 0.01 percentage decline in the net trade balance in these industries.

Table 8.2: Estimated National Impacts on MP&M Related Foreign Trade (millions 1999$)

	1999 Exports	1999 Imports	Trade Balance
Baseline	$380,305	$534,141	($153,836)
Change due to the rule	0	$21.1	($21.1)
Post-compliance	$380,305	$534,120	($153,815)
% Change from baseline	-	<0.01%	(0.01%)

a. Only 3 regulatory closures reported exports, totaling $16,613. These facilities reported no foreign competition in the international market.
Source: Bureau of Census and U.S. EPA analysis.

The analysis of trade impacts does not explicitly account for responses to price increases caused by the rule, as noted previously. EPA expects there to be little change in exports and imports resulting from the minimal price increases predicted for the proposed rule, however. The estimated price increases are less than two percent in all sectors, and in most cases are less than one percent. (See Table 5.4 in Chapter 5.) Annual rates of inflation for the United States' major trading partners are generally well above the projected increases in MP&M prices, and price increases in the projected range are not likely to have much impact on the terms of U.S. trade in MP&M products.[2]

[2] The following are 1990-98 annual inflation rates, as measured by the GDP implicit deflator, for nine of the U.S.' s top ten trading partners: Canada 1.4%, Mexico 19.5%, Japan 0.2%, China 9.7%, Germany 2.2%, United Kingdom 3.0%, Republic of Korea 6.4%, France 1.7%, and Singapore 2.1%. The annual change in the U.S. GDP deflator over the same period is 1.9% (Data were not reported for Taiwan.) World Bank, *2000 World Development Indicators*, Table 4.16.

REFERENCES

U.S. Department of Commerce, Bureau of the Census. 1997. *Current Industrial Reports:* Steel Mill Products.

U.S. Department of Commerce, Bureau of Census, Foreign Trade Division. FT900. 1999. http://www.census.gov/foreign-trade/Press-Release/99_press_releases/Final_Revisions_1999/

World Bank, *2000 World Development Indicators.*

Chapter 9: Firm Level, New Source, and Industry Impacts

INTRODUCTION

Previous chapters have assessed impacts on MP&M facilities, on governments and communities, and on the U.S. balance of trade. This chapter considers impacts on private businesses in more detail, by addressing three categories of impacts. The analysis of impacts on firms builds on the facility impact analysis to assess whether firms that own multiple facilities are likely to incur more significant impacts than indicated by the facility impact analysis. The ***new source*** facility impact analysis considers whether the proposed rule might impose disproportionate burdens on new sources relative to existing sources, and thereby pose a barrier to new entry. Finally, this chapter discusses potential industry-level impacts of the proposed rule.

CHAPTER CONTENTS:

9.1 FIRM LEVEL IMPACTS

EPA analyzed economic impacts on firms for three reasons:

- Impacts may be more significant at the firm level than at the facility level if a firm owns a number of facilities that incur significant costs. To the extent allowed by the available data, the analysis therefore looks at the combined effect of the facility compliance costs for all facilities owned by a given firm.

- Resources available to fund compliance costs are determined by a parent firm's financial strength rather than the individual facility's financial position. A financially-strong firm may decide to close a facility that incurs substantial costs and is no longer profitable, even if it has the resources to fund compliance costs. EPA therefore assesses potential closures based on facility-level conditions. However, an otherwise profitable facility would not have to be closed due to lack of financial resources or ability to issue debt, if its parent firm's financial position is not adversely affected by the proposed rule.

- A firm-level analysis is needed to assess impacts on small businesses, as required by the Regulatory Flexibility Act and SBREFA. (Chapter 10 presents an analysis of small business impacts.)

9.1.1 Sources

The firm-level analysis starts with the results of the facility-level analysis presented in Chapter 5, supplemented by firm-level information provided by the MP&M facility surveys and publically available information.

EPA was not able to conduct a rigorous national analysis of firm-level impacts because the sample frame used to provide national estimates from surveyed facilities reflect the population of facilities rather than firms. EPA therefore analyzed impacts for a hybrid dataset of MP&M firms that includes both national estimates (for single-facility firms) and sample firms (for multiple-facility firms.) The Agency believes that the analysis of firm-level impacts presented in this chapter provides a useful indication of national firm-level impacts, however, for two reasons:

- Most MP&M facilities are single-facility firms. The survey facility sample weights can be used to extrapolate to the national number of firms for these single-site firms.

- EPA requested voluntary information in the Phase II detailed questionnaires on other MP&M facilities owned by the firms responding to the survey for a sampled facility. EPA was able to aggregate multiple-facility compliance costs to the firm-level by including costs for all surveyed facilities and (for the Phase II survey) facilities identified in these voluntary responses.

It is unlikely that there will be a large number of firm-level impacts among all MP&M firms in the nation, if this partial analysis does not indicate significant impacts among the firms identified in this analysis.

9.1.2 Methodology

The various surveys asked respondents to provide firm-level revenues for the parent firm. For single-facility firms, firm revenue and compliance costs are identical to those for the facility. For firms that own more than one sample facility, compliance costs are the sum of costs for all facilities reported on in the survey.

Respondents to the Phase II survey had the option to submit additional voluntary data for other MP&M facilities owned by the same parent firm, in Part V of the detailed industry questionnaire. EPA included compliance costs for these facilities in calculating the total firm-level compliance costs for multi-facility firms. EPA identified the subcategory, flow range, and discharge type for each of the Part V MP&M facilities. The analysis assumed that these additional facilities would have the same average compliance costs as the facilities for which detailed technical compliance cost estimates were developed. EPA calculated average costs by subcategory, flow range, and discharge type from the detailed compliance cost estimates and assigned these costs to the additional facilities identified in Part V of the survey.

EPA then grouped together all facilities with a common parent firm from the Phase I, Phase II and Iron and Steel surveys. For each firm in the analysis, firm-level compliance cost is:

$$CC_{firm} = \sum_{i} CC_i$$

where:

CC_{firm} = firm-level compliance cost
CC_i = compliance cost for surveyed facility *i* owned by the firm

Firm-level compliance costs were compared to firm revenues. Firms with compliance costs less than one percent of revenues are unlikely to have any serious impacts due to the regulation. EPA identified firms as subject to potentially more serious impacts if their compliance costs exceeded three percent of revenues.

All firm-level data were inflated to 1999 dollars using the ***Producer Price Index*** (**PPI**), as described in Chapter 5.

9.1.3 Results

As noted in the introduction, the Agency was not able to estimate the national numbers of firms that own MP&M facilities precisely, because the sample weights based on the survey design represent numbers of facilities rather than firms. EPA assumed that the national facilities that are represented by the 319 single-site firms are also all single-site firms. Based on this assumption, EPA estimated that 43,118 of 54,591 (or 79 percent) of MP&M facilities nationwide are single-facility firms.

In addition, there are 289 firms that own more than one sample facility. It is not known how many multi-facility firms exist at the national level. EPA included these 289 firms identified by sample facilities in the firm-level analysis without extrapolation to the national level.

The combined set of 43,407 firms (43,118 national-level single-facility firms plus 289 sample multi-facility firms) provided the basis for the firm-level analysis. This total does not represent a valid national total for the number of affected MP&M firms. Nonetheless, this analysis provides a reasonable indication of likely firm-level impacts, given the large number of single-facility firms and the use of Part V facility data to supplement the sample facility data for multi-facility firms.

Table 9-1 presents the number of facilities and firms in the firm-level analysis. Nationally, there are 43,118 single-site facilities/firms, and 11,473 facilities owned by an unknown number of multi-site firms. Of those 43,118 facilities that are single-facility firms, 42,422 are owned by small firms. Of the 289 firms that own more than one sample facility, 87 are small firms. The analysis includes a total of 43,407 MP&M firms (43,118 + 289).

Table 9.1: Number of Privately Owned Facilities and Firms by Firm Type and Size

	Total Firms/ Facilities	Owned by a small firm	Owned by a large firm
National number of single-facility firms (319 unique sample firms)	43,118	42,422	695
Sample multi-facility firms	289	87	202
Number of firms in the firm-level analysis	43,407	42,509	897

Source: U.S. EPA analysis.

Table 9-2 presents estimated firm-level impacts of the MP&M rule. A small percentage (2.5 percent) of the firms in the analysis incur before-tax compliance costs equal to 3 percent or more of annual revenues. Ninety-five percent incur compliance costs less than 1 percent of annual revenues, and the remaining 2.5 percent incur costs between 1 and 3 percent of revenues. Of 2,171 firms in the analysis that incur costs greater than 1 percent of revenues, 636 are single-facility small firms that were reported in the facility impact analysis to close (161 firms) or experience moderate impacts (475 firms) due to the rule.

Table 9.2: Firm-level Before-Tax Annual Compliance Costs as a Percent of Annual Revenues

Number of Firms in the Analysis[a]	Number and Percent with Before-Tax Annual Compliance Costs/Annual Revenues Equal to:					
	Less than 1%		1-3%		Over 3%	
	Number	%	Number	%	Number	%
43,407	41,236	95%	1,070	2.5%	1,101	2.5%

[a] Firms whose only MP&M facilities close in the baseline are excluded.
Source: U.S. EPA analysis.

This analysis is likely to overstate costs at the firm level for two reasons. First, it includes compliance costs for facilities that are projected to close due to the rule. The estimated compliance costs for these facilities are higher than the true cost to the firm of shutting down the facility, as illustrated by the detailed facility impact analysis that projects closures. Second, the analysis does not consider actions a multi-facility firm might take to reduce its compliance costs under the proposed rule. These include transferring functions among facilities to consolidate wet processes and take advantage of scale economies in wastewater treatment.

9.2 New Source Impacts

The proposed rule includes **NSPS** and **PSNS** limitations that will apply to new direct and indirect MP&M dischargers. In this section, EPA examines the impact of these regulations for new dischargers to determine if they would impose an undue economic and financial burden on new sources seeking to enter the MP&M industry.

Disproportionate regulatory burdens for new sources could cause adverse industry-level outcomes in the long-run in several ways:

- Imposing more significant costs on new facilities can make existing sources more competitive than new sources causing barriers to new entry;
- Barriers to entry may increase the market power of existing firms and could discourage competition over time, with resulting losses in market efficiencies;
- Creating a competitive advantage for existing facilities may hinder technological innovation, with resulting losses in productivity.

Table 9-3 describes the proposed option for new sources in each subcategory, as well as the proposed technology option for existing sources in the same subcategory and discharge status.

Table 9.3: Proposed Rule for New Sources

Subcategory	Discharge Status	Existing Source Technology Option[a]	New Source Technology Option[a]
General Metals	D & I	2	4, with 1 mgy low flow cutoff for PSNS
Metal Finishing Job Shops	D & I	2	4
Non-Chromium Anodizing	D	2	2
Oily Wastes	D & I	6	6, with 2 mgy low flow cutoff for PSNS
Printed Wiring Board	D & I	2	4
Railroad Line Maintenance	D	10	10
Shipbuilding Dry Docks	D	10	10
Steel Forming & Finishing	D & I	2	4

[a] Technology options 1 through 10 are described in Chapter 4.
Source: U.S. EPA analysis.

EPA is proposing the same requirements for new and existing sources for Non-Chromium Anodizing and the oily waste subcategories (Railroad Line Maintenance, Shipbuilding Dry Dock, and Oily Wastes) and is proposing more stringent standards for new sources in other subcategories.

EPA estimated compliance costs as a percentage of revenues and compared these percentages for new facilities to the cost-to-revenue percentage for existing facilities in the same subcategory. This comparison indicates whether the proposed rule is likely to place new facilities at a competitive disadvantage relative to existing sources, and therefore to pose a barrier to new entry.

9.2.1 Methodology

EPA assessed the impacts of the proposed rule on new facilities based on the characteristics of a hypothetical model facility in each subcategory and discharge category. Engineering estimates of compliance costs for the model facilities reflect the typical flow size and other technical characteristics of facilities in each subcategory.

Model facilities for indirect sources in each subcategory were chosen based on the median baseline flow of all existing indirect facilities in that subcategory which will not contract haul under a regulatory option. Similarly, model facilities for direct sources in each subcategory were chosen based on the median baseline flow of all existing direct facilities in that subcategory which do not contract haul under a regulatory option. In cases where the existing facility with the median subcategory flow performed a representative sample of unit operations, it was chosen as the representative model facility for that subcategory. However, if the median flow facility did not perform representative unit operations, another existing facility with a flow either just above or just below the median was chosen (based on the unit operations performed).

EPA estimated compliance costs for Option 2/6/10 and Option 4/8 for these model facilities. Estimated capital costs for new sources are six percent lower than similar costs for existing sources because new sources do not have to retrofit facilities. These compliance cost estimates are described in more detail in the *Technical Development Document* (U.S. EPA, 2000). Annualized compliance costs estimated for model facilities under the proposed new source option are shown in Table 9-4.

New sources in the Metal Finishing Job Shop and Printed Wiring Board subcategories will have to comply with 40 CFR 433 new source requirements, and Steel Forming & Finishing new sources will have to comply with 40 CFR 440 new source requirements. The analysis considers only the incremental costs of proposed MP&M new source requirements beyond the 40 CFR 433 and 40 CFR 440 requirements that apply in the baseline.

EPA estimated facility revenues for the model facilities based on revenues reported for existing facilities in the Section 308 surveys. The analysis excludes facilities that are projected to close or to experience moderate economic impacts in the baseline, since the economic characteristics of these financially-weak facilities are unlikely to be representative of new facilities. EPA sorted the existing financially-sound facilities in each subcategory/discharge category by flow size, and identified facilities in each quartile based on flow size. The Agency then identified the flow size quartile that the hypothetical new facility would fall into, based on its flow size. Finally, EPA calculated the average revenue for the existing facilities in that same flow size quartile, and assumed that the hypothetical new facility would have revenues equal to that average.

The analysis assumes that new sources would benefit from price increases resulting from the proposed rule for existing sources to the same degree that existing sources will. EPA therefore increased the average baseline revenue for new facilities by the average percentage price increase estimated for existing facilities in each subcategory/discharge category, to calculate post-regulation revenues for new sources. Table 9-4 shows the post-regulation revenue estimated for each model facility.

EPA used compliance costs as a percentage of post-regulation revenues as a measure of impacts. Comparing the cost-to-revenue percentage for new facilities to the percentage for existing facilities under the proposed rule indicates whether the proposed regulation will place new facilities at a competitive disadvantage relative to existing sources.

9.2.2 Results

Cost-to-revenue comparisons for new facilities and existing facilities are presented in Table 9-4. Only existing facilities that continue operating post-compliance are considered, since these are the facilities with which new sources will compete. New sources in all but the Metal Finishing Job Shop category incur costs that are below one percent of post-regulation revenues. Costs for Metal Finishing Job Shop direct and indirect dischargers are less than two and five percent of estimated facility revenues, respectively. EPA believes that cost increases of this magnitude are unlikely to place new facilities at a competitive disadvantage relative to existing sources. Moreover, it appears that costs as a percentage of revenues are generally comparable for new sources and existing sources with which they will compete.

Table 9.4: Impacts on New Sources

Subcategory	Discharge Status	Annualized Compliance Costs (ACC) [a] ($1999)	Facility Revenue [b] ($1999)	New Source ACC as % of Revenue	Existing Source ACC as % of Revenue [c]
General Metals	I	$393,220	$417,071,318	0.09%	0.12%
General Metals	D	$167,342	$398,818,659	0.04%	0.10%
Metal Finishing Job Shops	I	$65,369	$1,428,443	4.58%	2.97%
Metal Finishing Job Shops	D	$70,735	$5,089,823	1.39%	5.38%
Non-Chromium Anodizing	D	$97,108	$24,201,166[d]	0.40%	- [d]
Oily Wastes	I	$355,874	$474,228,616	0.08%	0.01%
Oily Wastes	D	$37,815	$116,772,943	0.03%	0.01%
Printed Wiring Board	I	$70,563	$35,030,097	0.20%	0.61%
Printed Wiring Board	D	$160,184	$1,029,783,596	0.02%	0.01%
Railroad Line Maintenance	D	$184,261	N/A	N/A	N/A
Shipbuilding Dry Dock	D	$220,492	$192,018,827	0.11%	0.03%
Steel Forming & Finishing	I	$114,851	$69,640,244	0.16%	0.38%
Steel Forming & Finishing	D	$46,945	$32,759,295	0.14%	2.00%

a. Incremental to baseline new source requirements for Metal Finishing Job Shop, Printed Wiring Board and Steel Forming & Finishing new sources.
b. Equal to the average revenues of existing facilities in the same quartile based on flow size as the new source model facility, excluding existing facilities that close or experience moderate impacts in the baseline. Assumes the same percentage price increases for new as for existing sources under the proposed option.
c. Includes existing facilities in all flow categories that continue operating post-compliance.
d. No direct Non-Chromium Anodizer facilities were identified in the analysis of existing sources. The estimate of facility revenue is based on the average for indirect dischargers in this subcategory.
Source: U.S. EPA analysis.

Railroad line maintenance facilities do not have revenue reported at the facility level, and it is therefore not possible to compare costs as a percent of facility revenue for new and existing facilities in this subcategory. The representative direct discharging new source railroad line maintenance facility incurs annualized costs ($184,261) that are somewhat higher than those incurred by existing facilities in this subcategory (which range from zero to $122,042).

9.3 Industry Level Impacts

Potential industry-level impacts include price increases, reduced competitiveness within the domestic industry and in world markets, and reduced rates of innovation. EPA did not perform a sector-specific analysis for several reasons:

- Sector-level impacts are complicated by the large number of product and service markets included in the MP&M category (e.g., over 200 SICs and three activities--manufacturing, rebuilding, and repair);
- Revenue and cost information is not available on a product by product basis, so it is impossible to link price increases to individual products; and
- Many MP&M facilities derive revenue from multiple industry sectors.

EPA's analysis of facility- and firm-level impacts suggests, however, that industry-level impacts are unlikely in any of the affected industries.

The Agency does not expect any industry level impacts due to the MP&M regulation because of the low number of facilities that will have costs and the low number of facilities that have severe or moderate impacts. There are 89,000 facilities performing MP&M activities. Almost 63,000 of these facilities discharge water, while 26,000 facilities do not. This indicates that MP&M industries include a substantial number of facilities that do not discharge wastewater. Of the facilities that do discharge wastewater, only 9,839 will have costs under the proposed rule. This occurs because substantial numbers of facilities are exempted under the proposed rule by the subcategory exclusions and the low-flow cutoffs.

The percentage of facilities incurring significant or moderate impacts is low in all subcategories, as discussed in Chapter 5. Given the small percentages of facilities incurring impacts under the proposed rule and the small percentage of facilities incurring costs in any sector, EPA concludes that the proposed rule is unlikely to impose significant costs on a substantial number of facilities in any MP&M industry sector.

Chapter 5 also presented information on the prices increases predicted to occur in each industry sector due to the proposed rule. Table 5.8 in Chapter 5 presented EPA's estimates of price increases by sector. Projected price increases are less than one percent for all but two sectors, and less than two percent for those two sectors. Price increases of these magnitudes are unlikely to impose burdens on customers of the regulated facilities or have a substantial effect MP&M producers' position relative to competitive products (e.g., products made with plastics) or foreign producers. Price increases may affect only some components of a product. In these cases, prices to end-users would rise even less than the amounts detailed in Chapter 5.

EPA does not expect the proposed rule to have any impact on the rate of technological innovation in the MP&M industries. Such impacts on innovation could result if the rule discouraged new entry, contributed to increased concentration in the affected industries, or specified the use of particular technologies. The following factors suggest that these conditions do not apply for the proposed rule:

- EPA's analysis of new source impacts presented in the previous section suggests that the proposed rule will not retard new entry. The proposed rule will increase the investment required to build a new facility somewhat. However, the increased capital costs are generally small relative to the overall financial resources of the MP&M facilities, as indicated by the results of the facility impact analysis. In addition, the low flow cutoffs applicable to a large number of MP&M facilities reduce the potential impacts of large capital requirements on small facilities.
- Given the small portion of facilities regulated in each sector and the small number of projected closures, EPA does not expect the proposed rule to result in increased concentration in any of the MP&M sectors.
- The rule does not require the use of specific production or pollution control processes or technologies. Rather, it specifies a performance standard, based on levels of pollutants in wastewaters that have been shown to be achievable by available technologies. Facilities have the flexibility to achieve these limitations using a variety of approaches, which is likely to encourage rather discourage innovation in production and pollution control processes.

For these reasons, EPA does not expect the proposed rule to have any adverse effects on technology innovation in the MP&M industries.

The proposed rule will affect the relative competitive position of different firms and facilities in each MP&M industry sectors. Facilities that do not discharge wastewaters, that are eligible for the subcategory exclusions and low-flow cutoffs under the proposed rule, that already have treatment in place, or that can make process changes to reduce pollutant loads easily are likely to gain a competitive advantage from the proposed rule.

Facilities that have little or no treatment in place and that discharge substantial pollutant loads are likely to become less competitive. The proposed rule may level the competitive playing field for facilities that have taken steps to reduce their environmental impacts, relative to facilities that have avoided investments to reduce or eliminate pollutant discharges. EPA views these effects as beneficial, given that the proposed regulation does not have significant impacts on any industry as a whole, and as long as the rule does not disproportionately impact small entities as a group. Impacts on small entities are addressed in the next chapter.

GLOSSARY

new source: Any building, structure, facility, or installation from which there is or may be a discharge of pollutants, the construction of which commenced after promulgation of standards of performance under Section 306 of the Clean Water Act which are applicable to such source; and which (1) is constructed at a site at which no other source is located; (2) totally replaces the process or production equipment that causes the discharge of pollutants at an existing source; or (3) consists of processes that are substantially independent of an existing source at the same site.

New Source Performance Standards (NSPS): effluent limitations for new direct dischargers based on the best available demonstrated control technology. NSPS represents the greatest degree of effluent reduction attainable through the application of the best available demonstrated control technology for all pollutants (i.e., conventional, non-conventional, and priority pollutants). In establishing NSPS, EPA considers the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements.

Pretreatment Standards for New Sources (PSNS): pretreatment standards for new indirect dischargers, designed to prevent discharges of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Addresses all pollutants (i.e., conventional, non-conventional, and priority pollutants). Based on the same factors as are considered in promulgating NSPS.

Producer Price Index (PPI): a family of indexes that measures the average change over time in the selling prices received by domestic producers of goods and services. PPI's measure price change from the perspective of the seller. This contrasts with other measures, such as the Consumer Price Index (CPI), that measure price change from the purchaser's perspective. Sellers' and purchasers' prices may differ due to government subsidies, sales and excise taxes, and distribution costs. (http://stats.bls.gov/ppifaq.htm#1)

Acronyms

NSPS: New Source Performance Standards
PPI: Producer Price Index
PSNS: Pretreatment Standards for New Sources

REFERENCES

U.S. Bureau of Labor Statistics, Producer Price Index Revision-Current Series. On-line database at http://stats.bls.gov/ppihome.htm

U.S. Environmental Protection Agency. 2000. *Technical Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products & Machinery Point Source Category*. December.

Chapter 10: Regulatory Flexibility Analysis / SBREFA

Introduction

The Regulatory Flexibility Act **(RFA)**, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), requires EPA to consider the economic impacts a rule will have on ***small entities***. RFA/SBREFA requires an agency to prepare a regulatory flexibility analysis for any rule subject to notice and comment rulemaking requirements, unless the Agency certifies that the rule will not have a significant economic impact on a substantial number of small entities (Small Business Regulation Enforcement Fairness Act of 1996, P.L. 104-121, Section 243).

The economic analysis prepared for the 1995 MP&M Phase I proposal indicated that large numbers of small facilities could be impacted by the proposed regulation and that a significant number of publically-owned treatment works **(POTWs)** would also be affected by the rule.

EPA addressed this issue by crafting the rule to exclude as many small facilities as possible while still covering as much of the pollutant discharge as possible. With this in mind, EPA sought, from the beginning, to design a combined phase regulation that would not unreasonably burden small entities.

To make sure that all small entities were taken into consideration in developing the MP&M regulation, EPA developed, administered, and analyzed questionnaires for all entities that could potentially be impacted, including: privately- and government-owned facilities that would have to comply with the regulation, and POTWs that receive MP&M discharges. The Agency balanced several factors when selecting the proposed rule, including:

- The predominance of small entities in the MP&M industries,
- The pounds of pollutants discharged by large and small facilities,
- The toxicity of the pollutants discharged by large and small facilities,
- The need for additional reduction in effluent discharges from the MP&M industry,
- The need to achieve these reductions without imposing unreasonable burdens on small entities, and
- The need to minimize the burden on POTWs.

Given the large number of small entities potentially affected by the proposed rule, EPA prepared an ***Initial Regulatory Flexibility Analysis* (IRFA)**. The IRFA evaluates the impact of the proposed rule and alternative regulatory options on small entities. The following sections of this chapter describe the IRFA methodology and results, and discuss EPA's consideration of small entity impacts in designing the proposed rule.

Chapter Contents:

10.1 Defining Small Entities

EPA identified small entities using Small Business Administration **(SBA)** size threshold guidelines.[1] These thresholds define minimum employment or revenue sizes by industry (four-digit SIC codes), below which a business qualifies as a ***small business*** under SBA guidelines. The thresholds apply at the firm level, and are used to identify small firms that own MP&M facilities. The SBA guidelines also set a threshold for small public sector entities. A ***small government*** is one that serves a population of 50,000 or less. MP&M facilities are determined to be owned by a small entity if the parent firm or government falls below the SBA threshold.

The SBA guidelines use either employment or revenue to measure size, depending on the specific four-digit SIC industry. Manufacturing industries generally have employment size thresholds, while non-manufacturing industries typically have revenue size thresholds. EPA used employment-based thresholds for the manufacturing portion of each MP&M sector, and separate non-manufacturing thresholds for sectors that include significant non-manufacturing activities (e.g., maintenance and repair).

EPA selected the most common SBA threshold for the four-digit SIC codes that make up each sector as the sector threshold.[2] Table 10.1 presents the resulting employment size thresholds for manufacturers.

Table 10.1. Small Business MP&M Sector Thresholds for Manufacturers

MP&M Sector	Employees
Aerospace	1,000
Aircraft	1,000
Bus and Truck	500
Electronic Equipment	750
Hardware	500
Household Equipment	500
Instrument	500
Job Shop	500
Mobile Industrial Equipment	500
Motor Vehicle	500
Office Machine	1,000
Ordnance	1,000
Other Metal Products	500
Precious and Non-Precious Metals	500
Printed Circuit Board	500
Railroad	1,000
Ship and Boat	1,000
Stationary Industrial Equipment	500
Steel Forming & Finishing	1,000

Source: SBA and U.S. EPA analysis.

Table 10.2 presents the employment size thresholds for non-manufacturers, which are based on revenue except for the railroad sector. Some sectors do not have non-manufacturing industries and do not appear in this table.

[1] The SBA website provides the most recent size thresholds at http://www.sba.gov/regulations/siccodes.

[2] The SBA thresholds for four-digit SICs were not used directly because the Phase II §308 survey reports revenues by MP&M sector but does not report facility SIC codes.

Table 10.2. Small Business MP&M Sector Thresholds for Non-Manufacturers

MP&M Sector	Revenue
Aircraft	$5,000,000
Bus and Truck	$5,000,000
Household Equipment	$5,000,000
Instrument	$5,000,000
Motor Vehicle [b]	$5,000,000
Office Machine	$18,000,000
Other Metal Products	$5,000,000
Precious and Non-Precious Metals	$5,000,000
Railroad	1,500[a]
Ship and Boat [c]	$5,000,000
Stationary Industrial Equipment	$5,000,000

a Employees.
b Also has a threshold of 100 employees.
c Also has a threshold of 500 employees.
Source: SBA and U.S. EPA analysis.

EPA classified facilities as manufacturing or non-manufacturing and selected an MP&M sector threshold based on the source from which they received the most revenue, as reported in the §308 surveys.[3] EPA then compared the firm-level employment or revenue for the firm owning each facility to the appropriate manufacturing or non-manufacturing threshold for that sector.

The Phase II survey asked each respondent to provide firm-level employment and revenue data. The Phase I survey also asked for firm-level revenue but not for firm employment. This did not matter in the case of single facility businesses, where the facility's reported employment is the firm-level employment. EPA estimated Phase I firm-level employment for facilities that were part of a multiple-facility firm by assuming that the number of employees per revenue dollar for the firm was the same as the employees per dollar at the facility. Thus,

$$E_{firm} = E_{facility} \times \frac{R_{firm}}{R_{facility}} \qquad (10.1)$$

where:

E_{firm} = firm-level employment,
$E_{facility}$ = facility-level employment,
R_{firm} = firm-level revenue, and
$R_{facility}$ = facility-level revenue.

EPA identified facilities operated by governments that serve a population of 50,000 or fewer as being operated by small government entities. The §308 municipal survey responses provided population data in most cases, which EPA supplemented using the Bureau of the Census online 1990 Population Census database (Bureau of the Census.)

10.2 Methodology

The RFA requires EPA to determine whether the proposed rule imposes "significant impacts" on a "substantial number" of small entities. This determination depends both on the severity of impacts on individual entities and on the number of entities affected. EPA used several measures of impacts in this analysis. First, the results of the facility impact analyses described in Chapter 5 were disaggregated to determine whether facilities owned by small entities are disproportionately subject to regulatory closures or to moderate impacts at the facility level. Second, EPA calculated the ratio of annualized compliance costs to facility revenues and examined the distribution of this ratio for facilities owned by small versus large firms.

The analysis excludes facilities that the facility impact analysis identifies as baseline failures (see Chapter 5).

10.3 Results

10.3.1 Number of Affected Small Entities

The proposed rule could potentially affect an estimated 59,000 MP&M facilities nationwide (excluding baseline closures) without the subcategory exclusions and low flow cutoffs. A large number of these facilities are owned by small entities, as defined by SBA thresholds. Table 10.3 shows the total number of facilities operating in the baseline and the number owned by small entities. Overall, 82 percent of all MP&M facilities are owned by small entities.

[3] The §308 MP&M surveys did not collect firm-level revenues by sector and therefore cannot be used to assign a unique sector to each firm. The assignment of a threshold was therefore based on the facility-level revenues by sector.

Table 10.3 Number and Percent of MP&M Facilities Owned by Small Entities

Type of Facility	Number of Facilities of all Sizes Operating in the Baseline	Number of Facilities Owned by Small Entities	Percent of Facilities Owned by Small Entities
Private MP&M[a]	54,591	44,773	82%
Government-Owned	4,332	2,672	62%
Total[a]	58,923	47,445	81%

a. Excludes baseline closures.
Source: U.S. EPA analysis.

Table 10.4 shows that the proposed rule excludes a large percentage of potentially-regulated small entities. The subcategory exclusions and low flow cutoffs exclude 81 percent of the facilities owned by small entities that continue to operate in the baseline from MP&M regulatory requirements.

Table 10.4. Percent of Facilities Owned by Small Entities Excluded under the Proposed Rule

Type of Facility	Number of Facilities Operating in the Baseline	Number of Facilities Excluded in the Proposed Option	Percentage of Facilities Excluded
Owned by small business	44,773	38,563	86%
Owned by small government	2,672	2,262	85%
Total owned by small entities	47,445	40,825	86%

Source: U.S. EPA analysis.

10.3.2 Impacts on Facilities Owned by Small Entities

The results of the facility impact analysis (closures and moderate impacts) is the first basis used by EPA to assess impacts on facilities owned by small entities. Of the 199 facilities that may close as a result of the proposed rule, 181 of these are owned by small entities. Most of the 616 facilities projected to experience moderate impacts (492, or 80 percent) are owned by small entities.

A second approach to assessing small entity impacts, based on a comparison of compliance costs to post-compliance revenues, indicates that 1,064 facilities owned by small private businesses will incur costs exceeding 3 percent of revenues. This second approach to measuring impacts overlaps with the first approach. Of the 1,064 facilities that will incur costs in excess of 3 percent of revenues, 181 are the same facilities that are expected to close, and another 462 are facilities expected to experience moderate impacts as determined by the facility impact analysis.

The percentages of facilities owned by small entities subject to significant impacts, however, is quite small. The 181 small entity closures represent less than one-half of one percent of the small entities that operate in the baseline. Only 2.4 percent of the facilities owned by small private businesses that operate in the baseline would incur costs equal to 3 percent or more of annual revenues. Although the percentage of facilities owned by small entities projected to incur impacts is quite small, the number of such facilities with costs greater that three percent is large enough that EPA decided that a detailed small business analysis was warranted.

Table 10.5 summarizes the results of the facility impact analysis for facilities owned by small entities.

Table 10.5: Closures and Moderate Impacts for Facilities Owned by Small Entities			
	Proposed Rule	**Option 2/6/10**	**Option 4/8**
Number of facilities operating in the baseline	47,445	47,445	47,445
Number of facilities excluded	40,825		
Percent excluded	85%		
Number of closures	181	1,227	2,782
Percent closing	0.4%	2.6%	5.9%
Number of facilities with moderate impacts	492	755	835
Percent with moderate impacts	1.0%	1.6%	1.8%

Source: U.S. EPA analysis.

The projected number of closures under the proposed rule is very small compared to the large number of facilities owned by small entities. Less than one-half of one percent of the facilities owned by small entities that operate in the baseline are projected to close. The percentage of small entities experiencing moderate impacts is also low, at one percent.

Table 10.6 shows the results of the second approach to assessing small entity impacts, based on a comparison of compliance costs with facility revenues. EPA conducted this analysis only for MP&M facilities owned by private entities (i.e., businesses, but not governments), because of the low level of impacts on all sizes of governments.

Table 10.6: Before-Tax Annual Compliance Costs as a Percent of Annual Revenues under the Proposed Rule for Facilities Operating in the Baseline and Owned by Private Small Businesses										
Discharge Status	**Number of Facilities Owned by Small Private Businesses Operating in the Baseline**	**Number and Percent of Facilities Owned by Small Businesses with Before-Tax Annual Compliance Costs/Annual Revenues Equal to:**								
		No Costs		**Less than 1%**		**1-3%**		**Over 3%**		
		Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	
Direct	3,237	0	0.0%	2,969	91.7%	211	6.5%	57	1.8%	
Indirect	41,536	38,435	92.5%	1,175	2.8%	920	2.2%	1,007	2.4%	
Total	44,773	38,435	85.8%	4,144	9.3%	1,131	2.5%	1,064	2.4%	

Source: U.S. EPA analysis.

A small percentage (2.4 percent) of all facilities owned by small entities that operate under the proposed rule incur before-tax compliance costs equal to 3 percent or more of annual revenues. Over 85 percent incur no compliance costs, 9.3 percent incur compliance costs less than 1 percent of annual revenues, and the remaining 2.5 percent incur costs between 1 and 3 percent of revenues. These results are consistent with the finding that only a very small percentage of facilities owned by small businesses will close or experience even moderate financial impacts.

Finally, Table 10.7 compares the number of facilities owned by small and large businesses that are projected to close under the proposed rule with the total number of facilities owned by small and large businesses in the MP&M sectors, as reported by the 1996 Census Statistics of U.S. Businesses. This universe includes facilities that are not subject to MP&M requirements because they do not discharge wastewater or do not perform MP&M processes that generate wastewater. This comparison shows that a small percentage of the facilities owned by small firms in the MP&M sectors are potentially affected by the rule, and a very small percentage (less than 0.02%) of facilities owned by both small and large firms are projected to close under the proposed rule. While the absolute numbers of affected facilities owned by small businesses are large, the proportion of the small entities in the MP&M sectors that would experience significant impacts is extremely small.

Table 10.7 Percent of All MP&M Facilities Projected to Close under the Proposed Rule

Size of Firm	Total Establishments	Total # MP&M Facilities Operating in Baseline	% MP&M	# MP&M Facilities Projected to Close under the Proposed Rule	% of All Small Entity Facilities Projected to Close
Owned by small firms	1,034,867	44,773	4.3%	181	0.02%
Owned by large firms or potentially large firms	277,424	9,817	3.5%	18	0.01%
Total	1,312,291	54,590	4.2%	199	0.02%

Sources: U.S. Bureau of Census, Statistics of U.S. Businesses and U.S. EPA analysis.

10.3.3. Impacts on Small Firms

EPA compared compliance costs with revenue at the firm level as a measure of the relative burden of compliance costs. EPA applied this analysis only to MP&M facilities owned by private entities (i.e., businesses, but not governments). Table 10.8 shows the results of this comparison. The Agency was not able to estimate national numbers of firms that own MP&M facilities precisely, because the sample weights based on the survey design represent numbers of facilities rather than firms. Most of the facilities owned by small firms (42,422 of 44,774, or 95 percent) are single-facility firms, however. These single-facility firms can be analyzed using the survey weights. In addition, there are 87 small firms that own more than one sample firm. These firms are included in the analysis with a sample weight of one, since it is not known how many sample firms these 87 small firms represent. The results shown in Table 10.8 therefore represent a total of 42,509 small MP&M firms (42,422 + 87).

Table 10.8: Firm Level Before-Tax Annual Compliance Costs as a Percent of Annual Revenues for Private Small Businesses

Number of Small Firms in the Analysis[a]	Number and Percent with Before-Tax Annual Compliance Costs/Annual Revenues Equal to:					
	Less than 1%		1-3%		Over 3%	
	Number	%	Number	%	Number	%
42,509	40,560	95.4%	1,008	2.4%	941	2.2%

*Firms whose only MP&M facilities close in the baseline are excluded.
Source: U.S. EPA analysis.

A small percentage (2.2 percent) of the small businesses in the analysis incur before-tax compliance costs equal to 3 percent or more of annual revenues. More than 95 percent incur compliance costs less than 1 percent of annual revenues, and the remaining 2.4 percent incur costs between 1 and 3 percent of revenues. Of the 1,949 small firms in the analysis that incur costs greater than 1 percent of revenues, 612 are single-facility small firms that were reported in the facility impact analysis to close (149 firms) or experience moderate impacts (463 firms) due to the proposed rule.

10.4 Detailed Analysis of the Two Subcategories with Most of the Impacts

Two subcategories account for a majority of the projected small entity closures and moderate impacts: Metal Finishing Job Shops, which accounts for the largest number of small entity closures, and Printed Wiring Board, which accounts for the majority of small entity moderate impacts. This section examines the effect of the rule in more detail for these two subcategories.

10.4.1 Severe and Moderate Impacts in the Metal Finishing Job Shops Subcategory

The Metal Finishing Job Shop subcategory is the most highly impacted of the subcategories, with 128 or 64 percent of the facilities predicted to close, and 117 of the 616 predicted moderate impacts. This subcategory includes a substantial number of facilities owned by small entities. Table 10.9 summarizes projected impacts on Metal Finishing Job Shop facilities owned by small entities under the proposed rule.

Table 10.9: Regulatory Impacts for Small Entity Metal Finishing Job Shops by Option, National Estimates

	Proposed Rule Option 2/6/10	Option 4/8
Number of small entity Metal Finishing Job Shops operating in the baseline	943	943
Number of predicted regulatory closures	117	255
Percent of facilities closing due to the rule	12.4%	27.0%
Number of facilities operating post-regulation	826	688
Number of facilities experiencing moderate impacts	105	71
Percent of facilities operating in the baseline that experience moderate impacts	12.7%	7.5%

Source: U.S. EPA analysis.

Twelve percent of the facilities owned by small entities that operate in the baseline are projected to close under the proposed rule. This percentage is substantially higher than the percentage of facilities projected to close under the proposed rule for MP&M facilities as a whole.

The Metal Finishing Job Shop subcategory includes a number of facilities that are financially weak and that may have trouble affording the costs of the proposed rule. EPA concluded that it would be inappropriate to provide any further regulatory relief for this subcategory, however, for several reasons. First, the facilities that are subject to requirements under the rule account for significant toxic-weighted pollutant loadings per facility. Second, excluding facilities that are discharging substantial pollutant loads places more modern, cleaner job shop facilities at a competitive disadvantage.

Table 10.10 shows the average baseline toxic-weighted loadings per facility (in lbs. equivalent) for different groups of Metal Finishing Job Shops owned by small entities.

Table 10.10: Small Entity Metal Finishing Job Shops Toxic-Weighted Pollutant Loadings per Facility (lbs. equivalent/facility)[a]

	Proposed Rule/ Option 2/6/10	Option 4/8
Average loadings per facility for all small entity Metal Finishing Job Shops operating in the baseline	5,881	5,881
Average loadings per small entity facility for facilities that:		
close due to the regulation	29,749	16,337
experience moderate impacts	6,813	2,756
incur before-tax compliance costs ≥3% of post-compliance revenue	11,920	7,987
incur before-tax compliance costs > 1% and < 3% of post-compliance revenue	338	317
incur before-tax compliance costs ≤ 1% of post-compliance revenue	755	

a Discharges discussed in this table are facility discharges and do not account for POTW removals.
Source: U.S. EPA analysis.

This table indicates that the small entity Metal Finishing Job Shops most heavily impacted under the proposed rule contribute substantially more toxic-weighted loadings on average than do facilities that experience less significant impacts under the rule. For example, the facilities that close under the proposed rule discharge an average of 29,749 lbs. equivalents per facility, compared with an average of 5,881 lbs. equivalent per facility for all Metal Finishing Job Shops that operate in the baseline. These estimates do not account for POTW removals. In this analysis, EPA believes it is appropriate to analyze wastewater discharges disregarding the POTW removals because indirect discharges present environmental risks that are not fully addressed by POTW treatment. The MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 ***hazardous air pollutants*** **(HAPs)** that may present a threat to human health or the environment. Other pollutants released by the industry are found in POTW sludge. Only eight of these pollutants have land application pollutant criteria that limit the uses of sludge.

EPA believes that the proposed rule could not provide further exclusions for the significantly-impacted small entity job shops and still achieve the environmental objectives of the regulation. The proposed rule provides regulatory relief when compared with Option 4/8, and targets requirements on the most serious polluters.

The multi-stakeholder Sustainable Industries Project **(SIP)** for Metal Finishing (the predecessor to the Common Sense Initiative for Metal Finishing) recognized that metal finishers include four distinct groups with very different environmental performance characteristics (EPA, 1994). The SIP also recognized that these groups have very different propensities to close in the face of declines in financial performance. The SIP identified two particularly problematic groups of facilities. The first group (“Tier 3" facilities) accounts for a disproportionately large quantity of pollutant discharges and cannot afford to invest in pollution prevention and control technologies. This group is deterred from closing in spite of low or non-existent profits, however, by the threat of post-closure liabilities. The second group of facilities (“Tier 4") is comprised of "renegade" shops that are out of compliance and make no attempt to improve, and often escape enforcement attention.

The problem with Tier 3 and 4 firms is that they damage the reputation of the industry, and compete with Tier 1 firms (those consistently in compliance with regulatory requirements and making proactive environmental improvements) or with Tier 2 firms (those generally in compliance with requirements).

Unfortunately, some Tier 3 and Tier 4 firms may have an incentive to continue operating with disappearing profitability or even in the presence of negative cash flows, as they would incur substantial closure costs that exceed the value recovered by selling assets. These facilities, although operating, are not making any additional capital investments to improve production efficiency or environmental performance. Since they lack internal capital and cannot secure external financing to fund cleanups, these firms continue to pollute and represent a significant barrier to entry for cleaner, more efficient firms that may have higher costs in the short run.

10.4.2 Moderate Impacts in the Printed Wiring Board Subcategory

The Printed Wiring Board subcategory accounts for 298 or 61 percent of the 492 small entities experiencing moderate impacts under the proposed rule. EPA considered potential options for reducing impacts on this subcategory. Table 10.11 shows, however, that the average baseline toxic-weighted discharges from small entity Printed Wiring Board facilities are substantially greater on average than the average 31 lbs. equivalent discharged by facilities that are excluded under the proposed option. EPA did not find it possible to reduce impacts substantially in this subcategory without at the same time leaving significant pollutant loadings unregulated.

Table 10.11: Small Entity Printed Wiring Board Toxic-Weighted Pollutant Loadings per Facility (lbs. equivalent)[a]

	Proposed Rule Option 2/6/10	Option 4/8
Average loadings per facility for all small entity Printed Wiring Board facilities operating in the baseline	3,258	3,258
Average loadings per facility for small entity facilities that:		
close due to the regulation	35,645	10,282
experience moderate impacts	2,643	2,696
incur before-tax compliance costs ≥ 3% of post-compliance revenue	3,099	2,964
incur before-tax compliance costs > 1% and < 3% of post-compliance revenue	2,990	8,339
incur before-tax compliance costs ≤ 1% of post-compliance revenue	7,057	1,340

a. Discharges discussed in this table are total discharges and do not include POTW removals because the MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 hazardous air pollutants (HAPs) that may present a threat to human health or the environment. All non-volatile pollutants released by the industry are found in sludge from POTWs, but only 8 of these pollutants have land application pollutant criteria.
Source: U.S. EPA analysis

10.5 Consideration of Small Entity Impacts in the Selection of the Proposed Rule

EPA gave special consideration to impacts on small entities in selecting among regulatory options. In particular, EPA attempted to minimize impacts on small entities while at the same time reducing significant contributions to MP&M pollutant loadings. The proposed rule minimizes impacts on small entities primarily by excluding indirect dischargers with low flows in the General Metals and Oily Waste subcategories. As described earlier, these low flow cutoffs exclude a substantial percentage of the small entities potentially affected by the proposed rule, while excluding only a modest percentage of total baseline pollutant loadings from requirements.

Table 10.12 shows the number and percentage of facilities owned by small versus large entities that are projected to close under the various regulatory options.

Table 10.12: Percent of Facilities Projected to Close for Facilities Owned by Small versus Large Entities, by Regulatory Option

Regulatory Option and Type of Facility	Number of Facilities		
	Total	Projected to Close	Percent Closing
Proposed Rule			
Owned by Small Entities	47,445	181	0.4%
Owned by Large Entities	11,478	18	0.2%
Total	58,923	199	0.3%
Option 2/6/10			
Owned by Small Entities	47,445	1,227	2.6%
Owned by Large Entities	11,478	55	0.5%
Total	58,923	1,282	2.2%
Option 4/8			
Owned by Small Entities	47,445	2,920	6.2%
Owned by Large Entities	11,478	43	0.4%
Total	58,923	2,963	5.0%

Source: U.S. EPA analysis.

This table shows that the proposed rule particularly reduces impacts on facilities owned by small entities, compared with Options 2/6/10 and 4/8, which do not provide low flow cutoffs for General Metals and Oily Waste indirect dischargers or exclude Non-Chromium Anodizing, Railroad Line Maintenance or Shipbuilding Dry Dock indirect dischargers.

The low flow cutoffs and exclusions also substantially reduce the number of facilities that require permits, compared with the other regulatory options considered. Under the proposed rule, a total of 648 facilities would require permitting for the first time. Under Option 2/6/10, 24,013 facilities would require new permits, and Option 4/8 would require 22,678 new permits. The proposed rule therefore substantially reduces the potential permitting burden imposed on POTWs, including small POTWs. Chapter 11 and Appendix C discuss POTW administrative activities and costs under the three regulatory options.

In addition to the proposed low flow cutoffs and exclusions, EPA considered additional options that might further reduce impacts for facilities owned by small entities. These options included higher flow cutoffs for indirect dischargers. EPA concluded that excluding more facilities owned by small entities would have excluded facilities with unacceptably high toxic-weighted loadings, and would not achieve the purposes of the proposed rule.

Table 10.13 shows that facilities owned by small entities that remain regulated after the low flow cutoff and exclusions discharge substantially more pollutants per facility than the average toxic-weighted baseline loadings for all indirect dischargers (733 lbs. equivalent, not accounting for POTW removals) and the average for facilities excluded under the proposed rule (31 lbs. equivalent, not accounting for POTW removals).

Table 10.13: Number of Regulated Indirect Dischargers Owned by Small Entities and Average Baseline Toxic-Weighted Toxic Loadings, Proposed Rule

Subcategory	Number of Indirect Dischargers Operating Post-Regulation	Average Baseline Toxic-Wtd. Loadings per Facility[a]
General Metals	1,640	9,568
Metal Finishing Job Shop	1,228	5,130
Non-Chromium Anodizing	n.a.	
Printed Wiring Board	539	4,157
Steel Forming & Finishing	80	3,658
Oily Waste	47	1,472
Railroad Line Maintenance	n.a.	
Shipbuilding Dry Dock	n.a.	
All Categories	3,535	6,957

a. Discharges discussed in this table are facility discharges and do not account for POTW removals.
Source: U.S. EPA analysis.

Glossary

initial regulatory flexibility analysis: Prepared by the EPA, the IRFA evaluates the impact of the proposed rule and alternative regulatory options on small entities.

small entity: a business, government or non-profit organization defined as small for purposes of RFA/SBREFA evaluation.

small business: a business with employment or revenue below the threshold specified by the Small Business Administration for each 4-digit SIC.

small government: a government that serves a population of 50,000 or less, as defined by the Small Business Administration.

ACRONYMS

HAP: hazardous air pollutant
IRFA: initial regulatory flexibility analysis
POTW: Publicly-owned treatment works
RFA: Regulatory Flexibility Act
SBA: Small Business Administration
SBREFA: Small Business Regulatory Enforcement Fairness Act
SIP: Sustainable Industries Project

REFERENCES

U.S. Department of Commerce, Bureau of the Census, Statistics of U.S. Businesses.

U.S. Environmental Protection Agency and Industrial Economics, Incorporated. 1994. Sustainable Industry: Promoting Strategic Environmental Protection in the Industrial Sector: Phase I Report. Office of Policy, Planning, and Evaluation. June.

U.S. Small Business Administration, http://www.sba.gov/regulations/siccodes.

Chapter 12: Benefit Overview

INTRODUCTION

Part III of the EEBA assesses the benefits to society from the reduced effluent discharges that will result from the proposed MP&M industry regulations. EPA expects that benefits will accrue to society in several broad categories, including reduced health risks, enhanced environmental quality, and increased productivity in economic activities that are adversely affected by MP&M industry discharges.

The benefit chapters assess the national benefits expected to accrue from the regulation. This chapter provides a discussion of the ***pollutants of concern* (POCs)**, their effect on human health, their environmental effects, a framework for understanding the benefits likely to be achieved by the MP&M regulation, and a qualitative discussion of those benefits. The following chapters quantify and estimate the economic value of these benefit categories. Appendices E and G provide further information on environmental effects of MP&M pollutants and water quality models used to assess these effects.

CHAPTER CONTENTS:

12.1 MP&M POLLUTANTS

EPA defines three general categories of pollutants: priority or toxic pollutants; nonconventional pollutants; and conventional pollutants. ***Priority pollutants* (PPs)** are defined as any of 126 named pollutants.[1] Conventional pollutants include ***biological oxygen demand* (BOD)**, ***total suspended solids* (TSS)**, ***oil and grease* (O&G)**, ***pH***, and anything else the Administrator defines as a conventional pollutant. Nonconventionals are a catch-all category that includes everything that is not in the two previously described categories. The naming system is somewhat confusing in that some nonconventional pollutants may be as "toxic" as, or more "toxic" than some of the PPs.

MP&M effluents contain a variety of priority, nonconventional, and conventional pollutants. The release of these pollutants to our nation's surface water degrades aquatic environments, alters aquatic habitats, and affects the diversity and abundance of aquatic life. It also increases the health risks to humans who ingest contaminated surface waters or eat contaminated fish and shellfish (U.S. EPA, 1997). A number of the pollutants commonly found in MP&M effluents also inhibit biological wastewater treatment systems or accumulate in sewage sludge or sediment.

Metals are a particular concern because of their prevalence in MP&M effluents. Metals are inorganic compounds, generally non-volatile (with the notable exception of mercury), and cannot be broken down by biodegradation processes. Metals can accumulate in biological tissues, sequester into sewage sludge in ***publicly owned treatment works* (POTWs)**, and contaminate soils and sediments when released to the environment. Sediments contaminated with metals become resuspended by dredging, boat propellers, water currents or wave action, and storm events, releasing metals back into the water column. Metals can also become biologically available and enter terrestrial food chains once the sludge is applied on land. Sludges with high concentrations of metals are therefore unsuitable for land application. Some metals are quite toxic even when present at relatively low levels.

Human and ecological exposure and risk from environmental releases of MP&M pollutants depend on chemical-specific properties, the mechanism and medium of release, and site-specific environmental conditions.

[1] The Agency started with 129 PPs, but 3 have been dropped from the list.

Chemical-specific properties include toxicological effects on living organisms, ***hydrophobicity/lipophilicity***, reactivity and persistence. These properties are described in sections 12.1.1 through 12.1.4.

12.1.1 Characteristics of MP&M Pollutants

EPA sampled MP&M facilities nationwide to assess the concentrations of pollutants in MP&M effluents. The Agency collected samples of raw wastewater from MP&M facilities and applied standard water analysis protocols to identify and quantify the pollutant levels in each sample. EPA used these analytical data, along with selection criteria, to identify 132 contaminants of potential concern.[2]

EPA then evaluated the potential environmental fate and transport of these pollutants and their toxicity to humans and aquatic receptors.

Fate of the MP&M pollutants was estimated based on the propensity of those pollutants to volatilize, adsorb onto sediments, bioconcentrate, and biodegrade. Table E.1 in Appendix E lists MP&M pollutants and provides data on human health concerns, and fate and effects.

Some of the inorganic POCs found in MP&M effluents are also natural constituents of water, including potassium, calcium, magnesium, iron, chlorine, fluoride, sulfate, phosphates, silica, and a number of trace metals such as copper and zinc.

EPA used various data sources to evaluate pollutant-specific fate and toxicity. To evaluate potential human health effects, the Agency relied on ***reference doses*** **(RfDs)** and ***cancer potency slope factors*** **(SFs)**, ***human health-based water quality criteria*** **(WQC)**, ***maximum contaminant levels*** **(MCLs)** for drinking water protection and other drinking water related criteria, and ***hazardous air pollutant*** **(HAP)** and PP lists. Appendix E.1.1 provides short descriptions and definitions for each of these measures of human health effects.

To evaluate potential fate and effects in aquatic environments, the Agency relied on measures of ***acute*** and ***chronic toxicity*** to aquatic species, bioconcentration factors for aquatic species, ***Henry's Law constants*** (to estimate volatility), ***adsorption coefficients*** **(Koc)** (to estimate association with bottom sediments), and ***biodegradation half-lives*** (to estimate the removal of chemicals via ***microbial metabolism***).

[2] EPA identified 150 POCs. Of these 150 POCs, the Agency estimated loadings for 132 pollutants. The benefits analysis presented in this chapter and the following chapters addresses the 132 pollutants for which loadings are available.

The data sources used in the assessment include EPA ***Ambient Water Quality Criteria*** **(AWQC)** documents and updates, ***EPA's ASsessment Tools for the Evaluation of Risk*** **(ASTER)**, the ***AQUatic Information REtrieval System*** **(AQUIRE)**, and the ***Environmental Research Laboratory-Duluth fathead minnow database***, EPA's ***Integrated Risk Information System*** **(IRIS)**, ***EPA's Health Effects Assessment Summary Tables*** **(HEAST)**, EPA's 1991 and 1993 ***Superfund Chemical Data Matrix*** **(SCDM)**, Syracuse Research Corporation's ***CHEMFATE*** and ***BIODEG*** databases, EPA and other government reports, scientific literature, and other primary and secondary data sources.

To ensure that the assessment is as comprehensive as possible, EPA also obtained data on chemicals for which physical-chemical properties and/or toxicity data were not available from the sources listed above. To the extent possible, EPA estimated values for the chemicals using the ***quantitative structure-activity relationship*** **(QSAR)** model incorporated in ASTER, and for some physical-chemical properties, used published linear regression correlation equations.

12.1.2 Effects of MP&M Pollutants on Human Health

Individuals are potentially exposed to MP&M pollutants released to the aquatic environment via consumption of contaminated fish. Populations served by drinking water utilities located downstream of effluent discharges from MP&M facilities are also exposed to MP&M pollutants via contaminated drinking water. Many of these pollutants may increase risks to human health.

Based on the available human health toxicity data for the 132 POCs presented in Table E.1 (Appendix E), EPA found that:

- 77 pollutants are human ***systemic toxicants***;
- 13 pollutants with published SFs are classified as known, probable, or possible human carcinogens when ingested via drinking water or food. Lead is also classified as a possible human carcinogen in IRIS but EPA has not developed a SF for it;
- 36 pollutants have drinking water criteria (27 with enforceable health-based MCLs, 7 with ***secondary MCLs*** for taste or aesthetics, and 2 with action levels for treatment);
- 35 pollutants are designated as HAPs in wastewater;
- 43 pollutants are identified as PPs; and

- 77 pollutants have human-health based water quality criteria (WQC) to protect against the ingestion of water and organisms or organisms only (see Chapter 13, Table 13.3).

The carcinogens identified by EPA in MP&M effluent samples include known (A), probable (B1 and B2) and possible (C) human carcinogens. These pollutants are associated with the development of cancers in the spleen, liver, kidney, lung, bladder, and skin, among others. These pollutants and target organs are shown in Table 12.1.

Table 12.1: Human Carcinogens Evaluated, Weight-of-Evidence Classifications, and Target Organs

CAS Number	Carcinogen	Weight-of-Evidence Classification	Target Organs
62533	Aniline	B2	Spleen
7440382	Arsenic	A	Liver, kidneys, lungs, bladder and skin
117817	Bis(2-ethylhexyl) phthalate	B2	Liver
75003	Chloroethane [a]		
75092	Dichloromethane	B2	Liver, lungs
123911	Dioxane, 1,4-	B2	Liver, nasal cavity, gall bladder
78591	Isophorone	C	Preputial gland
62759	Nitrosodimethylamine, N-	B2	Liver, lungs, skin, seminal vesicle, lymphatic/hematopoetic system
86306	Nitrosodiphenylamine, N-	B2	Bladder tumors, reticulum cell sarcomas
127184	Tetrachloroethene	B2	Liver
79016	Trichloroethene [a]		
67663	Trichloromethane	B2	Kidneys

A = Human Carcinogen
B1 = Probable Human Carcinogen (limited human data)
B2 = Probable Human Carcinogen (animal data only)
C = Possible Human Carcinogen
a. Pollutant has been withdrawn from the IRIS database for additional study.
Source: U.S. Environmental Protection Agency verified (IRIS) or provisional (HEAST) (U.S. EPA (1998/99d), U.S. EPA (1997)).

Noncarcinogenic hazards associated with pollutants in MP&M effluent include systemic effects (e.g., impairment or loss of neurological, respiratory, reproductive, circulatory, or immunological functions), organ-specific toxicity (e.g., kidney, small intestines, blood, testes, liver, stomach, thyroid), fetal effects (e.g., increased fetal mortality, decreased birth weight), other effects (e.g., lethargy, cataracts, weight loss, hyperactivity), and mortality. These effects are listed by pollutant in Table 12.2.

Table 12.2: MP&M Pollutants Exhibiting Systemic and Other Non-Cancer Human Health Effects[a]

CAS Number	Toxicant	RfD Target Organ and Effects
83329	Acenaphthene	Liver, hepatotoxicity
67641	Acetone	Increased liver and kidney weights, nephrotoxicity
98862	Acetophenone	General toxicity
107028	Acrolein	Cardiovascular toxicity[c]
7429905	Aluminum	Renal failure, intestinal contraction interference, adverse neurological effects[d]
120127	Anthracene	General toxicity
7440360	Antimony	Longevity, blood glucose, cholesterol
7440382	Arsenic	Hyperpigmentation, keratosis and possible vascular complications
7440393	Barium	Increased kidney weight
65850	Benzoic acid	General toxicity
100516	Benzyl alcohol	Forestomach, epithelial hyperplasia
7440417	Beryllium	Small intestinal lesions
92524	Biphenyl	Kidney damage
117817	Bis(2-ethylhexyl) phthalate	Increased relative liver weight
7440428	Boron	Testicular atrophy, spermatogenic arrest
85687	Butyl benzyl phthalate	Significantly increased liver-to-body and liver-to-brain weight
7440439	Cadmium	Significant proteinuria (protein in urine)
75150	Carbon disulfide	Fetal toxicity, malformations
108907	Chlorobenzene	Histopathologic changes in liver
75003	Chloroethane	General toxicity
7440473	Chromium	Renal tubular necrosis (kidney tissue decay)[d]
18540299	Chromium-hexavalent	Reduced water consumption
7440484	Cobalt	Heart effects[d]
7440508	Copper	Gastrointestinal effects, liver necrosis[d]
95487	Cresol, o-	Decreased body weight and neurotoxicity
106445	Cresol, p-	Central nervous system hypoactivity and respiratory system distress
57125	Cyanide	Weight loss, thyroid effects and myelin degeneration
75354	Dichloroethene, 1,1-	Toxic effects on kidneys, spleen, lungs[d]; hepatic lesions
75092	Dichloromethane	Liver toxicity
68122	Dimethylformamide, N,N-	Liver and gastrointestinal system effects
105679	Dimethylphenol, 2,4-	Clinical signs (lethargy, prostration, and ataxia) and hematological changes
84742	Di-n-butyl phthalate	Increased mortality
51285	Dinitrophenol, 2,4-	Cataract formation
606202	Dinitrotoluene, 2,6-	Mortality, central nervous system neurotoxicity, blood heinz bodies and methemoglobinemia, bile duct hyperplasia, kidney histopathology
117840	Di-n-octyl phthalate	Kidney and liver increased weights, increased liver enzymes
122394	Diphenylamine	Decreased body weight, and increased liver and kidney weights

Table 12.2: MP&M Pollutants Exhibiting Systemic and Other Non-Cancer Human Health Effects[a]

CAS Number	Toxicant	RfD Target Organ and Effects
100414	Ethylbenzene	Liver and kidney toxicity
206440	Fluoranthene	Nephropathy, increased liver weights, hematological alterations, clinical effects
86737	Fluorene	Decreased red blood cell count, packed cell volume and hemoglobin
16984488	Fluoride	Objectionable dental fluorosis (soft, mottled teeth)
591786	Hexanone, 2-	Hepatotoxicity and nephrotoxcity[c]
7439896	Iron	Liver pathology, diabetes mellitus, endocrine disturbance, and cardiovascular effects[c]
78831	Isobutyl alcohol	Hypoactivity and ataxia
78591	Isophorone	Kidney pathology
7439965	Manganese	Central nervous system effects
78933	Methyl ethyl ketone	Decreased fetal birth weight
108101	Methyl isobutyl ketone	Lethargy, increased liver and kidney weights and urinary protein
80626	Methyl methacrylate	Increased kidney to body weight ratio
91576	Methylnaphthalene, 2-	
7439987	Molybdenum	Increased uric acid
91203	Naphthalene	Decreased body weight
7440020	Nickel	Decreased body and organ weights
100027	Nitrophenol, 4-	
59507	Parachlorometacresol	
108952	Phenol	Reduced fetal body weight
129000	Pyrene	Kidney effects (renal tubular pathology, decreased kidney weights)
110861	Pyridine	Increased liver weight
7782492	Selenium	Clinical selenosis (hair or nail loss)
7440224	Silver	Argyria (skin discoloration)
100425	Styrene	Red blood cell and liver effects
127184	Tetrachloroethene	Liver toxicity, weight gain
7440280	Thallium	Liver toxicity, gastroenteritis, degeneration of peripheral and central nervous system[c]
7440315	Tin	Kidney and liver lesions
7440326	Titanium	Considered to be physiologically inert[c]
108883	Toluene	Changes in liver and kidney weights
79016	Trichloroethene	Bone marrow, central nervous system, liver, kidneys[4]
75694	Trichlorofluoromethane	Histopathology and mortality
67663	Trichloromethane	Fatty cyst formation in liver
7440622	Vanadium	Kidney and central nervous system effects[b]
108383	Xylene, m-	Central nervous system hyperactivity, decreased body weight
179601231	Xylene, m- & p- (c)	
95476	Xylene, o-	Central nervous system hyperactivity, decreased body weight

Table 12.2: MP&M Pollutants Exhibiting Systemic and Other Non-Cancer Human Health Effects[a]

CAS Number	Toxicant	RfD Target Organ and Effects
136777612	Xylene, o- & p- (c)	
7440666	Zinc	47% decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult human females after 10 weeks of zinc exposure
137304	Ziram \ Cymate	

Notes:
a. Chemicals with EPA verified (IRIS) or provisional (HEAST, or other Agency document)) human health-based RfDs, referred to as "systemic toxicants" (U.S. EPA (1998/99d), U.S. EPA (1997)).
b. RfD based on a no-observed-adverse-effect level (NOAEL). Health effects summarized from Amdur, M.O., Doul, J., and Klaassen, C.D., eds. *Cassarett and Doul's Toxicology*, 4th edition, 1991.
c. Target organ and effects summarized from Klaassen, C.D., ed. *Cassarett and Doul's Toxicology*, 5th edition, 1996.
d. Target organ and effects summarized from Wexler, P., ed. *Encyclopedia of Toxicology*, Volumes 1-3, 1998.

12.1.3 Environmental Effects of MP&M Pollutants

Ecological impacts of MP&M pollutants include acute and chronic toxicity to aquatic receptors by dozens of pollutants present in MP&M effluents, ***uptake*** of certain pollutants into aquatic food webs, sublethal effects on metabolic and reproductive functions, habitat degradation from turbidity, eutrophication, dissolved oxygen depletion, and loss of prey organisms. Metals are of particular concern to this regulation because they (1) do not volatilize, (2) do not biodegrade, (3) can be toxic to plants, invertebrates and fish, (4) adsorb to sediments and (5) bioconcentrate in biological tissues.

EPA obtained the environmental fate and toxicity information for the 132 MP&M POCs. Table E.1 in Appendix E shows the environmental fate and toxicity of each MP&M pollutant.[3] EPA found that:

- 56 pollutants are not volatile or are only slightly volatile (all metals were assumed to be non-volatile except for mercury);
- 57 pollutants have moderate to high adsorption potentials (all metals were assumed to have high adsorption potential except for nickel);
- 42 pollutants have moderate to high bioconcentration factors;
- 62 pollutants biodegrade slowly or are resistant to biodegradation altogether (all metals were assumed to be resistant to biodegradation);
- For freshwater environments, 32 pollutants have acute toxicities to aquatic life that range from moderate to high, and 33 pollutants have chronic toxicities that range from moderate to high;
- For saltwater environments, 20 pollutants have acute toxicities to aquatic life that range from moderate to high, and 23 pollutants have chronic toxicities that range from moderate to high.

The available information shows that dozens of the MP&M POCs have the potential to pose significant hazards to the aquatic environment when released to receiving waters. A number of pollutants are of particular concern because of their combined toxicity and fate. These include several polyaromatic hydrocarbons (acenaphthene, anthracene, 3,6-dimethyl-phenanthrene, fluoranthene, phenanthrene, and pyrene), several metals (aluminum, cadmium, copper, mercury, and selenium) and several phthalates (di-n-octyl phthalate, butyl benzyl phthalate, and di-n-butyl phthalate). Other pollutants are of concern chiefly because of their toxicity (arsenic, cyanide, chromium, lead, nickel, silver, and zinc) or their fate (bis(2-ethylhexyl)phthalate, bromo-2-chlorobenzene, bromo-3-chlorobenzene, dibenzofuran, dibenzothiophene, diphenylamine, long-chained petroleum hydrocarbons, 1-methylfluorene, N-nitrosodiphenylamine, and several metals).

The available fate and toxicity data indicate that many MP&M pollutants tend to (1) be "toxic", (2) not readily volatilize from the water column, (3) adsorb to sediments, (4) bioconcentrate in aquatic organisms, and (5) do not biodegrade. Such pollutants accumulate in sediments and reach concentrations which can impair ***benthic*** communities. Pollutants that have accumulated in sediments can be released back into the water column

[3] Note that EPA was unable to obtain fate or toxicity data for a substantial number of POCs.

because sediments act as long-term sinks. The pollutants can also enter soils and reach high levels over time if present in sewage sludge that is applied to land. The tendency of these pollutants to resist biodegradation and to bioconcentrate in biological tissue also causes them to be taken up into aquatic food chains where they can affect predators or humans who consume fish and shellfish (U.S. EPA, 1998).

The toxicity data also indicate that a sizable number of the POCs in MP&M effluents have toxicities that result in lethal or sub-lethal responses in aquatic receptors, including algae, ***vascular plants***, invertebrates, fish and amphibians. Responses include death, which may occur within a matter of hours to days, or longer-term sublethal responses (such as reproductive failure or growth impairment) that manifest themselves over weeks, months, or even years. The effects of toxic chemicals are not shared equally among exposed species: sensitive species are typically more affected than species that are more resistant. Hence, toxic conditions could selectively remove sensitive species from receiving waters. Such a pattern is of particular concern to ***threatened and endangered*** **(T&E)** species, which may already be close to extinction. Aquatic receptors are exposed to many different toxicants at the same time, which may have additive effects. The EPA assessment is based on a chemical-by-chemical approach and therefore does not consider additive effects. This approach may understate the benefits of the rule.

EPA also did not evaluate the potential fate and effects of the four conventional pollutants (BOD, pH, O&G, TSS) and several other pollutants, including ***Total Petroleum Hydrocarbon*** **(TPH)**, ***Total Kjeldahl Nitrogen*** **(TKN)**, phosphorus, and ***chemical oxygen demand*** **(COD)**, which may nonetheless adversely affect aquatic environments.[4,5]

- Effluents with high levels of BOD or COD consume large amounts of dissolved oxygen in a short time, causing surface waters to become oxygen-depleted, thereby killing or excluding aquatic life (U.S. EPA, 1986). At current discharge levels, MP&M facilities discharge 414 million pounds of BOD per year.

- Low pH (high acidity) water can be lethal to aquatic organisms; sensitive species of fish and invertebrates are eliminated from surface waters at pH's between 6.0 and 6.5 (U.S. EPA, 1999).

- O&G and TPH can have lethal effects on fish by coating gill surfaces and causing asphyxia, depleting dissolved oxygen levels due to excessive BOD, and impairing stream re-aeration due to the presence of surface films. Compounds present in O&G or TPH can also be detrimental to waterfowl by affecting the buoyancy and insulating capacity of their feathers (U.S. EPA, 1998). At current discharge levels, MP&M facilities discharge 221 million pounds per year of O&G, including 73 million pounds a year of TPH.

- TSS increases the turbidity of surface water and impairs underwater visibility and transparency, thereby inhibiting photosynthesis by diminishing the amount of sunlight that reaches algae or submerged aquatic plants. TSS also causes a general degradation of aquatic habitats by increasing the rate of sedimentation, which smothers eggs, covers aquatic plants, and affects benthic invertebrates (U.S. EPA, 1998).

- High input of nitrogen in estuarine and marine systems or phosphorus in freshwater systems can increase primary productivity and result in eutrophication. Such a process overloads surface waters with algae and reduces the transparency of the water column. The excess algae sink to the bottom and decompose at the end of their life cycle. This process consumes large amounts of dissolved oxygen and can turn surface waters anoxic (U.S. EPA, 1998; U.S. EPA, 1999).

12.1.4 Effects of MP&M Pollutants on Economic Productivity

Releases of large quantities or high concentrations of toxic pollutants in MP&M effluents may interfere with POTW processes (e.g., inhibiting microbial degradation), reduce the treatment efficiency or capacity of POTWs, and reduce disposal options for the sludge. In addition, toxic pollutants present in the effluent discharges may pass through a POTW and adversely affect receiving water quality, or may contaminate sludges generated during primary or secondary wastewater treatment. EPA expects that the proposed regulation will reduce interferences of operations and contamination of sewage sludge at POTWs receiving effluent discharges from MP&M facilities.

[4] TKN is defined as the total of organic and ammonia nitrogen. It is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

[5] EPA, however, considered environmental effects of TKN in the Ohio case study. EPA evaluated the impact of in-stream TKN concentrations on recreational value of fishing, boating, swimming, and wildlife viewing sites. For detail see Chapter 22 of this report.

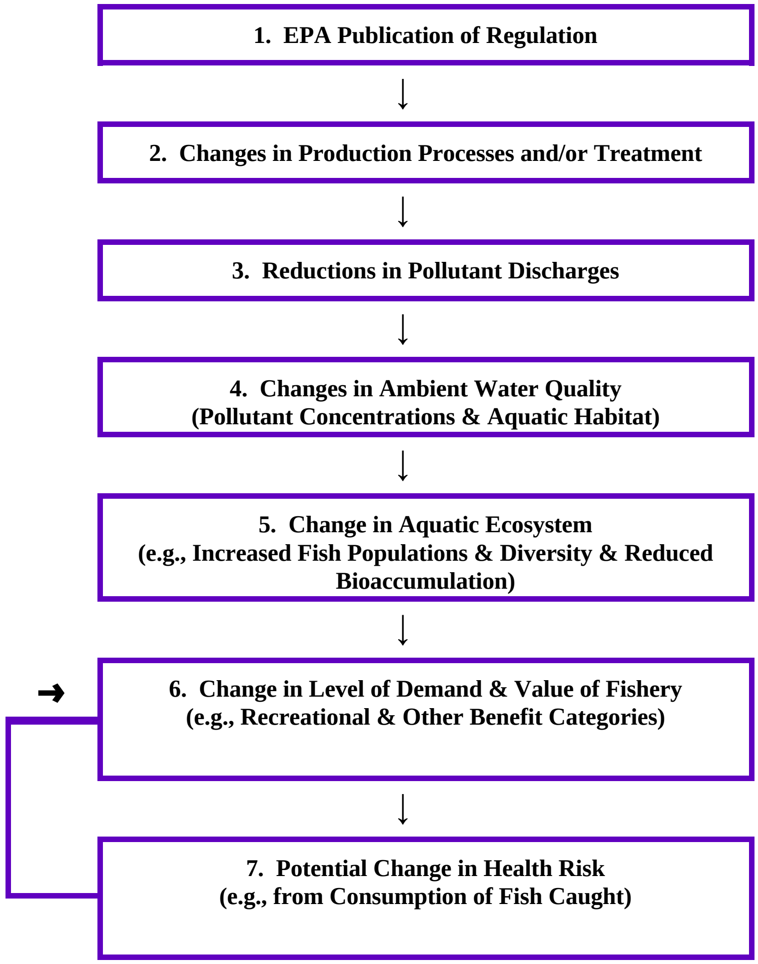
Because most MP&M pollutants associated with adverse health effects are subject to drinking water criteria, MP&M discharges to surface water can increase the cost of municipal water treatment by requiring investment in chemical treatment and filtration. Public water treatment systems must comply with drinking water criteria MCLs and secondary standards. Compliance may require treatment to reduce the levels of regulated pollutants below their MCLs. Capital investment and operating and maintenance (O&M) costs associated with treatment technologies can be substantial. To the extent that the proposed regulation reduces the concentration of MP&M pollutants in source waters to values that are below pollutant-specific drinking water criteria, public drinking water systems will accrue benefits in the form of reduced water treatment costs.

Releases of MP&M pollutants to surface waters may also increase treatment costs of irrigation water and industrial water.

12.2 Linking the Regulation to Beneficial Outcomes

This section describes the linkages between promulgation of a regulation and the expected benefits to society. As indicated in Figure 12.1, the benefits of the proposed regulation occur from a chain of events. These events include: (1) Agency publication of the regulation, (2) industry changes in production processes and/or treatment systems, (3) reductions in pollutant discharges, (4) changes in water quality, (5) changes in ecosystem attributes and sewage sludge quality, (6) changes in human responses, and (7) changes in human health and ecological risk. The first two events reflect the institutional and technical aspects of the regulation. The benefit analysis begins with the third event, the changes in the pollutant content of effluent discharges.

Figure 12.1: Chain of Events in a Benefits Analysis



Source: U.S. EPA analysis.

In event four, changes in pollutant discharges translate into improvements in water and sludge quality. In event five, these improvements in turn affect in-stream and near-stream biota (e.g., increased diversity of aquatic species and size of species populations) and sludge disposal options. Finally, human effects and the related valuation of benefits occur in events six and seven. For example, improvements to recreational fisheries and enhanced enjoyment by recreational anglers is connected to improved water quality and the value of reduced risk to human health. These linkages are the basis of the benefits analysis presented in this and the following chapters.

12.3 Qualitative and Quantitative Benefits Assessment

A benefit assessment defines and quantifies the types of improvements to human health and ecological receptors that can be expected from reducing the amount of MP&M pollutants released to the environment. The following sections provide an overview of the concepts and analytic approaches involved in the benefits assessment. The first section describes the general categories of benefits expected to result from the regulation and the level of analysis undertaken for them. The following three sections review, within the broad categories of benefits likely to be achieved by the MP&M regulation, the specific benefits that are evaluated in this analysis. Finally, Section 12.3.5 summarizes methods for attaching values to some of the benefit measures. Chapters 13 through 16 present the quantitative assessment of benefits.

12.3.1 Overview of Benefit Categories

The benefits of reduced MP&M discharges may be classified in three broad categories: human health, ecological, and economic productivity benefits. Table 12.3 summarizes the different types of benefits that fall in each of these categories. Each category is comprised of a number of more narrowly defined benefit categories. EPA expects that the MP&M regulation will provide benefits to society in all of these categories. EPA was not able to bring the same depth of analysis to all of these categories, however, because of imperfect understanding of the link between discharge reductions and benefit categories, and how society values some of the benefit events. EPA was able to quantify and monetize some benefits, quantify but not monetize other benefits, and assess still other benefits only qualitatively.

In addition to the national level benefits analysis, the Agency conducted a case study in the State of Ohio to provide in-depth analysis of the regulation's expected benefits. The Ohio case study improves on the national analysis in two ways. First, the analysis uses improved data and methods to address co-occurrence of MP&M facility benefits and other-source contributions of MP&M pollutants in the same locations. Second, the analysis of recreational benefits is based on original travel cost models of resource valuation in a random utility framework. The analysis values changes in the value of water resources for four recreational activities -- fishing, boating, swimming, and near-water recreation. Due to data limitations, only three of these four activities were valued at the national level benefits analysis.

To provide perspective on the extent to which this regulatory impact assessment was able to comprehensively analyze the benefits, Table 12.3 summarizes the specific benefits within each of the three broad benefit categories that are expected to accrue from the MP&M regulation and the level of analysis applied to each category. As shown in Table 12.3, only a few of the relevant benefit categories can be both quantified and monetized.

Table 12.3: Level of Analysis Performed for Specific Benefit Categories

Benefit Category	Quantified and Monetized	Quantified but Not Monetized	Qualitative
Human Health Benefits			
Reduced cancer risk due to ingestion of chemically-contaminated fish and unregulated pollutants in drinking water	X		
Reduced systemic health hazards (e.g. reproductive, immunological, neurological, circulatory, or respiratory toxicity) due to ingestion of chemically-contaminated fish and unregulated pollutants in drinking water		X	
Reduced systemic health hazards from exposure to lead from consumption of chemically-contaminated fish	X		
Reduced cancer risk and health hazards from exposure to unregulated pollutants in chemically-contaminated sewage sludge			X
Reduced health hazards from exposure to contaminants in waters used recreationally (e.g., swimming)			X
Ecological Benefits			
Reduced risk to aquatic life		X	
Enhanced water-based recreation including fishing, near-water recreation, and boating	X		
Other enhanced water-based recreation such as swimming, waterskiing, and white water rafting			X
Increased aesthetic benefits such as enhancement of adjoining site amenities (e.g. residing, working, traveling, and owning property near the water)			X
Nonuser value (i.e., existence, option, and bequest value)	X		
Reduced contamination of sediments			X
Reduced non-point source nitrogen contamination of water if sewage sludge is used as a substitute for chemical fertilizer on agricultural land			X
Satisfaction of a public preference for beneficial use of sewage sludge[a]			X
Economic Productivity Benefits			
Reduced sewage sludge disposal costs	X		
Reduced management practice and record-keeping costs for users of sewage sludge that meets exceptional quality criteria			X
Reduced interference with POTW operations		X	
Benefits to tourism industries from increased participation in water-based recreation			X
Improved commercial fisheries yields			X
Addition of fertilizer to crops (nitrogen content of sewage sludge is available as a fertilizer when sludge is land applied)[a]			X
Improved crop yield (the organic matter in land-applied sewage sludge increases soil's water retention)[a]			X
Avoidance of costly siting processes for more controversial sewage sludge disposal methods (e.g., incinerators) because of greater use of land application			X
Reduced water treatment costs for municipal drinking water, irrigation water, and industrial process and cooling water			X

a. Some of these benefit categories are accounted for and quantified under the "reduced sewage sludge disposal costs."

Source: U.S. EPA analysis.

Each category of benefits and the level of analysis applied to this category are discussed in greater detail below.

12.3.2 Human Health Benefits

Reduced pollutant discharges to the nation's waterways will generate human health benefits by several mechanisms. The most important and readily analyzed benefits stem from reduced risk of illness associated with the consumption of water, fish or other food that is taken from waterways affected by MP&M discharges. Human health benefits are typically analyzed by estimating the change in the expected number of adverse human health events in the exposed population resulting from a reduction in effluent discharges. While some health effects such as cancer are relatively well understood and thus may be quantified in a benefits analysis, others are less well characterized and cannot be assessed with the same rigor or at all.

EPA analyzed the following direct measures of change in risk to human health: incidence of cancer from fish and water consumption; reduced risk of non-cancer toxic effects from fish and water consumption; and lead-related health effects to children and adults. EPA was able to monetize only two of the three measures (cancer-related and lead-related health risks). Incidence of cancer was translated into an expected number of avoided mortality events and, on that basis, monetized. Lead impacts to children were evaluated in terms of potential intellectual impairment as measured by estimated changes in IQ. Changes in adverse health effects to adults from lead exposure were measured in terms of reduced risk of hypertension, non-fatal coronary heart disease, non-fatal strokes, and mortality.

EPA also quantified but did not monetize the expected reduction of pollutant concentrations in excess of health-based AWQC limits. This benefit measure was obtained by comparing in-waterway pollutant concentrations to toxic effect levels.

In concept, the value of these health effects to society is the monetary value that society is willing to pay to avoid the health effects, or the amount that society would need to be compensated to accept increases in the number of adverse health events. ***"Willingness-to-pay"*** **(WTP)** values are generally considered to provide a fairly comprehensive measure of society's valuation of the human and financial costs of illness associated with the costs of health care, losses in income, and pain and suffering of affected individuals and of their family and friends.

In some cases, available economic research provides little empirical data for society's WTP to avoid certain health effects. One component of the cost of an illness estimates the direct medical costs of treating a health condition (e.g., hypertension), and can be used to value changes in health risk from reduced exposure to toxic pollutants such as lead. These estimates represent only one component of society's WTP to avoid adverse health effects and therefore produce a partial measure of the value of reduced exposure to MP&M pollutants. Employed alone, these monetized effects will significantly underestimate society's WTP.

12.3.3 Ecological Benefits

EPA expects that the ecological benefits from the regulation will include protection of fresh- and saltwater plants, invertebrates, fish, and amphibians, as well as terrestrial wildlife and birds that prey on aquatic organisms exposed to MP&M pollutants. The regulation will reduce the presence and discharge of various pollutants and will enhance or protect aquatic ecosystems currently under stress. The drop in pollutant loading is expected to reestablish productive ecosystems in damaged waterways and to protect resident species, including T&E species. EPA also expects that the regulation will enhance the general health of fish and invertebrate populations, increase their propagation to waters currently impaired, and expand fisheries for both commercial and recreational purposes. Improvements in water quality will also favor increased recreational activities such as swimming, boating, and water skiing. Finally, the Agency expects that the regulation will augment nonuse values (e.g., option, existence, and bequest values) of the affected water resources.

It is frequently difficult to quantify and attach economic values to ecological benefits. The difficulty results from imperfect understanding of the relationship between changes in effluent discharges and the specific ecological changes, lack of water quality monitoring data for most locations, and time lags between water quality changes and changes in species population and composition. In addition, it is difficult to attach monetary values to these ecological changes because they often do not occur in markets in which prices or costs are readily observed. As such, ecological benefits may be loosely classified as nonmarket benefits. This classification can be further divided into nonmarket *use* benefits and nonmarket *nonuse* benefits.

Nonmarket use benefits stem from improvements in ecosystems and habitats, which in turn lead to enhanced human use and enjoyment of these areas. For example, reduced discharges may lead to increased recreational use and enjoyment of affected waterways in such activities as fishing, swimming, boating, hunting or near water activities such as bird watching. In some cases, it may be possible to quantify and attach partial economic values to ecological benefits using market values (e.g., an increase in tourism or boat rentals associated with improved recreational fishing opportunities); in this case, these benefit events might better be classified as economic productivity related events, which are discussed below. Economic markets, however, do not provide enough information to fully capture the value of these benefits. Such markets capture only related expenditures made by recreationists (e.g., food and lodging) and do not capture the value placed on the experience itself. A variety of nonmarket valuation techniques can be used to capture the value placed on the resource in question. These techniques include hedonic valuation (wage-risk studies) and ***travel cost methods*** **(TCM)**, stated preferences methods (i.e., ***contingent valuation*** **(CV)**, ***contingent rating*** **(CR)**, ***contingent activity*** **(CA)**), benefits transfer, and averting behavior models.

Nonmarket nonuse benefits are not associated with current use of the affected ecosystem or habitat, but rather arise from (1) the *realization* of the improvement in the affected ecosystem or habitat resulting from reduced effluent discharges and (2) the value that individuals place on the *potential for use* sometime in the future. Nonmarket nonuse benefits may also be manifested by other valuation mechanisms, such as cultural valuation, philanthropy, and bequest valuation. It is often extremely difficult to quantify the relationship between changes in discharges and the improvements in societal well-being associated with such valuation mechanisms. That these valuation mechanisms exist, however, is indisputable, as evidenced, for example, by society's willingness to contribute to organizations whose mission is to purchase and preserve lands or habitats to avert development.

12.3.4 Economic Productivity Benefits

Reduced pollutant discharges may also benefit economic productivity. First, economic productivity gains may occur through reduced costs to public sewage systems (POTWs) for managing and disposing of the sludge (i.e., biosolids) from treating effluent discharges. For example, higher quality sludge may be applied to agricultural land or otherwise beneficially used rather than being incinerated or disposed of in landfills. POTWs may also incur lower costs because of lower record keeping requirements.

Economic productivity benefits may also accrue from reduced treatment costs of drinking water, irrigation water, and industrial use water. Reduced pollutant concentrations in public water systems source water to levels at or below MCLs or secondary standards could reduce ongoing treatment costs and avoid the need to invest in treatment technologies in the future. Reduced pollutant discharges may also reduce sediment dredging costs. Contaminated sediments may contribute substantially to contamination of aquatic biota and human exposure to human health toxicants. Controlling point source discharges of toxic pollutants can prevent sediment contamination and eliminate the need for future remediation (i.e., dredging) of contaminated sediments.

Other economic productivity gains may result from improved tourism opportunities in areas affected by MP&M discharges. Improved aquatic species survival may contribute to increased commercial fishing yield. When such economic productivity effects can be identified and quantified, they are generally straightforward to value because they involve market commodities for which prices or unit costs are readily available.

Although some of these improvements can be seen as cost savings (i.e., reduced treatment and disposal costs), and could be included in the economic cost analysis rather than in the benefits analysis, they are treated in this analysis as a benefit of the proposed effluent guideline and not included in the cost analysis.

12.3.5 Methods for Valuing Benefit Events

Some of the benefits expected from the MP&M regulation will manifest themselves in economic markets through changes in price, cost, or quantity of market-valued activities. For benefits endpoints traded in markets, such as increased yields from commercial fisheries, benefits can be measured by market prices or market-based factor pricing. Competitive prices can be also used to measure ***avoided cost*** type of benefits. For example, reduced pollutant loadings to public water supplies may lower costs of drinking treatment. Similarly, improved sludge quality resulting from the MP&M regulation would translate into an observable reduction in sludge disposal costs for some POTWs (see Chapter 16). Finally, market prices can be used to value direct medical costs of illnesses associated with exposure to pollutants. For this analysis, we used medical costs associated with treating hypertension, coronary heart disease, and stroke to estimate benefits from reduced exposure to lead (see Chapter 14). The estimated values can be used as minimum measures of the benefits associated with reduced cases of these illnesses.

In other cases, benefits involve activities or sources of value that either do not involve economic markets or involve them only indirectly. Methods used to value such benefits are described briefly below:

a. Wage-risk approach.

The wage-risk approach uses regression estimates of the wage premium associated with greater risks of death on the job to estimate the amount that persons are willing to pay to avoid death. Benefit values based on this approach are used as part of the basis for valuing reduced cancer cases due to fish consumption in Chapter 13.

b. Travel cost method

The TCM uses information on the costs that people incur in traveling to and using a particular site to estimate a demand curve for that site. The demand curve is then used to estimate the "consumer surplus" associated with the use of the site, that is, the value that consumers receive from the site over and above the costs that they incur in using it. Consumer surplus is an estimate of the net benefits of the resource to the people using that resource. For example, if the resource is a recreational fishing site, the TCM can be used to value the recreational fishing experience. TCM is one of the approaches used to value recreational benefits in Chapter 15. The Agency also used an original travel cost study to value benefits from enhanced water-based recreation in Ohio (see Part IV: Chapter 21).

c. Contingent valuation

In the CV method, surveys are conducted to elicit individuals' WTP for a particular good, such as a fishery, or clean water. CV is more broadly applicable than TCM. Like TCM, CV can be used to estimate the consumer surplus associated with recreational fisheries. CV can also be used to estimate less tangible values, such as how much people care about a clean environment. Values from both the CV approach and the wage-risk approach support the estimated value of avoided death that is used to monetize reduced cancer cases from consumption of contaminated fish (Chapter 13). In addition, the analysis of recreational benefits in Chapter 15 uses a baseline value of the fishery that is derived from CV analysis.

d. Benefits transfer

When time and resource constraints preclude primary research, benefit assessment based on benefit transfer from existing studies is used. This approach involves extrapolating benefit findings for one analytic situation to another. The relevant study situations are defined by type of environmental resource (e.g., fishery), policy variable(s), and the characteristics of user populations. The benefits transfer approach is used to monetize several benefit categories, including changes in the incidence of cancer cases (Chapter 13) and the national-level benefits from enhanced water-based recreation (Chapter 15).

The techniques described above form the basis of the benefits methodologies described in Chapters 13,14 and 15.

GLOSSARY

acute toxicity: the ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance. (See: chronic toxicity, toxicity.) (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption coefficients (Koc): represents the ratio of the target chemical absorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium.

ambient water quality criteria (AWQC): AWQC present scientific data and guidance of the environmental effects of pollutants which can be useful to derive regulatory requirements based on considerations of water quality impacts; these criteria are not rules and do not have regulatory impact (U.S. EPA. 1986. Quality Criteria for Water 1986. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC. EPA 440/5-86-001).

AQUatic Information REtrieval System (AQUIRE): a web-based ecotoxicity database maintained by EPA's Mid-Continent Ecology Division (MED) which summarizes ecotoxicity data retrieved from the literature. (http://www.epa.gov/med/databases/databases.html#aquire).

ASsessment Tools for the Evaluation of Risk (ASTER): an ecological risk assessment tool developed by EPA's Mid-Continent Ecology Division (MED); ASTER integrates information from the AQUIRE toxic effects database and the QSAR system (a structure activity based expert system) to estimate ecotoxicity, chemical properties, biodegradation and environmental partitioning. (http://www.epa.gov/med/databases/aster.html)

avoided cost: costs that are likely to be incurred in the future if current conditions still prevail at the time, but which will be avoided if particular actions are taken now to change the status quo.

benthic: relating to the bottom of a body of water; living on, or near, the bottom of a waterbody.

BIODEG: a web-based biodegradation database developed by Syracuse Research Corporation (http://esc.syrres.com/efdb/BIODGSUM.HTM).

biodegradation half-lives: represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions.

biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in an aquatic environment.

cancer potency slope factor (SF): a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

CHEMFATE: a web-based chemical fate database developed by Syracuse Research Corporation (http://esc.syrres.com/efdb/Chemfate.htm).

chemical oxygen demand (COD): A measure of the oxygen required to oxidize all compounds, both organic and inorganic, in water. (http://www.epa.gov/OCEPAterms/cterms.html)

chronic toxicity: the capacity of a substance to cause long-term poisonous health effects in humans, animals, fish, and other organisms. (http://www.epa.gov/OCEPAterms/cterms.html)

contingent activity: is one of the stated preference methods (see: contingent valuation and contingent activity). Survey respondents are asked how their behavior would change in response to a proposed change in one or more attributes of an activity (e.g., cost of the activity, site accessibility, or site attractiveness). Given responses to this type of question, and given information about incremental travel costs and value of time, a revealed preference method can be used to estimate the value of change.

contingent rating: is one of the stated preference methods (see: contingent valuation and contingent activity). Survey respondents are asked to rate several alternatives on an ad hoc utility scale (e.g., 1 to 10). The choice set of alternatives usually includes the environmental effect to be valued, substitutes for the effect, and a good with a monetary price to act as a threshold. Based on the respondent's rating of the environmental effect and the threshold good, and the monetary price of the threshold good, the value of the environmental effect can be determined.

contingent valuation (CV): a method used to determine a value for a particular event, where people are asked what they are willing to pay for a benefit and/or are willing to receive in compensation for tolerating a cost. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids that are close to what would be revealed if an actual market existed. (http://www.damagevaluation.com/glossary.htm)

Environmental Research Laboratory-Duluth fathead minnow database: a data base developed by EPA's Mid-Continent Ecology Division (MED) which provides data on the acute toxicity of hundreds of industrial organic compounds to the fathead minnow. (http://www.eoa.gov/med/databases/fathead_minnow.html)

hazardous air pollutant (HAP): compounds that EPA believes may represent an unacceptable risk to human health if present in the air.

Health Effects Assessment Summary Tables (HEAST): a comprehensive listing of provisional human health risk assessment data relative to oral and inhalation routes for chemicals of interest to EPA. Unlike data in IRIS, HEAST entries have received insufficient review to be recognized as high quality, Agency-wide consensus information (U.S. EPA. 1997. Health Effects Assessment Table; FY 1997 Update. EPA-540-R-97-036).

Henry's Law constant: a numeric value which relates the equilibrium partial pressure of a gaseous substance in the atmosphere above a liquid solution to the concentration of the same substance in the liquid solution.

human health-based water quality criteria (WQC): human health-based criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes (see AWQC). http://www.epa.gov/OCEPAterms/wterms.html)

hydrophobicity: having a strong aversion to water (http://www.epa.gov/OCEPAterms/hterms.html)

Integrated Risk Information System (IRIS): IRIS is an electronic data base with information on human health effects of various chemicals. IRIS provides consistent information on chemical substances for use in risk assessments, decision-making and regulatory activities.

lipophilicity: having a strong attraction to oils

maximum contaminant levels (MCLs): the maximum permissible level of a contaminant in water delivered to any user of a public system. MCLs are enforceable standards. (http://www.epa.gov/OCEPAterms/mterms.html)

metals: inorganic compounds, generally non-volatile, and which cannot be broken down by biodegradation processes. They are a particular concern because of their prevalence in MP&M effluents. Metals can accumulate in biological tissues, sequester into sewage sludge in POTWs, and contaminate soils and sediments when released to the environment. Some metals are quite toxic even when present at relatively low levels.

microbial metabolism: biochemical reactions occurring in living microorganisms such as bacteria, algae, diatoms, plankton, and fungi. POTWs make use of bacterial metabolism for wastewater treatment purposes. This process is inhibited by the presence of toxics such as metals and cyanide because these pollutants kill bacteria.

oil and grease (O&G): organic substances that may include hydrocarbons, fats, oils, waxes, and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

pH: An expression of the intensity of the basic or acid condition of a liquid; Natural waters usually have a pH between 6.5 and 8.5. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutants of concern (POCs): are the 150 contaminants identified by EPA as being of potential concern for this rule and which are currently being discharged by MP&M facilities.

priority pollutant (PP): 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater or soil samples.

publicly-owned treatment works (POTWs): a treatment works, as defined by section 212 of the Act, that is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. It also includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW Treatment Plant. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

quantitative structure-activity relationship (QSAR) model: an expert system which uses a large database of measured physicochemical properties such as melting point, vapor pressure and water solubility to estimate the fate and effect of a specific chemical based on its molecular structure. (http://www.epa.gov/med/databases/aster.html)

reference doses (RfDs): chemical concentrations expressed in mg of pollutant/kg body weight/day, that, if not exceeded, are expected to protect an exposed population, including sensitive groups such as young children or pregnant women.

secondary MCLs: human health-based drinking water criteria to assess the health hazards associated with the presence of certain toxic chemicals in drinking water. SMCLs are established for taste or aesthetic effects.

Superfund Chemical Data Matrix (SCDM): a source for factor values and benchmark values applied when evaluating potential National Priorities List (NPL) sites using the Hazard Ranking System (HRS). (http://www.epa.gov/superfund/resources/scdm/index.htm).

suspended solids: small particles of solid pollutants that float on the surface of, or are suspended in, waterbodies. (http://www.epa.gov/OCEPAterms/sterms.html)

systemic toxicants: chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds.

threatened and endangered (T&E): animals, birds, fish, plants, or other living organisms threatened with extinction by anthropogenic (man-caused) or other natural changes in their environment. Requirements for declaring a species endangered are contained in the Endangered Species Act.

Total Petroleum Hydrocarbon (TPH): a general measure of the amount of crude oil or petroleum product present in an environmental media (e.g., soil, water, or sediments). While it provides a measure of the overall concentration of petroleum hydrocarbons present, TPH does not distinguish between different types of petroleum hydrocarbons.

Total Kjeldahl Nitrogen (TKN): the total of organic and ammonia nitrogen. TKN is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

total suspended solids (TSS): a measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids." (See: suspended solids.) (http://www.epa.gov/OCEPAterms/tterms.html)

total suspended particles (TSP): a method of monitoring airborne particulate matter by total weight. (http://www.epa.gov/OCEPAterms/tterms.html)

travel cost method (TCM): method to determine the value of an event by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site. (http://www.damagevaluation.com/glossary.htm)

uptake: the movement of one or more chemicals into an organism via ingestion, inhalation, and or trough the skin.

vascular plants: plants that are composed of, or provided with vessels or ducts that convey fluids. (www.infoplease.com)

willingness to pay (WTP): maximum amount of money one would give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

AQUIRE: AQUatic Information REtrieval System
ASTER: ASsessment Tools for the Evaluation of Risk
AWQC: ambient water quality criteria
BIODEG: biodegradation
BOD: biological oxygen demand
CA: contingent activity
CHEMFATE: chemical fate
CR: contingent rating
CV: contingent valuation
COD: chemical oxygen demand
HAP: hazardous air pollutant
HEAST: Health Effects Assessment Summary Tables
IRIS: Integrated Risk Information System
Koc: adsorption coefficient
MCL: maximum contaminant level
O&G: oil and grease
POC: pollutant of concern
POTW: publicly owned treatment work
PP: priority pollutant
QSAR: quantitative structure-activity relationship
RfD: reference dose
SCDM: Superfund Chemical Data Matrix
SF: cancer potency slope factor
T&E: threatened and endangered
TCM: travel cost method
TKN: Total Kjeldahl Nitrogen
TPH: Total Petroleum Hydrocarbon
TSS: total suspended solids
WQC: human health-based water quality criteria
WTP: willingness-to-pay

REFERENCES

Amdur, M.O., Doul, J., and Klaassen C.D., eds. 1991. *Cassarett and Doul's: Toxicology, the Basic Science of Poisons*. 4th ed. McGraw-Hill Inc., New York.

Amdur, M.O., Doul, J., and Klaassen C.D., eds. 1996. *Cassarett and Doul's: Toxicology, the Basic Science of Poisons*. 5th ed. McGraw-Hill Inc., New York.

Syracuse Research Corporation (BIODEG, CHEMFATE). 1999. Syracuse Research Corporation's Environmental Fate Data Bases. Syracuse Research Corporation, Syracuse, NY. http://esc.syrres.com/efdb/BIODGSUM.HTM and http://esc.syrres.com/efdb/Chemfate.htm.

U.S. Environmental Protection Agency. (U.S. EPA). 1980. Ambient water quality criteria documents. Washington, DC: Office of Water, U.S. EPA. EPA 440/5-80 Series. Also refers to any update of criteria documents (EPA 440/5-85 and EPA 440/5-87 Series) or any Federal Register notices of proposed criteria or criteria corrections, and EPA 822-Z-99-001. The most recent National Recommended Water Quality Criteria used in this report were published in the Federal Register on December 10, 1998.

U.S. Environmental Protection Agency. (U.S. EPA). 1986. *Ambient Water Quality Criteria for Dissolved Oxygen*. EPA 440/5-86-003.

U.S. Environmental Protection Agency. (U.S. EPA). 1995. *Proceedings of the First Gulf of Mexico Hypoxia Management Conference.* EPA-55-R-97-001.

U.S. Environmental Protection Agency. (U.S. EPA). 1997. Health Effects Assessment Summary Tables (HEAST). Office of Research and Development and Office of Emergency and Remedial Response, Washington, DC: U.S. EPA.

U.S. Environmental Protection Agency. (U.S. EPA). 1998. *National Water Quality Inventory. 1996 Report to Congress.* EPA 841-R-97-008.

U.S. Environmental Protection Agency. (U.S. EPA). 1998/99a. QSAR. Duluth, MN: Environmental Research Laboratory, U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (U.S. EPA). 1998/99b. Aquatic Toxicity Information Retrieval (AQUIRE) Data Base. Mid-Continent Ecology Division (MED), Duluth, MN. U.S. Environmental Protection Agency. Database retrieval @ http://www.epa.gov/ecotox/

U.S. Environmental Protection Agency. (U.S. EPA). 1998/99c. Assessment Tools for Evaluation of Risk (ASTER) Data Base. Duluth, MN: Environmental Research Laboratory, U.S. Environmental Protection Agency. 1998 Database retrieval.

U.S. Environmental Protection Agency. (U.S. EPA). 1998/99d. Integrated Risk Information System (IRIS). Washington, DC: U.S. Environmental Protection Agency. 1998 Database retrieval @ http://www.epa.gov/iris/

U.S. Environmental Protection Agency. (U.S. EPA). 1999. *Progress Report on the EPA Acid Rain Program.* U.S. EPA Office of Air and Radiation. EPA 430-R-99-011.

Wexler, P., ed. 1998. *Encyclopedia of Toxicology*, Volumes 1-3.

Chapter 13: Human Health Benefits

INTRODUCTION

EPA expects that the proposed MP&M regulation will yield human health benefits by reducing effluent discharges to ***waterways*** used for fishing or drinking water.

This chapter reviews four categories of expected human health benefits. The first two categories involve reductions in cancer cases from two exposure pathways: consumption of contaminated fish tissue and ingestion of contaminated drinking water. EPA evaluated the expected annual reduction in cancer cases in the exposed population and the associated monetary value of avoiding those cancer cases.

EPA quantified, but did not monetize, two additional measures of human health-related benefits. The first is the changes in fish consumption and drinking water exposures to non-cancer causing pollutants measured against systemic health effect ***reference doses*** (RfDs), an indicator of non-cancer, systemic health risk. The second benefit measure is the change in occurrence of pollutant concentrations that are estimated to exceed human health-based ***ambient water quality criteria*** (AWQC).

EPA also quantified and monetized changes in health risk to adults and children from reduced exposure to lead. This analysis is presented in Chapter 14.

The health-related measures were estimated for the baseline and for the proposed option for all of the benefit categories analyzed.[1] The reduction in the health-related measures (i.e., number of annual cancer cases) from baseline to the post-compliance case is the estimated benefit of the proposed regulation.

EPA estimated that, for combined recreational and subsistence angler populations, the proposed option would eliminate approximately 0.05 cancer cases per year due to fish consumption, from a baseline of about 0.13 cases estimated at current discharge levels, representing a reduction of 35.7 percent. The monetary value of avoiding these cancer cases yields benefits of $0.3 million (1997$) per year for the fish consumption pathway.

When considering the effect of the proposed regulation on the drinking water pathway, this analysis differentiates between the seven pollutants for which EPA has established drinking water criteria and the six pollutants that do not have criteria. This analysis assumes that public drinking water treatment systems will reduce the levels of seven of the 13 pollutants in the public water supply to levels that meet established criteria and are protective of human health. For this analysis, EPA does not estimate benefits of the avoided cancer cases associated with these seven pollutants via the

CHAPTER CONTENTS:

[1] Benefit values were also estimated for alternative options, which EPA considered for proposal. Cost and benefit results for these options are summarized in Chapter 19.

drinking water pathway.[2] This analysis focuses on the remaining six carcinogens for which drinking water criteria are not available. Based on the analysis of these six carcinogens, the proposed option would eliminate about 2.24 cancer cases per year for the drinking water pathway, from a baseline of 5.10 cases estimated at current discharge levels, representing a reduction of 43.9 percent. The monetary value of these reduced cancer cases is 13.0 million (1997$) per year. All dollar values presented throughout the rest of this chapter are in 1997 dollars unless specified otherwise. The total monetized human health benefits from reduced cancer cases from both the fish consumption and drinking water pathways is $13.3 million per year.

Additional benefits will also be realized in the form of reductions in non-cancer, systemic health risks. For this analysis, EPA measures the change in the population exposed to excessive levels of MP&M pollutants from consuming contaminated fish or ingesting contaminated drinking water.

EPA evaluated the distribution of populations exposed to quantities of pollutants that potentially pose a risk of systemic health effects. The results of the analysis suggest that the proposed option will reduce the risk of systemic health effects for a substantial portion of the exposed population and significantly increase the portion of the population that is not exposed to any systemic health hazard from MP&M pollutant discharges. However, the marginal risk of systemic health hazard from pollutants discharged by MP&M sample facilities alone is quite low. The significance of the marginal risk depends on the risk related to background exposures to pollutants from sources other than the MP&M industries.

Finally, EPA analyzed the effect of the proposed regulation in terms of AWQC. EPA estimated that under the proposed option, the number of waterways with concentrations for at least one affected pollutant that exceed human health-based AWQC will be reduced from 10,310 in the baseline to 9,205.

13.1 Methodology & Data Sources

Individuals are potentially exposed to pollutants from MP&M facilities via consumption of contaminated fish tissue and drinking water. Potential human health effects include cancer and non-cancer health effects. Risks such as skin, lung, liver, kidney, and bladder cancer and leukemia are associated with exposure to 13 MP&M pollutants (see Table 12.1). Non-cancer health effects are associated with exposure to 77 MP&M pollutants. These effects include increased blood pressure, gastrointestinal effects, liver and kidney toxicity, cardiovascular and central nervous system effects, and decreased birth weight (see Table 13.2).

This section summarizes the methodology for estimating national benefits for three benefit categories:

1. reduced incidence of cancer from consumption of fish taken from waterways affected by MP&M industry discharges,

2. reduced incidence of cancer from ingestion of water taken from waterways affected by MP&M industry discharges, and

3. reduced occurrence of pollutant concentrations resulting from MP&M discharges that exceed human health-based AWQC.

Benefits for a fourth category, the reduced frequency of ingestion of pollutants via fish and water consumption in quantities exceeding the RfD, an indicator of non-cancer, systemic health risk, was estimated only at the sample level and not at the national level due to data limitations associated with sample design.

To evaluate benefits, EPA compared discharges under the proposed option to baseline conditions. Human health-related benefit analyses were performed for sample MP&M facilities using EPA engineering estimates of baseline and option-specific pollutant loadings.

This analysis does not include all possible human health benefits and does not provide a comprehensive estimate of the total human health benefits associated with the proposed rule. Analyses of health benefits are not possible for a significant number of the pollutants whose discharges will be reduced by the proposed regulation.

Beyond these important limitations, the methodologies used to assess the human health benefits involve significant simplifications and uncertainties. Elements of the analysis involving significant simplifications and uncertainties include the following: sample design and analysis of benefits by location of occurrence; estimation of in-waterway concentrations of MP&M pollutants; consideration of the joint effects of pollutants; consideration of background concentrations of MP&M pollutants; consideration of downstream effects; and estimation of the exposed fishing population. Section 13.3 provides more detail on limitations and uncertainties associated with the human health benefits analyses. Whether these simplifications and uncertainties, taken together, are likely to lead to an understatement or overstatement of the estimated economic values for the human health benefits that were analyzed is not known.

[2] Due to resource constraints, EPA did not estimate the savings in treatment costs that might accrue to drinking water systems as a result of reduced concentrations of the seven pollutants in the intake waters.

13.1.1 Cancer from Fish Consumption

The analysis of reduced annual occurrence of cancer in exposed populations via the fish consumption pathway involves three analytic steps:

- estimating the reduced annual risk of incurring cancer per exposed individual;
- estimating the population that would be expected to benefit from reduced contamination of fish; and
- calculating the change in the number of cancer events in the exposed population. Each step is discussed in detail below.

a. Estimating change in individual cancer risk

The estimated marginal risk to an individual of developing cancer is based on four factors:[3]

- the quantity of carcinogenic chemicals that MP&M facilities discharge to waterways,
- the rate at which the discharged chemicals accumulate in fish tissue,
- the cancer effect of the chemicals, and
- the rate of personal consumption of contaminated fish.

For each sample MP&M facility and the waterway to which it discharges, EPA calculated the marginal cancer risk to two population classes with different fish consumption rates: recreational anglers and subsistence anglers. EPA calculated the marginal cancer risk values for baseline (i.e., before regulation) pollutant discharges and for post-compliance discharges based on the proposed option. The following discussion summarizes the marginal cancer risk calculations.

EPA calculated the in-waterway pollutant concentrations for each MP&M facility using a simplified waterway dilution model for all chemicals for which a quantitative relationship between ingestion rate and the annual probability of developing cancer has been estimated. EPA used a model that accounts for the dilution characteristics of different waterbody types (i.e., streams, estuaries, and lakes). The model does not account for other fate processes, such as chemical degradation or photolysis. In addition, the analysis considered only the discharge site and did not estimate concentrations below the initial point of discharge. For additional details on the calculation of waterway concentrations, see Appendix E.

The marginal cancer risk associated with each pollutant was calculated based on the estimated concentration of the pollutant in the affected waterway, the assumed uptake of the pollutant into fish flesh, the daily rate of fish ingestion, and the cancer risk factor for each pollutant. The formula for calculating the risk to an individual from consumption of a given chemical is as follows:

$$Risk = \frac{C \times CF_1 \times CR \times BCF \times EF \times ED}{BW \times LT \times CF_2} \times SF \qquad (13.1)$$

where:

Risk	=	marginal risk of incurring cancer from fish consumption (change in probability);
C	=	pollutant concentrations in surface water (µg/l);
CF_1	=	conversion factor, micrograms to milligrams (0.001 mg/µg);
CR	=	human consumption rate of fish (kg/day);
BCF	=	bioconcentration factor of pollutant in fish (l/kg);
EF	=	exposure frequency (365 days/year);
ED	=	exposure duration (years);
BW	=	human body weight (70 kg);
LT	=	human lifetime (70 years);
CF2	=	conversion factor, years to days (365 days/year); and
SF	=	pollutant cancer potency factor $(mg/kg/day)^{-1}$.

The pollutants analyzed and their cancer potency factors are presented in Table 13.1. EPA used the relationship outlined above to estimate risk values for subsistence and recreational fishing households. The risks for these population subgroups differ in the assumed consumption rates. Persons living in subsistence fishing households are assumed to consume 124.1 grams per day (0.124 kg/day) of fish over 70 years of exposure. Persons living in recreational fishing households are assumed to consume 12.1 grams of freshwater/estuarine fish per day (0.012 kg/day) over a 70-year period. The fish consumption values are based on uncooked fish weights, and use data from all ages of the population surveyed. They represent the 90^{th} and 99^{th} percentiles, respectively, of the empirical distribution of the U.S. per capita freshwater/estuarine finfish and shellfish consumption, and do not include consumption of marine fish.

Persons in recreational fishing households associated with ***marine reaches*** are assumed to consume 57.8 grams of fish per day (0.0578 kg/day) over a 70-year period. Persons

[3] The risk value is referred to as the *marginal* risk because it is the incremental lifetime probability that an individual will develop cancer above and beyond the baseline probability posed by all other extant factors that contribute to a risk of developing cancer.

living in subsistence fishing households associated with marine reaches are assumed to consume 189.9 grams per day (0.1899 kg/day) of fish over 70 years of exposure. These percentile point estimates are based on the U.S. Department of Agriculture 1994-96 Continuing Survey of Food Intake by Individuals (CSFII) (EPA, 2000).

To estimate the annual increased risk of cancer in recreational and subsistence anglers and their families, the lifetime risk values were then divided by 70 (an estimate of lifetime).

Table 13.1: Cancer Potency Factors for MP&M Pollutants

CAS Number	Regulated Pollutant	Cancer Potency Factor $(mg/kg/day)^{-1}$	Drinking Water Criterion?
62533	Aniline	0.0057	
62759	Nitrosodimethylamine, N-	51	
67663	Trichloromethane	0.0061	Yes
75003	Chloroethane	0.0029	
75092	Dichloromethane	0.0075	Yes
75354	Dichloroethene, 1,1-	0.6	Yes
78591	Isophorone	0.00095	
79016	Trichloroethene	0.011	Yes
86306	Nitrosodiphenylamine, N-	0.0049	
117817	Bis(2-ethylhexyl) phthalate	0.014	Yes
123911	Dioxane, 1,4-	0.011	
127184	Tetrachloroethene	0.052	Yes
7440382	Arsenic	1.5	Yes

The cancer potency factor is the incremental probability of developing cancer over a lifetime resulting from ingestion of the indicated chemical at the rate of one milligram per day per kilogram of body mass. For the marginal rates of exposure in this analysis and assuming reasonable background chemical exposures, the potency factor may be reasonably assumed to be a linear constant.
Source: U.S. EPA (1998/99); U.S. EPA (1997a).

The pollutant-specific risks to recreational and subsistence anglers from MP&M facility discharges were then summed *across pollutants* for each type of angler, to obtain marginal risks for each population group from each facility's discharge. EPA developed separate estimates of cancer risk for each combination of angler type and facility discharging at least one pollutant with a cancer risk factor. The total change in probability of developing cancer from exposure to *more than one* MP&M pollutant is assumed to be the sum of the marginal risk effects from each pollutant: that is, the effects of the individual pollutants are assumed to be linearly additive.[4] This analysis excludes populations exposed to MP&M pollutants, if the estimated individual lifetime risk from exposure to carcinogens discharged by MP&M facilities is less than 10^{-6} under the baseline discharge levels.

b. Estimating the affected population

The population exposed to contaminated fish and thus expected to benefit from reduced discharges includes recreational and subsistence anglers who fish the affected reaches, as well as members of such anglers' households. A "***reach***" is a specific length of river, lake shoreline, or marine coastline, and an "***MP&M reach***" is one to which an MP&M facility discharges. The geographic area from which anglers would travel to fish a reach is assumed to include only those counties that abut a given reach.[5] This

[4] Note that the assumption of linear additivity of cancer risk effects applies not only to the combination of pollutants from a single facility but also to the combined effects of multiple facility discharges. When more than one MP&M facility discharges to the same affected waterway — a circumstance found to occur with some frequency in the sample facility data — the combination of the multiple facility discharges may be accounted for by simply analyzing the effects of each facility independently. The cancer effects from multiple facilities can be aggregated to estimate cancer cases in the exposed population.

[5] The exposed, and thus potentially benefitting, population would also include a category of "all other individuals" who consume freshwater and estuarine fish. Although these individuals are expected to have a much lower average daily consumption rate than anglers in the adjacent counties, they nevertheless would likely receive some benefit from reduced exposure to pollutants

assumption is based on the finding in the *1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* that 65 percent of anglers travel less than 50 miles to fish (U.S. Department of the Interior, 1993). Estimating the number of persons fishing a reach involved the following steps:

- Estimating the licensed fishing population in counties abutting MP&M reaches;
- Estimating the population of subsistence fishermen in counties abutting MP&M reaches; and
- Estimating the fraction of the total fishing population in counties abutting an MP&M reach that fish the MP&M reach and, from that fraction, the size of population expected to fish each MP&M reach.

Adjusting the calculated fishing populations for the presence of fish advisories.

Including family members in the exposed population estimates.

❖ ***Estimating the licensed fishing population in counties abutting MP&M reaches***

The number of fishing licenses sold in counties abutting MP&M reaches is assumed to approximate the number of anglers residing in the abutting counties. EPA excluded the non-resident, one-day, and three-day license categories from the total number of licenses used in this analysis. Data on fishing licenses are not available for every state in which MP&M facilities are located. EPA used state-level data to estimate the number of fishing licenses per county for those states for which county-level data were not assembled. Total state licenses were apportioned to counties based on the ratio of total population in the county abutting a discharge reach to total state population. Where an MP&M reach spans more than one county, fishing licenses were summed across all counties abutting the discharge reach. Where a reach lies in more than one state, EPA separately calculated the number of licenses for the abutting county(ies) based on the fishing license and county population data for the respective states.

❖ ***Estimating the population of subsistence fishermen in counties abutting MP&M reaches***

Although fishing licenses may be sold to subsistence fishermen, many of these individuals do not purchase fishing licenses. The extent of subsistence fishing in the US or in individual states is not generally known. For this analysis, EPA assumed that the number of subsistence fishermen would be an additional 5 percent of the licensed fishing population.[6] That is, after estimating the licensed fishing population in counties abutting MP&M reaches, EPA added 5 percent to this value as the estimated number of subsistence fishermen.

❖ ***Estimating the population fishing an MP&M reach***

EPA assumed that fishing activity among anglers residing within counties abutting a discharge reach is distributed evenly among all reach miles within those counties. Thus, the number of anglers who fish an MP&M reach was estimated by computing the length of the reach as a percentage of total reach miles within corresponding counties and multiplying the estimated ratio by the total fishing population in counties abutting the reach.

❖ ***Adjusting for fish advisories***

For MP&M reaches where fish advisories are in place (typically due to non-MP&M regulated pollutants such as dioxin and mercury), EPA assumed that some proportion of anglers would adhere to the advisory and not fish those reaches (U.S. EPA, 1999b). Past studies suggest that anglers have a high, although not complete, level of awareness of fish advisories. These studies further suggest that while anglers may change their behavior in response to fish consumption advisories, they do not necessarily refrain from fishing in these reaches or consuming fish taken from reaches under an advisory. For example, studies conducted by Belton et al (1986), Knuth and Velicer (1990), Silverman (1990), West et al. (1989), Connelly, Knuth, and Bisogni (1992), and Connelly and Knuth (1993) indicate that 50 to 87 percent of anglers surveyed were aware of state fish advisories on water bodies where they fish.

These studies also indicate that only 10 to 34 percent of anglers who were aware of advisories modified their fishing behavior in response by no longer fishing a particular location, changing the location in which they fish, or taking fewer fishing trips. However, 13 to 68 percent of anglers who were aware of advisories changed their consumption or preparation habits in response to advisories. The study by Knuth and Velicer (1990) also found some confusion among anglers regarding which waters were under advisory: 37 percent of fishermen actually fishing in waters under advisory reported that they were fishing in uncontaminated waters.

On the basis of these data, EPA assumed that recreational fishing activity would be 20 percent less on reaches subject to an advisory than would otherwise be estimated. EPA also assumed that fish advisories *do not* affect fishing participation by subsistence anglers; thus, no adjustment was

through fish consumption. This analysis omits this consumption category and the associated benefit estimate.

[6] It is important to estimate recreational and subsistence populations separately because fish consumption rates for subsistence anglers are considerably higher than those for recreational anglers.

made to the estimates of the subsistence fishing population based on the presence of fish advisories.

The assumed 20 percent decrease in recreational fishing could lead to either an overestimate or underestimate of the risk associated with consumption of contaminated fish. For one thing, anglers who change locations may simply be switching to other locations where advisories are in place and therefore maintain or increase their current risk. Also, those who continue to fish contaminated waters may change their consumption and preparation habits to minimize the risks.

❖ ***Including family members in the exposed population estimates***

EPA assumed that, in addition to anglers themselves, families of anglers would also consume fish taken from waters affected by MP&M facility discharges. Therefore, for each MP&M reach, EPA multiplied the estimated numbers of recreational and subsistence anglers fishing the affected reaches by 2.65, the size of the average US household in 1996 based on Current Population Reports, (U.S. Bureau of the Census, 1997). These calculations yielded the household populations of recreational and subsistence anglers who are estimated to consume fish from the reach to which the MP&M facility discharges, either directly or indirectly through a POTW. EPA expects that family members will benefit from reduced MP&M industry discharges by consuming fish that has lower levels of pollutant contamination.

c. Calculating the change in the number of cancer events in the exposed population

EPA calculated the number of cancer cases associated with the pollutant discharges (baseline and post-compliance) from each facility by multiplying the marginal cancer risk value for the two population classes times the estimated sizes of the population classes living near the facility. The product of the marginal risk value and the population size yields the number of annual cancer events in the given population class estimated to result from consumption of fish taken from waterways affected by MP&M pollutant discharges. Summing the values for the recreational and subsistence fishing household classes yields the total number of cancer cases associated with the sample facility discharges. Because the number of cancer cases apply to *sample* facilities, EPA extrapolated the sample results to the total MP&M population by multiplying the result obtained for each sample facility by its sample weight and summing the sample-weighted facility results. The formula follows:

$$TCC_{fc} = \sum_{i}^{N} Wt_i \times \left[(POP_{i,sprt} \times Risk_{i,sprt}) + (POP_{i,sbst} \times Risk_{i,sbst} \right] \qquad (13.2)$$

where:

TCC_{fc} = Total national estimate of annual cancer cases associated with consumption of contaminated fish tissue (baseline or post-compliance);

Wt_i = Facility sample weight *i* (*i* = 1 to *N* facilities, where *N* is the number of facilities in the sample);

$POP_{i,sprt}$ = Exposed population in recreational fishing households for the reach to which facility *i* discharges (with adjustments as indicated for the presence of fish consumption advisories);

$POP_{i,sbst}$ = Exposed population in subsistence fishing households for the reach to which facility *i* discharges;

$Risk_{i,sprt}$ = Marginal cancer risk from fish consumption in the recreational fishing household population associated with MP&M pollutant discharges from facility *i*; and

$Risk_{i\ sbst}$ = Marginal cancer risk from fish consumption in the subsistence fishing household population associated with MP&M pollutant discharges from facility *i*.

These values were calculated for the baseline and post-compliance discharge cases. The *difference* is the number of cancer cases estimated to be avoided annually through the fish consumption pathway as a result of the proposed regulation.

13.1.2 Cancer from Drinking Water Consumption

The analysis of reduced cancer incidence via the drinking water pathway involves three analytical steps that are largely parallel to those performed for the fish consumption pathway:

- estimating cancer risk to an exposed individual from consumption of contaminated drinking water,
- estimating the population that would benefit, and

- calculating the change in the number of cancer events in the exposed population.

The major differences in the analysis for the drinking water pathway involve the identification of the exposed population and the analysis of pollutant discharge effects in both the reach to which a facility discharges and reaches downstream of the discharge point.

a. Estimating cancer risk from drinking water consumption

Estimating cancer risk from consumption of drinking water affected by MP&M discharges requires calculating in-waterway pollutant concentrations in locations where drinking water treatment systems draw water for public consumption. This analysis involves three elements:

Estimating in-waterway pollutant concentrations for each pollutant in the reach to which a facility directly or indirectly discharges. The method and formulas for this calculation are identical to those described for the analysis of cancer effects for the fish consumption pathway.

Estimating the pollutant concentrations over a distance of 500 kilometers downstream from each facility's discharge reach, using an exponential decay model in which pollution concentrations diminish below the initial point of discharge (e.g., dilution, adsorption, partitioning, volatilization, and hydrolysis). Methods used to calculate downstream pollutant concentrations are described in more detail in Appendix G.

Identifying the location of any drinking water intakes in the initial and downstream reaches where pollutant concentrations were calculated and assigning pollutant concentration values to each relevant intake point. The Water Supply Database **(WSDB)** file in the Graphical Exposure Modeling System **(GEMS)** provided information on drinking water intakes.

Estimated pollutant concentrations at each drinking water intake determines cancer risk. EPA assumed drinking water treatment systems will reduce concentrations to below adverse effect thresholds for all chemicals for which EPA has published a drinking water criterion. Therefore, pollutants examined in the MP&M drinking water analysis include only six carcinogens for which current drinking water criteria are not available. See Table 13.1 for a list of the pollutants, their cancer potency factors, and drinking water criteria.

The formula for calculating the marginal risk to an individual resulting from the discharge of a given pollutant from a given facility at reaches with a known public drinking water intake is as follows:

$$Risk = \frac{C \times CF_1 \times CR \times EF \times ED}{BW \times LT \times CF_2} \times SF \qquad (13.3)$$

where:

Risk	=	Marginal risk of incurring cancer from drinking water consumption (change in probability), calculated at each drinking water intake within 500 km of the initial discharge point;
C	=	pollutant concentration in surface water in the reach with an intake (µg/l);
CF_1	=	conversion factor, micrograms to milligrams (0.001 mg/µg);
CR	=	human consumption rate of water (2 l/day);
EF	=	exposure frequency (365 days/year);
ED	=	exposure duration (70 years);
BW	=	human body weight (70 kg);
LT	=	human lifetime (70 years);
CF_2	=	conversion factor (365 days/year); and
SF	=	pollutant cancer potency factor $(mg/kg/day)^{-1}$.

The marginal individual risk from each facility's pollutants are then summed over pollutants at each drinking water intake to calculate the marginal risk at each intake resulting from pollutant discharges by each upstream facility. The findings carried forward to the next step include the marginal cancer risk for each combination of facility and associated drinking water intake(s). If the estimated lifetime individual cancer risk is less than 10^{-6} under the baseline discharge levels, then the population served by a given water intake is excluded from further analysis.

To estimate the annual increased risk of cancer in consumers served by drinking water intakes affected by MP&M discharges, the lifetime risk values were then divided by 70 years (an estimate of lifetime). These values were calculated for both the baseline and post-compliance discharge cases.

b. Estimating the benefitting population

The exposed population for each combination of discharging facility and drinking water intake is the general population served by the drinking water system for which the drinking water intake was identified. The WSDB file in GEMS provided populations served by drinking water intakes (U.S. EPA, 1999c).

c. Calculating the changes in the number of cancer events

EPA calculated the number of cancer cases for baseline and post-compliance pollutant discharges for each combination of facility and affected drinking water intake by multiplying the marginal cancer risk value times the population served by the water system drawing water at the drinking water intake.

The total number of cancer cases associated with the facility discharges is the sum of cancer cases over all drinking water intakes. EPA extrapolated the sample results to the total MP&M population by multiplying the result for each sample facility by its sample weight and summing the sample-weighted facility results. Because marginal cancer effects are assumed to be linearly additive, cancer-risk effects are aggregated over facilities and drinking water intakes by simple addition of the effects calculated separately for each combination of facility and drinking water intake. The formula follows:

$$TCC_{dw} = \sum_{i}^{N} Wt_i \times \sum_{j}^{M} (POP_{i,j} \times Risk_{i,j}) \qquad (13.4)$$

where:

TCC_{dw} = Total national estimate of cancer cases associated with consumption of chemically-contaminated drinking water (baseline or post-compliance);

Wt_i = Facility sample weight *i* (*i* = 1 to *N* facilities)

$POP_{i,j}$ = Population exposed to discharges by facility i at drinking water intake *j* (*j* = 1 to *M* water supply intakes); and

$Risk_{i,j}$ = Marginal cancer risk for discharges by facility *i* at drinking water intake *j*.

EPA calculated these values for the baseline and post-compliance discharge cases. The difference in the values is the number of drinking water associated cancer cases estimated to be avoided annually by reduced MP&M industry discharges.

13.1.3 Exposures above Systemic Health Thresholds

Exposed populations are also at risk of developing non-cancer, systemic health problems (including reproductive, immunological, neurological, or circulatory problems) from fish ingestion and water consumption. Benefits from reduced systemic risks, other than lead, cannot be monetized.

The analysis of systemic health effects compares pollutant ingestion rates from fish consumption and drinking water pathways with the RfD for each pollutant. This analysis is done for discharges from all sample facilities, but is not performed at the national level because of analytical issues associated with extrapolation of threshold-based effects.

The RfD of a pollutant is an estimate of the maximum daily ingestion that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are available for 77 of the 132 MP&M pollutants of concern. The pollutants analyzed and their RfDs are listed in Table 13.2.

Table 13.2: RfDs for MP&M Pollutants

CAS Number	Regulated Pollutant	RfD (mg/kg/day)	Drinking Water Criterion? [a]	Target Organ and Effects
83329	Acenaphthene	0.060	No	Liver toxicity
67641	Acetone	0.100	No	Increased liver and kidney weights; nephrotoxicity
98862	Acetophenone	0.100	No	General toxicity
107028	Acrolein	0.020	No	Cardiovascular toxicity[b]
7429905	Aluminum	1.000	Yes	Renal failure, intestinal contraction interference, adverse neurological effects[c]
120127	Anthracene	0.300	No	
7440360	Antimony	0.000	Yes	Longevity, blood glucose, cholesterol
7440382	Arsenic	0.000	Yes	Hyperpigmentation, keratosis and possible vascular complications
7440393	Barium	0.070	Yes	Increased kidney weight
65850	Benzoic acid	4.000	No	
100516	Benzyl alcohol	0.300	No	Forestomach, epithelial hyperplasia
7440417	Beryllium	0.002	Yes	Small intestinal lesions
92524	Biphenyl	0.050	No	Kidney damage
117817	Bis(2-ethylhexyl) phthalate	0.020	Yes	Increased relative liver weight
7440428	Boron	0.090	No	Testicular atrophy, spermatogenic arrest
85687	Butyl benzyl phthalate	0.200	No	Significantly increased liver-to-body weight and liver-to-brain weight ratios
7440439	Cadmium	0.001	Yes	Significant proteinuria (protein in urine)

Table 13.2: RfDs for MP&M Pollutants

CAS Number	Regulated Pollutant	RfD (mg/kg/day)	Drinking Water Criterion? [a]	Target Organ and Effects
75150	Carbon disulfide	0.100	No	Fetal toxicity, malformations
108907	Chlorobenzene	0.020	No	Histopathologic changes in liver
75003	Chloroethane	0.400	No	
7440473	Chromium	1.500	Yes	Renal tubular necrosis (kidney tissue decay)[c]
18540299	Chromium hexavalent	0.003	Yes	Reduced water consumption
7440484	Cobalt	0.060	No	Heart effects[c]
7440508	Copper	0.040	Yes	Gastrointestinal effects, liver necrosis[c]
95487	Cresol, o-	0.050	No	Decreased body weights and neurotoxicity.
106445	Cresol, p-	0.005	No	Central nervous system hypoactivity and respiratory system distress
57125	Cyanide	0.020	Yes	Weight loss, thyroid effects and myelin degeneration
75354	Dichloroethene, 1,1-	0.009	Yes	Toxic effects on kidneys, spleen, lungs[c]; hepatic lesions
75092	Dichloromethane	0.060	Yes	Liver toxicity
60297	Diethyl ether	0.200	No	Depressed body weights
68122	Dimethylformamide, N,N-	0.100	No	Liver and gastrointestinal system effects
105679	Dimethylphenol, 2,4-	0.020	No	Clinical signs (lethargy, prostration, and ataxia) and hematological changes
84742	Di-n-butyl phthalate	0.100	No	Increased mortality
51285	Dinitrophenol, 2,4-	0.002	No	Cataract formation
606202	Dinitrotoluene, 2,6-	0.001	No	Mortality, central nervous system neurotoxicity, blood heinz bodies and methemoglobinemia, bile duct hyperplasia, kidney histopathology
117840	Di-n-octyl phthalate	0.020	No	Kidney and liver increased weights, liver increased SGOT and SGPT activity
122394	Diphenylamine	0.025	No	Decreased body weight, and increased liver and kidney weights
100414	Ethylbenzene	0.100	Yes	Liver and kidney toxicity
206440	Fluoranthene	0.040	No	Nephropathy, increased liver weights, hematological alterations, clinical effects
86737	Fluorene	0.040	No	Decreased red blood cell count, packed cell volume and hemoglobin
16984488	Fluoride	0.060	Yes	Objectionable dental fluorosis (soft, mottled teeth)
591786	Hexanone, 2-	0.040	No	Hypatotoxicity and nephrotoxcity[d]
7439896	Iron	0.300	Yes	Liver, diabetes mellitus, endocrine disturbance, and cardiovascular effects[d]
78831	Isobutyl alcohol	0.300	No	Hypoactivity and ataxia
78591	Isophorone	0.200	No	Kidney pathology
7439965	Manganese	0.140	Yes	Central nervous system effects
78933	Methyl ethyl ketone	0.600	No	Decreased fetal birth weight
108101	Methyl isobutyl ketone	0.080	No	Lethargy, increased liver and kidney weights and urinary protein
80626	Methyl methacrylate	1.400	No	Increased kidney to body weight ratio
91576	Methylnaphthalene, 2-	0.020	No	
7439987	Molybdenum	0.005	No	Increased uric acid
91203	Naphthalene	0.020	No	Decreased body weight
7440020	Nickel	0.020	Yes	Decreased body and organ weights
100027	Nitrophenol, 4-	0.008	No	
59507	Parachlorometacresol	2.000	No	

Table 13.2: RfDs for MP&M Pollutants

CAS Number	Regulated Pollutant	RfD (mg/kg/day)	Drinking Water Criterion? [a]	Target Organ and Effects
108952	Phenol	0.600	No	Reduced fetal body weight in rats
7723140	Phosphorus (elemental)	0.000	No	Parturition mortality; forelimb hair loss
129000	Pyrene	0.030	No	Kidney effects (renal tubular pathology, decreased kidney weights)
110861	Pyridine	0.001	No	Increased liver weight
7782492	Selenium	0.005	Yes	Clinical selenosis (hair or nail loss)
7440224	Silver	0.005	Yes	Argyria (skin discoloration)
100425	Styrene	0.200	Yes	Red blood cell and liver effects
127184	Tetrachloroethene	0.010	Yes	Liver toxicity, weight gain
7440280	Thallium	0.000	Yes	Liver toxicity, gastroenteritis,degeneration of peripheral and central nervous system[b]
7440315	Tin	0.600	No	Kidney and liver lesions
7440326	Titanium	4.000	No	
108883	Toluene	0.200	Yes	Changes in liver and kidney weights
79016	Trichloroethene	0.006	Yes	Bone marrow, central nervous system, liver, kidneys[d]
75694	Trichlorofluoromethane	0.300	No	Survival and histopathology
67663	Trichloromethane	0.010	Yes	Fatty cyst formation in liver
7440622	Vanadium	0.007	No	Kidney and central nervous system effects[b]
108383	Xylene, m-	2.000	Yes	Central nervous system hyperactivity, decreased body weight
179601231	Xylene, m- & p-*	2.000	Yes	
95476	Xylene, o-	2.000	Yes	Central nervous system hyperactivity, decreased body weight
136777612	Xylene, o- & p-*	2.000	Yes	
7440666	Zinc	0.300	Yes	47% decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult human females after 10 weeks of zinc exposure
137304	Ziram \ Cymate	0.020	No	

a. "Yes"= there is a published drinking water criterion for a given chemical.
b. Reference dose based on a ***no observed adverse effect level* (NOAEL)**. Health effects summarized from Amdur, M.O.; Doul, J.; and Klaassen, C.D.,eds. 1991. *Cassarett and Doul's Toxicology*, 4th edition.
c. Target organ and effects summarized from Wexler, P., ed. 1998. *Encyclopedia of Toxicology*, Volumes 1-3.
d. Target organ and effects summarized from Klaassen, C.D., ed.. 1996. *Cassarett and Doul's Toxicology*, 5th edition.
Source: U.S. EPA (1998/99); U.S. EPA (1997a).

This analysis used the hazard ratio as a systemic health effect indicator. The hazard ratio is calculated for each discharge reach associated with one or more MP&M sample facilities by dividing the estimated ingestion rate of each pollutant by the RfD value for the pollutant and summing these ratios over pollutants. The higher the hazard score value, the greater the risk to individuals of experiencing adverse systemic health effects.

A hazard ratio greater than 1 indicates that individuals may ingest MP&M pollutants at rates sufficient to pose a significant risk of systemic health. The formula follows:

$$HR = \sum_{k}^{K} \frac{DCR_k}{RfD_k} \qquad (13.5)$$

where:

HR = hazard ratio for the pollutants discharged from a facility and ingested by a specific consumption pathway;

DCR_k = estimated daily consumption rate per kilogram of body mass for pollutant k via a specific consumption pathway (mg/kg/day); and

RfD_k = Reference dose for pollutant k (mg/kg/day).

These hazard ratios are calculated separately for the fish and water consumption pathways, and separately for recreational and subsistence fish consumption rates. The procedures and formulas for estimating the in-waterway concentrations and ingestion of pollutants by exposed populations are the same as those used for the fish consumption and drinking water cancer analyses. The only exception is that the analysis of systemic health pathways was performed for the discharge reach only and not for reaches downstream, due to time and resource constraints. As a result, this analysis will likely understate populations exposed to non-cancer systemic risks via drinking water pathways.

EPA assumed that the combined effect of ingesting multiple pollutants is proportional to the sum of their effects individually. Thus, a cumulative hazard ratio applicable to all pollutants with RfD values for each combination of discharge reach and consumption pathway is calculated by summing across the pollutants discharged to each reach. For example, for three MP&M pollutants discharged from a facility (pollutant A with a hazard ratio of 0.10, pollutant B with a hazard ratio of 0.05, and pollutant C with a hazard ratio of 0.15), the combined hazard ratio is 0.30.

Distributions of these systemic health hazard ratios were calculated for the baseline and post-compliance discharge cases. The change in hazard ratio value distributions over the populations exposed to MP&M pollutants from the discharges of MP&M sample facilities is a measure of systemic health benefits from the proposed regulation. The basis for identifying exposed populations is the same as that described for the analysis of reduced incidence of cancer via the fish consumption and drinking water consumption pathways.[7] Thus, the hazard ratio values calculated in this analysis can be linked to specific exposed population estimates. The *shift* in populations from a *higher* to a *lower* hazard ratio value from the baseline to post-compliance cases is the quantitative measure of benefits from this analysis.

This analysis considers contributions to systemic risk resulting only from MP&M facility discharges, and does not take into account other sources of exposure to MP&M pollutants, or other chemicals that may contribute to an aggregate risk of systemic health hazard. The hazard ratios calculated for a given population are therefore likely to be systematically biased downwards. The net result is that the analysis understates the numerical value estimated for hazard ratios, but the marginal change in hazard ratios between the baseline and the proposed option would remain the same. EPA therefore evaluated potential marginal changes in systemic health risks over the entire distribution of hazard ratios, including hazard ratios below one. EPA did not monetize these benefits.

[7] The exposed populations for the drinking water consumption pathway are those associated with drinking water intakes only in a facility's discharge reach.

The results from the systemic health risk analysis apply to sample discharge locations only. Analytic tractability issues prevented this analysis from being conducted on a sample-weighted national basis.

13.1.4 Human Health AWQC

EPA used another approach to quantify reductions in health risk from the proposed MP&M regulation, based on the extent to which reduced MP&M discharges would decrease the occurrence of pollutant concentrations in affected waterways that exceed human health-based AWQC. This analysis provides a measure of the change in cancer and systemic health risk by comparing the number of discharge reaches exceeding health-based AWQC for regulated pollutants due to MP&M activities in the baseline to the number exceeding AWQC under the proposed option.

AWQC are set at levels to protect human health through ingestion of aquatic organisms and ingestion of water and aquatic organisms. Accordingly, reducing the frequency at which human health-based AWQC are exceeded should translate into reduced risk to human health. This measure should be viewed as an indirect indicator of reduced risk to human health, because it does not reflect the size of the exposed population and is not tied to changes in human health risk *per se*.[8]

EPA estimated the baseline concentrations of all MP&M pollutants for each reach to which one or more MP&M facilities discharge. The calculation of concentrations used the same in-waterway dilution and mixing model described in the analysis of cancer risk for the fish consumption pathway. The baseline concentrations were compared with human health-based AWQC values. (See Table 13.3 for a list of MP&M pollutants with AWQC values.) Reaches in which concentrations of one or more pollutants were estimated to exceed an AWQC value were identified as exceeding AWQC limits in the baseline.

This analysis was repeated using the post-compliance discharge values for the proposed option. Reaches estimated to have concentrations in excess of AWQC in the baseline but not in the post-compliance case were assessed as having substantial water quality improvements relative to human health-based criteria as a result of regulation. EPA deems such water quality improvements to be indicative of reduced risk to human health. Although not explicitly accounted for in this analysis, human health risk reductions are also likely to occur wherever in-waterway concentrations are reduced, regardless of whether or not they are reduced to levels below AWQC.

[8] The following chapter uses this same information *in part* as a direct indicator of improved water quality.

Table 13.3: MP&M Pollutants with Human Health-Based AWQC

		Human Health-Based AWQC (ug/l)		
CAS Number	**Pollutant**	**Organisms Only**	**Water & Organisms**	**Target Organ and Effects**[a]
83329	Acenaphthene	2700	1200	Liver, hepatotoxicity
67641	Acetone	2800000	3500	Increased liver and kidney weights; nephrotoxicity
98862	Acetophenone	98000	3400	General toxicity
107028	Acrolein	1000	410	Cardiovascular toxicity[c]
7429905	Aluminum	47000	20000	Renal failure, intestinal contraction interference, adverse neurological effects[d]
62533	Aniline	95	5.8	Spleen and body cavity
120127	Anthracene	6800	4100	No observed effects
7440360	Antimony	4300	14	Longevity, blood glucose, cholesterol
7440382	Arsenic	0.16	0.02	Liver, kidneys, lungs, bladder and skin
7440393	Barium		1000	Increased kidney weight
65850	Benzoic acid	2900000	130000	No observed adverse effects
100516	Benzyl alcohol	810000	10000	Forestomach, epithelial hyperplasia
7440417	Beryllium	1100	66	Small intestinal lesions
92524	Biphenyl	1200	720	Kidney damage
117817	Bis(2-ethylhexyl) phthalate	5.9	1.8	Liver
85687	Butyl benzyl phthalate	5200	3000	Significantly increased liver-to-body weight and liver-to-brain weight ratios
7440439	Cadmium	84	14	Significant proteinuria (protein in urine)
75150	Carbon disulfide	94000	3400	Fetal toxicity, malformations
108907	Chlorobenzene	21000	680	Histopathologic changes in liver
75003	Chloroethane	520	12	
18540299	Chromium hexavalent	2000	100	Reduced water consumption
7440473	Chromium	1000000	50000	Renal tubular necrosis (kidney tissue decay)[d]
7440508	Copper	1200	650	Gastrointestinal effects, liver necrosis[d]
106445	Cresol, p-	3100	170	Central nervous system hypoactivity and respiratory system distress
95487	Cresol, o-	30000	1700	Decreased body weights and neurotoxicity.
57125	Cyanide	220000	700	Weight loss, thyroid effects and myelin degeneration
117840	Di-n-octyl phthalate	39	37	Kidney and liver increased weights, liver increased SGOT and SGPT activity
84742	Di-n-butyl phthalate	12000	2700	Increased mortality
75354	Dichloroethene, 1,1-	3.2	0.057	Inconclusive
75092	Dichloromethane	1600	4.7	Liver, lungs
60297	Diethyl ether	770000	6900	Depressed body weights
131113	Dimethyl phthalate	2900000	310000	
68122	Dimethylformamide, N,N-	220000000	3500	Liver and gastrointestinal system effects
105679	Dimethylphenol, 2,4-	2300	540	Clinical signs (lethargy, prostration, and ataxia) and hematological changes
51285	Dinitrophenol, 2,4-	14000	70	Cataract formation
606202	Dinitrotoluene, 2,6-	900	34	Mortality, central nervous system neurotoxicity, blood heinz bodies and methemoglobinemia, bile duct hyperplasia, kidney histopathology

Table 13.3: MP&M Pollutants with Human Health-Based AWQC

		Human Health-Based AWQC (ug/l)		
CAS Number	Pollutant	Organisms Only	Water & Organisms	Target Organ and Effects[a]
123911	Dioxane, 1,4-	2400	3.2	Liver, nasal cavity, gall bladder
122394	Diphenylamine	1000	470	Decreased body weight gain, and increased liver and kidney weights
100414	Ethylbenzene	29000	3100	Liver and kidney toxicity
206440	Fluoranthene	370	300	Nephropathy, increased liver weights, hematological alterations, clinical effects
86737	Fluorene	14000	1300	Decreased red blood cell count, packed cell volume and hemoglobin
591786	Hexanone, 2-	65000	1400	Hypatotoxicity and nephrotoxcity[b]
7439896	Iron		300	Liver, diabetes mellitus, endocrine disturbance, and cardiovascular effects[c]
78831	Isobutyl alcohol	1500000	10000	Hypoactivity and ataxia
78591	Isophorone	2600	36	Preputial gland
7439965	Manganese	100	50	Central nervous system effects
7439976	Mercury	0.051	0.05	
80626	Methyl methacrylate	2300000	48000	Increased kidney to body weight ratio
78933	Methyl ethyl ketone	6500000	21000	Decreased fetal birth weight
108101	Methyl isobutyl ketone	360000	2800	Lethargy, increased liver and kidney weights and urinary protein
91576	Methylnaphthalene, 2-	84	75	
91203	Naphthalene	21000	680	Decreased body weight
7440020	Nickel	4600	610	Decreased body and organ weights
100027	Nitrophenol, 4-	1100	220	
62759	Nitrosodimethylamine, N-	8.1	0.00069	Tumors observed at multiple sites
86306	Nitrosodiphenylamine, N-	16	5	Bladder tumors, reticulum cell sarcomas
59507	Parachlorometacresol	270000	56000	
108952	Phenol	4600000	21000	Reduced fetal body weight in rats
7723140	Phosphorus (elemental)	2.2	0.53	Parturition mortality; forelimb hair loss
129000	Pyrene	290	230	Kidney effects (renal tubular pathology, decreased kidney weights)
110861	Pyridine	5400	35	Increased liver weight
7782492	Selenium	11000	170	Clinical selenosis (hair or nail loss)
7440224	Silver	110000	170	Argyria (skin discoloration)
100425	Styrene	160000	6700	Red blood cell and liver effects
127184	Tetrachloroethene	3500	320	Liver toxicity, weight gain
7440280	Thallium	6.5	1.8	Liver toxicity, gastroenteritis,degeneration of peripheral and central nervous system
108883	Toluene	200000	6800	Changes in liver and kidney weights
79016	Trichloroethene	92	3.1	
75694	Trichlorofluoromethane	66000	9100	Survival and histopathology
67663	Trichloromethane	470	5.7	Kidneys
108383	Xylene, m-	100000	42000	Central nervous system hyperactivity, decreased body weight
136777612	Xylene, o- & p- (c)	100000	42000	
95476	Xylene, o-	100000	42000	Central nervous system hyperactivity, decreased body weight
179601231	Xylene, m- & p- (c)	100000	42000	
7440666	Zinc	69000	9100	47% decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult human females after 10 weeks of zinc exposure

Table 13.3: MP&M Pollutants with Human Health-Based AWQC				
		Human Health-Based AWQC (ug/l)		
CAS Number	Pollutant	Organisms Only	Water & Organisms	Target Organ and Effects[a]
137304	Ziram \ Cymate	220000000	700	

a. Information on target organs are not available for some pollutants.
b. Reference dose based on a NOAEL. Health effects summarized from Amdur, M.O.; Doul, J.; and Klaassen, C.D.,eds. 1991. *Cassarett and Doul's Toxicology*, 4th edition/
c. Target organ and effects summarized from Klaassen, C.D., ed. 1996. *Cassarett and Doul's Toxicology*, 5th edition.
d. Target organ and effects summarized from Wexler, P., ed. 1998. *Encyclopedia of Toxicology*, Volumes 1-3.
Source: U.S. EPA (1980); U.S. EPA (1997a); U.S. EPA (1998/99).

EPA estimated the occurrence of pollutant concentrations in excess of AWQC on the basis of sample facility data. The findings from the sample facility analyses were extrapolated to national estimates using facility sample weights that capture the effect of multiple dischargers to the same reach in calculating whether pollutant concentrations would exceed AWQC. As a result, it was necessary to use an alternative weighting method to scale sample facility results to national estimates (see Appendix F).

13.2 Results

EPA estimated the monetary value to society associated with reduced cancer risk from consumption of fish and drinking water affected by MP&M pollutant discharges. Little information is available about dose-response relationships for non-cancer systemic health outcomes or about the monetary value of avoiding such health outcomes. As a result, EPA was unable to assign monetary values to the estimated reductions in systemic health risks. Such systemic health risks include reproductive, immunological, neurological, and circulatory problems. Although EPA was unable to assign monetary values to the latter two benefit measures for this regulation, the quantitative analyses of these events provide additional insight into the human health-related benefits likely to result from the proposed regulation.

The following sections present the findings from the analysis of each of the benefit measures.

13.2.1 Fish Consumption Cancer Results

Table 13.4 shows the number of cancer cases avoided by the proposed option through both the fish consumption and drinking water pathways. For combined recreational and subsistence angler populations, EPA estimates that the proposed option will eliminate approximately 0.045 cancer cases per year from a baseline value of about 0.126 cases, representing a reduction of 35.7 percent.

Table 13.4: Estimated Avoided Cancer Cases and Value of Annual Benefits for the Proposed Option

			Fish Consumption		Drinking Water	
CAS #	Chemical	Drinking Water Criterion?	Avoided Cancer Cases per Year	Mean Value of Benefit (Thousand 1997$)	Avoided Cancer Cases per Year [a]	Mean Value of Benefit[b] (Thousand 1997$)
62533	Aniline		0.000033	0.19	0.00001	0.03
62759	Nitrosodimethyl-amine, N-		0.010005	58.03	2.24217	13004.61
67663	Trichloromethane	yes	0.000014	0.08		
75003	Chloroethane		-0.000003	-0.02	0.00001	0.072
75092	Dichloromethane	yes	0.000005	0.03		
75354	Dichloroethene, 1,1-	yes	0.001417	8.22		
78591	Isophorone		-0.000004	-0.02	0.00000	0.022
79016	Trichloroethene	yes	0.00006	0.35		
86306	Nitrosodiphenyl-amine, N-		0.000619	3.59	0.00002	0.13
117817	Bis(2-ethylhexyl) phthalate	yes	0.018175	105.41		
123911	Dioxane, 1,4-		-0.000004	-0.02	0.0008	4.63
127184	Tetrachloroethene	yes	0.000804	4.67		
7440382	Arsenic	yes	0.014102	81.79		
Total Benefits			0.045223	262.3	2.24301	13009.49

a. Avoided cancer cases via the drinking water consumption pathway were not included for pollutants with drinking water criteria. EPA has published a drinking water criterion for seven of the 13 carcinogens and it is assumed that drinking water treatment systems will reduce concentrations of these chemicals to below adverse effect thresholds.
b. Estimated value of one avoided cancer case ($1997): $5.8 million
Source: U.S. EPA analysis.

The valuation of benefits is based on estimates of society's willingness-to-pay to avoid the risk of cancer-related premature mortality. Although it is not certain that all cancer cases will result in death, avoided cancer cases are valued on the basis of avoided *mortality* to provide a conservative estimate of benefits.

In this analysis, EPA used the $5.8 million estimate of the ***value of a statistical life saved*** (VSL) recommended in the *Draft Guidelines for Preparing Economic Analysis* (EPA, 1999a).[9] EPA based this value on its review and analysis of 26 policy-relevant value of life studies (EPA, 1997b). The reviewed studies used hedonic wage and contingent valuation analyses in labor markets to estimate the amounts that individuals would either be willing to pay to avoid slight increases in the risk of mortality, or would need to be compensated to accept a slight increase in risk of mortality.[10] EPA associated the ***willingness to pay*** (WTP) values estimated in these studies with small changes in the probability of mortality. To estimate a WTP value for avoiding certain or high probability mortality events, EPA extrapolated the smaller value to that for a 100 percent probability event.[11] The Agency used the resulting estimates of the value of a "statistical life saved" in regulatory analyses to value regulatory effects that are expected to reduce the incidence of mortality.

EPA estimated that the monetary benefits of reduced cancer cases from fish consumption for the proposed option is $0.3 million (1997$) per year (see Table 13.4).

[9] The value of a statistical life saved is given in 1997$ (U.S. EPA, 1999a). This underestimates benefits from the proposed regulation. The benefits analysis for promulgation of the MP&M regulation will adjust this value to 1999$.

[10] The question analyzed in these studies is: how much more must a worker be paid to accept an occupation with a slightly higher risk of mortality?

[11] These estimates, however, do not represent the willingness-to-pay to avoid the certainty of death.

13.2.2 Drinking Water Consumption Cancer Results

Table 13.4 also shows the number of cancer cases estimated to be avoided for each pollutant analyzed for drinking water populations. EPA estimated that the proposed option would eliminate approximately 2.24 cancer cases per year from a baseline value of about 5.10 cases, representing a reduction of about 44 percent. Annual monetary benefits from reduced cancer risk for the proposed regulation are estimated at $13.0 million (1997$) per year.

As noted in the preceding sections, EPA has established drinking water criteria for seven carcinogens. EPA assumes that public drinking water treatment systems will reduce these seven pollutants in the public water supply to levels that are protective of human health. To the extent that the proposed regulation reduces the concentration of MP&M pollutants to values that are below pollutant-specific drinking water criteria, public drinking water systems will accrue benefits in the form of reduced water treatment costs. EPA was not able to quantify such cost savings at the national level, however.

13.2.3 Systemic Health Threshold Results

Table 13.5 summarizes baseline and post-compliance distributions of systemic health hazard ratios and associated population estimates for each exposed population group for the proposed option. The shift in populations from higher to lower hazard score values between the baseline and post-compliance cases is the measure of benefit from reduced systemic health hazards.

Table 13.5: Change in Risk of Systemic Health Hazards from Reduced Exposure to MP&M Pollutants Distribution of Hazard Ratios[a]

Range of Ratios	Fish Consumption				Drinking Water Consumption			
	Baseline		Proposed Option		Baseline		Proposed Option	
	Population	Percent	Population	Percent	Population	Percent	Population	Percent
Ratio = 0.00	0	0%	385,726	5.8%	68,000	0.1%	11,074,668	13.9%
0.00 - 10^{-6}	1,528,589	22.7%	1,564,130	23.2%	73,050,966	91.3%	62,138,353	77.7%
10^{-6} - 10^{-3}	3,392,567	50.4%	3,425,711	50.9%	6,871,399	8.6%	6,777,344	8.5%
10^{-3} - 1.00	1,789,550	26.6%	1,346,623	20.0%	0	0%	0	0%
Score > 1.00	16,736	0.3%	5,252	0.1%	0	0%	0	0%
Totals	6,727,442	100%	6,727,442	100	79,990,365	100	79,990,365	100%

a. This analysis addresses only 77 of 132 chemicals of concern, excludes background exposures, and is based only on *sample* facility discharges and associated populations. The exposed population values are not national estimates of the populations that would benefit by reduced risk of systemic health hazard.
Source: U.S. EPA analysis.

Table 13.5 shows that the proposed option would shift substantial numbers of exposed population from higher to lower hazard ratio values. In particular, the population with a zero marginal risk of systemic health hazard increases substantially. For example, under baseline discharge conditions, no fishermen and 0.1 percent of individuals served by drinking water intakes are associated with hazard ratio values equal to zero. The percent of the population with zero marginal risk values increases to 5.8 percent for fishermen and 13.9 percent for individuals exposed to affected drinking water under the proposed option.

However, the marginal risk of systemic health hazard from pollutants discharged by MP&M facilities for which reference exposure values are available is generally quite low. For example, analysis of the in-waterway pollutant concentration data suggests that hazard ratios (based on both the fish consumption and drinking water pathways) for at least 99 percent of the population associated with sample facilities equals less than one in the baseline. These values do not consider background concentrations of MP&M or other pollutants or contributions to risk from MP&M pollutants for which reference exposure values are not available. Whether the *marginal* shifts in hazard ratio values are significant in reducing *absolute* systemic health risks is therefore uncertain, and will depend on the magnitude of pollutant exposures for a given population from sources that are not accounted for in this analysis.

Although EPA was unable to associate an economic value with changes in the number of individuals exposed to pollutant levels likely to result in systemic health effects, the reductions in health risk indicated by this benefit measure further indicate that the proposed regulation can be expected to yield human health benefits.

13.2.4 Human Health AWQC Results

The final human health benefit category is the reduced occurrence of pollutant concentrations that are estimated to exceed human health-based AWQC. This analysis provides an alternative measure of the expected reduction in risk to human health. Baseline in-waterway concentrations of MP&M pollutants are estimated to exceed AWQC limits for human health from consumption of water or organisms in 10,310 reaches. As shown in Table 13.6, EPA estimates that the proposed option would reduce the occurrence of concentrations in excess of human health AWQC limits. The proposed option would eliminate exceedances of either human health or aquatic life-based AWQC in 1,105 (10.72 percent) of those reaches. In addition, the proposed option would eliminate concentrations in excess of AWQC values for human health, consumption of organisms only, on 121 of the 192 reaches on which baseline discharges are estimated to cause concentrations in excess of the AWQC values. Note that the findings from the analysis of AWQC values for human health, consumption of organisms only, are a subset of the findings for the analysis relative to AWQC limits for human health from consumption of water or organisms. Results also show that 382 receiving reaches will experience partial water quality improvements from reduced occurrence of some pollutant concentrations in excess of AWQC limits for consumption of water and organisms.

Table 13.6: MP&M Discharge Reaches with Pollutant Concentrations Exceeding Human Health-Based AWQC Limits and Reductions Achieved by the Proposed Option

	Number of Reaches with Concentrations Exceeding Health-Based AWQC			
	# Pollutants (H_2O, Org.)	Human Health, Consumption of Water and Organisms	# Pollutants (Org. only)	Human Health, Consumption of Organisms Only
Baseline	19	10,310	6	192
Proposed Option	11	9,205	5	71
Percent Reduction		10.72%		63.02%

Source: U.S. EPA analysis.

13.3 Limitations and Uncertainties

This section discusses limitations and uncertainties in the human health benefits analysis. The analysis does not include all possible human health benefits, and therefore does not provide a comprehensive estimate of the total human health benefits associated with the proposed rule. Quantification of changes in human health risk described in this chapter are not possible for all pollutants whose discharges will be reduced by the proposed regulation. Due to current research limitations, cancer potency factors, reference doses, and AWQC are not available for 6 metals, 27 organics, 8 nonconventional pollutants, and 3 conventional pollutants. The methodologies used also involve significant simplifications and uncertainties, as described below. Whether these simplifications and uncertainties, taken together, are likely to lead to an understatement or overstatement of the estimated economic values *for the human health benefits that were analyzed* is not known.

13.3.1 Sample Design & Analysis of Benefits by Location of Occurrence

The MP&M industries are estimated to include over 62,752 facilities nationwide that generate wastewater while processing metal parts, metal products, and machinery. Many of these facilities are quite small and, individually, discharge relatively small quantities of pollutants. Most individual facilities are not likely to have a significant adverse impact on human health at any one MP&M reach. The industry discharges a significant quantity of pollutants in the aggregate, however, because of the large number of facilities. Thus, the combined effect of discharges from several facilities at a given reach may well result in appreciable risks to human health. Multiple dischargers affecting a single reach were found to be common, based on the sample facility data.

The sample of MP&M facilities on which this analysis is based (885 facilities) represents only approximately 1.5 percent of MP&M facilities nationwide. This sample was based on basic industry characteristics rather than geographic location. As a result, the sample does not accurately reflect the likelihood of co-occurrence of MP&M facilities on a reach and, therefore, the contribution to in-waterway pollutant concentrations made by multiple facilities. For example, the sample may include three MP&M facilities, all discharging to the same reach. In reality, however, five MP&M facilities might discharge to this reach.

The omission of co-occurrence of discharges from additional facilities does not create a problem in the analysis of marginal cancer risk, because each facility's contribution to total risk can be estimated separately and is assumed be linearly additive. The cancer effects associated with individual facility discharges can be summed over facilities to estimate occurrence of cancer events in the total population. Therefore, the application of sample weights in the cancer analysis accounts for pollutant contributions from facilities co-occurring on MP&M reaches that are not present in the sample of facilities.

This omission does present a problem, however, when analyzing changes in hazard ratios and changes in in-waterway pollutant concentrations relative to human health-based AWQC for reaches to which more than one facility discharge. For these reaches, changes in hazard ratios and in-waterway pollutant concentrations from reduced pollutant discharges should account for the total discharge of pollutants over the several facilities whose discharges may affect the reach. When facilities whose discharges to the reach have unequal sample weights, however, results from the sample facility analysis cannot be extrapolated to the population simply by multiplying estimated benefit values by the sum of the sample weights of the individual facilities. See Appendix F for an explanation of the sample weighting methodology devised to partially address this problem.

While this weighting methodology does recognize the contributions of facilities with different sample facility weights to aggregate results, it still does not account for the contributions made by co-occurring facilities *not included in the sample*. The omission of the frequency of true multiple discharger effects on aggregate instream concentrations and pollutant exposures understate the benefits.

13.3.2 In-Waterway Concentrations of MP&M Pollutants

Human health benefits are based on the estimated changes in in-waterway concentrations of MP&M pollutants. A variety of factors affect in-waterway concentrations, including flow rates under average and low flow conditions, flow depth, chemistry of the waterway, mixing processes, longitudinal dispersion, flow geometry, suspension of solids, and reaction rates. This analysis takes into account only site-specific variations in flow rates and flow depth. Standard values are used for other inputs to the water quality model, due to lack of data on the reaches affected by sample facility discharges. These standard values may not be accurate for all the sample facility reaches. In addition, the flow characteristics of the sample facility reaches may not be representative of the national distribution of those characteristics. Extrapolating the sample facility benefits to national results based on sample facility weights may therefore introduce distortions. The net effect of these assumptions and extrapolations on the aggregate benefits estimates is uncertain.

13.3.3 Joint Effects of Pollutants

The analyses of human health benefits ignore the potential for joint effects of more than one pollutant. Each pollutant is dealt with in isolation; the individually estimated effects are then added together. As such, the analyses do not account for the possibility that several pollutants may combine to yield more or less adverse effects to human health than indicated by the simple sum of the individual effects. The impact of this limitation on the results of this analysis is unknown.

13.3.4 Background Concentrations of MP&M Pollutants

Background concentrations of MP&M pollutants are not considered in the benefits analysis. Rather, the analysis assumes that MP&M facilities are the only source of each of the regulated pollutants in the waterway. Background contributions, either from other upstream sources or contaminated sediments from previous discharges, are not considered. Even if discharges of these contaminants are reduced or eliminated, sediment contamination and subsequent accumulation of the regulated pollutants in aquatic organisms may continue for years.

Excluding background contributions to in-waterway pollutant concentrations affects the results for systemic risk and changes in human health-based AWQC exceedances. In the systemic risk analysis, hazard ratios are likely to be systematically biased downwards by the omission of exposures to these chemicals from other water-related and non-water-related sources.[12] The net result is understated absolute risks of systemic health hazards. Similarly, reductions in human health-based AWQC exceedances calculated for a given MP&M reach are likely to be systematically biased downwards. The analysis is therefore likely to understate the frequency with which in-waterway pollutant concentrations move from values exceeding pollutant specific AWQC to values less than pollutant specific AWQC as a result of the regulation.

[12] Ideally, the analysis would include not only background concentration and exposure effects from water-related exposures but would also account for exposures to chemicals by other routes including, for example: air exposures including dust inhalation, and food contamination.

13.3.5 Downstream Effects

The analysis of cancer effects from drinking water consumption considered exposures from intakes downstream of the MP&M discharges. EPA, however, did not evaluate cancer risk to recreational and subsistence fishermen fishing downstream reaches, because of resource constraints. In addition, due to differential weighting of sample facility results, it was not possible to evaluate hazard ratios indicating non-cancer systemic health hazards or human health-based AWQC excursions in downstream reaches. By omitting these downstream effects, this analysis potentially understates baseline risks that would be reduced by the proposed option:

- cancer cases (from fish consumption),
- populations exposed to non-cancer systemic risks, and
- waterways with pollutant concentrations exceeding human health-based AWQC.

13.3.6 Exposed Fishing Population

Estimating the exposed fishing populations for specific MP&M reaches requires statistics on county fishing licences. EPA collect these data for every state where the MP&M facilities are located where the state collects these data at the county level. Where fishing license data were not available at the county level, EPA estimated the exposed fishing population based on state fishing license statistics and census data. This approach may under- or overstate actual fishing populations. In addition, data limitations hamper the estimate of the number of anglers who actually fish a given MP&M reach. Estimating the number of anglers fishing MP&M reaches based on the ratio of MP&M reach length to the total number of MP&M reach miles in the county recognizes the effect of the quantity of competing fishing opportunities on the likelihood of fishing a given reach, but it does not account for the differential quality of fishing opportunities. If water quality in substitute sites is distinctly worse or better, the estimates of the exposed populations are likely to be overstated or understated.

In addition, the number of subsistence anglers was assumed to equal 5 percent of the recreational fishing population. The magnitude of subsistence fishing in the United States or in individual states is not known. As a result, this estimate may understate or overstate the actual number of subsistence anglers.

Finally, to account for the effect of a fish advisory on fishing activity, and therefore on the exposed fishing population, EPA reduced the fishing population at an MP&M reach under a fish advisory by 20 percent. This could either overestimate or underestimate the risk associated with consumption of contaminated fish, because (1) anglers who change locations may simply be switching to other locations where advisories are in place and therefore maintain or increase their current risk, and (2) anglers who continue to fish contaminated waters may change their consumption and preparation habits to reduce the risks from the contaminated fish.

13.3.7 Cancer Latency & Human Health

Cancer latency refers to the time between the initial event that leads to cancer (e.g., chemical damage to DNA) and the onset of cancer. Ideally, cancer would be detected at a very early stage, when very few cells are involved. In reality, cancer latency is a very complex issue, and the time to detection varies considerably.

- Latency is related to health, age, immune status, genetics and other characteristics of the individual.
- Latency is also related to the specific carcinogen, the route of exposure, the type of cancer, the technology used for cancer detection, and numerous other factors.
- Environmentally induced cancers may not follow a typical progression pattern; their latency may be unusually shortened.
- Cancers may begin long before they are detected. The exact progress and time of recognition/ detection of cancer cannot be predicted, because of the numerous factors involved.
- Variations in timing of cancer detection are partially attributable to the type of cancer involved, the individuals affected, and differences in the medical technology used.
- The fundamental issue is when the damage related to cancer actually begins in an individual and when the continued cell damage stops. Damage to the individual begins when cancer is induced. Once cellular changes begin, the immune system and other body resources are diverted to limiting the carcinogenic process and organ system damage is occurring.

New instances of DNA mutation and cancer induction cease when exposure ceases. Benefits of avoiding cancer begin to accrue when cellular-level damage from the pollutant ceases. This benefit occurs even though the benefits may not be clinically measurable until some point in the future.

EPA assumed that benefits of avoiding cancer begin to accrue when the initial events leading to cancer cease, even though the benefits may not be clinically measurable until some point in the future. In making this assumption, the Agency considered two factors:

- uncertainty as to how and when exposure changes translate into reduced cancer risk, and

- economic uncertainty associated with the value of avoiding cancer and the timing at which a value of cancer avoidance is recognized.

The monetary valuation of mortality risk from cancer in EPA benefit-cost analyses is based on the VSL. This is derived from a number of revealed-preference studies that estimate the value of avoided premature mortality. The estimates correspond to the value of unforeseen instant death with no significant period of morbidity. The value of an avoided cancer case used in this analysis may therefore be underestimated, and ultimately the estimated value of the human health benefit of the proposed regulation may be understated.

GLOSSARY

marine reach: a specific length of marine coastline.

MP&M reach: a reach to which an MP&M facility discharges.

Ambient Water Quality Criteria (AWQC): are published and periodically updated by EPA under the auspices of the Clean Water Act. The criteria reflect the latest scientific knowledge on the effects of water pollutants on public health and welfare, aquatic life, and recreation. The criteria do not reflect consideration of economic impacts or the technological feasibility of reducing chemical concentrations in ambient water. The criteria serve as guides to states, territories, and authorized tribes in developing water quality standards and ultimately provide a basis for controlling discharges or releases of pollutants into our nation's waterways. AWQC are developed for two exposure pathways: ingestion of the pollutant via contaminated aquatic organisms only, and ingestion of the pollutant via both water and contaminated aquatic organisms.

no observed adverse effect level (NOAEL): exposure level at which there are no statistically or biologically significant differences in the frequency or severity of any effect in the exposed or control populations.

reach: a specific length of river, lake shoreline, or marine coastline

reference dose (RfD): an estimate of the maximum daily ingestion in that is likely to be without an appreciable risk of deleterious effects during a lifetime.

value of a statistical life saved (VSL): a monetary value of fatalities. A statistical life is saved when the mortality rate of a group of people is reduced sufficiently that one less person will die than would otherwise be the case. One must distinguish between statistical and actual lives. An actual life is saved when the identity of the beneficiary is know before the lifesaving expenditure is made.

waterway: streams, lakes, bays, and estuaries.

willingness to pay (WTP): maximum amount of money one would give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

AWQC: ambient water quality criteria
GEMS: Graphical Exposure Modeling System
NOAEL: no observed adverse effect level
RFD: reference dose
VSL: value of a statistical life saved
WSDB: The Water Supply Database
WTP: willingness to pay

REFERENCES

Amdur, M.O., J. Doul, and C.D. Klaassen, eds. 1991. *Cassarett and Doul's: Toxicology, the Basic Science of Poisons*. 4th ed. New York, NY: McGraw-Hill Inc.

Belton, T., R. Roundy, and N. Weinstein. 1986. "Urban Fishermen: Managing the Risks of Toxic Exposure." *Environment*, Vol. 28. No. 9, November.

Connelly, N. and B. Knuth. 1993. *Great Lakes Fish Consumption Health Advisories: Angler Response to Advisories and Evaluation of Communication Techniques*, Human Dimensions Research Unit, Dept. of Natural Resources, NY State College of Agriculture and Life Sciences, Cornell University, HDRU Series No 93-3, February.

Connelly, N., B. Knuth, and C. Bisogni. 1992. *Effects of the Health Advisory and Advisory Changes on Fishing Habits and Fish Consumption in New York Sport Fisheries*, Human Dimensions Research Unit, Dept. of Natural Resources, NY State College of Agriculture and Life Sciences, Cornell University, HDRU Series No 92-9, September.

Jones-Lee, M.W., M. Hammerton, and P.R. Philips. 1985. "The Value of Safety: Results of a National Sample Survey." *Economic Journal* (March): 49-72.

Klaassen, C.D., ed. 1996. *Cassarett and Doul's: Toxicology, the Basic Science of Poisons*. 5th ed. New York, NY: McGraw-Hill Inc.

Knuth, B. and C. Velicer. 1990. *Receiver-Centered Risk Communication for Sportfisheries: Lessons from New York Licensed Anglers*. Paper presented at the American Fisheries Society Annual Meeting, Pittsburgh, Penn, August.

Silverman, W. 1990. Michigan's Sport Fish Consumption Advisory: A Study in Risk Communication. Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science (Natural Resources) at the University of Michigan, May.

Tolley, G., D.Kenkel, and R.Fabian. 1994. "State-of-the Art Health Values." In G.Tolley et al., eds., *Valuing Health for Policy: An Economic Approach*. Chicago and London: The University of Chicago Press, Ltd., pp. 323-344.

U.S. Bureau of the Census. 1997. http://www.census.gov

U.S. Department of the Interior. 1993. *1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*, DOI, March.

U.S. EPA. 1980. Ambient water quality criteria documents. Washington, DC: Office of Water, U.S. EPA. EPA 440/5-80 Series. Also refers to any update of criteria documents (EPA 440/85 and EPA 440/5-87 Series) or any Federal Register notices of proposed criteria or criteria corrections.

U.S. EPA. 1984. *Summary of Current Oral Acceptable Daily Intakes (ADIs) for Systemic Toxicants*. Cincinnati, Ohio: Environmental Criteria and Assessment Office, U.S. EPA (May), 19 pp.

U.S. EPA. 1997a. *Health Effects Assessment Summary Tables (HEAST)*. Office of Research and Development and Office of Emergency and Remedial Response, Washington, DC: U.S. EPA. OERR 9200/6-303 (92-1).

U.S. EPA. 1997b. *The Benefits and Costs of the Clean Air Act, 1970 to 1990.* EPA 410-R-97-002, October, 1997. U.S. EPA, Office of Air and Radiation

U.S. EPA. 1998/99. *Integrated Risk Information System (IRIS) Retrieval*. Washington, DC: U.S. EPA.

U.S. EPA. 1999a. *Guidelines for Preparing Economic Analysis.* Draft report. Washington, DC: U.S. EPA.

U.S. EPA. 1999b. *National Listing of Fish and Wildlife Consumption Advisories*. Washington, DC: U.S. EPA, Office of Water.

U.S. EPA. 1999c. Drinking Water Supply (DWS) File, Washington, DC: U.S. EPA, Office of Wetlands, Oceans and Watersheds.

U.S. EPA. 2000. *Estimated Per Capita Fish Consumption in the United States, Based on the Data Collected by the United States Department of Agriculture's 1994-1996 Continuing Survey of Food Intakes by Individuals.* Draft Report, March.

Viscusi, K. 1992. *Fatal Tradeoffs: Public & Private Responsibilities for Risk.* New York, NY: Oxford University Press.

West, P., R. Marans, F. Larkin, and M. Fly. 1989. *Michigan Sport Anglers Fish Consumption Survey: A Report to the Michigan Toxic Substances Control Commission*, University of Michigan School of Natural Resources, Natural Resources Sociology Research Lab, Technical Report #1, May.

Wexler, P., ed. 1998. *Encyclopedia of Toxicology*, Vol. 1-3.

Chapter 14: Lead-Related Benefits

Introduction

The main benefits analysis performed by EPA examined ***systemic health risks*** from exposure to MP&M pollutants. EPA performed a separate analysis of benefits from reduced exposure to lead. The analysis of health effects from exposure to lead is based on ***dose-response functions*** tied to specific ***health endpoints*** to which monetary values can be applied. In this way it differs from the analysis of systemic health risk from exposure to other MP&M pollutants. This analysis assessed benefits of reduced lead exposure from consumption of contaminated fish tissue to three population groups: (1) preschool age children, (2) pregnant women, and (3) adult men and women.

EPA estimated benefits to preschool children based a ***dose-response relationship*** for intelligence quotient (IQ) decrements. The proposed rule would result in avoided IQ loss of 489 IQ points. The Agency estimated monetary values for avoided neurological and cognitive damages based on the impact of an additional IQ point on an individual's future earnings and the value of compensatory education for children with learning disabilities. The estimated monetary value of avoided cognitive damages to children is $4.9 million (1999$) per year.

The proposed rule would also reduce the incidence of neonatal mortality by 1.6 cases annually due to changes in maternal ***blood lead*** **(PbB)** levels during pregnancy. Based on the ***willingness to pay*** **(WTP)** values for avoiding death, the estimated monetary benefits to pregnant women and infants are $9.33 million (1997$) annually. The aggregated lead-related benefits for children from the proposed rule are $14.39 million annually.

The health effects in adults that EPA was able to quantify all relate to lead's effect on ***blood pressure*** **(BP)**. Quantified health effects include incidence of hypertension in adult men, initial non-fatal ***coronary heart disease*** **(CHD)**, non-fatal strokes (***cerebrovascular accidents*** **(CBA)** and ***atherothrombotic brain infarctions*** **(BI)**), and premature mortality. EPA used ***cost of illness*** **(COI)** estimates (i.e., medical costs and lost work time) to estimate monetary values of reduced incidence of hypertension, initial CHD, and strokes. This analysis uses the $5.8 million estimate of the value of a statistical life saved recommended in the *Draft Guidelines for Preparing Economic Analysis* (EPA, 1999b).[1]

Chapter Contents:

[1] The value of a statistical life saved is given in 1997$ (U.S. EPA, 1999b). This underestimates benefits from the proposed regulation. The benefits analysis for promulgation of the MP&M regulation will adjust this value to 1999$.

14.1 Overview of Lead-Related Health Effects

Lead and lead compounds are toxic and pose threats to human health and well being. The health effects of very high levels of PbB include convulsions, coma and death from lead toxicity. These effects have been understood for many years. The effects of lower doses of lead are not fully understood, however, and continue to be the subject of intensive scientific investigation (CDC,1991b).

Lead accumulates in the body and is stored in various organ systems. While high level exposures are of immediate concern due to ***acute toxicity***, exposure to small amounts can accumulate over time to harmful levels. Accumulated lead is very persistent, with a ***half-life*** in bone of approximately 27 years.[2] Known or strongly suspected health effects include kidney, stomach, and respiratory cancer, nervous system disorders, hypertension, anemia and blood disorders, gastrointestinal disorders, renal damage and other effects (ATSDR, 1997; CARB, 1996). Increased mortality from these effects has been observed in studies (ATSDR, 1997).

Many lead-associated adverse health effects are both chronic in nature and relatively common. These effects include but are not limited to hypertension, coronary artery disease, and impaired cognitive function. Specific cases of these conditions are difficult to link to lead exposure because the same adverse health effects or endpoints can arise from a variety of causes. Despite numerous studies conducted by EPA and other institutions, dose-response functions are available only for a handful of health endpoints associated with elevated PbB levels.[3] The available research does not always allow complete economic evaluation, even for quantifiable health effects.

Lead is harmful to any exposed individual, and the effects of lead on children are of particular concern. Children's rapid development rate makes them more susceptible to ***neurobehavioral deficits*** resulting from lead exposure. U.S. EPA identifies three sensitive populations: children under age one, children between the ages one and six, and adult men and women (U.S. EPA, 1990). New research suggests that children older than six may also be a hypersensitive population. Recent research on brain development among 10- to 18-year-old children shows unanticipated and substantial growth in brain development, mainly in the early teenage years (Giedd et al., 1999). This analysis does not, however, include this group due to data limitations. Table 14.1 summarizes the quantifiable health effects on children under six and adult men and women, along with other important, non-quantified, known health effects on these populations.

[2] A half-life of 27 years means that it takes 27 years for the levels measured in bone to decrease by 50 percent.

[3] In a pioneering study, Schwartz et al. quantified a number of health benefits that would result from reducing the lead content of gasoline (U.S. EPA, 1985). EPA extended this work by analyzing lead in drinking water (U.S. EPA, 1986a) and by funding the study of lead in the air (U.S. EPA, 1987).

Table 14.1: Quantified and Unquantified Health Effects of Lead

Population Group	Quantified Health Effect	Unquantified Health Effect
Children ages 0-6	Neonatal mortality due to decreased gestational age and low birth weight caused by maternal exposure to lead Nervous system effects in children younger than 6 years - IQ decrements, cases of IQ less than 70, PbB levels greater than 20 µg/dL	Fetal effects from maternal exposure (including diminished IQ and reduced birth weight) Low IQ (70 <IQ< 84) Permanent brain structure changes Slowed/delayed growth Delinquent and anti-social behavior Metabolic effects, impaired ***heme synthesis***, anemia Impaired hearing Probable cancer - stomach, kidney, respiratory tract Lead effects in children over 6 years
Adult Female ages 45-74	*For women in specified age ranges:* Non-fatal CHD Non-fatal stroke Mortality	Non-fatal CHD, non-fatal strokes and mortality for women in other age ranges Other cardiovascular diseases Hypertension Hypertension in pregnant women Reproductive effects - reduced fertility ***Neurobehavioral function*** Gastrointestinal effects - nausea, constipation, loss of appetite Renal effects - chronic ***nephropathy***, gout Probable cancer - stomach, kidney, respiratory tract
Adult Male ages 20 - 74	*For men in specified age ranges:* Ages 20-74 Hypertension Ages 40-75 Non-fatal CHD Mortality Ages 45-74 Non-fatal stroke	Non-fatal CHD, non-fatal strokes and mortality for men in other age ranges Other cardiovascular diseases Reproductive - men: sperm abnormalities Neurobehavioral function Gastrointestinal effects - nausea, constipation, loss of appetite Renal effects - chronic nephropathy, gout Probable cancer - stomach, kidney, respiratory tract

Source: U.S. EPA analysis.

14.1.1 Children Under Age One

Fetal exposure to lead *in utero* from maternal lead intake may result in several adverse health effects, including decreased gestational age, reduced birth weight, late fetal death, and increased infant mortality. The Centers for Disease Control **(CDC)** estimated that the risk of infant mortality increases by 10^{-4} for each 1 µg/dL increase in maternal PbB level during pregnancy. Neurobehavioral deficits in infants can result from both pre-natal and early post-natal exposure. The metabolic effects described for children in the section below have also been identified in infants. These effects can be quantified based on the dose-response relationship between PbB levels and intelligence quotient (IQ) decrements (Schwartz, 1994).

14.1.2 Children Between The Ages of One and Six

Elevated PbB levels in children may result in metabolic effects such as impaired heme synthesis, anemia, slowed growth, and cancer (U.S. EPA 1987). Severe lead poisoning may result in seizures, impaired coordination, recurrent vomiting, coma, and acute lead ***encephalopathy***, a potentially fatal condition (Piomelli et al., 1984). Elevated lead exposure may also induce a number of effects on the human nervous system. These effects include hyperactivity, behavioral and attentional difficulties, delayed mental development, and motor and perceptual skill deficits. The neurobehavioral effects on children can be quantified based on the dose-response relationship for IQ decrements.

14.1.3 Adults

Lead has been strongly suggested as the causative agent in numerous studies of kidney, stomach, and respiratory cancer in humans. The cancers observed in human studies are usually lethal. EPA has classified lead as a probable human carcinogen (Group 2b) based on animal toxicological evidence. A cancer potency value for lead has not been published, however, due to uncertainties associated with human studies. The California Environmental Protection

Agency **(CEPA)** has also classified lead as a carcinogen and estimated a preliminary cancer potency value ranging from 2.8×10^{-1} to 3.88×10^{-2} per mg/kg/day for oral exposure to lead compounds (California Air Resource Board [CARB], 1996). Reduced cancer risk associated with reduced exposure to lead can be estimated based on cancer cases avoided (see Section 13.2.1).

Elevated PbB has been linked to elevated BP in adults, especially in men aged 40 to 59 (Pirkle et al., 1985). Elevated BP, itself a health hazard, is also a risk factor for heart attack, stroke (Shurtleff, 1974; McGee and Gordon, 1976; Pooling Project Research Group **[PPRG]**, 1978), and premature death. Although elevated BP in women results in the same effects as for men, the general relationships between BP and these health effects differ somewhat across gender.

Other known or strongly suspected health endpoints include nervous system disorders in adults, anemia and blood disorders, gastrointestinal disorders, and renal damage. Finally, data suggest that lead is ***genotoxic*** and may cause chromosomal damage in humans leading to birth defects. Lead may also cause other adverse reproductive effects in women, including increased miscarriage and stillbirth (U.S. EPA 1990). A study of National Health and Nutrition Examination Surveys **(NHANES)** II data by Silbergeld et al. suggests that accumulated lead is stored in women's bone tissues and is mobilized back into the blood during the bone demineralization associated with pregnancy, lactation, and osteoporosis (Silbergeld et al., 1988). Many of these effects cannot be quantified due to a lack of information on the dose-effect relationship.

14.2 Children Health Benefits

The following analysis assesses benefits to children from reduced lead exposure, via reduced consumption of contaminated fish tissue.[4] This analysis uses PbB concentrations as a ***biomarker*** of lead exposure.[5] EPA measured PbB levels in the population of exposed children to obtain both baseline and post-compliance readings. Changes in those readings yielded estimated benefits from reduced lead exposure in the form of avoided damages. Avoided neurological and cognitive damages are expressed as changes in overall IQ levels, including reduced incidence of extremely low IQ scores (<70, or two standard deviations below the mean), and reduced incidence of PbB levels above 20 µg/dL. The neurological and cognitive damages avoided are then quantified using the value of compensatory education that an individual would otherwise need, and the impact on that individual's future earnings. This analysis does not quantify additional benefit categories, such as the costs of PbB screening and medical treatment. The reduced loss in IQ points, reduced cases of IQ levels below 70 points, and reduced special education costs associated with various PbB levels are likely to be the largest benefit categories. This analysis does not estimate the cost of group homes and other special care facilities.

The analysis of health benefits to children involves the following steps:

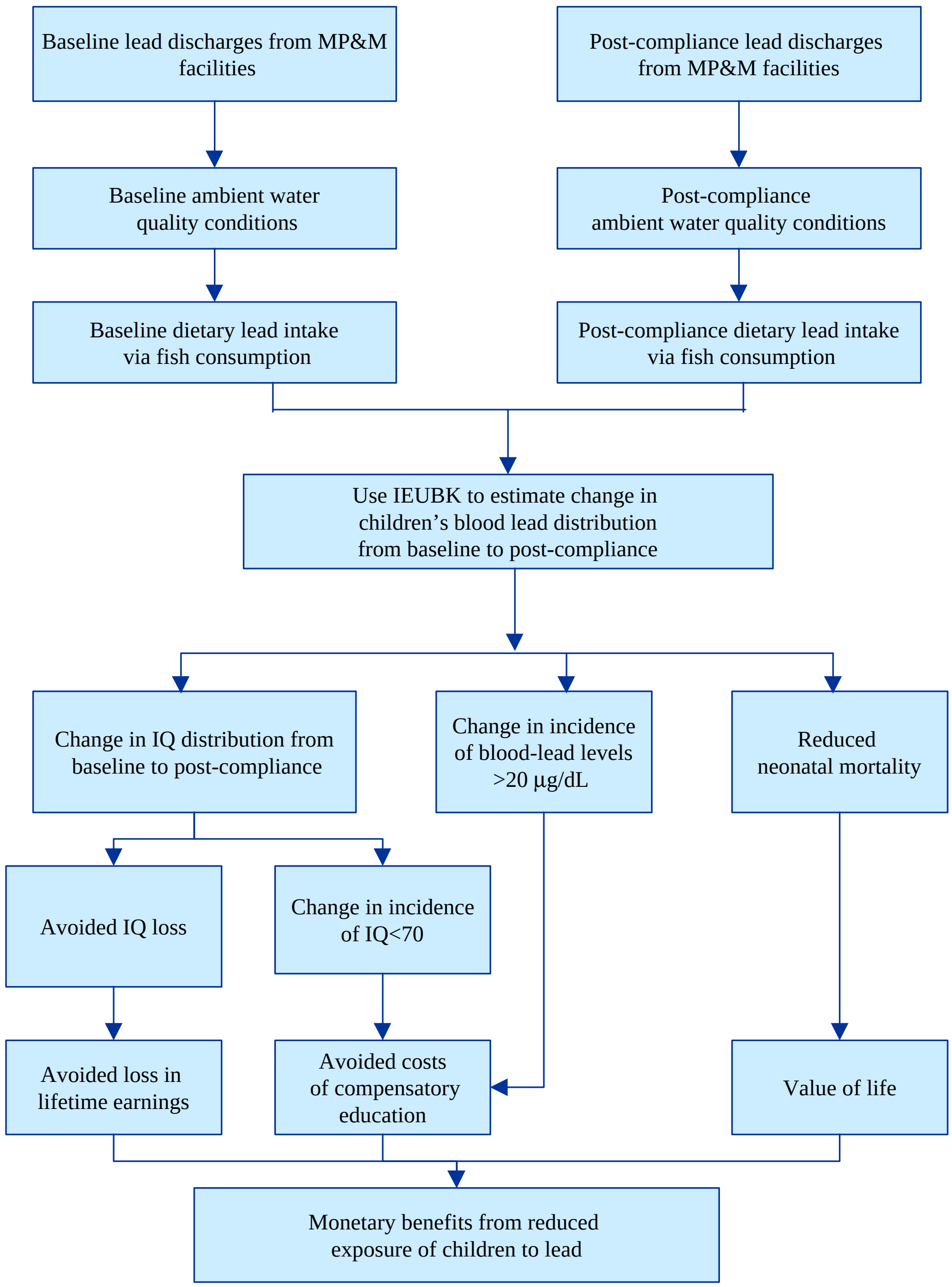
- Estimate the baseline and post-compliance lead discharges from MP&M facilities;
- Estimate lead concentrations in receiving water bodies before and after proposed effluent guidelines based on lead discharge estimates, effluent flow, characteristics of the receiving POTWs, and characteristics of receiving water bodies;
- Estimate the baseline and post-compliance dietary lead intake of children via fish consumption;
- Estimate PbB levels of exposed children before and after the proposed regulation, based on in-stream lead concentrations, bioaccumulation factors, and fish consumption rates for children;
- Assess changes in health impacts to children from reduced lead exposure, including changes in IQ loss, changes in incidence of IQ<70, and changes in neonatal mortality.
- Estimate monetary benefits resulting from reduced adverse health impacts to children;
- Estimate benefits from changes in neonatal mortality from reduced maternal exposure to lead.

Figure 14.1 depicts the above steps.

[4] This analysis does not consider the beneficial effects due to reduced drinking water exposure. EPA has issued drinking water criteria for lead. This analysis assumes drinking water treatment has already reduced lead content below threshold levels.

[5] PbB concentration is the most common measure of body-lead burden. Other measures of body-lead burden include lead in bones, teeth, and hair.

Figure 14.1 Assessing Benefits to Children from Reduced Lead Discharges from MP&M Facilities



Source: U.S. EPA analysis.

The following sections summarize the relevant dose-response relationships for children, and discuss data sources used for the dose-response relationships. Each section also includes the methods used to value the changes in health effects based upon dose-response relationships.

14.2.1 PbB Distribution of Exposed Children

This section describes the estimation of changes in PbB distribution of exposed children.

a. Estimating lead concentrations in the receiving water bodies

Estimating health risks associated with lead exposure from fish consumption requires calculating in-waterway lead concentrations. The method and formulas for this calculation were identical to those described for the analysis of cancer effects for the fish consumption pathway (see Chapter 13 on Human Health Benefits and the Environmental Assessment in Appendix E for details.)[6]

b. Estimating PbB levels in exposed children

This analysis considers children that are born today and live in recreational and subsistence fishermen households. The analysis considers a continuous exposure pattern for children from birth through the sixth birthday. Exposure, health effects, and benefits are calculated separately for children living in recreational and subsistence fishing households. This analysis relies on EPA's ***Integrated Exposure, Uptake, and Biokinetics* (IEUBK)** Model for Lead in Children.

❖ *Description of the IEUBK model*

The IEUBK model uses exposure, uptake, and biokinetic response information to estimate the PbB level distribution for a population of children receiving similar exposures. The estimated distribution may be used to predict the probability of elevated PbB levels in children exposed to a specific combination of environmental-lead levels. The model addresses four components of environmental risk assessment:

- the multimedia nature of exposure to lead;
- the differential ***bioavailability*** of various sources of lead;
- the ***pharmacokinetics*** of internal distribution of lead to bone, blood, and other tissues; and
- inter-individual variability in PbB levels.

The model uses estimated or measured lead concentrations in fish tissues and other media, such as soil, dust, air, and water, to estimate a continuous exposure pattern for children from birth through the sixth birthday (U.S. EPA, 1995). The model then estimates a distribution of PbB levels for a population of children receiving similar exposures by predicting its ***geometric mean* (GM)**. The inter-individual and biological variability in PbB levels of children exposed to similar environmental lead levels is represented by the ***geometric standard deviation* (GSD)**. This analysis uses an empirical estimate of the variability in PbB concentrations, a GSD of 1.6, estimated from residential community PbB studies (U.S. EPA, 1995). This estimate is applied for predictions of the national distribution of PbB concentrations.

The model has three distinct functional components that work together in a series:

- exposure,
- uptake, and
- ***biokinetics*** response.

Each model component is a set of complex equations and parameters. The Technical Support Document (U.S. EPA, 1995) provides the scientific basis of the parameters and equations used in the model, while the Guidance Manual (U.S. EPA, 1994) includes a detailed description of the exposure pathways, absorption mechanism, biokinetic compartments, and associated comparted transfers of lead.

❖ *Inputs to the IEUBK model*

The IEUBK model uses three sets of parameters:

- exposure parameters estimate the amount of environmental lead taken into the body, through breathing or ingestion;
- uptake parameters estimate the amount of lead absorbed from environmental sources;
- biokinetic parameters characterize the transfer of lead between compartments of the body (e.g., between blood and bone) and elimination of lead from the body.

The IEUBK model allows the user to input values for most exposure and uptake parameters. The biokinetic parameter values cannot be altered. When exposure and uptake values are not specified, the IEUBK model provides default values. Table 14.2 summarizes exposure parameters used in this analysis.

[6] The water quality model used for the Ohio case study is discussed in Appendix G.

1. Exposure parameters include exposure concentrations and exposure rates:

   - Exposure concentrations: EPA used estimated in-stream concentrations of lead to calculate lead concentration of the dietary (i.e., fish consumption) exposure pathway. The Agency used 1996 monitoring data on lead concentrations in air, dust, and soil to characterize lead exposure concentrations for pathways other than fish consumption.[7] This analysis uses median concentration values for these three pathways as inputs to the IEUBK to characterize background exposure to environmental lead. EPA used the IEUBK default value for lead concentration in drinking water that takes into account contributions of lead from plumbing. Because of past use of lead in plumbing, lead concentrations in tap water are likely to be above the current water quality standard for lead in drinking water.

   - Exposure rates: Children in recreational fishing households are assumed to consume 14.97 grams of fish per day. Children living in subsistence households are assumed to consume 77.95 grams of fish per day. These fish consumption data are based on uncooked fish weights and use data on individuals younger than 14 years of age (U.S. EPA, 1998d). The Agency used the IEUBK default values to characterize exposure rates for pathways other than fish consumption.

2. Uptake of ingested lead: Lead bioavailability varies across the chemical forms in which lead can exist. Many factors complicate the estimation of bioavailability, including nutritional status and timing of meals relative to lead intake. The Agency used the default media-specific bioavailabilities in the IEUBK model for this analysis.

3. Biokinetic parameters: The data on which these parameter values are based originate from a variety of sources, including available clinical data (U.S. EPA, 1995). These parameters cannot be changed by the user.

[7] EPA found that the typical PbB level distribution predicted in the IEUBK Model for Lead in Children based on the default values for air, dust, soil, and drinking water lead concentrations did not correspond to the most recent national population PbB distribution (NHANES III, Phase 2, 1994). Therefore, the Agency used more recent data to characterize the background exposure to environmental lead. Median values from recent monitoring data allowed the Agency to match the IEUBK-predicted PbB distribution to the NHANES-derived distribution.

Table 14.2: Summary of Exposure Concentrations Used in the IEUBK Model

Medium	Exposure Concentrations	Comments
Air - indoor - outdoor	 0.025 µg/m^3 30% of outdoor value	Median value from 1996 air monitoring data IEUBK default value
Water	4 µg/L	IEUBK default value
Soil	61.78 µg/g	Median value from Housing and Urban Development national survey (U.S. Department of Housing and Urban Development, 1995)
Dust	181.11 µg/g	Median value from Housing and Urban Development national survey (U.S. Department of Housing and Urban Development, 1995)
Fish tissue	site-specific	Estimated based on predicted lead concentrations in the receiving reaches and the bioconcentration factor for lead (49 L/kg)

Source: U.S. EPA analysis.

c. Estimating changes in the PbB level in exposed children from reduced MP&M discharges

EPA used the IEUBK model in this analysis to estimate the effect of lead-contaminated fish consumption on children's PbB concentrations. The Agency first calculated lead concentration in fish tissue corresponding to each reach affected by MP&M discharges to provide inputs to the IEUBK model. The model uses the specified fish tissue concentrations in conjunction with fish ingestion rates and bioavailability factors to determine the dose of lead absorbed by the body. This dose is then used to predict the GM PbB concentration for children associated with each reach affected by lead discharges from the MP&M facilities.

EPA used the IEUBK model to predict the baseline and post-compliance PbB distributions for children that consume fish from reaches affected by lead discharges from MP&M facilities. The difference between the estimated baseline and post-compliance PbB distribution is the basis for the analysis of benefits to children from the MP&M regulation.

14.2.2 Relationship Between PbB Levels and IQ

A dose-response relationship between PbB and IQ decrements determined by Schwartz (1994) suggests that a decrease of 0.25 IQ points can be expected for every 1 µg/dL increase in PbB(Schwartz, 1994). The ***p-value*** (< 0.0001) indicates that this relationship is highly significant.

EPA multiplied the 0.25 IQ points lost per µg/dL increase in PbB by the average increase in PbB level for children and by the number of exposed children to obtain the total change in number of IQ points for the population. The average PbB level modeled in this analysis is a GM, not the ***arithmetic mean*** used by Schwartz (1993). To adjust for this difference, equation 14.1 uses a ratio between the arithmetic mean and the GM of a ***lognormally-distributed random variable***. The ratio between the expected value (mean) of the distribution and the GM is 1.117 for the assumed GSD of children's PbB levels (1.6).

The total avoided loss of IQ points for each group is estimated as:

$$\begin{aligned}&(AVOIDED\ \ LOSS\ \ of\ \ IQ\ \ POINTS)_k\\&= \Delta GM_k \times .25 \times (Pop_k)\ /6\end{aligned} \qquad (14.1)$$

where:

$(Pop)_k$ = the number of children (up to age six) in anglers' families in the vicinity of a given MP&M reach; and

GM_k = the GM of the PbB distribution in the population of children.

As shown in equation 14.1, the population of children up to age six is divided by six to avoid double-counting. The IEUBK model calculates the GM of the PbB distribution in the population of children born today, assuming a continuous exposure pattern for children from birth through the sixth birthday. Assuming that children are evenly distributed by age, this division adjusts this equation to apply only to children age 0-1. Dividing by six undercounts overall benefits. Children from age 1 to 6 are not accounted for in the base year of the analysis, although they are presumably affected by the lead exposure, because the IEUBK model assumes a continuos exposure pattern for children from birth trough the sixth birthday.

14.2.3 Value of Children's Intelligence

Available economic research provides little empirical data on society's overall WTP to avoid a decrease in an infant's IQ. This analysis uses research that monetizes a subset of effects associated with decreased IQ. These effects represent only some components of society's WTP to avoid

IQ decreases, and underestimate society's WTP when employed alone. For the purpose of this analysis, these effects are the only ones available at this time to approximate the WTP to avoid IQ decrements.

Recent studies provide concrete evidence of long-term effects from childhood lead exposure. This analysis assumes a permanent loss of IQ points based on PbB levels estimated for children up to age six, and considers two consequences of this IQ decrement:

- the decreased present value of the infant's expected lifetime earnings, and
- the increased educational resources expended for an infant who becomes mentally handicapped or needs compensatory education as a consequence of lead exposure.

a. Estimating the effect of IQ on earnings

Reduced IQ has direct and indirect effects on earnings. This analysis models the overall impact from a one-point reduction in IQ as the sum of these direct and indirect effects on lifetime earnings. EPA used the most recent estimates of the effects of IQ on earnings based on Salkever (1995).[8] Salkever provided updated estimates of the direct and indirect effects of IQ loss on earnings, using the most recent available data set, the National Longitudinal Survey of Youth **(NLSY)**. Salkever used ***regression analysis*** techniques to estimate direct and indirect effects of IQ on earnings. Three different relationships are estimated separately for male and female respondents:

- A ***least-squares regression*** of highest grade on IQ test scores;
- A ***probit regression*** of an 0-1 indicator of positive earnings on highest grade and IQ test scores;
- A least-squares regression, for persons with positive earnings, of the logarithm of earnings on highest grade and IQ test scores.

Other variables were included in each regression to control for effects of family background (parents' education and income), the age of the respondent, ethnic group, and residence location (urban U.S., non-urban U.S., south versus non-south).

[8] EPA did not incorporate earlier studies of the effects of IQ on earnings in this analysis, because the labor market has undergone many changes over the quarter-century in which earlier studies have appeared

Based on the regression results, Salkever estimated the effects of IQ on earnings as the sum of direct and indirect effects:

- The direct effect is the sum of effects of IQ test scores on employment and earnings for employed persons, holding the years of schooling constant.
- The indirect effect is the sum of effects of IQ test scores on years of schooling attained, and the subsequent effect of years of schooling on the probability of employment and on earnings for employed persons.

The analysis found that percentage effects of lead exposure are greater for females than for males. The total estimated effect of the loss of an IQ point on earnings, based on the Salkever study, is an earnings reduction of 2.094 percent for men and 3.631 percent for women. This analysis uses a workforce participation-weighted average of 2.626 percent. The total effect of the loss of an IQ point on earnings also includes non-IQ effects on schooling (e.g., behavioral problems).

b. Valuing foregone earnings

EPA monetized IQ loss effects by combining the percent earnings loss estimate with an estimate of the present value of expected lifetime earnings. EPA used the 1992 data on money income for the U.S. population (U.S. Department of Commerce, 1993) to calculate the mean present value of lifetime earnings of a person born today. The data included earnings for employed persons and employment rates as a function of educational attainment, age, and gender. The following assumptions were used to calculate the mean present value of lifetime earnings of a person born today:

- The distribution of earnings for employed persons and labor force participation rates remains constant over time,
- A person earns income from age 18 through age 67,
- Real wages grow one percent per year, and
- Future earnings are discounted at a three percent annual rate.

The money income data (U.S. Department of Commerce, 1993) form the best available basis for projecting lifetime earnings, but involve some uncertainties. Labor force participation rates of women, the elderly, and other groups will likely continue to change. Currently, men tend to earn more than women due to higher wage rates and higher labor force participation. Expected lifetime earnings increase with education for both men and women. Real earnings of women will probably continue to rise relative to real earnings of men. Educational attainment has risen over time and may continue to rise. Unpredictable fluctuations in the economy's growth rate will probably affect labor force participation rates and real wage growth for all groups. Medical advances that increase life expectancy will probably increase lifetime earnings.

Although earnings data alone form an incomplete measure of an individual's value to society, this analysis does not account for those individuals who do not participate in the labor force at all throughout their working years and whose productive services are not measured by wage rates. The largest group in this population are those who remain at home doing housework and child rearing. Volunteer work also contributes significantly to social welfare, and volunteerism rates tend to increase with educational attainment and income. Assuming that the ***opportunity cost*** of non-wage-compensated work equals the average wage earned by persons of the same sex, age, and education, the average lifetime earnings estimates would be significantly higher. Recalculating the tables using full employment rates for all age, sex, and education groups would provide higher lifetime earnings estimates. To be conservative, this analysis considered only the value of lost wages and does not include the opportunity cost of non-wage-compensated work.

The adjusted value of expected lifetime earnings equals the present value for an individual entering the labor force at age 18 and working until age 67. Given a three percent social discount rate, the other assumptions mentioned, and current survival probabilities, the present value of lifetime earnings of a person born today in the U.S. would be $428,115 (1999$).

c. Valuing costs of education

The increase in lifetime earnings from additional education equals the gross return on education. The cost of education is subtracted from the gross return to obtain the net increase in earnings from additional education. The cost of education has two components: the direct cost of the education, and the opportunity cost of lost income during the education. The ***marginal cost*** of education used in this analysis was assumed to be $8,036 (1999$) per year. This figure was derived from the U.S. Department of Education's reported ($6,961) average per-student annual expenditure (current plus capital expenditures) in public primary and secondary schools in 1995-96 (U.S. Department of Education, 1998). EPA adjusted this value to 1999 dollars based on CPI for education.

Salkever's study found the estimated effect of IQ on educational attainment to be 0.1007 years per IQ point. The estimated cost of an additional 0.1007 years of education per IQ point is $809 (i.e., 0.1007 × $8,036). This marginal cost was discounted to the time the exposure and damage is modeled to occur (age zero) because this cost is incurred after the completion of formal education. The average level of educational attainment in the population over age 25 is 12.9 years. The marginal educational cost was therefore assumed to occur at age 19, resulting in a discounted present value cost of $461 (1999$).

The other component of the cost of education is the opportunity cost of lost income while in school. Income loss is frequently cited as a major factor in the decision to terminate education, and must be subtracted from the gross returns to education. An estimate of the lost income was derived assuming that people in school are employed part-time but that people out of school are employed full-time. The opportunity cost of lost income is the difference between full-time and part-time earnings. The value of lost income associated with being in school an additional 0.1007 years is $713 (1999$) discounted to age zero.

d. Estimating the total effect of IQ on earnings.

Combining the value of lifetime earnings ($428,115) with the estimate of percent wage loss per IQ point yielded $11,251 per IQ point. Subtracting the education and opportunity costs reduced this value to $ 10,077 per IQ point (1999$).

14.2.4 Value of Additional Educational Resources

Children with IQ less than 70 and whose PbB is greater than 20 µg/dL will require additional educational resources including an educational program tailored to the mentally handicapped. Some children whose PbB is greater than 20 µg/dL will need additional instruction while attending school later in life. The following sections describe approaches used to quantify the number of children with IQs less than 70 and to estimate increased educational costs resulting from lead exposure.

a. Children with IQs less than 70

❖ ***Quantifying the number of children with IQs less than 70***

Increases in the mean PbB levels of children results in an increased incidence of children with very low IQ scores. IQ scores are normalized to have a mean of 100 and a standard deviation of 15. An IQ score of 70 is two standard deviations below the mean, and is generally regarded as the point below which children require significant special compensatory education tailored to the mentally handicapped.

The relationship presented here for estimating changes in the incidence of IQ less than 70 used the most current IQ point decrement function provided by Schwartz (1993). It assumed that, for a baseline children's PbB distribution (defined by GM and GSD), the population also has a normalized IQ point distribution with a mean of 100 and a standard deviation of 15. The proportion of the population expected to have IQ less than 70 was determined from the standard normal distribution function for this baseline condition:

$$P(IQ<70)=\Phi(z) \qquad (14.2)$$

where:

P(IQ <70) = probability of IQ scores less than 70

z = standard normal variate (i.e., the number of standard deviations); computed for an IQ score of 70, with mean IQ score of 100 and standard deviation of 15 as:

$$Z=\frac{70-100}{15}=-2 \qquad (14.3)$$

Φ(z) = standard normal distribution function:

$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{z} e^{-\frac{u^2}{2}}du \qquad (14.4)$$

The integral in the standard normal distribution function does not have a closed form solution. Values for Φ(z) are usually obtained using software with basic statistical functions or from tables typically provided in statistics texts. The solution for Φ(z) where z = -2 is 0.02275. That is, for the normalized IQ score distribution with a mean of 100 and standard deviation of 15, approximately 2.3 percent of children are expected to have IQ scores below 70.

EPA made two key assumptions to relate changes in the proportion of children with IQ scores below 70 to changes in population mean PbB levels:

1. The mean IQ score will change as a result of changes in the mean PbB level as:

$$\triangle\ Mean\ IQ = -0.25\ x\ \triangle\ Mean\ PbB \qquad (14.5)$$

where:

$\triangle$ *Mean IQ* = the change in the mean IQ score between the baseline and post-compliance scenarios, and

$\triangle$ *Mean PbB* = the change in the mean PbB level between the two scenarios.

This relationship relies on Schwartz' estimate (1993) of a decrease of 0.25 IQ points for each µg/dL increase in PbB. The mean PbB level referred to here is the arithmetic mean (or expected value) for the distribution, obtained as described previously from the GM and GSD.

2. The standard deviation for the IQ distribution is 15 for both the baseline and the post-compliance scenario.

Using these assumptions, EPA determined the change in the probability of children having IQ less than 70 for a given change in mean PbB from:

$$\Delta P(IQ<70)=\Phi(z_{Bl})-\Phi(z_{Pc}) \\ =\Phi(z_{Bl})-0.02275 \qquad (14.6)$$

where:

$\Phi(z_{Bl})$ = baseline standard normal distribution function,

$\Phi(z_{Pc})$ = post-compliance standard normal distribution function.

$$z_{Bl}=\frac{70-(100+0.25\times\Delta Mean\,PbB)}{15} \qquad (14.7)$$

EPA then converted a given change in the mean PbB level between the baseline and post-compliance scenarios into a measure of IQ. The procedure above yielded an estimate of the percent of the population with IQs less than 70. EPA multiplied this percent by the population of exposed children to estimate the increased incidence of children with low IQs. As in the IQ point loss equation, EPA applied the results of this function to children age 0-6 and divided by six to avoid double counting. (See discussion under equation 14.1.)

This procedure quantified only the change in the number of children who pass below the 70 point IQ threshold. EPA quantified other changes in children's IQ using the IQ point loss function (Equation 14.1) described previously. Treating these two endpoints additively does not result in double counting, because the value associated with the IQ point loss function is the change in individual lifetime earnings, while the value associated with IQs less than 70 is the increased educational costs for the individual, as discussed below.

❖ *Valuing educational costs*

EPA estimated the number of avoided cases of children with IQ less than 70. Compensatory education expenses will no longer be incurred for these cases. Kakalik et al. (1981), using data from a study prepared for the Department of Education's Office of Special Education Programs, estimated part-time special education costs for children who remained in regular classrooms at $3,064 extra per child per year in 1978. Adjusting for changes in the ***GDP price deflator*** yielded an estimate of $8,036 per child in 1999 dollars. EPA used the incremental estimate of the cost of part-time special education to estimate the annual cost per child needing special education as a result of lead impacts on mental development. EPA assumed that compensatory education begins at age six and continues through age 18 (grades one through twelve). ***Discounting*** future expenses at a rate of three percent yielded an expected present value cost of approximately $72,664 per child ($1999). This discounting underestimates the cost because Kakalik et al. measured the increased cost to educate children attending regular school rather than a special education program. The costs of attending a special education program are likely to be much higher than those associated with regular schooling. In addition, some compensatory education programs begin earlier than at age six. For example, some states, such as Connecticut and Rhode Island, offer Head Start programs to disadvantaged children beginning at age three.

b. Children with PbB levels greater than 20 μg/dL

❖ ***Quantifying the number of children with PbB levels greater than 20 μg/dL***

EPA obtained the percentage of children with PbB levels greater than 20 μg/dL directly from the estimated distribution of PbB levels for a given location (IEUBK). EPA then multiplied this percentage by the number of exposed children in the vicinity of a given MP&M reach to estimate the number of children with PbB levels greater than 20 μg/dL.[9]

❖ ***Estimating and valuing compensatory education for children with PbB levels greater than 20 μg/dL***

EPA assumed that 20 percent of the children with PbB levels greater than 20 μg/dL would require and receive compensatory education for three years. After this time, no further educational expenditures are incurred by those children. These assumptions are conservative. Many studies show adverse cognitive effects at PbB levels at 15 μg/dL. Some studies of the persistence of cognitive effects indicate that the effects often last longer than three years.

The Kakalik et al. (1981) estimate of part-time special education costs for children who remained in regular classrooms can be used to estimate the cost of compensatory education for children suffering low-level cognitive damage. As indicated above, the part-time special education cost per child is $8,036 per year in 1999 dollars. The Agency assumes that compensatory education starts at age 6 and continues for 3 years. Discounting future costs at a rate of 3 percent annually to account for the age at which costs are incurred (i.e., age 6 through 8) yields a present value estimate of $20,649 in 1999 dollars.

[9] See Section 13.1.1 for detail on estimating the affected population. The percentage of children in the affected population is estimated based on the Census data.

14.2.5 Changes in Neonatal Mortality

a. Quantifying the relationship between maternal PbB levels and neonatal mortality

U.S. EPA (1990b) cites a number of studies linking fetal exposure to lead (via *in utero* exposure from maternal lead intake) to several adverse health effects. These effects include decreased gestational age (i.e., premature birth), reduced birth weight, late fetal death, and increases in infant mortality.

The CDC (CDC, 1991a) developed a method to estimate changes in infant mortality due to changes in maternal PbB levels during pregnancy. The analysis linked the following two relationships:

- Gestational age as a function of maternal PbB (Dietrich et al., 1987), and
- Infant mortality as a function of gestational age. This is performed using data from the Linked Birth and Infant Death Record Project from the National Center for Health Statistics (CDC, 1991a).

Combining the two relationships provided a decreased risk of infant mortality of 10^{-4} (or 0.0001) for each 1 μg/dL decrease in maternal PbB level during pregnancy. EPA used this relationship for its analysis of maternal PbB levels and neonatal mortality.

b. Valuing changes in neonatal mortality

This analysis used the estimated WTP for avoiding a mortality event to estimate the monetary benefit associated with reducing risks of neonatal mortality. This analysis uses the $5.8 million (1997$) estimate of the value of a statistical life saved recommended in the *Draft Guidelines for Preparing Economic Analysis* (EPA, 1999b). For detail on valuing reduced mortality risks see Section 13.2.1.

14.3 Adult Health Benefits

Lead exposure has been shown to have adverse effects on the health of adults as well as children. The quantified adult health effects included in the benefits analysis all relate to lead's effects on BP.[10] The estimated relationships between these health effects and lead exposure differ between men and women. Quantified health effects include increased incidence of hypertension (estimated for males only), initial

[10] Citing laboratory studies with rodents, U.S. EPA (1990) also presents evidence of the genotoxicity and/or carcinogenicity of lead compounds. The animal toxicological evidence suggests that human cancer effects are possible, but dose-response relationships are not currently available.

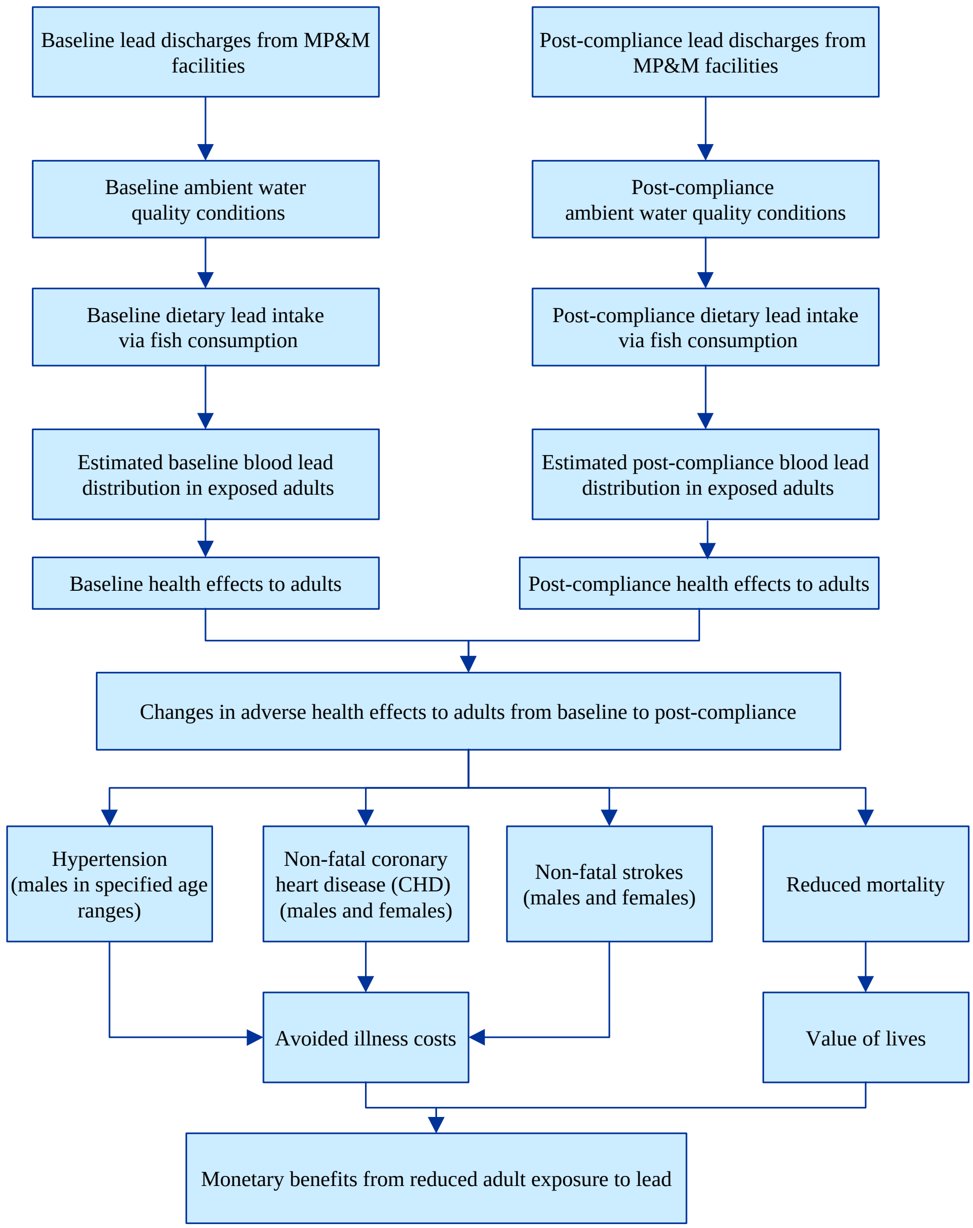
CHD, strokes (initial CBA and BI), and premature mortality. This analysis does not include other health effects associated with elevated BP, and other adult health effects of lead including neurobehavioral and possible cancer effects.

Estimating adult health benefits from reduced exposure to lead requires analytic steps similar to those used in estimating children's health benefits. These steps are:

- Estimate in-stream lead concentrations in the reaches affected by MP&M discharges;
- Estimate baseline and post-compliance adult dietary lead intake via fish consumption. The analysis of adult health benefits from reduced exposure to lead via contaminated fish uses the results from water quality modeling efforts described in Appendix E;
- Estimate changes in the PbB level distribution in the affected adult population;
- Estimate changes in health status in the affected population of adult men, and the monetary value of health benefits from reduced lead discharges from MP&M facilities; and
- Estimate changes in health status in the affected population of adult women, and the monetary value of health benefits from reduced lead discharges from MP&M facilities.

Figure 14.2 depicts the above steps. Table 14.3 summarizes per-case costs of lead-related illnesses.

Figure 14.2 Assessing Benefits to Adults from Reduced Lead Discharges from MP&M Facilities



Source: U.S. EPA analysis.

Table 14.3: Per-Case Costs of Lead-Related Illnesses

Illness	Gender	Cost per Case (1999$)	Cost Description
Hypertension	Male	$1,048	The cost estimates were derived by taking Krupnick et al.'s average annual per-person costs of hypertension (Krupnick et al., 1989).
	Female	$1,048	
CHD #1[a]	Male	$70,240	The costs were estimated (Wittels et al., 1990) for three CHDs (acute myocardial infarction, uncomplicated ***angina pectoris***, and unstable angina pectoris) for 5 years post-diagnosis using a three percent discount rate. The probability of medical service was multiplied by the estimated price of the service and the average cost for the three CHD types was determined. Since the effect of elevated PbB on CHD incidence rates is beyond the scope of this analysis, weighting factors were not used to account for the different probabilities of contracting the three types of CHD.
	Female	$70,240	
Stroke[a]	Male	$262,379	The cost estimates (Taylor et al., 1996) represent the expected lifetime cost of a stroke for males and females age 45-74, including the present discounted value of the stream of medical expenditures and the stream of lost earnings. Note that the study used a five percent discount rate. EPA did not adjust this value to reflect a 3 percent discount rate used elsewhere in this analysis.
	Female	$196,783	
Low Birth Weight[b]	Female	$82,219	The cost estimate was extrapolated from direct costs for LBW taken from Lewitt et al., using a three percent discount rate (Lewitt et al., 1995). The value includes medical, special education, and grade repetition costs.
Death -- Any Illness [b]	Male	$5.8 Million	A range of values taken from hedonic wage studies and/or contingent valuation studies of primarily middle aged adults was used to determine the cost of death (see Chapter 13 for detail).
	Female	$5.8 Million	

a. Costs were taken from U.S. EPA, 1999a.
b. The value of a statistical life saved is given in 1997$ (U.S. EPA, 1999b). This underestimates benefits from the proposed regulation. The benefits analysis for promulgation of the MP&M regulation will adjust this value to 1999$.
c. Note that this analysis does not estimate occurrence of low birth weight cases, due to data limitations.
Source: U.S. EPA, 1999a.

14.3.1 Estimating Changes in Adult PbB Distribution Levels

a. Estimating values of PbB concentrations in exposed adults

EPA adapted the methodology described in the Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil (hereafter, Interim Guidance) to estimate changes in the distribution of PbB levels in exposed adults from reduced MP&M discharges (U.S. EPA, 1996). The methodology presented in the Interim Guidance report used a simplified representation of lead biokinetics to predict quasi-steady-state PbB concentrations among adults who have relatively steady patterns of exposures to lead. This methodology is recommended by the ***Technical Review Workgroup* (TRW)** to assess the effects of ingesting lead-contaminated soil on PbB levels of women of childbearing age, to derive ***risk-based remediation goals* (RBRG)** protective of the developing fetus in exposed adult women.[11] The Interim Guidance describes the basic algorithms to be used in the analysis and provides a set of default parameters that can be used in cases where site-specific data are not available. The TRW points out that this methodology is an interim approach recommended for use pending further development and evaluation of integrated exposure biokinetic models for adults.

The dose-response relationship recommended in the Interim Guidance for exposures to lead-contaminated soil can be modified to analyze PbB levels in recreational and subsistence anglers exposed to lead-contaminated fish tissue. In both cases, the exposure pathways involve ingestion. The Interim Guidance differs from this analysis mainly in the medium containing lead (soil versus fish tissue). Substituting ingestion of lead in fish for ingestion of lead in soil yields the following equation:

[11] EPA's TRW for lead began considering methodologies to evaluate nonresidential adult exposure to lead in 1994. A TRW committee on adult lead risk assessment formed in January 1996 to develop a generic methodology that could be adapted for use in site-specific assessments of adult health risks.

$$PbB\ adult,\ central = PbB_{adult,0} + \frac{PbW \times BCF \times IN_F \times AF_F \times BKSF \times EF \times CF}{AT} \quad (14.8)$$

where:

- $PbB_{adult,\ central}$ = ***central tendency estimate*** of PbB concentrations (µg/dL) in adults exposed to lead in fish at a concentration of PbW;
- $PbB_{adult,\ 0}$ = typical PbB concentration (µg/dL) in adults in the absence of exposures via fish consumption;
- PbW = in-stream lead concentrations (µg/L);
- BCF = bioconcentration factor of lead in fish tissue (L/kg);
- BKSF = biokinetic slope factor relating (***quasi-steady state***) increases in typical adult PbB concentrations to average daily lead uptake (µg/dL PbB increase per mg/day lead uptake);
- IN_F = average daily fish consumption (g/day);
- AF_F = absolute gastrointestinal ***absorption fraction*** for ingested lead in fish tissue (dimensionless);
- EF = exposure frequency for ingestion of contaminated fish (days of exposure during the averaging period); may be taken as days per year for continuing, long-term exposure;
- AT = averaging time, the total period during which fish consumption may occur; 365 days/year for continuing long-term exposure; and
- CF = conversion factor (10^{-3} kg/g).

Equation 14.8 is recommended for females aged 17 to 45 (U.S. EPA, 1996). Studies of adult males, however, provided many of the parameters used in the Interim Guidance. Thus, EPA judged that this model can be applicable to all adults. Table 14.4 summarizes values for the model parameters.

Table 14.4: Summary of Parameter Values for Estimating PbB Levels in Adults

Parameter	Unit	Value		Comment
$PbB_{adult,0}$	µg/dL	4.55-3.45		Male adult PbB levels based on NHANES III Phase 2. Female adult PbB levels based on NHANES III Phase 2 (U.S. EPA, 1996).
BKSF	µg/dL per µg/day	0.4		Based on analysis of Pocock et al. (1983) and Sherlock et al. (1984) data.
INF(females)	g/day			Daily fish consumption; lower value (on left) for recreational anglers and higher value (on right) for subsistence anglers (U.S. EPA, 1998d).
Age 15 - 44		7.36	109.72	
Age ≥ 45		17.78	108.80	
INF (males):				
Age 15-44		15.57	150.20	
Age ≥ 45		32.47	165.92	
EF	day/yr	365		Days per year for continual long-term exposure.
BCF	L/kg	49		Bioconcentration factor of lead in fish tissue.
AF_F	dimen-sionless	0.03		Absolute gastrointestinal absorption fraction for ingested lead in fish tissue. Based on Maddaloni (1998).

For detailed information on the sources of the parameters and uncertainties associated with their use, see U.S. EPA, 1996.
Source: U.S. EPA analysis.

❖ ***Typical adult PbB concentrations at baseline***

Previous research suggests males have a higher background PbB level (TRW, 1996). This analysis uses population-specific typical concentrations to account for differences in background lead exposure between genders and between two socioeconomic subgroups considered in the analysis (i.e., recreational and subsistence fishermen). EPA used data for adult males and females from NHANES III to characterize the baseline distribution of PbB concentrations in the relevant subpopulations for each MP&M reach and affected population. The baseline PbB distribution scenario reflects site-specific population characteristics because baseline PbB levels differ across ethnic, income, and urban status groups.

❖ ***Bioavailability of lead from fish tissue***

To identify lead bioavailability in fish tissue, EPA reviewed lead absorption data from various materials reported in the lead toxicity summary document: *Toxicity Profile for Lead* (ATSDR, 1997). EPA also reviewed *Measurement of Soil-Borne Lead Bioavailability in Human Adults, and its Application to Biokinetic Modeling* (Maddaloni, 1998) and consulted with the study author (March, 2000). Numerous studies have found that lead ingested with food is absorbed at a significantly lower rate than lead ingested after fasting. The Interim Guidance reports this dynamic and notes that "the bioavailability of ingested soluble lead in adults varies from less than 10 percent when ingested with a meal to between 60 and 80 percent when ingested after a fast" (TRW, 1996). TRW uses a 20 percent lead bioavailability factor for soil. This factor is based on lead consumption interspersed with and between meals throughout the day, and is therefore likely to overestimate PbB levels in adults exposed to lead-contaminated fish. In the absence of data on lead incorporated into food, however, EPA considered this to be the most appropriate data to use in estimating absorption.

In the most recent study reviewed for this analysis (Maddaloni, 1998), non-fasted subjects showed a mean percent absorption of 2.52 with a range of 0.2 to 5.2 percent and a confidence value of 0.66). The male and female study subjects had normal clinical chemistry parameters and were between 21 and 40 years of age. The study used soil as the dosing vehicle. Other studies have used water as the dosing vehicle, but soil is considered to be more similar to fish consumption.

EPA selected an absorption value of 3 percent for lead ingested in fish tissue, based on Maddaloni's results. The value of 3 percent provides a reasonable estimate for most adults. This analysis does not address individuals who may have higher lead absorption, or be at elevated risk due to lead exposure. These individuals include pregnant women, who have higher calcium requirements (and are therefore more likely to be calcium-deficient), people with poor nutritional status (including iron and calcium deficiencies), and individuals with other metabolic disorders. By evaluating subsistence and recreational anglers, the analysis is already focusing on subpopulations at higher risk than the average population. To maintain an approach that represents likely exposures, intakes, and risks, EPA chose not to consider individuals at unusually high risk within an already-high risk subpopulation.

14.3.2 Men Health Benefits

This section describes the health effects of reduced lead exposure that this analysis has quantified for men; the next section presents a similar discussion for women.

a. Hypertension

❖ ***Quantifying the relationship between PbB levels and hypertension***

Studies have linked elevated PbB to elevated BP in adult males, especially men aged 40 to 59 (Pirkle et al., 1985). Further studies have demonstrated a dose-response relationship for hypertension (defined as diastolic BP above 90 mm Hg for this model) in males aged 20 to 74 (Schwartz, 1988). This relationship is:

$$\Delta Pr(HYP) = \frac{1}{1 + e^{2.744 - .793*(\ln PbB_1)}} - \frac{1}{1 + e^{2.744 - 0.793*(\ln PbB_2)}} \qquad (14.9)$$

where:

ΔPr(HYP)	=	the change in the probability of hypertension,
e	=	base of the natural logarithm (2.76)
PbB_1	=	PbB level in the baseline scenario, and
PbB_2	=	PbB level in the post-compliance scenario.

❖ ***Valuing reductions in hypertension***

The best measure of the social costs of hypertension, society's WTP to avoid the condition, cannot be quantified without basic research that is well beyond the scope of this project. Ideally, the measure would include all the medical costs associated with treating hypertension, the individual's WTP to avoid the worry that hypertension could lead to a stroke or CHD, and the individual's WTP to avoid the behavioral changes required to reduce the probability that hypertension leads to a stroke or CHD.

This analysis used recent research results to quantify two benefit category components: medical costs and lost work time. Krupnick and Cropper (1989) estimated the medical costs of hypertension, using data from the National Medical Care Expenditure Survey (Krupnick and Cropper, 1989). Medical costs include expenditures for physician care, drugs, and hospitalization. In addition, hypertensives have more bed disability days and work-loss days than non-hypertensives of comparable age and sex. Krupnick and Cropper estimated the increase in work-loss days at 0.8 per year. Valuing this estimate at the estimated mean daily wage rate and adjusting the costs to 1999 dollars yields an estimate of the annual cost of each case of hypertension of $1,048.

The benefits estimate in this analysis likely underestimates the true social benefit of avoiding a case of hypertension for several reasons:

- It does not include a measure of the value of pain, suffering, and stress associated with hypertension;
- It does not value the direct costs (out-of-pocket expenses) of diet and behavior modification (e.g., salt-free diets, etc.). These costs, which are typical for severe modifications, are likely to be significant;
- This analysis does not address the loss of satisfaction associated with the diet and behavior modifications;
- This analysis does not include the value of avoiding side effects associated with the medication for hypertension, which include drowsiness, nausea, vomiting, anemia, impotence, cancer, and depression; and
- The analysis does not include the effects of the disease on family members.

b. Changes in CHD

❖ *Quantifying the relationship between PbB and BP*

EPA quantified the effect of changes in PbB levels on changes in BP to predict the probability of both hypertension and other cardiovascular illnesses, such as CHD, strokes, and premature mortality. Several cardiovascular illnesses include PbB as a risk factor (Shurtleff, 1974; McGee and Gordon, 1976; PPRG, 1978). Based on the results of a meta-analysis of several studies, Schwartz (1992a) estimated a relationship between a change in BP associated with a decrease in PbB from 10 µg/dL to 5 µg/dL. The following equation uses the coefficient reported by Schwartz to relate BP to PbB for men:

$$\Delta DBP_{men} = 1.4 \times \ln\left(\frac{PbB_1}{PbB_2}\right) \qquad (14.10)$$

where:

ΔDBP_{men} = the change in men's diastolic BP expected from a change in PbB;

PbB_1 = PbB level in the baseline scenario (in µg/dL); and

PbB_2 = PbB level in the post-compliance scenario (in µg/dL).

EPA used this PbB to BP relationship to estimate the incidence of initial CHD, strokes (BI and initial CBA), and premature mortality in men.

❖ *Quantifying the relationship between BP and CHD*

This analysis used estimated BP changes to predict the increased probability of initial CHD and stroke occurrence (U.S. EPA, 1987). Increased BP also increases the probability of CHD and stroke recurrence, but EPA did not quantify these relationships in this analysis. An equation with different coefficients for each of three age groups can predict first-time CHD events in men. A 1978 study by the PPRG supplied information for men between ages 40 and 59 (PPRG, 1978). PPRG used a multivariate model (controlling for smoking and serum cholesterol) relating the probability of CHD to BP. The model used data from five different epidemiological studies. The equation for the change in 10-year probability of a first-time occurrence of CHD related to an increase in BP is:

$$\Delta Pr(CHD_{40-59}) = \frac{1}{1 + e^{4.996 - 0.030365 * DBP_1}} - \frac{1}{1 + e^{4.996 - 0.030365 * DBP_2}} \qquad (14.11)$$

where:

$\Delta Pr(CHD_{40-59})$ = the change in 10-year probability of an occurrence of a CHD event for men between ages 40 and 59;

DBP_1 = mean diastolic BP in the baseline scenario. Based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 40 to 59 is 81.8 and 80.0, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

Information presented in Shurtleff (1974) helped define the relationship between BP and first-time CHD in older men. This study used data from the Framingham Study (McGee and Gordon, 1976) to estimate univariate relationships between BP and a variety of health effects, by sex and for three age ranges: 45 to 54, 55 to 64, and 65 to 74 years. The study performed single composite analyses for ages 45 to 74 for each sex. For every equation, t-statistics on the BP variable are significant at the 99th percent confidence interval. EPA predicted first-time CHD related to an increase in BP for men aged 60 to 64 from the following equation:

$$\Delta Pr(CHD_{60-64}) = \frac{1}{1 + e^{5.19676 - 0.02351 * DBP_1}} - \frac{1}{1 + e^{5.19676 - 0.02351 * DBP_2}} \tag{14.12}$$

where:

$\Delta Pr(CHD_{60\text{-}64})$ = the change in 2-year probability of occurrence of a CHD event for men aged 60 to 64;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 60 to 64 is 79.5 and 77.8, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

The following equation uses data from Shurtleff (1974) to predict the probability of first-time CHD related to an increase in BP for men aged 65 to 74:

$$\Delta Pr(CHD_{65-74}) = \frac{1}{1 + e^{4.90723 - 0.02031 * DBP_1}} - \frac{1}{1 + e^{4.90723 - 0.02031 * DBP_2}} \tag{14.13}$$

where:

$\Delta Pr(CHD_{65\text{-}74})$ = the change in 2-year probability of occurrence of a CHD event for men aged 65 to 74;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 65 to 74 is 79.5 and 76.4, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

EPA used the above equations to estimate the number of CHD events avoided in a given year due to water quality improvements from reduced MP&M lead discharges. The resulting CHD incidence estimates include both fatal and non-fatal events. Only the non-fatal CHD events are considered here because mortality benefits are estimated independently in this analysis (see Section 14.3.2.d, below). Shurtleff (1974) reported that two-thirds of all CHD events were non-fatal. This factor was therefore applied to the estimate of avoided CHD events due to reductions in PbB and BP for each age category.

❖ ***Valuing reductions in CHD events***

EPA first estimated the number of CHD events avoided each year by multiplying the number of exposed recreational and subsistence anglers in the relevant age group by the change in annual probability of a CHD event. Changes in annual probability of CHD events for different age groups are calculated by dividing the change in probability over ten- and two-year periods by the relevant number of years.

EPA then used the central tendency estimate of the COI associated with pollution-related CHD to estimate the benefits of avoiding an initial CHD event. The cost estimates (Wittels et al., 1990) represent the weighted medical costs of three separate CHDs (acute myocardial infarction, uncomplicated angina pectoris, unstable angina pectoris), experienced within five years of diagnosis. EPA estimated the costs by multiplying the probability of a medical test or treatment (within five years of the initial CHD event) by the estimated price of the test or treatment.[12] EPA then calculated the final cost estimate by taking the simple average of the three CHD types. EPA used a three percent discount rate to calculate the present value of these costs. The central tendency estimate of the COI associated with a case of pollution-related CHD is about $58,043 (1999$).

This estimate likely underestimates the full COI because it does not include lost earnings. It likely underestimates total WTP to avoid CHD to an even greater extent because it does not include WTP to avoid the pain and suffering associated with the CHD event.

This analysis combined the value of reducing CHD events with the value of reducing hypertension, even though these conditions often occur together. The two values represent different costs associated with the conditions. The valuation for hypertension includes hypertension-associated work day loss and medical costs. CHD valuation is based on WTP to avoid the pain and suffering of the CHD itself. EPA estimated these two values separately and added them together.

[12] EPA obtained costs from Appendix G of the *Benefits and Costs of the Clean Air Act: 1970 to 1990*, prepared for U.S. Congress by U.S. EPA, Office of Air and Radiation, 1997.

c. Changes in initial CBA and initial BI

❖ *Quantifying the relationship between BP and first-time stroke*

Strokes include two types of health events: initial CBA and initial BI. The risk of CBA has been quantified for the male population between 45 and 74 years old (Shurtleff, 1974). For initial CBA, the equation is:

$$\Delta Pr(CBA_{men}) = \frac{1}{1 + e^{8.58889 - 0.04066 * DBP_1}} - \frac{1}{1 + e^{8.58889 - 0.04066 * DBP_2}} \qquad (14.14)$$

where:

$\Delta Pr(CBA_{men})$ = the change in 2-year probability of CBA in men;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 45 to 74 is 81.1 and 78.8, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

For initial BI, the equation is (Pirkle et al., 1985):

$$\Delta Pr(BI_{men}) = \frac{1}{1 + e^{9.9516 - 0.04840 * DBP_1}} - \frac{1}{1 + e^{9.9516 - 0.04840 * DBP_2}} \qquad (14.15)$$

where:

$\Delta Pr(BI_{men})$ = the change in 2-year probability of brain infarction in men;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 45 to 74 is 81.1 and 78.8, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

Similar to CHD events, this analysis estimates only non-fatal strokes to avoid double-counting with premature mortality. Shurtleff reported that 70 percent of strokes were non-fatal. EPA applied this factor to the estimates of both CBA and BI to ensure that the estimate of avoided CBA and BI events included only non-fatal events (Shurtleff, 1974).

❖ *Valuing reductions in strokes*

Similarly to CHD events, EPA first calculates the number of avoided strokes per year and then uses the estimated lifetime cost of a stroke to value reductions in strokes. Taylor et al. estimated the lifetime cost of stroke, including the present value (in 1990 dollars) of the stream of medical expenditures and the present discounted value of the stream of lost earnings, using a five percent discount rate (Taylor et al., 1996). The estimated expected lifetime cost of a non-fatal stroke for males aged 45 to 74 is 262,379 (1999$).[13]

d. Changes in premature mortality

❖ *Quantifying the relationship between BP and premature mortality*

It is well-established that elevated BP increases the probability of premature death. There are, however, several underlying conditions that cause elevated BP (e.g., cholesterol level). U.S. EPA (1987) used population mean values for serum cholesterol and smoking to reduce results from a 12-year follow-up of men aged 40 to 54 in the Framingham Study (McGee and Gordon, 1976) to an equation with one explanatory variable (DBP):

[13] This analysis used cost estimates from the EPA *Cost of Illness Handbook.*

$$\Delta Pr(MORT_{40-54}) = \frac{1}{1 + e^{5.3158 - 0.03516 * DBP_1}} - \frac{1}{1 + e^{5.3158 - 0.03516 * DBP_2}} \qquad (14.16)$$

where:

ΔPr($MORT_{40-54}$) = the change in 12-year probability of death for men aged 40 to 54;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 40 to 54 is 81.9 and 79.9, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

This analysis used information from Shurtleff (1974) to estimate the probability of premature death in men older than 54 years. The present analysis estimates a two-year probability based on the Shurtleff study's two-year follow-up period. EPA predicted mortality for men aged 55 to 64 years old using the following equation:

$$\Delta Pr(MORT_{55-64}) = \frac{1}{1 + e^{4.89528 - 0.01866 * DBP_1}} - \frac{1}{1 + e^{4.89528 - 0.01866 * DBP_2}} \qquad (14.17)$$

where:

ΔPr($MORT_{55-64}$) = the change in two-year probability of death in men aged 55 to 64;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 55 to 64 is 80.6 and 79.0, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

Using data from Shurtleff (1974), EPA predicted premature mortality for men aged 65 to 74 using the following equation:

$$\Delta Pr(MORT_{65-74}) = \frac{1}{1 + e^{3.05723 - 0.00547 * DBP_1}} - \frac{1}{1 + e^{3.05723 - 0.00547 * DBP_2}} \qquad (14.18)$$

where:

ΔPr($MORT_{65-74}$) = the change in two-year probability of death in men aged 65 to 74;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 65 to 74 is 79.5 and 76.4, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

❖ ***Valuing reductions in premature mortality***

Similarly to health outcomes discussed in the preceding sections, EPA first estimated changes in annual probability of premature mortality for men in different age groups. The Agency then calculated avoided premature death cases by multiplying the estimated change in annual probability of premature mortality by the relevant population. This analysis uses the $5.8 million (1997$) estimate of the value of a statistical life saved recommended in the *Draft Guidelines for Preparing Economic Analysis* (EPA, 1999b). This value is based on WTP to avoid the risk of death.

Although the value of avoiding CHD, BA, and BI events is based on WTP to avoid the pain and suffering of a non-fatal CHD event, the value of the change in premature mortality is based on the value of avoiding an event that does end in death. These two endpoints are therefore additive.

14.3.3 Women Health Benefits

Recently expanded analysis of data from NHANES II by Schwartz indicates a significant association between PbB and BP in women (Schwartz, 1990). Another study, by Rabinowitz et al. (1987), found a small but demonstrable association between maternal PbB, pregnancy hypertension, and BP at time of delivery.

a. Relationship between BP and PbB

Although women are at risk for lead-induced hypertension, no dose-response function for hypertension in women is available at this time. Therefore, the Agency did not quantify changes in risk for lead-induced hypertension in women for this analysis. This analysis used an adjusted dose-response function for a change in BP associated with a decrease in PbB in men (Equation 14.10) to estimate lead-induced changes in blood pressure in women. Equation 14.19 is used to provide input values for the analyses discussed in the following sections.

A review of ten published studies examined the effect of lead exposure on the BP of women, relative to the effect on men (Schwartz, 1992). All of the reviewed studies included data for men; some included data for women. Schwartz used a concordance procedure that combined data from each study to predict the decrease in diastolic BP associated with a decrease from 10 µg/dL to 5 µg/dL PbB (Schwartz, 1992). The results suggest that when PbB is decreased, women experience a BP change that is 60 percent of the change seen in men. Equation (14.10) can be rewritten for women as:

$$\Delta DBP_{women} = (0.6 \times 1.4) \times \ln\left(\frac{PbB_1}{PbB_2}\right) \qquad (14.19)$$

where:

- ΔDBP_{women} = the change in women's diastolic BP expected from a change in PbB;
- PbB_1 = PbB level in the baseline scenario; and
- PbB_2 = PbB level in the post-compliance scenario.

b. Changes in CHD

❖ ***Quantifying the relationship between BP and CHD***

Elevated BP in women results in the same effects as for men (CHD, two types of stroke, and premature death). However, the general relationships between BP and these health effects are not identical to the dose-response functions estimated for men. All relationships presented here have been estimated for women aged 45 to 74 years old using information from Shurtleff (1974). EPA estimated first-time CHD related to an increase in BP in women using the following equation:

$$\Delta Pr(CHD_{women}) = \frac{1}{1 + e^{6.9401 - 0.03072 * DBP_1}} - \frac{1}{1 + e^{6.9401 - 0.03072 * DBP_2}} \qquad (14.20)$$

where:

- $\Delta Pr(CHD_{women})$ = change in 2-year probability of occurrence of CHD event for women aged 45-74;
- DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for women in subsistence and recreational households aged 45 to 74 is 76.5 and 74.8, respectively; and
- DBP_2 = mean diastolic BP in the post-compliance scenario.

EPA estimated non-fatal CHD events by assuming that two-thirds of all estimated CHD events are not fatal (Shurtleff, 1974).

❖ ***Valuing reductions in CHD events***

The Agency first calculated the number of avoided CHD events for women using Equation 14.20. EPA assumed that values of reducing CHD events for women equal those calculated for men (above): $58,043 (1999$) per CHD event.

c. Changes in BI and initial CBA

❖ ***Quantifying the relationship between BP and first-time stroke***

EPA predicted the relationship between BP and initial CBA for women using the following equation:

$$\Delta Pr(CBA_{women}) = \frac{1}{1 + e^{9.07737 - 0.04287 * DBP_1}} - \frac{1}{1 + e^{9.07737 - 0.04287 * DBP_2}} \qquad (14.21)$$

where:

- $\Delta Pr(CA_{women})$= change in two-year probability of cerebrovascular accident in women aged 45 to 74;
- DBP_1 = mean diastolic BP in the baseline scenario; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

The following equation illustrates the relationship between BI and initial BI in women:

$$\Delta Pr(BI_{women}) = \frac{1}{1 + e^{10.6716 - 0.0544 * DBP_1}} - \frac{1}{1 + e^{10.6716 - 0.0544 * DBP_2}} \qquad (14.22)$$

where:

$\Delta Pr(BI_{women})$ = change in 2-year probability of brain infarction in women aged 45 to 74;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for women in subsistence and recreational households aged 45 to 74 is 76.5 and 74.8, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

EPA multiplied the predicted incidences of avoided BI and CBA by 70 percent to estimate only non-fatal strokes (Shurtleff, 1974).

❖ ***Valuing reductions in strokes***

EPA calculated the value of avoiding an initial CBA or an initial BI for women in the same way as for men (see above). EPA predicted lead-related stroke for women in the United States between the ages of 45 and 74, of whom 38.2 percent are aged 45 to 54 and the remaining 61.8 percent are aged 55-74. Using the gender- and age-specific values in Taylor et al. (1996), EPA estimated the average value of avoiding a stroke among women aged 45 to 74 to be about $196,783 (1999$).

d. Changes in premature mortality

❖ ***Quantifying the relationship between BP and premature mortality***

The following equation estimates the risk of premature mortality in women (Shurtleff, 1974):

$$\Delta Pr(MORT_{women}) = \frac{1}{1 + e^{5.40374 - 0.01511 * DBP_1}} - \frac{1}{1 + e^{5.40374 - 0.01511 * DBP_2}} \qquad (14.23)$$

where:

$\Delta Pr(MORT_{women})$ = the change in two-year probability of death for women aged 45 to 74;

DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for women in subsistence and recreational households aged 45 to 74 is 76.5 and 74.8, respectively; and

DBP_2 = mean diastolic BP in the post-compliance scenario.

❖ ***Valuing reductions in premature mortality***

EPA predicted changes in lead-related premature mortality for women in the same way as for men (see above). EPA assumed the value of reducing premature mortality in women to be equal to that estimated for all premature mortality, $5.8 million ($1997) per incident (see Section 13.2.1).

14.4 Lead-Related Benefit Results

This section describes the estimated benefits of reduced lead exposure from consumption of fish in three populations: (1) preschool age children, (2) pregnant women, and (3) adult men and women. Benefit estimates for pregnant women are presented with those for preschool age children, because the beneficiaries in this category are children under the age of one who suffer *in utero* fetal lead exposure from maternal lead intake during pregnancy. Benefits for both children and adults from reduced lead-related health effects due to the proposed rule are estimated to total $28 million (1999$) annually.

14.4.1 Preschool Age Children Lead-Related Benefit Results

EPA estimated the monetary value of health benefits to children from reduced lead exposure in four categories:

- reduced neo-natal mortality,
- avoided IQ loss,

- reduced incidence of IQ below 70, and
- reduced incidence of PbB levels above 20 µg/dL.

Table 14.5 presents estimates of lead-related benefits from the proposed rule for children for these four categories.

EPA estimated changes in the risk of infant mortality due to changes in maternal PbB levels during pregnancy. The proposed rule would reduce the incidence of neonatal mortality by 1.6 cases annually. EPA estimated the monetary benefits of reduced neonatal mortality based on the WTP values for avoiding death. The estimated monetary benefits to pregnant women and infants are $9.33 million (1997$) annually.

Table 14.5: National Annual Benefits from Reduced Lead in Children ($1999) Proposed Rule

Category	Reduced Cases or IQ Points	Benefit Value ($1999)
Neonatal Mortality [a]	1.6	$9,331,613
Avoided IQ Loss	489.1	$4,928,514
Reduced IQ < 70	1.7	$126,390
Reduced PbB > 20 µg/L	0.1	$746
Total Benefits		**$14,387,263**

a. Unlike other benefits in this table, benefits from reduced neonatal mortality are expressed in 1997 dollars.
Source: U.S. EPA analysis.

EPA estimated benefits to preschool children based on a dose-response relationship for IQ decrements. The avoided neurological and cognitive damages are expressed as changes in overall IQ levels, including reduced incidence of extremely low IQ scores (<70, or two standard deviations below the mean) and reduced incidence of PbB levels above 20 µg/dL. The Agency estimated monetary values for avoided neurological and cognitive damages based on the impact of an additional IQ point on future earnings and the value of compensatory education that a lower IQ individual needs.

The proposed rule will avoid the loss of an estimated 489 IQ points among exposed preschool children. This translates into $4.9 million (1999$) per year in benefits. The avoided costs of compensatory education due to reduced incidence of children with IQ below 70 and PbB levels above 20 µg/dL equal about $127 thousand. The proposed rule will result in aggregated lead-related benefits for children of $14.39 million annually. EPA believes that these estimates are conservative, since this analysis omits other lead-related impacts, such as the cost of group homes and other special care facilities. Table 14.1 presents other omitted benefits categories. Section 14.5 discusses uncertainty and limitations inherent in this analysis.

14.4.2 Adult Lead-Related Benefit Results

As discussed previously, EPA quantified only the lead-related health effects in adults that relate to lead's effect on BP. These health effects include increased incidence of hypertension, initial non-fatal CHD, non-fatal stokes (CBA and BI), and premature mortality. EPA used COI estimates (i.e., medical costs and lost work time) to estimate monetary values for reduced incidence of hypertension, initial CHD, and strokes. EPA based monetary values for changes in risk of premature mortality on estimates of the value of a statistical life saved. The results are conservative estimates, because this analysis does not include other health effects associated with elevated BP or with lead. Other effects of lead in adults can include nervous system disorders, anemia, and possible cancer effects.

As shown in Table 14.6, the proposed rule would reduce hypertension by an estimated 960 cases annually among males, resulting in benefits of approximately $1,005,917 (1999$). The other health effects benefits were estimated for both males and females. Reducing the incidence of initial CHD, strokes, and premature mortality would result in estimated benefits of $114,331, $266,004, and $12.23 million respectively. Overall, adult lead-related benefits are $13.61 million annually.

Table 14.6: National Adult Lead Annual Benefits ($1999) Proposed Rule[a]

Category			Reduced Cases	Mean Value of Benefits
Men	Hypertension		959.8	$1,005,917
	CHD	Age 40-59	0.5	$38,459
		Age 60-64	0.3	$19,125
		Age 65-74	0.4	$29,700
	CBA	Age 45-74	0.5	$135,579
	BI	Age 45-74	0.3	$76,540
	Mortality [b]	Age 40-54	0.7	$4,055,744
		Age 55-64	0.7	$3,893,977
		Age 65-74	0.3	$1,901,325
Women	CHD	Age 45-74	0.4	$27,047
	CBA	Age 45-74	0.2	$33,385
	BI	Age 45-74	0.1	$20,500
	Mortality [b]	Age 45-74	0.4	$2,377,236
Total Benefits				**$13,614,534**

a. National Level Exposed Population:
Hypertension: 428,363 men ages 20 to 74;
CHD, CBA, BI, and mortality: 173,386 men and 192,091 women ages 45-74.
b. Unlike other benefits in this table, mortality is expressed in 1997 dollars.
Source: U.S. EPA analysis.

14.5 Limitations and Uncertainties

This section discusses limitations and uncertainties in the lead-related benefits analysis. Developing dose-response functions depends on relating lead exposure to PbB levels, then evaluating PbB levels in relation to specific health outcomes. Quantitative dose-response functions for most health effects associated with lead exposure currently do not exist. For this reason, the analysis does not provide a comprehensive estimate of health benefits from reduced lead discharges from MP&M facilities.

Table 14.1 summarizes quantified and non-quantified health effects. Economic research does not always yield a complete evaluation, even for those effects that can be quantified. This uncertainly is likely to bias the estimate of lead-related benefits of the MP&M regulation downward. The analysis methodologies used here also involve significant simplifications and uncertainties. Section 13.3 discusses similar limitations and uncertainties associated with the assessment of risk associated with non-lead-related human health hazards and the possible direction of bias associated with sample design and benefits analysis by:

- occurrence location,
- estimated in-waterway concentrations of MP&M pollutants, and
- estimated exposed fishing population.

The next five sections discuss other omissions, biases, and uncertainties in the lead-benefit analysis. Table 14.7 provides a summary of this discussion.

14.5.1 Excluding Older Children

Recent research on brain development among 10- to 18-year-old children shows unanticipated and substantial growth in brain development, mainly in the early teenage years (Giedd et al., 1999). This growth appears to be a second "burst" of cell development in some brain areas, in addition to the previously recognized period of rapid growth during early childhood. One of lead's fundamental effects is to disrupt the protective coating (myelin) on nerve cells. This disruption can lead to permanent impairment if it occurs during development. New research suggests that older children may be a hypersensitive subpopulation, along with children aged 0 to 6. Excluding this subpopulation from the analysis may significantly underestimate benefits from reduced lead discharges.

14.5.2 Compensatory Education Costs

This analysis assumes that compensatory education is required only for children with IQs less than 70, and that part-time special education costs are assumed to be incurred only from grades 1 through 12 (Section 14.2.4). This assumption underestimates compensatory education costs for the following reasons:

- Children with IQ scores between 70 and 85 will likely be assigned to special education or "slow" classes that will likely be smaller than regular classes and require more teacher attention. Children in this IQ range may frequently require more than 12 years to graduate and are more likely to drop out of school. Such children therefore require additional education costs.

- Compensatory education may begin before grade one. Some states (e.g., Connecticut) offer compensatory education programs for disadvantaged children beginning at age three.

- This analysis is based on a study that measured the increased cost to educate children with low IQs attending a regular school, not a special education program (Kakalik et al., 1981). The cost to attend a special education program is generally much higher than that for regular schooling.

14.5.3 Dose-Response Relationships

The dose-response functions described for each health outcome considered above generally quantify the adverse health effects expected from increased lead exposure. For children, these effects are defined in terms of changes in PbB. For adults, these effects are estimated in terms of changes in BP, which are in turn related to changes in PbB levels. Uncertainty is inherent in the dose-response functions, which are typically expressed in terms of the standard deviations of the dose-response coefficients used in the analysis. Any uncertainty affecting the dose-response coefficients will also indirectly affect the accuracy of this analysis.

14.5.4 Absorption Function for Ingested Lead in Fish Tissue

Numerous research groups have evaluated lead absorption under a variety of conditions. ATSDR reports a range of 3 percent to 45 percent in the studies they present, which consider lead intake with and without food (ATSDR, 1997). Absorption appears to be affected by total lead intake, with some studies showing a higher absorption proportion with higher doses. Animal studies show a saturation effect, which modifies absorption.

Lead's chemical form also determines its absorption rate. For example, lead sulfide has approximately 10 percent the bioavailability of lead acetate (ATSDR, 1997). Particle size, solubility, and lead's chemical form are also important absorption factors. EPA could not obtain data to describe lead's precise chemical form, particle size, and other physical parameters in fish tissue, which would allow more refined absorption estimates. These characteristics vary because MP&M facilities produce lead using different processes and release it in different forms.

An individual's nutritional status also affects lead absorption rates. People who are malnourished, particularly with respect to calcium and iron, have high absorption rates (ATSDR, 1997). EPA assumed that anglers were not malnourished, and made no adjustment for their nutritional status. See the section on lead absorption in Maddaloni, (1998) for a discussion of factors influencing absorption. In the absence of data on lead incorporated into food, EPA considered data from studies of lead absorption during meals to be the most appropriate data to use in estimating absorption.

14.5.5 Economic Valuation

This analysis used IQ differentials to represent cognitive damage to children resulting from lead exposure. The economic analysis relates IQ level to annual earnings, which serve as the basis for valuing benefits from reduced lead exposure. IQ differentials are used rather than WTP, the preferred measure to use, because WTP values to avoid cognitive damage are not available. This analysis likely underestimates the value of an IQ point because special education and lost wages form only a portion of the costs associated with lost cognitive functioning. A simple IQ change analysis does not capture all the ways in which a child, family, and society are affected by the effects of lead-induced cognitive damage.

Dollar values associated with most of the adult health and welfare endpoints represent only some components of society's WTP to avoid these health effects. EPA used COI estimates to value reductions in CHD events, strokes, and hypertension. These values are likely to be downward-biased because the value of pain and suffering avoided is not included. Employed alone, these monetized effects will underestimate society's WTP.

Table 14.7: Key Omissions, Biases, and Uncertainties in the Lead-Benefit Analysis

Omissions/Biases/ Uncertainties	Directional Impact on Benefits Estimates	Comments
Excluding older children	downward	New research suggests that older children may be a hypersensitive subpopulation, as children aged 0 to 6 are now considered. Excluding this subpopulation from the analysis may significantly underestimate benefits from reduced lead discharges.
Compensatory education costs	downward	Assuming that compensatory education is required only for children with IQs less than 70 and that part-time special education costs are assumed to be incurred from grades 1 through 12 underestimates the special education costs because: ▸ Children with IQ scores between 70 and 85 will likely be assigned to special education or "slow" classes, requiring more teacher attention, and taking longer to graduate or dropping out altogether. ▸ Compensatory education may begin before grade one. ▸ The cost to attend a special education program is generally much higher than that for regular schooling.
Dose-response relationship	uncertain	Uncertainty is inherent in the dose-response functions (expressed in changes in PbB for children, changes in BP for adults). Any uncertainty affecting the dose-response coefficients will also indirectly affect the accuracy of this analysis.
Absorption factor for lead in fish tissue	uncertain	Absorption rate appears to be affected by: ▸ Total lead intake, with some studies showing a higher absorption proportion with higher doses. ▸ Lead's chemical form. Because MP&M facilities produce lead using different processes and release it in different forms, EPA could not obtain data to describe lead's precise chemical form, particle size, and other physical parameters in fish tissue, which would allow more refined absorption estimates. ▸ An individual's nutritional status. ▸ Time of lead ingestion. In the absence of data on lead incorporated into food, EPA considered data from studies of lead absorption during meals to be the most appropriate data to use in estimating absorption.
Economic valuation	downward	The values associated with cognitive damage to children and adult health effects are likely to be downward-biased. For children, a simple IQ change analysis does not capture all effects of lead-induced IQ loss on a child, family, and society. The valuation of adult's health effects from lead exposure do not include the value of avoided pain and suffering. Employed alone, these monetized effects will underestimate society's WTP.
Overall impact	downward	

Source: U.S. EPA analysis.

GLOSSARY

absolute gastrointestinal absorption fraction: the fraction of lead in food ingested daily that is absorbed from the gastrointestinal tract.

acute toxicity: the ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance (see: chronic toxicity, toxicity). (http://www.epa.gov/OCEPAterms/aterms.html)

angina pectoris: a syndrome characterized by paroxysmal, constricting pain below the sternum, most easily precipitated by exertion or excitement and caused by ischemia of the heart muscle, usually due to a coronary artery disease, as arteriosclerosis. (www.infoplease.com)

arithmetic mean: the mean obtained by adding several quantities together and dividing the sum by the number of quantities. (www.infoplease.com)

atherothrombotic brain infarctions (BI): scientific name for a stroke.

bioaccumulation factors: the ratio of a substance's steady-state concentration in the tissue of an aquatic organism to its steady-state concentration in the ambient water where both the organism and its food are exposed.

bioavailability: degree of ability to be absorbed and ready to interact in organism metabolism. (http://www.epa.gov/OCEPAterms/bterms.html)

biokinetics: the study of movements of or within organisms. (www.infoplease.com)

biomarker: a physical, functional, or biochemical indicator of a certain process or event. It is commonly used to measure the progress of a disease, the effects of treatment, or the status of a condition.

blood lead (PbB): concentration level of lead in blood stream; usually expressed in µg/dL.

central tendency estimate: major trend in group of data.

cerebrovascular accident (CBA): stroke.

coronary heart disease (CHD): disorder that restricts blood supply to the heart; occurs when coronary arteries become narrowed or clogged due to the build up of cholesterol and fat on the inside walls and are unable supply enough blood to the heart.

diastolic: pertaining to or produced by diastole, or (of blood pressure) indicating the arterial pressure during the interval between heartbeats. (www.infoplease.com)

discounting: degree to which future dollars are discounted relative to current dollars. Economic analysis generally assumes that a given unit of benefit or cost matters more if it is experienced now that if it occurs in the future. The present is more important due to impatience, uncertainty, and the productivity of capital. This analysis uses a three percent discount rate to discount future benefits. (http://www.damagevaluation.com/glossary)

dose-response functions: see dose-response relationship.

dose response: shifts in toxicological responses of an individual (such as alterations in severity) or populations (such as alterations in incidence) that are related to changes in the dose of any given substance.

dose-response assessment: 1. Estimating the potency of a chemical. 2. In exposure assessment, the process of determining the relationship between the dose of a stressor and a specific biological response. 3. Evaluating the quantitative relationship between dose and toxicological responses.

dose response curve: graphical representation of the relationship between the dose of a stressor and the biological response thereto.

dose-response relationship: the quantitative relationship between the amount of exposure to a substance and the extent of toxic injury or disease produced. (http://www.epa.gov/OCEPAterms/dterms.html)

encephalopathy: any brain disease. (www.infoplease.com)

GDP price deflator: measure of the percentage increase in the average price of products in GDP over a certain base year published by the Commerce Department. (http://www.damagevaluation.com/glossary.htm)

genotoxic: may cause chromosomal damage in humans leading to birth defects.

geometric mean (GM): for a set of n numbers $\{x_1, x_2, x_3, ..., x_n\}$ it is the n-th root of their product: $(X_1 \text{ x } X_2 \text{ x } X_3 \ldots X_n)^{1/n}$.

geometric standard deviation (GSD): is a measure of the inter-individual variability in blood lead concentrations in a population whose members are exposed to the same environmental lead levels. For a lognormal distribution, GSD is the exponential of the standard deviation of the associated normal distribution.

half-life: time required for a living tissue, organ, or organism to eliminate one-half of a substance which has been introduced into it.

health endpoints: An observable or measurable biological event or chemical concentration (e.g., metabolite concentration in a target tissue) used as an index of an effect of a chemical exposure.

heme synthesis: creation of heme; an iron compound of protoporphyrin which constitutes the pigment portion or protein-free part of the hemoglobin molecule and is responsible for its oxygen-carrying properties.

Integrated Exposure, Uptake, and Biokinetics (IEUBK): the IEUBK model is an exposure-response model that uses children's environmental lead exposure to estimate risk of elevated blood lead (typically> 10 µg/dL) through estimation of lead body burdens in mass balance framework.

least-squares regression: a tool of regression analysis that computes a best-fit line to represent the relationship between two (or more) variables based on the principle that the squared deviations of the observed points from that line are minimized (see also: regression analysis).

ln: natural logarithm.

lognormal distribution: a distribution of a random variable for which the logarithm of the variable has a normal distribution. (www.infoplease.com)

lognormally-distributed random variable: same as lognormal distribution.

marginal cost: the increase in total costs as one more unit is produced. (http://www.damagevaluation.com/glossary.htm)

probit regression: a regression model, where the dependent variable is set up as a 0-1 dummy variable and regressed on the explanatory variables. The predicted value of the dependent variable could be interpreted as the probability that a certain event will take place (e.g., an individual will buy a car, visit a particular location, or get a specific disease.)

multivariate: (of a combined distribution) having more than one variate or variable. (www.infoplease.com)

nephropathy: any kidney disease. (www.infoplease.com)

neurobehavioral deficits: neurologic effects as assessed by observation of behavior. These effects may include behavioral and attentional difficulties, delayed mental development, lack of motor and perceptual skills, and hyperactivity.

neurobehavioral function: see neurobehavioral deficits.

normal distribution: a random variable X is normally distributed if its density is given by $f_x(x) = f(x; \mu, ó)$, where µ and ó are the mean and the variance of the distribution.

opportunity costs: the highest-valued sacrifice needed to get a good or service. (http://www.damagevaluation.com/glossary.htm)

p-value: the probability of obtaining a given outcome due to chance alone. For example, a study result with a significance level of $p \leq 0.05$ implies that 5 times out of 100 the result could have occurred by chance. (http://www.teleport.com/~celinec/glossary.htm)

pharmacokinetics: the study of the way drugs move through the body after they are swallowed or injected. (http://www.epa.gov/OCEPAterms/pterms.html)

probability distribution: a distribution of all possible values of a random variable together with an indication of their probabilities. (www.infoplease.com)

quasi-steady state: almost not changing state.

regression analysis: a procedure for determining a relationship between a dependent variable, such as predicted success in college, and an independent variable, such as a score on a scholastic aptitude test, for a given population. The relationship is expressed as an equation for a line. (www.infoplease.com)

risk-based remediation goals (RBRG): target human health and environmental risk levels to be achieved via remedial actions at Superfund sites.

systemic health risks: health risks pertaining to or affecting the body as a whole.

Technical Review Workgroup (TRW): a workgroup formed in 1994 to evaluate methodologies for adult lead risk assessment.

µg/L: microgram per liter

µg/dL: microgram per decaliter

willingness to pay (WTP): maximum amount of money one would give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

ATSDR: Agency for Toxic Substances and Disease Registry
BI: atherothrombotic brain infarction
BP: blood pressure
CARB: California Air Resources Board
CBA: cerebrovascular accidents
CDC: Centers for Disease Control
CEPA: California Environmental Protection Agency
CHD: coronary heart disease
COI: cost of illness
GM: geometric mean
GSD: geometric standard deviation
IEUBK: Integrated Exposure, Uptake, and Biokinetics
NCHS: CDC's National Center for Health Statistics
NHANES: National Health and Nutrition Examination Surveys
NLSY: National Longitudinal Survey of Youth
PbB: blood lead
PCS: Permit Compliance System
PPRG: Pooling Project Research Group
RBRG: risk-based remediation goals
TRW: Technical Review Workgroup
WTP: willingness to pay

REFERENCES

ATSDR (Agency for Toxic Substances and Disease Registry). 1997. Draft toxicological profile for lead. Atlanta, GA.

CARB (California Air Resource Board). 1996. Draft summary of lead and lead compounds. Proposed Identification of Inorganic Lead as a Toxic Air Contaminant, Part B: Health Assessment. Draft SRP Version, CA EPA. September.

Centers for Disease Control (CDC). 1991a. *Strategic Plan for Elimination of Childhood Lead Poisoning*. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Atlanta, GA. February.

Centers for Disease Control (CDC). 1991b. *Preventing Lead Poisoning in Young Children.* U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Atlanta, GA. October.

Dietrich, K.N., K.M. Krafft, R. Shukla, R.L. Bornschein, and P.A. Succop. 1987. The Neurobehavioral Effects of Prenatal and Early Postnatal Lead Exposure. In: *Toxic Substances and Mental Retardation: Neurobehavioral Toxicology and Teratology,* S.R. Schroeder, Ed. American Association of Mental Deficiency, Washington, DC, pp. 71-95 (Monograph No. 8).

Giedd, J.N., L. Blumenthal, N.O. Jeffries, F.X. Castellanes, Hong Liu, A. Zijdenbos, Tomas Paus, Alan C. Evans, and J. Rapoport. 1999. Brain Development During Childhood and Adolescence: A Longitudinal MRI Study. *Nature Neuroscience*, Vol. 2, No. 10, pp. 861-863, October.

Kakalik, J., et al. 1981. *The Cost of Special Education*. Rand Corporation Report N-1791-ED.

Krupnick, A.J. and M.L. Cropper. 1989. *Valuing Chronic Morbidity Damages: Medical Costs and Labor Market Effects*. Draft Final Report to U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation. June 26.

Lewit, E.M., L Schuurmann Baker, Hope Corman, and Patricia H. Shiono. 1995. “The Direct Cost of Low Birth Weight.” *The Future of Children Vol 5*, No 1, Spring.

Maddaloni, M. A. 1998. Measurement of Soil-Borne Lead Bioavailability in Human Adults, and Its Application in Biokinetic Modeling. Ph.D. Dissertation. School of Public Health, Columbia University, New York.

McGee and Gordon. 1976. The Results of the Framingham Study Applied to Four Other U.S.-based Epidemiologic Studies of Coronary Heart Disease. *The Framingham Study: An Epidemiological Investigation of Cardiovascular Disease*. Section 31, April.

Needleman, H.L., Riess, Y.A., Tobin, M.D., Biesecar, G.E., Greenhouse, J.B. 1996. Bone Lead Levels and Delinquent Behavior. *Journal of the American Medical Association*, Vol. 275, No. 5, February 7.

NHANES III, Phase 2, National Health and Nutrition Examination Survey, 1991-1994.

Piomelli et al. 1984. “Management of Childhood Lead Poisoning.” *Pediatrics* 4: 105.

Pirkle, J.L., J. Schwartz, J.R. Landis, and W.R. Harlan. 1985. “The Relationship Between Blood Lead Levels and Blood Pressure and its Cardiovascular Risk Implications.” *American Journal of Epidemiology* 121: 246-258.

Pirkle, J. L., et al. 1994. “Decline in Blood Lead Levels in the United States, the National Health and Nutrition Examination Survey (NHANES).” *JAMA* 272(4): 284.

Pocock, S.J., A.G. Shaper, M. Walker, C.J. Wale, B Clayton, T. Delves, R.F. Lacey, R.F. Packham, and P. Powell. 1983. “Effects of Tap Water Lead, Water Hardness, Alcohol, and Cigarettes on Blood Lead Concentrations.” *J. Epidemiol. Commun. Health*. 37: 1-7.

Pooling Project Research Group (PPRG). 1978. "Relationship of Blood Pressure, Serum Cholesterol, Smoking Habit, Relative Weight and ECG Abnormalities to Incidence of Major Coronary Events: Final Report of the Pooling Project." *Journal of Chronic Disease*. Vol. 31.

Rabinowitz, M., D. Bellinger, A. Leviton, H. Needleman, and S. Schoenbaum. 1987. "Pregnancy Hypertension, Blood Pressure During Labor, and Blood Lead Levels." *Hypertension* 10(4): October.

Salkever, D.S. 1995. "Updated Estimates of Earnings Benefits from Reduced Exposure of Children to Environmental Lead." *Environmental Research* 70: 1-6.

Schwartz, J. 1988. "The Relationship Between Blood Lead and Blood Pressure in the NHANES II Survey." *Environmental Health Perspectives*. 78: 15-22.

Schwartz, J. 1990. "Lead, Blood Pressure, and Cardiovascular Disease in Men and Women." *Environmental Health Perspectives*, in press.

Schwartz, J. 1992. "Chapter 13: Lead, Blood Pressure and Cardiovascular Disease." In H. L. Needleman, ed., *Human Lead Exposure*. CRC Press.

Schwartz, J. 1993. "Beyond LOEL's, p Values, and Vote Counting: Methods for Looking at the Shapes and Strengths of Associations." *Neurotoxicology* 14(2/3): October.

Schwartz, J. 1994. "Low-level Lead Exposure and Children's IQ: A Meta-analysis and Search for a Threshold." Environmental Research 65: 42-55.

Sherlock, J.C., D. Ashby, H.T. Delves, G.I. Forbes, M. R. Moore, W. J. Patterson, S.J. Pocock, M.J. Quinn, W. N. Richards and T.S. Wilson. 1984. "Reduction in Exposure to Lead from Drinking Water and Its Effect on Blood Lead Concentrations." *Human Toxicology*. 3: 183-392.

Shurtleff, D. 1974. Some Characteristics Related to the Incidence of Cardiovascular Disease and Death. *The Framingham Study: An Epidemiological Investigation of Cardiovascular Disease*. Section 30, February.

Silbergeld, E.K., J. Schwartz, and K. Mahaffey. 1988. "Lead and Osteoporosis: Mobilization of Lead from Bone in Postmenopausal Women." *Environmental Research* 47: 79-94.

Taylor, T.N., P.H. Davis, J.C. Torner, J. Holmes, J.W. Meyer, and M. F. Jacobson. 1996. "Lifetime Cost of Stroke in the United States." *Stroke* 27(9): 1459-1466.

U.S. Department of Commerce, Bureau of the Census. 1993. "Money Income of Households, Families, and Persons in the United States: 1992," Current Population Reports, Consumer Income, Series P60-184, Washington, D.C..

U.S. Department of Housing and Urban Development. 1995. "The Relation of Lead Contaminated House Dust and Blood Lead Levels Among Urban Children. Vol. I and II. Final Report to the U.S. Department of Housing and Urban Development. Grant from the University of Rochester School of Medicine, Rochester, NY, and the National Center for Lead-Safe Housing, Columbia, MD.

U.S. Environmental Protection Agency (U.S. EPA). 1985. *Costs and Benefits of Reducing Lead in Gasoline: Final Regulatory Impact Analysis*. Prepared by U.S. Environmental Protection Agency, Office of Policy Analysis, Economic Analysis Division. February.

U.S. Environmental Protection Agency (U.S. EPA). 1986a. *Reducing Lead in Drinking Water: A Benefit Analysis*. Prepared by U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, Draft Final Report. December.

U.S. Environmental Protection Agency (U.S. EPA). 1986b. *Air Quality Criteria for Lead: Volume III.* Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA-600/8-83/028cF. June.

U.S. Environmental Protection Agency (U.S. EPA). 1989. *Air Quality Criteria Document for Lead: 1989 Addendum.*

U.S. Environmental Protection Agency (U.S. EPA). 1987. *Methodology for Valuing Health Risks of Ambient Lead Exposure*. Prepared by Mathtech, Inc. for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Ambient Standards Branch, Contract No. 68-02-4323.

U.S. Environmental Protection Agency (U.S. EPA). 1990. *Review of the National Ambient Air Quality Standards for Lead: Assessment of Scientific and Technical Information*. OAQPS Staff Paper, Air Quality Management Division, Research Triangle Park, NC. December.

U.S. Environmental Protection Agency (U.S. EPA). 1994. *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*. February. EPA 540-R-93-081, PB 93-963510.

U.S. Environmental Protection Agency (U.S. EPA). 1995. "Technical Support Document: Parameters and Equations Used in the IEUBK Model for Lead in Children." EPA 540-R-94-040.

U.S. Environmental Protection Agency (U.S. EPA). 1996. *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*. EPA, Technical Review Workgroup for Lead, December 1996, pp. A16 - A17.

U.S. Environmental Protection Agency (U.S. EPA). 1997. The Benefits and Costs of the Clean Air Act: 1970 to 1990. EPA 410-R-97-002, October, 1997. U.S. EPA, Office of Air and Radiation, Appendix G: Lead Benefits Analysis.

U.S. Environmental Protection Agency (U.S. EPA). 1998a. Economic Analysis of Toxic Substances Control Act Section 403: Hazard Standards. Prepared for EPA by Abt Associates Inc., May 1998.

U.S. Environmental Protection Agency (U.S. EPA). 1998b. Risk Analysis to Support Standards for Lead in Paint, Dust and Soil. EPA/OPPT 747-R-97-006, Washington, D.C., June 1998.

U.S. Environmental Protection Agency (U.S. EPA). 1998c. Lead; Identification of Dangerous Levels of Lead; Proposed Rule. Federal Register June 3, 1998, pp. 30302-30355

U.S. Environmental Protection Agency (U.S. EPA). 1998d. Daily Average per Capita Fish Consumption Estimates Based on the Combined USDA 1988, 1990, and 1991 Continuing Survey of Food by Individuals (CSF II), Volumes I and II, March.

U.S. Environmental Protection Agency (U.S. EPA). 1999a. Cost of Illness Handbook (Draft). OPPT, Washington, D.C.

U.S. EPA. 1999b. *Guidelines for Preparing Economic Analysis.* Draft report. Washington, DC: U.S. EPA.

Wittels, E.H., J.W. Hay, and A.M. Gotto, Jr. 1990. "Medical Costs of Coronary Artery Disease in the United States," *The American Journal of Cardiology* 65: 432-440.

Chapter 15: Recreational Benefits

INTRODUCTION

The proposed MP&M regulation will provide recreational and nonuse benefits by reducing effluent discharges and improving habitats or ecosystems (aquatic and terrestrial) used for recreational activities. EPA estimated national recreational benefits for three activities:

- recreational fishing,
- wildlife viewing, and
- recreational boating.

The analysis of recreational benefits presented in this chapter uses the ***National Demand Study* (NDS)** data to estimate the number of participants in wildlife viewing, and boating in the counties affected by MP&M discharges. To estimate the number of recreational fishermen, EPA used fishing license data. The NDS survey asked respondents to report the number of recreational trips taken annually for the *primary purpose* of boating and wildlife viewing. Additional information on the NDS survey can be found in Chapter 21. Appendix H provides information on the number of participants and the number of recreational trips taken annually by state and activity type.

Recreational trips corresponding to fishing, boating, and wildlife viewing considered in this analysis are stochastically independent (i.e., only the primary activity is counted on each trip occasion). Benefits from improved recreational opportunities corresponding to these activities are therefore additive.

EPA chose to use fish license data rather than the NDS data to estimate the number of recreational anglers fishing the MP&M reaches because these data are often available at the county level and therefore provide location-specific information. Although the use of the NDS and fish license data yields similar estimates of the number of recreational anglers at the state level (see Chapter 20) fish license data are likely to be more accurate at the county level. The use of the fish license data in the recreational fishing benefit analysis also provides consistency with other parts of the benefits analysis (see Chapters 13 and 14 for detail).

This chapter also presents an estimate of nonuse benefits. People who do not use or expect to use affected waterways for recreational or other purposes may still value protecting habitats and species impacted by effluent discharges.

CHAPTER CONTENTS:

EPA assessed recreational and nonuse benefits in terms of reduced occurrences of pollutant concentrations that exceed chronic and acute toxic effect levels for aquatic species and human health. The analysis estimated the ***in-waterway pollutant concentrations*** of MP&M facility discharges for the baseline and the proposed rule. EPA identified those reaches in which estimated facility discharges would cause one or more pollutant concentrations to exceed ***ambient water quality criteria* (AWQC)** for aquatic species and human health.[1]

AWQC set limits on pollutant concentrations that are assumed to be protective of aquatic life. Pollutant concentrations that exceed AWQC can harm organisms that live in or consume water. MP&M pollutants can also harm other organisms that consume these organisms. These organisms at risk include humans who may spend time in or consume aquatic organisms.

[1] For this analysis, a reach is a length of river, shoreline, or coastline on which a pollutant discharge may be expected to have a relatively uniform effect on concentrations. The typical length of a reach in this analysis was five to ten kilometers, although some were considerably longer.

An analysis of the effect of the proposed MP&M regulation on reducing the number of reaches with concentrations in excess of AWQC provides a quantitative measure of the improvement in aquatic species habitat expected to result from the proposed regulation. Elimination of pollutant concentrations in excess of AWQC will achieve water quality that is protective of aquatic life and human health.

Reducing concentrations of MP&M pollutants to below AWQC limits for protection of aquatic species and human health will generate benefits to users of water resources for recreation, including fishermen, boaters, and viewers. Benefits include:

- increased value of the recreational trip or day, and
- increased number of days that consumers of water-based recreation choose to visit the cleaner waterways.

EPA estimated national annual recreational use benefits for three water-based recreation activities (i.e., recreational fishing, boating, and viewing) and nonuse benefits, but did not estimate national swimming benefits due to data limitations.[2] EPA estimated the following recreational benefits of the proposed MP&M rule (1999$):

- Recreational fishing benefits ranging from $196 to $627 million,
- Near-water recreation (viewing) benefits ranging from $500 to $920 million,
- Boating benefits ranging from $265 to $672 million,
- Nonuse benefits ranging from $240 to $1,464 million.

The total annual recreational benefit is estimated at $1,201 to $3,683 million (1999$), with a midpoint estimate of $2,281 million (1999$).

Benefit categories examined in this chapter are different from and generally do not overlap with benefits associated with reduced risk to human health discussed in Chapter 13. Nevertheless, there is some likelihood that the valuation of ecological benefits based on enhanced recreational fishing overlaps to a degree with the valuation of human health benefits from reduced cancer risk via fish consumption.

The rest of this chapter reviews the methodology and findings from the recreational and nonuse benefits analysis of the MP&M regulation. The methodology for assessing these benefits involves two elements:

- identifying MP&M discharge reaches expected to have a reduced occurrence of pollutant concentrations exceeding AWQC for aquatic species and human health as a result of the proposed rule, and
- attaching a monetary value to occurrences of pollutant concentrations in excess of AWQC.

15.1 Improvements from the MP&M Regulation

15.1.1 Ecological Improvements

Many MP&M pollutants can adversely affect the survival, growth, and reproduction of aquatic organisms. Such effects are ecologically significant when they affect the size, structure, or function of populations:

- MP&M pollutants can affect ***population size*** by reducing prey, and by affecting development or reproduction in sensitive life stages of target species;
- MP&M pollutants can alter ***population structure*** by impairing sensitive age groups or affecting the development or maturation rates of target species; and
- MP&M pollutants can impact ***population function*** by decreasing genetic diversity and changing interactions among different populations in the affected areas.

Recreational and nonuse benefits result from ecological improvements in aquatic habitat and associated changes in aquatic life. Ecological effects of the proposed MP&M regulation may include:

- recovery of populations of aquatic species that are particularly sensitive to MP&M pollutants;
- decreases in noxious algae, which affect the taste and odor of the receiving waters;
- increases in the concentrations of ***dissolved oxygen*** (DO) in the water column;

[2] Fewer waterbodies are designated for primary contact recreation such as swimming than for secondary contact recreation such as boating and fishing. Assessing recreational swimming benefits requires first obtaining information on designated uses of the sample MP&M reaches from the 305(b) database. This analysis was not feasible due to resource and time constraints.

- improvements in the natural assimilative capacity of the affected waterways; and
- terrestrial life benefits.

15.1.2 Quantification of Ecological Improvements

EPA quantified the ecological improvements of the proposed regulation by comparing estimates of in-waterway concentrations of pollutants discharged by MP&M facilities with the estimates of concentrations within AWQC limits for protection of aquatic species, as required by the proposed MP&M regulation. Pollutant concentrations in excess of AWQC limits indicate a significant detriment to the aquatic species habitat. Eliminating these exceedances as the result of the MP&M regulation significantly improves aquatic species habitat.

The analysis estimates in-waterway concentrations for all MP&M pollutants that may adversely affect aquatic life. Table E.3 in Appendix E lists the pollutants evaluated in this analysis and their acute and chronic aquatic life AWQC. The acute value is the maximum allowable one-hour average concentration at any time at which aquatic life can survive. The chronic value is the average concentration of a toxic pollutant over a four-day period at which aquatic life is not unacceptably affected. The endpoints of concern are one or more sublethal responses, such as changes in reproduction or growth in the affected organisms. The chronic levels should not be exceeded more than once every three years. EPA calculated in-waterway concentrations for acute and chronic exposure and compared the estimated concentration values to the relevant AWQC limits.

EPA used the mixing and dilution methods outlined in Appendix E to estimate the in-waterway concentrations resulting from MP&M facility discharges. Acute and chronic exposure concentrations for each pollutant are calculated on the basis of 7Q10 and 1Q10 stream flow rates, where 7Q10 is the lowest consecutive seven-day average flow with a recurrence interval of ten years, and 1Q10 is the lowest one-day average flow with a recurrence interval of ten years.

EPA estimated baseline discharge values by identifying the MP&M discharge reaches in which MP&M discharges alone caused one or more pollutant concentrations to exceed AWQC limits for aquatic species. If concentrations of all MP&M pollutants exceeding the limits in the baseline fell below AWQC limits as a result of the proposed rule, then aquatic species habitat conditions on that discharge reach would likely improve significantly as a result of the proposed regulation. The proposed regulation would result in partial aquatic habitat improvements if concentrations of some, but not all, MP&M pollutants fell below their AWQC limits.

15.1.3 AWQC Exceedances for Human Health

EPA analyzed recreational benefits of occurrences in which pollutants exceed AWQC limits for both aquatic life (acute and chronic) and human health, where human-health AWQC are established in terms of a pollutant's toxic effects, including carcinogenic potential. Table E.2 in Appendix E lists the pollutants evaluated in the human health analysis and their human health-based AWQC values. The human health-based values are set at levels to protect human health through ingestion of water or aquatic organisms. Chapter 13 addresses the impact of the proposed MP&M regulation on human health, while this chapter addresses the impact of improved aquatic and human habitats on recreational benefits.

This chapter evaluates an individuals' willingness to pay (WTP) to recreate in areas with reduced concentrations of pollutants affecting aquatic life and human health. Knowing that the water is cleaner and does not contain any or contains fewer pollutants that harm humans and aquatic life, increases individuals enjoyment of their recreational experience. Recent studies valuing recreational fishing showed that the value of water resources for recreational fishing increases as the level of toxic contamination in fish tissue decreases (Lyke, 1993; Phaneuf et al., 1998; and Jakus et al. 1997). Increased benefits also come from knowing there are more fish, larger fish, healthier fish, and more species present in the water.

Elimination of human health-based AWQC exceedances is likely to reduce the level of toxic contamination in fish tissue and therefore to increase the value of fishery resources. Although EPA estimated the value of reduced cancer risk from consumption of contaminated fish tissue, the Agency was unable to estimate the value of reduced systemic risk from consumption of fish caught in the reaches affected by MP&M discharges (see Chapter 13). The recreational benefits analysis presented in the following sections assumes that some of the value of reduced systemic health risk is implicitly captured in the increased value of water resources from reduced occurrence of human health-based AWQC exceedances.

15.1.4 Benefiting Reaches

EPA identified reaches where it expects the MP&M rule to eliminate existing AWQC exceedances (hereafter, ***benefiting reaches***). These receiving waters are likely to experience significant water quality improvements from reduced MP&M discharges. This analysis combines two AWQC calculation procedures:

- concentrations relative to human health AWQC limits described in Chapter 13, and

- concentrations relative to aquatic life AWQC limits described in the preceding section of this chapter.

A reach is considered to benefit from the MP&M rule if at least one AWQC exceedance is eliminated due to reduced MP&M discharges. This approach differs from some past approaches where EPA took credit for pollution reductions only in cases where all AWQC exceedances are eliminated. EPA believes that the latter approach significantly underestimates benefits from reduced pollutant discharges.

AWQC are developed on a chemical-by-chemical basis, however; they are not designed to assess the toxicity of multiple chemicals. In most cases, the toxicities of chemicals in a mixture are considered additive (i.e., the total toxicity is the sum of the toxicities of the individual chemicals). Total toxicity decreases by the amount of a chemical removed from the mixture.

Benefits to sensitive aquatic species (i.e., amphibians, fish, benthic invertebrates, zooplankton) could occur if the concentration of one chemical fell below its AWQC even when two or more other chemicals still were at or exceeding their respective AWQC. The reason is that the total toxic pressure in the receiving water decreases such that a smaller fraction of the most sensitive species remain affected. For example, three chemicals exceeding their chronic AWQC adversely affected seven percent of all aquatic species in a receiving water . If certain species are particularly sensitive to one of the three chemicals, then eliminating the AWQC exceedance for this chemical would lower the percentage of sensitive species being adversely affected.

The effects of partially removing AWQC exceedances, however, are difficult to generalize. The overall improvement in surface water quality from reduced toxic loadings will depend on the amount and duration of exceedances, together with the kinds of chemical(s) that are removed from the mixture by regulatory action.

Surface water valuation studies show that benefits from partial improvements are likely to be considerable. For example, Carson and Mitchell (1993) found that almost nine out of ten individuals indicated that “halfway” improvements are worth the same as a complete improvement in water quality. The remaining one out of ten individuals were willing to pay a reduced amount for partial improvements in water quality.

EPA’s analysis indicates that baseline pollutant concentrations at current industry discharge levels exceed acute exposure criteria for protection of aquatic species on 878 reaches, and exceed chronic exposure criteria for protection of aquatic species on 2,466 reaches. EPA estimates that the proposed rule would eliminate concentrations in excess of the acute aquatic life exposure criteria on 775 reaches, and would eliminate concentrations in excess of the chronic aquatic life exposure criteria on 1,437 reaches. Table 15.1 summarizes these results.

Table 15.1: Estimated MP&M Discharge Reaches with MP&M Pollutant Concentrations in Excess of AWQC Limits for Protection of Aquatic Species or Human Health

Regulatory Status	Number of Reaches with Concentrations Exceeding AWQC Limits				Total Number of Reaches with Concentrations Exceeding AWQC Limits	Number of Benefiting Reaches	
	AWQC Limits for Aquatic Species		AWQC Limits for Human Health			All AWQC Exceedances Eliminated	Reaches with Some Exceedances Eliminated
	Acute	Chronic	H20 and Organisms	Organisms Only			
Baseline	878	2,466	10,310	192	10,443		
Preferred Option	103	1,437	9,205	71	9,258	1,185	1,837

Note: In the baseline, the total number of reaches with concentrations exceeding AWQC limits does not equal the sum of the numbers in the separate analysis categories because some reaches were estimated to have concentrations in excess of AWQC limits for more than one analysis category.
Source: U.S. Environmental Protection Agency.

Table 15.1 summarizes the number of reaches with estimated baseline concentrations that exceed AWQC limits for either human health or aquatic species, and the number of those reaches where the regulation is estimated to eliminate or reduce exceedances. The combined analysis over *all* AWQC limit categories (i.e., acute and chronic aquatic life and human health) indicates that MP&M pollutant concentrations would exceed at least one AWQC limit on 10,310 reaches as the result of baseline MP&M discharges. The expected discharge reductions from the proposed rule eliminate exceedances on 1,185 of these discharge reaches, leaving 9,258 reaches with concentrations of one or more pollutants that exceed AWQC limits. Of these 9,258 reaches, 1,837 reaches will experience partial water quality improvements.

EPA assigned full benefits in situations where all AWQC exceedances are eliminated by the regulation and partial benefits where the rule eliminates one or more, but not all, AWQC exceedances. EPA calculates partial benefits as the ratio of the AWQC exceedances removed by reducing MP&M discharges to the total number of AWQC exceedances caused by MP&M facilities in the baseline. For example, if the MP&M rule removes seven out of a total ten baseline AWQC exceedances on a benefiting reach, the Agency attributes a 70 percent benefit to the MP&M regulation, where 100 percent would represent a "contaminant-free" level.

15.1.5 Geographic Characteristics of Benefiting Reaches

EPA cannot identify all of the specific reaches affected by MP&M facilities that reduce discharges under the proposed rule because location is known only for the facilities included in the random stratified sample. EPA assumes that facilities represented by the sample facility have the same environmental and geographic characteristics that affect benefits from the proposed rule. These characteristics include waterbody type and physical characteristics (e.g., stream flow conditions), populations residing near the waterbody, and the number of potential recreational users affected. Maps presented in Appendix H depict locations of the discharge reaches estimated to benefit from reduced sample facility discharges. These maps also show locations of the sample MP&M facilities and provide information on populations residing in the counties traversed by benefiting reaches.

The analysis of the sample reach locations indicates that reaches estimated to benefit from the proposed regulation tend to be located in heavily populated areas (see Appendix H). Approximately 20 percent of the sample benefiting reaches are located adjacent to counties with populations of at least one million residents; almost half of the benefiting reaches are located adjacent to counties with populations of at least 500 thousand residents. These reaches have a greater number of potential recreation users than do reaches in less populated areas. The estimated number of potential beneficiaries from the proposed regulation is therefore large (see Section 15.2 for detail).

15.1.6 Extrapolating Sample-based Results to the National Level

EPA used facility sample weights to extrapolate the discharge reach analysis findings from sample facility discharges to national estimates. Where only one facility discharged to a reach, the number of reaches expected to benefit at the national level is the sample weight of the facility. Where more than one sample facility discharged to a reach, EPA used the differential sample-weighting technique outlined in Appendix F to extrapolate national estimates. Section 15.4 discusses limitations and uncertainties associated with this extrapolation technique.

15.2 VALUING ECONOMIC RECREATIONAL BENEFITS

The proposed MP&M rule will improve aquatic habitats by reducing concentrations of ***priority (i.e., toxic)***, ***nonconventional***, and ***conventional*** contaminants in water. These improvements will enhance the quality and value of water-based recreation, such as fishing, wildlife viewing, camping, waterfowl hunting, and boating. This analysis measures the economic benefit of the MP&M regulation to society by estimating the increased monetary value of recreational opportunities resulting from water quality improvements.

This analysis uses ***benefits transfer*** to monetize changes in water resource recreational values for reaches affected by MP&M discharges.[3] The benefits transfer analysis estimates the total WTP value (including both use and nonuse values) for improvements in surface water quality. This approach builds upon an analysis of applicable surface water valuation literature to estimate recreational benefits from improved water quality. The analysis estimates economic benefits for fishing, wildlife viewing, and boating.

15.2.1 Transferring Values from Surface Water Valuation Studies

EPA identified several surface water evaluation studies that quantified the effects of water quality improvements on various water-based recreational activities. The Agency used the following technical criteria for evaluating study transferability (Boyle and Bergstrom, 1990):

The environmental change valued at the study site must be the same as the environmental quality change caused by the rule (e.g., changes in toxic contamination vs changes in turbidity);

The populations affected at the study site and at the policy site must be the same (e.g., recreational users vs nonusers);

- The assignment of property rights at both sites must lead to the same theoretically appropriate welfare measure (e.g., willingness to pay vs willingness to accept compensation).

[3] Benefits transfer involves the application of value estimates, functions, and/or models developed in one context to address a similar resource valuation question in another context.

In addition to the above criteria, the Agency considered authors' recommendations regarding robustness and theoretical soundness of various estimates.

Existing studies are unlikely to meet all of the above criteria. Boyle and Bergstrom (1990) reported that most researchers will likely encounter problems with at least one criterion. This analysis is no exception. The major limitation in performing the national analysis is the comparability of the water quality changes considered in the original studies with the water quality changes considered in this analysis. These comparisons are discussed below.

The Agency used eight of the most comparable studies and calculated the changes in recreation values resulting from water quality improvements (as a percentage of the baseline value) implied by those studies. EPA took a simple mean of upper- and lower-bound estimates from these studies to derive a range of percentage changes in the water resource values due to water quality improvements. The studies used for benefits transfer in the MP&M regulatory analysis included Lyke (1993), Jakus et al. (1997), Montgomery and Needelman (1997), Phaneuf et al. (1998), Desvousges et al. (1987), Lant and Roberts (1990), Farber and Griner (2000), and Tudor et al. (2000). Appendix I presents WTP values for various water quality improvements and summarizes EPA's reasoning for selecting specific WTP estimates for benefits transfer. Each of the eight studies and the WTP values selected for benefit transfer are discussed briefly below.

- Lyke's (1993) study of the Wisconsin Great Lakes open water sport fishery showed that anglers may place a significantly higher value on a contaminant-free fishery than on one with some level of contamination. Lyke estimated the value of the fishery to Great Lakes trout and salmon anglers if it were improved enough to be "completely free of contaminants that may threaten human health," and found that this value would add between 11 and 31 percent of the fishery's current value.

- Jakus et al. (1997) used a repeated discrete choice ***travel cost*** **(TC)** model to examine the impacts of sportfishing consumption advisories in eastern Tennessee. The model controlled for anglers' knowledge of advisories, the type of angler (i.e., fish consumption vs. catch and release), and catch rate. The estimated welfare gain (as a percentage of baseline) from cleaning up six reservoirs and removing these advisories ranges from six to eight percent. These estimates are below Lyke's estimated 11 to 31 percent range, due to the difference in methodology used. The TC method captures use values only, while the combined TC and stated preferences method used in Lyke captures both the use and nonuse components of the resource value to users. Differences in the fisheries and user populations may also affect the estimated percentage changes in the resource value.

- Montgomery and Needelman (1997) estimated benefits from removing "toxic" contamination from lakes and ponds in New York State. They used a binary variable as their primary water quality measure, which indicates whether the New York Department of Environmental Conservation considers water quality in a given lake to be impaired by toxic pollutants. The model controls for major causes of impairments other than "toxic" pollutants to separate the effects of various pollution problems that affect the fishing experience. The estimates from Montgomery and Needelman imply that removing "toxic" impairments in all New York lakes and ponds would increase recreational fishing value by 13.7 percent.

- Phaneuf et al. (1998) studied angling in Wisconsin Great Lakes. They estimated changes in recreational fishing values resulting from a 20 percent reduction of toxin levels in lake trout flesh. The study uses a TC model to value water quality improvements when ***corner solutions*** are present in the data. Corner solutions arise when consumers visit only a subset of the available recreation sites, setting their demand to zero for the remaining sites. Phaneuf et al. found that improved industrial and municipal waste management results in general water quality improvement. This improvement leads in turn to a 20 percent decrease in fish tissue toxin levels, yielding a welfare gain of $156.36 (1999$) per angler per year.[4] This estimate implies that recreational fishing values would increase by approximately 27.5 to 34.3 percent from reduced toxin levels. This analysis estimates use values only.

- Desvousges et al. (1987) used findings from a ***contingent valuation*** **(CV)** survey to estimate WTP for improved recreational fishing from enhanced water quality in the Pennsylvania portion of the Monongahela River. In a hypothetical market, each survey respondent was asked to provide an option price for different water quality changes, including "raising the water quality from suitable for boating (hereafter, "boatable" water) to a level where gamefish would survive (hereafter, "fishable" water)."

[4] The study used the 1989 survey data. Therefore, this analysis assumes that all estimates in the original study are in 1989 dollars.

The MP&M analysis assumed that reaches with AWQC exceedences under the baseline conditions are likely to support rough fishing but may not be clean enough to support game fishing. Removing AWQC exceedences is therefore comparable to shifting water quality from "boatable"to "fishable." This is a relatively conservative assumption. Desvousges et al. found that improving water quality from “boatable” to “fishable” would yield a 5.9 to 7.9 percent increase in water resource value to recreational anglers.

- Lant and Roberts (1990) used a CV study to estimate the recreational and nonuse benefits of improved water quality in selected Iowa and Illinois river basins. River quality was defined by means of an interval scale of “poor,” “fair,” “good,” and “excellent.” The authors defined “fair” water quality as adequate for boating and rough fishing and “good” water quality as adequate for gamefishing.

  The MP&M analysis assumes that eliminating AWQC exceedences is roughly equivalent to shifting water quality from "fair"to "good." The estimates from this study imply an increase of 9.7 to 13.1 percent in recreational fishing value from improving water quality from “fair” to “good.”

- Farber and Griner (2000) used a CV study to estimate changes in water resource values to users from various improvements in water quality in Pennsylvania. The study defines water quality as “polluted,” “moderately polluted,” and “unpolluted” based on a water quality scale developed by EPA Region III: “Polluted” streams are unable to support aquatic life; “moderately polluted” streams are somewhat unable to support aquatic life; and “unpolluted” streams adequately support aquatic life. Streams unable to support aquatic life (i.e., "severely polluted") are likely to be affected by environmental stressors unrelated to MP&M discharges, such as acidity or severe oxygen depletion.

  The MP& analysis assumes that most streams affected by MP&M facility discharges are moderately polluted; i.e., these streams support aquatic life, but sensitive species may be adversely affected by MP&M pollutants that exceed AWQC values protective of aquatic life. Removing all AWQC exceedences would make such streams unpolluted. The estimates from this study imply that improving water quality from “moderately polluted” to “unpolluted’ would yield an increase in recreation fishery value ranging from 3.9 to 9 percent.

- Tudor et al. (2000) used a TC model to estimate changes in water resource recreation values resulting from eliminating MP&M pollutant concentrations in excess of AWQC limits at recreation sites in Ohio.[5] The study involves four recreation activities -- fishing, boating, near-water recreation, and swimming -- and covers most recreationally-important water bodies in all Ohio counties. The study considers two types of water quality effects from MP&M pollutants on consumers’ decisions to visit a particular waterbody:

  (1) visible or otherwise perceivable effects (e.g., turbidity and odor); and
  (2) "toxic" effects that are not directly perceivable by consumers.

  Because priority and nonconventional pollutants at high enough concentrations may adversely affect aquatic species, “toxic” effects may be indirectly observable via species abundance and diversity. The study uses a dummy variable to account for effects of "toxic" MP&M pollutants, identifying recreation sites at which estimated concentrations of one or more MP&M pollutants exceed AWQC for protection of aquatic life. The study estimated that eliminating AWQC exceedances would yield seasonal per user benefits ranging from $27.6 to $37.0, $92.2 to $107.6, $11.2 to $16.9, and $12.06 to 13.58 (1999$) from improved fishing, boating, wildlife viewing, and swimming opportunities, respectively. The estimated changes in the recreational use value of Ohio water resources, range from 3.4 to 5.0, 13.7 to 17.0, 6.8 to 10.7 percent for fishing, boating, and wildlife viewing, and swimming, respectively. This analysis estimates use values only.

With the exception of the Tudor et al. (2000) study, the types of water quality changes assessed in these studies are only roughly comparable to those studied in the MP&M analysis. Whereas the analysis of the proposed MP&M regulation and Tudor et al. (2000) assessed the impact of eliminating AWQC exceedances, the other studies used other measures of water quality improvement. EPA addressed the differences in measurement between the other studies and the MP&M analysis by linking water quality changes expected from the MP&M regulation to the type of

[5] Preliminary results of this study were presented at the annual American Agricultural Economic Association meeting (L. Tudor et al., 1999a) and at the annual Northeastern Agricultural and Resource Economic Association Meeting (L. Tudor et al., 1999b). This study can be found in Chapter 21.

water quality changes assessed in the other studies. EPA assumed that eliminating AWQC exceedances is roughly comparable to the following discrete water quality changes:[6]

- "achieving a contaminant free fishery;"
- reducing the level of toxins in fish tissue;
- removing fish consumption advisories (FCA); and
- improving water quality from "boatable" to "fishable," from "fair" to "good," and from "moderately polluted" to "unpolluted."

The MP&M analysis uses the estimates derived from the eight surface water evaluation studies described above to calculate a range of national WTP values.

The following sections present the methodology and relevant values used to estimate the value of improved fishing, wildlife viewing, and boating opportunities resulting from the MP&M regulation.

15.2.2 Recreational Fishing

The MP&M rule will improve the recreational angling experience by reducing concentrations of priority, nonconventional, and conventional contaminants in water. EPA estimated the benefits of these reductions by estimating:

- the number of recreational fishing days on benefiting reaches;
- the baseline fishery value of each benefiting reach; and
- changes in recreational fishery value, using values from the available surface water valuation studies.

[6] Section 15.1.4 discusses a method used for estimating partial water quality improvements.

a. Number of recreational fishing days

EPA calculated the annual number of person-days of recreational fishing for each benefiting reach using a two-step approach:

❖ ***Participating population***

The geographic area from which anglers would travel to fish a reach is assumed to include only those counties that abut a given reach. As noted in Chapter 13, this assumption is based on the finding in the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation that 65 percent of anglers travel less than 50 miles to fish (U.S. Department of the Interior, 1993). NDS data showed that recreational anglers travel from 20 to 54 miles to their destination, with an average one-way travel distance of 30 miles.[7]

EPA estimated the population participating in recreational fishing using the number of licensed fishermen in counties bordering MP&M discharge reaches using the following steps:

- assume that fishing activity among these anglers is distributed evenly among all reach miles within those counties;
- compute the length of the MP&M reach as a percentage of total reach miles within corresponding counties;
- multiply the estimated ratio by the total fishing population in counties abutting the reach to estimate the number of anglers who may fish an MP&M reach; and
- reduced the number of anglers by 20 percent in reaches where MP&M and other pollutants have required a fish consumption advisory. This reduction is an estimate of angler response to the presence of a fish consumption advisory.[8]

❖ ***Average number of fishing days***

Anglers generally participate in recreational fishing several times a year. The ***U.S. Fish and Wildlife Service (FWS)*** provides estimates of the average number of fishing days per angler in each state. The FWS estimates range from 10.5 days per angler in Arizona to 21.1 days per angler

[7] See Chapter 21 for detail on the NDS data.

[8] See Belton et al. (1986), Knuth and Velicer (1990), Silverman (1990), West (1989), Connelly et al. (1992), and Connelly and Knuth (1993) for more information on angler response to fish advisories.

in Alabama for freshwater fishing, and 7.3 days per angler in Louisiana to 18.7 days per angler in Virginia for saltwater fishing.[9]

EPA calculated the total number of angler days by multiplying the number of recreational anglers for each benefiting reach by the average number of fishing days for the reach (based on the state in which the reach is located).

b. Baseline fishery value

The net value of a recreational fishing day is the total value of the fishing day exclusive of any fishing-related costs (e.g., license fees, travel costs, bait, tackle, charter boats, etc.) incurred by the angler.

EPA used two recreational fishing valuation studies (Bergstrom and Cordell (1991) and Walsh et al. (1992)) to calculate the net economic value per recreational fishing day under the baseline conditions. Both studies used a meta-analysis of recreational fishery valuation studies to estimate per-day values of the three types of recreational fishing: warmwater, coldwater, and anadromous. Based on the two studies, EPA developed an average per-day value for each type of recreational fishing. This analysis uses low and high average benefit values for fishing days of $26.44 and $56.85 (1999$) to estimate a range of the baseline fishery values.

Table 15.2: Baseline Values of Fishing

Fishery Type	Per-day Value (1999$)[a]		Average Per-day Value (1999$)
	Bergstrom and Cordell (1991)[b]	Walsh et al. (1992)[c]	
Warmwater	$18.36	$34.52	$26.44
Coldwater	$26.12	$44.88	$35.50
Anadromous	$34.55	$79.16	$56.85
Range of above			$26.44-$56.85

a. Original study values were adjusted to $1999 based on the relative change in CPI from 1987 to 1999.
b. Study location: various U.S. locations. Estimating approach: meta-analysis of TC studies.
c. Study location: various U.S. locations. Estimating approach: meta-analysis of CV and TC studies.

EPA calculated the total baseline value for each fishery located on a benefiting reach by multiplying the estimated net value of a recreational fishing day by the total number of fishing days calculated in subsection (a) above. Applying facility weights and summing over all benefiting reaches provides a total baseline recreational fishing value for MP&M reaches expected to benefit from the elimination of pollutant concentrations in excess of AWQC limits.

c. Changes in recreational fishery value

Expected benefits from the proposed MP&M regulation include an increase in the quality of an angler's recreational opportunities and/or the number of days an angler chooses to fish each season.

EPA assumes that the expected welfare gain for recreational anglers is a function of changes in the overall quality of all recreational opportunities available to each angler. Recreational anglers residing in the counties abutting MP&M reaches will therefore benefit from improved recreational opportunities whether or not they actually visit an MP&M reach.

EPA used the eight studies discussed above to calculate the changes in recreation values from water quality improvements (as a percentage of baseline) implied by those studies. Table 15.1 compiles information on the baseline values, values of changes in water quality, and percentage changes in values reported or implied by these studies.

[9] These averages reflect participation levels in the 48 contiguous states. No sample facility is located in Hawaii or Alaska.

Table 15.3: Studies Estimating Changes in Value of a Recreational Fishery

Study	Type of Water Quality Change Valued	Baseline Value of Recreational Angling (1999$)	Value of Water Quality Change (1999$)	Value of Change as % of Baseline	Type of Benefits Included
Lyke (1993)	Fish tissue is completely free of toxic contaminants that may threaten human health	$89.4-$111.9 million per year [a]	$9.9-$34.9 million per year [a]	11% -31%[a]	Use and nonuse values for recreational anglers
Jakus et al. (1997)	Lifting FCAs	$24.5-$49.5 per trip	$1.92-$2.97 per trip	6.0% -8.0%	Use values for recreational anglers
Montgomery and Needelman (1997)	Elimination of toxic impairment	$617.7 per angler per year [b]	$84.9 per angler per year	13.7%	Use values for recreational anglers
Phaneuf at al. (1998)	20% reduction of toxic contamination in trout flesh	$455.8 - $569.9 per angler per year [a]	$156.36 per angler per year	27.5% -34.3%	Use values for recreational anglers
Desvousges et al. (1987)	Improvement from “boatable” to “fishable”	$26.44- $35.50 per trip (1999$)[c]	$2.08 per trip (1999$)[d]	5.9% -7.9%	Recreational and nonuse values to users
Lant and Roberts (1990)	Improvement from “fair” to “good”	$26.44- $35.50 per trip (1999$)[c]	$3.45 per trip (1999$)[e]	9.7% -13.1%	Recreational and nonuse values to users
Farber and Griner (2000)	Improvement from “moderately polluted” to “unpolluted”	$26.44- $35.50 per trip (1999$)[c]	$1.40-$2.40 per trip (1999$)[f]	3.9% -9.0%	Recreational use values to users and nonusers
Tudor et al. (2000) [g]	Elimination of AWQC exceedances	$ 1,691-$1,933 per angler per year	$27.6-$37.0 per angler per year	3.4%-5.0% [h]	Use values for recreational anglers
Average percentage change in recreational fishery value (based on above studies) [i]				10.2% -15.2%	Recreational and nonuse values to users

a. The baseline fishery value for the study site location is based on the baseline fishery value reported in Lyke (1993). The study used data from two mail surveys conducted in 1989 at the University of Wisconsin-Madison. These surveys were originally used by Lyke (1993).
b. Based on the average value for a coldwater fishing day of $35.50 (see Table 15.2), multiplied by the average number of freshwater (non-Great Lakes) angling days per year in New York State (17.4 days, USFWS, 1996).
c. Range based on the range of values for a fishing day used in this analysis (see Table 15.2);
d. Based on the value of water quality improvement of $34.61per year (updated from 1987 dollars reported in Desvousges et al.) divided by the average number of freshwater angling days per year in Pennsylvania (16.6 days, USFWS, 1996).
e. Based on the value of water quality improvement of $54.38 per year (updated from 1990 dollars reported in Lant and Roberts) divided by the average number of freshwater angling days per year in Iowa and Illinois (16.6 and 15.5 days, USFWS, 1996).
f. Based on the values of water quality improvements ranging from $23.09 to $39.44 per year reported in Farber and Grinner (2000), divided by the average number of freshwater angling days per year in Pennsylvania (16.6 days, USFWS, 1996).
g. See Chapter 21 of this report for detail. The baseline value of recreational fishery is based on the estimated mean value of water resources for recreational anglers reported by Tudor et. al (2000). The estimated median value of recreational fishing ranges from $414.09 to $516.86.
h. To derive a range of the percentage change in water resource value for anglers, EPA estimated the lower and upper bounds of the percentage change in resource value for each angler and then averaged these estimates over all fishing participants.
i. EPA took a simple mean of lower- and upper-bound estimates from the eight studies to calculate a range of percentage changes in the recreational fishery value from improved water quality conditions.

EPA used the percentage change in the fishery value implied by the eight studies to estimate increased recreational fishing values for all MP&M reaches in which the regulation eliminates AWQC exceedances of one or more MP&M pollutants. That is, the Agency estimated benefits for all MP&M discharge reaches where at least one AWQC exceedance is eliminated due to reduced MP&M discharges.

As noted above, EPA took a simple mean of lower- and upper-bound estimates from the eight studies described above to calculate a range of percentage changes in the recreational fishery value from reduced MP&M discharges. These studies yielded estimates of increased value ranging from 10.2 to 15.2 percent. Multiplying these percentages by the baseline value of fisheries located on benefiting reaches yielded a range of benefits from eliminating pollutant concentrations in excess of AWQC limits.

Table 15.4 below summarizes the results of EPA's recreational fishing benefits analysis.

15.4: Summary of Recreational Fishing Benefits

	Number of Benefiting Reaches	Participating Population (millions)	Average Number of Fishing Days	Total Angler Days (millions)	Baseline Fishery Value/ Recreation Day	Baseline Fishery Value ($ billions)	% Change in Fishery Value	MP&M Benefits ($ millions)
Low Estimate	3,022	20.2	14.9	301.1	$26.4	$7.80	10.2%	$195.8
High Estimate	3,022	20.2	14.9	301.1	$56.9	$17.1	15.2%	$627.1

Source: U.S. EPA analysis

15.2.3 Wildlife Viewing

EPA expects that water quality improvements from the MP&M regulation will decrease the load of pollutants that are taken up into aquatic food chains. These changes are expected to increase the health and reproductive success of sensitive wildlife species that feed on fish and other aquatic organisms. In particular, ***Piscivorous*** (i.e., fish-eating) bird species - such as the osprey (*Pandion haliaetus*), bald eagle (*Haliaeetus leucocephalus*), great blue heron (*Ardeidae herodias*), mergansers (*Merginae* sp.), and cormorants (*Phalacrocorax* sp.) - will benefit from increased numbers, size, and health of forage fish. Increased food and lower pollutant levels in fish flesh will improve reproduction in these birds, leading to healthier and larger bird populations. Reducing conventional pollutant loadings will also improve visual aesthetics, thereby enhancing wildlife viewing and other near-water-based recreation experiences, such as photography, camping, picnicking, and waterfowl hunting (hereafter, this discussion refers to all of these activities as "wildlife viewing").

As with the recreational fishing analysis, EPA assumes that the expected welfare gain for consumers of viewing activities is a function of changes in the overall quality of all recreational opportunities available to each consumer. Consumers of water-based recreation residing in the counties abutting MP&M reaches are therefore likely to benefit from improved recreational opportunities whether or not they actually visit an MP&M reach.

EPA estimated wildlife viewing benefits using an approach similar to that used in estimating recreational fishing benefits. EPA estimated:

- the number of wildlife viewing days on benefiting reaches;
- the baseline value of wildlife viewing for each benefiting reach; and
- changes in wildlife viewing value, using values from the available surface water valuation studies.

a. Number of wildlife viewing days

EPA calculated the annual number of person-days of wildlife viewing for each benefiting reach using a two-step approach:

❖ ***Participating population***

The analysis of the NDS data showed that participants in viewing activities travel from 18 to 55 miles to their destination, with an average one-way travel distance of 34 miles. EPA therefore assumes that improvements in recreational opportunities will only benefit recreational users residing within the counties abutting MP&M reaches. EPA estimated the population participating in viewing activities using the number of water-based recreation consumers residing in the counties traversed by benefiting reaches using the following steps:

- estimate resident populations in the counties traversed by the benefiting reaches using Census data;
- calculate the number of wildlife viewing participants based on the percent of the population engaged in wildlife viewing activities;

- estimate the percentage of individuals that participate in wildlife viewing in each state using NDS data. The total state population participating in wildlife viewing ranges from 8.5 percent in New Mexico to 44 percent in Maine; and

- adjust the number of wildlife viewing participants within the affected county based on the ratio of the affected reach length to the number of total reach miles in the affected county to calculate the population potentially benefiting from the rule.[10,11]

❖ ***Average number of viewing days:***
Recreators generally participate in wildlife viewing several times a year. The Agency used NDS data on the number of wildlife viewing trips to estimate the average number of user days in each state. The NDS data show that the number of wildlife viewing trips in the 48 states range from 1.07 days per user in South Dakota to 24 days per user in Mississippi.[12]

EPA multiplied the number of wildlife viewing consumers by estimates of the average number of days per user in each state to estimate the annual number of user days for each benefiting MP&M reach.

b. Baseline value of wildlife viewing

EPA estimated the baseline value of wildlife viewing for the benefiting reaches based on the estimated annual person-days calculated in subsection (a) above and the estimated value per person-day of wildlife viewing.

EPA used two recreational activity valuation studies (Bergstrom and Cordell (1991) and Walsh et al. (1992)) to calculate the net economic values per wildlife viewing day. These studies estimate net benefit values for four recreational activities: wildlife viewing, waterfowl hunting, camping, and picnicking. Based on the two studies, EPA developed an average per-day value for three of the four activities.[13] EPA's MP&M benefits analysis uses the lowest average benefit value, $21.38, for the low estimate of wildlife viewing benefits and the highest average value, $27.03, for the high estimate. Table 15.5 presents information on the relevant values reported in these studies.

Using facility sample weights and summing over all benefiting reaches provides the total baseline value of wildlife viewing for MP&M reaches that EPA expects to benefit by eliminating pollutant concentrations in excess of AWQC limits.

Table 15.5: Baseline Values of Wildlife Viewing

Recreational Activity	Per-day Value (1999$)[a] Bergstrom and Cordell (1991)[b]	Walsh et al. (1992)[c]	Average Per-day Value (1999$)
Camping	$25.49	$28.58	$27.03
Picnicking	$17.37	$25.40	$21.38
Near-water Activities	$18.88	$32.54	$25.71
Range of above			$21.38 - $27.03

a. Original study values were adjusted to $1999 the base year of the analysis based on the relative change in CPI from 1987 to 1999.
b. Study location: various U.S. locations; estimating approach: meta-analysis of TC studies.
c. Study location: various U.S. locations; estimating approach: meta-analysis of contingent valuation (CV) and TC studies.

c. Changes in wildlife viewing value

EPA selected a subset of the candidate benefits transfer studies discussed in Section 15.2.1 to estimate changes in water resource value to wildlife viewers due to the MP&M rule. The four selected studies include Tudor et al. (2000), Desvousges et al. (1987), Lant and Roberts (1990), and Farber and Griner (2000).[14] Table 15.6 compiles information on the baseline values of wildlife viewing, values of changes in water quality, and percentage change in values reported or implied by these studies.

[10] Information in EPA's Reach File 1 indicates that the ratio of affected reach length to the total number of reach miles within a county ranges from 0.02 to 0.39.

[11] This analysis assumes that recreation activities among residents of the counties affected by MP&M discharges are distributed evenly across all reach miles within those counties.

[12] See Chapter 21 for details on the NDS data.

[13] EPA excluded the per-day value of waterfowl hunting ($52.24) from the activities included in this analysis, because this activity is limited to designated hunting areas only.

[14] The remaining four studies value changes in the value recreational fishing only.

Table 15.6: Studies Estimating Changes in Value of Wildlife Viewing

Study	Water Quality Change Valued	Baseline Value of Wildlife Viewing (1999$)	Value of Water Quality Change (1999$)	Value of Change as % of Baseline	Type of Benefits Included
Desvousges et al. (1987)	Improvement from "boatable" to "fishable"	$21.4 - $27.0 per trip [a]	$4.70 per trip [b]	17.4% - 22.0%	Recreational and nonuse values to users
Lant and Roberts (1990)	Improvement from "fair" to "good"	$21.4 - $27.0 per trip [a]	$8.09 per trip [c]	29.9% - 37.8%	Recreational and nonuse values to users
Farber and Griner (2000)	Improvement from "moderately polluted" to "unpolluted"	$21.4 - $27.0 per trip [a]	$3.13 - $5.35 per trip [d]	11.6% - 25.0%	Recreational and nonuse values to users
Tudor et al. (2000)	Elimination of AWQC exceedances	$376.3 - $427.6 per user per year [e]	$11.16 - $16.88 per user per year	6.8% - 10.7% [f]	Recreational use values to users
Average percentage change (based on the above studies)[g]				16.4%-23.9%	

a. Based on the range of median values for a near-water recreation day (updated to 1999 dollars) reported in Walsh et al. (1992) and Bergstrom and Cordell (1991) (see Table15.5).
b. Based on the value of water quality improvement of $34.61per person per year (updated from 1987 dollars reported in Desvousges et al.) divided by the average number of near-water recreation days per year in Pennsylvania (7.37 days, NDS, 1993).
c. Based on the value of water quality improvement of $54.36 per year (updated from 1990 dollars) reported in Lant and Roberts divided by the average number of near-water recreation days per year in Iowa and Illinois (9.58 and 5.04 days, NDS, 1993).
d. Based on the value of water quality improvements ranging from $23.09 to $39.44 per person per year reported in Farber and Griner (2000) divided by the average number of near-water recreation days per year in Pennsylvania (7.37 days, NDS, 1993).
e. The baseline value of viewing is based on the estimated mean value of water resources for wildlife viewers reported by Tudor et. al (2000). The estimated median value of recreational fishing ranges from $108.74 to $135.41.
f. To derive a range of the percentage change in water resource value for wildlife viewers, EPA estimated the lower and upper bounds of the percentage change in resource value for each consumer and then averaged these estimates over all viewing participants.
g. EPA took a simple mean of lower- and upper-bound estimates from the four studies to calculate a range of percentage changes in the wildlife viewing value from improved water quality conditions.

This analysis uses the change of 16.4 percent for the low benefits estimate and 23.9 percent for the high benefits estimate to calculate benefits from reduced MP&M facility discharges to users of water-based recreation. These values represent the average of the low and high values, respectively, estimated in the four studies.

Table 15.7 below summarizes the results of EPA's wildlife viewing benefits analysis.

Table 15.7: Summary of Wildlife Viewing Benefits

	Number of Benefiting Reaches	Participating Population (millions)	Ave. Number of Viewing Days	Total Viewing Days (millions)	Baseline Value/ Rec. Day	Total Baseline Value ($ billions)	% Change in Value	Benefit from MP&M ($ million)
Low Estimate	3,022	57.1	9.9	567	$21.4	$12.1	16.4%	$500.1
High Estimate	3,022	57.1	9.9	567	$27.0	$15.3	23.9%	$919.9

Source: U.S. EPA analysis.

15.2.4 Recreational Boating

Improvements in water quality from the proposed MP&M rule may enhance recreational boating by (1) providing more opportunities for companion activities (e.g., fishing and wildlife viewing) and (2) improving visual aesthetics. EPA assumes that the expected welfare gain for boaters is a function of changes in the overall quality of all recreational opportunities available to each boater on a given day.

This analysis estimates recreational boating benefits the same way as recreational fishing and wildlife viewing benefits. The analysis estimates:

- the number of recreational boating days on benefiting reaches,
- the baseline value of boating for each benefiting reach, and
- changes in recreational boating value.

a. Number of recreational boating days

EPA calculated the annual number of recreational boating days for each benefiting reach using two steps:

❖ ***Participating population***

The analysis of the NDS data showed that boaters travel from 11 to 52 miles to their destination, with an average one-way travel distance of 32 miles. This analysis therefore considers only boaters residing in the counties abutting MP&M reaches. EPA estimated the number of boaters residing in the counties traversed by benefiting reaches by combining information from Census data and NDS data on the proportion of individuals participating in boating in each state. The percent of the total state population in the 48 states participating in boating ranges from 6 percent in Colorado to 25 percent in Washington. EPA further adjusted the number of boaters likely to use MP&M reaches within the affected county based on the ratio of the affected reach length to the number of total reach miles in the affected county.[15]

❖ ***Average number of boating days***

People using benefiting reaches for boating generally participate in this activity several times per year. The NDS data show the number of boating trips in the 48 states ranging from 2.2 days per user in South Dakota to 17.5 days per user in Kansas.

EPA estimated the annual number of user days for recreational boating activities by multiplying the number of boaters by the average number of boating days per user in each state.

b. Baseline value of boating

EPA estimated the baseline value of boating on benefiting reaches using the estimated annual person-days of boating per reach and estimated values per person-day of various types of boating. EPA calculated a range of net economic values per recreation day of boating based on studies by Bergstrom and Cordell (1991) and Walsh et al. (1992). Mean net benefit values for motorized and non-motorized boating are \$35.09 to \$55.75 in 1999 dollars. Table 15.8 compiles information on the relevant values reported in these studies.

Table 15.8: Baseline Values of a Boating Day

Recreational Activity	Per-day Value (1999$)[a] Bergstrom and Cordell (1991)[b]	Per-day Value (1999$)[a] Walsh et al. (1992)[c]	Average Per-day Value (1999$)
Motorized	\$23.92	\$46.26	\$35.09
Non-motorized	\$40.14	\$71.35	\$55.75
Boating (any type)			\$35.09 - \$55.75

a. Original study values were adjusted to \$1999 based on the relative change in CPI from 1987 to 1999.
b. Study location: various U.S. locations. Estimating approach: meta-analysis of TC studies.
c. Study location: various U.S. locations. Estimating approach: meta-analysis of CV and TC studies.

Weighting by facility sample weights and summing over all benefiting reaches provides a total baseline value of boating for MP&M reaches expected to benefit by eliminating pollutant concentrations in excess of AWQC limits.

c. Changes in recreational boating values

The Agency used the same four studies discussed in Section 15.2.3 to calculate the change in per-day boating value as a result of water quality improvements. EPA expressed this change as a percentage of the baseline value. Table 15.9 compiles information on the baseline values of boating, values of changes in water quality, and percentage change in boating values reported or implied by these studies.

[15] See section 13.1.1 for detail.

Table 15.9: Studies Estimating Changes in Value of Recreational Boating

Study	Water Quality Change Valued	Baseline Value of Boating (1999$)	Value of Water Quality Change (1999$)	Value of Change as % of Baseline	Type of Benefits Included
Desvousges et al. (1987)	Improvement from "boatable" to "fishable"	$35.09 - $55.75 per trip [a]	$3.69 per trip [b]	6.6% -10.5%	Recreational and nonuse values to users
Lant and Roberts (1990)	Improvement from "fair" to "good"	$35.09 - $55.75 per trip [a]	$7.44 per trip [c]	13.3% -21.2%	Recreational use values to users and nonusers
Farber and Griner (2000)	Improvement from "moderately polluted" to "unpolluted"	$35.09 - $55.75 per trip [a]	$2.46 - $4.21 per trip [d]	4.4%-12.0%	Recreational and nonuse values to users
Tudor et al. (2000)	Elimination of AWQC exceedances	$1,154 - $1,243 per user per year [e]	$92.15 - $ 107.55 per user per year	13.7% - 17% [f]	Recreational values for users
Average percentage change (based on the above studies)[g]				9.5%-15.2%	

a. Based on the average value for a boating day (updated to 1999 dollars) reported in Walsh et al. (1992) and Bergstrom and Cordell (1991).
b. Based on the value of water quality improvement of $34.61per person per year (updated from 1987 dollars) reported in Desvousges et al. divided by the average number of boating days per year in Pennsylvania (9.37 days, NDS, 1993).
c. Based on the value of water quality improvement of $54.36 per person per year (updated from 1990 dollars) reported in Lant and Roberts divided by the average number of boating days per year in Iowa and Illinois (9.58 and 5.04 days, NDS, 1993).
d. Based on the value of water quality improvements ranging from $23.09 to $39.44 per person per year reported in Farber and Griner (2000) divided by the average number of boating days per year in Pennsylvania (9.37 days, NDS, 1993).
e. The baseline value of boating is based on the estimated mean value of water resources for boaters reported by Tudor et. al (2000). The estimated median value of recreational boating ranges from $181.99 to $199.82.
f. To derive a range of the percentage change in recreational boating value, EPA estimated the lower and upper bounds of the percentage change in resource value for each consumer and then averaged these estimates over all recreational boaters.
e. EPA took a simple mean of lower- and upper-bound estimates from the four studies described to calculate a range of percentage changes in the recreational boating value from improved water quality. When only one value is available from the study (i.e., Tudor et al.), EPA used this value in calculating both the lower- and upper-bound estimates.

This analysis uses the change of 9.5 percent for the low benefits estimate and 15.2 percent for the high benefits estimate to calculate benefits to boaters from reduced MP&M facility discharges. These values represent the average of the low and high values, respectively, estimated in the four studies.

Table 15.10 summarizes the results of EPA's recreational boating benefits analysis.

Table 15.10: Summary of Recreational Boating Benefits

	Number of Benefiting Reaches	Participating Population (millions)	Ave. Number of Boating Days	Total Boating Days (millions)	Baseline Value/ Rec. Day	Total Baseline Value ($ billion)	% Change in Value	MP&M Benefits ($ millions)
Low Estimate	3,022	33.1	8.9	296	$35.1	$10.4	9.50%	$265.0
High Estimate	3,022	33.1	8.9	296	$55.8	$16.5	15.20%	$672.1

Source: U.S. EPA analysis.

15.2.5 Nonuse Benefits

Individuals who never visit or otherwise use a natural resource may still be affected by changes in its status or quality. Empirical estimates indicate that such "nonuse values" may be substantial for some resources (Harpman et al., 1993; Fisher and Raucher, 1984; Brown, 1993). Most studies have found that nonuse values exceed use values. Brown reviewed CV studies in which both use and nonuse values were estimated, and calculated the ratio of nonuse values to use values (Brown, 1993). His 34 estimated ratios range from 0.1 to 10, with the median ratio of 1.92. Carson and Mitchell suggested that nonuse benefits account for 19 to 39 percent of total WTP values for water quality improvements depending on the definition of nonuse values (Carson and Mitchell, 1993). The ratio of nonuse to use value ranges from one-fourth to two-thirds based on the Carson and Mitchell study (1993). Fisher and Raucher (1984) found that nonuse benefits comprise one-half of recreational use benefits.

EPA estimated changes in nonuse values for this analysis because nonuse value is a sizeable portion of the total value of water resources. Based on the studies discussed above, this analysis estimated that nonuse benefits (i.e., benefits to individuals who do not participate in water-based recreation) comprise one-fourth, one-half, and two-thirds of recreational use benefits for low, mid, and high estimate, respectively.

15.3 Summary of Recreational Benefits

EPA assumes that eliminating concentrations of MP&M pollutants in excess of AWQC limits will achieve water quality protective of aquatic life and human health. This improved water quality then generates benefits for both users and nonusers of water-based recreation. These benefits can be seen as an increase in the value of each day spent on or near the waterway, as well as an increase in the number of days spent on or near the waterway. EPA estimated the monetary value of improved water-based recreational opportunity for the 1,185 discharge reaches for which concentrations in excess of AWQC limits would be eliminated. The Agency also assigned partial benefits to the 1,837 reaches that would experience reduced numbers of AWQC exceedences.

EPA first estimated the number of recreational days on benefiting reaches for each water-based activity. The Agency then calculated the baseline value of these activities and then calculated the percentage changes in this value stemming from water quality improvements.

EPA calculated partial benefits for the 1,837 reaches with reduced numbers of AWQC exceedances by adjusting the percentage increase in the recreational value of these reaches. EPA made these adjustments based on the ratio of the number of AWQC exceedances eliminated post-compliance to the number of AWQC exceedances occurring at baseline.

Table 15.13 summarizes benefit estimates by recreational category. The activities considered in this analysis are stochastically independent; EPA calculated the total value of enhanced water-based recreation opportunities by summing over the three recreation categories. EPA also estimated the changes in nonuse value resulting from reduced MP&M discharges based on the ratio of use to nonuse values implied by the Fisher and Raucher study (Fisher and Raucher, 1984). The estimated increase in nonuse value ranges from $240 to $1,464 million (1999$), with a midpoint value of $760 million (1999$) The resulting increased value of recreational activities to consumers (users and nonusers) of water-based recreation ranges from an estimated $1,201 to $3,683 million (1999$) annually. The estimated mean value of recreational benefits is $2,281 million (1999$) annually.

Table 15.13: Estimated Recreational Benefits from Reduced MP&M Discharges

Recreational Activity	Estimated Annual Benefits (Million 1999$)		
	Low Value	**Midpoint Value**	**High Value**
Fishing	$195.78	$365.36	$627.13
Boating	$265.03	$445.69	$672.12
Viewing and Near-water Activities	$500.12	$709.96	$919.94
Total Recreational Use Benefits	$960.82	$1,521.02	$2,219.18
Nonuse Benefits (1/2 of the Recreational Use Benefits)	$240.21	$760.33	$1,464.25
Total Recreational Benefits (million 1999$)	**$1,201.01**	**$2,281.34**	**$3,683.43**

Source: U.S. EPA analysis.

15.4 Limitations and Uncertainties Associated with Estimating Recreational Benefits

EPA assessed recreational benefits in terms of reduced occurrences of pollutant concentrations exceeding acute and chronic toxic effect levels for aquatic species. EPA also attached a monetary value to ecological improvements expected to result from the MP&M regulation, in the form of the increased value of three water-based recreation activities -- recreational fishing, wildlife viewing, and boating -- plus the increase in nonuse value. The estimated increase in value detailed in this chapter constitutes only a partial measure of the value to society of improving aquatic habitats and aquatic life. This benefits analysis is limited because it ignores improvements to recreational activities other than fishing, boating, and wildlife viewing (e.g., swimming), as well as non-recreational benefits, such as increased assimilative capacity and improvements in the taste and odor of the affected waters.

The methodologies used to assess ecological benefits also involved significant simplifications and uncertainties, whose combined effect on the estimated benefits is not known. Estimated economic values may be under- or overestimated. Some of these simplifications and uncertainties also apply to the human health benefits analysis, and have been discussed at length in the previous chapter, including those associated with:

- developing the sample of MP&M facilities analyzed in the EEBA,
- estimating in-waterway concentrations of MP&M pollutants,
- considering background concentrations of MP&M pollutants, and
- considering downstream effects.

Table 15.14 summarizes the additional elements of uncertainty that are specific to the recreational benefits analysis.

Table 15.14: Key Omissions, Biases, and Uncertainties in the Analysis for Improved Recreational and Nonuse Benefits

Assumption/Limitation	Direction of Impact on Benefit Estimates
Scope of Recreational Benefits Analysis	
Only the receiving reach itself is estimated to provide benefits.	(-) Water quality in reaches downstream of the reaches affected by MP&M discharges may also improve, generating additional benefits to society. Excluding these benefits from the analysis biases benefits estimates downward.
Only recreational users living in the counties abutting MP&M reaches are assumed to benefit from water quality improvements due to the MP&M rule.	(-) The analysis underestimates the total value of benefits from the MP&M regulation because it does not account for people's WTP for water quality improvements to distant waterbodies. For example, economic values for improving nationally-significant waterbodies (e.g., Great Lakes, Chesapeake Bay, Long Island Sound) are likely to be substantial at a regional level or even nationwide.
The analysis of recreational fishing ignores effects that occur in secondary industries.	(-) The analysis of recreational benefits ignores potential economic effects on tourism industries stemming from improved recreational opportunities. Improved recreational fishing may have a positive effect on industries supplying bait, tackle, charter boats, etc. An increase in consumer demand for boating may have positive effects on industries such as boat construction, sales, rentals, boating equipment, marinas, racing activities, etc. Improvements in wildlife viewing and near water recreation opportunities may benefit industries involved in providing other recreational opportunities such as tours, books, binoculars, etc.
The analysis of recreational benefits ignores changes in the value of water-based recreational activities other than fishing, wildlife viewing, and boating (e.g., swimming or waterskiing).	(-) The estimate of recreational benefits is incomplete because it includes only a subset of recreational activities (i.e., fishing, wildlife viewing, and boating) for which society may value improved aquatic habitat. It ignores changes in value for other water-based recreational activities, such as swimming or waterskiing. In addition, the analysis did not consider other changes in the affected reaches, such as improved taste and odor.
Extrapolating from sample facility results to national results is based on the sample facility weights	(?) This extrapolation technique is not ideal and introduces uncertainty into the analysis. Facility sample weights are based on facility size and type of industry. These weights do not necessarily account for the frequency benefit pathway characteristics in the MP&M facility universe. Therefore benefit estimates may suffer from uncertainties associated with the extrapolation method. For example, a sample facility may have a significant impact on benefit estimates if it is more likely to be located in a densely populated area, such a facility located in Cleveland, Ohio or a facility discharging in Long Island Sound, than the facilities it represents. The opposite may also be true.
Congestion Externalities	(+) Recreational benefits associated with water quality improvements can be eroded by congestion if policies greatly increase the number of participants. This can be particularly problematic when policies affect geographically scattered sites, so that there is considerable switching to the improved site from substitute sites. Congestion may be a lesser problem for national regulations that might affect the total number of recreation days and the overall value of recreational opportunities, but are less likely to have a large effects on industrial sites relative to its substitutes.

Table 15.14: Key Omissions, Biases, and Uncertainties in the Analysis for Improved Recreational and Nonuse Benefits

Assumption/Limitation	Direction of Impact on Benefit Estimates
Benefits Transfer	
The waters assessed by local-level studies are not necessarily nationally representative.	(?) The studies selected came from the Midwest and the Northeast. As a result, the resources valued, as well as respondent preferences, may not be representative of the rest of the country.
Types of water quality changes expected from the MP&M rule may differ from the water quality changes considered in the original studies.	(?) The types of water quality changes expected from the MP&M regulation are only roughly comparable with the majority of water quality changes considered in the original studies (Tudor et al. is the only exception). Due to the paucity of available studies, the Agency made simplifying assumptions to "map" the water quality changes valued in the original studies onto those expected from the rule. Although these assumptions are likely to increase uncertainty associated with recreational benefits estimates, the direction of bias is not known.
Compatibility of time periods considered in the original studies and in the analysis of MP&M costs and benefits.	(+) Most studies considered in the benefits transfer analysis did not specify payment periods. The scenario in the Farber and Griner (2000) paper asked for payments for the next five years. This scenario implies that five years of pollution control will result in permanent water quality changes. The analysis of the MP&M regulation assumes that pollution control continues over 15 years and that water quality improvements depend on continued operation of the water pollution controls. EPA therefore chose the annual WTP values presented in the paper, as opposed to the total value paid over five years, annualized over the 15 years considered in the cost analysis. This assumption may result in an overestimation of the regulation's benefit. The magnitude of this error is unlikely to be significant because this study is used in combination with other surface water valuation studies.
Baseline Value of Fishery	
Converting annual WTP values to per-trip values	(+) EPA converted annual WTP values reported in the three CV studies used in this analysis to per-trip values by dividing seasonal welfare gain per user reported in the each CV study by the average number of fishing, boating, or viewing days in a given state. This calculation implies that every individual participates in only one activity, which may not be the case. This implication may result in an overestimation of the per-trip welfare gain, and, consequently, total recreational benefits from the proposed rule.
This analysis estimates the baseline value of the fisheries at locations across the country using a range of values for all types of fisheries.	(?) Site-specific fisheries may have higher or lower baseline values, and thus, higher or lower benefits from reduced MP&M discharges.
The total number of recreational person-days in the counties abutting MP&M reaches is evenly distributed across all reach miles in these counties	(+) This method for estimating the number of recreational users potentially affected by water quality improvements from the proposed regulation accounts for the quantity but not quality of potential recreational opportunities available to recreational users. There may be important substitute sites in or outside the counties abutting MP&M reaches. Ignoring recreationally importance substitute sites may result in overestimation of benefits from the proposed regulation. Ideally the analysis would consider recreational importance of both sites affected by MP&M discharges and substitute sites.

Table 15.14: Key Omissions, Biases, and Uncertainties in the Analysis for Improved Recreational and Nonuse Benefits	
Assumption/Limitation	**Direction of Impact on Benefit Estimates**
Nonuse Values	
Nonuse values are estimated as one-fourth, one-half, and two-thirds of recreational use benefits.	(?) It is unknown what bias estimating nonuse values based on recreational use values has on benefits.
Overall Impact on Benefits Estimates	**(?)**

\+ Potential overestimate.
? Uncertain impact.
\- Potential underestimate.
Source: U.S. EPA analysis.

GLOSSARY

1Q10: the lowest one-day average flow with a recurrence interval of ten years.

7Q10: the lowest consecutive seven-day average flow with a recurrence interval of ten years.

Ambient Water Quality Criteria (AWQC): published and periodically updated by the EPA under the Clean Water Act. The criteria reflect the latest scientific knowledge on the effects of specific pollutants on public health and welfare, aquatic life, and recreation. The criteria do not reflect consideration of economic impacts or the technological feasibility of reducing chemical concentrations in ambient water. The criteria serve as guides to states, territories, and authorized tribes in developing water quality standards and ultimately provide a basis for controlling discharges or releases of pollutants into our nation's waterways. AWQC are developed for two exposure pathways: ingestion of the pollutant via contaminated aquatic organisms only, and ingestion of the pollutant via both water and contaminated aquatic organisms.

benefiting reaches: reaches where the MP&M rule is expected to eliminate existing AWQC exceedences. These receiving waters are likely to experience significant water quality improvements as a result of the reduced MP&M discharges. A reach is considered to benefit if at least one AWQC exceedance is eliminated due to reduced MP&M discharges.

benefits transfer: involves the application of value estimates, functions, and/or models developed in one context to address a similar resource valuation question in another context. Often a meta-analysis is undertaken where benefits estimates based on existing studies are used to develop new estimates which are applicable to the scenario under consideration. This process accounts for relevant differences in study characteristics such as the quality of environmental resource, the environmental change considered, and the user population being investigated.

contingent valuation (CV): directly asks people what they are willing to pay for a benefit and/or willing to receive in compensation for tolerating a cost through a survey or questionnaire. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids that are close to what would be revealed if an actual market existed.

conventional pollutants: biological oxygen demand (BOD), total suspended solids (TSS), oil and grease (O&G), pH, and anything else the Administrator defines as a conventional pollutant.

Metal Products and Machinery (MP&M): industry includes facilities that manufacture, rebuild, and maintain metal parts, products, or machines.

National Demand Study (NDS): U.S. EPA and the National Forest Service conducted the National Demand Survey for Water-Based Recreation in 1993. The survey collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over.

nonconventional pollutant: catch-all category that includes everything that is not classified as a priority pollutant or a conventional pollutant.

piscivorous: feeding preferably on fish.

toxic pollutants: EPA's Office of Water narrowly defines a toxic pollutant as one of 126 priority pollutants. This definition is not completely synonymous with pollutants that have a "toxic" effect. Many nonconventional pollutants may also be hazardous to aquatic life and human health.

"toxic" pollutant: any pollutant that has an adverse effect on aquatic life or human health.

travel cost (TC) model: derives values by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site. (http://www.damagevaluation.com/glossary.htm)

U.S. Fish and Wildlife Service (FWS): the principal Federal agency responsible for conserving, protecting, and enhancing fish, wildlife, and plants and their habitats for the continuing benefit of the American people. (http://www.fws.gov/r9extaff/pafaq/fwsfaq.html)

willingness to pay (WTP): maximum amount of money one would give to buy some good. (http://www.damagevaluation.com/glossary.htm)

Acronyms

1Q10: the lowest 1-day average flow with a recurrence interval of 10 years
7Q10: the lowest 7-day average flow with a recurrence interval of 10 years
AWQC: ambient water quality criteria
CV: contingent valuation
DO: dissolved oxygen
MP&M: Metal Products and Machinery
NDS: National Demand Study
TC: travel cost
WTP: willingness to pay

REFERENCES

Belton, T., R. Roundy and N. Weinstein. 1986. *Urban Fishermen: Managing the Risks of Toxic Exposure*. Environment, Vol. 28. No. 9, November.

Brown, T. 1993. "Measuring Nonuse Value: A Comparison of Recent Contingent Valuation Studies." In Bergstrom, J.C., *Benefits and Costs Transfer in Natural Resource Planning*. Sixth Interim Report, University of Georgia, Department of Agriculture and Applied Economics; Athens, GA.

Bergstrom, J.C. and H.K. Cordell. 1991. "An analysis of the Demand for and Value of Outdoor Recreation in the United States." *Journal of Leisure Research*, Vol. 23, No. 1, pp. 67-86.

Carson, R. T., and R. C. Mitchell. 1993. "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable, and Swimmable Quality Water." *Water Resources Research* 29(7), pages 2445-2454.

Connelly, N. and B. Knuth. 1993. *Great Lakes Fish Consumption Health Advisories: Angler Response to Advisories and Evaluation of Communication Techniques*, Human Dimensions Research Unit, Dept. of Natural Resources, NY State College of Agriculture and Life Sciences, Cornell University, HDRU Series No 93-3, February.

Connelly, N., B. Knuth, and C. Bisogni. 1992. *Effects of the Health Advisory and Advisory Changes on Fishing Habits and Fish Consumption in New York Sport Fisheries.* Human Dimensions Research Unit, Dept. of Natural Resources, NY State College of Agriculture and Life Sciences, Cornell University, HDRU Series No 92-9, September.

Desvousges, W. H. et al. 1987. "Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River." *Journal of Environmental Economics and Management*, 14, pages 248-267.

Farber, S. and B. Griner. 2000. *Valuing Watershed Quality Improvements Using Conjoint Analysis.* University of Pittsburgh, PA.

Fisher, A. and R. Raucher. 1984. Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives. In: *Advances in Applied Microeconomics*, Vol. 3, V.K. Smith, editor, JAI Press.

Harpman, D.A., M.P. Welsh, and R.C. Bishop. 1993. Nonuse Economic Value: Emerging Policy Analysis Tool. *Rivers*, Vol. No.4.

Jakus, P.M., M. Downing, M.S. Bevelhimer, and J.M. Fly. 1997. "Do Sportfish Consumption Advisories Affect Reservoir Anglers' Site Choice?" *Agricultural and Resource Economic Review*, 26(2).

Knuth, B. and C. Velicer. 1990. *Receiver-Centered Risk Communication for Sportfisheries: Lessons from New York Licensed Anglers.* Paper presented at the American Fisheries Society Annual Meeting, Pittsburgh, Penn, August.

Lant, C. L. and R.S. Roberts. 1990. "Greenbelts in the Cornbelt: Riparian Wetlands, Intrinsic Values, and Market Failure." *Environment and Planning A*, Vol. 22, pp. 1375-1388.

Lyke, A.J. 1993. "Discrete Choice Models to Value Changes in Environmental Quality: A Great Lakes Case Study." PhD dissertation, University of Wisconsin, Department of Agricultural Economics, Madison.

Montgomery, M. and M. Needelman. 1997. "The Welfare Effects of Toxic Contamination in Freshwater Fish." *Land Economics* 73(2): 211-223.

Phaneuf, D. J., C. L. Kling, and J.A. Herriges. 1998. "Valuing Water quality Improvements Using Revealed Preference Methods When Corner Solutions are Present." *American Journal of Agricultural Economics* 80, pp. 1025-1031.

Silverman, W. 1990. *Michigan's Sport Fish Consumption Advisory: A Study in Risk Communication*. Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science (Natural Resources) at the University of Michigan, May.

Tudor, L., E. Besedin, M. Fisher, and S. Smith. 1999a. "Economic Analysis of Environmental Regulations: Application of the Random Utility Model to Recreational Benefit Assessment for the MP&M Effluent Guideline." Presented at the annual American Agricultural Economics Association meeting, Nashville TN.

Tudor, L., E. Besedin, S. Smith, and L. Snyder. 1999b. " What Pollutants Matter for Consumers of Water-Based Recreation?" Presented at the annual Northeastern Agricultural and Resource Economics Association meeting, Morgantown, WV, June.

Tudor, L., et al. 2000. *Economic Analysis of Environmental Regulations: Using a Random Utility Model to Assess Recreational Benefits for Effluent Guidelines*. Final Report, U.S. EPA, Washington, D.C. January.

US Bureau of Census. 1996. Projections of Household by Type 1995-2010 (series 1). http://www.census.gov/population/projections/nation/hh-fam/table1n.txt

U.S. EPA (U.S. Environmental Protection Agency). 1986. *Quality Criteria for Water*. EPA 440/5-86-001.

USFWS (U.S. Fish and Wildlife Service). 1996. *1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.* U.S. Fish and Wildlife Service and Bureau of the Census.

Walsh, R.G., D.M. Johnson, and J.R. McKean. 1992. "Benefit transfer of Outdoor Recreation Demand Studies, 1968-1988." *Water Resource Research*, Vol. 28, No. 3, pp. 707-713.

West, P., R. Marans, F. Larkin, and M. Fly. 1989. *Michigan Sport Anglers Fish Consumption Survey: A Report to the Michigan Toxic Substances Control Commission*, University of Michigan School of Natural Resources, Natural Resources Sociology Research Lab, Technical Report #1, May.

Chapter 16: POTW Benefits

INTRODUCTION

Reducing effluent discharges from the MP&M industry should result in two categories of productivity benefits for ***publicly owned treatment works* (POTWs)**:

- reduced ***interference*** with the operations of POTWs, and
- reduced contamination of sewage sludge (i.e., biosolids) at POTWs that receive discharges from MP&M facilities.

Interference with POTW processes occurs when high levels of toxics, such as metals or cyanide, kill bacteria required for wastewater treatment processes. The MP&M regulation should remove 703 million pounds of 89 such pollutants per year from the wastewater of indirect dischargers (see Table 16.1), thereby reducing the potential for interference with POTW operations. The removal of these pollutants would eliminate the need for extra labor and materials to maintain POTW operations. EPA estimated that the proposed regulation would eliminate potential inhibition problems caused by MP&M facilities at 306 POTWs nationwide. This analysis is presented in Section 16.1.

Toxic priority and nonconventional pollutants may also pass through a POTW and contaminate sludge generated during primary and secondary wastewater treatment.[1] EPA estimates that the proposed regulation would remove 30.1 million pounds per year of the eight pollutants for which there are published sludge concentration limits (see Table 16.1). POTW treatment of wastewater with reduced pollutant concentrations translates into cleaner sludge, which can be disposed of using less expensive and more environmentally benign methods. In some cases, cleaner sludge may have agricultural applications, which would generate additional resource conservation benefits. EPA estimated that potential cost savings for POTWs expected to upgrade their sludge disposal practices under the post-compliance scenario are $61.1 to $61.5 million (1999$). This analysis is presented in Section 16.2.

CHAPTER CONTENTS:

Some MP&M pollutants that pass through a POTW and contaminate sludge are not currently subject to sewage sludge pollutant concentration limits. The proposed regulation would reduce concentrations of these pollutants in sewage sludge as well, which may translate into reduced environmental and human health risks. EPA did not estimate the reduced risk attributable to the reduction of these pollutants.

Wastewater from MP&M facilities also ***contains hazardous air pollutants* (HAPs)**. These pollutants may represent unacceptable health risks to POTW workers if released into the air at high enough concentrations during the wastewater treatment cycle. The proposed regulation is expected to remove approximately one million pounds per year of HAPs from wastewater transferred to POTWs. This reduction in pollutants may translate into health benefits to POTW workers and those living near POTWs.

[1] The term sewage sludge, also called biosolids, is often shortened to sludge throughout this chapter for simplicity.

Table 16.1 National Estimates of MP&M Pollutants Loadings

POTW Effects	Baseline	Proposed Option
Activated Sludge Inhibition		
# of Pollutants	89	89
million lbs/yr	1,031	328
Sludge Contamination		
# of Pollutants	8	8
million lbs/yr	31.7	1.61
HAP (Explosivity)		
# of Pollutants	35	35
million lbs/yr	2.1	1.11

Source: U.S. EPA analysis.

16.1 Reduced Interference with POTW Operations

High levels of some MP&M pollutants (such as metals, chlorobenzene, polyaromatic hydrocarbons, and oil and grease) can kill bacteria that are required for the wastewater treatment process (U.S. EPA, 1987). POTWs affected by such "inhibition problems" may incur extra labor and materials costs to maintain system operations. As a partial measure of the economic benefits resulting from the proposed regulation, EPA estimated the extent to which reduced MP&M discharges would decrease pollutant concentrations to below POTW ***pollutant inhibition values***, using the following steps:

- Estimate the baseline and post-compliance ***influent concentrations*** for each POTW receiving discharges from MP&M facilities, based on annual pollutant loadings from the MP&M facility, the number of POTW operating days per year, and the gross volume of influent.

- Compare baseline and post-compliance influent concentrations with available inhibition levels (see Table E.5 in Appendix E).

- Estimate the change in the number of POTWs in which influent concentrations of MP&M pollutants exceed POTW inhibition values.

Adverse effects on POTW operations, including inhibition of ***microbial degradation***, are likely when influent concentrations of one or more pollutants exceed an inhibition value. EPA estimated influent concentrations in excess of POTW inhibition values for the sample facilities, and then extrapolated these findings to national estimates using a differential weighting technique (see Appendix F).

EPA estimated that 515 POTWs had influent concentrations that exceeded biological inhibition values for one or more of 18 pollutants in the baseline. (Table E.12 in Appendix E provides detailed information on pollutants exceeding POTW inhibition criteria.) Exceedances would be eliminated with post-compliance discharge levels under the proposed option for 306 affected POTWs. Eliminating the exceedances will result in operating cost savings to POTWs. EPA has not estimated a monetary value for this benefit, however, due to data limitations.

POTWs may impose local limits to prevent inhibitions. If local limits are in place, the estimated reduction in potential inhibition problems at the affected POTWs is overstated. In this case, however, the estimated social cost of the MP&M regulation is also overstated.

16.2 Assessing Benefits from Reduced Sludge Contamination

16.2.1 Data Sources

The analysis of POTW benefits from improved sludge quality draws on several data sources.

The §308 POTW surveys provide most of the required information. EPA collected information from 147 POTWs representing a 98 percent response rate to the 150 surveys that were mailed. EPA also used the §308 survey of MP&M

facilities. The two data collection efforts were not designed to provide a match between the MP&M sample facilities and the POTWs to which they discharge. EPA obtained a significant amount of information from the POTW surveys, but had substantially less information on the POTWs that receive discharges from the MP&M facilities. To address this data limitation, EPA used the POTW Survey data to infer information on the key factors that are likely to influence choice of sewage sludge use and disposal practices for the POTWs receiving discharges from the MP&M facilities. EPA also used other data sources in this analysis, including *Handbook for Estimating Sludge Management Costs* (EPA, 1985) and *Regulatory Impact Analysis of the Part 503 Sludge Regulation* (EPA, 1993b).

The POTW Survey contains three sections. Section 1 provides general information on POTW location and size. Section 2 provides data on the cost of administering pre-treatment programs (see Appendix C). Section 3 contains data on the cost of treating and disposing of sewage sludge and provides new and more consistent data for analyzing the effect of reduced pollutant loadings on sewage sludge management costs.

The POTW Survey asked for the following information:

- current sludge disposal practices;
- sludge disposal costs for one or more disposal methods;
- reasons for not using a less expensive disposal method;
- number of MP&M facilities discharging to the POTW, by flow size (less than 1 million gal/year; 1-6.25 million gal/year; greater than 6.25 million gal/year);
- total metal loadings discharged to the POTW from all sources; and
- percentage of total metal loadings attributable to MP&M facilities.

The POTW Survey was intended to address data limitations encountered in the Phase 1 analysis, particularly the inadequacy of information about POTWs that receive discharges from the MP&M sample facilities. The only information available for the Phase I analysis was POTW geographic location, influent volume, and the metals content of the discharge received from the sampled MP&M facilities. Discharges to the POTW by non-sampled MP&M facilities and by non-MP&M facilities were not known. These discharges may significantly affect sewage sludge quality, however, resulting in a discrepancy between predicted and actual pollutant concentrations in sewage sludge and the corresponding disposal practices. In addition, lack of information on the factors that may influence a POTW's decisions about sludge management practices introduced additional uncertainty in the analysis.

EPA used the POTW Survey to calculate the following parameters:

- baseline percentage of the total metal loadings to POTWs by POTW flow category attributable to MP&M facilities;
- post-compliance loading reductions for non-sampled MP&M facilities discharging to the receiving POTWs;
- costs of sewage sludge disposal practices; and
- percentage of qualifying sludge that is not beneficially used for any of the following reasons: lack of land; lower cost alternative; inability to meet vector or pathogen requirements; poor weather; stricter state standards; and other reasons.

16.2.2 Sludge Generation, Treatment, and Disposal Practices

a. Sludge generation

POTWs generally treat wastewater from industrial indirect dischargers along with domestic wastewater. Sludge results from primary, secondary, and advanced wastewater treatment. The extent and type of wastewater treatment determine the chemical and physical character of the sludge. Sludge may be conditioned, thickened, stabilized, and dewatered to reduce its volume.

Sludge contains five classes of components: organic matter, pathogens, nutrients, inorganic chemicals, and organic chemicals. The mix and levels of these components ultimately determine the human health and environmental impact of sludge use/disposal, and so may also dictate the most appropriate uses and disposal practices (EPA, 1993b).

Organic matter (the primary constituent of sludge) comes from human waste, kitchen waste, and storm water runoff. Organic and inorganic chemicals in sludge come from industrial processes that discharge to municipal sewers. The concentration of inorganic pollutants in sludge, including metals, depends upon the volume and type of industrial wastes discharged to the POTW, as well as the extent and character of stormwater runoff.

b. Sludge use/disposal practices

After treatment, sludge can be used in the following ways:

- *Land Application:* Spraying or spreading on the land surface, injection below the surface, or incorporation into the soil, for soil conditioning or fertilization of crops or vegetation. Agricultural lands (pasture, range land, crops), forest lands (***silviculture***), and drastically disturbed lands (land reclamation sites) may all receive sludge;

- *Bagged Application:* Collection of sludge in containers for application to land (i.e., distribution and marketing);

- *Surface Disposal:* Disposal on land specifically set aside for this use, including surface impoundments (also called lagoons), sludge monofills (i.e., sludge-only landfills), and dedicated sites (i.e., land on which sludge is spread solely for final disposal);

- *Co-disposal:* Disposal in a ***municipal solid waste landfill* (MSWL)** or ***hazardous waste landfill***; and

- *Incineration:* Combustion of organic and inorganic matter at high temperatures in an enclosed device.

Land application and bagged application are beneficial uses of sludge. Both methods can be categorized as being "high" or "low," depending on pollutant concentrations in sewage sludge. "High" applications meet stringent limits on the total concentration of a given pollutant at a given application site. "High" sludge is exempt from meeting pollutant loading rate limits and certain record-keeping requirements. "Low" applications meet less stringent "ceiling" limits for pollutants. Ceiling limits govern whether a sewage sludge can be applied to land at all. "Low" applications require more record-keeping because POTWs must track total (cumulative) loadings applied to each given site, in addition to tracking the concentration of sludge applied at any given time.

Many POTWs use more than one use/disposal practice, which helps to maintain flexibility and avoid the capacity limitations of a single practice. The practice chosen depends on several factors, including:

- cost to prepare sludge for use/disposal;

- pollutant concentrations;

- market demand for sludge;

- cost to transport sludge to use/disposal sites;

- availability of suitable sites for land application, landfilling, or surface disposal;

- weather and other local conditions;

- allowance of a safety factor to account for unplanned or unforseen conditions;

- state environmental regulations; and

- public acceptance (EPA, 1993b).

The choice of use/disposal method is restricted by the quality of the sludge generated by the POTW. Sludge for beneficial uses must meet more stringent standards for pollutant concentrations than sludge used or disposed of in other ways. Similarly, sludge that is surface-disposed in an unlined unit generally must meet more stringent standards than sludge surface-disposed in a lined unit, disposed in an MSWL, or incinerated. Sludge disposed in a MSWL must meet more stringent standards than incinerated sludge.

Table 16.2 summarizes sludge use/disposal methods according to the number and percent of dry metric tons **(DMT)**, based on information provided in Section 3 of the §308 POTW Survey.

Table 16.2: Sludge Use/Disposal (1996) by POTWs Discharging > 2 Million Gallons/Day[a]

Use/Disposal Sub-Class	Thousand DMT	Percent of DMT
Total Beneficial Use	**2,873.4**	**39.2%**
Land Application-High	1,143.6	15.6%
Bag Application-High	351.5	4.8%
Land Application-Low	1,378.3	18.8%
Bagged Application-Low	0	0%
Total Surface Disposal	**572.7**	**7.8%**
Surface Disposal: Unlined Unit	347.2	4.7%
Surface Disposal: Lined Unit	225.5	3.1%
Co-Disposal: Municipal Landfill	**2,213.5**	**30.2%**
Incineration	**1,129.9**	**15.4%**
Unknown: Other	**543.2**	**7.4%**
All	**7,332.6**	**100.0%**

a. The §308 POTW Survey did not collect information from POTWs discharging < 2 million gallons per day.
Source: U.S. EPA, POTW Survey.

As Table 16.2 shows, 39 percent of total sludge tons reported by respondents is used beneficially (land application and bagged application). Co-disposal in a municipal landfill is the second most frequently used disposal method, accounting for 30.2 percent of all sludge disposed in the U.S. Surface disposal in unlined and lined units, incineration, and "other" disposal methods account for 4.7 percent, 3.1 percent, 15.4 percent, and 7.4 percent of all sludge tons, respectively. No sludge was sent to a hazardous waste landfill by the POTW Survey respondents.

c. Pollutant limits and disposal options

Section 405(d) of the Clean Water Act, as amended, requires EPA to specify acceptable management practices and numerical limits for certain pollutants in sludge. The Agency published *Standards for the Use/Disposal of Sludge* (40 CFR Part 503, February 1993) to protect public health and the environment from reasonably anticipated adverse effects of pollutants in sludge (U.S. EPA, 1993a). The standards include general requirements, pollutant limits, management practices, operational standards, monitoring frequency, record-keeping, and reporting for the final use and disposal of sludge in four circumstances:

- sludge co-disposed with household waste in an MSWL;
- sludge land-applied for beneficial purposes (including bagged sludge);
- sludge disposed on land or on surface disposal sites; and
- incinerated sludge.

With the exception of MSWLs, the standards for each practice include numerical limits on sludge pollutant concentrations. Part 503 sets limits on pollutant concentrations for land application at two levels:

- Land Application-Low limits, which govern whether a sludge can be applied to land at all; and
- more stringent Land Application-High limits which define, in part, sludge that is exempt from meeting certain record-keeping requirements.

For sludge meeting only the Land Application-Low limits, Part 503 contains pollutant loading rate limits. These determine the amount of sludge and associated pollutant content that may be applied to a particular site.

EPA did not establish pollutant-specific, numerical criteria for toxic pollutants of concern in the sludge disposed in MSWLs, because the design standards applicable to MSWLs are considered adequate to protect human health and the environment. Also, MSWL sludge is co-disposed with household waste, making precise numerical criteria infeasible. The *Solid Waste Disposal Facility Criteria* (40 CFR Part 258, Federal Register 50978, October 9, 1991) specify that POTWs using an MSWL must ensure that their sewage is non-hazardous and passes the Paint Filter Liquid Test.

The pollutant limits for sludge land application, surface disposal, and incineration constrain a POTW's choice of sludge use/disposal practice. Table 16.3 presents numerical limits for the three sludge use/disposal practices for eight MP&M pollutants. The land application pollutant limits place restrictions on concentrations of metals in sludge; the surface disposal criteria cover a subset of the metals regulated for land application. The MP&M effluent limitations guideline covers five metals and causes incidental removal of the remaining three metals regulated under the Part 503 sludge regulation. The proposed regulation would improve quality of sewage sludge generated by POTWs receiving discharges from MP&M facilities and, as a result, would increase sludge use/disposal options for the affected POTWs.

Table 16.3: Sludge Use/Disposal Pollutant Limits

Pollutant	Application Limits: Low Limits (Low) (mg/kg dry weight)	Application Limits: High Limits (High) (mg/kg dry weight)	Surface Disposal Limits (mg/kg dry weight)[a]	MP&M Pollutants of Concern
Arsenic	75	41	73	✔
Cadmium	85	39		✔
Copper	4,300	1,500		✔
Lead	840	300		✔
Mercury	57	17		✔
Nickel	420	420	420	✔
Selenium	100	36		✔
Zinc	7,500	2,800		✔

a. Pollutant limits for active sludge unit whose boundary is greater than 150 meters from the surface disposal site property line.

Source: Standards for the Use or Disposal of Sludge; Final Rules. 40 CFR Part 257 et al. Federal Register February 19, 1993.

d. Reasons for not land-applying qualifying sludge

POTW characteristics including location, state regulations, and community concerns also affect use/disposal methods for sludge. The POTW Survey provided information on the percentage of sludge that qualified for beneficial use but was not beneficially used. Survey data indicate that 52 percent of qualifying sludge was not land-applied, for the following reasons:

- land application is more expensive than another method;
- land is not available for sludge application;
- the cumulative pollutant loads at the land application site used had been exceeded;
- the ***vector*** or ***pathogen*** requirements to land apply could not be met at an acceptable cost; and
- inclement weather, concern over liability, stakeholder complaints, stricter state standards, desire to diversify practices, or technical problems.

Of the 52 percent of sludge that was not land-applied, only 12 percent of qualifying sludge was otherwise beneficially used (i.e., sold in bags). Therefore, only 54 percent of the total qualifying sludge is beneficially used.[2] In addition, POTW Survey data indicate that, on average, 7.5 percent of all sludge that qualifies for surface disposal is not surface disposed.

16.2.3 Overview of Improved Sludge Quality Benefits

This section discusses potential economic productivity benefits resulting from cleaner sludge, describes the methodology used to estimate benefits to POTWs directly affected by the regulation, and presents the results of the analysis.

EPA expects the proposed regulation to reduce MP&M facility discharges of eight metals with Part 503 limits. The influent pollutant reductions to these POTWs translate into sludge with reduced pollutant concentrations, allowing the sludge to meet the criteria for lower-cost use/disposal methods. The reduction in pollutants will then provide many POTWs with greater flexibility in the disposal of their sludge, and for some the opportunity to use less expensive methods of sludge use/disposal. In some cases, wastewater treatment systems may be able to use the cleaner sludge in agricultural applications, generating additional agricultural

[2] Percent Beneficially Used = (100% − 52%) +{(52% × 12%)/100%}.

productivity benefits. Numerous benefits will result from reduced contamination of sludge, including the following:

- POTWs may have less expensive options for use/disposal of sludge. Methods involving stricter criteria pollutants are generally less expensive than the alternatives. In particular, land application usually costs substantially less than incineration or landfilling. As a result of the proposed regulation, sludge from some POTWs may meet more stringent criteria for less expensive use/disposal methods.

- Some sludge currently meeting only Land Application-Low Concentration limits and pollutant loading rate limits would meet the more stringent Land Application-High Concentration limits. Users applying sludge meeting Land Application-High pollutant limits would be exempt from meeting pollutant loading rate limits. They would have fewer record-keeping requirements than users of sludge meeting only Land Application-Low concentration and loading rate limits.

- By land-applying sludge, POTWs may avoid costly siting negotiations for more contentious sewage sludge use or disposal practices, such as incineration.

- POTW sludge provides supplemental nitrogen, which enhances soil productivity when land-applied. Sludge applied to agricultural land, golf courses, sod farms, forests, or residential gardens is a valuable source of nitrogen fertilizer.

- Nonpoint source nitrogen contamination of water may be reduced if sludge is used as a substitute for chemical fertilizers on agricultural land. Compared to nitrogen in most chemical fertilizers, nitrogen in sludge is relatively insoluble in water. The release of nitrogen from sludge occurs largely through continuous microbial activity, resulting in greater plant uptake and less nitrogen runoff than from conventional chemical fertilizers.

- The organic matter in land-applied sludge can improve crop yields by increasing the ability of soil to retain water.

- Reduced concentrations of sludge pollutants not currently regulated may reduce human health and environmental risks. Human health risks from exposure to these unregulated sludge pollutants may occur from particulate inhalation, dermal exposure, ingestion of food grown in sludge-amended soils, ingestion of surface water containing sludge runoff, ingestion of fish from surface water containing sludge runoff, or ingestion of contaminated ground water.

- Land application of sludge satisfies an apparent public preference for this practice of sludge disposal, apart from considerations of costs and risk.

This analysis assumes that POTWs will choose the least expensive sludge use/disposal practice for which their sludge meets pollutant limits. POTWs with sludge pollutant concentrations exceeding the Land Application-High, Land Application-Low, or surface disposal pollutant limits in the baseline may be able to reduce sludge use/disposal costs after MP&M facilities have complied with the proposed effluent limitations.

As public entities, POTWs are not forced by the market to act as profit-maximizing or cost-minimizing agents, but rather are assumed to optimize their jurisdictional welfare function. POTWs take factors other than cost into consideration when determining their sludge use/disposal methods. These factors may include the desire to be perceived by the public as using sludge in an environmentally friendly way, or the desire to enhance relationships with clients by providing no-cost or low-cost fertilizer. Greater flexibility in disposal practices may therefore provide benefits beyond cost savings.

16.2.4 Sludge Use/Disposal Costs and Practices

This section summarizes the estimated cost differences of various use and disposal methods, based on the POTW Survey.

Alternative sludge use/disposal practices costs vary considerably among POTWs, based on several factors, the most important being the availability of local agricultural land or land suitable for surface disposal of sludge. Table 16.4 lists and ranks the use/disposal methods from least expensive to most expensive, according to the average qualitative ranking of each method in the POTW Survey.

Table 16.4: National Estimate of Qualitative Ranking of Use/Disposal Methods

	Mean Rankings
Least Expensive	Land Application-High
↕	Land Application-Low
	MSWL
↕	Bagged Application-High
	Surface Disposal in Unlined Unit
↕	Bagged Application-Low
	Surface Disposal in Lined Unit
↕	Incineration
Most Expensive	Hazardous Waste Landfill

Source: U.S. EPA, §308 POTW Survey.

Land Application-Low and Land Application-High were ranked as the two cheapest sewage sludge disposal options, supporting the assumption that beneficial use of sludge offers cost savings. The third least expensive option — co-disposal in an MSWL — costs less on average than either bagging sludge or surface disposing in an unlined unit.

EPA used the POTW Survey data as the primary source for estimating an average *difference* in costs among certain combinations of use/disposal practices (e.g., the cost savings achieved by switching from incineration to land application). Table 16.5 compares the cost savings realized by switching to sludge land application and surface disposal practices from less stringently regulated sludge use/disposal practices. While on average the estimates provided in Table 16.5 are expected to hold, the cost savings will vary for individual POTWs. POTWs whose sludge qualifies for beneficial use post-compliance but did not qualify for such use in the baseline may achieve cost savings in some, but not all, circumstances. For example, a POTW may not achieve cost savings from agricultural application due to sludge transportation costs or because there are less expensive alternatives for that particular facility. Switching from sewage sludge co-disposal in a MSWL to surface disposal offers no savings to a POTW.

Table 16.5: Cost Savings for Shifts in Sludge Use/Disposal Practices (1999$/DMT)

	Switch To:				
Switch From:	**Land Application[a] (High)**	**Land Application[a] (Low)**	**Sold in a Bag for Land Application**	**Surface Disposal on Unlined Unit**	**Surface Disposal on Lined Unit**
Incineration	$99.20	$99.20	$91.65	$98.5	No Saving
Surface Disposal on Lined Unit	$120.77	$120.77	$68.69		
Surface Disposal on Unlined Unit	$6.15	$6.15	$0.56		
Co-disposal: MSWL	$95.95	$97.95	$66.85	No Saving	No Saving
Land Application-Low	$0.65-1.30				

a. EPA assumes that the costs of land application to forests, public contact sites, and reclaimed land are similar to the costs of agricultural application.
Source: U.S. EPA analysis of the §308 POTW Survey data.

The cost section of the POTW Survey did not distinguish between low and high land application or low and high bagged application. Therefore, costs provided in the survey reflect the cost of both methods. To estimate the cost savings of avoiding these requirements by meeting Land Application-High limits, EPA used the compliance requirements for meeting Land Application-Low limits for bulk sludge (U.S. EPA, 1997). These cost savings provide a partial measure of the monetary benefit of improved sludge quality.

EPA estimates that the incremental record-keeping associated with the cumulative Land Application-Low limits requires two to four hours per application. Materials costs for meeting these requirements should be negligible. EPA estimated the record-keeping costs avoided from upgrading sludge quality from Land Application-Low to Land Application-High standards, using the following assumptions:

- a 40-acre site is a typical site size for land application (approximately 16 hectares) (US EPA, 1997);
- the typical application rate for land application is 7 DMT per hectare per application (US EPA, 1997); and
- labor at POTWs costs an average of $37 per hour (1999$), based on the §308 POTW Survey.[3]

Based on these assumptions, EPA estimated that $0.65 to $1.30 would be saved per DMT of sludge upgraded from Land Application-Low to Land Application-High.[4]

16.2.5 Quantifying Sludge Benefits

EPA estimated the number of POTWs receiving MP&M discharges and the associated quantity of sludge that would not meet Land Application-High pollutant limits, Land Application-Low pollutant limits, or surface disposal pollutant limits under both the baseline and regulatory options. EPA then assumed that, as a result of compliance with the MP&M effluent limitations guideline, a POTW meeting all pollutant limits for a less costly sludge use/disposal method would benefit from the reduced cost of that particular method. EPA estimated the reduction in sludge use/disposal costs using the steps described below:

1. Estimate total industrial baseline and post-compliance loadings of Part 503 regulated metals for each POTW with MP&M sample facility discharges;
2. Calculate the baseline and post-compliance sludge pollutant concentrations for all MP&M wastewater discharged to the POTW;
3. Compare POTW sludge pollutant concentrations with sludge pollutant limits for surface disposal and land application;
4. Estimate baseline and post-compliance sludge use/disposal practices based on the estimated pollutant concentrations in sewage sludge;
5. Identify POTWs that upgrade their sewage sludge disposal practices under the proposed option; calculate the economic POTW benefits by multiplying the cost savings for the shift in practices by the quantity of newly qualified sludge. Adjust the estimate of benefits for the percentage of POTWs that cannot land apply sewage sludge due to transportation costs or other reasons, such as cold temperature; and
6. Estimate national benefits using MP&M sample facility weights.

a. Step 1: Estimate total industrial baseline and post-compliance loadings of Part 503 regulated metals

EPA estimated the quantities of Part 503 metals discharged to POTWs receiving wastewater from MP&M sample facilities and facilities operating in other metal discharging industries.[5] EPA used POTW Survey data to estimate the total metal loadings and percent of total loadings discharged to POTWs by MP&M facilities.

The POTW Survey provides the following information:

- number of known MP&M facilities discharging to the POTW,
- total loadings of each regulated metal received by the POTW, and
- percent of the total metal loadings attributable to MP&M industries.

Table 16.6 summarizes this information by POTW flow volume.

[3] See Appendix C of this EIA for detail.

[4] Savings per DMT are calculated by dividing the estimated labor cost per application ($37 per Hour * Hours per Application) by the total amount of sludge disposed of per one application (16 Hectares * 7 DMT per hectare).

[5] EPA did not include metals from residential wastewater due to lack of data. The effect on the analysis of omitting residential metal loadings is not known.

Table 16.6: MP&M Contribution to Total Industrial Loadings Received by POTWs

	POTW size (million gallons per day)		
MP&M Contribution	**2-10**	**11-50**	**>50**
MP&M facilities	***Average number of MP&M facilities per POTW***		
small (<1 MG/year)	33.0	106.0	269.6
medium (1-6.25 MG/year)	2.5	9.1	85.0
large (>6.25 MG/year)	1.2	2.9	16.3
Chemicals	***MP&M percentage of total loadings by weight***		
Arsenic	7.4	14.0	7.0
Cadmium	16.1	23.4	12.8
Copper	18.9	21.6	10.9
Lead	13.8	19.8	10.3
Mercury	7.9	20.8	6.0
Nickel	25.1	24.4	15.8
Selenium	7.2	8.5	3.3
Zinc	20.2	16.0	8.2

Source: U.S. EPA, §308 POTW Survey.

EPA estimated total baseline metal loadings from all MP&M sources, as follows:

$$PLM_{k,\ i} = \frac{LMP_{small,\ k,\ i} \times Avg\ Num\ Sm}{Sample\ Sm} + \frac{LMP_{medium,\ k,\ i} \times Avg\ Num\ Med}{Sample\ Med} + \frac{LMP_{large,\ k,\ i} \times Avg\ Num\ Lg}{Sample\ Lg} \tag{16.1}$$

where:

$PLM_{k,i}$ = Baseline loadings of pollutant *k* to POTW; from all MP&M sources (µg/year);

$LMP_{small,k,i}$ = loadings of pollutant *k* from small (< 1 MG/year) sample MP&M facilities, discharging to POTW *i* (µg/year);

AvgNumSm = the average number of small MP&M facilities discharging to POTW *i*; EPA estimated the average number of MP&M facilities of a given size (small, medium, large) that discharge to POTWs in given flow categories, based on the §308 POTW Survey (see Table 16.6);[6,7]

SampleSm = number of MP&M small (< 1 MG/year) sample facilities discharging to POTW;

$LMP_{medium,k,i}$ = loadings of pollutant *k* from medium (1-6.25 MG/year) sample MP&M facilities, discharging to POTWs (µg/year);

AvgNumMed = the average number of medium MP&M facilities discharging to POTW *i* (based on the POTW flow category (see Table 16.6));

SampleMed = number of MP&M medium (1-6.25 MG/year) sample facilities discharging to POTW *i*;

$LMP_{large,k,i}$ = loadings of pollutant *k* from large (>6.25 MG/year) sample MP&M facilities discharging to POTW *i* (µg/year);

AvgNumLg = the average number of large MP&M facilities discharging to POTW *i* (based on the POTW flow category (see Table 16.6)); and

SampleLg = number of MP&M large (>6.25 MG/year) sample facilities discharging to POTW *i*.

---

[6] EPA classified MP&M facilities as small, medium, and large flow in the POTW Survey, based on their discharge volume.

[7] This analysis considers the following POTW flow categories: (1) from 2 MG/day to10 MG/day; (2) from 11 to 50 MG/day; and (3) greater than 50 MG/day.

EPA estimated total baseline metal loadings from all industrial sources using data from the POTW Survey, as follows:

$$PL_{k,\ i} = \frac{PLM_{k,i} \cdot 100\%}{\%MP_k} \qquad (16.2)$$

where:

$PL_{k,i}$ = total baseline loadings of pollutant k from all industrial sources to POTW i (µg/year),

$PLM_{k,i}$ = baseline loadings of pollutant k to POTW i from all MP&M sources (µg/year),

100% = the total reported POTW transfers of pollutant k from all industrial sources, and

$\%MP_{,k}$ = the percentage of total reported POTW transfers of pollutant k from MP&M facilities in a given POTW flow category (see Table 16.6),

Post-compliance pollutant loadings to POTWs are calculated by subtracting the reduction in MP&M loadings due to the regulation from the estimated total baseline loadings.

b. Step 2: Calculate baseline and post-compliance sludge quality

First, for each metal with limits under the Part 503 regulation, EPA calculated POTW influent concentrations based on the pollutant loading and POTW flow rates, as follows:

$$IC_{k,i} = \frac{PL_{k,i}}{FL_i \times OD_{ise}} \qquad (16.3)$$

where:

$IC_{k,i}$ = POTW influent concentration of pollutant k (µg/liter) for POTW i;

$PL_{k,i}$ = total loading of pollutant k to POTW i (µg/year) ;

Fl_i = POTW i flow (liters/day); and

OD_i = POTW i operation days (365 days/year).

Second, EPA calculated sludge pollutant concentrations for each pollutant:

$$PC_{k,i} = IC_{k,i} \times TRE_k \times PF_k \times SG \qquad (16.4)$$

where:

$PC_{k,i}$ = concentration of pollutant k in POTW i sludge (mg/kg or ppm),

$IC_{k,i}$ = POTW i influent concentration of pollutant k (µg/liter or ppb),

TRE_k = treatment removal efficiency for pollutant k (unitless),

PF_k = sludge partition factor for pollutant k (unitless), and

SG = sludge generation factor ((L-mg)/(µg-kg) or ppm/ppb).

The partition factor represents the fraction of the pollutant load expected to partition to sludge during wastewater treatment. This factor is chemical-specific. EPA used 1988 data on volume of sewage sludge produced (Federal Register, February 19, 1993, p.9257) and volume of wastewater treated (1988 Needs Survey, Table C-3) to estimate the sludge generating factor. The estimated sludge generation factor is 7.4, indicating that concentration in sludge is 7.4 ppb dry weight for every 1 ppb of pollutant removed and partitioned to sludge.

c. Step 3: Compare sludge pollutant concentrations at each POTW with limits for surface disposal and land application

EPA next compared sludge baseline and post-compliance pollutant concentrations to pollutant limits for land application and surface disposal using the following formula:

$$SE_p = 1 \ \ if \ \frac{PC_k}{CR_{k,p}} > 1 \qquad (16.5)$$

where:

SE_p = sludge exceeds concentration limits for disposal or use practice, p;

PC_k = sludge pollutant, k, concentration; and

$CR_{k,p}$ = sludge pollutant, k, criterion for disposal or use practice, p.

If *any* sludge pollutant concentration at a POTW exceeds the pollutant limit for a sludge use/disposal practice in the baseline (i.e., PC/CR >1), then EPA assumed that the POTW cannot use that sludge use/disposal practice. If, as a result of compliance with the MP&M regulation, a POTW meets all pollutant limits for a sludge use/disposal practice (i.e., PC/CR $\leq$ 1), that POTW is assumed to benefit from an increase in sludge use/disposal options.

d. Step 4: Estimate baseline sludge use/disposal practices at POTWs that can meet land application or surface disposal pollutant limits post-compliance

Benefits from changes in sludge use/disposal practices depend on the baseline practices employed. EPA assumes that POTWs choose the least expensive sludge use/disposal practice for which their sludge meets pollutant limits. POTWs with sludge qualifying for land application in the baseline are assumed to dispose of their sludge by land application; likewise, POTWs with sludge meeting surface disposal pollutant limits (but not land application pollutant limits) are assumed to dispose of their sludge on surface disposal sites.

EPA assumed that the mix of surface disposal practices employed by POTWs in the baseline (e.g., surface disposal on a lined unit and surface disposal on an unlined unit) matches that of national surface disposal practices as calculated from the POTW Survey (see Table 16.2).

POTW Survey data indicate that 24 percent of total sludge meeting Land Application-High standards is sold in bags and 76 percent is land-applied. None of the sludge meeting Land Application-Low standards is sold in bags. Each POTW meeting Land Application-High standards in the post-compliance scenario is assumed to sell 24 percent of its sludge in bags and to land-apply the remainder.

The POTW Survey shows that 39 percent of total surface disposed sludge is disposed of in lined units and 61 percent in unlined units. This mix of surface disposal practices may not match the actual sludge disposal surface practices of any individual POTW. In aggregate, however, the assumed surface disposal practices are consistent with actual POTW sludge surface disposal practices. Survey data also showed that, on average, 7.5 percent of all sludge that qualifies for surface disposal was not surface disposed.

POTWs generating sludge exceeding land application and surface disposal pollutant limits in the baseline are assumed to either incinerate sludge or place sludge in a MSWL. The survey indicates that 34 percent of sludge not land-applied or deposited in surface disposal sites is incinerated and 66 percent is placed in MWSLs. Each POTW exceeding surface disposal and land application limits in the baseline is assumed to incinerate 34 percent of its sludge and co-dispose of the remainder. Again, this mix of sludge use/disposal practices may not match the actual sludge disposal practices of any single POTW; in aggregate, however, the assumed distribution corresponds to actual practices.

Using the sludge disposal cost differentials from Table 16.5, EPA estimated savings for shifts into land application and surface disposal from the assumed mix of baseline use/disposal practices (see Table 16.7). As previously discussed, EPA assumed that 46 percent of sludge could not be used beneficially (land-applied or sold in bags) and disposed less expensively through agricultural application of sludge due to transportation costs, land availability, or weather constraints. The Agency did not estimate benefits for this percentage of the sludge newly qualified for land application.

e. Step 5: Calculate economic benefits for POTWs receiving wastewater from sample MP&M facilities

Table 16.7 shows the cost savings for shifts from composite baseline sludge use/disposal practices to land application or surface disposal. Reductions in sludge use/disposal costs are calculated for each POTW receiving wastewater from a MP&M facility, using the following formula:

$$SCR_i = FL_i \times \frac{S}{2200} \times CD_i \qquad (16.6)$$

where:

SCR_i	=	estimated sludge use/disposal cost reductions resulting from the proposed regulation for POTW *i* (1999$);
FL_i	=	POTW *i* wastewater flow (million gallons/year);
S	=	sludge to wastewater ratio, assumed to be 1,127 lbs. (dry weight) per million gallons of water (lbs./million gallons) and divided by 2,200 to convert pounds to metric tons; and
CD_i	=	estimated cost differential between least costly composite baseline use/disposal method for which POTW *i* qualifies and least costly use/disposal method for which POTW *i* qualifies post-compliance (1999$/DMT).

Table 16.7: Cost Savings from Shifts in Sludge Use/Disposal Practices from Composite Baseline Disposal Practices (1999$/DMT)

	Post-Compliance POTW Sludge Use/disposal Practice			
Baseline POTW Mix of Sludge Use/Disposal Practices	**Agricultural Application-High (76% of sludge meeting Land Application-High pollutant limits)**	**Bagged Sludge (24% of sludge meeting Land Application-High pollutant limits)**	**Agricultural Application-Low**	**Surface Disposal[a] (Meet surface pollutant limits; do not meet land application pollutant limits)**
Meets Land Application-Low pollutant limits, but not Land Application-High limits	\$0.65-\$1.30	N/A[b]	N/A	N/A
Meets surface disposal pollutant limits, but not Land Application-Low limits Assumed disposal mix: 39% lined unit 61% unlined unit	 \$120.77 \$6.15	 \$68.69 \$0.56	 \$120.77 \$6.15	N.A.
Does not meet land application pollutant limits or surface disposal pollutant limits Assumed disposal mix: 34% incineration, 66% co-disposal	 \$99.20 \$95.97	 \$91.65 \$66.85	 \$99.20 \$95.97	 \$0-\$98.5 N/A

a. Surface disposal includes monofills, surface impoundments, and dedicated sites.
b. Not applicable (i.e., there is no cost savings).
Source: U.S. EPA, POTW Survey.

EPA assumed that only 54 percent of the sludge qualified for land application is beneficially used (i.e., land-applied or sold in bags). The remaining 46 percent of the sludge newly qualified for land application will be disposed of by other methods. EPA assumed that no cost savings will be associated with 46 percent of the sludge qualified for land application. To ensure that these benefits are not overstated, this analysis includes an adjustment to the estimate of national sludge use/disposal cost benefits for POTWs that may be located at some distance from agricultural sites. This adjustment does not apply to benefits from shifts into surface disposal.

f. Step 6: Estimate national sludge benefits

EPA scaled the sludge use/disposal cost reductions to the national level as follows:

$$NSCR = \sum_{i=1}^{n} (FW_i \times SCR_i) \tag{16.7}$$

where:

$NSCR$ = national estimated sludge use/disposal cost reductions resulting from the proposed regulation (1999\$);

n = number of POTWs estimated to shift into meeting surface disposal or land application pollutant limits as a result of MP&M effluent limitations;

FW_i = facility sample weights for facility or facilities discharging to POTW *i*; and

SCR_i = estimated sludge use/disposal cost reductions resulting from the proposed regulation for POTW *i* (1999\$).

16.3 Estimated Savings in Sludge Use/Disposal Costs

Of the POTWs receiving discharge wastewater from MP&M facilities, 6,953 POTWs exceed the Land Application-High pollutant limits and 4,714 exceed the Land Application-Low pollutant limits under the baseline discharge levels. EPA estimated that 62 POTWs will be newly qualified for lower-cost land application based on estimated reductions in sludge contamination. EPA also estimated that 21 POTWs that previously met only the Land Application-Low limits would, as a result of regulation, meet the more stringent Land Application-High limits.

Table 16.8: POTW Exceeding Land Application Limits in the Baseline and Under the Proposed Rule

Numbers of POTWs Exceeding the Limits	Baseline	Proposed Rule	Change
Land Application-High	6,953	6,889	64
Land Application-Low	4,714	4,652	62

Source: U.S. EPA analysis.

EPA used the estimated sludge use/disposal cost differentials presented in Table 16.7 to calculate cost savings for the POTWs expected to upgrade their sludge disposal practices. The benefits are estimated at $61.1 to $61.5 million (1999$) annually for the proposed option. Table 16.9 shows the cost savings by shift in disposal method.

These estimated benefit values reflect only part of the economic benefits expected to result from reduced pollutant concentrations in MP&M discharges to POTWs, and the lower pollutant concentrations of the resulting sludge. EPA expects but did not quantify additional benefits from meeting the Land Application-High limits:

1. If a POTW's sludge meets Land Application-High limits, farmers may be more easily convinced to take the sludge, reducing the time a POTW has to spend to locate application sites.

2. POTWs may be able to sell the sludge they currently give away.

3. Composted sludge may command a higher price than received for composted sludge subject to annual limits (which apply when the sludge does not meet Land Application-High limits).

4. Facilities whose land application is limited only by vectors could decide to meet the more stringent Class A pathogen and vector attraction reduction requirements (by composting sludge, for example) if the subsequent product is not subject to any Part 503 requirements, increasing its ease of distribution.

These benefits are not easily monetized.

Table 16.9: National Estimate of Cost Savings from Shifts in Sludge Use/Disposal Under the Proposed Option

Shift	Category/Number of POTWs	Associated Sludge Quantity (DMT/Year)	Estimated Benefits (million 1999$)
Upgrade from minimum Land Application-Low limits to Land Application-High pollutant limits	21	510,600	$0.33 to $0.66
Upgrade from not meeting land application or surface disposal limits to Land Application-High pollutant limits	43	661,227	$32.9
Upgrade from not meeting land application or surface disposal limits to Land Application-Low pollutant limits	19	529,945	$27.9
Total	83	1,701,712	$61.1 to $61.5

Source: U.S. EPA analysis.

16.4 Methodology Limitations

EPA used the POTW Survey to develop estimates of the cost-saving differentials for the various sludge use/disposal practices. Sludge use/disposal costs vary by POTW. The POTWs affected by the MP&M regulation may face costs that differ from those estimated. As a result, the analysis may over- or under-estimate the cost differentials.

POTW Survey data were also used to estimate metal loadings to POTWs in the baseline analysis. There are two major limitations associated with this approach:

- The baseline metal loadings from individual MP&M facilities of interest may differ from this estimate. The effect of using the §308 survey data to characterize the POTWs that receive MP&M discharges is therefore not known.

- The total share of metals coming from MP&M facilities is likely to be underestimated because lower flow MP&M facilities are not always known by the POTW. During the pretest of the MP&M POTW questionnaire, POTWs told EPA that they were not aware of many of the lower flow facilities that were discharging to them. the POTW would have to use the phone book in order to find and permit these facilities. EPA is consequently proposing to exempt low flow facilities in the general metals and only oily wastes indirect discharge categories.

This analysis assumes that the mix of disposal practices estimated for a specific POTW may not match the actual sludge disposal practices used by that POTW. We know that the mix in the aggregate, as confirmed by the POTW Survey, is correct. The practices used in this analysis are therefore consistent with actual POTW sludge surface disposal practices. Because accurate assumptions for specific POTWs could not be made, the analysis may over- or underestimate the cost differentials.

EPA did not estimate changes in risk associated with changes in sludge. Nor did EPA estimate the productivity benefits of removing any pollutants from the sludge other than the eight metals discussed above.

EPA quantified, but did not monetize economic benefits from reducing interference with POTW operations. EPA did not estimate cost reductions that occur at POTWs with sludge inhibition problems caused by MP&M discharges. These omissions thereby underestimate the benefits of the regulation.

GLOSSARY

hazardous air pollutants (HAPs): air pollutants that are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride. MP&M pollutants include but are not limited to: chlorobenzene, dioxin,1,4-, isophorone, and pyrene.
(http://www.epa.gov/OCEPAterms/hterms.html)

hazardous waste landfill: an excavated or engineered site where hazardous waste is deposited and covered. (http://www.epa.gov/OCEPAterms/hterms.html)

influent concentrations: measure of a pollutant's concentration in wastewater being received by a POTW for treatment (See also: pollutant inhibition values).

interference: is the obstruction of a routine treatment process of POTWs that is caused by the presence of high levels of toxics, such as metals and cyanide in wastewater discharges. These toxic pollutants kill bacteria used for microbial degradation during wastewater treatment (See: microbial degradation).

microbial degradation: the breakdown of organic molecules via biochemical reactions occurring in living microorganisms such as bacteria, algae, diatoms, plankton, and fungi. POTWs make use of microbial degradation for wastewater treatment purposes. This process is inhibited by the presence of toxics such as metals and cyanide because these pollutants kill microorganisms.

municipal solid waste landfill (MSWL): common garbage or trash generated by industries, businesses, institutions, and homes. Also known as municipal solid waste. (http://www.epa.gov/OCEPAterms/mterms.html)

pathogens: microorganisms (e.g., bacteria, viruses, or parasites) that can cause disease in humans, animals and plants. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutant inhibition values: determined threshold concentration for a pollutant, which when exceeded by the pollutant's influent concentration in wastewater received for treatment will have adverse effects on POTW operations, such as inhibition of microbial degradation (See: microbial degradation).

publicly owned treatment works (POTWs): a treatment works as defined by section 212 of the Act, which is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature.
(http://www.epa.gov/owm/permits/pretreat/final99.pdf)

silviculture: management of forest land for timber. (http://www.epa.gov/OCEPAterms/sterms.html)

vector: 1. An organism, often an insect or rodent, that carries disease. 2. Plasmids, viruses, or bacteria used to transport genes into a host cell. A gene is placed in the vector; the vector then "infects" the bacterium. (http://www.epa.gov/OCEPAterms/vterms.html)

ACRONYMS

DMT: dry metric tons
HAPs: hazardous air pollutants
MSWL: municipal solid waste landfill
POTWs: publicly-owned treatment works

REFERENCES

Solid Waste Disposal Facility Criteria (40 CFR Part 258, Federal Register 50978, October 9, 1991).

Standards for the Use/Disposal of Sludge (40 CFR Part 503, February 1993).

U.S. EPA. 1985. *Handbook for Estimating Sludge Management Costs*

U.S. EPA. 1987. *Guidance for Preventing Interference with POTW Operations*.

U.S. EPA. 1988. *National Sewage Sludge Survey*.

U.S. EPA. 1993a. Standards for the Use and Disposal of Sludge; Final Rules. 40 CFR Part 257 et al., *Federal Register*, February 19.

U.S. EPA. 1993b. *Regulatory Impact Analysis of the Part 503 Sludge Regulation*. Final. Office of Water, March. EPA 821-12-93-006.

U.S. EPA. 1997. *Economic Assessment for Proposed Pretreatment Standards for Existing and New Sources for the Industrial Laundry Point Source Category*. Office of Water. EPA 821-R-97-008 (pp 10-51 - 10-54).

Chapter 17: Environmental Justice & Protection of Children

Introduction

Executive Order 12898 requires that, to the greatest extent practicable and permitted by law, each federal agency must make achieving environmental justice part of its mission. EPA examined whether the proposed regulation will promote environmental justice in areas affected by MP&M discharges.

The proposed rule is not subject to Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (62 FR 19885, April 23, 1997), because it is based on technology performance and not on health or safety risks. The regulation is still expected to reduce lead and other pollutants that affect children's health. EPA has therefore analyzed the reduction of children's health impacts associated with the MP&M regulation.

EPA concludes that the proposed rule reduces risks to disadvantaged populations (e.g., subsistence anglers), and that MP&M discharges have a disproportionally high environmental impact on minority populations, based on the demographic characteristics of the populations residing in the counties affected by MP&M discharges.

The following three sections present EPA's environmental justice analysis. Section 17.1.1 discusses the proposed rule's impacts on subsistence anglers. Section 17.1.2 assesses whether MP&M discharges have a disproportionally high impact on minority populations. Section 17.2 addresses the proposed regulation's effects on children from subsistence and recreational fishing families.

Chapter Contents:

17.1 Environmental Justice

17.1.1 Changes in Health Risk for Subsistence Anglers

Subsistence anglers include low-income and minority populations that rely heavily on fishing for their food supply. Subsistence anglers are at a disproportionally higher risk from MP&M pollutants than other people who eat fish because their diets rely heavily on fish caught in local waters.

EPA estimated changes in cancer and systemic health risk to subsistence anglers and recreational fishermen in Chapter 13, *Human Health Benefits*. EPA's estimates show that subsistence anglers have a significantly higher average lifetime cancer risk from fish consumption than do recreational anglers at the baseline discharge levels. Subsistence fishing families also have a greater risk of systemic health effects in the baseline. EPA's analysis of changes in adverse health effects from the proposed rule show that subsistence anglers receive a large share of benefits, due to their disproportionately higher baseline risk.

a. Cancer risk

EPA estimates that approximately 3,772,703 subsistence anglers fish 58,530 MP&M reaches nationwide. Individuals in subsistence fishing households are exposed to 13 cancer causing agents that are discharged by 62,752 MP&M facilities to our nation's waters. The estimated average lifetime cancer risk in the baseline for subsistence and recreational anglers is 20.3 in one million and 8.08 in one million, respectively. The estimated reduction in average lifetime cancer risk for subsistence anglers is more than double the reduction in risk for sport anglers (i.e., 7.70 in one million vs. 3.77 in one million) (see Table 17.1).

Table 17.1: Estimated National Changes in Average Lifetime Cancer Risk to Subsistence vs. Recreational Anglers (62,752 MP&M Facilities)

Exposed Population Category	Average Lifetime Cancer Risk per Individual		Estimated Changes in Individual Lifetime Cancer Risk
	Baseline	Preferred Option	Preferred Option
Subsistence Anglers	0.00002030	0.00001260	0.00000770
Recreational Anglers	0.00000808	0.00000431	0.00000373

Source: U.S. EPA analysis.

b. Systemic health risk

The Agency conducted a similar analysis to assess reductions in systemic health risks from fish consumption. This study used the ***hazard ratio*** analysis performed and discussed in Chapter 13. A hazard ratio greater than one (HR > 1) indicates that individuals are expected to ingest MP&M pollutants at rates sufficient to pose a significant risk of suffering systemic health effects.

Table 17.2 presents systemic health risk analysis results for the fish consumption pathway. These results show that pollutant discharges from MP&M facilities are likely to have a disproportional impact on subsistence anglers. Approximately 320,000 subsistence anglers fish 627 reaches to which *885 sample* MP&M facilities directly or indirectly discharge. Anglers fishing 18 of these reaches ingest MP&M pollutants at rates sufficient to pose a significant risk of health effects at the baseline discharge levels. Approximately 7,000 subsistence anglers face a hazard ratio greater than one. This figure represents 2.2 percent of all subsistence anglers on MP&M sample facility reaches. A much smaller proportion of recreational anglers (0.15 percent) face a hazard ratio of greater than one under baseline conditions.

The number of subsistence anglers at systemic health risk from the sample MP&M facility discharges is reduced by 4,616 (66 percent) (see Table 17.2). The actual number of subsistence anglers expected to benefit from reduced systemic health risk from the MP&M regulation is much greater, because this analysis includes only 885 MP&M facilities, not the full 62,752 whose discharges will be affected by the proposed regulation.[1] The proportion of recreational anglers expected to suffer systemic health effects after the MP&M rule is implemented declines from 0.15 to 0.05 percent. While the proposed rule does not eliminate the differential risks to subsistence anglers, it does provide the majority of benefits to the disadvantaged populations at greatest risk in the baseline.

[1] EPA did not evaluate non-cancer benefits at the national level due to analytic tractability issues. These issues come about because the exact location of facilities represented by sample weights is unknown.

Table 17.2: Estimated Changes in Systemic Health Risk to Subsistence and Recreational Anglers

Regulatory Status	Total Exposed Anglers	Anglers Exposed to HR>1		Anglers Benefiting from the MP&M Rule	
		Number of Individuals	Percent of Total Exposed Individuals	Number of Individuals	Percent of Baseline
Subsistence Anglers					
Baseline[a]	320,366	6,971	2.2%		
Preferred Option	320,366	2,355	0.7%	4,616	66%
Recreational Anglers					
Baseline[a]	6,407,076	9,765	0.15%		
Preferred Option	6,407,076	2,897	0.05%	6,868	70%

a. This analysis is based on 885 facilities.
Source: U.S. EPA analysis.

17.1.2 Demographic Characteristics of Populations Living in the Counties Near MP&M Facilities

EPA assessed whether adverse environmental, human health, or economic effects associated with MP&M facility discharges are more likely to affect minorities and low-income populations. This analysis uses the 1990 Census data on the race, national origin, and income level of populations residing in counties traversed by reaches receiving discharges from 885 sample MP&M facilities. The 885 sample facilities are located in 643 counties in 46 states (excluding Alaska, Hawaii, Nevada, and Wyoming). This survey was designed to provide a representative coverage of various types of MP&M facilities, but not of their geographical location. EPA is therefore able to analyze only the location characteristics of the sample facilities, and not all 62,752 MP&M dischargers.

EPA compared demographic data on the counties traversed by sample ***MP&M reaches*** with the corresponding state level indicators. Table 17.3 presents the results of this analysis:

- Counties affected by MP&M effluents tend to have a larger proportion of African-Americans in their populations than the state average in 41 of the 46 states included in the analysis. The proportion of African-Americans in the counties affected by MP&M discharges ranges from about 0.6 percent in Montana to 41.4 percent in Louisiana (see Table 17.3). The state averages of the proportion of African-Americans are lower, ranging from 0.3 percent in Montana to 35.6 in Mississippi. In five states (District of Columbia, North Carolina, South Carolina, Vermont, and West Virginia), the proportion of African-Americans in MP&M counties corresponds to the state averages. Of these, however, only two states (NC and SC) are associated with more than one sample MP&M facility. The proportion of Native Americans in the population of counties affected by MP&M effluents is less than or equal to the state average in 42 of the 46 states. In 38 of the 46 states, counties affected by MP&M effluents have a larger proportion of Asians and Pacific Islanders in their populations than the state average. Both these population groups, however, comprise only a very small part of the total population of most states.

- Other socioeconomic characteristics of the populations residing in the counties abutting reaches affected by MP&M discharges generally reflect state averages. These characteristics include percent of population below poverty level, percent unemployed, and percent children.

- Counties abutting reaches affected by MP&M effluents tend to have slightly higher median incomes than the state-level median income. EPA calculated median income for the group of counties receiving MP&M discharges as an average of each county's median household income.[2] EPA calculated this summary variable in place of the true median household income for which appropriate census data are not available. Comparing this weighted average median income to the state-level median income may introduce uncertainty in the analysis.

[2] Average income in MP&M counties = Σ_i Median Income (i) × Number of Households (i)/Σ Number of Households (i) where i is a sample MP&M county.

Table 17.3: County Level Comparison of Demographic Data: Counties with Sample MP&M Facilities Versus Entire State

State	Counties	% White	% African-American	% Native American, Eskimo, or Aleut	% Asian or Pacific Islander	Median Income	% Below Poverty Level	% Un-employed	% Children
Alabama									
MP&M Only	10	70.44%	28.27%	0.43%	0.73%	$26,418	16.76%	6.75%	26.21%
Entire State	67	73.63%	25.24%	0.45%	0.54%	$23,597	18.34%	6.87%	26.23%
Arizona									
MP&M Only	5	81.56%	3.27%	4.49%	1.59%	$28,918	14.68%	6.75%	26.45%
Entire State	15	80.97%	3.00%	5.58%	1.48%	$27,540	15.74%	7.17%	26.70%
Arkansas									
MP&M Only	17	82.29%	16.43%	0.58%	0.45%	$23,676	16.04%	6.04%	25.87%
Entire State	75	82.71%	15.89%	0.61%	0.51%	$21,147	19.07%	6.76%	26.43%
California									
MP&M Only	26	67.61%	7.90%	0.73%	10.34%	$36,584	12.54%	6.58%	25.90%
Entire State	58	69.07%	7.39%	0.84%	9.57%	$35,798	12.51%	6.65%	26.01%
Colorado									
MP&M Only	7	86.46%	5.39%	0.76%	2.27%	$32,040	10.45%	5.64%	25.85%
Entire State	63	88.31%	3.98%	0.87%	1.80%	$30,140	11.68%	5.74%	26.10%
Connecticut									
MP&M Only	8	87.09%	8.32%	0.21%	1.49%	$42,319	6.82%	5.36%	22.81%
Entire State	8	87.09%	8.32%	0.21%	1.49%	$41,721	6.82%	5.36%	22.81%
Delaware									
MP&M Only	1	80.50%	16.41%	0.17%	1.54%	$38,617	7.54%	3.82%	23.97%
Entire State	3	80.36%	16.83%	0.33%	1.32%	$34,875	8.71%	3.99%	24.47%
District of Columbia									
MP&M Only	1	29.61%	65.87%	0.26%	1.85%	$30,727	16.87%	7.16%	19.22%
Entire State	1	29.61%	65.87%	0.26%	1.85%	$30,727	16.87%	7.16%	19.22%
Florida									
MP&M Only	22	82.64%	13.71%	0.29%	1.26%	$28,200	12.67%	5.88%	21.90%
Entire State	67	83.13%	13.57%	0.33%	1.16%	$27,483	12.69%	5.78%	22.14%
Georgia									
MP&M Only	22	67.53%	29.89%	0.21%	1.67%	$33,979	11.87%	5.35%	25.85%
Entire State	159	71.06%	26.93%	0.24%	1.14%	$29,021	14.65%	5.74%	26.71%
Idaho									
MP&M Only	1	93.78%	0.54%	2.41%	1.28%	$26,275	13.78%	6.20%	32.52%
Entire State	44	94.44%	0.36%	1.46%	0.90%	$25,257	13.25%	6.15%	30.58%
Illinois									
MP&M Only	27	74.05%	17.58%	0.21%	2.96%	$34,825	11.50%	6.70%	25.97%
Entire State	103	78.37%	14.79%	0.21%	2.49%	$32,252	11.91%	6.64%	25.79%
Indiana									
MP&M Only	36	87.27%	10.73%	0.25%	0.80%	$28,865	11.31%	5.88%	25.93%
Entire State	93	90.59%	7.75%	0.26%	0.66%	$28,797	10.68%	5.74%	26.29%
Iowa									
MP&M Only	8	94.34%	4.19%	0.26%	0.65%	$27,057	12.58%	5.64%	26.54%
Entire State	99	96.70%	1.70%	0.28%	0.88%	$26,229	11.48%	4.53%	25.91%
Kansas									
MP&M Only	8	87.10%	8.79%	0.89%	1.52%	$32,647	9.71%	5.02%	27.41%
Entire State	105	90.16%	5.73%	0.94%	1.26%	$27,291	11.48%	4.70%	26.72%

Table 17.3: County Level Comparison of Demographic Data: Counties with Sample MP&M Facilities Versus Entire State

State	Counties	% White	% African-American	% Native American, Eskimo, or Aleut	% Asian or Pacific Islander	Median Income	% Below Poverty Level	% Un-employed	% Children
Kentucky									
MP&M Only	38	88.90%	9.98%	0.20%	0.68%	$25,500	15.53%	6.48%	25.44%
Entire State	120	92.06%	7.11%	0.19%	0.47%	$22,534	19.03%	7.37%	25.93%
Louisiana									
MP&M Only	10	56.65%	41.40%	0.22%	1.17%	$22,834	24.40%	10.25%	28.43%
Entire State	64	67.30%	30.77%	0.48%	0.94%	$21,949	23.58%	9.65%	29.13%
Maine									
MP&M Only	4	98.07%	0.58%	0.44%	0.75%	$29,686	9.98%	5.97%	24.29%
Entire State	17	98.35%	0.44%	0.52%	0.56%	$27,854	10.80%	6.65%	25.19%
Maryland									
MP&M Only	9	66.13%	28.97%	0.28%	3.50%	$40,452	8.73%	4.51%	23.96%
Entire State	24	71.03%	24.87%	0.30%	2.88%	$39,386	8.27%	4.30%	24.31%
Massachusetts									
MP&M Only	9	89.53%	5.20%	0.19%	2.41%	$37,847	8.94%	6.75%	22.56%
Entire State	14	89.95%	4.94%	0.21%	2.34%	$36,952	8.93%	6.72%	22.46%
Michigan									
MP&M Only	22	77.53%	19.72%	0.47%	1.27%	$32,064	14.05%	8.58%	26.67%
Entire State	84	83.47%	13.87%	0.63%	1.11%	$31,020	13.12%	8.24%	26.48%
Minnesota									
MP&M Only	16	92.56%	3.40%	0.90%	2.59%	$35,651	8.26%	4.53%	26.12%
Entire State	88	94.47%	2.17%	1.13%	1.75%	$30,909	10.22%	5.15%	26.69%
Mississippi									
MP&M Only	10	61.17%	38.23%	0.14%	0.35%	$24,559	21.21%	7.28%	28.83%
Entire State	82	63.46%	35.59%	0.34%	0.49%	$20,136	25.21%	8.43%	29.04%
Missouri									
MP&M Only	18	79.23%	18.78%	0.33%	1.10%	$28,883	12.04%	6.27%	25.21%
Entire State	115	87.68%	10.69%	0.44%	0.77%	$26,362	13.34%	6.16%	25.71%
Montana									
MP&M Only	1	97.70%	0.59%	0.54%	0.35%	$22,658	15.20%	6.53%	25.62%
Entire State	56	92.78%	0.26%	5.98%	0.53%	$22,988	16.07%	6.96%	27.88%
Nebraska									
MP&M Only	8	90.67%	6.67%	0.55%	1.20%	$29,801	9.70%	3.89%	26.79%
Entire State	93	93.83%	3.62%	0.80%	0.80%	$26,016	11.14%	3.66%	27.19%
New Hampshire									
MP&M Only	2	97.57%	0.77%	0.23%	0.97%	$39,194	5.77%	6.02%	25.52%
Entire State	10	98.02%	0.65%	0.22%	0.81%	$36,329	6.42%	6.22%	25.16%
New Jersey									
MP&M Only	12	77.33%	14.43%	0.19%	4.03%	$42,046	7.76%	5.96%	23.02%
Entire State	21	79.37%	13.39%	0.19%	3.49%	$40,927	7.58%	5.75%	23.27%
New Mexico									
MP&M Only	3	76.59%	2.51%	4.85%	1.35%	$27,220	15.16%	6.70%	27.14%
Entire State	33	75.81%	1.97%	8.85%	0.95%	$24,087	20.61%	8.02%	29.47%
New York									
MP&M Only	32	71.09%	17.98%	0.32%	4.31%	$34,563	13.55%	7.08%	23.44%
Entire State	63	74.47%	15.90%	0.33%	3.83%	$32,965	13.03%	6.88%	23.66%

Table 17.3: County Level Comparison of Demographic Data: Counties with Sample MP&M Facilities Versus Entire State

State	Counties	% White	% African-American	% Native American, Eskimo, or Aleut	% Asian or Pacific Islander	Median Income	% Below Poverty Level	% Un-employed	% Children
North Carolina									
MP&M Only	26	76.77%	21.67%	0.32%	0.95%	$29,802	10.66%	4.09%	23.62%
Entire State	100	75.60%	21.96%	1.25%	0.76%	$26,647	12.97%	4.79%	24.27%
North Dakota									
MP&M Only	1	97.34%	0.09%	2.15%	0.40%	$24,248	12.24%	5.72%	27.18%
Entire State	53	94.71%	0.55%	3.96%	0.50%	$23,213	14.38%	5.30%	27.50%
Ohio									
MP&M Only	43	85.69%	12.60%	0.20%	0.92%	$29,485	12.15%	6.40%	25.67%
Entire State	89	87.81%	10.62%	0.21%	0.82%	$28,706	12.54%	6.60%	25.85%
Oklahoma									
MP&M Only	5	82.64%	8.39%	7.14%	1.05%	$26,325	13.75%	5.87%	26.19%
Entire State	77	82.26%	7.38%	8.03%	1.04%	$23,577	16.71%	6.87%	26.60%
Oregon									
MP&M Only	9	92.01%	2.15%	1.13%	3.02%	$29,022	11.47%	5.62%	25.10%
Entire State	36	92.80%	1.60%	1.46%	2.38%	$27,250	12.42%	6.20%	25.49%
Pennsylvania									
MP&M Only	39	86.76%	10.72%	0.13%	1.29%	$30,240	11.05%	5.91%	23.40%
Entire State	68	88.57%	9.15%	0.13%	1.14%	$29,069	11.13%	5.97%	23.54%
Rhode Island									
MP&M Only	4	90.97%	4.13%	0.35%	1.82%	$31,791	9.95%	6.77%	22.48%
Entire State	5	91.59%	3.79%	0.43%	1.76%	$32,181	9.61%	6.64%	22.52%
South Carolina									
MP&M Only	15	74.91%	24.24%	0.20%	0.50%	$26,692	14.01%	5.36%	25.91%
Entire State	46	69.05%	29.83%	0.26%	0.61%	$26,256	15.37%	5.58%	26.44%
South Dakota									
MP&M Only	2	91.36%	1.19%	5.72%	1.15%	$24,539	13.96%	5.17%	27.67%
Entire State	66	91.55%	0.45%	7.24%	0.48%	$22,503	15.86%	4.16%	28.58%
Tennessee									
MP&M Only	21	75.45%	23.31%	0.25%	0.80%	$25,904	15.86%	6.28%	24.75%
Entire State	95	83.01%	15.93%	0.26%	0.63%	$24,807	15.70%	6.41%	24.93%
Texas									
MP&M Only	18	71.56%	13.80%	0.39%	2.55%	$29,534	16.93%	7.02%	28.23%
Entire State	254	75.28%	11.88%	0.41%	1.85%	$27,016	18.10%	7.11%	28.47%
Utah									
MP&M Only	4	93.12%	0.85%	0.87%	2.42%	$30,281	9.79%	4.98%	34.92%
Entire State	29	93.88%	0.64%	1.41%	1.92%	$29,470	11.36%	5.32%	36.45%
Vermont									
MP&M Only	1	98.69%	0.40%	0.30%	0.59%	$28,485	11.30%	7.53%	25.06%
Entire State	14	98.55%	0.39%	0.39%	0.54%	$29,792	9.86%	5.85%	25.51%
Virginia									
MP&M Only	29	75.03%	20.17%	0.30%	3.49%	$38,074	9.05%	4.26%	24.64%
Entire State	135	77.47%	18.80%	0.26%	2.57%	$33,328	10.25%	4.48%	24.31%
Washington									
MP&M Only	7	88.93%	3.29%	1.34%	5.58%	$34,174	8.79%	4.83%	24.87%
Entire State	40	88.64%	3.03%	1.71%	4.34%	$31,183	10.92%	5.72%	25.86%

Table 17.3: County Level Comparison of Demographic Data: Counties with Sample MP&M Facilities Versus Entire State

State	Counties	% White	% African-American	% Native American, Eskimo, or Aleut	% Asian or Pacific Islander	Median Income	% Below Poverty Level	% Un-employed	% Children
West Virginia									
MP&M Only	2	98.57%	1.10%	0.10%	0.21%	$20,613	19.06%	9.12%	25.48%
Entire State	55	96.24%	3.09%	0.17%	0.42%	$20,795	19.66%	9.58%	24.77%
Wisconsin									
MP&M Only	24	89.07%	8.00%	0.59%	1.16%	$30,056	11.10%	5.25%	26.02%
Entire State	73	92.28%	4.99%	0.81%	1.08%	$29,442	10.70%	5.20%	26.39%

Note: Alaska, Hawaii, Nevada, and Wyoming are not represented because no MP&M facilities from these states were surveyed.
Source: U.S. EPA analysis of 1990 Census of Population Data.

This comparison indicates that African-American households are expected to receive a relatively larger share of the benefits from the MP&M rule. The higher representation of these households among the benefiting population is to some extent likely to be explained by their relatively higher concentration in urban areas, where most MP&M facilities are situated and their effluents released.

17.2 Protection of Children from Environmental Health and Safety Risks

Lead is harmful to all exposed individuals, and its effects on children are of particular concern. Lead exposure is more likely to cause neurobehavioral deficits in children because their rapid rate of development makes them more susceptible to adverse effects. EPA expects that the proposed regulation will benefit children in many ways, including:

- Reducing health risk from exposure to MP&M pollutants from consumption of contaminated fish tissue and drinking water, and
- Improving recreational opportunities for children and their families.

In Chapter 14, EPA measured one category of benefits specific to children: avoided health damages to pre-school-age children from reduced exposure to lead. The analysis considered several measures of children's health benefits associated with lead exposure for children up to age six. Avoided neurological and cognitive damages included:

- Lower overall IQ levels,
- Increased incidence of low IQ scores (<70), and
- Increased incidence of blood-lead levels above 20 µg/dL.

The Agency also assessed changes in incidence of neonatal mortality from reduced lead exposure.

EPA expects the proposed rule to yield $14.4 million (1999$) in annual benefits to children from reduced neurological and cognitive damages and reduced incidence of neonatal mortality.

EPA also examined whether lead discharges from MP&M facilities are likely to have a disproportionate impact on children in subsistence anglers' families. Table 17.4 compares risk levels and benefits to children from subsistence fishing families and recreational fishing families. Children from subsistence fishing families have a much greater risk of adverse health effects from exposure to lead due to consumption of a high proportion of fish from local waters.

EPA's analysis shows that the lead reductions under the proposed MP&M rule are particularly beneficial for children from subsistence fishing families. The average estimated risk reduction per child for each of the four estimated lead-related health effects was much larger for children in subsistence fishing families than for those from recreational fishing families. This finding is also supported by the monetary estimates of benefits per child in each population category.

EPA estimated that the monetary value of benefits per child from a subsistence fishing family is $764, as compared to $74 per child from recreational fishing families. These benefits comprise a larger portion of subsistence fishing families' income compared to the benefits received by a recreational fishing family, because subsistence fishing families generally have lower household income.

EPA estimated that the monetary value of benefits from reduced cognitive damages to children in subsistence household is about 2.9 percent of their current household income, while benefits to recreational fishing families is 0.2 percent of their household income. This analysis uses average household income in low income/minority families and average household income of all households in the United States (1990 Census data).

Table 17.4 summarizes estimated changes in health risk and the monetary value of benefits to children from recreational and subsistence fishing families.

Table 17.4: Estimated Benefits to Pre-School Children from Reduced Exposure to Lead

Benefit Category	Population Category	Number of Exposed Children	Reduction in the Number of Adverse Health Effect Cases	Estimated Monetary Value of Avoided Health Damages to Children (1999$)	
				Total	Per Child
Neonatal Mortality	Recreation		0.92	$5,336,000	$47
	Subsistence		0.69	$4,002,000	$609
Avoided IQ Loss (Points)	Recreation		390.43	$3,934,410	$30
	Subsistence		98.65	$994,104	$151
Occurrence of IQ < 70	Recreation		1.39	$101,311	$1
	Subsistence		0.35	$25,079	$4
Occurrence of PbB > 20 µg/dL	Recreation		0.03	$686	negligible
	Subsistence		0.06	$60	negligible
Total	**Recreation**	**131,511**		**$9,372,407**	**$74**
	Subsistence	**6,576**		**$5,021,243**	**$764**
	All Children	**138,087**		**$14,393,650**	**$104**

Source: U.S. EPA analysis

GLOSSARY

hazard ratio: a ratio of the estimated ingestion rate of a pollutant to the reference dose (RfD) value for the pollutant. The RfD is an estimate of the maximum daily ingestion rate in mg/kg per day that is likely to be without an appreciable risk of deleterious effects during a lifetime. A hazard ratio greater than one indicates that individuals would be expected to ingest MP&M pollutants at rates sufficient to pose a significant risk of systemic health effects.

MP&M reach: a reach to which an MP&M facility discharges.

REFERENCE

1990 Census data: http://www.census.gov/

Chapter 18: MP&M Benefit / Cost Comparison

INTRODUCTION

The preceding Chapters 12 through 16 provided quantitative and qualitative assessments of the expected benefits to society from reduced MP&M effluent discharges under the proposed regulation. Chapter 11 assessed the regulation's expected social costs. This chapter sums the estimated values for the benefit categories that EPA was able to monetize, and compares the aggregate benefits estimate with the estimate of social costs.

CHAPTER CONTENTS:

18.1 SOCIAL COSTS

As discussed in Chapter 11, EPA estimated three categories of social cost for the proposed regulation:

- the cost of society's economic resources used to comply with the proposed regulation,
- the cost to governments of administering the proposed regulation, and
- the social costs of unemployment resulting from the regulation.

Summing these social cost accounts results in total social costs ranging from $2,034 to $2,113 million annually (1999$). The midpoint estimate of social costs for the proposed option equals $2,073 million (1999$).

The social cost estimates do not explicitly estimate losses in consumers' and producers' surpluses resulting from the changed quantity of goods and services sold in affected product markets. Instead, EPA developed an upper-bound estimate of social costs by including compliance costs for facilities predicted to close due to the rule. This approach results in an upper-bound estimate of the social costs of compliance, since the lost value incurred by closing facilities is presumably less than the estimated cost of compliance .[1]

18.2 BENEFITS

EPA was able to develop a partial monetary estimate of expected benefits for the proposed regulation in three categories: human health, water-based recreation (including nonuse value), and economic productivity benefits. Summing the monetary values reported in the preceding chapters across these categories results in total monetized benefits of $1,284 to $3,833 million (1999$) annually for the proposed rule (see Table 18.1). The midpoint estimate of monetized benefits for the proposed rule equals $2,396 million (1999$). As noted in Chapter 12, this benefit estimate is necessarily incomplete because it omits numerous mechanisms by which society is likely to benefit from reduced effluent discharges from the MP&M industry. Examples of benefit categories not reflected in this monetized estimate include:

- non-lead and non-cancer related health benefits,
- improved aesthetic quality of waters near discharge outfalls,
- benefits to wildlife and to threatened or endangered species,
- tourism benefits, and
- reduced costs of drinking water treatment.

[1] Including costs for regulatory closures in effect calculates the social costs of compliance incurred if every facility continued to operate post-regulation. Calculating costs as if all facilities continue operating will overstate social costs because some facilities find it more economic to close.

18.3 Comparing Monetized Benefits and Costs

EPA cannot perform a complete cost-benefit comparison because not all of the benefits resulting from the proposed regulatory alternative can be valued in dollar terms. Table 18.1 shows that combining the estimates of social benefits and social costs yields an estimate of net monetizable benefits ranging from negative $809 million to positive $1,752 million annually (1999$) at the national level. Comparing the midpoint estimate of social costs with the midpoint estimate of monetized benefits results in a net benefit of $311 million (1999$). The lack of a comprehensive benefits valuation limits this assessment of the relationship between costs and benefits of the proposed rule. EPA believes that the benefits of regulation, even in the low-estimate case, would likely exceed the social costs if all of the benefits of regulation could be quantified and monetized.

Table 18.1: Comparison of National Annual Monetizable Benefits to Social Costs: Proposed Rule (millions of 1999$)

Benefit and Cost Categories	Low	Mid	High
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$0.3	$0.3	$0.3
Reduced Cancer Risk from Water Consumption	$13.0	$13.0	$13.0
Reduced Risk from Exposure to Lead	$28.0	$28.0	$28.0
Enhanced Water-Based Recreation[a]	$960.6	$1,520.7	$2,218.7
Nonuse Benefits	$240.2	$760.3	$1,464.3
Avoided Sewage Sludge Disposal Costs	$61.1	$61.3	$61.5
Total Monetized Benefits	**$1,303.2**	**$2,383.6**	**$3,785.8**
Cost Categories			
Resource Costs of Compliance	$2,033.7	$2,033.7	$2,033.7
Costs of Administering the Proposed Regulation	$0.1	$0.3	$0.9
Social Costs of Unemployment	$0	$39.0	$78.0
Total Monetized Costs	$2,033.9	$2,073.0	$2,112.6
Net Monetized Benefits (Benefits Minus Costs)[b]	**($809.4)**	**$310.6**	**$1,751.9**

a. EPA adjusted the value of recreational fishing benefits to avoid double counting the benefits from cancer case reductions resulting from avoided consumption of contaminated fish tissue. The adjusted value is simply the difference between the estimated value of recreational fishing benefits and the value of benefits from reducing the cancer risk caused by fish consumption.
b. EPA calculated the low net benefit value by subtracting the high value of costs from the low value of benefits, and calculated the high net benefit value by subtracting the low value of costs from the high value of benefits. The mid value of net benefits is the mean value of benefits less the median value of costs.
Source: U.S. EPA analysis.

18.4 Comparing Monetized Benefits and Costs at the Sample Facility Level

Extrapolating from sample facility results to national results can introduce uncertainty into the analysis for both the cost and the benefits estimates. EPA therefore compared costs and benefits for the sample facilities alone, basing the sample results on known facility and benefit pathway characteristics. Table 18.2 presents the results of this analysis. EPA found that the relationship between benefits and costs for sample facilities alone are similar to that found in the national analysis. Specifically, in both analyses the low estimate for net benefits is negative while the midpoint and high estimates for net benefits are positive. This similarity in the relationship between benefits and costs in the two analyses, which is also matched by results from the Ohio case study (Chapter 22), increases EPA's confidence in its extrapolation of results to the national level.

Table 18.2: Comparison of Annual Monetizable Benefits to Social Costs for Sample Facilities: Proposed Rule (thousands of 1999$)

Benefit and Cost Categories	Low	Mid	High
Reduced Cancer Risk from Fish Consumption	$17.4	$17.4	$17.4
Reduced Cancer Risk from Water Consumption	$1,057.1	$1,057.1	$1,057.1
Reduced Risk from Exposure to Lead	$2,585.0	$2,585.0	$2,585.0
Enhanced Water-Based Recreation	$68,990.4	$108,803.9	$158,121.1
Nonuse Benefits	$17,247.6	$54,402.0	$104,359.9
Avoided Sewage Sludge Disposal Costs	$7,532.1	$7,532.4	$7,532.7
Total Monetized Benefits	**$97,429.6**	**$174,397.8**	**$273,673.2**
Total Monetized Costs[a]	**$121,392.9**	**$121,392.9**	**$121,392.9**
Net Monetized Benefits (Benefits Minus Costs)[b]	**($23,963.3)**	**$53,004.9**	**$152,280.3**

a. Total monetized costs represent the resource cost of compliance only. This analysis does not include the cost of administering the proposed regulation and the social cost of unemployment. Their relatively small size makes their exclusion unlikely to affect the conclusions that can be drawn from this analysis.
b. EPA calculated the low net benefit value by subtracting costs from the low value of benefits, and calculated the high net benefit value by subtracting costs from the high value of benefits.
Source: U.S. EPA analysis.

Chapter 19: Social Costs and Benefits of Regulatory Alternatives

INTRODUCTION

EPA considered two alternative regulatory options when developing the proposed MP&M rule. These options (Option 2/6/10 and Option 4/8) are described in Chapter 4. EPA estimated the social costs and benefits of these two options, using the same methods applied in the analyses of the proposed rule. This chapter summarizes the results of these benefit and cost analyses.

CHAPTER CONTENTS:

19.1 ESTIMATED SOCIAL COSTS

EPA estimated social costs for the alternative options based on the methodologies discussed in Chapter 11 for the proposed regulatory option.

19.1.1 Compliance Costs for MP&M Facilities

Table 19.1 presents the estimated resource value of compliance costs by discharge status and subcategory under the proposed option and Options 2/6/10 and 4/8, respectively. These compliance costs are not adjusted for the effect of taxes, and therefore represent the social value of resources used for compliance. EPA annualized compliance costs using a seven percent discount rate over a 15-year analysis period.

EPA's estimates included compliance costs for facilities that close due to the rule and costs for facilities that continue operating subject to the proposed regulation. This approach results in an upper-bound estimate of the social costs of compliance, since the lost value incurred by closing facilities is presumably less than the estimated cost of compliance.[1]

Under Option 2/6/10, compliance costs for indirect dischargers and direct dischargers equal $2,585 million and $253 million, respectively (1999$). The total annualized compliance costs are $2,838 million, representing a 40 percent increase over compliance costs under the proposed rule. This cost increase results from the elimination of low flow and subcategory exclusions under Option 2/6/10. General Metals indirect dischargers account for approximately 71 percent of the total compliance costs under this option.

Under Option 4/8, compliance costs for indirect dischargers and direct dischargers equal $4,141 million and $391 million, respectively (1999$). The total annualized compliance costs are $4,532 million, representing a 123 percent increase over compliance costs under the proposed rule. This significantly larger cost increase results from the more stringent technology requirements for all subcategories, as well as the elimination of the proposed low flow and subcategory exclusions. General Metals indirect dischargers account for approximately 65 percent of the total compliance costs under this option.

[1] Including costs for regulatory closures in effect calculates the social costs of compliance incurred if every facility continued to operate post-regulation. Calculating costs as if all facilities continue operating will overstate social costs because some facilities find it more economical to close.

Table 19.1: Resource Value of Compliance Costs under Different Options (million 1999$)

Subcategory	Indirect	Direct	Total
	Proposed Option		
General Metals	$1,454.4	$203.3	$1,657.7
MF Job Shop	$149.2	$1.2	$150.4
Non Chromium Anodizing	$0.0		$0.0
Oily Wastes	$8.5	$11.0	$19.5
Printed Wiring Boards	$145.5	$2.4	$148.0
Railroad Line Maintenance	$0.0	$1.1	$1.1
Shipbuilding Dry Docks	$0.0	$2.1	$2.1
Steel Forming & Finishing	$23.4	$31.5	$54.9
Total	$1,781.0	$252.7	$2,033.7
	Option 2/6/10		
General Metals	$2,035.0	$203.3	$2,238.3
MF Job Shop	$149.2	$1.2	$150.4
Non Chromium Anodizing	$36.0		$36.0
Oily Wastes	$195.4	$11.0	$206.4
Printed Wiring Boards	$145.5	$2.4	$148.0
Railroad Line Maintenance	$0.3	$1.1	$1.4
Shipbuilding Dry Docks	$0.2	$2.1	$2.3
Steel Forming & Finishing	$23.4	$31.5	$54.9
Total	**$2,585.0**	**$252.7**	**$2,837.7**
	Option 4/8		
General Metals	$2,950.1	$294.8	$3,244.9
Steel Forming & Finishing	$35.3	$34.2	$69.5
MF Job Shop	$269.9	$2.1	$272.0
Non Chromium Anodizing	$53.4		$53.4
Oily Wastes	$611.9	$53.7	$665.7
Printed Wiring Boards	$219.8	$4.4	$224.2
Railroad Line Maintenance	$0.5	$1.2	$1.7
Shipbuilding Dry Docks	$0.2	$0.6	$0.7
Steel Forming & Finishing	$35.3	$34.2	$69.5
Total	**$4,141.2**	**$391.0**	**$4,532.2**

Source: U.S. EPA analysis.

19.1.2 Government Administrative Costs

Substantially more indirect dischargers require permitting under the alternative options than under the proposed rule, because the alternative options do not include the proposed low flow and subcategory exclusions. Table 19.2 shows the number of facilities requiring permitting of different types under the proposed option and Options 2/6/10 and 4/8. These options require permitting for 48,065 and 46,400 more facilities, respectively, than does the proposed rule. Option 4/8 involves more regulatory closures and thus requires permitting for fewer facilities than does Option 2/6/10.

Table 19.2: Permitting Requirements for Regulatory Alternatives (number of indirect discharging facilities)

Permitting required:	Proposed Option	Option 2/6/10	Option 4/8
Convert from existing concentration-based to mass-based[a]	223	8,424	8,422
New concentration-based permit[a]	432	16,009	15,119
New mass-based permit[a]	216	8,004	7,559
Repermit within 5 rather than 3 years	4,073	20,752	20,244
Regulatory closures (no longer requiring permits)[b]	143	1,020	1,348
Total with permits	4,944	53,009	51,344

a. EPA assumes, for costing purposes, that permitting authorities will choose to issue mass-based permits to one-third of the facilities requiring new permits, and one-third of the facilities with existing concentration-based permits, except for Steel Forming & Finishing facilities. EPA assumes that all Steel Forming & Finishing facilities will be issued mass-based permits, including the 20 facilities that currently have a concentration-based permit.
b. Some facilities with existing permits will no longer require permitting due to regulatory closures.
Source: U.S. EPA analysis.

Table 19.3 presents the estimated permitting costs to governments of administering the proposed rule and alternative options. These costs include the labor and material resources required to write permits under the regulation and conduct compliance monitoring and enforcement activities. Chapter 7 describes the methodology used to estimate these administrative costs.

Estimated government administration costs for Option 2/6/10 range from $5.0 million to $9.3 million (1999$). The median cost estimate, $11.8 million, exceeds the corresponding cost estimate for the proposed rule by $11.5 million.

Government administration costs under Option 4/8 range from $4.7 million to $36.5 million (1999$). The median cost estimate, $10.9 million, exceeds the corresponding cost estimate for the proposed rule by $10.7 million. Permitting costs are lower under Option 4/8 than under Option 2/6/20 because there are more facilities that close under Option 4/8 that no longer require permitting.

Table 19.3: Government Administrative Costs for Alternative Options (million 1999$)

Option	Low	Mid	High
Proposed Option	$0.1	$0.3	$0.9
Option 2/6/10	$5.0	$11.8	$39.3
Option 4/8	$4.7	$10.9	$36.5

Source: U.S. EPA analysis.

19.1.3 Cost of Unemployment

Table 19.4 presents the estimated social costs of unemployment under the proposed option and Table 19.5 presents the same information for Options 2/6/10 and 4/8. These estimates include the estimated willingness-to-pay to avoid cases of involuntary unemployment, and the cost of administering the unemployment compensation system for unemployed workers. EPA annualized costs using a seven percent discount rate over a 15-year analysis period.

The Agency based lower-bound estimates of the number of net job losses expected from compliance. Unlike the proposed rule, both alternative options involve net employment losses because the increased employment due to compliance expenditures do not outweigh the expected job losses from regulatory closures. Net unemployment expected under Option 2/6/10 and Option 4/8 is 4,811 and 20,534 jobs, respectively. The upper-bound estimate for lost employment, which does not consider increased employment due to compliance expenditures, is 16,834 and 48,070 lost jobs under Option 2/6/10 and Option 4/8, respectively. Based on these estimates for lost employment, social costs of unemployment under Option 2/6/10 range from $168 million to $222 million (1999$). The midpoint estimate, $195 million, exceeds the corresponding cost estimate under the proposed rule by $156 million. Social costs of unemployment under Option 4/8 range from $480 million to $633 million (1999$). The midpoint estimate, $557 million, exceeds the corresponding estimate under the proposed rule by $518 million.

Table 19.4: Social Costs of Unemployment for The Proposed Option (million 1999$)

Unemployment/Cost Category	Proposed Option Low	Proposed Option Mid	Proposed Option High
Net Unemployment (FTE-years)[a]		(2,575)	
Gross Unemployment (FTE-years)[a]		5,916	
Annualized Social Cost of Unemployment	$59.0	$68.4	$77.9
Annualized Administrative Cost	$0.1	$0.1	$0.1
Total Social Cost of Unemployment	$59.1	$68.5	$78.0

[a] Number of FTE positions multiplied by the duration of employment/unemployment. EPA assumed that workers losing jobs due to regulatory closures would be unemployed for one year. The timing and duration of employment gains due to compliance expenditures differs for employment associated with manufacturing and installing equipment (in the first year) and operating and maintaining equipment (all 15 years of the analysis period).
Source: U.S. EPA analysis.

Table 19.5: Social Costs of Unemployment for Alternative Options (1999$)

Unemployment/Cost Category	Option 2/6/10 Low	Option 2/6/10 Mid	Option 2/6/10 High	Option 4/8 Low	Option 4/8 Mid	Option 4/8 High
Net Unemployment (FTE-years)[a]		4,811			20,534	
Gross Unemployment (FTE-years)[a]		16,834			48,070	
Annualized Cost of Unemployment	$167,899,414	$194,755,187	$221,610,961	$479,433,297	$556,119,402	$632,805,508
Annualized Administrative Cost	$221,796	$221,796	$221,796	$633,333	$633,333	$633,333
Total Social Cost of Unemployment	$168,121,209	$194,976,983	$221,832,757	$480,066,630	$556,752,736	$633,438,841

[a] Number of FTE positions multiplied by the duration of employment/unemployment. EPA assumed that workers losing jobs due to regulatory closures would be unemployed for one year. The timing and duration of employment gains due to compliance expenditures differs for employment associated with manufacturing and installing equipment (in the first year) and operating and maintaining equipment (all 15 years of the analysis period).
Source: U.S. EPA analysis.

19.1.4 Total Social Costs

Based on the cost estimates presented above, EPA estimates the social cost of regulation under Option 2/6/10 to lie in the range of $3,011 million to $3,099 million (1999$) annually. The midpoint estimate, $3,045 million, represents a 47 percent increase in the social cost of regulation over the proposed rule. This increase results because the proposed low flow and subcategory exclusions are eliminated under Option 2/6/10.

EPA estimates the social costs of regulation under Option 4/8 to lie in the range of $5,017 million to $5,202 million (1999$) annually. The midpoint estimate, $5,100 million, represents a 146 percent increase in the social cost of regulation over the proposed rule. This increase results from the more stringent technology requirements for all subcategories under Option 4/8 compared to those under the proposed rule. In addition, this alternative option eliminates low flow and subcategory exclusions.

19.2 Estimated Benefits

EPA estimated the benefits for the alternative options based on the methodologies described in Chapters 12 through 16.

19.2.1 Human Health Benefits

EPA used the methodology described in Chapter 13 to assess human health benefits from reduced incidence of cancer from consumption of contaminated fish tissue and drinking water under the two alternative options.

EPA estimates that Option 2/6/10 would reduce incidence of cancer from consumption of contaminated fish by 0.045 cases per year, representing a reduction of approximately 36 percent from the baseline level of 0.126. Option 4/8 would eliminate approximately 0.062 cancer cases per year representing a reduction of about 49 percent. The estimated monetary value of reduced incidence of cancer from consumption of contaminated fish is $0.3 million (1999$) under Option 2/6/10 and $0.4 million (1999$) under Option 4/8. Option 4/8 has the largest benefits from reduced incidence of cancer from contaminated fish consumption. The proposed option and Option 2/6/10 result in the same level of benefits and are both inferior to Option 4/8.

Under Option 2/6/10, 2.36 fewer cancer cases are expected annually, a decline of 46 percent from the baseline level. Similarly, under Option 4/8, 2.37 fewer cancer cases are expected annually, a decline of 47 percent from the baseline level. EPA estimates that the proposed option will reduce the incidence of cancer from consumption of contaminated drinking water by 2.24 cases per year. This figure is 0.12 or 013 cases fewer than Option 2/610 or Option 4/8, respectively. Estimated annual monetary benefits under Option 2/6/10 and Option 4/8 equal $13.7 and $13.8 million (1999$), respectively.

EPA used the methodology described in Chapter 14 to assess benefits to children and adults from reduced exposure to lead under Option 2/6/10 and Option 4/8. EPA estimates that reduced consumption of contaminated fish will result in annual lead-related benefits for children equaling $14.8 million (1999$) for both Option 2/6/10 and Option 4/8. EPA estimates neonatal mortality to decrease by 1.7 cases, and estimates an avoided loss of 504 IQ points under both options. Lead-related benefits for adults under both options equal $14.1 million. Lead-related benefits for children and adults combined equal $28.9 million, an increase of $0.9 million over the proposed option. Table 19.6 provides a summary of all health-related benefits.

Table 19.6: Annual Human Health Benefits for the Alternative Options (1999$)

Benefit Category	Baseline	Proposed Option	Option 2/6/10	Option 4/8
Reduced Cancer Risk from Fish Consumption				
Number of Cancer Cases	0.126	0.081	0.081	0.064
Monetary Value (millions $)		$0.3	$0.3	$0.4
Reduced Cancer Risk from Water Consumption				
Number of Cancer Cases	5.10	2.86	2.74	2.73
Monetary Value (millions $)		$13.0	$13.7	$13.8
Lead Related Benefits				
Children		$14.4	$14.8	$14.8
Adult		$13.6	$14.1	$14.1

Source: U.S. EPA analysis.

19.2.2 Recreational Benefits

EPA used the methodology described in Chapter 15 to assess improvements in recreational benefits under the alternative options. The Agency found that Option 2/6/10 eliminated the occurrence of pollutant concentrations in excess of ***ambient water quality criteria*** (AWQC) limits in 6,226 of the 10,443 baseline occurrences (see Table 19.7). Similarly, EPA found that Option 4/8 eliminated the occurrence of pollutant concentrations in excess of AWQC limits in 6,217 of the baseline occurrences. EPA estimated that these habitat improvements would increase the recreational value, including both use and nonuse value, of improved reaches by $3,014.3 million to $9,261.9 million annually under Option 2/6/10 and by $2,923.7 million to $9,044.5 million annually under Option 4/8 (1999$). The midpoint estimates for annual recreational benefits under

Option 2/6/10 and Option 4/8 are $5,728.9 million and $5,575.7 million (1999$), respectively. The midpoint estimates of recreational and nonuse benefits are approximately 2.5 times greater under Option 2/6/10 and Option 4/8 than under the proposed option.

Table 19.7: Number of MP&M Discharge Reaches with MP&M Pollutant Concentrations Exceeding AWQC Limits

Regulatory Option	Number of Reaches with Concentrations Exceeding			Number of Reaches with Concentrations Exceeding AWQC Limits
	AWQC Acute Exposure Limits for Aquatic Species	AWQC Chronic Exposure Limits for Aquatic Species	AWQC Limits for Human Health	
Baseline	878	2,466	10,310	10,443
Proposed Option	103	1,437	9,205	9,258
Option 2/6/10	61	1,394	4,159	4,217
Option 4/8	52	1,310	4,168	4,226

Note: All reaches exceeding aquatic acute exposure limits also exceed chronic exposure limits. In order not to double count the number of reaches expected to benefit from the regulation, the total number of reaches exceeding AWQC limits is the sum of the number of reaches that exceed human health criteria and the number exceeding aquatic chronic criteria.
Source: U.S. EPA analysis.

19.2.3 Avoided Sewage Sludge Disposal or Use Costs

Reduced metals discharges to POTWs resulting from Option 2/6/10 and Option 4/8 would enable 1,408 and 1,450 POTWs, respectively, to dispose of sewage sludge by land application. The regulations would decrease the cost to POTWs for disposal or use of sewage sludge by an estimated $69.6 million and $127.4 million annually (1999$) under Option 2/6/10 and Option 4/8, respectively. Compared to the proposed option, Option 6/2/10 and Option 4/8 offer an additional $8.3 million (1999$) and $66.1 million (1999$) in cost savings from reduced contamination of sewage.

Table 19.8: Cost Savings from Land Application

Option	# of POTWs Land Applying	Cost Savings from Upgrading Sewage Sludge Disposal Methods
Baseline	6,953	
Proposed Option	6,889	61.3
Option 2/6/10	5,574	68.5
Option 4/8	5,574	127.4

19.2.4 Total Monetized Benefits

EPA estimates that total monetized benefits under Option 2/6/10 range from $3,125 million to $9,376 million (1999$) annually, with a midpoint estimate of $5,841 million. Total monetized benefits under Option 4/8 range from $3,092 million to $9,217 million (1999$) annually, with a midpoint estimate of $5,746 million. The midpoint estimate of Monetized Option 2/6/10 benefits are 145 percent higher than the midpoint estimate of benefits for the proposed rule, and Option 4/8 benefits are 141 percent higher than under the proposed rule.

19.3 Comparison of Estimated Benefits and Costs

Combining the estimates of social benefits and social costs under Option 2/6/10 yields net monetized benefits ranging from $26 million to $6,366 million annually (1999$), with a midpoint estimate of $2,797 million (see Table 19.9). Net monetized benefits under Option 4/8 range from a net cost of$2,110 million to a net benefits of $4,200 million annually (1999$), with a midpoint net benefit of $646 million (see Table 19.9). As discussed in Chapter 12, the assessment of benefits is necessarily incomplete due to the omission of numerous mechanisms by which society is likely to benefit from reduced effluent discharges.

Table 19.9: Comparison of Social Benefits and Costs for Option 2/6/10 (millions of 1999$)

Benefit and Cost Categories	Low	Mid	High
Proposed Option			
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$0.3	$0.3	$0.3
Reduced Cancer Risk from Water Consumption	$13.0	$13.0	$13.0
Reduced Risk from Lead Exposure	$28.0	$28.0	$28.0
Enhanced Water-Based Recreation	$960.6	$1,520.7	$2,218.7
Nonuse Benefits	$240.2	$760.3	$1,464.3
Avoided Sewage Sludge Disposal Costs	$61.1	$61.3	$61.5
Total Monetized Benefits	**$1,303.2**	**$2,383.6**	**$3,785.8**
Cost Categories			
Resource Costs of Compliance	$2,033.7	$2,033.7	$2,033.7
Costs of Administering the Proposed Regulation	$0.1	$0.3	$0.9
Social Costs of Unemployment	$0	$39.0	$78.0
Total Monetized Costs	$2,033.9	$2,073.0	$2,112.6
Net Monetized Benefits (Benefits Minus Costs)[a]	**($809.4)**	**$310.6**	**$1,751.9**
Option 2/6/10			
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$0.3	$0.3	$0.3
Reduced Cancer Risk from Water Consumption	$13.7	$13.7	$13.7
Reduced Risk from Lead Exposure	$28.9	$28.9	$28.9
Enhanced Water-Based Recreation	$22,411.5	$3,819.3	$5,579.5
Nonuse Benefits	$602.9	$1,909.6	$3,682.4
Avoided Sewage Sludge Disposal Costs	$67.8	$69.6	$71.3
Total Monetized Benefits	$3,125.1	$5,841.4	$9,376.1
Cost Categories			
Resource Costs of Compliance	$2,837.7	$2,837.7	$2,837.7
Costs of Administering the Proposed Regulation	$5.0	$11.8	$39.3
Social Costs of Unemployment	$168.1	$195.0	$221.8
Total Monetized Costs	$3,010	$3,044.5	$3,098.8
Net Monetized Benefits (Benefits Minus Costs)[a]	**$26.3**	**$2,796.9**	**$6,366.1**
Option 4/8			
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$0.4	$0.4	$0.4
Reduced Cancer Risk from Water Consumption	$13.8	$13.8	$13.8
Reduced Risk from Lead Exposure	$28.9	$28.9	$28.9
Enhanced Water-Based Recreation	$2,338.9	$3,717.2	$5,448,5
Nonuse Benefits	$584.7	$1,858.6	$3,596.0
Avoided Sewage Sludge Disposal Costs	$125.6	$127.4	$129.2
Total Monetized Benefits	$3,092.3	$5,746.3	$9,216.8
Cost Categories			
Resource Costs of Compliance	$4,532.2	$4,532.2	$4,532.2
Costs of Administering the Proposed Regulation	$4.7	$10.9	$36.5
Social Costs of Unemployment	$480.1	$556.8	$633.4
Total Monetized Costs	$5,017.0	$5,099.9	$5,202.1
Net Monetized Benefits (Benefits Minus Costs)[a]	**($2,109.8)**	**$646.4**	**$4,199.8**

a. EPA calculated the low net benefit value by subtracting the high value of costs from the low value of benefits, and calculated the high net benefit value by subtracting the low value of costs from the high value of benefits. The mid net benefit value is the mean value of benefits less the midpoint of costs.
Note: Categories may not sum to totals due to rounding of individual estimates for presentation purposes.
Source: U.S. EPA analysis.

GLOSSARY

ambient water quality criteria (AWQC): AWQC present scientific data and guidance of the environmental effects of pollutants which can be useful to derive regulatory requirements based on considerations of water quality impacts; these criteria are not rules and do not have regulatory impact (U.S. EPA. 1986. Quality Criteria for Water 1986. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC. EPA 440/5-86-001).

ACRONYM

AWQC: ambient water quality criteria

Chapter 20: Baseline Conditions in Ohio

INTRODUCTION

Section IV of this EEBA focuses on the State of Ohio as a case study of the MP&M regulation's expected benefits and costs. Ohio has a diverse water resource base, a relatively large number of MP&M industry facilities, and a more extensive water quality ecological database than many other states. EPA gathered extensive data on MP&M facilities and on Ohio's baseline water quality conditions and water-based recreation activities, to support the case study analysis. These data characterize current water quality conditions, water quality changes expected from the regulation, and the expected welfare changes from water quality improvements at waterbodies affected by MP&M discharges.

The case study analysis supplements the national level analysis performed for the MP&M regulation in two important ways. First, the case study used improved data and methods to determine MP&M pollutant discharges from both MP&M facilities and other sources. In particular, EPA oversampled the State of Ohio with 1,600 screener questionnaires to augment information on Ohio MP&M facilities. The Agency also used information from the sampled MP&M facilities to assign discharge characteristics to non-sampled MP&M facilities[1]. Second, the analysis used an original travel cost study to value four recreational uses of water resources affected by the regulation: swimming, fishing, boating, and near-water activities. The added detail provides a more complete and reliable analysis of water quality changes from reduced MP&M discharges. The case study analysis therefore provides more complete estimates of changes in human welfare resulting from reduced health risk, enhanced recreational opportunities, and improved economic productivity.

The statewide case study of recreational benefits from the MP&M regulation combines water quality modeling with a ***random utility model*** (RUM) to assess how changes in water quality from the regulation will affect consumer valuation of water resources. The study addresses a wide range of pollutant types and effects, including water quality measures not often addressed in past recreational benefits studies. The estimated model supports a more complete analysis of recreational benefits from reductions in ***nutrients*** and "***toxic***" pollutants.[2]

This and the next two chapters present the Ohio case study. This chapter provides background information on the state of Ohio, the following chapter presents the results from the

CHAPTER CONTENTS:

[1] Appendix G provides a detailed discussion on the approach used to estimate discharge characteristics for non-sampled MP&M facilities.

[2] The term "toxic" used here refers to the 126 ***priority or toxic pollutants*** specifically defined as such by EPA, as well as ***nonconventional pollutants*** that have a toxic effect on human health or aquatic organisms.

recreational benefits analysis, and the last chapter summarizes social costs and benefits of the proposed regulation for the state of Ohio.

20.1 Overview of Ohio s Geography, Population, and Economy

Table 20.1 summarizes general information on Ohio. Ohio is large, heavily-industrialized, and densely-populated. The state covers a total surface area of 44,828 sq. mi. (106,607 sq. km.), of which water represents 3,875 sq. mi. (10,036 sq. km.). About 90 percent of the water surface area consists of Lake Erie; the remainder includes inland waters, such as lakes, reservoirs, and rivers (including the Ohio River). The state housed 11,173,000 people in 1996. The three largest metropolitan areas are located on Lake Erie (Toledo and Cleveland) and the Ohio River (Cincinnati).

Table 20.1: Facts about the State of Ohio

Geography			
Location	Midwest United States, northeast part: • south of Lake Erie • east of Indiana • north of the Ohio River		
Total land area	40,953 sq. mi. (106,607 sq. km.) Of the 26,451,000 acres of terrestrial surface area in Ohio: • 97 percent is non-federal land (National Resources Inventory (NRI)) • 3,558,000 acres, representing 13.5 percent of the total area of Ohio, are developed The remaining non-federal lands are rural land, classified mostly as crop land, forest, and pasture lands. (USDA, 1992)		
Total water surface area	3,875 sq. mi. (10,036 sq. km.) Approx. 90 percent is represented by Lake Erie, and 10 percent are inland waters including rivers, lakes, and reservoirs.[a]		
Total area	44,828 sq. mi. (116,104 sq. km.)		
Demographics			
Population	11,173,000 in 1996, approximately 4.2 percent of total U.S. population (U.S. Census Bureau) Population increase: three percent from 1990 to 1996, compared to a six percent increase in the U.S. population overall. Most densely populated part of the state: northeastern Ohio, both urban and rural areas. Largest cities: Cleveland, Cincinnati, and Toledo.		
Economics			
	Ohio	**Midwest**	**U.S.**
Per Capita Income (1996$)	$23,537 Rank in per capital income in the U.S.: 21	$24,166	$24,231
Percent of population below the poverty level (1995 Current Population Survey data, DOC 1996)	11.5%		13.8%
	Ohio per capita income increased by 16 percent from 1986 to 1996. Income growth is consistent with other Midwestern states and is two percent greater than overall U.S. per capita income growth.		
Gross State Product (GSP)	$303,569,000 (1996$), representing 4 percent of Gross Domestic Product (GDP) for the U.S. in 1996.		
Percent increase in GSP/GDP from 1986 to 1996 (in adjusted 1996$)	Ohio GSP: 25%	U.S. GDP: 29%	

a. Total water surface uses are estimated by the USDA's National Resources Inventory (NRI). See "http://www.ftw.nrcs.usda.gov/nri_data.html"

Source: U.S. EPA analysis.

20.2 PROFILE OF MP&M FACILITIES IN OHIO

EPA selected Ohio as the case study state because MP&M industries account for a large share of the state's economy (see Table 20.2). Data from the 1992 Economic Censuses show that industries containing MP&M facilities employ 16.5 percent of Ohio's total industrial workers and produce 20.4 percent of industrial worker output by value. MP&M industries also account for 21.9 percent of payroll payments, indicating that jobs in MP&M industries are more highly paid than industrial jobs on average in Ohio. The discussion below explains the sources and methodology EPA used, and then presents detailed results and caveats.

Table 20.2: MP&M Share of Industrial Output and Employment in Ohio, 1992

	Total Employment	Payroll	Value of Output
MP&M	615,706	$18,667,630,000	$111,052,845,000
TOTAL	3,723,809	$85,085,182,000	$544,340,216,000
MP&M Share	**16.5%**	**21.9%**	**20.4%**

Source: Department of Commerce 1992 Economic Censuses.

EPA obtained employment, payroll, and output data from the 1992 Economic Census CD-ROM, drawing from the eight economic censuses in Table 20.3. Employment and payroll numbers include all employees (i.e., production plus non-production workers). The measure of output differs according to the source, but in each case the output measures shown in Table 20.2 correspond conceptually to total revenue. EPA extracted the EMPLOYEE, PAYROLL, and VALUE fields for each 4-digit SIC industry in the MP&M category and for the entire state of Ohio. Industries include both in-scope and out-of-scope facilities.

Table 20.3: The Economic Censuses

Source	Measure of Output
Census of Retail Trade	Value of sales
Census of Wholesale Trade	Value of sales
Census of Service Industries[a]	Value of receipts
Census of Transportation, Communications, and Utilities	Value of revenue
Financial, Insurance, and Real Estate Industries	Value of receipts
Census of Manufacturers	Value of shipments
Census of Mineral Industries	Value of shipments
Census of Construction Industries	Value of construction work

a. Includes both taxable and non-taxable establishments.
Source: Department of Commerce 1992 Economic Censuses.

The MP&M industries include facilities to which the MP&M rule may not apply. For example, MP&M industries include non-dischargers, but census data do not distinguish between in-scope and out-of-scope facilities.

Also, the analysis examines only the industrial sectors for which the Department of Commerce compiles statistics in the Economic Censuses. Published industrial employment and output measures often exclude military and other government personnel and farm output and employment, whether those exclusions are noted or not. The analysis excludes $3.9 billion in value of agricultural products sold in 1992 by farms in Ohio, according to the U.S. Department of Agriculture's 1992 Census of Agriculture. The Ohio analysis also excludes the government sector, which employed approximately 734,000 people in Ohio in 1992, according to the U.S. Bureau of Labor Statistics.[3] These exclusions are normal when economists compare the size of industrial groups.

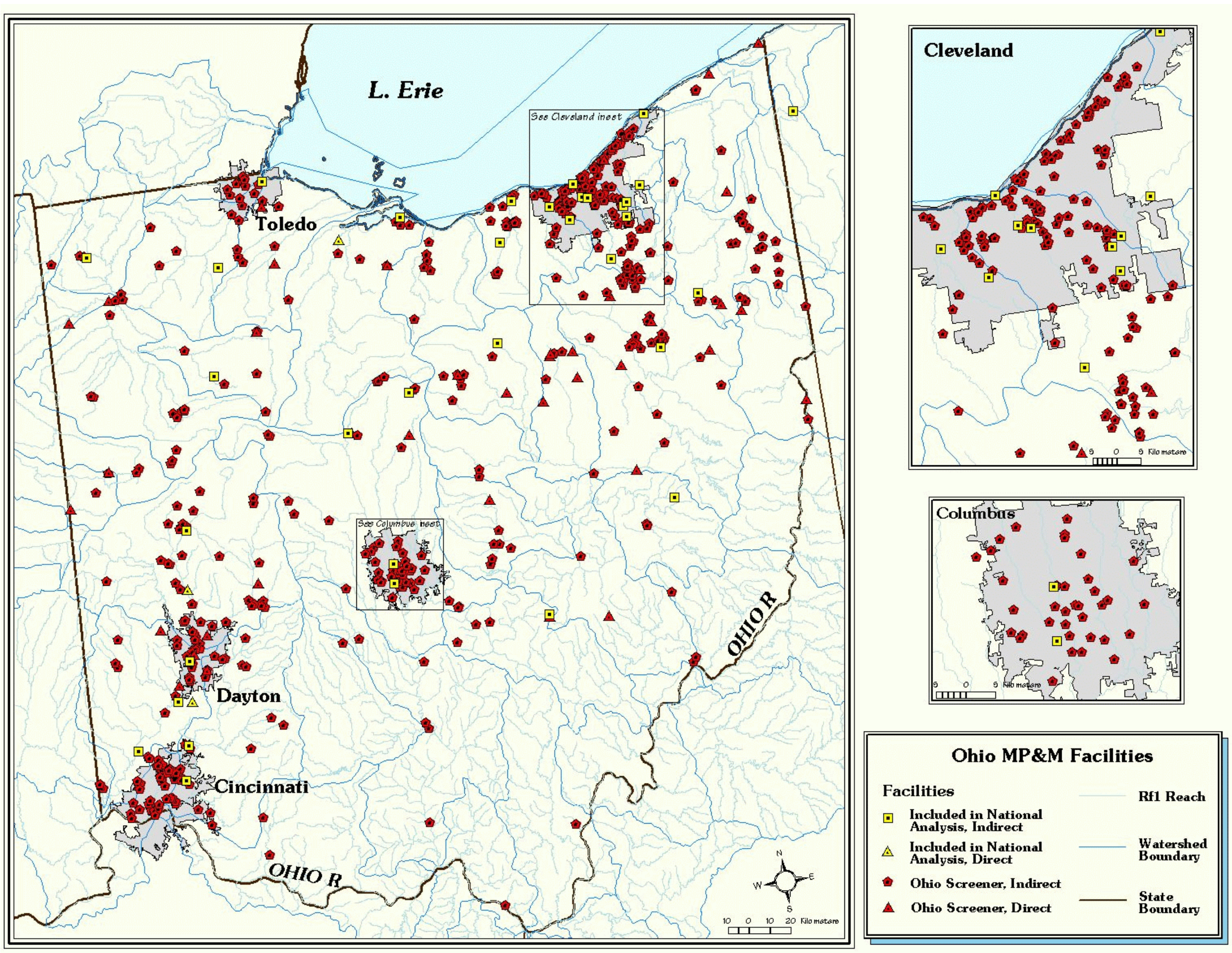
If total employment in Ohio includes the government sector, then MP&M industries account for only 13.6 percent, rather than 16.3, percent of employment. If total industrial manufacturing and non-manufacturing output in Ohio includes the agricultural sector, then MP&M industries account for only 19.8, rather than 20.0, percent of output. This said, data from the Bureau of Labor Statistics and USDA are not completely consistent with the Economic Census data.

[3] U.S. Bureau of the Census, *Statistical Abstract of the United States, 1993*, Washington, D.C., 1993.

EPA augmented information on MP&M facilities available from published data sources and the Section 308 survey by oversampling the State of Ohio with 1,600 screeners. The Agency used information from the Section 308 Survey and the 1,600 screeners to characterize discharges from MP&M facilities in Ohio and to assess the economic impact of the proposed regulation at the state level. Figure 20.1 depicts locations of the Ohio facilities included in the case study analysis.

The map of facility locations shows that additional information from 1,600 screeners enabled EPA to perform the benefits assessment with a greater level of detail than is possible at the national level. The added detail results in a more complete and reliable analysis of changes in human welfare resulting from improved recreational opportunities.

Figure 20.1: Location of Sample MP&M Facilities in Ohio



Source: U.S. EPA analysis.

20.3 OHIO S WATER RESOURCES

The benefits of enhanced water quality stem directly from enhancing water quality and/or quantity of services provided by water resources. To aid in understanding the analysis of benefits from the proposed rule in Ohio, this section summarizes environmental services provided by Ohio's water resources.

Ohio is a water-rich state:

- 24,000+ miles of named and designated rivers and streams;
- 451-mile border on the Ohio River;

- 200,000 acres among 450 lakes, ponds, rivers, and reservoirs; and

- 230+ miles of Lake Erie shoreline.

These water resources provide three broad categories of services: ***in-stream***, ***withdrawal***, and ***existence*** services. Water resources provide in-stream services prior to the withdrawal of water from the waterbody. Major in-stream services include life support for animals and plants, water-based recreation, commercial fishing and navigation, water storage, and aesthetics. Withdrawal services include uses of water resources after the water is withdrawn from the waterbody. These uses include drinking water supply, irrigation, production and processing services, and sanitary services. Existence services are not linked to current uses of waterbodies, and arise from knowing that species diversity or the natural beauty of a given waterbody is preserved.

The Ohio Environmental Protection Agency (Ohio EPA) assesses surface waters in their ***Ohio Water Resource Inventory (OWRI)*** report based on water resource services provided by the assessed waterbody. The main focus of this assessment is on beneficial uses associated with Ohio's water resources, including aquatic life use, recreation, and public water supply. Table 20.4 shows how Ohio surface waters fall into these use designations.

Table 20.4: Summary of Designated Life Uses for Ohio Surface Waters (1996)

Use Designation	Stream/River (Miles)[a]	Lakes / Reservoir (Acres)[a]	Lake Erie (Shore Miles)[a]
Total	43,917	200,000	236
Aquatic Life Use[a]	24,067	193,903	236
Exceptional Warmwater Habitat (EWH)	3,217	193,903	236
Warmwater Habitat (WWH)	18,318		
Other	2,532		
Recreation			
Primary Contact (PCR)[b]	224,96	200,000	236
Secondary Contact (SCR)	1,188		
Public Water Supply		118,801	

a. Total river/stream miles are based on Ohio EPA estimates. U.S. EPA estimates 61,532 total river miles and 29,113 total perennial miles based on RF3, which includes many smaller undesignated streams.
b. Note that some waterbodies have more than one designated use (e.g., aquatic life and primary recreation).
Source: Ohio EPA, OWRI, 1996.

The aquatic life use category is further subdivided into seven categories. The most widely-applied aquatic use designation in Ohio is ***Warmwater Habitat (WWH)***, accounting for 18,318 (76 percent) stream and river miles (Ohio EPA, OWRI, 1996). The second most widely applied designation is ***Exceptional Warmwater Habitat (EWH)***, accounting for 3, 217 stream and river miles (13 percent), 236 Lake Erie shore miles (100 percent), and 193,903 acres of inland lakes (100 percent). Other aquatic life categories include:

- ***Modified Warmwater Habitat (MWH)***,

- ***Limited Resource Waters (LRW)***,

- ***Limited Warmwater Habitat (LWH)***,

- ***Seasonal Salmonid Habitat (SSH)***, and

- ***Coldwater Habitat (CWH)***.

Recreational uses are subdivided into ***Primary Contact Recreation (PCR)*** and ***Secondary Contact Recreation (SCR)***:

- Primary Contact Recreation (PCR) — rivers and streams deep enough for full human body immersion activities such as swimming.

- Secondary Contact Recreation (SCR) — only deep enough to permit wading and incidental contact, such as boating.

Approximately half of the designated stream miles, all inland lakes, and all of the Lake Erie shore miles are designated for PCR (see Table 20.4). In addition, three percent of the designated stream miles (1,188 miles) are suitable for SCR.

The following sections detail each category of water resource use.

20.3.1 Aquatic Life Use

The Ohio water resources support hundreds of aquatic species and plants. Ohio water resources are also home to a number of endangered and threatened species. Suitable stream and lake habitat are essential for both resident and transient animal populations, including imperiled aquatic species. Habitats include specific ***biotic*** components (e.g., assemblages of plant and animal species) and physical (e.g., ***dissolved oxygen*** **(DO)** content and temperature range) components. Water quality impairments associated with siltation, excess nutrients, or low DO can adversely affect habitat that supports important activities, such as reproduction, foraging, migration, and overwintering.

The following sections briefly introduce water-dependent biological resources Ohio. Water quality effects on life support for animals and plants are discussed in Section 20.5

a. Ohio fish species

Fish are found throughout Ohio in almost every inland surface waterbody and Lake Erie. Many fish species serve important recreational or commercial functions, while others are important forage for birds, other fish, and land-based species. Ecosystem well-being therefore depends on the health of fish and other aquatic species populations. The Ohio EPA monitors biological data, especially those on sensitive aquatic species, to determine the aquatic life use attainment of surface waters. The state gives high priority to healthy aquatic ecosystem maintenance.

Ohio's rivers and lakes offer a variety of manmade and natural habitats that offer excellent fishing opportunities for numerous gamefish species. The state of Ohio spends significant resources on fishery management, trout stocking, and recreational area maintenance to enhance these fish populations. Table 20.5 below provides brief summaries of the habitat and diet of major recreational and commercial fish species in Ohio (Ohio DNR, 1999):

Table 20.5: Recreationally or Commercially Valuable Fish Species in Ohio

Fish	Native or introduced?	Habitat	Spawning season	Diet
Bass	Most native bass (e.g., largemouth, smallmouth, spotted, and sock)	Ponds, lakes, rivers, and streams in every county; Lake Erie	Mid-April to mid-June	Frogs, crayfish, insects, and other fish
Bullhead	Native	Throughout Ohio. Concentrations in northern and west central Ohio	Mid-May to June	Insect larvae, crayfish, snails, dead animals
Burbot	Native	Lakes and rivers. Prefer deep waters, but move inshore to spawn	Winter	Minnows and the young of other fish species
Carp	Introduced	Warm lakes, streams, and ponds with abundant organic matter, in every county	Late April to June	Insect larvae, mollusks, fish, crustaceans
Catfish (Channel, Flathead)	Native	Throughout Ohio's rivers and lakes. Tolerate a wide range of conditions	When waters reach 70° F in temperature	Bottom feeders with a diet of insect larvae, mollusks, and fish both dead and alive
Crappie, White		Larger ponds, reservoirs, and rivers, including nearshore habitats of Lake Erie, in most areas of Ohio	May and June	Insects and small fish
Crappie, Black		Same general habitat as white crappie, slightly less widely distributed	May and June	Insects and small fish
Drum	Native	Lake Erie; drums support a commercial fishery	Spring into late summer	Mollusks, crayfish, fish, insects
Lamprey		Lake Erie and tributaries; Ohio River and larger tributaries		Some species parasitize other fish by attaching themselves to a larger host's flank and feeding on its flesh

Table 20.5: Recreationally or Commercially Valuable Fish Species in Ohio

Fish	Native or introduced?	Habitat	Spawning season	Diet
Muskellunge (Muskie)	Native	Historically found in Lake Erie bays and tributaries and streams of Ohio River drainage; now also found in several impoundments	April and early May, when temperatures reach low to mid-50s	Suckers, gizzard shard, and other soft-rayed fish
Perch, White	Introduced	Lake Erie and tributaries	April and May	Insects, crustaceans, other fish
Perch, Yellow	Native	Lakes, impoundments, ponds, slow-moving rivers		
Pike	Native	Historically abundant in Lake Erie and tributaries. Today distributed in a small portion of Lake Erie, Sandusky Bay, Maumee Bay, and their tributary streams in marshes, bays, and pools with abundant vegetation	As ice breaks in late February and early March Pike is a popular ice-fishing species	Mostly fish, but are opportunistic feeders; will occasionally eat frogs, muskrats, small ducks
Salmon (Chinook and Coho)	Introduced	Stocked in Lake Erie for both recreational and commercial fishing purposes		
Sauger	Native	Lake Erie and its tributaries; Ohio River	Spring, when water temperatures reach high 40s	Insects, crayfish, other small fish during low light (dawn and dusk)
Saugeye (cross between Sauger and Walleye)	Introduced	Stocked into many Ohio impoundments		
Sucker, White	Native	Every county; Lake Erie	April to May	Bottom feeders, consuming various plant and animal species
Sunfish	Bluegill, Pumpkinseed, Green, Warmouth, and Longear sunfish are native; Redear sunfish are introduced	Rivers, streams, and lakes throughout Ohio, and Lake Erie	Between May and August	Adults feed mostly on smaller fish, insects, crustaceans
Trout	Lake and Brook trout are native; Rainbow and Brown trout are introduced and maintained by stocking	Lake trout populations are stocked in Pennsylvania and New York and are not highly prevalent in Ohio and Lake Erie waters; Brook trout are stocked in several locations throughout Ohio		
Walleye	Native	Historically found in Lake Erie, but has been stocked in the Ohio River and reservoirs throughout the state	April	Shiners, gizzard shad, alewives, rainbow smelt
Whitefish	Native	Shallow bays of Lake Erie's western basin		Bottom feeders with a diet of mollusks and insect larvae

Source: U.S. EPA analysis.

b. Other species dependent on aquatic resources

Resident and migratory bird species make extensive use of Ohio waters. Areas along the banks or shorelines of rivers, streams, lakes, ponds, and reservoirs provide high quality nesting areas; the waters themselves are an abundant source of food. Ohio waters also serve as important staging areas for birds migrating to or from points north or south. Wading or aquatic birds are generally unaffected by water quality impairments directly. They are affected indirectly, however, through feeding on fish or invertebrates whose populations may be affected by point and nonpoint pollution sources. The regulations aimed at protecting aquatic species will therefore benefit wading and aquatic bird species indirectly. More than 130 aquatic bird species rely on Lake Erie and its tributaries. Many species are also found near inland surface waters. Major classifications of birds in Ohio include (Ohio DNR, 1999):

- Waterfowl, residing year-round in Ohio waters, especially Lake Erie. Large groups of migrating and breeding birds are also found elsewhere in the state. More than 30 species are associated with the Great Lakes area alone. All species depend on fish and crustaceans or aquatic plants for feeding. Waterfowl include loons, grebes, swans, ducks and geese. The trumpeter swan is of particular interest to Ohio, which became one of several states involved in efforts to restore these birds to the Midwest beginning in 1996 (Ohio DNR, 1999).

- Wading birds, including bitterns, herons, and egrets. These species both reside in Ohio waters and use them as breeding grounds. They use "stand-and-wait" methods to catch fish or other aquatic organisms in shallow waters. Many wading birds, such as the great egret, black-crowned night heron, and American bittern, frequent Lake Erie and surrounding areas.

- Marsh birds, including rails, moorhens, coots, and gallinules. They may feed on insects, crustaceans, mollusks, frogs, invertebrates, and small fish. These bird populations suffer from excessive development and habitat destruction. Ohio surface waters, especially those around Lake Erie, can serve as important breeding grounds for these and other bird species.

- Shore birds, including 42 species of plovers, sandpipers, gulls, and terns, in the Lake Erie and other Ohio areas. Many of them feed on aquatic organisms from Lake Erie.

- Raptors, including the bald eagle and osprey. These birds of prey rely on fishing for a large part of their diet. Bald eagles are also a nationally-listed threatened species.

- The belted kingfisher, which relies on fish in Ohio waters as a main source of food.

Ohio's biological resources also includes reptiles. Several species of lizards, snakes, and turtles depend on aquatic habitats for food and breeding. These reptiles include:

- Lizards **-** The Five-Lined Skink, reported in areas along Lake Erie, can be found throughout Ohio.

- Snakes **-** The Eastern Fox Snake, Eastern Massassasuga, Eastern Ribbon Snake, Copperbelly Water Snake, Lake Erie Water Snake, and Northern Water Snake feed within aquatic habitats.

- Turtles **-** The Midland Smooth Softshell Turtle and Eastern Spiny Softshell Turtle, found in the Ohio River and tributaries, are among Ohio turtles requiring aquatic habitats.

20.3.2 Water Recreation in Ohio

EPA used the 1993 ***Survey of National Demand for Water-based Recreation*** **(NDS)** (U.S. EPA, 1993) to characterize recreational uses of Ohio's water resources. The 1993 survey collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. Respondents reported on water-based recreation trips taken within the previous 12 months, including the primary purpose of their trips (e.g., fishing, boating, swimming, and viewing), total number of trips, trip length, distance to the recreation site(s), and number of participants. EPA estimated recreational water use in Ohio by taking the following steps:

- Estimate the percentage of survey respondents that visited Ohio, by state.

- Apply this percentage to the total number of state residents aged 16 and over, to yield the total number of participants from each state.

- Estimate the total number of recreation trips during the 12-month period for in-state and out-of-state participants.

- Estimate the total number of recreation trips for out-of-state participants by multiplying an average number of trips per Ohio waterbody visitor by the total number of participants from each state.

- Estimate the average number of annual trips per out-of-state visitor based on the number of times the respondents visited the site of their last recreational trip (i.e., Ohio waterbody).[4] EPA assumed that Ohio residents whose last recreation trip was in-state used Ohio waterbodies for all of their recreation trips during the 12-month period.

- Estimate the total number of in-state trips, summing the weighted number of recreation trips over all Ohio respondents.

EPA found that:

- An estimated one million individuals made about 6.3 million boating trips to Ohio waters in 1993. In-state residents made 90 percent of the boating trips.

- Approximately one million people visited Ohio waterbodies for recreational fishing.[5] These visitors accounted for about 15.6 million fishing trips to the area. Recreational fishermen from Ohio were the most frequent users of the state water resources, representing approximately 97 percent of all visitors.

- Approximately 972,000 and 896,000 visitors used the Ohio waterbodies for near-water viewing and swimming, respectively, in 1993. These visitors account for approximately 9.4 and 7.8 million viewing and swimming trips to the area. Ohio residents account for 89 percent of viewers and 93 percent of swimmers.

- Most out-of-state recreational users came from the states surrounding Ohio, such as Indiana, Michigan, and Pennsylvania.

20.3.3 Commercial Fishing in Ohio

Commercial fishing is a minor activity in Lake Erie: 12 license holders share a total of 19 licenses (www.lecba.org). Commercial catch data compiled by the Great Lakes Fishery Commission are summarized in Table 20.6.

Table 20.6: Commercial catches for Ohio Lake Erie Waters (1990)

Fish	Catch (1990 lbs)
Yellow Perch	1,559,000
Carp	1,190,000
White Perch	786,000
Sheepshead	640,000
White Bass	392,000
Channel Catfish	365,000
Quillback	134,000
Buffalo	132,000
Bullheads	59,000
Suckers	41,000
Goldfish	31,000
Gizzard Shad	19,000
Lake Whitefish	10,000
Rock Bass	1,000

Source: Great Lakes Fishery Commission, www.glfc.org/fishmgmt/comdat.

Yellow perch represents about half of the dockside value for the entire commercial fishery in the Ohio waters of Lake Erie. The value of this fishery ranged from $1.3 million to $2.5 million between 1993 and 1998. Overfishing and pollution have decreased the yellow perch population throughout Lake Erie dramatically over the past 30+ years. Annual catches averaged around 20 million pounds during the 1960s and 70s. The Lake Erie Committee set the 1998 lakewide ***total allowable catch*** (TAC) quota for this species at 7.44 million pounds. The yellow perch fishery rebounded somewhat over the past couple of years, due to strong annual recruitment, strict commercial catch restrictions, and a strict creel limit of 30 fish per day for the sport angler (www.lecba.org).

20.3.4 Surface Water Withdrawals

Water resources provide a wide range of services upon being withdrawn (removed) from the waterbody. Once used, water can be returned to its original sources, returned to another waterbody, or consumed (e.g., for human drinking water). Water withdrawals from surface water averaged 9,615 mgd in 1995 (http://water.usgs.gov/watuse). The majority of this water is used in power generation, accounting for 85 percent of all surface water withdrawals. Public water supply accounts for ten percent of all withdrawals. Industrial and commercial water use account for one and four percent of the total, respectively. Water quality and quantity impairments can have substantial impacts on the key withdrawal services that water provides to a wide range of economic entities.

[4] NDS collected information only on the last site visited. Its numbers do not reflect people whose last visit was to a different area, but who may have also visited an Ohio waterbody on a previous trip during the year. See Section 21.3 for detail on the NDS data.

[5] EPA compared the estimated number of participants with total fishing licenses issued by Ohio in 1996. Ohio issued a total of 895,770 licenses for resident and nonresident fishing. The NDS data therefore provide relatively accurate information on participation rates.

20.4 Surface Water Quality in Ohio

This section describes current water quality conditions in Ohio and the effects of water quality impairments on beneficial uses of Ohio's water resources. Ohio EPA assessed designated use attainment in approximately 42 percent of Ohio streams and rivers; approximately 64 percent of lakes, ponds, and reservoirs; and all of the Lake Erie shoreline (Ohio EPA, OWRI, 1996). The OWRI report summarizes the results of this assessment. This report provides information on designated use support by water type and use designation, identifies major pollutant/stressors that affect the quality of surface waterbodies and prevent designated use attainment, and lists major sources of impairment. The following three sections summarize findings from the 1996 OWRI report.

20.4.1 Use Attainment in Streams and Rivers in Ohio

Most waterbodies are designated for several uses and more than one use can be impaired at a time. The most commonly occurring sole impairment in fresh waterbodies is to aquatic life support. The Ohio EPA used an ecosystem approach that relies on various tools to determine aquatic life use attainment. Water chemistry, physical and habitat assessment, and direct sampling of biota all contribute to determine whether a waterbody meets an attainment status. Field data yield biological indices that eventually determine a final attainment score.

Ohio EPA assessed 6,560 perennial river miles for aquatic life use attainment. Of the 6,560 river miles assessed for aquatic life use:

- 38.5 percent (2,536 miles) are in full attainment, i.e., all water quality indicators meet criteria for specific waterbodies;
- 10.8 percent (708 miles) are in full attainment, but are threatened by pollution and other sources;
- 23.3 percent (1,528 miles) are in partial attainment, i.e., one of two, or two water quality indicators do not meet criteria; and
- 27.4 percent (1,797 miles) are in non-attainment; i.e., no criteria are met or the river experiences a severe toxic impact.

Fecal coliform bacteria counts determine recreational use attainment. Such counts are less stringent for SCR than for PCR. Ohio EPA has assessed 2,402 river miles for recreation use since 1988 (Ohio EPA, OWRI, 1996). Of the 2,402 river miles assessed for recreation use:

- 57 percent (1,370.3 miles) of the sampled rivers and streams are in full attainment; i.e., a waterbody meets all chemical criteria for recreational use and human contact;
- 19.7 percent (474.1 miles) are in partial attainment; i.e., a waterbody only partially meets human contact criteria; and
- 23.2 percent (557.4 miles) are in non-attainment; i.e., a waterbody fails to meet human contact criteria.

20.4.2 Lake Erie and Other Lakes Use Attainment

Lake Erie, which has a history of pollution problems, currently has fish consumption advisories for carp and channel catfish (Ohio DNR, 1999). Ohio EPA assesses Lake Erie as having partial use attainment for aquatic life and fish consumption, and full attainment for recreation.[6] Ohio EPA used parameters specified by the ***Ohio EPA Lake Condition Index*** (LCI) to develop use attainment for other lakes. Only approximately two percent of all lakes are in full use attainment for aquatic life, recreation, and fish consumption. Approximately 82, 50, and 53 percent are in full attainment for aquatic life, recreation, and fish consumption, respectively, but are threatened for these categories. High percentages of lake acres are in partial attainment for recreation (38.8 percent) and public supply (43.8 percent) use designations. Table 20.7 shows use attainment for Lake Erie and other lakes, ponds, and reservoirs.

[6] Further methodologies to better assess use attainment in Lake Erie are still under development by the Ohio EPA.

Table 20.7: Use Attainment Summary for Lake Erie ane Other Lakes

Use Category	% of Total Units Assessed	Full Attainment		Full Attainment, threatened		Partial Attainment		Non-Attainment	
	%	Units	%	Units	%	Units	%	Units	%
Lake Erie (Unit: Shore Miles)									
Aquatic Life (EWH)	100					236	100		
Recreation	100	231	98			5	2		
Fish Consumption	100					236	100		
Lakes, Ponds, & Reservoirs (Unit: Acres)									
Aquatic Life (EWH)	64.7	1,651	2.2	63,174	82.2	10,686	13.9	1,302	1.7
Recreation (PCR)	64.4	1,392	1.8	38,499	50.3	29,793	38.9	6,582	9.0
Public Water Supply	64.1	1,301	1.7	40,846	53.6	33,365	43.8	673	0.9

Assessments are based on unit of measure presented in parentheses.
Source: Ohio EPA, OWRI 1996.

20.4.3 Causes and Sources of Use Non-Attainment in Ohio

Ohio EPA assessed the causes and sources of impairment to Ohio surface waters and examined trends in major causes and sources from previous assessment cycles. The following discussion summarizes findings from the 1996 OWRI report (Ohio EPA, 1996).

a. Causes

Causes are the agents responsible for damage and threats to aquatic life. The major causes of impairment in Ohio surface waters include:

- Organic enrichment/low DO,
- Habitat modifications,
- Siltation,
- Flow alteration,
- Nutrients, and
- Metals.

Ohio EPA examined trends in these major causes from previous assessment cycles through 1996. They found that point source-related causes declined, while nonpoint sources became major contributors. Ohio EPA concluded that this trend "reflects the relative effectiveness of the programs to control point sources compared to general lack of measures to control many [nonpoint sources]" (Ohio EPA, OWRI, 1996).

Organic enrichment, which alters DO levels and affects aquatic communities, is the main cause of impairment in Ohio's rivers and streams. Inadequate wastewater treatment from municipal and industrial point sources account for most of this impairment. Metals are a major cause of impairment to approximately 226 river miles, a moderate cause of impairment to 179 river miles, and a minor cause of impairment or threat to 165 river miles.

Nutrients, resulting mostly from agricultural nonpoint sources, are the main cause of impairment in lakes. Metals are a major cause for impairment in approximately 250 acres of Ohio's lakes, ponds, and reservoirs, and form the main cause of impairment in Lake Erie, the major water resource in Ohio (90 percent of the surface water volume). Highly developed areas bordering the lake contribute urban runoff, along with discharges from industrial and municipal sources. Other causes of impairment in Lake Erie include ***priority organics***, DO, and nutrients.[7]

b. Sources

Sources are the origins of the agents responsible for damage and threats to water resources. The major sources of impairment to Ohio surface waters include:

- Municipal and industrial discharges,
- Hydromodification,
- Agricultural runoff,
- Urban runoff, and
- Mining.

[7] Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA for the 301(b) report.

Point source-caused impairment has declined over time, while that from nonpoint sources, such as agricultural and urban runoff, has increased. Point sources remain a major source of impairment in almost 900 miles, or 25 percent, of Ohio's affected rivers and streams. Point sources are the major source of impairment for Lake Erie. They form a major source of impairment for 24 shore miles, and a moderate source of impairment for an additional 281 shore miles of Lake Erie. In addition, point sources adversely affect 1,678 lake acres.

Nonpoint sources related to agricultural and urban runoff form the major source of impairment for some 9,000 acres, or two-thirds of Ohio's lakes, ponds, and reservoirs. In addition, 46 Lake Erie shore miles list nonpoint sources as their major impairment source.

20.5 Effects of Water Quality Impairments on Water Resource Services

Water resource services are negatively affected by pollutants that impair the aquatic ecosystems. Certain pollutants can adversely affect aquatic species directly by increasing species morbidity and/or impairing reproductive success, or indirectly by adversely altering food chain interactions. These direct and indirect impacts can change quantity and type of fish and other species in the aquatic ecosystem. In the worst case scenario, an impaired ecosystem no longer supports any aquatic life. High pathogen counts or excessive eutrophication in waterbodies that are suitable for swimming may force swimmers to go elsewhere or forego swimming altogether. Any aesthetic degradation decreases the value of each individual's recreational experience. In severe cases, the affected waterbodies become unsuitable for recreation. Water quality impairments also increase the cost of treating water to meet drinking water standards.

This section details the effects of water quality impairments on in-stream services provided by Ohio's water resources.

20.5.1 Effect of Water Quality Impairment on Life Support for Animals and Plants

Deficiencies in water quantity and quality can impair the health of aquatic ecosystems. In worst case scenarios, the ecosystem may no longer support aquatic life at all. The major causes of water quality impairment in Ohio include high ***biological oxygen demand*** **(BOD)** from organic enrichment, habitat and flow alterations, nutrients, ***siltation*** and ***turbidity***, ***metals***, ***pH***, ***ammonia***, and priority organics. Habitat, flow alterations, and thermal discharges are unrelated to MP&M effluents and are not discussed here. MP&M effluents contribute to the remaining major causes of water quality impairment, with the ecological effects outlined below.

a. BOD/COD

BOD and ***chemical oxygen demand*** **(COD)** are two methods to determine the oxygen requirements of pollutants in wastewater. Low oxygen level is the primary cause of impairment in Ohio's rivers and streams and a major course of impairments in Ohio's lakes. When bacteria decompose excess organic matter, they consume DO in surface waters. Oxygen is needed to chemically (abiotically) oxidize the pollutants present in wastewater. When too much oxygen is needed to oxidize pollutants, hypoxic (oxygen deficient) or anoxic (oxygen depleted) conditions result. Sources of high oxygen demand include effluents from municipal treatment plants and certain industries, and runoff from feedlots or farms. Another source is ***eutrophication*** caused by excessive nutrient input. The nutrients stimulate algal blooms. Bacteria consume the algae when they die, decreasing DO in the water column. DO is a critical variable for fish and invertebrate survival. If oxygen concentrations drop below a minimum level, organisms suffocate and either move out or die (EPA, 1986). This effect can drastically reduce the amount of useable aquatic habitat.

b. Nutrients

Nutrients are the leading causes of impairment in Ohio lakes and comprise one of the major causes of impairment in rivers, streams, and Lake Erie. The overabundance of nitrogen and phosphorus is one of the most documented forms of aquatic ecosystem pollution. Although both compounds are essential nutrients for phytoplankton (free-floating algae) and periphyton (attached algae), which form the base of the aquatic food web, too much nutrient input overstimulates primary productivity and results in eutrophication. The impact of these compounds has contributed significantly to water quality decline in the United States (EPA, 1992). Phosphorus is a limiting nutrient in most freshwater systems (Wetzel, 1983), whereas nitrogen is typically limited in estuarine and marine systems.

In freshwater, excess phosphate (PO_4) has been linked to eutrophication and nuisance growth of algae and aquatic weeds (Wetzel, 1983), even though direct toxicity to fish and other aquatic species is not a major concern. DO in the water column decreases, however, when algae and other aquatic plants die off, and certain toxins may be produced, both of which can contribute to fish kills.

c. Siltation and turbidity

Siltation and turbidity are the third leading causes of impairments in Ohio rivers and lakes, except Lake Erie. Siltation is the most important factor in surface water degradation in the U.S. (EPA, 1992). Major sources include urban and storm water runoff, mining and logging activities, and runoff from plowed fields (EPA, 1992). All these inputs create cloudy water with increased turbidity and decreased visibility and light penetration. High primary productivity by phytoplankton following excessive nutrient input can also increase turbidity. Excess suspended matter decreases the amount of light penetrating the water column, which can reduce primary productivity. This turbidity can eliminate or displace fish species requiring clear water to live, feed, or reproduce.

d. Metals

Metals are the leading cause of impairment in Lake Erie and comprise one of the major causes of impairment in inland lakes and rivers. Metals are naturally-occurring inorganic constituents of the earth's crust. Priority pollutant metals commonly found in the aquatic environment include antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium and zinc (EPA, 1998a). These compounds enter the aquatic environment via urban stormwater runoff, industrial and municipal effluents, and atmospheric deposition. As a group, metals can be highly toxic: ***water quality criteria*** (WQC) for acute toxicity range from around 1,100 µg/l (chromium VI in salt water) to around 1 µg/l (mercury in freshwater); WQC for chronic toxicity range from 120 µg/l (zinc in freshwater) to <1.0 µg/l (mercury in salt- and freshwater) and are therefore an order of magnitude lower (EPA, 1998a).

Once metals reach the aquatic environment, they tend to associate with organic and inorganic particulates in the water column. Sediments become long-term sinks for metals, which accumulate in the bottom. Metals can enter the food chain when ingested by benthic invertebrates or other burrowing organisms. Most metals have ***bioconcentration factors*** (BCFs) ranging from 100 to 10,000 and can therefore bioaccumulate in aquatic organisms. A few, including selenium, lead, and mercury, may reach hazardous levels in fish or wildlife receptors and result in avian developmental or neurological abnormalities.

e. Organic chemicals

Priority organics are the second most frequent cause of impairment in Lake Erie and comprise one of the major causes of impairment in rivers and streams. Thousands of different compounds exist as organic chemicals, including petroleum hydrocarbons and myriad industrial chemicals. They enter the aquatic environments via municipal and industrial effluents, stormwater runoff, contaminated groundwater, atmospheric deposition, illegal dumping, or accidental releases. Aquatic toxicities vary by orders of magnitude depending on the compound. Factors influencing toxicity and long-term ecological effects include water solubility, volatility, biodegradation potential, and bioaccumulation potential.

Excessive amounts of organic chemicals degrade surface water quality by causing acute or (more typically) chronic toxicity. This toxicity impairs growth, development, and/or reproductive success in fish and aquatic invertebrates. Persistent and low water-soluble organic chemicals accumulate in sediments and are taken up into local aquatic food chains. They can reach dangerous concentrations in fish and avian receptors, resulting in reproductive failures or other avian health effects.

f. pH

Approximately 180 river miles are pH-impaired in Ohio. pH is a measure of acidity. Acid reaches surface waters via atmospheric deposition ("acid rain"), industrial effluents, and leachates from mine ***overburdens*** or spoils. Acidity by itself is a key variable shaping aquatic communities: it is a toxicant in its own right but also controls metal solubility, and the toxicity of several metals and ammonia.

Aquatic species vary widely in their sensitivity to pH: the most sensitive vertebrate and invertebrate species die off when average pH ranges between 6.0 and 6.5. Most fish species are eliminated when pH reaches 5.0. Only a few can survive at pH 4.5 (U.S. EPA, 1999). Macro invertebrates exhibit the same pattern, except that hardy species can survive down to a pH of about 3.5.

g. Ammonia

Large amounts of ammonia enter lakes and rivers via wastewater treatment plants and industrial effluents, atmospheric deposition, and nonpoint surface runoff. Approximately 150 river miles in Ohio are ammonia-impaired. This compound, unique among regulated pollutants, is also produced naturally inside fish as a metabolic waste product. Excess ammonia usually diffuses rapidly out of the blood stream and into the surrounding water via the gills. High concentrations of external ***unionized*** ammonia (NH_3) reduce or reverse this diffusive gradient and allow ammonia to build up to toxic levels inside the organism (EPA, 1998c).
Ammonia in surface water exists in two major forms: un-ionized ammonia (NH_3), which is highly toxic to fish or invertebrates, and ammonium ion (NH_4^+), which is much less toxic. Which form prevails depends mainly upon the pH level; temperature and ionic composition play a smaller role. EPA calculated a WQC that becomes more severe with decreasing acidity. For example, the acute criteria for surface waters containing salmonids equals 36.7 mg/l at pH=6.0 but only 2.14 mg/l at pH=8.5. For surface waters without salmon, the acute criteria for the same pH equal 55.0 mg/l and 3.2 mg/l, respectively (EPA, 1998c).

20.5.2 Effect of Water Quality Impairment on Recreational Services

Healthy surface waters are essential to support a diversity of recreational uses, including viewing and other near-water activities. Industrial or other human activities impair surface water quality. Certain metals and chlorinated compounds can bioaccumulate in aquatic food chains and reach unhealthy levels in carnivorous fish or shellfish. Health advisories to limit or avoid their consumption may result. High concentrations of toxic compounds can also lead to human contact advisories. The release of untreated or poorly treated sewage can cause high levels of pathogenic bacteria in water and result in swimming advisories or beach closures. All of these actions limit the full use of surface waters and can have significant local economic impacts.

a. Fish consumption advisories

In 1997, the ***Ohio Department of Health*** **(ODH)** issued a statewide fish consumption advisory to protect women of childbearing age and children six years or younger against mercury's neurological and developmental effects. The advisory, which applies only to these two population groups, recommended that these women and children eat no more than one meal per week of any fish caught in Ohio waters. The advisory covers all state waters because most of the mercury measured in fish tissues originates from region-wide fossil fuel combustion processes. The mercury reaches surface waters via atmospheric deposition on the surrounding landscape (Ohio DNR, 1999).

Since 1983, the ODH has developed numerous waterbody-specific fish consumption advisories for approximately 174 waterbody segments (rivers and lakes) and Lake Erie. These waterbodies represent a relatively small fraction of Ohio's 5,000 discrete waterbody segments, as determined by Ohio EPA. The contaminants of greatest concern include ***polychlorinated biphenyls*** **(PCBs)**, mercury, ***polycyclic aromatic hydrocarbons*** **(PAHs)**, lead, organometallics, Mirex, phthalate esters, Chlordane, and hexachlorobenzene. Of these, four — mercury, PAHs, lead, and phthalates — are included on the MP&M list of ***pollutants of concern*** **(POCs)**. As a group, these contaminants are generally characterized as lipophilic (i.e., fat loving), resistant to biological degradation or cellular metabolism, and toxic. Once they reach surface water, they concentrate in sediments and bioaccumulate or biomagnify through aquatic food chains. These compounds can linger for decades in aquatic systems.

The kind of sports or recreational fish species affected by the consumption advisories varies by waterbody segment. More than 23 different species are covered by advisories, including walleye, common carp, sauger, saugeye, white crappie, freshwater drum, and various species of bass, perch, catfish, salmon, trout, suckers, and sunfish. Restrictions vary depending on the pollutant, the fish species concerned, and the concentrations measured in edible tissues. The ODH developed maximum recommended rates of fish consumption that include outright consumption bans, one meal every two months, one meal a month, or one meal a week. The same waterbody segments can commonly have different advisories for different fish species (Ohio DNR, 1999).

b. Contact advisories

The ODH also issued human contact advisories for nine waterbody segments in Ohio located on the Black River, Little Scioto River, Mahoning River, the middle fork of the Little Beaver Creek, and the Ottawa River. Swimming or wading is prohibited due to the presence of high levels of PAHs, PCBs, Mirex, phthalate esters, and/or Chlordane. Of these, PAHs and phthalates are included on the list of MP&M POCs. Fish consumption advisories also cover all of these segments (Ohio DNR, 1999).

c. Beach closures

Beach closures typically occur during the summer months when high levels of fecal coliform bacteria or other disease-causing organisms (e.g., *Escherichia coli*) proliferate in surface waters. Such waters can become contaminated from several sources, including: agricultural runoff, sewer overflows, boating wastes, and poor hygienic practices by some bathers. Excessive levels of indicator pathogens in surface waters can indicate a serious threat to human health and may cause health departments to post warnings, restrict access, or forbid swimming altogether. The MP&M regulation is not expected to reduce beach closures during summer months.

Numerous public bathing beaches dot Ohio's 262-mile shoreline along Lake Erie. The ODH has developed a composite metric based on *E. coli* counts in surface waters at 11 selected beaches along Ohio's north coast. The metric tracks the average number of days that swimming advisories are posted at the 11 beaches for a 15 week period beginning around Memorial Day and continuing through Labor Day. The most recent data available show that the 11 beaches were under advisement an average of 21 days during the summer months (minimum of 0 days and maximum of 49 days) in 1996.

The ODH developed a 4-tiered scale to score and track the average number of days that the 11 public beaches are under advisement from one year to the next. Between 1990 and 1996, the average (based on a five-year running average) number of beach advisories scored in the "fair" category consistently, meaning that the beaches were under advisement between 20 and 30 days in the summer (State of Ohio, 1998).

Ohio's lakes, ponds and reservoirs (excluding Lake Erie) yielded no quantitative data on beach closures. The 1996 Ohio Water Resource Inventory of Public Lakes, Ponds and Reservoirs provides a breakdown of the portion of Ohio's 446 public lakes that are threatened or impaired as a result of high levels of fecal coliform bacteria.

20.6 Presence and Distribution of Endangered and Threatened Species in Ohio

Many factors can affect the survival of ***endangered and threatened*** **(E&T)** species. Some factors are species-specific; others result from one or more anthropogenic stressors. Inherent vulnerability factors include narrow geographic distribution, slow reproductive rates, or requirements for large areas. Major anthropogenic stressors include intentional taking (e.g., fishing), incidental taking, physically altering habitat (e.g., converting wetlands into agricultural land), water pollution, and introducing alien species. A single stressor or a set of stressors can contribute to a species' decline or extinction. Previous studies reported that more than 40 percent of endangered aquatic species were affected by five or more environmental stressors, and only seven percent of federally-listed species had a single threat to their survival. Although stressors seldom act alone, water pollution is one of the major hazards to E&T aquatic species, cited as responsible for the decline of 19 (54 percent) out of 35 E&T fish species in Ohio (Ohio DNR, 1998).

The following sections provide an overview of E&T species found in Ohio, their distribution, and the major hazards threatening their survival. Species discussed below include those listed under both the federal ***Endangered Species Act*** (50 CFR Part 17) and the ***Ohio Department of Natural Resources***'**(DNR)** Division of Natural Areas and Preserves. The MP&M regulation concentrates on water-related benefits; these sections therefore describe only those species associated with aquatic environments.[8] The DNR list includes 90 E&T species with a total of 1,227 observations throughout Ohio. "Observations" refers to locations where species were observed; most species have multiple observations. This analysis includes observations spanning the years 1980 to 1988.

20.6.1 E&T Fish

E&T fish inhabit almost every major waterbody in Ohio, including Lake Erie and the Ohio River and its tributaries. The Ohio DNR lists 35 total state-listed E&T fish species, of which 13 are threatened and 22 endangered. The list includes only one federally-listed species, the Scioto Madtom.

Of the total E&T fish, approximately 12 species use Lake Erie as a possible habitat and nine use the Ohio River. Most of the species listed live in riverine habitats. Approximately 28 species were identified in a river system in Ohio, including the Ohio, Scioto, Muskingham, Miami, Walhondig, and Maumee River systems. MP&M facilities are found on all these major river systems.

The DNR lists 384 observations of E&T fish in Ohio, of which 240 observations of 30 different species have been reported since 1980. Figure 20.2 maps the observations of E&T fish in Ohio and shows the extent to which these observations were reported in the state. Multiple observations can occur for a single species. In southern Ohio, most observations come from the Muskingham and Scioto River systems and the Ohio River. Most observations in northern Ohio came from Lake Erie tributaries or the lake itself.

In addition to water pollution, cited above as major hazard to E&T aquatic species, other major hazards to E&T fish include siltation and impoundments. Approximately two-thirds of E&T fish species are threatened by siltation, and 17 percent are threatened by impoundments or dams. MP&M regulations can improve affected ecosystems or habitats by reducing discharges from MP&M facilities. These improvements can then help reduce siltation and restore some of the E&T fish populations.

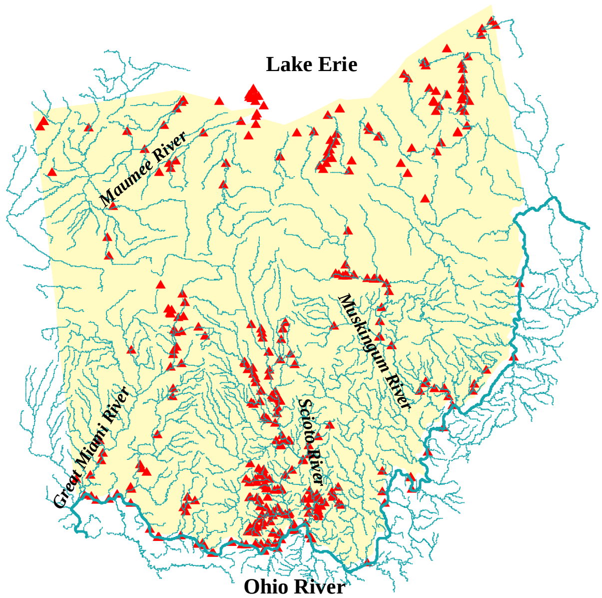
Many obscure E&T fish species have a pure existence value. Some E&T species, like brook trout and lake sturgeon, have high potential for consumptive uses. Restoring their populations and those of other commercial and recreational fish species may enhance recreational fishing opportunities. Table 20.8 lists E&T fish in Ohio, their habitat locations, and the cause for their E&T listing. The table lists species alphabetically by scientific name.

20.6.2 E&T Mollusks

Mollusks yield the largest number of reported observations of aquatic E&T species in Ohio, representing 48 percent of the total 1,227 observations. The Ohio DNR lists 29 E&T mollusk species, four threatened and 25 endangered. Of these, five mollusk species are on the federal endangered species list: Catspaw, Clubshell, Fanshell, White Catspaw, and Pink Mucket. Ohio's E&T mollusks concentrate in five major areas: Lake Erie and the Grand River tributary, Scioto River and Big Darby tributary, Muskingham River, Little Miami River, and the Ohio River. E&T mollusk populations reside mostly along the mainstems of large rivers and in Lake Erie, but are also found in the St. Joseph, Sandusky, and Cuyahoga Rivers.

[8] "Aquatic species" were identified by the Ohio Department of Natural Resources, Division of Natural Areas and Preserves. These species include any species that are "closely associated with aquatic habitats through their breeding or feeding requirements."

Figure 20.2: E&T Fish Observances in Ohio (1980-1997)



Source: U.S. EPA analysis.

20.6.3 Other Aquatic E&T Species

Improved water quality resulting from the MP&M regulation may also benefit other aquatic E&T species. Unlike fish and mollusks, whose primary habitat is a surface waterbody at all times, these species may use only surface water-related habitats for breeding or feeding. Improved water quality may benefit these populations indirectly by enhancing the quality and quantity of aquatic biological resources.

Other aquatic-associated E&T species of Ohio include:

- Birds — ten state-listed species, one threatened and nine endangered, include one federally-listed threatened species, the Bald Eagle. The state-listed species include: American and Least Bitterns, Common and Black Terns, Yellow- and Black-Crowned Night-Herons, King Rail, Osprey, and Snowy Egret. These species are observed mostly along the Lake Erie coast. The Bald Eagle is observed mostly in Ohio's northeast corner.

- Amphibians — three state-listed endangered species: Blue-Spotted Salamander, observed in the very northwest section of the state along small streams and near the Maumee River; Eastern Spadefoot, found near the Ohio and Muskingham Rivers; and Eastern Hellbender, observed along the Muskingham and Scioto River systems and tributaries of the Ohio River.

- Reptiles — two species: the Copperbelly Water Snake, a state-listed endangered and federally-listed threatened species found in lakes and ponds in the northwest corner of Ohio; and the Lake Erie Water Snake, state-listed as threatened and a proposed threatened species for the federal list, found only along the edges of the Lake Erie islands.

- Mammals — the River Otter is state-listed as endangered. Sparse observations of the animal come from various small creeks and lakes in the eastern part of Ohio.

- Crustaceans — the state-listed endangered Sloan's Crayfish has been observed in several small tributaries of the Great Miami River system.

- Insects — nine state-listed species, one threatened and eight endangered, are reported throughout the state.

Table 20.8: Endangered and Threatened Fish Species of Ohio

Common Name	Scientific Name	Number of Observations	Last Observed	Federal Status	State Status	Habitat	Causes for Listing
Lake Sturgeon	*Acipenser fulvescens*	3	1979		E	Lake Erie, spawning in larger rivers such as Maumee and Auglaize	Pollution and dams
Longnose Sucker	*Catostomus catostomus*	1	1950		E	Lake Erie	Pollution creating low-oxygen levels
Rosyside Dace	*Clinostomus funduloides*	53	1997		T	Small, upland streams of Teays and Little Scioto River systems	Runoff and siltation
Cisco	*Coregonus artedi*	1	1976		E	Lake Erie	Pollution and overfishing
Blue Sucker	*Cycleptus elongatus*	2	1985		E	Ohio River and lower reaches of large tributaries	Pollution, dams, increases in turbidity and siltation
Lake Chubsucker	*Erimyzon sucetta*	28	1994		T	Lakes (not Erie) and larger streams	Increased turbidity and siltation
Bluebreast Darter	*Etheostoma camurum*	19	1995		T	Scioto and Muskingham River systems, large streams	Pollution and siltation
Spotted Darter	*Etheostoma maculatum*	8	1992		E	Large streams of Muskingham and Scioto systems	Pollution and siltation
Tippecanoe Darter	*Etheostoma tippecanoe*	11	1994		T	Muskingham and Scioto River systems	
Tonguetied Minnow	*Exoglossum laurae*	16	1996		T	Great Miami River system	Undetermined, likely pollution and siltation
Western Banded Killifish	*Fundulus diaphanus menona*	9	1994		E	Lake Erie and larger tributaries	Siltation
Goldeye	*Hiodon alosoides*	16	1989		E	Ohio River and lower reaches of large tributaries	Pollution
Mississippi Silvery Minnow	*Hybognathus nuchalis*	1	1983		E	Ohio River and tributaries	Siltation
Ohio Lamprey	*Ichthyomyzon bdellium*	4	1992		E	Ohio River and lower reaches of large tributaries	Pollution and siltation
Northern Brook Lamprey	*Ichthyomyzon fossor*	25	1992		E	Small streams, tributaries of Grand and Scioto rivers	Pollution, siltation, and dams
Mountain Brook Lamprey	*Ichthyomyzon greeleyi*	6	1993		E	Mahoning River and tributaries	Pollution, siltation, and dams
Silver Lamprey	*Ichthyomyzon unicuspis*	40	1993		T	Lake Erie and larger tributaries	Pollution, siltation, and dams
Blue Catfish	*Ictalurus furcatus*	1	1987		E	Scioto River	
Spotted Gar	*Lepisosteus oculatus*	1	1978		E	Lake Erie	Siltation and dredging
Shortnose Gar	*Lepisosteus platostomus*	9	1981		E	Scioto River and tributaries	Pollution and siltation
Speckled Chub	*Macrhybopsis aestivalis*	1	1990		E	Ohio and Muskingham rivers, large rivers	Pollution and siltation
Greater Redhorse	*Moxostoma valenciennesi*	12	1989		T	Maumee river system, large streams	Pollution and siltation
Popeye Shiner	*Notropis ariommus*	4	1993		E	Extirpated from Ohio, creeks and small rivers of Maumee system	Siltation
Bigeye Shiner	*Notropis boops*	22	1995		T	Great Miami River and Ohio River systems, upland streams	Siltation and impoundments

Table 20.8: Endangered and Threatened Fish Species of Ohio

Common Name	Scientific Name	Number of Observations	Last Observed	Federal Status	State Status	Habitat	Causes for Listing
Bigmouth Shiner	*Notropis dorsalis*	16	1994		T	Black and Rocky river systems, brooks and small streams	Competition with silver minnow
Blackchin Shiner	*Notropis heterodon*	2	1983		E	Lake Erie and other lakes	Increased turbidity and siltation
Blacknose Shiner	*Notropis heterolepis*	7	1983		E	Lake Erie and other lakes	Siltation
Mountain Madtom	*Noturus eleutherus*	11	1991		E	Ohio River tributaries, larger streams and rivers	Pollution and siltation
Northern Madtom	*Noturus stigmosus*	10	1989		E	Muskingham, Little Miami, Walhondig Rivers	
Scioto Madtom	*Noturus trautmani*	1	1957	E	E	Big Darby Creek, tributary of Scioto	Pollution and siltation
Pugnose Minnow	*Opsopoeodus emiliae*	6	1982		E	Lakes, canals, streams, and Lake Erie	Increased turbidity and siltation
Channel Darter	*Percina copelandi*	18	1991		T	Lake Erie and Ohio River	Siltation
River Darter	*Percina shumardi*	8	1989		T	Lake Erie and larger tributaries of Ohio River	Pollution and siltation
Paddlefish	*Polyodon spathula*	11	1996		T	Ohio River tributaries, larger streams and rivers	Pollution and siltation
Brook Trout	*Salvelinus fontinalis*	1	1997		T	Tributaries of Lake Erie	Habitat destruction - timbering and non-native species

Source: Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Natural Heritage Program 1998

GLOSSARY

ammonia: a compound of nitrogen and hydrogen (NH_3). It is a colorless, pungent gas.

biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in polluted water.

bioconcentration factors (BCFs): indicators of the potential for chemicals dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually gills.

biotic: pertaining to the characteristics of a naturally occurring assemblage of plants and animals that live in the same environment and are mutually sustaining and interdependent.

chemical oxygen demand (COD): The amount of oxygen consumed in the complete chemical oxidation of matter, both organic and inorganic, present in polluted water.

Coldwater Habitat (CWH): a designation assigned to a waterbody based on the potential aquatic assemblage.

conventional pollutants: biological oxygen demand (BOD), total suspended solids (TSS), oil and grease (O&G), pH, and anything else the Administrator defines as a conventional pollutant.

dissolved oxygen (DO): oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a waterbody's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to ensure adequate DO in waste-receiving waters. (http://www.epa.gov/OCEPAterms/dterms.html)

endangered and threatened (E&T): animals, birds, fish, plants, or other living organisms threatened with extinction by anthropogenic (i.e., man-caused) or other natural changes in their environment. The Endangered Species Act contains requirements for declaring a species endangered.

Endangered Species Act: federal legislation enacted in 1973 that protects animals, birds, fish, plants, or other living organisms threatened with extinction by anthropogenic or other natural changes in their environment. For a species to be protected under this act it must be "listed" as either an "endangered" or "threatened" species.

eutrophication: process by which bodies of water receive increased amounts of dissolved nutrients, such as nitrogen and phosphorus, that encourage excessive plant growth and result in oxygen depletion.

Exceptional Warmwater Habitat (EWH): the aquatic life use designed to protect aquatic communities of exceptional diversity and biotic integrity. Such communities typically have a high species richness; often include strong populations of rare, endangered, threatened, and declining species; and/or are exceptional sport fisheries.

existence: services that are not linked to current uses of waterbodies. They arise from the knowledge that species diversity or the natural beauty of a given waterbody is being preserved.

in-stream: water use taking place within the stream channel for purposes such as life support for animals and plants, water-based recreation, hydroelectric power generation, navigation, commercial fishing, water storage, and aesthetics.

Limited Resource Waters (LRW): an aquatic life use assigned to streams with very limited aquatic life potential, usually restricted to highly acidic mine drainage streams, or highly modified small streams (<3 sq. mi. drainage area) in urban or agricultural areas with little or no water during the summer months.

Limited Warmwater Habitat (LWH): see limited resource waters.

metals: inorganic compounds, generally non-volatile (with the notable exception of mercury), that cannot be broken down by biodegradation processes. They are of particular concern due to their prevalence in MP&M effluents. Metals can accumulate in biological tissues, sequester into sewage sludge in POTWs, and contaminate soils and sediments when released into the environment. Some metals are quite toxic even when present at relatively low levels.

µg/l: micrograms per liter.

Modified Warmwater Habitat (MWH): aquatic life use assigned to streams that have irretrievable, extensive, man-induced modifications that preclude attainment of the Warmwater Habitat use, but which harbor the semblance of an aquatic community. Such waters are characterized by poor chemical quality (low and fluctuating dissolved oxygen), degraded habitat conditions (siltation, habitat simplification), and species that are tolerant of these effects.

nonconventional pollutants: a catch-all category that includes everything not classified as either a priority or conventional pollutant.

nutrients: any substance, assimilated by living things, that promotes growth. The term is generally applied to nitrogen and phosphorus in wastewater, but is also applied to other essential and trace elements. (http://www.epa.gov/OCEPAterms/nterms.html)

Ohio EPA Lake Condition Index (LCI): an ecologically-based index that aggregates results across ten ecological metrics.

Ohio Water Resource Inventory (OWRI): a biennial report to U.S. EPA and Congress required by Section 305(b) of the Clean Water Act. The report is composed of four major sections: (1) inland rivers and streams, wetlands, Lake Erie, and water program description; (2) fish tissue contaminants; (3) inland lakes, ponds, and reservoirs; and (4) groundwater.

overburdens: rock and soil cleared away before mining. (http://www.epa.gov/OCEPAterms/oterms.html)

pH: an expression of the intensity of the basic or acid condition of a liquid; Natural waters usually have a pH between 6.5 and 8.5. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutants of concern (POCs): the 131 contaminants identified by EPA as being of potential concern for this rule and that are currently being discharged by MP&M facilities. EPA used fate and toxicity data, in conjunction with various modeling techniques, to identify these pollutants and assess their potential environmental impacts on receiving waterbodies and POTWs. MP&M pollutants of concern include 43 priority pollutants, 3 conventional pollutants, and 86 non-conventional pollutants.

polychlorinated biphenyls (PCBs): group of toxic, persistent chemicals that are mixtures of chlorinated biphenyl compounds having various percentages of chlorine. PCBs are industrial chemicals formerly used in electrical transformers and capacitors for insulating purposes, and in gas pipeline systems as a lubricant.

polycyclic aromatic hydrocarbons (PAHs): class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

Primary Contact Recreation (PCR): water recreation activities requiring full human body immersion, such as swimming, diving, water skiing, and surfing.

priority organics: prority pollutants that are organic chemicals.

priority pollutants: 126 individual chemicals that EPA routinely analyses when assessing contaminated surface water, sediment, groundwater, or soil samples.

random utility model (RUM): a model of consumer behavior. The model contains observable determinants of consumer behavior and a random element.

Secondary Contact Recreation (SCR): water recreation activities requiring some direct contact with water but where swallowing of water is unlikely, such as paddling, wading, and boating.

siltation: deposition of finely divided soil and rock particles on the bottom of stream and river beds and in reservoirs.

Survey of National Demand for Water-based Recreation (NDS): a U.S. EPA survey of recreational behavior. The 1993 survey collected data on socioeconomic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over (http://www.epa.gov/opei).

total allowable catch (TAC): amount of fish permitted to be removed under a fishery management regime in which the total catch allowed of a certain species for a fishing season has been fixed in advance.

"toxic" pollutants: refers to the 126 priority or toxic pollutants specifically defined as such by EPA, as well as nonconventional pollutants that have a toxic effect on human health or aquatic organisms.

turbidity: cloudy condition in water that interferes with the passage of light through the water column. It is caused by the presence of suspended silt or organic matter in the waterbody.

unionized: neutral form of an ionizable compound. With reference to ammonia, it is the neutral form of ammonia-nitrogen in water, usually occurring as NH_4OH. Unionized ammonia is the principal form of ammonia that is toxic to aquatic life. The relative proportion of unionized to ionized ammonia (NH^{4+}) is controlled by water temperature and pH.

Warmwater Habitat (WWH): a designation assigned to a waterbody based on the potential aquatic assemblage.

water quality criteria (WQC): specific levels of water quality that, if reached, are expected to render a body of water suitable for certain designated uses.

withdrawal: water removed from the ground or diverted from a surface-water source for uses such as drinking water supply, irrigation, production and processing services, and sanitary services.

ACRONYMS

BCFs: bioconcentration factors
BOD: biological oxygen demand
COD: chemical oxygen demand
CWH: Coldwater Habitat
DO: dissolved oxygen
E&T: endangered and threatened
EWH: Exceptional Warmwater Habitat
LRW: Limited Resource Waters
LWH: Limited Warmwater Habitat
MWH: Modified Warmwater Habitat
ODH: Ohio Department of Health
DNR: Ohio Department of Natural Resources
LCI: Ohio EPA Lake Condition Index
OWRI: Ohio Water Resource Inventory
POCs: pollutants of concern
PCBs: polychlorinated biphenyls
PAHs: polycyclic aromatic hydrocarbons
PCR: Primary Contact Recreation
RUM: random utility model
SSH: Seasonal Salmonid Habitat
SCR: Secondary Contact Recreation
NDS: Survey of National Demand for Water-based Recreation
TAC: total allowable catch
WWH: Warmwater Habitat
WQC: water quality criteria

REFERENCES

Department of Agriculture, National Resources Conservation Services, 1992 National Resources Inventory. http://www.ftw.nrcs.usda.gov/nri_data.html.

Department of Commerce. 1992. Bureau of the Census. *Census of Manufactures, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries*.

Department of Commerce, U.S. Census Bureau. 1999. *Ohio Population, Demographic, and Housing Statistics.* http://www.census.gov/cgi-bin/datamap/state?39.

Ohio Department of Natural Resources, Ohio Division of Wildlife. 1999. *Fish Consumption Advisories.* http://www.dnr.state.oh.us/odnr/wildlife/index.html.

Ohio Department of Natural Resources, Division of Natural Areas and Preserves. 1998. Database File of Aquatic and Associated Aquatic Endangered & Threatened Animals.

Ohio Environmental Protection Agency. 1998. *State of the Lake Report* (www.epa.ohio.gov/oleo/leqi/leqi.html)

Ohio Environmental Protection Agency. 1996. *Ohio Water Resource Inventory. Volume 1: Summary, Status , and Trends* and *3: Ohio's Public Lakes, Ponds, and Reservoirs* (chagrin.epa.state.oh.us/document_index)

USDA (U.S. Department of Agriculture). 1992. *Agricultural Waste Management Field Handbook*. National Engineering Handbook Series, Part 651. 210-AWMFH, 4/92.

United States Geological Survey (USGS). 1995. *Water Use in the United States* (http://water.usgs.gov/watuse).

U.S. EPA (U.S. Environmental Protection Agency). 1986. *Ambient Water Quality Criteria for Dissolved Oxygen*. EPA 440/5-86-003.

U.S. EPA (U.S. Environmental Protection Agency). 1992. *Managing Nonpoint Source Pollution: Final Report to Congress*. EPA-506/9-90.

U.S. EPA (U.S. Environmental Protection Agency). 1998a. National Recommended Water Quality Criteria; Notice; Republication. 63(237:68354-68364).

U.S. EPA (U.S. Environmental Protection Agency). 1998b. *Condition of the Mid-Atlantic Estuaries*. EPA 600-R-98-147.

U.S. EPA (U.S. Environmental Protection Agency). 1998c. *1988 Update of Ambient Water Quality Criteria for Ammonia*. EPA 822-R-98-008.

U.S. EPA (U.S. Environmental Protection Agency). 1999. *Progress Report on the EPA Acid Rain Program*. U.S. EPA Office of Air and radiation. EPA 430-R-99-011.

Wetzel, R.G. 1983. *Limnology, 2nd ed*. Saunders College Publishing.

Chapter 21: Modeling Recreational Benefits in Ohio with a RUM Model

Introduction

The recreational benefits analysis outlined in this chapter focuses on Ohio as a case study of the MP&M regulation's expected benefits. EPA combined water quality modeling and a ***random utility model*** of consumer behavior **(RUM)** to assess how changes in water quality from the MP&M regulation will affect consumer valuation of water resources for recreational uses. The RUM analysis provides a framework for estimating the effect of ambient water quality and other site characteristics on the total number of trips taken for different water-based recreation activities and the allocation of these trips among particular sites.

The Agency used this case study to address limitations inherent in the benefits transfer method used in the analysis of recreational benefits at the national level (see Chapter 15 for detail). The RUM model assesses water quality characteristics directly affected by the MP&M regulation, such as presence of ***ambient water quality criteria*** **(AWQC)** exceedences and nonconventional nutrient ***Total Kjeldahl Nitrogen*** **(TKN)** concentrations and their effect on recreation behavior.

The direct link between the water quality measures included in the RUM model and the water quality measures used in developing the regulation reduces uncertainty in benefit estimates. Two studies that use the same water quality measures to analyze recreational benefits are more reliable than other analyses that require additional assumptions to transfer value from one study to the other.

Benefits transfer often requires additional assumptions because water quality changes evaluated in available recreation demand studies are only roughly comparable with water quality measures considered in regulatory development. This case study analysis improves upon previous recreation demand studies that focused mainly on directly observable water quality effects: e.g., designated use support (i.e., whether a water body supports fishing), the presence of fish advisories, an oil sheen, or eutrophication.

Chapter Contents:

The Ohio case study includes unobservable water quality effects as well. The MP&M regulation affects a broad range of pollutants, many of which are toxic to human and aquatic life but are not directly observable (i.e., ***priority*** and ***non-conventional*** pollutants). These unobservable toxic pollutants degrade aquatic habitats, decrease the size and abundance of fish and other aquatic species, increase fish deformities, and change watershed species composition.

Water quality changes (i.e., changes in toxic pollutant concentrations) affect consumers' water resource valuation for recreation, even if consumers are unaware of changes in ambient pollutant concentrations.

This study allows for a more complete estimate of recreational benefits from reduced discharges of MP&M pollutants. In addition to estimates of recreational benefits from reduced frequency of AWQC exceedences, the Ohio case study evaluated changes in the water resource values from reduced discharges of TKN. The analysis also values additional recreational uses affected by the regulation, such as swimming.

The study used data from the ***National Demand Survey for Water-Based Recreation*** **(NDS)**, conducted by U.S. EPA and the National Forest Service, to examine the effects of in-stream pollutant concentrations on consumer decisions to visit a particular waterbody (U.S. EPA, 1993).

21.1 Methodology

21.1.1 Overview

The Ohio study combines direct simulation and ***inferential*** analyses to assess how changes in water quality will affect consumer valuation of water resources.

- The direct simulation analysis component estimates baseline and post-compliance *water quality* at recreation sites actually visited by the surveyed consumers *and* all other sites within the ***consumers' choice set***, visited or not.

- The inferential analysis component, a RUM analysis of consumer behavior, estimates the effect of ambient water quality and other site characteristics on the total number of trips taken for different water-based recreation activities and the allocation of these trips among particular recreational sites. The RUM analysis is a TCM, in which the cost to travel to a particular recreational site represents the "price" of a visit.

EPA modeled two consumer decisions:

- how many water-based recreational trips to take during the recreational season (the ***trip participation model***); and

- conditional on the first decision, which recreation site to choose (the ***site choice model***).

The econometric estimation proceeded in two steps; each corresponding to the above decisions. The Agency estimated these decisions in reverse order (i.e., EPA modeled the second decision, site choice, first).

- *Modeling the Site Choice Decision*. Assuming a consumer decides to take a water-based recreation trip, EPA estimated the likelihood that the consumer will choose a particular site as a function of site characteristics, the price paid per site visit, and household income.

  EPA estimated the RUM using a two-level ***nested multinomial logit*** **(NMNL)** procedure. Level one was a choice among inland Ohio water sites (i.e., rivers, small lakes and reservoirs), Lake Erie sites in Ohio, and sites outside Ohio; the second level was the choice of the actual site within one of these categories. EPA estimated the value to the consumer of being able to choose among Ohio inland recreation sites, Ohio Lake Erie recreation sites, and sites outside Ohio on a given day using the site-choice model coefficients. This measure is referred to as the "***inclusive value***."

- *Modeling Trip Frequency*. The NMNL model estimated in the previous step treats the total number of recreational trips taken each season as ***exogenous*** to the site selection. The Agency estimated the expected number of trips taken during the recreation season using a ***Negative Binomial Poisson model*** (Hausman et al., 1995; Feather et al., 1995; and Creel and Loomis, 1992), which treats trip frequency as a pre-season decision regarding total participation.

  EPA estimated the total number of trips during the recreation season as a function of the expected maximum utility (inclusive value) from recreational activity participation on a trip, and socioeconomic characteristics affecting demand for recreation trips (e.g., number of children in the household). The coefficient on the inclusive value (i.e., the individual's expected maximum utility of taking a trip) provided a means of estimating the seasonal ***welfare effect*** of water quality improvements, because changes in water quality change the value of available recreation sites.

Estimating site choice and total trip participation models jointly is theoretically possible, but computational requirements make an integrated ***utility-theoretic*** model infeasible. EPA estimated separate site choice and trip frequency models for four recreational activities: boating, swimming, fishing, and near-water recreation, (e.g., viewing wildlife).

The Agency used estimated coefficients of the ***indirect utility function*** with estimated changes in water quality to calculate per-trip changes in consumer welfare from improved water quality at recreation sites within each ***consumer choice set***. Trip frequency per season increases if site water quality changes are substantial. A sample consumer's expected seasonal welfare gain is therefore a function of both welfare gain per trip and the estimated change in number of trips per season.

Combining the trip frequency model's prediction of trips under the baseline and post-compliance and the site choice model's corresponding per-trip welfare measure yields the ***total seasonal welfare measure***.

EPA calculated each individual's seasonal welfare gain for each recreation activity from post-compliance water quality changes, then used Census data to aggregate the estimated welfare change to the state level. The sum of estimated welfare changes over the four recreation activities yielded estimates of total welfare gain.

To analyze water quality improvement benefits in the RUM framework, EPA used available discharge, ambient concentration, and other relevant data to show baseline and post-compliance water quality at the impact sites. Appendix G provides detail on water quality modeling used in this analysis.

21.1.2 Modeling the Site Choice Decision

EPA used the RUM framework to estimate the probability of a consumer visiting a recreation site. This framework is based on the assumption that a consumer derives utility from the recreational activity at each recreation site. Each visit decision involves choosing one site and excluding others.

The consumer's decision involves comparing each site and choosing the site that produces the maximum utility. An observer cannot measure all potential determinants of consumer utility, so the indirect utility function will have a non-random element (V) and a random error term (ξ), such that the actual determinants of consumer utility V′ = V + ξ. The probability (π_{jn}) that site *j* will be visited by an individual *n* is defined as:

$$B_{jn}\,'\,Pr(V_{jn}\%>_{jn} > V_{sn}\%>_{sn}) \qquad (21.1)$$

where:

$V_{jn} + \xi_{jn}$ = utility of visiting site *j*, and
$V_{sn} + \xi_{sn}$ = utility of visiting a substitute site.

Estimating the model requires specifying the functional form of the indirect utility function, V, in which site choice is modeled as a function of site characteristics and the "price" to visit particular sites. For example, a set of conditional utility functions (one for each site alternative *j* in the choice set) can be determined as follows:

$$V_{jn} = \beta_M (M_{jn} - P_{jn}) + \beta X_{jn} \qquad (21.2)$$

where:

- V_{jn} = the utility realized from a conventional budget-constrained, utility maximization model conditional on choice of site *j* by consumer *n*;
- β_M = marginal utility of income;
- M_{jn} = the income of individual *n* available to visit site *j;*
- P_{jn} = a composite measure of travel and time costs for consumer *n* on site alternative *j*;
- â = a vector of coefficients representing the marginal utility of a specified site characteristic to be estimated along with β_M (e.g., size of the waterbody, presence of boating ramps); and
- X_{jn} = a vector of site characteristics for site alternative *j* as perceived by consumer *n*. These characteristics include the actual monitored and/or modeled water quality parameters that are hypothesized to be determinants of consumer valuation of water-based recreation resources, and that may also be affected by the MP&M regulation.

The magnitude of the coefficients in Equation 21.2 reflects the relative importance of site characteristics when consumers decide which site to visit. The coefficients (β) of water quality characteristics of recreation sites are expected to be positive; that is, all else being equal, consumers of water-based recreation would prefer "cleaner" recreation sites. The coefficient on travel cost is expected to be negative, i.e., consumers prefer lower travel costs.

To estimate the site choice probabilities, EPA specified and estimated a nested multinomial logit model (NMNL). The nested structure explicitly groups similar alternatives, which allows for a richer pattern of substitution among alternative sites. The NMNL is based on the assumption that an individual chooses first between groups of alternatives and then, within the chosen group, between individual alternatives. For this analysis, EPA grouped all recreational sites by location based on site similarities. The model uses three site groups:[1]

[1] Three of the four models (fishing, boating, and viewing) passed specification tests for appropriateness of the nested structure that includes all three site groups (see Section 21.3 for detail). Test results showed that only two site groups are appropriate for the

- inland sites in Ohio (i.e., rivers and lakes),
- Lake Erie sites, and
- out-of-state sites.

Lake Erie is a unique water resource that offers a large variety of recreation opportunities. This analysis therefore assumed that Lake Erie recreation sites are likely to be more similar to each other than to inland sites in Ohio. The Agency also assumed that sites outside of Ohio offer recreational alternatives that may be different from those found in Ohio.

The model assumes that an individual first decides to visit inland waterbodies, Lake Erie, or sites outside of Ohio, then decides which site within each group to visit. An individual probability of visiting site *j*, given the choice of region *R*, is a simple multinomial logit. If the random terms ξ_{nj} for individual *n* at site *j* are independently and identically distributed and have an extreme value Weilbull distribution, then π_{jn} takes the form (McFadden, 1981):

$$\pi_{jn|r} = \frac{e^{V_{jn}}}{\sum_{j \in r} e^{V_{jn}}} \qquad (21.3)$$

where:

$e^{V_{jn}}$ = the consumer's utility from visiting site *j*;
r = regions -- "Great Lakes," "inland," or "out-of-state;" and
$\sum_{j=1}^{Jr} e^{V_{jn}}$ = the sum of the consumer's utility at each site *j* for all sites in the opportunity set for region R.

Estimated parameters of the indirect utility function are then used to estimate the inclusive value. For consumer *n*, the inclusive value measures the overall quality of recreational opportunities for each water-based activity and represents the expected maximum utility of taking a trip. Note that although EPA used a random draw from the opportunity set for the purpose of estimating the model parameters, the Agency calculated the inclusive value (i.e., the expected maximum utility) using all recreation sites in the consumer's opportunity set in a given region.

The inclusive value is calculated as the log of the denominator in Equation 21.2 (McFadden, 1981).

$$I_r = \ln\left(\sum_{j=1}^{J} e^{V_{jn}(W)}\right) \qquad (21.4)$$

where:

I_r = inclusive value for sites associated with region *R*;
$e^{V_{jn}}$ = individual *n*'s utility from visiting site *j*; and
W = a vector of baseline water quality characteristics.

The probability of choosing a particular region is:

$$\pi_r = \frac{e^{I_r \gamma_r}}{\sum_{r=1}^{r=R} e^{I_r \gamma_r}} \qquad (21.5)$$

where:

I_r = the inclusive values for a given region; and
r = "Lake Erie," "inland," and "out-of-state."

To estimate the model described by equations 21.2 and 21.5, EPA used a standard statistical software package, **LIMDEP**.

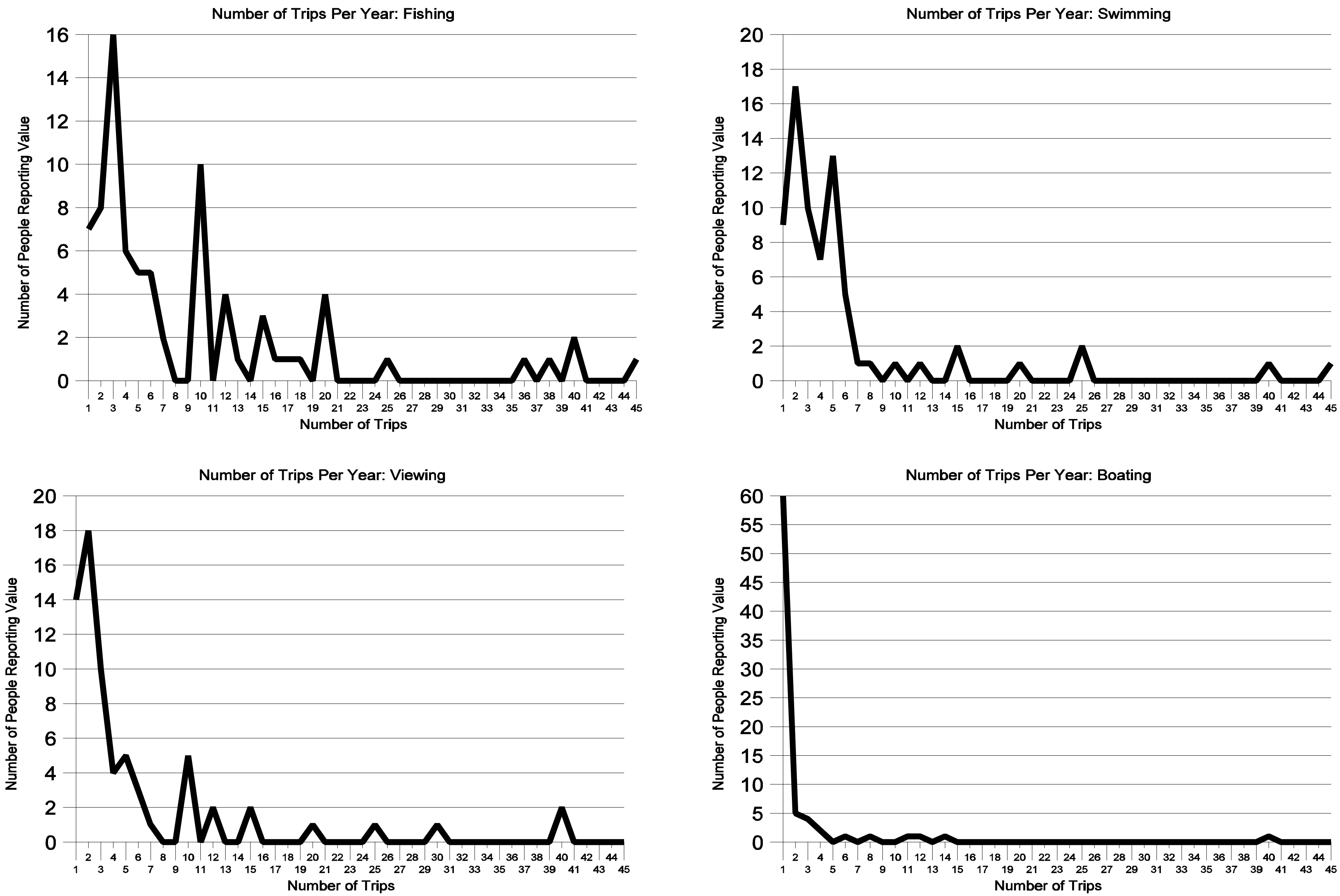
21.1.3 Modeling Trip Participation

After modeling the site choice decision, the next step modeled the determinants of the number of water-based recreation trips a consumer takes during a season. To link the quality of available recreation sites with consumer demand for recreation trips, EPA modeled the number of recreation trips taken during the recreation season as a function of the inclusive value estimated in the previous step and socioeconomic characteristics affecting demand for recreation activities. The dependent variable, the number of recreation trips taken by an individual during the recreation season, is an integer value greater than or equal to zero. To account for the non-negative property of the dependent variable, EPA used count data models based on probability densities that have the non-negative integers as their domain.

One of the simplest count data models is a ***Poisson estimation process***, which is commonly used with count data, such as number of recreation trips during the recreation season. Inherent in the model specification is the assumption that each observation of a number of trips is drawn from a ***Poisson distribution***. Such a distribution favors a large number of observations with small values (e.g., two trips, four trips) or zeros, resulting in its being skewed toward the lower end. Due to the nature of the observed number of trips, it is quite reasonable to assume that the underlying distribution can be characterized as a Poisson distribution. Figure 21.1 shows the number of recreation trips taken per year and the number of respondents who reported taking that number of trips.

swimming model — Ohio sites, including inland lakes and Lake Erie, and out-of-state sites.

Figure 21.1: Number of Trips Per Year By Activity Type



Source: U.S. EPA analysis.

Estimating the Poisson model is similar to estimating a nonlinear regression. The single parameter of the Poisson distribution is λ, which is both the mean and variance of y_n. The probability that the actual number of trips taken is equal to the estimated number of trips is estimated as follows (Green, 1993):

$$Prob(Y_n = y_n) = \frac{e^{-\lambda_n}\lambda_n^{y_n}}{y_n!} \qquad (21.6)$$

where:

- Y_n = the actual number of trips taken by an individual in the sample;
- y_n = the estimated number of trips taken by an individual in the sample;
- n = 1, 2,..., *N*, the number of individuals in the sample; and
- λ_n = β′X, expected number of trips for an individual in the sample, where X is a vector of variables affecting the demand for recreational trips (e.g., inclusive value and socioeconomic characteristics) and b is the vector of estimated coefficients.

From Equation 21.6, the expected number of trips per recreation activity season is given by:

$$E[y_n|x_n] = Var[y_n|x_n] = e^{\beta' x_n} \qquad (21.7)$$

where:

- $E[y_n|x_n]$ = the expected number of trips, y_n, given x_n;
- $Var[y_n|x_n]$ = the variance of the number of trips, y_n, given x_n;
- β = a vector of coefficients on x; and
- x = a matrix of socioeconomic variables and inclusive values.

An empirical drawback of the Poisson model is that the variance of the number of trips taken must be equal to the mean number of trips, and this equality is not always supported by actual data. In particular, the NDS survey data exhibit ***overdispersion***, a condition where variance exceeds the mean. The estimated variance to mean ratios of the number of trips in the NDS data sample are 31, 27.9, 35.6, and 10.5 for fishing, swimming, viewing, and boating trips, respectively. Overdispersion is therefore present in the data set.

To address the problem of overdispersion, EPA used the ***negative binomial regression model***, an extension of the Poisson regression model, which allows the variance of the number of trips to differ from the mean. In the negative binomial model, λ is respecified so that (Green, 1993):

$$\ln \lambda_n = \beta X_n + \epsilon \qquad (21.8)$$

where the error term (ϵ) has a gamma distribution, $E[\exp(\epsilon_i)]$ is equal to 1.0, and the variance of ϵ is α.

The resulting probability distribution is:

$$Prob[Y = y_n | \epsilon] = \frac{e^{\lambda_n}\exp(\epsilon)\lambda_n^{y_n}}{y_n!} \qquad (21.9)$$

where:

- y_n = 0,1,2... number of trips taken by individual *n* in the sample;
- n = 1,2,..., *N* number of individuals in the sample; and
- λ_n = expected number of trips for an individual in the sample.

Integrating å from Equation 21.9 produces the unconditional distribution of y_n. The negative binomial model has an additional parameter, a, which is the overdispersion parameter, such that:

$$Var[y_n] = E[y_n](1 + \alpha E[y_n]) \qquad (21.10)$$

The overdispersion rate is then given by the following equation:

$$\frac{Var[y_n]}{E[y_n]} = 1 + \alpha E[y_n] \qquad (21.11)$$

EPA used the negative binomial model to predict the seasonal number of recreation trips for each recreation activity based on the inclusive value, individual socioeconomic characteristics, and the overdispersion parameter, ". If the inclusive value has the anticipated positive sign, then increases in the inclusive value stemming from improved ambient water quality at recreation sites will lead to an increase in the number of trips. The combined MNL model site choice and count data trip participation models allowed the Agency to account for changes in per-trip welfare values, and for increased trip participation in response to improved ambient water quality at recreation sites.

21.1.4 Calculating Welfare Changes from Water Quality Improvements

EPA estimated the welfare change associated with water quality improvements from the baseline to post-compliance conditions as a ***compensating variation* (CV)**, that equates the expected value of realized utility under the baseline and post-compliance conditions. The expected seasonal change in welfare attributed to the quality improvements for an individual *n* in the sample consists of two components:

- per trip welfare gain, and
- increased number of trips under the post-compliance water quality condition.

The Agency first calculated the welfare gain from water quality improvement for each consumer on a given day by using a CV measure for consumer *n* (Kling and Thompson, 1996):

$$CV_n = \frac{\ln\left[\sum_{r=1}^{R}\left(\sum_{j=1}^{J_r} e^{V_{jn}(W^0)}\right)\right] - \ln\left[\sum_{r=1}^{R}\left(\sum_{j=1}^{J_r} e^{V_{jn}(W^1)}\right)\right]}{\beta_M} \qquad (21.12)$$

where:

Cvn	=	the compensating variation for individual *n* at site *j* on a given day;
R	=	"Lake Erie," "inland," and "out-of-state;"
j	=	$1,\ldots J_r$ represents a set of alternative sites for a given recreational activity in region *R*;
$\ln\left[\sum_{r=1}^{R}\left(\sum_{j=1}^{J_r} e^{V_{jn}(W)}\right)\right]$	=	the inclusive value index (I);
W^0	=	a vector of information describing baseline water quality;
W^1	=	a vector of information describing post-compliance water quality; and
β_M	=	the implicit coefficient on income that influences recreation behavior.

In deriving Equation 21.12, EPA assumed that the marginal utility of income, β_M, is constant across alternatives (as well as across quality changes). If this assumption does not apply, the derivation of Eq. 21.12 is more complicated (Hausman et al., 1995).

EPA then estimated the low and high values of the seasonal welfare gain for individual n in the sample as follows: [2]

$$W_{low,\ n} = \frac{(I^1 - I^0) \times Y^0}{-\beta_\mu} \qquad (21.13)$$

$$W_{high,\ n} = \frac{(I^1 - I^0) \times Y^1}{-\beta_\mu} \qquad (21.14)$$

where:

$W_{low,\ n}$	=	lower bound estimate of the seasonal welfare gain for individual n;
$W_{high,\ n}$	=	upper bound estimate of the seasonal welfare gain for individual n;
I^1	=	the post-policy inclusive value;
Y^1	=	the estimated number of trips after water quality improvement;
I^0	=	the baseline inclusive value;
Y^0	=	the estimated number of trips in the baseline; and
β_M	=	the implicit coefficient on income that influences recreation behavior.

These estimates are *per individual* in the population for those individuals meeting qualifications for inclusion in the NDS response set (i.e., respondents whose home state is Ohio and respondents from the neighboring states whose last trip was to Ohio's sites).[3] EPA extrapolated the estimates of value per individual to the Ohio state level based on Census data (U.S. Bureau of the Census, 1999). The following section details the extrapolation method used in the analysis.

21.1.5 Extrapolating Results to the State Level

EPA used a simplified extrapolation technique to estimate the state-level benefits. EPA first estimated the number of participants in fishing, swimming, boating, and wildlife viewing in Ohio, based on the estimated percentage of the NDS survey respondents residing in Ohio who participate in

[2] EPA selected this approach for calculating seasonal welfare gain per individual based on Dr. Parsons' recommendation (G.R. Parsons, 1999).

[3] Section 21.2.1 provides a detailed description of the data sample used in the analysis.

a given activity and the state adult population. The 1990 Census data provides information on the number of Ohio residents aged 16 and older. EPA then multiplied the estimated average seasonal welfare gain per participant in a given recreational activity by the corresponding number of recreational users. The total welfare gain to the users of water-based recreation in Ohio is the sum of fishing, swimming, boating, and wildlife viewing benefits.

21.2 Data

This section describes the data and supporting analyses required to implement the RUM analysis. The following general categories of data and supporting analyses are required:

- information on the consumers of water-based recreation responding to the NDS in Ohio;
- recreation sites identified for the water quality and RUM analyses, including the sites visited by consumers of water-based recreational activity and supplemental sites in their choice sets;
- estimated price of visiting the sites. The “visit price” is estimated as a function of travel distance (and travel time) between each consumer’s hometown and each site in the choice set;
- information on site characteristics likely to be important determinants of consumer behavior. Of particular importance to this analysis are the water quality and related characteristics of sites in the choice set, and how those characteristics may be expected to change as a result of regulation.

The following sections discuss each category of data and/or supporting analysis below.

21.2.1 The Ohio Data

EPA obtained information on survey respondent socioeconomic characteristics and recreation behavior from the NDS (U.S. EPA, 1993). The 1993 survey collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. Respondents reported on water-based recreation trips taken within the past 12 months, including the primary purpose of their trips (e.g., fishing, boating, swimming, and viewing), total number of trips, trip length, distance to the recreation site(s), and number of participants. Where fishing was the primary purpose of a trip, respondents were also asked to state the number of fish caught. Table 21.1 shows the number of trips taken per year by primary recreation activity, as reported in the NDS.

EPA selected case study observations for Ohio residents who took trips within or outside of that state. Trips to Ohio recreation sites by residents of neighboring states were also included in the site choice models, but not in the trip participation models[4]. All four activity models included single-day trips only. EPA included only activity participants with valid hometown ZIP codes, whose destination site was uniquely identified. The Agency used data on both Ohio participants and Ohio non-participants to estimate total seasonal trips, but included only Ohio participants and several residents of nearby states in the site choice models. Unusable site choice participant observations from Ohio with missing location information were used to analyze the number of trips. Tables 21.1 and 21.2 list valid observations by activity, residence, and model type. Figure 21.2 illustrates the distribution of the sample observations in relation to the location of MP&M facilities in Ohio.

[4] These additional observations total 10 across the four activities and represent only a small fraction of total observations. Including only Ohio respondents in the trip participation models underestimates the benefits associated with water quality improvements, because the welfare gains to recreators from neighboring states are ignored.

Table 21.1: Classification of Sample Observations for Estimation of the Site Choice Models

	Total Ohio Residents		Ohio Residents with Last Trip In-State		Valid Ohio Residents with Last Trip In-State		Valid Ohio Residents with Last Trip Outside State		Valid Non-Residents with Last Trip in Ohio		Valid for Site Choice Model	
Participants (Total)	609		408		227		34		10		271	
Fishing		122		103		69		4		1		74
Swimming		147		100		53		9		2		64
Viewing		231		126		56		7		5		68
Boating		109		79		49		14		2		65

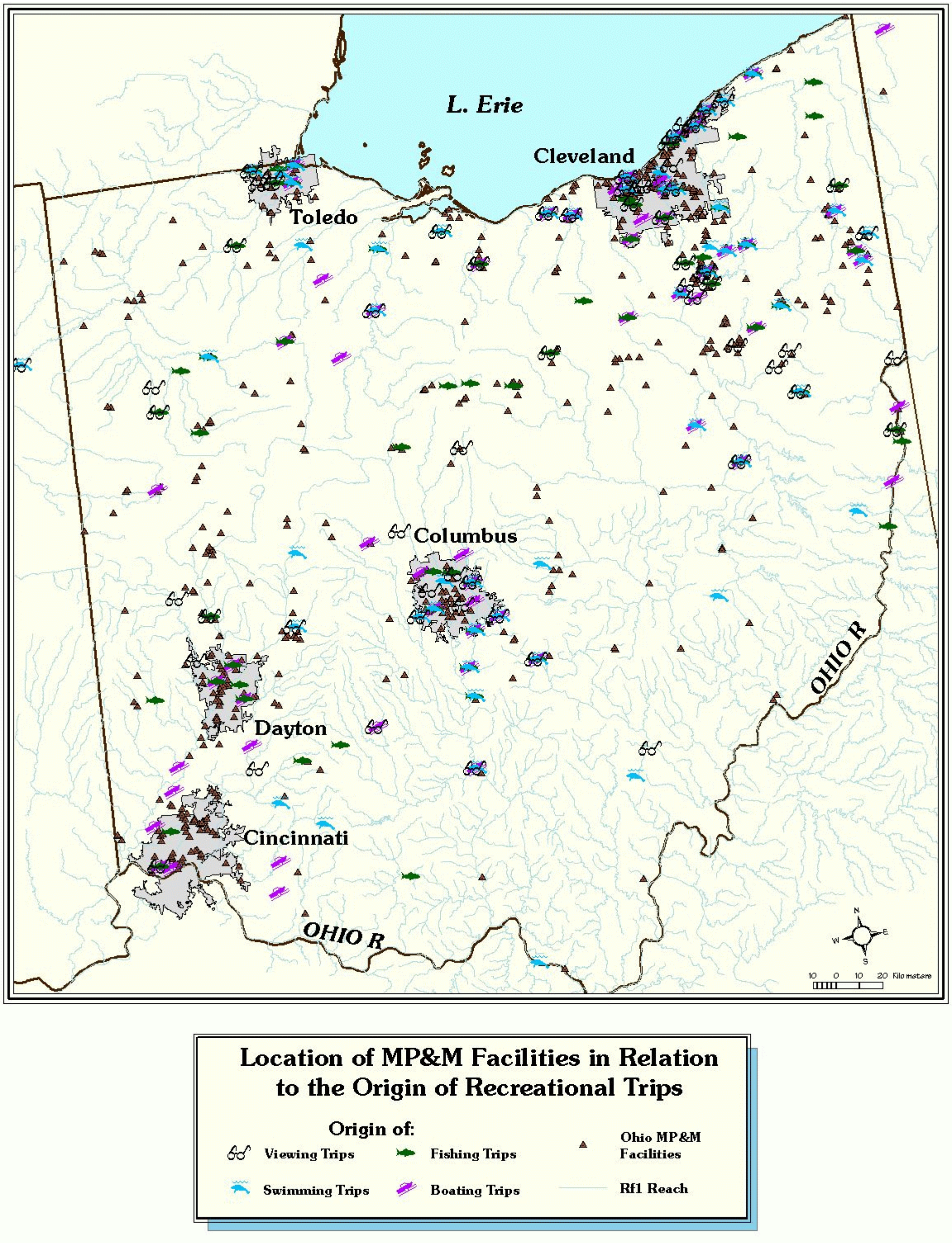
Source: U.S. EPA analysis.

Table 21.2: Classification of Sample Observations for Estimation of the Trip Participation Models

Ohio Residents	Total		Residents with Last Trip In-State		Residents with Last Trip Outside State		Valid for Trip Participation Model	
Non-Participants	300						291	
Participants (Total)	609		408		34		322	
Fishing		122		103		4		84
Swimming		147		100		9		78
Viewing		231		126		7		75
Boating		109		79		14		85
Total Observations	909		408		34		613	

Source: U.S. EPA analysis.

Figure 21.2: Location of MP&M Facilities in Relation to the Origin of Recreational Trips



Source: U.S. EPA analysis.

21.2.2 Estimating the Price of Visits to Sites

The Agency estimated trip "price" as the sum of travel costs plus the opportunity cost of time. Based on Parsons and Kealy (1992), EPA assumed that time spent "on-site" is constant across sites and can be ignored in the price calculation. To estimate travel cost, the Agency multiplied round-trip distance by average motor vehicle cost per mile ($0.29, 1993 dollars), and by the respondent family's share of total recreation party size, to estimate consumer travel cost.[5,6] EPA used trip time and hourly wage to compute the consumer's opportunity cost of time. The Agency divided round-trip distance by 40 miles per hour to estimate trip time, and used one-half the average hourly income to yield the opportunity cost of time.[7] Visit price was thus calculated as:

$$\begin{aligned} Visit\ Price &= Round\ Trip\ Distance \\ &\times \$.29 \times \%Paid \\ &+ \frac{Round\ Trip\ Distance}{40\,mph \times 0.5 \times Hourly\ Income} \end{aligned} \qquad (21.16)$$

21.2.3 Site Characteristics

EPA identified 1,954 recreation sites on 1,631 reaches in the universal opportunity set. Of these, 580 observations are known recreational sites (e.g. parks); 1,366 observations are ***Reach File 1*** **(RF1)** reaches without a known recreational site, and eight observations are neither located in RF1 nor identified as known recreation sites but were visited by an NDS respondent.

Each consumer choice set theoretically includes hundreds of substitutable recreation sites in Ohio and in the neighboring states. To prevent the recreation site analysis from becoming unmanageable, EPA analyzed a sample of recreation sites for each consumer observation. The Agency then created randomly-chosen reduced choice sets consisting of ten Lake Erie sites, ten inland recreation sites, and a dummy variable representing sites outside of Ohio for each participant in the three nested models.[8] The choice set for the fourth model, swimming, consisted of 20 Ohio sites (including inland and Lake Erie) and a dummy variable representing sites outside Ohio. Each participant choice set, by definition, includes the site actually visited by the respondent. For each consumer, EPA drew additional sites from a geographic area defined by a travel time constraint. The Agency defined the limit for inland recreation sites and all sites chosen in the swimming model as the greater of:

- 120 miles, or
- the estimated travel distance to the visited site.

All Lake Erie sites are eligible for inclusion in the choice sets for the fishing, boating, and wildlife viewing models. EPA assumed that consumers of water-based recreation would be willing to travel farther to visit Lake Erie sites, because this water resource presents unique recreational opportunities.[9] EPA used the resulting aggregate choice set of sites for all individuals participating in a given recreation activity to model consumer decisions regarding trip allocation across recreation sites.

The Agency used two classes of characteristics to estimate site choice:

- those unaffected by the MP&M regulation, but likely to determine valuation of water-based recreational resources; and
- those affected by the regulation *and* hypothesized to be significant in explaining recreation behavior and resource valuation.

Regulation-independent site characteristics include waterbody type and size, location characteristics, and the presence of site amenities (e.g., boat ramps, swimming beaches, picnic areas). Regulation-dependent site characteristics include regulation-affected water quality variables.

a. Regulation-independent site characteristics

Site characteristics that are likely to be important determinants of consumer valuation of water-based recreational resources but that are independent of the MP&M regulation include general site descriptors. These

[5] Note that all expenditures are in 1993 dollars because the trip choices and the associated expenditure occurred in 1993.

[6] The estimate of motor vehicle cost per mile was based on estimates compiled by the Insurance Information Institute.

[7] For respondents who did not report household income, EPA estimated household income using a simple OLS regression that modeled income as a function of employment status, years of schooling, age, gender, number of adults in the household, and a dummy variable indicating whether the respondent participated in water-based recreation activities.

[8] McFadden (1981) has shown that estimating a model using random draws can give unbiased estimates of the model with the full set of alternatives.

[9] Travel distance from respondents hometown to the Lake Erie sites did not exceed 200 miles.

descriptors include the type and size of the waterbody and location characteristics, and the presence of site amenities. EPA obtained data on regulation-independent site characteristics from two main sources, RF1 and the ***Ohio Department of Natural Resources* (ODNR)**.

RF1 provided waterbody type (i.e., lake, river, or reservoir) and physical dimension (i.e., length, width, and depth). The dummy variable, RIVER, characterizes waterbody type. If a river waterbody, RIVER takes the value of 1; 0 otherwise. EPA used the logarithm of the waterbody area LN_ACRE to define waterbody size.[10] EPA multiplied reach width by segment length to yield waterbody area. Waterbody size data for sites not located in RF1 came from the ODNR.

ODNR, supplemented by the *Ohio Atlas and Gazetteer*, provided data on recreational amenities and site setting (e.g., presence/absence of boat ramps, swimming beaches, or picnic areas; public accessibility; and size of land available for recreation). EPA used land available for recreation, LN_LNDAC, (e.g., state park acreage, fishing, hunting, and other recreation areas) to approximate site setting and attractiveness. Dummy variables represent the presence of three recreational amenities: BEACH is a swimming beach; DOCK is a boating dock; and PARK indicates a park. In the case of the swimming model, EPA included a dummy variable for whether or not a site is on Lake Erie (Great Lake = 1) because no explicit nest is present in the model.

b. Regulation-dependent site characteristics

Selecting regulation-dependent site characteristic variables that are both policy-relevant and significant in explaining recreation behavior proved challenging. MP&M facilities discharge many pollutants, most of them unlikely to have visible indicators of degraded water quality (e.g., odor, reduced turbidity, etc). EPA hypothesized that pollutant loadings can, nonetheless, reduce the likelihood of selecting a recreation site. Reduced pollutant discharges improve water quality and aquatic habitat, thereby increasing fish populations and enhancing the recreational fishing experience. In addition, in-stream nutrient concentrations are good predictors of eutrophication, which causes aesthetic losses and may thus affect the utility of a water resource for all four recreational uses.

The connection between the policy variables (i.e., the change in concentrations of MP&M pollutants) and the effects perceived by consumers (e.g., increased catch rate, increased size of fish, greater diversity of species, or improved aesthetic qualities of the waterbody) are not modeled directly, but are captured implicitly in the differential valuation of water resources as reflected in the RUM analyses.

[10] EPA uses the logarithm of acres because it expects effect of waterbody size on utility to diminish as that size increases.

EPA considered two types of pollutant effects in defining water quality variables for model inclusion:

- visible or otherwise directly observable effects (e.g., TKN); and
- unobservable toxic effects likely to impact aquatic habitat and species adversely.

The Agency accounted for directly observable effects using the ambient concentrations of nutrients (e.g., TKN) as an explanatory variable.

Rather than include the concentrations of all toxic pollutants separately, EPA constructed a variable to reflect the adverse impact potential of toxic pollutants on aquatic habitat. EPA identified recreation sites at which estimated concentrations of one or more MP&M pollutants exceed AWQC limits for aquatic life protection, to assess the likely adverse impacts on aquatic organisms. A dummy variable, AWQC_EX, takes the value of 1 if in-stream concentrations of at least one MP&M pollutant exceed AWQC limits for aquatic life protection, 0 otherwise. This approach accounts for the fact that adverse effects on aquatic habitat are not likely to occur below a certain threshold level.

c. Biological factors

Numerous biological parameters (e.g., abundance of sport fish) that are a function of the availability and quality of suitable habitat for breeding and feeding are also likely to affect recreation behavior. To account for biological parameters affecting the demand for water-based recreation, EPA used the ***index of well being* (IWB2)** obtained from the ***Ohio Water Resource Inventory* (OWRI)** database (OH EPA, 1996). The index is defined as follows:

$$IWB = 0.5 \times \ln N + 0.5 \times \ln B + H(no) + H(wt) \qquad (21.17)$$

where:

N	=	relative number of all species (i.e., number of fish per unit distance);
B	=	relative weight of all species (i.e., weight of all species per unit distance);
H(no)	=	Shannon diversity index based on relative numbers of species (i.e., number of all fish species per unit distance); and
H(wt)	=	Shannon diversity index based on relative weight of all fish species in the sample.

The Shannon diversity index, $\bar{H}$, is defined as follows:

$$\bar{H} = -\Sigma \frac{(n_i)}{N} \log_e \frac{(n_i)}{N} \qquad (21.18)$$

where:

n_i = relative numbers or weight of the *i*th species, and

N = total number or weight in the sample.

Chemical properties of the waters (e.g., pollutant concentrations) are likely to affect the diversity and abundance of the fishery resources. Biological parameters may also be affected by numerous anthropogenic stressors unrelated to water quality, such as over-fishing, physical alteration of habitat, invasion of exotic species, etc. Although EPA used the baseline values of IWB2 to estimate the site choice models, the Agency did not estimate changes in biological parameters in the following analysis due to data limitations and the challenges posed by modeling population impacts of a broad spectrum of pollutants at hundreds of recreation sites.

d. Presence of fish advisories

Another important factor that may affect a recreational consumer's decision to visit a particular site is presence of ***fish consumption or contact advisories*** **(FCAs)**. EPA obtained information on fish consumption advisories and contact advisories at reaches in Ohio from the ODNR (Ohio DNR, 1999). Fish consumption advisories and contact advisories were listed by the name of the stream or river with the consumption advisory. An advisory that applied to only part of the river included the names of cities, towns, or highways to identify the stretch of the reach for which the advisory was relevant. The name of the river and the other geographic identifiers were used to assign reach numbers from RF1 to the consumption advisories. EPA created a dummy variable for each type of advisory (i.e., fish advisories and contact advisories). The variable takes the value of 1 if the relevant advisories are present; 0 otherwise.

21.3 Site Choice Model Estimates

EPA estimated four separate models of recreational demand: fishing, boating, swimming, and viewing. The Agency classified trips by the primary activity listed by the respondent. All four activity models cover single-day trips. EPA estimated the site choice model using the site actually visited, 19 randomly drawn sites from the choice set for each recreation activity, and an alternative constant representing sites outside of Ohio.

EPA estimated activity models for five alternative choice sets (i.e., five random draws from the universal choice set), producing five sets of estimated coefficients. Median estimates from the five alternative draws represent EPA's best estimate of actual coefficient values. Table 21.3 lists the variables used as arguments in the utility function and presents the median estimation results for the four models.

The following sections provide a short description of the results of the site choice model corresponding to each recreation activity.

Table 21.3: Site Choice Model Estimation Results (Median parameter estimates from five random draws) [a]

Variable	Fishing	Boating	Swimming	Viewing
Price [b]	-0.08 (-18.83)	-0.11 (-17.7)	-0.08 (-13.85)	-0.12 (-22.19)
Ln_Lndac [c]	0.26 (8.24)	0.22 (3.88)	0.05 (1.89)	0.24 (6.39)
Ln_Acre [d]	0.54 (9.25)	0.99 (8.01)	-0.11 (-2.63)	0.70 (9.38)
Dock [e]	1.42 (7.43)	N/A	N/A	N/A
Beach [f]	N/A	N/A	0.93 (4.34)	N/A
Park [g]	N/A	N/A	2.82 (8.1)	0.36 (1.22)
AWQC_Ex [h]	-0.97 (-4.48)	-1.51 (-6.31)	-0.39 (-1.93)	-1.05 (-4.73)
IWB2 [i]	0.12 (2.79)	-0.25 (-3.8)	N/A	0.12 (2.97)
TKN [j]	-0.34 (-1.58)	-1.49 (-6.87)	-0.01 (-0.04)	-0.84 (-4.47)
River [k]	1.69 (3.4)	6.81 (6.42)	-2.21 (-9.63)	0.17 (0.33)
ASC [l]	3.51 (3.04)	0.19 (0.28)	-1.45 (-4.72)	-1.06 (-2.77)
Great Lake [m]	N/A	N/A	2.22 (5.17)	N/A
IV on Great Lakes	0.76 (6.95)	0.33 (6.91)	N/A	0.24 (9.52)
IV on Inland Sites	0.65 (6.33)	0.25 (4.75)	N/A	0.30 (9.12)
IV on ASC (Fixed)	1.00	1.00	1.00	1.00

a. EPA performed this analysis based on five alternative draws to assess sensitivity of the estimated coefficients with respect to random draws. Swimming model median estimates are from seven random draws. Extra draws were required to ensure stability of model estimates.
b. Price is calculated as 0.5 × opportunity cost + travel cost.
c. Log of the number of land acres.
d. Log of the number of water acres.
e. 1 if a boating dock is present, and 0 otherwise.
f. 1 if a swimming beach is present, and 0 otherwise.
g. 1 if the site is a park, and 0 otherwise.
h. 1 for any reach if in-stream concentrations of at least one MP&M pollutant exceed the AWQC limits for protection of aquatic life, and 0 otherwise.
i . Index of well being representing biological factors, such as species abundance and diversity.
j. In-stream concentrations of TKN (mg/l).
k. 1 if the site is a river, and 0 otherwise (e.g., lake or reservoir).
l. 1 if visited a site outside of Ohio, and 0 otherwise.
m. 1 if the site is on Lake Erie, and 0 otherwise.
Note: T-statistic for test that coefficient equals 0 is given in parentheses beside coefficient estimates.
N/A indicates that the variable was not included in the estimation for this activity.
Source: U.S. EPA analysis.

21.3.1 Fishing Model

The most significant variables in determining fishing site choice are price, presence of boating docks, waterbody size (log of water acres), whether the site is a river, the IWB2, exceedences of AWQC limits, and land available for recreation (Ln_Lndac). All coefficients have the expected sign and are significantly different from zero at the 95th percentile. The estimated coefficient on TKN has the expected sign but is significant only at the 90th percentile. Estimated inclusive values on Lake Erie sites and inland sites are positive and significantly different from 1 at the 95th percentile, indicating that the nested choice structure is appropriate.[11]

EPA found other variables, tested as explanatory variables, to be insignificant, including the presence of FCAs. It might be expected, *a priori*, that the presence of an FCA decreases a site's likelihood as a fishing choice. In fact, the existence of FCAs did not significantly affect a site's probability of being chosen; 59 percent of the sites actually chosen by NDS respondents had an FCA in place. Creel surveys provided by ODNR indicated that, on average, anglers released 70 percent of their catch (ODNR, 1997). This finding suggests that recreational anglers are aware of FCAs, and catch but do not consume fish in the affected areas.

21.3.2 Boating Model

Boaters prefer to visit cheaper, cleaner, larger river sites. Of the variables representing site amenities and attractiveness, only the acres of land available for recreation is significant. All coefficients on water quality variables are significantly

[11] Inclusive values equal to 1 cause the model to collapse to a flat multinomial logit.

different from zero at the 95th percentile. The IWB2 coefficient has a negative sign. As with the fishing model, the estimated inclusive values for Lake Erie sites and inland recreation sites are significantly different from 1 at the 95th percentile supporting the nested model framework. This finding is likely to be due to colinearity between the AWQC and the IWB2 variables. Colinearity between these two variables did not present a problem in the fishing and viewing models. The boating model restricts the opportunity set to the site where boating is allowed. This additional restriction may have exacerbated the colinearity problem.

21.3.3 Swimming Model

Price, the presence of a park with a beach, and location on Lake Erie affect the probability of a particular site being chosen for swimming. Swimmers are less likely to visit large sites, sites located on a river, sites with AWQC exceedences, and sites with relatively high in-stream concentrations of TKN.

Again, some variables expected to be significant, such the presence of contact advisories, are not. This variable's insignificance probably stems from its scarcity. Of 1,954 sites included in the universal opportunity set, contact advisories are in place for only 13. (None of the sites actually visited had contact advisories in place.) The probability that a chosen site has contact advisories in place is very small, because individual choice sets are randomly selected. The IWB2 variable representing biological characteristics of a waterbody did not have a significant influence on consumer decisions to visit a particular site and was dropped from the model. This outcome is not surprising, since abundant aquatic life may, in fact, interfere with swimming activities. All coefficients have the expected signs and are significantly different from zero with the exception of the coefficient on TKN.

21.3.4 Viewing (Near-water Activity) Model

The probability of choosing a site for near-water activities is most significantly related to visit price, waterbody and land size, whether the site is on a river, IWB2, the presence of AWQC exceedences, and in-stream concentrations of TKN. All coefficients have the correct sign and, with the exception of the coefficient on the RIVER variable, are significantly different from zero.

Estimated inclusive values for Lake Erie sites and inland sites are significantly different from 1, supporting the nested model structure.

21.4 Trip Participation Model

EPA estimated the determinants of individual choice concerning how many trips to take during a recreation season with a separate model for each of the four activities. These participation models rely on socioeconomic data, and on estimates of individual utility (the inclusive value) derived from the site choice models. Variables of importance include age, ethnicity, gender, education, and the presence of young or older children in the household. Whether or not the individual owns a boat is particularly important in boating participation, and is included in the model for that activity only. Variable definitions for trip participation model are:

- IVBASE: the inclusive value is estimated using the coefficients obtained from the site choice models;
- #TRIPS: number of trips taken by the individual;
- AGE: individual's age. If the individual did not report age, their age is set to the sample mean;
- MALE: equals 1 if the individual is a male, 0 otherwise;
- NOHS: equals 1 if the individual did not complete high school, 0 otherwise;
- COLLEGE: equals 1 if the individual completed college, 0 otherwise;
- AFAM: equals 1 if the individual is African American, 0 otherwise;
- YNGKIDS: equals 1 if there are kids 6 years or younger, 0 otherwise;
- OLDKIDS: equals 1 if there are kids 7 years or older, 0 otherwise;
- OWNBT: equals 1 if individual owns a boat, 0 otherwise;
- Constant: a constant term representing each individual's utility associated with not taking a trip; and
- α (alpha): overdispersion parameter estimated by the Negative Binomial Model.

Table 21.4 presents explanatory variables and a mean value for each.[12]

[12] The data on the number of trips in the season from the NDS suffer from overdispersion. EPA used a negative binomial model in place of the simple Poisson model to correct for this overdispersion.

Table 21.4: Mean Values for Explanatory Variables Used in the Participation Models

Variables (Mean)	Non-Participant (N=291)	Boating (N=85)	Fishing (N=84)	Swimming (N=78)	Viewing (N=75)
# TRIPS	0.00	7.71	10.07	9.46	9.59
AGE	43.99	39.06	38.53	34.76	36.91
MALE	0.33	0.49	0.65	0.47	0.47
NOHS	0.17	0.09	0.14	0.13	0.13
COLLEGE	0.15	0.32	0.20	0.32	0.35
AFAM	0.11	0.02	0.05	0.03	0.12
YNGKIDS	0.18	0.26	0.24	0.24	0.27
OLDKIDS	0.38	0.48	0.58	0.56	0.48
OWNBT	0.00	0.53	N/A	N/A	N/A

Source: U.S. EPA analysis.

Table 21.5 presents the results for the participation models of the four recreation activities.

Table 21.5: Trip Participation Negative Binomial Model Estimates

Variables/ Statistics	Boating	Fishing	Swimming	Viewing
IVBASE	0.12 (0.71)	0.82 (2.86)	0.72 (4.57)	0.47 (3.66)
AGE	-0.07 (-4.73)	-0.04 (-2.06)	-0.06 (-2.24)	-0.05 (-2.77)
MALE	1.23 (2.75)	2.22 (3.25)	1.15 (1.52)	0.91 (2.00)
NOHS	1.29 (2.37)	-1.09 (-1.56)	-0.92 (-0.96)	0.1 (0.17)
COLLEGE	-0.19 (-0.29)	-0.40 (-0.721)	0.53 (0.71)	1.22 (2.05)
AFAM	-3.74 (-1.81)	-1.44 (-1.53)	-4.07 (-2.68)	-1.16 (-1.34)
YNGKIDS	1.51 (2.96)	-0.95 (-1.26)	0.35 (0.42)	-0.17 (-0.38)
OLDKIDS	-1.67 (-3.58)	1.11 (2.78)	0.4 (0.65)	0.8 (1.81)
OWNBT	3.82 (5.26)	N/A	N/A	N/A
Constant	0.20 (0.11)	-5.74 (-3.01)	-0.1 (-0.06)	-1.98 (-1.6)
Alpha á	5.77 (5.85)	9.03 (7.16)	8.92 (6.78)	8.17 (6.03)

Note: T-statistic for test that coefficient equals 0 is given in parentheses below coefficient estimates.
N/A indicates that the variable was not included in the estimation for this activity.
Source: U.S. EPA analysis.

All parameter estimates of the inclusive value index (IVBASE) are within the unit interval [0,1], which ensures that the model does not violate random utility maximization assumptions. IVBASE coefficients in the swimming, fishing, and viewing models are positive and differ significantly from zero at the 95th percentile, indicating that water quality improvements have a positive effect on the number of trips taken during a recreation season.

The estimated coefficient on IVBASE in the boating model, while positive, was not statistically significant. Taking a boating trip often requires more preparation (e.g., taking a boat to the waterbody) than taking other trips. Therefore, although water quality improvements increase the value of a boating day, factors other than water quality are likely to have a stronger impact on the number of boating trips per season.

The AGE variable is negative and significant for all four recreation activities: younger people are likely to take more recreation trips. Ethnicity and gender (the AFAM and MALE variables) also have a significant impact on whether an individual participates in water-based recreation. African-Americans living in Ohio are less likely to participate in any of the four recreation activities than representatives of other ethnic groups. Males are more likely than females to participate in any of the recreation activities.

Education also influences trip frequency significantly. People who did not complete high school (NOHS=1) tend to take fewer fishing or swimming trips. Those with a college degree (COLLEGE=1) are more likely to participate in swimming and viewing. Respondents who attended college are less likely, however, to participate in fishing and boating than those who completed only a high school education. For the boating model, the COLLEGE variable is not significantly different from zero.

The presence of older children (OLDKIDS) in the household is associated with greater participation in swimming, viewing (near-water recreation), and fishing activities, but is not a significant determinant in decisions to participate in boating. Younger children in the household (YNGKIDS) tend to lead to greater participation in boating and swimming, but lead to fewer fishing or viewing trips.

21.5 Estimating Benefits from Reduced MP&M Discharges in Ohio

21.5.1 Benefiting Reaches in Ohio

EPA identified reaches where it expects the MP&M rule to eliminate or reduce the number of existing AWQC exceedances (hereafter, benefiting reaches). The Agency first identified the reaches in which baseline discharges from industrial sources, including both MP&M and non-MP&M facilities, caused one or more pollutant concentrations to exceed AWQC limits for aquatic species. A reach is considered to benefit from the MP&M rule if at least one AWQC exceedance is eliminated due to reduced MP&M discharges. Although the method for identifying benefiting reaches is similar to the method used in the national analysis (see Chapter 15 for detail), there are three notable differences:

- Unlike the national analysis, the Ohio case study incorporates information on all industrial and municipal point source discharges and nonpoint sources to assess in-stream concentrations of toxic and non-conventional pollutants in the baseline and post-compliance. Appendix G provides detail on the water quality model used in this analysis. The appendix also provides information on the data sources and methods used to assess ambient water quality conditions in Ohio.

- The analysis of recreational benefits in Ohio takes into account only aquatic life-based AWQC exceedences to avoid any potential double counting of human health and recreational benefits.

- The analysis of recreational benefits accounts for changes in TKN concentrations.

EPA's analysis indicates that baseline pollutant concentrations at discharge levels from all industrial sources exceed acute exposure criteria on 124 reaches, and exceed chronic exposure criteria for protection of aquatic species on 169 reaches. EPA estimates that the proposed rule would eliminate concentrations in excess of the acute aquatic life exposure criteria on 113 reaches, and would eliminate concentrations in excess of the chronic aquatic life exposure criteria on 73 reaches. Table 21.6 summarizes these results. In addition, the proposed regulation is estimated to reduce in-stream concentrations of TKN in the affected reaches. The estimated average reductions are 7.7 percent in lakes and 12.2 percent in rivers and streams.

Table 21.6.: Estimated MP&M Discharge Reaches with MP&M Pollutant Concentrations in Excess of AWQC Limits for Protection of Aquatic Species or Human Health

Regulatory Status	Number of Reaches with Concentrations Exceeding AWQC Limits for Aquatic Species		Number of Benefiting Reaches	
	Acute	Chronic	All AWQC Exceedances Eliminated	Partial AWQC Exceedance Elimination
Baseline	124	169		
Proposed Regulation	11	96	74	91

Source: U.S. EPA analysis.

21.5.2 Estimating Recreational Benefits in Ohio

To estimate peoples' willingness to pay for water quality improvements, the Agency first calculated per person seasonal welfare gain corresponding to the proposed regulation. Table 21.7 presents, for each recreation activity, the compensating variation per trip (averaged over all individuals in the sample) associated with the reduced MP&M discharges. Because the trip choices and the associated expenditures occurred in 1993, the welfare gain was calculated in 1993 dollars and then adjusted to 1999 dollars based on CPI.

The model indicates that the reductions in MP&M discharges from the proposed regulation result in a substantial increase in per-trip values for all recreation activities. Note that the per trip-welfare gain for boaters is greater than for participants in other activities. This result is not intuitive. One possible explanation is that boating was the only activity for which multiple day trips were modeled. Multi-day trips may also be multi-activity trips. For example, people may have participated in fishing and swimming while on a boating trip. Because the NDS data provided information on the primary purpose of the trip only, apportioning welfare gain among various activities that may have taken place during boating trips is not feasible. This finding is consistent, however, with the existing literature. Previous economic studies have found that per-trip welfare gain from water quality improvements is likely to be greater for multi-day trips than for single-day trips (Jones and Sung, 1993).

Table 21.7: Average Welfare Gain per Recreational User in Ohio

Activity	Per Trip Welfare in 1999$	Seasonal Welfare Range (in 1999$) Lower Bound	Mid	Upper Bound
Fishing	$3.93	$27.56	$32.26	$36.97
Boating	$9.10	$92.15	$99.85	$107.55
Viewing	$4.01	$11.16	$14.02	$16.88
Swimming	$1.55	$12.06	$12.82	$13.58

Source: U.S. EPA analysis.

Table 21.7 also reports seasonal compensating variation per individual. As noted before, seasonal welfare gain is derived from both the increase in the utility from better water quality at the available recreation sites receiving MP&M discharges and the increase in utility from greater recreational trip participation.

Both the per trip and seasonal welfare estimates are consistent with values reported in the existing studies, with the exception of welfare estimates from improved boating opportunities. This estimate is somewhat higher than expected, and is likely to be due to the fact that boating is often a multi-activity trip.

To calculate state-level recreational benefits from the proposed rule, EPA first calculated seasonal welfare gain from water quality improvements per individual in the sample. The Agency then multiplied the average welfare gain per individual by the corresponding number of participants in a given activity (see section 21.1.5 above for detail). The resulting product is the annual benefit from the proposed MP&M rule to consumers of a given water-based recreation activity in Ohio. Table 21.8 summarizes state level results.

Table 21.8: Estimated Recreational and Nonuse Benefits from Reduced MP&M Discharges in Ohio

Ohio State Recreational Benefits			Estimated Recreational Benefits (million 1999$)		
Activity	Percentage Participating in the Activity (from the NDS)	Number of Participants[a]	Low	Mid	High
Fishing	14.2%	1,143,691	$31.5	$36.9	$42.3
Boating	11.5%	932,360	$85.9	$93.1	$100.3
Viewing	15.8%	1,280,441	$14.3	$18.0	$21.6
Swimming	14.0%	1,131,263	$13.6	$14.5	$15.4
Total Recreational Use Benefit			$145.4	$162.5	$179.5
Nonuse Benefits			$36.3	$81.2	$118.5
Total Recreational Benefits (Use + Nonuse)			$181.7	$243.7	$298.0

a. EPA estimated the number of participants in each recreation activity by multiplying the percent of NDS survey respondents from Ohio participating in each activity by the total adult population (8,080,452). This analysis uses the 1990 Census data to estimate current population in Ohio.
Source: U.S. EPA analysis.

Under the proposed regulation, the extrapolation from the sample to the adult population in Ohio yields average annual benefits estimates of $36.9, $14.5, $18.0, and $93.1 million (1999$) for fishing, swimming, viewing, and boating, respectively. The total recreational use benefits range from $145.4 to $179.5 million (1999$). The Agency used the same approach as in the national analysis to estimate nonuse benefits. EPA estimated nonuser benefits as one-fourth, one-half, and two-thirds of recreational use benefits for low, mid, and high estimates, respectively. The estimated nonuse benefits range from $36.3 to $118.5 million (1999$).

21.6 Limitations and Uncertainty

21.6.1 One-State Approach

Some benefits are likely to be missed by a state-level case study. For example, residents from neighboring states undoubtedly recreate in Ohio waters, and residents of Ohio undoubtedly recreate in neighboring states. A state-by-state approach that restricts its analysis to recreation activities within the state misses these categories of benefits.[13] This omission is likely to be more significant for unique locations of high quality (e.g., Lake Erie), where participants travel significant distances, and for sites very close to state boundaries.

21.6.2 Including One-Day Trips Only

Use of day-trips only tends to understate recreational benefits for swimming, fishing, and viewing, since recreation as part of multi-day trips is excluded. Inclusion of multi-day trips, however, can be problematic. Multi-day trips are frequently multi-activity trips. An individual might travel a substantial distance, participate in several recreation activities, go shopping and sightseeing, all as part of one trip. Recreational benefits from improved recreational opportunities for the primary activity are overstated if all travel costs are treated as though they are associated with the one recreational activity of interest. The total benefits per trip from water quality improvements are not overstated, however, if individuals participated in several water-based activities.

21.6.3 Considering Only Recreational Values

This study understates the total benefits of water quality improvements because estimates are limited to recreation benefits, when many other forms of benefits are also likely to be important. Other benefits include aesthetic benefits for residents living near waterbodies, habitat values for a variety of species (in addition to recreational fish), nonuse values, etc. To correct for this limitation inherent in travel cost models, EPA quantified nonuse values in proportion to recreation values. This approach provides only a rough approximation of the value of water resources to nonusers. For example, some natural resources have high use values but small or negligible nonuse values (e.g., cows), while other species have very high nonuse values but small or negligible use values (e.g., blue whales). This approach may therefore lead to either overestimation or underestimation of benefits.

[13] Note that EPA used a few observation on visitors from neighboring states to estimate site choice models. The analysis does not include these observations in calculating state-level benefits from water quality improvements.

21.6.4 Potential Sources of Survey Bias

The survey results could suffer from bias, such as recall bias (e.g., Westat, 1989), nonresponse bias, and sampling effects.

a. Recall bias

Recall bias can occur when respondents are asked the number of days in which they recreate over the previous season, such as in the NDS survey. Some researchers believe that recall bias tends to lead to an overstatement of the number of recreation days, particularly for more avid participants. Avid participants tend to overstate the number of recreation days, since they count days in a "typical" week and then multiply them by the number of weeks in the recreation season.[14] They often neglect to consider days missed due to bad weather, illness, travel, or when fulfilling "atypical" obligations. Some studies also found that the more salient the activity, the more "optimistic" the respondent tends to be in estimating number of recreation days. Individuals also have a tendency to overstate the number of days they participate in activities that they enjoy and value. Taken together, these sources of recall bias may result in an overstatement of the actual number of recreation days.

b. Nonresponse bias

A problem with sampling bias may arise when extrapolating sample means to population means. This could happen, for example, when avid recreation participants are more likely to respond to a survey than those who are not interested in the forms of recreation, are unable to participate, assume that the survey is not meant for them, or consider the survey not worth their time.

c. Sampling effects

Recreational demand studies frequently face two types of observations that do not fit general recreation patterns: non-participants and avid participants:

Non-participants are those individuals who would not participate in the recreation activity under any conditions. This analysis assumes that an individual is a non-participant in a particular activity if he or she did not participate in that activity at *any* site. This assumption tends to understate benefits, since some individuals may not have participated during the sampling period simply by chance, or because price/quality conditions were unfavorable during the sampling period.

[14] Westat (1989) uses ten or more activity-days per year as an indicator of an "avid" user.

Avid participants can also be problematic because they claim to participate in an activity an inordinate number of times. This reported level of activity is sometimes correct, but often overstated, perhaps due to recall bias (see Westat, 1989). Even where the reports are correct, these observations tend to be overly influential. EPA dropped observations of participants who reported more than 100 trips per year when estimating trip participation models, to correct for potential bias caused by these observations.

21.6.5 Using IWB2 to Predict Recreational Behavior

Using IWB2 in the model can be counterproductive for welfare measurement unless policy-related pollution reductions are linked to associated changes in the index. EPA used the IWB2 index to predict site choice (with the exception of the swimming model) because biological factors are usually significant determinants of recreational behavior. Excluding the IWB2 from the model would reduce the accuracy of the site choice estimates. The IWB2 index, however, may extract explanatory power from other water quality measures to the extent that IWB2 is correlated with these other measures, unless changes in IWB2 resulting from policies to control MP&M pollutants are predicted. Benefits of water quality improvements may therefore be understated. As noted in Section 21.2.3, the act of modeling changes in IWB2 is beyond the scope of this study.

GLOSSARY

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

compensating variation (CV): the amount of money a person would need to pay or receive in order to leave that person as well off as they were before a change.

consumer choice set: the set of alternatives from which a consumer may choose.

exogenous: external to the inner workings of a system or model; variables are exogenous to the extent that they are "given" and not the result of the operation of the system or anything going on in the model itself.

expected maximum utility of a trip: see "inclusive value."

fish consumption advisories (FCAs): an official notification of the public about specific areas where fish tissue samples have been found to be contaminated by toxic chemicals which exceed FDA action limits or other accepted guidelines. Advisories may be species specific or community wide.

inclusive value: the value to the consumer of being able to choose among X alternatives (e.g., among a number of recreational sites) on a given trip occasion.

index of well being (IWB2): a composite index of diversity and abundance measures (density and biomass) based on fish community data.

indirect utility function: gives the maximum value of utility for any given prices and money income. The indirect utility function is obtained when quantity of goods that maximize consumer utility subject to the budget constraint are substituted into a utility function.

inferential analysis: based on interpretation.

multinomial logit (MNL): a utility maximization model. In this model, an individual is assumed to have preferences defined over a set of alternatives (e.g., recreation sites). The choice model takes the form of comparing utilities from different alternatives and choosing the one that produces the maximum utility. In this framework, observed data consist of attributes of the choices (e.g., available recreational amenities at different sites) and the choice actually made. Usually no characteristics of the individuals are observed beyond their actual choice.

National Demand Survey for Water-Based Recreation (NDS): a U.S. EPA survey of recreational behavior. The 1993 survey collected data on socioeconomic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over (http://www.epa.gov/opei).

negative binomial regression model: an extension of the Poisson regression model that allows the variance of the process to differ from the mean (see also Poisson distribution and Poisson estimation process).

Negative binomial Poisson model: (see negative binomial regression model).

nested multinomial logit model (NMNL): an extension of MNL (see above). In this model, an individual is assumed to choose among different groups of alternatives first (i.e., Great Lakes or inland recreation sites) and then to choose elemental alternatives (e.g., a particular river reach, lake, or Great Lakes site) in the choice set.

non-conventional pollutants: a catch-all category that includes everything that is not classified as a priority pollutant or a conventional pollutant.

Ohio Water Resource Inventory (OWRI): a biennial report to U.S. EPA and Congress required by Section 305(b) of the Clean Water Act. The report is composed of four major sections: (1) inland rivers and streams, wetlands, Lake Erie, and water program description; (2) fish tissue contaminants; (3) inland lakes, ponds, and reservoirs; and (4) groundwater.

overdispersion: condition for a distribution where the variance exceeds the mean. It usually signifies a nonrandom dispersion, for example the case where a small minority of the population is responsible for the majority of recreational trips taken.

Poisson distribution: a random variable X is defined to have a Poisson distribution if the probability density of X is given by $f_x(X) = f_x(X;\lambda) = e^{-\lambda} \lambda^x / x!$ for x = 0,1,2.., and 0 otherwise. In this model, ë is both the mean and variance of X.

Poisson estimation process: is used to model discrete random variables. Typically, a Poisson random variable is a count of the number of events that occur in a certain time interval or spatial area. For example, the number of recreational trips taken during a recreational season.

priority pollutants: 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples.

random utility model (RUM): a model of consumer behavior. The model contains observable determinants of consumer behavior and a random element.

Reach File 1 (RF1): a database of approximately 700,000 miles of streams and open waters in the conterminous United States. The database contains information on streamflow, time travel velocity, reach length, width, depth, and other stream attributes.

site choice model: is used to determine which recreational site is chosen by the consumer. EPA estimated the likelihood that the consumer will choose a particular site as a function of site characteristics, the price paid per site visit, and household income.

Total Kjeldahl Nitrogen (TKN): TKN is defined as the total of organic and ammonia nitrate. It is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

travel cost model (TCM): method to determine the value of an event by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site. (http://www.damagevaluation.com/glossary.htm)

total seasonal welfare: see "welfare effect."

trip participation model: is used to estimate the number of water-based recreational trips taken during the recreation season. EPA estimated the total number of trips during the recreation season as a function of the expected maximum utility (inclusive value) from recreational activity participation on a trip, and socioeconomic characteristics affecting demand for recreation trips (e.g., number of children in the household).

utility-theoretic: consistent with the behavioral postulate of maximum utility that underlines the structure of models of consumer behavior.

welfare effect: gain or loss to the group of individuals (e.g., fishermen) as a whole.

ACRONYMS

AWQC: Ambient Water Quality Criteria
CV: compensating variation
FCAs: fish consumption advisories
IWB2: index of well being
LIMDEP: Limited Dependent Variable
MNL: multinomial logit
MP&M: Metal Product and Machinery industries
NDS: National Demand Survey for Water-Based Recreation
NMNL: nested multinomial logit model
ODNR: Ohio Department of Natural Resources
OWRI: Ohio Water Resource Inventory
RUM: random utility model
RF1: Reach File 1
TKN: Total Kjeldahl Nitrogen
TCM: travel cost model

REFERENCES

Bockstael, N.E., I.E. Strand, and W.M. Hanemann. 1987. Time and the Recreation Demand Model. *American Journal of Agricultural Economics* 69:213-32.

Creel, M. and J. Loomis. 1992. Recreation Value of Water to Wetlands in the San Joaquin Valley: Linked Multinomial Logit and Count Data Trip Frequency Models. *Water Resource Research*. Vol 28. No 10 pp.2597-2606, October.

Feather, Peter M. ; Daniel Hellerstein, and Theodore Tomasi. 1995. A Discrete-Count Model of Recreation Demand. *Journal of Environmental Economics and Management*, 29:214-227.

Green, W.H. 1993. *Econometric Analysis*. New York, NY: Macmillan Publishing Company.

Hausman, J., G. Leonard, and D. McFadden. 1995. A Utility-Consistent, Combined Discrete Choice and Count Data Model: Assessing Recreational Use Losses Due to Natural Resource Damage. *J. of Public Economics* No 56 pp.1-30.

Jones, C.A. and Y.D. Sung. 1993. *Valuation of Environmental Quality at Michigan Recreational Fishing Sites: Methodological Issues and Policy Application.* Final Report. EPA Contract No. CR-816247-01-2. September.

Kling, C.L. and C.J. Thomson. 1996. "The Implication of Model Specification for Welfare Estimation in Nested Logit Model." *American Journal of Agricultural Economics Association*, No. 78, February, pp. 103-114.

McFadden, D. 1981. "Econometric Models of Probabilistic Choice." In C.F. Manski and D.L. McFadden, eds., *Structural Analysis of Discrete Data.* Cambridge, MA: MIT Press.

Ohio Atlas and Gazetteer, The. 1995. Freeport, ME: Delorme.

Ohio Department of Natural Resources, Division of Wildlife. Creel Survey Summaries from 1992 to 1997.

Ohio Department of Natural Resources, Division of Wildlife. 1999. Fish Consumption Advisories.

Ohio EPA. 1996. Ohio Waste Resource Inventory Volume 1: Summary Status, and Trends; and Volume 3: Ohio Public Lakes, Ponds, and Reservoirs. Chagrin.EPA.State.OH.US/document index.

Parsons, G. and M.J. Kealy. 1992. Randomly Drawn Opportunity Sets in a Random Utility Model of Lake Recreation. *Land Economics* 68 No. 4(1992): pp. 418-33.

Parsons, G.R. 1999. Comments on *Assessing the Recreational Benefits of the MP&M Regulation: a State-level Case Study Based on the Random Utility Model Approach*. Memo to Abt Associates Inc., August.

U.S. Bureau of the Census. 1999. Internet web site: http://www.state.oh.us/odhs/octf/stats/gjcs/ohio.pdf

U.S. EPA. 1993. *National Demand for Water-Based Recreation Survey*. Washington, D.C.: Office of Policy Evaluation and Information.

Chapter 22: MP&M Benefit-Cost Analysis in Ohio

INTRODUCTION

This chapter presents estimated benefits and costs of the proposed MP&M regulation in Ohio. The preceding chapter summarized the methodology and results of the case study of the expected recreational benefits from water quality improvements in Ohio. This chapter first presents estimates of the remaining three benefit categories, including:

- reduced human health risk from exposure to carcinogens and systemic health toxicants,
- changes in health risk from exposure to lead for adults and children, and
- ***publicly-owned treatment works* (POTW)** benefits.

Then, the chapter presents the social costs of the proposed regulation for the state of Ohio. Finally, the chapter compares the aggregate benefits and social costs estimates for the proposed regulation in Ohio. Analysis of the benefits and costs of the proposed regulation shows that the proposed regulation will have net benefits in Ohio ranging from $40.3 to $149.2 million (1999$).

EPA estimated MP&M costs and benefits in Ohio using similar methodologies to those used for the national-level analysis. In addition to the RUM study of recreational benefits discussed in the previous chapter, the additional analytical improvements included the following:

- the use of more detailed data on MP&M facilities. EPA oversampled the state of Ohio with 1,600 screeners to obtain information on co-occurrence of MP&M discharges;
- the use of data on non-MP&M discharges to estimate current baseline conditions in the state; and
- the use of a first-order decay model to estimate in-stream concentrations in the Ohio waterbodies. This model allows the assessment of the environmental effects of MP&M discharges on the reaches receiving MP&M discharges and downstream reaches.

CHAPTER CONTENTS:

Appendix G describes the water quality model used in this analysis and the approach and data sources used to estimate total pollutant loadings from all industrial and municipal sources to Ohio's waterbodies. The Agency believes that the added level of detail results in more robust benefit cost estimates.

22.1 BENEFITS OF THE PROPOSED REGULATION

EPA estimates that approximately 564 million pounds of pollutants per year are discharged to POTWs, and approximately 615 million pounds of pollutants are discharged directly to surface water in Ohio. The proposed regulation is estimated to remove 503 million pounds discharged to POTWs and 31 million pounds discharged directly to surface waters.

22.1.1 Human Health Benefits (Other than Lead)

Benefits from the reduced number of cancer cases from consumption of drinking water account for the bulk of the monetized human health benefits. Total monetized human health benefits from the proposed regulation are $142.6 thousand (1999$). Chapter 13 details the methodologies used to estimate human health benefits from reduced exposure to carcinogens and systemic health toxicants other than lead.

a. Reduced incidence of cancer cases from consumption of contaminated fish and drinking water

Table 22.1 shows the number of cancer cases avoided by the proposed regulation through both the drinking water and fish consumption pathways. EPA estimates that improved water quality resulting from the proposed regulation will reduce the incidence of cancer cases via the drinking water and fish consumption pathways from the total of 0.036 cases respectively in the baseline to 0.012 cases under the proposed regulation. Monetized benefits from reduced cancer incidence from drinking water are $142.6 thousand. Estimated benefits from reduced cancer risk associated with fish consumption pathways are negligible.

Table 22.1: Estimated Annual Benefits from Avoided Cancer Cases from Fish and Drinking Water Consumption

		Cancer Cases	Benefits (1999$)
Baseline			
	Drinking Water	0.036	
	Fish Consumption	0.00001	
Total		**0.036**	
Proposed Regulation			
	Drinking Water	0.012	$142,600
	Fish Consumption	0.00001	$39
Total		**0.012**	**$142,639**

Source: U.S. EPA analysis.

b. Systemic health effects

EPA's analysis of the in-waterway pollutant concentration data suggests that baseline hazard ratios, for both the fish consumption and drinking water pathways, for the population associated with sample facilities only are less than one. The results of the analysis show shifts in populations from higher (but less than 1.0) to lower hazard score values between the baseline and post-compliance scenarios.

c. Reduced frequency of human-health based AWQC exceedances in Ohio s waterbodies

Baseline in-waterway concentrations of MP&M pollutants exceed human health-based ***ambient water quality criteria* (AWQC)** limits for consumption of water or organisms in 11 reaches. No reaches exceeded human-health based AWQC for consumption of organisms only. The proposed regulation will eliminate exceedences of human health AWQC in six (45.5 percent) of these reaches.

22.1.2 Lead-Related Benefits

Total monetized lead-related benefits in Ohio for children and adults combined under the proposed regulation are $104,951 (1999$). Chapter 14 of this report describes the methodologies used to estimate these benefits.

a. Estimated benefits to Ohio s children

Table 22.2 presents lead-related benefits from the proposed regulation for preschool age children and pregnant women in Ohio. The proposed regulation will reduce the incidence of neonatal mortality by 0.005 cases annually. This yields the monetary value of benefits of $33,668 (1999$).

The proposed regulation will avoid the loss of an estimated 1.74 IQ points among preschool children in Ohio, which translates into $17,538 (1999$) per year in benefits. The avoided costs of compensatory education due to reduced incidence of children with IQ below 70 and blood-lead levels above 20 µg/dL equal about $459. The proposed regulation will therefore result in aggregated lead-relatedbenefits for children in Ohio of $51,665 (1999$).

Table 22.2: Ohio Child Lead Annual Benefits (1999$) Proposed Regulation

Category	Reduced Cases or IQ Points	Monetary Value of Benefits
Neonatal Mortality	0.005	$33,668
Avoided IQ Loss	1.741	$17,538
Reduced IQ < 70	0.001	$453
Reduced PbB > 20	negligible	$6
Total Benefits		**$51,665**

Source: U.S. EPA analysis.

b. Adult benefits

Table 22.3 presents benefit estimates for reduced lead-related health effects in adults. These health effects include increased incidence of hypertension, initial non-fatal ***coronary heart disease* (CHD)**, non-fatal stokes (***cerebrovascular accidents* [CBA]** and ***brain infarction* [BI]**), and premature mortality. The proposed regulation would reduce hypertension in Ohio by an estimated 3.6 cases annually among males, resulting in benefits of approximately $3,796 (1999$). Reducing the incidence of initial CHD, strokes, and premature mortality among adult males and females in Ohio would result in estimated benefits of $449, $1,052, and $47,989 respectively. Overall, adult lead-related benefits of $53,286. This analysis does not include other health effects associated with elevated ***blood pressure*** (BP) or with lead, such as nervous system disorders, anemia, and possible cancer effects.

Table 22.3: Ohio Adult Lead Benefits (1999$) Proposed Regulation

Category		Reduced Cases	Monetary Value of Benefits
Men	Hypertension	3.623	$3,796
	CHD	0.005	$343
	CBA	0.002	$538
	BI	0.001	$304
	Mortality	0.006	$38,741
Women	CHD	0.001	$105
	CBA	0.001	$130
	BI	0.000	$80
	Mortality	0.001	$9,248
Total Benefits			**$53,286**

Source: U.S. EPA analysis.

22.1.3 Economic Productivity Benefits

EPA estimates that the proposed regulation would remove 3.5 million pounds of the eight pollutants in Ohio for which there are published sludge concentration limits. EPA estimated the total monetized POTW benefits for the proposed regulation to be $10,000 (1999$). Chapter 16 describes the methodologies used to estimate these benefits.

The Agency estimated that 28 POTWs in Ohio exceed the Land Application-High pollutant limits and 20 exceed the Land Application-Low pollutant limits under the baseline discharge levels. EPA estimated that four POTWs will be newly qualified for lower-cost land application based on estimated reductions in sludge contamination, and that approximately 200 ***dry metric tons*** (DMT) of sludge will be newly qualified for land application.[1]

EPA also estimated that 11.6 DMT of sewage sludge generated by two POTWs that previously met only the Land Application-Low limits would, as a result of regulation, meet the more stringent Land Application-High limits. These two POTWs will benefit from reduced recordkeeping.

22.1.4 Total Monetized Benefits

Summing the monetary values over all benefit categories (Chapters 21 and 22) yields total monetized benefits in Ohio of $182.0 to $298.3 million (1999$) annually for the proposed regulation (see Table 22.4). The midpoint estimate of monetized benefits for the proposed regulation is $243.9 million (1999$). As noted in Chapter 12, this benefit estimate is necessarily incomplete because it omits some mechanisms by which society is likely to benefit from reduced effluent discharges from the MP&M industry. Examples of benefit categories not reflected in this monetized estimate include: non-lead related non-cancer health benefits, improved aesthetic quality of waters near discharge outfalls, benefits to wildlife and to threatened or endangered species, tourism benefits, and reduced costs of drinking water treatment.

[1] This newly qualified sludge can meet either Land Application-High or -Low pollution limits.

Table 22.4: Estimated Benefits in Ohio from Reduced MP&M Discharges under the Proposed Regulation (Annual Benefits - 1999$)

Benefit Category	Low	Mid	High
1. Reduced Cancer Risk:			
Fish Consumption	$39	$39	$39
Water Consumption	$142,600	$142,600	$142,600
2. Reduced Risk from Exposure to Lead:			
Children	$51,665	$51,665	$51,665
Adults	$53,286	$53,286	$53,286
3. Enhanced Water-Based Recreation	$145,365,723	$162,449,204	$179,532,685
4. Nonuse benefits	$36,341,431	$81,224,602	$118,492,572
5. Avoided Sewage Sludge Disposal Costs	$10,000	$10,000	$10,000
Total Monetized Benefits	**$181,964,744**	**$243,931,396**	**$298,282,847**

Source: U.S. EPA analysis.

22.2 Social Costs of Proposed Regulation

22.2.1 Baseline and Post-Compliance Closures

The methodology used to assess baseline and post-compliance closures differed from the methodology used for the national analysis presented in Chapter 5. The screener data collected for Ohio facilities did not provide financial data to perform an after-tax cash flow or net present value test. EPA therefore used data from the national analysis to estimate the percentage of facilities that close in the baseline and post-compliance. EPA assumed that the ratio of facilities that close in the national analysis with the same discharge status, subcategory, and flow category would be comparable to the facilities in Ohio. For example, eight percent of indirect general metals facilities discharging more than 6.25 million gallons per year close in the baseline in the national data set, and this same percent distribution is assumed for Ohio screener indirect dischargers in that flow size category.

Table 22.5 provides an overview of the numbers of facilities in Ohio closing or excluded in the proposed regulation by discharge status. There are 607 facilities that do not close in the baseline, subject to flow or subcategory exclusions, and are therefore subject to requirements under the proposed regulation. Approximately 84 percent of the indirect dischargers operating post-regulation are excluded from requirements by the low flow cutoffs and the subcategory exclusions. All of the 215 direct dischargers operating in the baseline are subject to regulatory requirements.

Table 22.5: Regulatory Impacts for All Ohio Facilities by Discharge Type

	Indirect	Direct	Total
Number of facilities operating in the baseline	2,518	215	2,733
Number of regulatory closures	26	0	26
Number of facilities operating post-regulation	2,492	215	2,707
Number of facilities below low flow cutoffs	2,080		2,080
Number of facilities with subcategory exclusions	20		20
Percent of facilities operating in the baseline that are regulatory closures	1.0%	0.0%	1.0%
Percent of facilities operating in the baseline excluded or below cutoffs	84.3%		77.6%
Number of facilities operating subject to regulatory requirements	392	215	607

Source: U.S. EPA analysis.

22.2.2 Compliance Costs for MP&M Facilities

The calculation of annualized compliance costs in Ohio uses the methodology presented in Chapter 11. These compliance costs are not adjusted for the effect of taxes, and therefore represent the social value of resources used for compliance. Compliance costs are annualized using a seven percent discount rate over a 15-year life of the plant. EPA developed estimates of compliance costs for each Ohio facility, and then calculated an average annualized compliance cost by subcategory, flow range, and discharge status for the Ohio facilities. The Agency was not able to determine which specific facilities would close in the baseline and due to the regulation; EPA therefore used these average compliance costs, along with the percent of facilities remaining open in the baseline and post-compliance, to calculate total compliance costs.

As in the national social cost analysis reported in Chapter 11, EPA included compliance costs for facilities that close due to the regulation, as well as costs for continuing to operate subject to the proposed regulation. This inclusion results in an upper-bound estimate of the social costs of compliance, since the lost value incurred by closing facilities is presumably less than the estimated cost of compliance.[2]

Table 22.6 shows the estimated resource value of compliance costs by discharge status and subcategory. General Metals and MF Job Shop indirect dischargers together account for approximately 89 percent of the total compliance costs under the proposed regulation. The total estimated annualized compliance costs are $141.7 million.

[2] Including costs for regulatory closures in effect calculates the social costs of compliance that would be incurred if every facility continued to operate post-regulation. In fact, some facilities find it more economic to close, and calculating costs as if all facilities continue to operate will overstate social costs.

Table 22.6: Resource Value of Compliance Costs (1999$) in Ohio

Subcategory	Indirect	Direct	Total
General Metals	$67,404,989	$5,426,008	$72,830,997
Steel Forming & Finishing	$147,485	$114,124	$261,609
MF Job Shop	$58,218,101	$24,831	$58,242,932
Non Chromium Anodizer	$0	$28,551	$28,551
Oily Waste	$0	$23,597	$23,597
Printed Wiring Boards	$8,096,391	$0	$8,096,391
Railroad Line Maintenance	$0	$2,250,001	$2,250,001
Total	**$133,866,966**	**$7,867,112**	**$141,734,078**

Source: U.S. EPA analysis.

22.2.3 Ohio Government Administrative Costs

The calculation of government administrative costs in Ohio uses the methodology presented in Chapter 7 and Appendix C. The screener data collected for Ohio facilities did not provide information on the types of permits currently held by facilities. It was therefore necessary to estimate the number of indirect-discharging facilities that currently hold a concentration-based permit, a mass-based permit, or no permit. EPA assumed that the screener Ohio facilities' baseline permit status is the same as the permit status of facilities in the national analysis in the same subcategory and discharge status. For example, 43 percent of Oily Waste indirect dischargers in the national data set have a concentration-based permit in the baseline, less than 1 percent have a mass-based permit, and 57 percent have no permit. EPA assumes that the same percent distribution applies to Ohio screener indirect dischargers in the Oily Waste subcategory.

Table 22.7 shows the estimated numbers of Ohio facilities by baseline permit status, and the numbers of facilities requiring various types of permits under the proposed regulation. EPA calculated the costs in Ohio using the POTW administrative cost model described in Appendix C.

Table 22.7: Estimated Number of Ohio Indirect Dischargers by Permit Status: Baseline and Proposed Regulation

Permit Status	Subcategory								
	Gen'l Metals	Steel Forming & Finishing	MF Job Shops	NonCh Anodiz	Oily Waste	PWBs	RR Line Maint	Dry Docks	Total
Baseline Permit Status (for facilities operating in the baseline):									
Concentration-based	1,065	1	63	7	87	6			1,229
Mass-based	217	2	125	6		40			390
None	774		3	1	115		5		898
Total	2,056	3	191	14	202	46	5		2,518
Proposed Regulation:									
Requiring new concentration-based	43		2		1				46
Requiring new mass-based	22		1		1				24
Requiring upgrading from concentration-to mass-based	30	1	18		1	2			52
Earlier repermitting: concentration-based	60		37		1	4			102
Earlier repermitting: mass-based	18	2	108			40			168
Excluded under proposed regulation	1,882			15	198		5		2,100
Regulatory closure			26						26
Total	2,055	3	192	15	202	46	5		2,518

Source: U.S. EPA analysis.

Ohio permit writers would need to issue 46 new concentration-based permits and 24 new mass-based permits, and to upgrade an estimated 52 concentration-based permits to mass-based permits, under the proposed regulation. In addition, they would have to reissue 102 concentration-based permits and 168 mass-based permits within the three-year compliance period, rather than on the normal five-year schedule.

The estimated annualized costs of these permitting activities ranges from $10,649 to $83,328, with a median estimate of $25,364. As described in Chapter 7, this estimate assumes that all Steel Forming & Finishing facilities will be issued a mass-based permit, that one-third of the existing concentration-based permits will be revised to a mass basis, and that one third of new permits issued will be mass-based.

22.2.4 Costs of Unemployment in Ohio

Chapter 11 described the methodology used to estimate the social costs of unemployment caused by the regulation. Because it is not possible to determine which Ohio facilities would close under the proposed regulation, EPA estimated employment (FTEs) at the closing Ohio facilities by assuming that these facilities have the same employment as the average for closing facilities in the national analysis, in the same subcategory, flow size category, and discharge status.

EPA estimates that closures due to the proposed regulation would result in lost employment of up to 557 FTEs in Ohio. The upper-bound estimated social costs of 557 job losses is $7,338,313, based on the methodology used for the national analysis. This estimate includes the estimated willingness-to-pay to avoid 557 cases of involuntary unemployment, plus the cost of administering the unemployment compensation system for 557 unemployed workers. EPA estimated that the costs of unemployment would range from $7,337 to $7,338,313 because the regulation will also result in increased employment due to compliance expenditures, which are likely to more than offset the proposed regulation job losses. This is the same approach that EPA used to estimate a range as the Agency used for the national social cost analysis.

22.2.5 Total Social Costs

Table 22.8 shows the total estimated social costs of the proposed regulation in Ohio. The social costs range from $141.7 to $149.1 million 1999$. As in the national analysis, the resource value of compliance costs account for virtually all of the estimated social costs.

Table 22.8: Annual Social Costs for Proposed Regulation in Ohio (millions 1999$, costs annualized at 7%)

Component of Social Costs	Lower bound	Median	Upper bound
Resource value of compliance costs		$141.7	
Government administrative costs	$0.011	$0.025	$0.083
Social cost of unemployment	$.007	$3.673	$7.338
Total Social Cost	$141.7	$145.4	$149.1

Source: U.S. EPA analysis.

22.3 Comparison of Monetized Benefits and Costs in Ohio

EPA cannot perform a complete cost-benefit comparison because not all of the benefits resulting from the proposed regulatory alternative can be valued in dollar terms. The social cost of the proposed regulation in Ohio is estimated at $141.7 to $149.1 million annually (1999$). The sum total of benefits that can be valued in dollar terms ranges from $182.0 million to $298.3 million annually (1999$). Combining the estimates of social benefits and social costs yields a net monetizable benefit ranging from $32.9 million to $156.6 million annually. Comparing the midpoint estimate of social costs ($145.4 million) with the mean estimate of monetizable benefits ($243.9 million) results in a net social benefit of $98.5 million.

In contrast to the national estimates of costs and benefits for the proposed regulation, the Ohio case study shows substantial net positive benefits even for the lower-bound estimate of benefits. This difference is in part due to EPA's ability in the Ohio case study to take more accurate account of baseline water quality. EPA also included an additional recreational benefit category in the Ohio analysis – swimming. Although the estimated per-trip welfare gain to swimmers is lower than to users of other water-based activities, this benefit category accounts for a sizable portion of the state-level benefits. Other factors that affect the Ohio benefit cost comparison results include a large number of MP&M facilities in the state and the presence of unique water resources. Ohio is one of the six states with large numbers of MP&M facilities.[3] The state also has unique water resources such as Lake Erie that offer numerous recreational opportunities. The estimated benefits for Ohio are therefore likely to reflect the upper bound estimates for the nation.

[3] Other states with large numbers of MP&M facilities include New York, Pennsylvania, Indiana, Illinois, and Michigan.

GLOSSARY

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

blood pressure (BP): the pressure of the blood on the walls of the arteries.

brain infarction (BI): stroke.

cerebrovascular accidents (CBA): stroke.

coronary heart disease (CHD): disorder that restricts blood supply to the heart; occurs when coronary arteries become narrowed or clogged due to the build up of cholesterol and fat on the inside walls and are unable supply enough blood to the heart.

publicly-owned treatment works (POTW): a treatment works as defined by section 212 of the Act, which is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

Acronyms

AWQC: ambient water quality criteria
BI: brain infarction
BP: blood pressure
CBA: cerebrovascular accidents
CHD: coronary heart disease
DMT: dry metric tons
FTE: full-time employment
POTW: publicly-owned treatment works

Appendix A: Detailed Economic Impact Analysis Information

Introduction

This appendix provides information to support the economic analyses of MP&M industries presented in Chapter 3 to Chapter 11 of the EEBA. The first section below provides the SIC and NAICS codes that define the MP&M sectors. The second section presents information on the annual turnover of establishments ("births" and "deaths") in the MP&M manufacturing industries. The third section provides a description of the MP&M surveys that supported the economic impact and benefits analyses presented in the EEBA.

Chapter Contents:

A.1 MP&M SIC and NAICS Codes

Table A.1 lists and describes the 4-digit Standard Industrial Classification (SIC) codes that make up the MP&M industry sectors. These codes were used until recently to define industries for reporting of Federal Census and other data, and are the basis for the portion of the industry profile that was prepared from publically available materials in Chapter 3.

Table A.1: MP&M Sectors and SIC Codes

SIC Code	Standard Industrial Classification Groups
	Aerospace
3761	Guided Missiles and Space Vehicles
3764	Guided Missile and Space Vehicle Propulsion
3769	Other Space Vehicle and Missile Parts
	Aircraft
3721	Aircraft
3724	Aircraft Engines and Engine Parts
3728	Aircraft Parts and Auxiliary Equipment
4581	Airports, Flying Fields, Airport Terminal Services
	Bus And Truck
3713	Truck and Bus Bodies
3715	Truck Trailers
4111	Local And Suburban Transit
4119	Local Passenger Transit, N.E.C.
4131	Intercity And Rural Bus Transportation
4141	Local Bus Charter Service

Table A.1: MP&M Sectors and SIC Codes

SIC Code	Standard Industrial Classification Groups
4142	Bus Charter Service, Except Local
4173	Bus Terminal And Service Facilities
4212	Local Trucking without Storage
4213	Trucking, Except Local
4214	Local Trucking with Storage
4215	Courier Services, Except by Air
4231	Trucking Terminal Facilities
	Electronic Equipment
3661	Telephone and Telegraph Apparatus
3663	Radio and Television Broadcast and Communications Equipment
3669	Communications Equipment, N.E.C.
3671	Electron Tubes
3675	Electronic Capacitors
3677	Electronic Coils and Transformers
3678	Connectors for Electronic Applications
3679	Electronic Components, N.E.C.
3699	Electrical Machinery, Equipment, And Supplies, N.E.C.
	Hardware
2796	Platemaking and Related Services
3398	Metal Heat Treating
3412	Metal Shipping Barrels, Drums, Kegs, Pails
3421	Cutlery
3423	Hand And Edge Tools, Except Machine Tools and Handsaws
3425	Hand Saws and Saw Blades
3429	Hardware, N.E.C.
3433	Heating Equipment, Except Electric and Warm Air Furnace
3441	Fabricated Structural Metal
3443	Fabricated Plate Work (Boiler Shops)
3444	Sheet Metal Work
3446	Architectural and Ornamental Metal Work
3448	Prefabricated Metal Buildings And Components
3449	Miscellaneous Metal Work
3451	Screw Machine Products
3452	Bolts, Nuts, Screws, Rivets, and Washers
3462	Iron and Steel Forgings
3466	Crowns and Closures
3469	Metal Stamping, N.E.C.
3492	Fluid Power Valves and Hose Fittings
3493	Steel Springs
3494	Valves And Pipe Fittings, Except Brass
3495	Wire Springs
3496	Miscellaneous Fabricated Wire Products
3498	Fabricated Pipe and Fabricated Pipe Fitting
3499	Fabricated Metal Products, N.E.C.

Table A.1: MP&M Sectors and SIC Codes

SIC Code	Standard Industrial Classification Groups
3541	Machine Tools, Metal Cutting Types
3542	Machine Tools, Metal Forming Types
3544	Special Dies and Tools, Die Sets, Jigs and Fixtures, and Industrial Molds
3545	Machine Tool Access and Measuring Devices
3546	Power Driven Hand Tools
3965	Fasteners, Buttons, Needles, Pins
Household Equipment	
2514	Metal Household Furniture
2522	Office Furniture, Except Wood
2531	Public Building and Related Furniture
2542	Partitions and Fixtures, Except Wood
2591	Drapery Hardware and Window Blinds/shades
2599	Furniture and Fixtures, N.E.C.
3431	Metal Sanitary Ware
3432	Plumbing Fittings and Brass Goods
3442	Metal Doors, Sash, and Trim
3631	Household Cooking Equipment
3632	Household Refrigerators and Home and Farm and Freezers
3633	Household Laundry Equipment
3634	Electric Housewares and Fans
3635	Household Vacuum Cleaners
3639	Household Appliances, N.E.C.
3641	Electric Lamps
3643	Current-carrying Wiring Devices
3644	Noncurrent-carrying Wiring Devices
3645	Residential Electrical Lighting Fixtures
3646	Commercial, Industrial, and Institutional
3648	Lighting Equipment, N.E.C.
3651	Radio/television Sets Except Communication Types
7623	Refrigeration and Air-conditioning Service and Repair Shops
Instruments	
3812	Search, Detection, Navigation, Guidance, Aeronautical, Nautical Systems and Instruments
3821	Laboratory Apparatus and Furniture
3822	Automatic Environmental Controls
3823	Process Control Instruments
3824	Fluid Meters and Counting Devices
3825	Instruments to Measure Electricity
3826	Laboratory Analytical Instruments
3827	Optical Instruments and Lenses
3829	Measuring and Controlling Devices, N.E.C.
3841	Surgical and Medical Instruments and Apparatus
3842	Orthopedic, Prosthetic and Surgical Suppl.
3843	Dental Equipment and Supplies
3844	X-ray Apparatus and Tubes

Table A.1: MP&M Sectors and SIC Codes

SIC Code	Standard Industrial Classification Groups
3845	Electromedical Equipment
3851	Ophthalmic Goods
7629	Electric Repair Shop
	Iron and Steel
3315	Steel Wiredrawing and Steel Nails and Spikes
3316	Cold-Rolled Steel Sheet, Strip, and Bars
3317	Steel Pipe and Tubes
	Job Shop
3471	Plating and Polishing
3479	Metal Coating and Allied Services
	Mobile Industrial Equipment
3523	Farm Machinery and Equipment
3524	Garden Tractors and Lawn and Garden Equipment
3531	Construction Machinery and Equipment
3532	Mining Machinery and Equipment, Except Oil Field
3536	Hoists, Industrial Cranes and Monorails
3537	Industrial Trucks, Tractors, Trailers
3795	Tanks and Tank Components
	Motor Vehicle
3465	Automotive Stampings
3592	Carburetors, Piston Rings, Valves
3647	Vehicular Lighting Equipment
3694	Electrical Equipment for Motor Vehicles
3711	Motor Vehicle and Automobile Bodies
3714	Motor Vehicle Parts and Accessories
3716	Mobile Homes
3751	Motorcycles
3792	Travel Trailers and Campers
3799	Miscellaneous Transportation Equipment
4121	Taxicabs
5013	Motor Vehicle Supplies and New Parts
5511	Motor Vehicle Dealers (New and Used)
5521	Motor Vehicle Dealers (Used Only)
5561	Recreational Vehicle Dealers
5571	Motorcycle Dealers
5599	Automotive Dealers, N.E.C.
7514	Passenger Car Rental
7515	Passenger Car Lease
7519	Utility Trailer and Recreational Vehicle Rental
7532	Top, Body, and Upholstery Repair and Paint Shops
7533	Auto Exhaust Systems
7537	Auto Transmission Repair
7538	General Automotive Repair
7539	Auto Repair Shop, N.E.C.

Table A.1: MP&M Sectors and SIC Codes

SIC Code	Standard Industrial Classification Groups
7549	Auto Services, Except Repair and Carwashes
	Office Machine
3571	Electronic Computers
3572	Typewriters
3575	Computer Terminals
3577	Computer Peripheral Equipment, N.E.C.
3578	Calculating, Accounting Machines Except Computers
3579	Office Machines, N.E.C.
7378	Computer Maintenance and Repairs
7379	Computer Related Services, N.E.C.
	Ordnance
3482	Small Arms Ammunition
3483	Ammunition, Except for Small Arms
3484	Small Arms
3489	Ordnance and Accessories, N.E.C.
	Other Metal Products
3497	Metal Foil and Leaf
3861	Photographic Equipment and Supplies
3931	Musical Instruments
3944	Games, Toys, Children's Vehicles
3949	Sporting and Athletic Goods, N.E.C.
3951	Pens and Mechanical Pencils
3953	Marking Devices
3993	Signs and Advertising Displays
3995	Burial Caskets
3999	Manufacturing Industries, N.E.C.
7692	Welding Repair
7699	Repair Shop, Related Serv
	Precious Metals and Jewelry
3873	Watches, Clocks, and Watchcases
3911	Jewelry, Precious Metal
3914	Silverware, Plated Ware and Stainless
3915	Jewelers' Materials and Lapidary Work
3961	Costume Jewelry
7631	Watch, Clock, Jewelry Repair
	Printed Circuit Boards
3672	Printed Circuit Boards
	Railroad
3743	Railcars, Railway Systems
4011	Railroad Transportation
4013	Railroad Transportation
	Ships and Boats
3731	Ship Building and Repairing
3732	Boat Building and Repairing

Table A.1: MP&M Sectors and SIC Codes	
SIC Code	**Standard Industrial Classification Groups**
4412	Deep Sea Foreign Transportation
4424	Deep Sea Domestic Transportation
4432	Freight Transportation Great Lakes
4449	Water Transportation of Freight, N.E.C.
4481	Deep Sea Passenger Transportation
4482	Ferries
4489	Water Passenger Transportation, N.E.C.
4491	Marine Cargo Handling
4492	Towing and Tugboat Service
4493	Marinas
4499	Water Transportation Services, N.E.C.
Stationary Industrial Equipment	
3511	Steam, Gas, Hydraulic Turbines, Generating Units
3519	Internal Combustion Engines, N.E.C.
3533	Oil Field Machinery and Equipment
3534	Elevators and Moving Stairways
3535	Conveyors and Conveying Equipment
3543	Industrial Patterns
3547	Rolling Mill Machinery and Equipment
3548	Electric and Gas Welding and Soldering
3549	Metal Working Machinery, N.E.C.
3552	Textile Machinery
3553	Woodworking Machinery
3554	Paper Industries Machinery
3555	Printing Trades Machinery and Equipment
3556	Food Products Machinery
3559	Special Industry Machinery, N.E.C.
3561	Pumps and Pumping Equipment
3562	Ball and Roller Bearings
3563	Air and Gas Compressors
3564	Blowers and Exhaust and Ventilation Fans
3565	Industrial Patterns
3566	Speed Changers, High Speed Drivers and Gears
3567	Industrial Process Furnaces and Ovens
3568	Mechanical Power Transmission Equipment, N.E.C.
3569	General Industrial Machinery, N.E.C.
3581	Automatic Merchandising Machines
3582	Commercial Laundry Equipment
3585	Refrigeration and Air and Heating Equipment
3586	Measuring and Dispensing Pumps
3589	Service Industry Machines, N.E.C.
3593	Fluid Power Cylinders and Actuators
3594	Fluid Power Pumps and Motors
3596	Scales and Balances, Except Laboratory

Table A.1: MP&M Sectors and SIC Codes

SIC Code	Standard Industrial Classification Groups
3599	Machinery, Except Electrical, N.E.C.
3612	Transformers
3613	Switchgear and Switchboard Apparatus
3621	Motors and Generators
3629	Electric Industrial Apparatus, N.E.C.
7353	Heavy Construction Equip Rental, Leasing
7359	Equipment Rental, Leasing, N.E.C.

N.E.C. = Not Elsewhere Classified
Source: Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1987.

In 1997, the Census Bureau has adopted the new North American Industry Classification System to replace the SIC codes. NAICS codes will be used throughout North American. The new system allows for greater comparability with the International Standard Industrial Classification System (ISIC), which is developed and maintained by the United Nations. The new system also better reflects the structure of today's economy, including the growth of the service sectors and new technologies, than does the decades-old SIC system.

The switch to the NAICS makes it difficult to report historica trends for some industries when there is more than one NAIC code for a single SIC code or more than one SIC code for a single NAICS code. If a one-to-one relationship exists betwe a 4-digit SIC and a new NAICS code, combining data based the two systems poses no difficulties.

Table A.2 provides the cross-walk between SIC codes and th new NAICS codes.

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
2514	Household Eq.	Metal Household Furniture	33712400	Metal household furniture manufacturing	420	2,422,853	22,835
2522	Household Eq.	Office Furniture, Except Wood	33721400	Office furniture (except wood) manufacturing	359	8,230,935	44,222
2531	Household Eq.	Public Buildng & Relatd Furniture	33636030	Motor vehicle seating and interior trim manufacturing (part)	184	6,060,320	20,784
2531	Household Eq.	Public Buildng & Relatd Furniture	33712710	Institutional furniture manufacturing (part)	267	1,697,870	15,254
2531	Household Eq.	Public Buildng & Relatd Furniture	33994210	Lead pencil and art goods manufacturing (part)	17	110,985	941
2542	Household Eq.	Partitions & Fixtures, Exc Wood	33721530	Showcase, partition, shelving, and locker manufacturing (part)	926	5,249,474	44,472
2591	Household Eq.	Drapery Hrdwr and Window Blinds/Shades	33792000	Blind and shade manufacturing	488	2,393,564	19,617
2599	Household Eq.	Furniture and Fixtures, N.E.C.	33712720	Institutional furniture manufacturing (part)	727	2,305,770	22,448
2599	Household Eq.	Furniture and Fixtures, N.E.C.	33911310	Surgical appliance and supplies manufacturing (part)	16	645,688	2,925
2796	Hardware	Platemaking and Related Services	32312220	Prepress services (part)	1,276	2,663,020	24,942
3398	Hardware	Metal Heat Treating	33281100	Metal heat treating	808	3,485,459	22,674
3412	Hardware	Metal Shipping Barrels, Drums, Kegs, Pails	33243910	Other metal container manufacturing (part)	151	1,310,595	6,318
3421	Hardware	Cutlery	33221110	Cutlery and flatware (except precious) manufacturing (part)	164	2,198,365	11,129
3423	Hardware	Hand & Edge Tools, Except Mach. Tools, Saws	33221210	Hand and edge tool manufacturing (part)	1,069	5,677,903	42,947
3425	Hardware	Hand Saws and Saw Blades	33221300	Saw blade and handsaw manufacturing	176	1,452,540	9,149
3429	Hardware	Hardware NEC	33243920	Other metal container manufacturing (part)	117	402,378	4,135
3429	Hardware	Hardware NEC	33251010	Hardware manufacturing (part)	952	10,359,952	70,884
3429	Hardware	Hardware NEC	33291910	Other metal valve and pipe fitting manufacturing (part)	16	n/a	n/a
3431	Household Eq.	Metal Sanitary Ware	33299800	Enameled iron and metal sanitary ware manufacturing	88	1,575,505	9,994

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
3432	Household Eq.	Plumbing Fittings and Brass Goods	33291300	Plumbing fixture fitting and trim manufacturing	116	3,590,128	16,202
3432	Household Eq.	Plumbing Fittings and Brass Goods	33299920	All other miscellaneous fabricated metal product manufacturing (part)	5	118,059	474
3433	Hardware	Heatg. Equip. Except Elec. & Warm Air Frnc.	33341410	Heating equipment (except warm air furnaces) manufacturing (part)	453	3,387,391	22,495
3441	Hardware	Fabricated Structural Metal	33231210	Fabricated structural metal manufacturing (part)	2,900	14,200,270	84,704
3442	Household Eq.	Metal Doors, Sash, and Trim	33232120	Metal window and door manufacturing (part)	1,384	9,876,049	2,970
3443	Hardware	Fabricated Plate Work (Boiler Shops)	33231300	Plate work manufacturing	1,035	2,806,913	25,453
3443	Hardware	Fabricated Plate Work (Boiler Shops)	33241000	Power boiler and heat exchanger manufacturing	472	3,849,100	27,542
3443	Hardware	Fabricated Plate Work (Boiler Shops)	33242000	Metal tank (heavy gauge) manufacturing	614	4,764,118	33,704
3443	Hardware	Fabricated Plate Work (Boiler Shops)	33341510	Air-conditioning and warm air heating equipment and commercial and industrial refrigeration equipment manufacturing (part)	9	43,264	339
3444	Hardware	Sheet Metal Work	33232200	Sheet metal work manufacturing	4,479	15,957,992	129,826
3444	Hardware	Sheet Metal Work	33243930	Other metal container manufacturing (part)	126	275,440	2,074
3446	Hardware	Architectural and Ornamental Metal Work	33232310	Ornamental and architectural metal work manufacturing (part)	1,744	3,536,413	30,960
3448	Hardware	Prefabricated Metal Buildings & Components	33231100	Prefabricated metal building and component manufacturing	604	4,199,550	25,946
3449	Hardware	Miscellaneous Metal Work	33211400	Custom roll forming	401	3,074,662	15,219
3449	Hardware	Miscellaneous Metal Work	33231220	Fabricated structural metal manufacturing (part)	152	2,166,021	8,729
3449	Hardware	Miscellaneous Metal Work	33232130	Metal window and door manufacturing (part)	33	364,564	1,974
3449	Hardware	Miscellaneous Metal Work	33232320	Ornamental and architectural metal work manufacturing (part)	6	91,939	349
3451	Hardware	Screw Machine Products	33272100	Precision turned product manufacturing	2,745	8,326,077	80,404
3452	Hardware	Bolts, Nuts, Screws, Rivets, and Washers	33272200	Bolt, nut, screw, rivet, and washer manufacturing	1,040	8,134,661	52,995

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
3462	Hardware	Iron and Steel Forgings	33211100	Iron and steel forging	421	4,924,426	26,432
3465	Motor Vehicle	Automotive Stampings	33637000	Motor vehicle metal stamping	810	23,668,110	126,905
3466	Hardware	Crowns and Closures	33211500	Crown and closure manufacturing	67	969,982	4,682
3469	Hardware	Metal Stamping NEC	33211600	Metal stamping	2,166	12,041,638	93,086
3469	Hardware	Metal Stamping NEC	33221400	Kitchen utensil, pot, and pan manufacturing	77	1,369,914	7,724
3471	Job Shop	Plating and Polishing	33281300	Electroplating, plating, polishing, anodizing, and coloring	3,404	5,979,405	74,640
3479	Job Shop	Metal Coating & Allied Services	33281200	Metal coating, engraving (except jewelry and silverware), and allied services to manufacturers	2,156	8,460,896	55,904
3479	Job Shop	Metal Coating & Allied Services	33991110	Jewelry (except costume) manufacturing (part)	22	5,798	79
3479	Job Shop	Metal Coating & Allied Services	33991210	Silverware and plated ware manufacturing (part)	12	6,296	103
3479	Job Shop	Metal Coating & Allied Services	33991410	Costume jewelry and novelty manufacturing (part)	16	2,257	29
3482	Ordnance	Small Arms Ammunition	33299200	Small arms ammunition manufacturing	113	938,818	6,863
3483	Ordnance	Ammunition, Except for Small Arms	33299300	Ammunition (except small arms) manufacturing	53	1,497,045	9,427
3484	Ordnance	Small Arms	33299400	Small arms manufacturing	198	1,251,792	9,907
3489	Ordnance	Ordnance and Accessories NEC	33299500	Other ordnance and accessories manufacturing	70	1,750,485	12,285
3492	Hardware	Fluid Power Valves and Hose Fittings	33291210	Fluid power valve and hose fitting manufacturing (part)	424	6,602,909	37,132
3493	Hardware	Steel Springs	33261100	Spring (heavy gauge) manufacturing	129	761,711	5,381
3494	Hardware	Valves & Pipe Fittings, Except Brass	33291920	Other metal valve and pipe fitting manufacturing (part)	222	2,753,397	17,652
3494	Hardware	Valves & Pipe Fittings, Except Brass	33299930	All other miscellaneous fabricated metal product manufacturing (part)	23	73,983	564
3495	Hardware	Wire Springs	33261200	Spring (light gauge) manufacturing	394	2,481,151	18,798
3495	Hardware	Wire Springs	33451810	Watch, clock, and parts manufacturing (part)	2	n/a	n/a
3496	Hardware	Miscellaneous Fabricated Wire Products	33261830	Other fabricated wire product manufacturing (part)	1,253	4,587,656	41,821
3497	Other	Metal Foil and Leaf	32222500	Laminated aluminum foil manufacturing for flexible packaging uses	43	1,546,143	4,967

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
3497	Other	Metal Foil and Leaf	33299940	All other miscellaneous fabricated metal product manufacturing (part)	64	1,711,600	5,648
3498	Hardware	Fabricated Pipe and Fabricated Pipe Fitting	33299620	Fabricated pipe and pipe fitting manufacturing (part)	856	4,024,999	29,364
3499	Hardware	Fabricated Metal Products NEC	33211700	Powder metallurgy parts manufacturing	128	1,317,301	10,760
3499	Hardware	Fabricated Metal Products NEC	33243940	Other metal container manufacturing (part)	98	273,541	2,331
3499	Hardware	Fabricated Metal Products NEC	33251020	Hardware manufacturing (part)	58	435,815	3,401
3499	Hardware	Fabricated Metal Products NEC	33291930	Other metal valve and pipe fitting manufacturing (part)	7	n/a	n/a
3499	Hardware	Fabricated Metal Products NEC	33299950	All other miscellaneous fabricated metal product manufacturing (part)	2,592	7,558,137	63,736
3499	Hardware	Fabricated Metal Products NEC	33721540	Showcase, partition, shelving, and locker manufacturing (part)	78	123,057	1,295
3499	Hardware	Fabricated Metal Products NEC	33991420	Costume jewelry and novelty manufacturing (part)	82	49,953	568
3511	Stationary Ind. Eq.	Steam, Gas, Hydraul. Turbines, Gen. Units	33361100	Turbine and turbine generator set unit manufacturing	86	5,783,057	19,529
3519	Stationary Ind. Eq.	Internal Combustion Engines NEC	33361810	Other engine equipment manufacturing (part)	297	n/a	n/a
3519	Stationary Ind. Eq.	Internal Combustion Engines NEC	33639910	All other motor vehicle parts manufacturing (part)	7	123,954	896
3523	Mobile Ind. Eq.	Farm Machinery and Equipment	33221220	Hand and edge tool manufacturing (part)	1	n/a	n/a
3523	Mobile Ind. Eq.	Farm Machinery and Equipment	33232330	Ornamental and architectural metal work manufacturing (part)	140	380,152	3,082
3523	Mobile Ind. Eq.	Farm Machinery and Equipment	33311100	Farm machinery and equipment manufacturing	1,339	15,921,455	66,370
3523	Mobile Ind. Eq.	Farm Machinery and Equipment	33392210	Conveyor and conveying equipment manufacturing (part)	28	33,377	320
3524	Mobile Ind. Eq.	Garden Tractors & Lawn & Garden Equipment	33221230	Hand and edge tool manufacturing (part)	3	n/a	n/a
3524	Mobile Ind. Eq.	Garden Tractors & Lawn & Garden Equipment	33311200	Lawn and garden tractor and home lawn and garden equipment manufacturing	145	7,454,511	28,617

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
3531	Mobile Ind. Eq.	Constr Mach and Eq.	33312000	Construction machinery manufacturing	785	21,965,455	74,965
3531	Mobile Ind. Eq.	Constr Mach and Eq.	33392310	Overhead traveling crane, hoist, and monorail system manufacturing (part)	87	1,805,198	10,263
3531	Mobile Ind. Eq.	Constr Mach and Eq.	33651010	Railroad rolling stock manufacturing (part)	25	346,760	2,379
3532	Mobile Ind. Eq.	Mining Mach. & Equip., Except Oil Field	33313100	Mining machinery and equipment manufacturing	292	2,710,923	13,547
3533	Stationary Ind. Eq.	Oil Field Machinery and Equipment	33313200	Oil and gas field machinery and equipment manufacturing	563	6,240,079	29,451
3534	Stationary Ind. Eq.	Elevators and Moving Stairways	33392100	Elevator and moving stairway manufacturing	196	1,607,066	9,442
3535	Stationary Ind. Eq.	Conveyors and Conveying Equipment	33392220	Conveyor and conveying equipment manufacturing (part)	871	6,346,525	39,279
3536	Mobile Ind. Eq.	Hoists, Industrial Cranes & Monorails	33392320	Overhead traveling crane, hoist, and monorail system manufacturing (part)	220	1,340,561	7,751
3537	Mobile Ind. Eq.	Industrial Trucks, Tractors, Trailers	33243950	Other metal container manufacturing (part)	4	6,775	64
3537	Mobile Ind. Eq.	Industrial Trucks, Tractors, Trailers	33299960	All other miscellaneous fabricated metal product manufacturing (part)	19	27,488	240
3537	Mobile Ind. Eq.	Industrial Trucks, Tractors, Trailers	33392400	Industrial truck, tractor, trailer, and stacker machinery manufacturing	461	5,538,326	25,953
3541	Hardware	Machine Tools, Metal Cutting Types	33351210	Machine tool (metal cutting types) manufacturing (part)	393	5,183,521	28,849
3542	Hardware	Machine Tools, Metal Forming Types	33351300	Machine tool (metal forming types) manufacturing	225	2,255,011	14,185
3543	Stationary Ind. Eq.	Industrial Patterns	33299700	Industrial pattern manufacturing	673	623,927	7,959
3544	Hardware	Special Dies & Tools, Die Sets, Jigs, Etc.	33351100	Industrial mold manufacturing	2,529	5,116,635	48,657
3544	Hardware	Special Dies & Tools, Die Sets, Jigs, Etc.	33351400	Special die and tool, die set, jig, and fixture manufacturing	4,746	8,244,855	80,113
3545	Hardware	Machine Tool Access & Measuring Devices	33221240	Hand and edge tool manufacturing (part)	185	714,277	6,379
3545	Hardware	Machine Tool Access &	33351500	Cutting tool and machine tool accessory	1,920	5,347,173	47,925

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
		Measuring Devices		manufacturing			
3546	Hardware	Power Driven Hand Tools	33399100	Power-driven handtool manufacturing	217	3,609,779	16,816
3547	Stationary Ind. Eq.	Rolling Mill Machinery and Equipment	33351600	Rolling mill machinery and equipment manufacturing	100	700,084	4,149
3548	Stationary Ind. Eq.	Elec and Gas Welding and Soldering	33399210	Welding and soldering equipment manufacturing (part)	244	4,433,877	22,434
3548	Stationary Ind. Eq.	Elec and Gas Welding and Soldering	33531110	Power, distribution, and specialty transformer manufacturing (part)	0	0	0
3549	Stationary Ind. Eq.	Metal Working Machinery NEC	33351800	Other metalworking machinery manufacturing	474	3,463,811	19,023
3552	Stationary Ind. Eq.	Textile Machinery	33329210	Textile machinery manufacturing (part)	478	1,779,034	13,600
3553	Stationary Ind. Eq.	Woodworking Machinery	33321000	Sawmill and woodworking machinery manufacturing	327	1,321,752	9,117
3554	Stationary Ind. Eq.	Paper Industries Machinery	33329100	Paper industry machinery manufacturing	366	3,438,235	18,594
3555	Stationary Ind. Eq.	Printing Trades Machinery and Equipment	33329310	Printing machinery and equipment manufacturing (part)	546	n/a	n/a
3556	Stationary Ind. Eq.	Food Products Mach	33329400	Food product machinery manufacturing	597	2,877,841	19,026
3559	Stationary Ind. Eq.	Special Industry Machinery NEC	33322000	Plastics and rubber industry machinery manufacturing	455	3,584,992	18,574
3559	Stationary Ind. Eq.	Special Industry Machinery NEC	33329500	Semiconductor machinery manufacturing	257	11,158,627	40,087
3559	Stationary Ind. Eq.	Special Industry Machinery NEC	33329810	All other industrial machinery manufacturing (part)	1,677	n/a	n/a
3559	Stationary Ind. Eq.	Special Industry Machinery NEC	33331910	Other commercial and service industry machinery manufacturing (part)	78	644,019	2,890
3561	Stationary Ind. Eq.	Pumps and Pumping Equipment	33391110	Pump and pumping equipment manufacturing (part)	489	6,826,043	36,552
3562	Stationary Ind. Eq.	Ball and Roller Bearings	33299100	Ball and roller bearing manufacturing	185	6,120,940	36,991
3563	Stationary Ind.	Air and Gas Compressors	33391200	Air and gas compressor manufacturing	314	5,633,008	24,821

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
	Eq.						
3564	Stationary Ind. Eq.	Blowers and Exhaust and Ventilation Fans	33341100	Air purification equipment manufacturing	370	2,174,729	16,183
3564	Stationary Ind. Eq.	Blowers and Exhaust and Ventilation Fans	33341200	Industrial and commercial fan and blower manufacturing	204	1,901,196	13,723
3565	Stationary Ind. Eq.	Industrial Patterns	33399300	Packaging machinery manufacturing	689	4,858,270	31,581
3566	Stationary Ind. Eq.	Speed Changers, High Speed Drivers & Gears	33361200	Speed changer, industrial high-speed drive, and gear manufacturing	268	2,402,392	16,231
3567	Stationary Ind. Eq.	Industrial Process Furnaces and Ovens	33399400	Industrial process furnace and oven manufacturing	404	2,871,475	17,585
3568	Stationary Ind. Eq.	Mechanical Power Transmission Equip. NEC	33361300	Mechanical power transmission equipment manufacturing	299	3,301,091	21,604
3569	Stationary Ind. Eq.	General Industrial Machinery NEC	33399910	All other miscellaneous general-purpose machinery manufacturing (part)	1,257	7,991,746	50,088
3571	Office Machine	Electronic Computers	33411100	Electronic computer manufacturing	563	66,331,909	100,115
3572	Office Machine	Typewriters	33411200	Computer storage device manufacturing	211	13,907,367	42,364
3575	Office Machine	Computer Terminals	33411300	Computer terminal manufacturing	142	1,483,460	5,764
3577	Office Machine	Computer Peripheral Eq NEC	33411910	Other computer peripheral equipment manufacturing (part)	1,006	25,130,308	87,253
3578	Office Machine	Calculating, Accting Mach except Computers	33331310	Office machinery manufacturing (part)	35	144,380	966
3578	Office Machine	Calculating, Accting Mach except Computers	33411920	Other computer peripheral equipment manufacturing (part)	61	1,870,426	6,717
3579	Office Machine	Office Machines, N.E.C.	33331320	Office machinery manufacturing (part)	134	3,047,549	13,865
3579	Office Machine	Office Machines, N.E.C.	33451820	Watch, clock, and parts manufacturing (part)	16	n/a	n/a
3579	Office Machine	Office Machines, N.E.C.	33994220	Lead pencil and art goods manufacturing (part)	13	257,020	1,234
3581	Stationary Ind. Eq.	Automatic Merchandising Machines	33331100	Automatic vending machine manufacturing	121	1,325,960	8,178
3582	Stationary Ind. Eq.	Commercial Laundry Equipment	33331200	Commercial laundry, drycleaning, and pressing machine manufacturing	68	604,966	4,523
3585	Stationary Ind.	Refrigeration & Air and Heating	33341520	Air-conditioning and warm air heating equipment	792	22,846,865	119,456

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
	Eq.	Equip.		and commercial and industrial refrigeration equipment manufacturing (part)			
3585	Stationary Ind. Eq.	Refrigeration & Air and Heating Equip.	33639100	Motor vehicle air-conditioning manufacturing	60	5,626,596	21,522
3586	Stationary Ind. Eq.	Measuring and Dispensing Pumps	33391300	Measuring and dispensing pump manufacturing	71	1,316,899	6,824
3589	Stationary Ind. Eq.	Service Industry Machines, NEC	33331920	Other commercial and service industry machinery manufacturing (part)	1,165	7,596,253	44,172
3592	Motor Vehicle	Carburetors, Piston Rings, Valves	33631100	Carburetor, piston, piston ring, and valve manufacturing	141	2,755,311	17,518
3593	Stationary Ind. Eq.	Fluid Power Cylinders and Actuators	33399510	Fluid power cylinder and actuator manufacturing (part)	320	3,528,906	23,062
3594	Stationary Ind. Eq.	Fluid Power Pumps and Motors	33399610	Fluid power pump and motor manufacturing (part)	170	2,712,058	15,482
3596	Stationary Ind. Eq.	Scales and Balances, except Laboratory	33399700	Scale and balance (except laboratory) manufacturing	122	682,940	4,871
3599	Stationary Ind. Eq.	Machinery, Except Electrical NEC	33271000	Machine shops	23,619	27,143,131	290,951
3599	Stationary Ind. Eq.	Machinery, Except Electrical NEC	33299970	All other miscellaneous fabricated metal product manufacturing (part)	132	506,611	4,199
3599	Stationary Ind. Eq.	Machinery, Except Electrical NEC	33331930	Other commercial and service industry machinery manufacturing (part)	50	172,536	1,335
3599	Stationary Ind. Eq.	Machinery, Except Electrical NEC	33399920	All other miscellaneous general-purpose machinery manufacturing (part)	836	1,146,348	11,063
3612	Stationary Ind. Eq.	Transformers	33531120	Power, distribution, and specialty transformer manufacturing (part)	318	4,716,162	26,638
3613	Stationary Ind. Eq.	Switchgear and Switchboard Apparatus	33531300	Switchgear and switchboard apparatus manufacturing	583	7,609,164	41,291
3621	Stationary Ind. Eq.	Motors and Generators	33531210	Motor and generator manufacturing (part)	528	11,788,281	71,112
3629	Stationary Ind. Eq.	Electric Industrial Apparatus NEC	33599910	All other miscellaneous electrical equipment and component manufacturing (part)	413	2,838,366	18,682
3631	Household Eq.	Household Cooking Equipment	33522100	Household cooking appliance manufacturing	84	3,543,231	17,543

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries							
SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
3632	Household Eq.	Household Refrig. & Home & Farm & Freezers	33522200	Household refrigerator and home freezer manufacturing	27	4,887,364	24,597
3633	Household Eq.	Household Laundry Equipment	33522400	Household laundry equipment manufacturing	17	3,723,375	14,801
3634	Household Eq.	Electric Housewares and Fans	33341420	Heating equipment (except warm air furnaces) manufacturing (part)	16	329,270	2,171
3634	Household Eq.	Electric Housewares and Fans	33521100	Electric housewares and household fan manufacturing	138	3,488,251	17,058
3635	Household Eq.	Household Vacuum Cleaners	33521210	Household vacuum cleaner manufacturing (part)	34	2,399,206	10,537
3639	Household Eq.	Household Appliances NEC	33329820	All other industrial machinery manufacturing (part)	4	n/a	n/a
3639	Household Eq.	Household Appliances NEC	33521220	Household vacuum cleaner manufacturing (part)	0	0	0
3639	Household Eq.	Household Appliances NEC	33522800	Other major household appliance manufacturing	36	3,300,662	13,309
3641	Household Eq.	Electric Lamps	33511000	Electric lamp bulb and parts manufacturing	82	3,306,009	15,903
3643	Household Eq.	Current-Carrying Wiring Devices	33593100	Current-carrying wiring device manufacturing	519	5,877,522	44,907
3644	Household Eq.	Noncurrent-Carrying Wiring Devices	33593200	Noncurrent-carrying wiring device manufacturing	219	4,451,186	23,540
3645	Household Eq.	Residential Electrical Lighting Fixtures	33512120	Residential electric lighting fixture manufacturing (part)	497	2,177,355	16,395
3646	Household Eq.	Commercial, Industrial, and Institutional	33512200	Commercial, industrial, and institutional electric lighting fixture manufacturing	356	4,047,437	23,090
3647	Motor Vehicle	Vehicular Lighting Equipment	33632100	Vehicular lighting equipment manufacturing	106	3,282,824	16,506
3648	Household Eq.	Lighting Equipment NEC	33512910	Other lighting equipment manufacturing (part)	327	3,054,806	18,274
3651	Household Eq.	Radio/Television Sets Except Commun. Types	33431000	Audio and video equipment manufacturing	554	8,454,194	31,727
3661	Electronic Eq.	Telephone and Telegraph Apparatus	33421000	Telephone apparatus manufacturing	598	38,300,044	104,262
3661	Electronic Eq.	Telephone and Telegraph Apparatus	33441610	Electronic coil, transformer, and other inductor manufacturing (part)	7	8,904	63
3661	Electronic Eq.	Telephone and Telegraph Apparatus	33441810	Printed circuit assembly (electronic assembly) manufacturing (part)	20	1,364,671	6,083
3663	Electronic Eq.	Radio and Television Broadcast and Comm Eq	33422010	Radio and television broadcasting and wireless communications equipment manufacturing (part)	1,091	37,042,241	148,156

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
3669	Electronic Eq.	Communications Eq, NEC	33429000	Other communications equipment manufacturing	497	4,233,288	25,187
3671	Electronic Eq.	Electron Tubes	33441100	Electron tube manufacturing	159	3,858,499	21,976
3672	Printed Circuits	Printed Circuit Boards	33441200	Bare printed circuit board manufacturing	1,401	9,787,576	76,702
3675	Electronic Eq.	Electronic Capacitors	33441400	Electronic capacitor manufacturing	129	2,482,163	18,882
3677	Electronic Eq.	Electronic Coils and Transformers	33441620	Electronic coil, transformer, and other inductor manufacturing (part)	426	1,512,232	19,178
3678	Electronic Eq.	Connectors for Electronic Applications	33441700	Electronic connector manufacturing	347	5,598,906	37,232
3679	Electronic Eq.	Electronic Components NEC	33422020	Radio and television broadcasting and wireless communications equipment manufacturing (part)	126	2,265,873	16,305
3679	Electronic Eq.	Electronic Components NEC	33441820	Printed circuit assembly (electronic assembly) manufacturing (part)	695	24,704,154	104,971
3679	Electronic Eq.	Electronic Components NEC	33441900	Other electronic component manufacturing	1,851	10,547,090	92,200
3679	Electronic Eq.	Electronic Components NEC	33632210	Other motor vehicle electrical and electronic equipment manufacturing (part)	253	1,420,996	12,786
3694	Motor Vehicle	Electrical Equipment for Motor Vehicles	33632220	Other motor vehicle electrical and electronic equipment manufacturing (part)	569	9,074,335	52,216
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33221250	Hand and edge tool manufacturing (part)	4	140,811	424
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33329220	Textile machinery manufacturing (part)	0	0	0
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33329320	Printing machinery and equipment manufacturing (part)	5	n/a	n/a
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33331410	Optical instrument and lens manufacturing (part)	5	7,320	56
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33331510	Photographic and photocopying equipment manufacturing (part)	0	0	0
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33331940	Other commercial and service industry machinery manufacturing (part)	57	934,728	8,513
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33351220	Machine tool (metal cutting types) manufacturing (part)	8	151,363	522
3699	Electronic Eq.	Electronic Mach., Equipment, &	33361820	Other engine equipment manufacturing (part)	2	n/a	n/a

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
		Suppl. NEC					
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33399220	Welding and soldering equipment manufacturing (part)	6	11,101	71
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33411930	Other computer peripheral equipment manufacturing (part)	0	0	0
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33451010	Electromedical and electrotherapeutic apparatus manufacturing (part)	11	52,855	542
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33451110	Search, detection, navigation, guidance, aeronautical, and nautical system and instrument manufacturing (part)	7	77,832	604
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33451610	Analytical laboratory instrument manufacturing (part)	10	36,473	159
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33451910	Other measuring and controlling device manufacturing (part)	5	6,174	29
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33512920	Other lighting equipment manufacturing (part)	4	859	8
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33599920	All other miscellaneous electrical equipment and component manufacturing (part)	567	4,051,267	26,072
3699	Electronic Eq.	Electronic Mach., Equipment, & Suppl. NEC	33911410	Dental equipment and supplies manufacturing (part)	0	0	0
3711	Motor Vehicle	Motor Vehicle and Automobile Bodies	33611100	Automobile manufacturing	194	95,385,563	114,060
3711	Motor Vehicle	Motor Vehicle and Automobile Bodies	33611200	Light truck and utility vehicle manufacturing	112	110,400,169	94,033
3711	Motor Vehicle	Motor Vehicle and Automobile Bodies	33612000	Heavy duty truck manufacturing	84	14,490,344	28,214
3711	Motor Vehicle	Motor Vehicle and Automobile Bodies	33621110	Motor vehicle body manufacturing (part)	76	82,633	404
3711	Motor Vehicle	Motor Vehicle and Automobile Bodies	33699210	Military armored vehicle, tank, and tank component manufacturing (part)	6	n/a	n/a
3713	Bus & Truck	Truck and Bus Bodies	33621120	Motor vehicle body manufacturing (part)	715	8,719,326	41,779
3714	Motor Vehicle	Motor Vehicle Parts and Accessories	33621130	Motor vehicle body manufacturing (part)	23	265,552	1,201

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
3714	Motor Vehicle	Motor Vehicle Parts and Accessories	33631200	Gasoline engine and engine parts manufacturing	881	25,974,369	81,368
3714	Motor Vehicle	Motor Vehicle Parts and Accessories	33632230	Other motor vehicle electrical and electronic equipment manufacturing (part)	193	6,446,681	30,489
3714	Motor Vehicle	Motor Vehicle Parts and Accessories	33633000	Motor vehicle steering and suspension component (except spring) manufacturing	212	10,750,312	48,944
3714	Motor Vehicle	Motor Vehicle Parts and Accessories	33634020	Motor vehicle brake system manufacturing (part)	269	10,033,288	43,132
3714	Motor Vehicle	Motor Vehicle Parts and Accessories	33635000	Motor vehicle transmission and power train parts manufacturing	523	33,288,093	111,954
3714	Motor Vehicle	Motor Vehicle Parts and Accessories	33639920	All other motor vehicle parts manufacturing (part)	1,508	34,193,298	173,569
3715	Bus & Truck	Truck Trailers	33621200	Truck trailer manufacturing	390	5,507,768	30,678
3716	Motor Vehicle	Mobile Homes	33621300	Motor home manufacturing	88	3,943,709	18,086
3721	Aircraft	Aircraft	33641100	Aircraft manufacturing	204	56,273,651	200,961
3724	Aircraft	Aircraft Engines and Engine Parts	33641200	Aircraft engine and engine parts manufacturing	369	22,617,284	82,557
3728	Aircraft	Aircraft Parts and Auxiliary Equipment	33291220	Fluid power valve and hose fitting manufacturing (part)	0	0	0
3728	Aircraft	Aircraft Parts and Auxiliary Equipment	33399520	Fluid power cylinder and actuator manufacturing (part)	0	0	0
3728	Aircraft	Aircraft Parts and Auxiliary Equipment	33399620	Fluid power pump and motor manufacturing (part)	0	0	0
3728	Aircraft	Aircraft Parts and Auxiliary Equipment	33641300	Other aircraft parts and auxiliary equipment manufacturing	1,138	20,073,061	127,729
3731	Ship	Ship Building and Repairing	33661100	Ship building and repairing	700	10,571,810	97,385
3732	Ship	Boat Building and Repairing	33661200	Boat building	1,043	5,622,040	41,422
3732	Ship	Boat Building and Repairing	81149020	Boat repair	1,739	821,273	9,454
3743	Railroad	Railcars, Railway Systems	33391120	Pump and pumping equipment manufacturing (part)	0	0	0
3743	Railroad	Railcars, Railway Systems	33651020	Railroad rolling stock manufacturing (part)	207	7,916,635	31,633
3751	Motor Vehicle	Motorcycles	33699110	Motorcycle, bicycle, and parts manufacturing	385	n/a	n/a

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries							
SIC	**MP&M Sector**	**Industry**	**1997 NAICS Code**	**1997 NAICS Industry**	**Number of Establishments, 1997**	**Sales, Shipments or Receipts, 1997 ($1,000)**	**Number of Employees, 1997**
				(part)			
3761	Space	Guided Missiles and Space Vehicles	33641400	Guided missile and space vehicle manufacturing	22	14,791,466	52,158
3764	Space	Guided Missile and Space Vehicle Propulsion	33641500	Guided missile and space vehicle propulsion unit and propulsion unit parts manufacturing	28	3,239,033	18,540
3769	Space	Other Space Vehicle and Missile Parts	33641900	Other guided missile and space vehicle parts and auxiliary equipment manufacturing	49	898,758	6,110
3792	Motor Vehicle	Travel Trailers and Campers	33621410	Travel trailer and camper manufacturing (part)	315	3,076,049	20,112
3795	Mobile Ind. Eq.	Tanks and Tank Components	33699220	Military armored vehicle, tank, and tank component manufacturing (part)	37	n/a	n/a
3799	Motor Vehicle	Miscellaneous Transportation Equipment	33221260	Hand and edge tool manufacturing (part)	1	n/a	n/a
3799	Motor Vehicle	Miscellaneous Transportation Equipment	33621420	Travel trailer and camper manufacturing (part)	498	1,485,367	13,240
3799	Motor Vehicle	Miscellaneous Transportation Equipment	33699900	All other transportation equipment manufacturing	378	4,557,989	19,466
3812	Instruments	Search, Det, Nav, Ggnc, Aero, Naut Sys/Inst	33451120	Search, detection, navigation, guidance, aeronautical, and nautical system and instrument manufacturing (part)	680	32,497,776	187,557
3821	Instruments	Laboratory Apparatus and Furniture	33911100	Laboratory apparatus and furniture manufacturing	385	2,471,153	18,253
3822	Instruments	Automatic Environmental Controls	33451200	Automatic environmental control manufacturing for residential, commercial, and appliance use	317	2,935,692	21,450
3823	Instruments	Process Control Instruments	33451300	Instruments and related products manufacturing for measuring, displaying, and controlling industrial process variables	1,002	7,890,923	49,196
3824	Instruments	Fluid Meters and Counting Devices	33451400	Totalizing fluid meter and counting device manufacturing	222	3,765,769	17,390
3825	Instruments	Instruments to Measure Electricity	33441630	Electronic coil, transformer, and other inductor manufacturing (part)	17	24,303	190
3825	Instruments	Instruments to Measure Electricity	33451500	Instrument manufacturing for measuring and testing electricity and electrical signals	826	13,852,897	63,332
3826	Instruments	Laboratory Analytical	33451620	Analytical laboratory instrument manufacturing	664	7,157,038	38,200

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
		Instruments		(part)			
3827	Instruments	Optical Instruments and Lenses	33331420	Optical instrument and lens manufacturing (part)	495	3,174,652	20,801
3829	Instruments	Measuring and Controlling Devices NEC	33451920	Other measuring and controlling device manufacturing (part)	853	5,114,547	33,904
3829	Instruments	Measuring and Controlling Devices NEC	33911210	Surgical and medical instrument manufacturing (part)	6	62,148	521
3841	Instruments	Surgical & Medical Instruments & Apparatus	33911220	Surgical and medical instrument manufacturing (part)	1,598	18,450,024	107,298
3842	Instruments	Orthopedic, Prosthetic & Surgical Suppl.	32212130	Paper (except newsprint) mills (part)	2	n/a	n/a
3842	Instruments	Orthopedic, Prosthetic & Surgical Suppl.	32229120	Sanitary paper product manufacturing (part)	16	651,398	2,236
3842	Instruments	Orthopedic, Prosthetic & Surgical Suppl.	33451020	Electromedical and electrotherapeutic apparatus manufacturing (part)	74	807,427	6,722
3842	Instruments	Orthopedic, Prosthetic & Surgical Suppl.	33911320	Surgical appliance and supplies manufacturing (part)	1,636	14,743,779	82,390
3843	Instruments	Dental Equipment and Supplies	33911420	Dental equipment and supplies manufacturing (part)	877	2,699,867	18,072
3844	Instruments	X-Ray Apparatus and Tubes	33451700	Irradiation apparatus manufacturing	155	3,942,256	14,276
3845	Instruments	Electromedical Equipment	33451030	Electromedical and electrotherapeutic apparatus manufacturing (part)	460	10,567,566	47,121
3851	Instruments	Ophthalmic Goods	33911500	Ophthalmic goods manufacturing	575	3,607,813	26,366
3861	Other	Photographic Equipment & Supplies	32599200	Photographic film, paper, plate, and chemical manufacturing	311	12,895,637	38,935
3861	Other	Photographic Equipment & Supplies	33331520	Photographic and photocopying equipment manufacturing (part)	428	8,410,124	24,707
3873	Precious Metals	Watches, Clocks, and Watchcases	33451830	Watch, clock, and parts manufacturing (part)	128	718,191	5,646
3911	Precious Metals	Jewelry, Precious Metal	33991120	Jewelry (except costume) manufacturing (part)	2,272	5,416,836	34,694
3914	Precious Metals	Silverware, Plated Ware & Stainless	33221120	Cutlery and flatware (except precious) manufacturing (part)	11	8,032	101
3914	Precious Metals	Silverware, Plated Ware &	33991220	Silverware and plated ware manufacturing (part)	151	899,684	6,356

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
		Stainless					
3915	Precious Metals	Jewelers' Materials & Lapidary Work	33991300	Jewelers' material and lapidary work manufacturing	394	919,066	5,396
3931	Other	Musical Instruments	33999200	Musical instrument manufacturing	576	1,356,651	13,411
3944	Other	Games, Toys, Children's Vehicles	33699120	Motorcycle, bicycle, and parts manufacturing (part)	4	n/a	n/a
3944	Other	Games, Toys, Children's Vehicles	33993200	Game, toy, and children's vehicle manufacturing	785	4,534,497	29,622
3949	Other	Sporting and Athletic Goods, NEC	33992000	Sporting and athletic goods manufacturing	2,571	10,591,160	69,664
3951	Other	Pens and Mechanical Pencils	33994100	Pen and mechanical pencil manufacturing	112	1,590,770	8,394
3953	Other	Marking Devices	33994300	Marking device manufacturing	634	643,007	7,831
3961	Precious Metals	Costume Jewelry	33991430	Costume jewelry and novelty manufacturing (part)	826	1,223,475	13,976
3965	Hardware	Fasteners, Buttons, Needles, Pins	33999320	Fastener, button, needle, and pin manufacturing (part)	249	n/a	n/a
3993	Other	Signs and Advertising Displays	33995000	Sign manufacturing	5,709	7,910,809	82,956
3995	Other	Burial Caskets	33999500	Burial casket manufacturing	177	1,271,184	6,962
3999	Other	Manufacturing Industries, N.E.C.	31499950	All other miscellaneous textile product mills (part)	52	173,353	2,167
3999	Other	Manufacturing Industries, N.E.C.	31611020	Leather and hide tanning and finishing (part)	26	24,625	329
3999	Other	Manufacturing Industries, N.E.C.	32199950	All other miscellaneous wood product manufacturing (part)	0	0	0
3999	Other	Manufacturing Industries, N.E.C.	32229930	All other converted paper product manufacturing (part)	0	0	0
3999	Other	Manufacturing Industries, N.E.C.	32311030	Commercial lithographic printing (part)	0	0	0
3999	Other	Manufacturing Industries, N.E.C.	32311130	Commercial gravure printing (part)	0	0	0
3999	Other	Manufacturing Industries, N.E.C.	32311230	Commercial flexographic printing (part)	0	0	0
3999	Other	Manufacturing Industries, N.E.C.	32311340	Commercial screen printing (part)	0	0	0
3999	Other	Manufacturing Industries, N.E.C.	32311930	Other commercial printing (part)	0	0	0
3999	Other	Manufacturing Industries, N.E.C.	32599840	All other miscellaneous chemical product and	9	80,624	572

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
				preparation manufacturing (part)			
3999	Other	Manufacturing Industries, N.E.C.	32619920	All other plastics product manufacturing (part)	140	319,241	3,141
3999	Other	Manufacturing Industries, N.E.C.	33221270	Hand and edge tool manufacturing (part)	7	n/a	n/a
3999	Other	Manufacturing Industries, N.E.C.	33299980	All other miscellaneous fabricated metal product manufacturing (part)	185	285,362	3,231
3999	Other	Manufacturing Industries, N.E.C.	33512130	Residential electric lighting fixture manufacturing (part)	53	69,864	1,216
3999	Other	Manufacturing Industries, N.E.C.	33712740	Institutional furniture manufacturing (part)	5	28,296	329
3999	Other	Manufacturing Industries, N.E.C.	33999920	All other miscellaneous manufacturing (part)	2,284	7,183,815	60,397
4011	Railroad	Railroad Transportation*			n/a	n/a	n/a
4013	Railroad	Railroad Transportation*			n/a	n/a	n/a
4111	Bus & Truck	Local & Suburban Transit	48511100	Mixed mode transit systems	28	51,567	759
4111	Bus & Truck	Local & Suburban Transit	48511200	Commuter rail systems	16	n/a	n/a
4111	Bus & Truck	Local & Suburban Transit	48511300	Bus and motor vehicle transit systems	542	1,152,525	27,448
4111	Bus & Truck	Local & Suburban Transit	48511900	Other urban transit systems	32	n/a	n/a
4111	Bus & Truck	Local & Suburban Transit	48599910	Scheduled airport shuttle service	534	601,988	13,435
4119	Bus & Truck	Local Passenger Trans, N.E.C.	48532000	Limousine service	3,234	1,873,924	29,432
4119	Bus & Truck	Local Passenger Trans, N.E.C.	48541020	Employee bus service	158	158,947	4,223
4119	Bus & Truck	Local Passenger Trans, N.E.C.	48599100	Special needs transportation	1,789	1,141,413	31,791
4119	Bus & Truck	Local Passenger Trans, N.E.C.	48599920	All other passenger transportation	232	67,395	1,078
4119	Bus & Truck	Local Passenger Trans, N.E.C.	48711010	Sightseeing buses	307	462,186	6,858
4119	Bus & Truck	Local Passenger Trans, N.E.C.	62191090	Ambulance or rescue service (except by air)	3,275	4,443,174	106,354
4121	Motor Vehicle	Taxicabs	48531000	Taxi service	3,184	1,280,597	27,850
4131	Bus & Truck	Intercity & Rural Bus Trans	48521000	Interurban and rural bus transportation	407	1,147,432	19,900
4141	Bus & Truck	Local Bus Charter Service	48551010	Charter bus service, local	482	459,953	8,694
4142	Bus & Truck	Bus Charter Service, Exc Local	48551020	Charter bus service, interstate/interurban	1,049	1,308,246	22,789
4173	Bus & Truck	Bus Terminal & Svce Facilities	48849010	Terminal and maintenance facilities for motor vehicle passenger transportation	26	15,253	220

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
4212	Bus & Truck	Local Trucking w/o Storage	48411010	General freight trucking without storage, local, truckload (tl)	10,296	7,783,545	73,967
4212	Bus & Truck	Local Trucking w/o Storage	48411020	General freight trucking without storage, local, less than truckload (ltl)	4,249	3,324,800	47,246
4212	Bus & Truck	Local Trucking w/o Storage	48421010	Used household and office goods moving, local, without storage	3,259	1,198,983	20,858
4212	Bus & Truck	Local Trucking w/o Storage	48422010	Hazardous materials trucking (except waste), local	1,434	1,267,441	10,951
4212	Bus & Truck	Local Trucking w/o Storage	48422020	Agricultural products trucking without storage, local	8,065	2,785,495	29,925
4212	Bus & Truck	Local Trucking w/o Storage	48422030	Dump trucking	17,440	9,748,351	81,553
4212	Bus & Truck	Local Trucking w/o Storage	48422040	Specialized trucking without storage, local	7,996	5,131,564	56,450
4212	Bus & Truck	Local Trucking w/o Storage	56211100	Solid waste collection	7,083	18,211,495	137,049
4212	Bus & Truck	Local Trucking w/o Storage	56211200	Hazardous waste collection	414	1,095,553	8,468
4212	Bus & Truck	Local Trucking w/o Storage	56211900	Other waste collection	827	837,625	7,227
4213	Bus & Truck	Trucking, Except Local	48412100	General freight trucking, long-distance, truckload (tl)	23,111	51,142,148	425,758
4213	Bus & Truck	Trucking, Except Local	48412200	General freight trucking, long-distance, less than truckload (ltl)	6,210	25,010,091	258,972
4213	Bus & Truck	Trucking, Except Local	48421020	Used household and office goods moving, long-distance	3,555	9,111,477	65,734
4213	Bus & Truck	Trucking, Except Local	48423010	Hazardous materials trucking (except waste), long-distance	2,043	3,840,724	28,396
4213	Bus & Truck	Trucking, Except Local	48423020	Agricultural products trucking, long-distance	5,389	3,693,332	32,371
4213	Bus & Truck	Trucking, Except Local	48423030	Other specialized trucking, long-distance	7,007	12,966,336	103,860
4214	Bus & Truck	Local Trucking w/ Storage	48411030	General freight trucking with storage, local, truckload (tl)	542	678,272	7,468
4214	Bus & Truck	Local Trucking w/ Storage	48411040	General freight trucking with storage, local, less than truckload (ltl)	373	486,659	6,096
4214	Bus & Truck	Local Trucking w/ Storage	48421030	Used household and office goods moving, local, with storage	2,286	2,273,241	34,958
4214	Bus & Truck	Local Trucking w/ Storage	48422050	Specialized trucking with storage, local	543	782,939	9,227

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
4215	Bus & Truck	Courier Svces, Exc by Air	49211010	Courier services (except by air)	2,362	19,289,602	317,630
4215	Bus & Truck	Courier Svces, Exc by Air	49221000	Local messengers and local delivery	5,384	3,519,100	67,413
4231	Bus & Truck	Trucking Terminal Facilities	48849020	Motor freight terminal and joint terminal maintenance facility transportation	14	12,989	120
4412	Ship	Deep Sea Foreign Trans	48311100	Deep sea freight transportation	487	11,570,718	18,542
4424	Ship	Deep Sea Foreign Trans	48311310	Coastal and intercoastal freight transportation	292	3,114,639	12,547
4432	Ship	Freight Trans Great Lakes	48311320	Great Lakes - St. Lawrence Seaway freight transportation	32	519,863	1,614
4449	Ship	Wtr Trans of Freight, N.E.C.	48321110	Inland waterways freight transportation (except towing)	222	2,821,121	10,628
4481	Ship	Deep Sea Passenger Trans	48311200	Deep sea passenger transportation	80	3,908,143	12,266
4481	Ship	Deep Sea Passenger Trans	48311410	Coastal and Great Lakes - St. Lawrence Seaway passenger transportation	64	89,597	923
4482	Ship	Ferries	48311420	Coastal and Great Lakes - St. Lawrence Seaway ferry transportation	61	92,493	879
4482	Ship	Ferries	48321210	Inland waterways ferry transportation	76	121,992	1,017
4489	Ship	Water Passenger Trans, N.E.C	48321220	Other water passenger transportation (including water taxi)	154	171,135	1,877
4489	Ship	Water Passenger Trans, N.E.C	48721010	Excursion and sightseeing boats (including dinner cruises)	654	861,001	10,827
4491	Ship	Marine Cargo Handling	48831010	Operation of port and waterfront terminals	168	889,125	6,802
4491	Ship	Marine Cargo Handling	48832000	Marine cargo handling	623	4,456,243	48,463
4492	Ship	Towing & Tugboat Service	48311330	Coastal and intercoastal towing service	292	1,043,440	7,529
4492	Ship	Towing & Tugboat Service	48321120	Inland waterways towing transportation	161	566,027	5,035
4492	Ship	Towing & Tugboat Service	48833010	Tugboat service (including fleeting and harbor service)	361	1,014,026	7,989
4493	Ship	Marinas	71393000	Marinas	4,217	2,541,481	22,765
4499	Ship	Water Trans Svces, NEC	48831020	Seaway and lighthouse operations	0	0	0
4499	Ship	Water Trans Svces, NEC	48833020	Navigational services	461	377,596	2,142
4499	Ship	Water Trans Svces, NEC	48833030	Marine salvaging and wrecking (including dismantling of ships)	43	121,580	669

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
4499	Ship	Water Trans Svces, NEC	48839010	Other services incidental to water transportation	640	444,499	4,389
4499	Ship	Water Trans Svces, NEC	53241110	Commercial vessel rental and leasing	126	454,392	1,657
4581	Aircraft	Airports, Flying Fields, Arpt Terminal Svcs	48811110	Nongovernment air traffic control	114	43,450	502
4581	Aircraft	Airports, Flying Fields, Arpt Terminal Svcs	48811910	Airport operation and terminal services	1,699	3,243,149	61,547
4581	Aircraft	Airports, Flying Fields, Arpt Terminal Svcs	48819000	Other support activities for air transportation	2,400	5,859,631	53,318
4581	Aircraft	Airports, Flying Fields, Arpt Terminal Svcs	56172020	Airplane cleaning and janitorial services	127	203,918	5,843
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	42112010	Motor vehicle supplies and new parts - warehouse distributors	4,357	19,025,397	59,564
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	42112010	Motor vehicle supplies and new parts - warehouse distributors	5,095	30,313,120	67,362
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	42112020	Motor vehicle supplies and new parts - jobbers	6,942	51,468,506	84,003
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	42112020	Motor vehicle supplies and new parts - jobbers	5,732	20,760,962	57,724
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	42112030	Petroleum products marketing equipment wholesalers	583	1,433,102	4,673
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	42112030	Petroleum products marketing equipment wholesalers	507	1,070,443	4,376
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	44131030	Motor vehicle supplies and new parts jobbers (retail)	16,253	22,093,428	150,408
5013	Motor Vehicle	Motor Vehicle Supplies&New Parts	44131030	Motor vehicle supplies and new parts jobbers (retail)	16,253	22,093,428	150,408
5511	Motor Vehicle	Motor Vehicle Dealers (New and Used)	44111000	New car dealers	25,897	518,971,824	1,046,243
5521	Motor Vehicle	Motor Vehicle Dealers (New and Used)	44112000	Used car dealers	23,340	34,680,468	92,752
5561	Motor Vehicle	Recreational Vehicle Dealers	44121000	Recreational vehicle dealers	3,014	10,069,749	29,463
5571	Motor Vehicle	Motorcycle Dealers	44122100	Motorcycle dealers	3,635	7,369,260	29,026

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
5599	Motor Vehicle	Automotive Dealers, NEC	44122900	All other motor vehicle dealers	1,678	2,517,267	9,145
7353	Stationary Ind. Eq.	Heavy Construction Equip Rental, Leasing	23499020	All other heavy construction (part)	2,295	2,734,732	94,344
7353	Stationary Ind. Eq.	Heavy Construction Equip Rental, Leasing	53241210	Rental and leasing of heavy construction equipment without operators	3,286	5,339,163	32,848
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	53221000	Consumer electronics and appliances rental	3,011	1,790,890	17,491
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	53229990	Other consumer goods rental and leasing	3,133	2,133,450	26,134
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	53231000	General rental centers	6,509	3,910,618	40,284
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	53241190	Aircraft rental and leasing	498	n/a	n/a
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	53241290	Oilfield and well drilling equipment rental and leasing	671	1,555,089	8,697
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	53242010	Office machinery rental and leasing	400	436,178	2,895
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	53249020	Industrial equipment rental and leasing	3,408	6,775,140	40,122
7359	Stationary Ind. Eq.	Equip Rental, Leasing, NEC	56299120	Portable toilet rental	563	n/a	n/a
7378	Office Machine	Comp Maintenance/Rep	81121230	Computer maintenance and repair	6,087	7,565,169	60,406
7379	Office Machine	Computer Rel Ser, NEC	33461100	Software reproducing	124	1,258,435	8,027
7379	Office Machine	Computer Rel Ser, NEC	54151220	Computer systems consultants (except systems integrators)	20,233	15,942,861	129,785
7379	Office Machine	Computer Rel Ser, NEC	54151910	Computer consultants (except computer systems consultants)	7,604	3,432,145	27,598
7379	Office Machine	Computer Rel Ser, NEC	54151990	All other computer related services	801	907,844	9,516
7514	Motor Vehicle	Passenger Car Rental	53211100	Passenger car rental	4,367	14,783,704	102,623
7515	Motor Vehicle	Passenger Car Lease	53211200	Passenger car leasing	879	3,800,424	8,325
7519	Motor Vehicle	Utility Trailer and Recreational Vehicle Rental	53212090	Utility trailer, and RV (recreational vehicle) rental and leasing	360	256,119	1,890

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
7532	Motor Vehicle	Top,Body,Uphol,Paint	81112110	Paint or body repair shops	33,144	16,645,229	192,853
7532	Motor Vehicle	Top,Body,Uphol,Paint	81112120	Van conversion services	639	723,189	6,507
7532	Motor Vehicle	Top,Body,Uphol,Paint	81112130	Upholstery and interior repair shops	1,786	386,878	5,812
7533	Motor Vehicle	Auto Exhaust Systems	81111200	Automotive exhaust system repair	5,251	1,985,377	23,015
7537	Motor Vehicle	Auto Transmission Rp	81111300	Automotive transmission repair	6,768	2,431,584	29,442
7538	Motor Vehicle	Gen Automotive Repair	81111100	General automotive repair	77,751	25,598,455	290,634
7539	Motor Vehicle	Auto Repair Shop, NEC	81111810	Carburetor repair shops	1,091	363,763	4,802
7539	Motor Vehicle	Auto Repair Shop, NEC	81111820	Brake, front end, and wheel alignment	3,741	1,553,732	18,216
7539	Motor Vehicle	Auto Repair Shop, NEC	81111830	Electrical repair shops, motor vehicle	1,679	494,744	6,890
7539	Motor Vehicle	Auto Repair Shop, NEC	81111840	Radiator repair	2,295	728,297	8,372
7539	Motor Vehicle	Auto Repair Shop, NEC	81111890	All other motor vehicle repair shops	868	354,107	3,954
7549	Motor Vehicle	Auto Serv,Ex Rep/Wash	48841000	Motor vehicle towing	5,893	2,295,188	36,845
7549	Motor Vehicle	Auto Serv,Ex Rep/Wash	81119100	Automotive oil change and lubrication shops	7,413	2,787,318	57,083
7549	Motor Vehicle	Auto Serv,Ex Rep/Wash	81119820	All other motor vehicle services (except repair and carwashes)	1,646	798,626	11,789
7623	Household Eq.	Refrig,Air Condition	81131030	Commercial refrigeration equipment repair	2,343	1,890,237	16,281
7623	Household Eq.	Refrig, Air Condition	81141220	Refrigeration and air-conditioning service and repair shops (except commercial)	1,671	789,622	9,174
7629	Instruments	Electric Repair Shop	81121210	Business and office machine repair, electrical	1,538	913,258	9,735
7629	Instruments	Electric Repair Shop	81121310	Telephone set repair	201	231,458	2,294
7629	Instruments	Electric Repair Shop	81121910	Electrical equipment repair and maintenance, including medical equipment	2,033	2,509,452	20,446
7629	Instruments	Electric Repair Shop	81141120	Consumer equipment repair (except computer, television, VCR, and stereo)	579	185,507	2,171
7629	Instruments	Electric Repair Shop	81141210	Electric appliance and washing machine repair	4,327	3,125,853	42,324
7631	Precious Metals	Watch, Clock, Jewelry Rp	81149010	Watch, clock, and jewelry repair	1,716	345,774	5,599
7692	Other	Welding Repair	81149030	Welding repair	4,840	1,640,808	22,291
7699	Other	Repair Shop, Rel Serv	48839030	Ship scaling	12	4,737	49

Table A.2: Relationships between SIC and NAICS Codes for MP&M Industries

SIC	MP&M Sector	Industry	1997 NAICS Code	1997 NAICS Industry	Number of Establishments, 1997	Sales, Shipments or Receipts, 1997 ($1,000)	Number of Employees, 1997
7699	Other	Repair Shop, Rel Serv	56162200	Locksmiths	3,799	1,081,317	14,501
7699	Other	Repair Shop, Rel Serv	56179010	Furnace, duct, chimney, and gutter cleaning	878	n/a	n/a
7699	Other	Repair Shop, Rel Serv	56179030	Drain cleaning	376	n/a	n/a
7699	Other	Repair Shop, Rel Serv	56299110	Cesspool cleaning, sewer cleaning, and rodding	2,538	n/a	n/a
7699	Other	Repair Shop, Rel Serv	81121220	Typewriter repair	104	23,844	291
7699	Other	Repair Shop, Rel Serv	81121990	Dental and lab instrument, and other precision equipment repair (except typewriters)	838	404,627	4,183
7699	Other	Repair Shop, Rel Serv	81131010	Industrial machines and equipment repair	16,404	13,600,413	131,793
7699	Other	Repair Shop, Rel Serv	81141110	Home and garden equipment repair and maintenance (except consumer equipment repair)	3,032	816,008	9,726
7699	Other	Repair Shop, Rel Serv	81141290	Nonelectrical appliances and other nonelectronic equipment repair	181	59,338	659
7699	Other	Repair Shop, Rel Serv	81143010	Leather goods, luggage, and pocketbook repair	82	18,294	349
7699	Other	Repair Shop, Rel Serv	81149090	All other repair and related services	3,946	1,362,271	18,854

Source: Department of Commerce, Bureau of the Census, 1997 Economic Census, Bridge Between NAICS and SIC.

A.2 Annual Establishment Births and Deaths in MP&M Industries

EPA used the Statistics of U.S. Businesses (SUSB) dynamic data to estimate the rate at which MP&M facilities enter and leave the industry each year. The SUSB dynamic data report numbers of facilities starting up, closing, expanding employment and contracting employment each year from 1989 through 1997 (the latest currently available.)

Table A.3 shows the average number of facilities (establishments) operating at the beginning of each year for the period 1989 through 1997, the number of facility "births" and "deaths", and the average "birth rate" and "death rate" for each of the major 3-digit manufacturing SIC codes that include an MP&M 4-digit SIC codes.[1] This table shows that, over the period 1989-1997, annual closure rates ranged from 6 to over 12 percent in the different industries, with an overall average of almost 8 percent.

[1] The data are disaggregated only to the 3-digit SIC level, and EPA therefore was unable to calculate closure rates for the specific 4-digit SICs that comprise the MP&M industries. The analysis does not include 3-digit SICs that may include large numbers of non-metal products producers, for example SIC 241 (furniture, both wood and metal.)

Table A.3: Annual MP&M Establishment Births and Deaths by 3 Digit SIC Codes (1989-1997)

SIC	SIC Description	Average # Establishments at the Beginning of the Year	Average Establishment Births	Average Establishment Deaths	% Births	% Deaths
3410	Metal Cans And Shipping Containers	464	22	35	4.7%	7.5%
3420	Cutlery, Handtools, And Hardware	2,294	143	139	6.2%	6.1%
3430	Plumbing And Heating, Except Electric	687	45	53	6.6%	7.8%
3440	Fabricated Structural Metal Products	12,268	853	908	7.0%	7.4%
3450	Screw Machine Products, Bolts, Etc.	2,436	84	111	3.4%	4.6%
3460	Metal Forgings And Stamping	3,812	199	226	5.2%	5.9%
3470	Metal Services, Nec	5,028	341	340	6.8%	6.8%
3480	Ordnance & Accessories, Nec	390	39	40	10.0%	10.2%
3490	Misc. Fabricated Metal Products	7,084	606	531	8.6%	7.5%
3510	Engines And Turbines	346	26	24	7.5%	6.8%
3520	Farm And Garden Machinery	1,711	133	129	7.8%	7.5%
3530	Construction And Related Machinery	3,165	217	230	6.9%	7.3%
3540	Metalworking Machinery	11,072	672	660	6.1%	6.0%
3550	Special Industry Machinery	4,427	307	317	6.9%	7.1%
3560	General Industrial Machinery	3,961	243	225	6.1%	5.7%
3570	Computer And Office Equipment	2,025	262	246	12.9%	12.1%
3580	Refrigeration And Service Machinery	2,104	154	165	7.3%	7.9%
3590	Industrial Machinery, Nec	21,972	1,996	1,659	9.1%	7.5%
3610	Electric Distribution Equipment	764	53	51	6.9%	6.6%
3620	Electrical Industrial Apparatus	2,024	117	130	5.8%	6.4%
3630	Household Appliances	461	44	41	9.5%	8.9%
3640	Electric Lighting And Wiring Equipment	1,905	123	143	6.5%	7.5%
3650	Household Audio & Video Equip	766	96	87	12.5%	11.4%
3660	Communications Equipment	1,794	169	159	9.4%	8.9%
3670	Electronic Components And Accessories	6,068	614	522	10.1%	8.6%
3690	Misc. Electrical Equipment & Supplies	1,890	136	157	7.2%	8.3%
3710	Motor Vehicles And Equipment	4,477	387	372	8.6%	8.3%
3720	Aircraft And Parts	1,633	122	127	7.5%	7.8%
3730	Ship And Boat Building And Repairing	2,669	343	339	12.9%	12.7%
3740	Railroad Equipment	189	15	15	7.9%	7.7%
3750	Motorcycles, Bicycles, & Parts	256	38	25	14.8%	9.7%
3760	Guided Missiles, Space Vehicles, Parts	127	7	11	5.5%	8.4%
3790	Miscellaneous Transportation Equipment	962	106	109	11.0%	11.3%
3810	Search & Navigation Equipment	758	34	60	4.5%	7.9%
3820	Measuring And Controlling Devices	4,209	275	295	6.5%	7.0%
3840	Medical Instruments And Supplies	3,770	334	289	8.9%	7.7%
3850	Ophthalmic Goods	536	40	48	7.5%	8.9%
3860	Photographic Equip & Supplies	784	71	72	9.1%	9.1%
3870	Watches, Clocks, Watchcases &	159	12	20	7.5%	12.7%

Table A.3: Annual MP&M Establishment Births and Deaths by 3 Digit SIC Codes (1989-1997)

SIC	SIC Description	Average # Establishments at the Beginning of the Year	Average Establishment Births	Average Establishment Deaths	% Births	% Deaths
	Parts					
3910	Jewelry, Silverware, And Plated Ware	2,606	246	275	9.4%	10.6%
3930	Musical Instruments	434	46	35	10.6%	8.0%
3940	Toys And Sporting Goods	2,843	384	345	13.5%	12.1%
3950	Pens, Pencils, Office, & Art Supplies	975	62	70	6.4%	7.2%
3960	Costume Jewelry And Notions	1,010	105	128	10.4%	12.7%
3990	Miscellaneous Manufactures	7,338	784	740	10.7%	10.1%
TOTAL		**136,653**	**11,103**	**10,698**	**8.1%**	**7.8%**

Source: Small Business Administration, Statistics of U.S. Businesses.

A.3 Description of MP&M Surveys

EPA collected financial and technical data from a sample of facilities that might be subject to the proposed MP&M rule, including two screener and seven detailed questionnaires (surveys) between 1989 and 1996. The responses to these surveys provided the basic financial and economic information used in the facility and firm impact analyses. In addition, the POTW survey provided information on facility permitting costs. EPA used the POTW survey data to calculate government administrative costs associated with the rule. The various surveys are described below as they relate to the financial and economic analyses. The MP&M rulemaking docket provides copies of the survey instruments and detailed information on the conduct of the surveys.

A.3.1 Screener Surveys

In 1990, EPA distributed 8,342 screener surveys to sites believed to be engaged in the original seven Phase I MP&M sectors. In 1996, EPA distributed 5,325 screener surveys to sites believed to be engaged in the eleven Phase II MP&M sectors. The screener surveys helped EPA to identify sites to receive the more detailed follow-up surveys and to make a preliminary assessment of the MP&M industry. EPA identified the SIC codes applicable to the respective MP&M sectors and randomly selected names and addresses in those SICs to receive the screener surveys based on Dun & Bradstreet databases.

A.3.2 Ohio Screener Surveys

EPA also sent the 1996 screener survey to 1,600 randomly selected sites in Ohio to support the Ohio case study.

A.3.3 Detailed MP&M Industry Surveys

Based on responses to the screener surveys, EPA sent a more detailed survey to a selected group of water-using MP&M sites. EPA collected financial and technical data from sample facilities in two phases.

Based on responses to the 1990 screener, EPA sent the Phase I detailed survey to a select group of water-using MP&M sites. The Agency designed this survey to collect detailed technical and financial information. EPA selected 1,020 detailed survey recipients from water-discharging screener respondents, water-using screener respondents that did not discharge process water, and water-discharging sites from well-known MP&M companies that did not receive the screener.

EPA used information from the first two groups of survey recipients to develop pollutant loadings and reductions and to develop compliance cost estimates. Because EPA did not randomly select the third group of recipients, EPA did not use the data to develop national estimates.

To reduce burden on survey recipients for Phase II of the data collection effort, EPA developed two similar detailed surveys. Based on the development of the 1995 MP&M proposal, EPA chose to collect more detailed information from sites with annual process wastewater discharges greater than one million gallons per year (1 MGY). EPA sent the "long" detailed survey to all 353 1996 screener respondents who indicated they discharged one million or more gallons of MP&M process wastewater annually and performed MP&M operations. The Agency sent the "short" detailed survey to 101 randomly selected 1996 screener respondents who indicated they discharged less than one million gallons of MP&M process wastewater annually and performed MP&M operation

The detailed surveys responses provide site number of employees and detailed financial and economic information about the site or the company owning the site. In addition, the 1996 long detailed questionnaire included a section that requested supplemental information on other MP&M facilities owned by the company. EPA included this voluntary section to measure the combined impact of proposed MP&M effluent guidelines on companies with multiple MP&M facilities that discharge process wastewater. This section requested the same information collected in the 1996 MP&M screener survey. Responses to questions in this section provided information on the size, industrial sector, revenue, unit operations, and water usage of the company's other MP&M facilities.

The 1996 short survey included the identical general site and economic information collected in the long detailed survey, with one exception. Short survey recipients were not asked to provide information on the liquidation value of their plant.

A.3.4 Iron and Steel Survey

EPA also developed a detailed survey, under a separate rulemaking effort, to collect detailed information from facilities that are currently covered by the Iron and Steel Manufacturing effluent guidelines. Following field sampling of iron and steel sites and review of the completed industry surveys, EPA decided that some iron and steel operations would be more appropriately covered by the MP&M rule because they were more like MP&M operations. EPA relied on the Iron & Steel survey for financial and economic information on 47 iron and steel facilities.

A.3.5 Municipality Survey

EPA distributed surveys in 1996 to city and county facilities that might operate MP&M facilities. The Agency designed this survey to measure the impact of this rule on municipalities and other government entities that perform maintenance and rebuilding operations on MP&M products (e.g., bus and truck, automobiles). The Agency sent the municipality survey to 150 city and county facilities randomly selected from the *Municipality Year Book-1995* based on population and geographic location. EPA allocated sixty percent of the sample to municipalities and 40 percent to counties. The 60/40 distribution was approximately proportional to their aggregate populations in the frame. EPA divided the municipality sample and the county sample into three size groupings as measured by population. The surveys collected information on MP&M site costs of service and on the financial and economic characteristics of the governments operating the MP&M facilities.

A.3.6 Federal Facility Survey

EPA designed this survey to assess the impact of the MP&M effluent limitations guidelines and standards on federal agencies that operate MP&M facilities. EPA distributed the survey to federal agencies likely to perform industrial operations on metal products or machines. The Agency requested that the representatives of the seven chosen federal agencies voluntarily distribute copies of the survey to sites they believed performed MP&M operations. The information collected in the 1996 federal survey was identical to the long survey. After engineering review and coding, EPA entered data from 44 federal surveys into the database. Because EPA did not randomly select the survey recipients, data from these questionnaires was not used to develop national estimates.

A.3.7 POTW Survey

EPA distributed the Publicly Owned Treatment Works (POTW) survey in November 1997. The Agency designed this survey to estimate possible costs and burden that POTWs might incur in writing MP&M permits or other control mechanisms and to estimate benefits associated with implementation of the MP&M regulations. The Agency sent the POTW survey to 150 POTWs with flow rates greater than 0.50 million gallons per day. EPA randomly selected the recipients from the 1992 Needs Survey Review, Update, and Query System Database (RUQus), and divided the POTW sample into two strata by daily flow rates: 0.50 to 2.50 million gallons, and 2.50 million gallons or more.

In addition to the total volume of wastewater treated at the site, the POTW survey requested the number of industrial permits written, the cost to write the permits, the permitting fee structure, the percentage of industrial dischargers covered by National Categorical Standards (i.e., effluent guidelines), and the percentage of permits requiring specific administrative activities. EPA used this information to estimate administrative burden and costs. In addition, EPA requested information on the use or disposal of sewage sludge generated by the POTW. The Agency only required POTWs that received discharges from an MP&M facility to complete those questions. The sewage sludge information requested included the amount generated, use or disposal method, metal levels, use or disposal costs, and the percentage of metal loadings from MP&M facilities. The Agency used this information to assess the potential changes in sludge handling resulting from the MP&M rule and to estimate economic benefits to the POTW

References

U.S. Bureau of the Census. 2000. *The Bridge Between NAICS and SIC Report.* March. http://www.census.gov/epcd/www/naicensu.html

Small Business Administration. *Statistics of U.S. Businesses*. http://www.sba.gov/advo/stats/int_data.html

Appendix B: MP&M Sector Cost Pass-Through Potential

Appendix Contents:

Introduction[1]

This appendix describes the methodology used to calculate compliance cost pass-through coefficients for each sector. The cost pass-through coefficient is a measure of how much of compliance-related cost increases a sector can be expected to pass on to its consumers. EPA conducted a two-part analysis, including an econometric analysis of the historical relationship of output prices to changes in input costs and an analysis of market structure characteristics. These analyses together provide a numerical estimate of pass-through potential at the MP&M sector level.

This appendix includes five sections. The first describes the econometric analysis of cost pass-through potential based on the historical changes in output prices relative to changes in input costs. The second discusses the market structure factors that are expected to affect the recovery of costs. Section B.3 describes how the results of the econometric and market structure analyses are combined to develop a quantitative estimate of cost pass-through potential. Section B.4 discusses adjustments to that estimate to take account of the portion of each sector that will incur costs. Finally, the last section describes the use of the estimated cost pass-through values in the facility-level financial analysis.

B.1 Historical Changes in Output Prices Relative to Changes in Input Costs

Two factors determine the share of a cost increase that a facility can pass through to its customers: the elasticity of demand and the elasticity of supply in the facility's market. Both factors are difficult to measure accurately. One reason for the difficulty is that observed changes in price are due to simultaneous changes in demand and supply. In view of this difficulty, this pass-through analysis does not decompose cost pass-through into the separate effects stemming from elasticity of demand and elasticity of supply. This restriction is reasonable because the value of interest is the composite of the two elasticity effects: that is, the change in *equilibrium* revenue due to a change in input costs.

An additional analytic challenge involves joint consideration of quantity and price effects. Specifically, the amount of cost increase that a firm may recover through a revenue increase may generally be decomposed into a change in price and a change in quantity. In most markets, increased prices (in response to increased costs) translate into reduced quantity of sales. Whether or not total revenue increases depends on the interaction of supply and demand elasticities.

For practical reasons, this analysis focused on *the change in equilibrium price* due to a change in input costs. Changes in market quantities were determined from closures, rather than by estimating changes in output in non-closing facilities.

[1] This analysis was performed to support the Phase I MP&M proposal, and will be updated prior to promulgation of the final MP&M rule.

The analysis assumes that the quantity of shipments or sales does not vary with the increase in fixed and average costs, unless the facility closes.

The methodology measures the sensitivity of equilibrium prices to changes in input costs. The "cost elasticity of price," denoted E_p, measures the percentage change in output price per percent change in unit input costs.[2] The cost elasticity of price was estimated by linear regression on ten years of annual input price indices, for 15 MP&M sectors.[3] The 15 MP&M industry sectors encompass 163 industrial 4-digit SIC codes. Estimation of E_p requires for each MP&M sector a measure of the change over time in input costs (input cost index) and a measure of the change in output price (output price index).

The input cost index is an average of the producer price index values for commodity inputs to the sector in question, weighted by the share of each input to sector output. The weighted average calculation involves two steps.

First, *at the 4-digit SIC level*, an aggregate measure of input cost was developed from yearly Producer Price Index (PPI) values from the Bureau of Labor Statistics, weighted by the direct requirement coefficients from the *1982 Benchmark Input-Output Tables of the United States*.[4] The Employment Cost Index (ECI) from the Bureau of Labor Statistics for all private manufacturers was used for the value-added component of production cost. Estimating a contribution to value-added from labor costs alone excludes consideration of changes in payments to equity capital. However, available measures of payments to capital are not likely to improve the accuracy of the input cost index. Furthermore, the direct requirements coefficients from the input-output table include information on the purchase of capital goods, and changes in the cost of capital goods are reflected in the PPI series for the associated industries. The input cost index for a 4-digit SIC group was calculated as a weighted average of prices of a sample bundle of inputs comprised of the most significant inputs that collectively account for at least 50 percent of the total input cost associated with the relevant 4-digit SIC industry.

The Bureau of Economic Analysis' Input-Output Table uses its own industry classification system, which is similar to the Standard Industrial Classification (SIC) used in the Census of Manufactures. This classification system is referred to in this appendix as the BEA classification. The BEA classification has more categories than the SIC system, but the BEA classification codes were grouped so that they map to the more aggregate SIC codes that form the MP&M sectors.

Second, *at the MP&M sector level*, the input cost index was developed by weighting the individual 4-digit SIC group cost index values by 4-digit SIC value of shipments from the *Census of Manufactures* and various *Annual Surveys of Manufactures* from the corresponding years. The resulting values provided an aggregate measure of input costs over the 10-year period 1982-1991 for each MP&M sector.

To summarize, the input cost index was calculated as follows:

For each 4-digit SIC industry, i, that uses non-labor inputs, j, the average input price for the year k is:

$$P_{i,\,k} = \frac{\sum_j r_j \times PPI_{j,\,k}}{\sum_j r_j} \tag{B.1}$$

where:

$P_{i,k}$	=	average input price index for SIC industry i, year k;
r_j	=	direct requirements coefficient for input commodity j by industry i; and
$PPI_{j,k}$	=	Producer Price Index, commodity j, year k.

For each MP&M industry sector, containing N 4-digit SIC industries, the average input price in each year k is:

$$P_{in,\,k} = \frac{\sum_i^N q_{i,\,k} \times P_{i,\,k}}{\sum_i^N q_{i,\,k}} \tag{B.2}$$

where:

$P_{in,k}$	=	average input price index value for a given MP&M sector in year k;
$P_{i,k}$	=	input price index value for SIC industry i, year k ; and
$q_{i,k}$	=	value of shipments for SIC industry i, year k.

The direct requirements coefficients and weights by production value are constants over time. However, the underlying price index values from the PPI and the measure of labor cost vary over time. Thus, the input cost index of $P_{in,k}$ values is a fixed-weight input cost index.

---

[2] Because quantity of production is assumed constant, the elasticity measure applies to revenue as well.

[3] The Phase I analysis did not include the Iron & Steel, Printed Circuit Board, or Other Metals sectors. These sectors, along with Metal Finishing Job Shops, were assigned the average of the cost pass-through coefficients for the 15 sectors that were analyzed.

[4] The direct requirement coefficients describe the composition of production inputs required to produce the output from a given industry. The direct requirement coefficients may be defined as follows: for each of dollar of output from industry *i*, the direct requirements coefficient r_j indicates the value of input *j* required to achieve one dollar of output from industry *i*. The sum of all requirements coefficients r_j for industry *i* equals one.

Similarly, the output price index, which is the dependent variable, is the weighted average of Producer Price Indices for the goods produced by the industries in each sector and is calculated as follows:

$$P_{out,\ k} = \frac{\sum_i^N q_{i,\ k} \times PPI_{i,\ k}}{\sum_i^N q_{i,\ k}} \qquad \text{(B.3)}$$

where:

$P_{out,k}$	=	average output price index value for a given MP&M sector in year k
$q_{i,k}$	=	value of shipments for SIC industry i, year k
$PPI_{i,k}$	=	Producer Price Index for the output of SIC industry i, year k.

The Producer Price Index is an appropriate measure of output price because it measures changes in the price received at the plant gate by the producer and is therefore the relevant price for the producer's production decisions. MP&M products are often intermediate goods, whose market prices are producer prices.

For each MP&M sector, a relationship for the k = 1 to10 yearly observations was estimated by least-squares linear regression, as follows:

$$\ln(P_{out,k}) = a + \mathrm{E}_p \times \ln(P_{in,k}) + b \times \ln(W_k) + \epsilon \qquad \text{(B.4)}$$

where:

$P_{out,k}$	=	price index for the bundle of goods produced by the MP&M sector, year k
a	=	intercept
E_p	=	elasticity of output price with respect to input costs (non-employment) for a given MP&M sector
$P_{in,k}$	=	price index of inputs to sector, year k
b	=	elasticity of output price with respect to employment costs
W_k	=	Employment Cost Index, all private manufacturing, year k
ϵ	=	error term
ln(x)	=	natural log of x

Specifying the key variables in the regression as logarithms permits direct estimation of the elasticities of output prices with respect to the independent variables. That is,

$$\mathrm{E}_p = \frac{\mathrm{d}\ln(P_{out,k})}{\mathrm{d}\ln(P_{in,k})} = \frac{\mathrm{d}(P_{out,k}/P_{out,k})}{\mathrm{d}(P_{in,k}/P_{in,k})} \qquad \text{(B.5)}$$

which is the elasticity of output price with respect to input cost.

The coefficients E_p from this regression are the estimated cost-elasticities of price for each MP&M sector. The estimated coefficients address the question: over the period of analysis, by how much did output prices change as input costs increased? The value of E_p for each sector, linked with other information on market structure, yields a composite measure of pass-through potential by MP&M sector. As discussed below, the estimated values of E_p were used to define the numerical range of expected cost pass-through potential for the different MP&M industrial sectors. The E_p values estimated for a given sector are not necessarily the cost pass-through values that are ultimately assigned to that sector for the economic/financial impact analysis. The actual assignment of a cost pass-through coefficient depends on both the estimated E_p values for the sector *and* the market structure information discussed in the following section.

Table B.1 gives the estimated parameter coefficients and t-statistics for each of the sectors. Based on historical data, MP&M industries have been able to increase prices, at the margin, between 0.77 percent and 0.94 percent for every one percent increase in non-labor input costs. These estimates are highly significant: the *R-square* values, a measure of goodness of fit, exceed 99 percent in each sector.

The coefficients on labor also appear with significant coefficients, at the 95 percent confidence level, but with lower estimated values. Within the context of this analysis, this finding suggests that output prices have varied less in response to changes in labor costs than in response to price increases of other inputs — all other things being equal. When both labor cost and output prices rise, non-labor costs are probably increasing also, and it is this non-labor cost increase that, in this regression analysis, is found to drive output prices upward. Goodness of fit notwithstanding, a regression analysis cannot prove causality. The lower coefficient on labor may reflect long-term contracts that stabilize labor costs with respect to other input costs, which may vary in a way that is more similar to output prices. In addition, improvements in labor productivity weaken the link between changes in labor costs and output prices.

A high degree of collinearity between labor and non-labor inputs might cause problems in estimating on the basis of OLS regression. However, the parameter estimates were stable across alternative model specifications, suggesting that multicollinearity is not a problem in this regression analysis.

Table B.1: Cost Pass-Through Regression Results By Sector

	Regression Coefficients (t-statistics in parenthesis)		
MP&M Sector	**Input Price Index**	**Employment Cost Index**	**Rank[a]**
Aerospace	.7735 (12.73)	.0098 (4.21)	1
Aircraft	.9241 (37.22)	.0031 (3.32)	12
Bus & Truck	.9301 (30.91)	.0028 (2.46)	13
Electronic Equipment	.8990 (25.28)	.0047 (3.46)	4
Hardware	.8888 (27.02)	.0046 (3.68)	2
Household Equipment	.9205 (43.033)	.0034 (4.16)	10
Instruments	.9231 (46.44)	.0033 (4.34)	11
Mobile Industrial Equipment	.9010 (23.94)	.0039 (2.68)	5
Motor Vehicle	.8984 (27.85)	.0042 (3.36)	3
Office Machines	.9201 (35.05)	.0035 (3.52)	9
Ordnance	.9068 (29.05)	.0038 (3.18)	6
Precious and Non-Precious Metals	.9383 (24.82)	.0024 (1.68)	14
Railroad	.9106 (30.52)	.0037 (3.23)	8
Ships and Boats	.9703 (34.68)	.0010 (0.93)	15
Stationary Industrial Equipment	.9090 (28.09)	.0038 (3.06)	7

[a] Rank from lowest to highest cost pass-through potential as measured by the regression-based input price index.
Source: U.S. EPA analysis.

The median pass-through coefficient over the 15 MP&M sectors is 0.91.

The direct estimation used in this methodology measures actual changes in output price with respect to changes in input costs. It has the advantage of taking into account the full range of possible mechanisms by which input costs affect output prices, including technical changes, substitution, non-competitive pricing mechanisms, imperfect information phenomena and any other shifts or irregularities in the supply and demand functions.

B.2 Market Structure Effects[5]

The second part of the analysis of cost pass-through potential builds from an analysis of current market structure in the MP&M industry sectors and uses information from the industry profile and the Phase I Section 308 Survey of MP&M facilities. This second method for estimating E_p gives ordinal rather than numerical results.

Information on the competitive structure and market characteristics of an industry provide insight into the likely ranges of values for supply and demand elasticities and the sensitivity of output prices to input costs. When an input cost increases, the profit-maximizing firm attempts to

[5] This analysis was performed only for the Phase I sectors. It will be updated and expanded to include the Phase II sectors prior to promulgation of the final MP&M rule.

maintain its profits by increasing output prices accordingly. How much of the cost increase the firm can pass on through higher prices depends on the relative market power of the firm and its customers. The following discussion identifies six indicators of market power used to assess cost pass-through potential. The first five of these indicators depend on analysis at the MP&M sector level, while the sixth indicator uses facility-specific information. As a result, the estimate of cost pass-through potential from this analysis is facility-specific, but the variation between facilities in the same sector is small. These six indicators are as follows:

1. ***Concentration***. The extent of concentration among a group of market participants is an important determinant of that group's market power. A group of many small firms typically has less market power than a group of a few large firms. Eight-firm ***concentration ratios*** measure the percentage of value of shipments concentrated in the top eight companies in each four-digit industry. Sector concentration ratios are the weighted averages of component industry concentration ratios, weighted by value of shipments. As the sector concentration ratio increases, firms in an industry are expected to be better able to pass on input cost increases, all other things being equal.

2. ***Vertical Integration***. ***Specialization ratios***, also from the Department of Commerce, provide a measure of vertical concentration. A vertically integrated industry includes firms that produce several commodities that are typically sequentially ordered in production. The specialization ratio is not a direct measure of the relationship between products produced by an industry; no such measure is readily available. The specialization ratio, however, does measure the percentage of the value of shipments by an industry *outside* of the industry's primary commodity. Accordingly, a high specialization ratio means that the firms in an industry cannot have significant vertical concentration. Alternatively, a lower specialization in an industry means more production of other commodities, which permits the possibility of vertical integration. Thus, a lower specialization ratio increases the *potential* that the firms in an industry produce commodities that are vertically linked in production, which in turn would imply higher market power.

3. *Import Competition*. ***Import penetration***, defined as the ratio of imports in a sector to the total value of domestic consumption in that sector, measures the availability of substitutes from abroad. Higher import penetration generally means that firms are exposed to greater competition from foreign producers and will thus possess less market power to increase prices in response to regulation-induced increases in production costs. The Census Bureau provides import data at the 4-digit SIC code level.

If historical changes in input costs have affected both domestic and foreign firms more or less uniformly, then the econometrically estimated E_p would not address situations in which only domestic firms face higher costs. Foreign firms could offer a substitute supply of goods that is not subject to the compliance costs of the proposed rule, which would reduce the cost pass-through potential that would apply if there were only domestic competition in a sector.

4. *Export Competition*. ***Export dependence***, defined as the percentage of shipments from a sector that is exported, measures the degree to which that sector is exposed to competitive pressures abroad in export sales. The MP&M regulation is not expected to increase the production costs of foreign producers, with whom domestic firms must compete in export markets. As a result, sectors that rely more on export sales are expected to have less latitude to increase prices of their exported products in response to regulation-induced increases in production costs, other things being equal. The fact that domestic producers export a substantial share of their input does not necessarily imply that they are subject to more competition than they face in domestic markets. U.S. producers could be the dominant suppliers world-wide. It is likely that export sales are subject to more international competition on average than are domestic sales, however, and therefore that a high export share would imply less ability to pass on domestic production cost increases.

5. *Long-Term Industry Growth*. The competitiveness of an industry and the ability of facilities to engage in price competition differ between declining industries and growing industries. EPA compared the average growth rate in the value of shipments between 1982 and 1991 for each sector to the median of those average growth rates among the 15 sectors. Those with higher than median growth rates are deemed to be better positioned to pass through compliance costs, rather than absorb cost increases in order to retain market share.

6. *Competition Barriers*. Barriers to entry and exit help a concentrated industry exert market power by deterring potential competitors from entering the market. Without these barriers, a firm that tries to pass on compliance costs by raising its prices would risk losing market share to new firms that see an opportunity to compete at these higher prices. Entry barriers include high capital costs, brand name reputations that would require a large advertising expense to overcome, a long learning curve, and any other factors that make the fixed cost for new entrants higher than the fixed cost of existing firms.

Exit barriers include factors that make it difficult for a firm to liquidate its assets, such as specialized machinery that cannot be sold or converted to alternative uses, brand names that cannot transfer well to other products, or substantial shutdown liabilities that would offset the value of assets in liquidation. If entry barriers are the fixed costs of beginning business in an industry, then exit barriers are the fixed costs that cannot be salvaged upon leaving the industry. They are sometimes called ***sunk costs*** and are measured as the difference between the replacement value of a facility's capital and its liquidation value. It is difficult to estimate accurately the capital valuations needed to measure exit barriers. One way to avoid the data availability problem is to identify directly the presence of above-normal profits that entry and exit barriers permit.

A facility's risk-normalized profit rate is measured as its pre-tax return on assets (ROA), as calculated from survey data, divided by that facility's ***beta***. A facility's beta is a measure of its riskiness as an investment relative to the market for equity investments as a whole. Each Phase I survey facility was assigned to the sector from which it receives the largest portion of its revenues, as indicated on the facility's survey response. EPA calculated, for each sector, the revenue-weighted average of risk-normalized ROAs for facilities assigned to the sector.[6] The revenue-weighted average of risk-normalized ROAs by sector was used as a measure of above-normal profits in a sector, which in turn was taken as an indicator of barriers to entry and exit.

This measure does not state that MP&M industries face high or low barriers to competition in absolute terms; it only assigns them relative rankings. Above-median profits indicate sectors with above average market power and the likely presence of entry and exit barriers.

EPA used these six measures to assign each sector a cost pass-through score. For some variables (e.g., industry concentration), higher numerical values indicate greater cost pass-through potential, while for other variables (e.g., specialization ratio), higher numerical values indicate lower cost pass-through potential. A value that, relative to the median, indicates greater cost pass-through potential receives a score of +1 and a value that indicates lower cost pass-through potential than the median receives a score of -1. The sector at the median is assigned a score of 0. Table B.2 summarizes the specific scoring definitions for each variable.

[6] This measure was calculated only for the seven sectors covered by the Phase I survey. This analysis will be expanded to all sectors prior to promulgation of the final rule.

Table B.2: Summary of Scoring Rules for Assessing Relative Pass-Through Potential Based on Market Structure Considerations[a]

Variable	Variable Indicates Greater Pass-Through Potential (Score +1)	Variable Indicates Lower Pass-Through Potential (Score -1)	Variable Indicates Neutral Pass-Through Potential (Score 0)
8-Firm Concentration Ratio (CR_8)	Greater than median	Lower than median	Equal to median
Specialization Ratio (SR)	Lower than median	Greater than median	Equal to median
Ratio of Imports to Shipments (M)	Lower than median	Greater than median	Equal to median
Ratio of Exports to Shipments (X)	Lower than median	Greater than median	Equal to median
Average Growth Rate of Shipments (G)	Greater than median	Lower than median	Equal to median
Risk-Adjusted Pre-Tax Return on Assets (P)	Greater than median	Lower than median	Equal to median

a. All assessments of pass-through potential are relative among the 15 MP&M Sectors.
Source: U.S. EPA analysis.

On the basis of this scoring system, the possible scores from the market structure analysis range from -6 to +6. These point scores based on the individual market structure variables are in turn used to assign summary scores of structure-based pass-through potential. Sectors with a score of 2 or greater are assigned a summary score +1, while sectors with scores of -2 or less are assigned a summary score of -1. Sectors with scores of 1, -1 or 0 are assigned a summary score of 0.

B.3 Combining the Measures of Pass-Through Potential

The regression analysis provides a quantitative assessment of what the cost pass-through ability of each sector appears to be. The market structure analysis yields a judgment of what the pass-through ability *ought* to be. Information from both analyses contribute to the assignment of cost pass-through estimates to facilities in each sector.

The procedure for assigning a composite score of cost pass-through potential involved three steps:

1.Define high, medium and low ranges of cost pass-through elasticity. These ranges are defined by the cost pass-through elasticities estimated for the top third, middle third and lower third of all MP&M sectors, ranked by elasticity of output price. These ranges are defined relative to other MP&M sectors, and do not indicate high, medium, or low cost pass-through potential in an absolute sense.

2. *Assign each sector a high, medium, or low pass-through potential based on the econometric estimate of pass-through elasticity*. Each sector was assigned a +1, -1 or 0 rating depending on whether its estimated E_p is in the top, bottom or middle third, respectively, of the estimated values of E_p across all MP&M sectors.

3. *Assign each sector a high or low pass-through potential based on the market structure analysis of pass-through potential*. As discussed in the preceding section, each sector received a +1, -1, or 0 score based on the number of market structure considerations that indicate relatively higher or relatively lower expected cost pass-through potential.

4. *Combine the assigned pass-through potential scores from the econometric estimation and market structure analysis techniques to yield a composite measure of pass-through potential, E^**[7]. If the sum of the structural analysis and the direct estimation scores is positive, then that sector was assigned to the high range of observed E_p values. Conversely, if the sum is negative, it was assigned to the low value range of E_p. When the sum is zero, the sector was assigned to the middle range of E_p values.

Table B.3 summarizes the resulting assignments of MP&M sectors to the estimated pass-through potential range.

[7] The "*" in the E^* term identifies the cost pass-through value as that assigned to the given sector based on the composite cost pass-through analysis and subsequent adjustment. The "*" distinguishes the cost pass-through value from the E_p values that were estimated by sector and that form the basis for the numerical ranges of cost pass-through potential to which MP&M sectors were assigned.

Table B.3: Estimated Pass-Through Potential by MP&M Sector
Combined Econometric and Structural Scores

Sector	Econometric Estimation Score[a]	Structural Analysis Score	Assigned Pass-Through Range
Aerospace	-1	1	Middle
Aircraft	1	0	High
Bus and Truck	1	N/A	N/A
Electronic Equipment	-1	0	Low
Hardware	-1	0	Low
Household Equipment	0	N/A	N/A
Instruments	1	N/A	N/A
Iron & Steel	N/A	N/A	N/A
Job Shops	N/A	N/A	N/A
Mobile Industrial Equipment	-1	-1	Low
Motor Vehicle	-1	N/A	N/A
Office Machine	0	N/A	N/A
Ordnance	0	0	Middle
Other Metal Products	N/A	N/A	N/A
Precious and Non-Precious Metals	1	N/A	N/A
Printed Circuit Boards	N/A	N/A	N/A
Railroad	0	N/A	N/A
Shipbuilding	1	N/A	N/A
Stationary Industrial Equipment	0	-1	Low

[a] This score is +1, 0, or -1, depending on whether the econometric estimate of cost pass-through coefficient for the sector is in the high, middle or low end of the range, respectively. These ranges were defined as follows:
Low = 0.773 to 0.901
Middle = 0.907 to 0.921
High = 0.923 to 0.937
Source: U.S. EPA analysis.

B.4 Adjusting the Composite Estimate of Pass-Through Potential for Share of Output Bearing Compliance Costs

The cost effects of an effluent guideline differ from those of an across-the-board change in the cost of a production input (e.g., energy costs). Although cost increases for general production inputs such as energy may affect essentially all of the facilities in an industry, the cost effects of an effluent guideline are likely to be less pervasive. In particular, MP&M facilities that do not discharge process wastewater will not incur costs due to the proposed rule. Even among those facilities that do discharge wastewater, the costs of achieving compliance with the proposed regulation will vary in their impact on facility finances and business operations. In general, facilities that incur little or no costs to achieve compliance with the proposed regulation will compete with facilities that incur higher costs, and limit their ability to raise prices.

A final adjustment was undertaken to the estimated cost pass-through coefficients to reflect the presence of facilities that are expected to bear no compliance-related cost increases as a result of regulation. From the analysis of survey responses, EPA estimated the total business revenue in each MP&M sector that is associated with water-discharging facilities and thus likely to be affected by compliance-related cost increases.[8] Separately, from Department of Commerce data, EPA estimated the total revenues by MP&M facilities, regardless of discharge status. The ratio of these values — revenues in water-discharging facilities divided by total revenues in the MP&M sector — provided a measure of the fraction of production in the MP&M sector likely to be affected by compliance cost increase. For each sector, the ratio was multiplied by the estimated cost pass-through potential to yield an adjusted estimate of compliance cost pass-through potential, taking into account competition from same-industry facilities that are not expected to incur compliance-related cost increases.

Table B.4 summarizes the final adjustment to the estimates of cost pass-through potential. The first column lists the pass-through potential value assigned to each sector *before*

[8] This analysis included only the seven sectors addressed by the Phase I rule. This analysis will be expanded to all sectors prior to promulgation of the final rule.

adjustment for the share of sector output bearing compliance costs. The second column gives each sector's adjustment coefficient (i.e., the fraction of business activity that is expected to incur compliance-related cost increases), and the final column shows the resulting pass-through values that were used in the facility impact analysis.

Table B.4: Adjusted Estimates of Compliance Cost Pass-Through Potential by MP&M Sector

Sector	Unadjusted Cost Pass-Through Potential	Estimated Fraction of Revenue Subject to Regulation	Adjusted Cost Pass-Through Potential
Aerospace	0.914	100.0%	0.914
Aircraft	0.937	100.0%	0.937
Bus & Truck	.9301	N/A	.9301
Electronic Equipment	0.872	100.0%	0.872
Hardware	0.872	34.8%	0.303
Household Equipment	.9205	N/A	.9205
Instruments	.9231	N/A	.9231
Iron & Steel	.9076	N/A	.9076
Job Shops[a]	.9076	N/A	.9076
Mobile Industrial Equipment	0.872	100.0%	0.872
Motor Vehicle	.8984	N/A	.8984
Office Machinery	.9201	N/A	.9201
Ordnance	0.914	100.0%	0.914
Other Metal Products[a]	.9076	N/A	.9076
Precious and Non-Precious Metals	.9383	N/A	.9383
Printed Circuit Boards[a]	.9076	N/A	.9076
Railroad	.9106	N/A	.9106
Ships and Boats	.9703	N/A	.9703
Stationary Industrial Equipment	0.872	39.7%	0.346

Source: U.S. EPA analysis.

As shown by the table, the fraction of business activity to which the regulation is expected to apply varies considerably by sector. The survey data indicate, for Aircraft, Electronic Equipment, Ordnance, Aerospace, and Mobile Industrial Equipment, that essentially all of the business operations within the sector will be subject to regulatory effects. However, for Hardware and Stationary Industrial Equipment, the fraction of business operations within the sector expected to incur compliance costs is much smaller. The resulting adjusted cost pass-through potential values also vary quite broadly from a low of 0.303 for Hardware to a high of 0.937 for Aircraft. Note that these values are elasticity values — that is, the percentage change in output revenues for a percentage change in input prices — and are not cost pass-through fractions— that is, the fraction of compliance-related cost increase expected to be recovered from customers through increased revenues. The use of the elasticity values in the facility impact analysis to calculate cost pass-through fractions is described in the last section of this appendix.

B.5 Using the Estimated Cost Pass-Through Potential in the Facility-Level Financial Analysis

The estimated cost elasticity of price E^* for each sector was used to develop an estimated percentage price increase for each sector and for each regulatory option considered. Total compliance costs for all facilities in a sector were divided by total baseline costs for same facilities, as reported in the surveys. This percentage price increase multiplied by E^* provided a percentage price increase expected to result from the increased costs in each sector. That is,

$$P_j^* = E_j^* \times \frac{\sum_i^n ACC_i}{\sum_i^n ABC_i} \qquad \text{(B.6)}$$

where

P_j^* = percentage sector *j* price increase,
E_j^* = cost elasticity of price for sector *j*,
ACC_i = annualized compliance cost for facility *i* in sector *j*,
ABC_i = annualized baseline cost for facility *i* in sector *j*, and
n = number of facilities in sector *j*.

This analysis assumes that all facilities in a given sector benefit from the same price increase, regardless of their own compliance costs. The percentage of compliance costs that any given facility recovers through price increases varies across facilities within a sector. Whether a facility's profits increase or decrease as a result of the rule depends on the sector cost elasticity of price and that facility's compliance costs relative to those incurred by other facilities in the same sector. Facilities that do not incur any compliance costs enjoy increased profits, because their revenues increase as a result of the price increase without any increase in costs. Facilities that incur large costs relative to their competitors will suffer a decrease in profitability.

Table 5.4 in Chapter 5 reports the percentage price increases predicted for each sector for the proposed rule. Price increases range from 0.01 percent to 1.91 percent, with increases less than one percent for all but two sectors.

GLOSSARY

barriers to entry: Factors that hinder or prevent firms from entering a market. Examples include economies of scale, absolute cost advantages, high capital cost requirements, and product differentiation.

barriers to exit: Factors that hinder or prevent firms from liquidating its assets and ceasing production. Examples include high shutdown costs (e.g., due to employee termination costs or environmental liabilities) and investments in specialized equipment that cannot be transferred (a form of sunk costs).

beta: A firm's beta is a measure of its riskiness as an investment relative to the market for equity investments as a whole. Calculated by comparing the firm's return to a measure of market-wide returns over time.

Concentration ratio: A way of measuring the concentration of market share held by particular suppliers in a market. An eight-firm concentration ratio is the total market share of the eight firms with the largest market shares. In this analysis, measured as the percentage of value of shipments accounted for by the top eight companies in each 4-digit SIC, as reported by the Census Bureau.

Employment Cost Index (ECI): ECI measures changes in labor costs for money wages and salaries and noncash fringe benefits in nonfarm private industry and state and local governments for workers at all levels of responsibility. Published by the Bureau of Labor Statistics.

export dependence: The share of shipments by domestic producers that is exported; calculated by dividing the value of exports by the value of domestic shipments.

import penetration: The share of all consumption in the U.S. that is provided by imports; calculated by dividing imports by reported or apparent domestic consumption (the latter calculated as domestic value of shipments minus exports plus imports).

input cost index: An average of the Producer Price Index values for commodity inputs to the sector in question, weighted by the share of each input to sector output. Used in this analysis as a measure of sector-level cost increases.

output price index: The weighted average of Producer Price Indices for the goods produced by the industries in each sector. Used in this analysis as a measure of sector-level output price increases.

Producer Price Index (PPI): A family of indexes that measures the average change over time in selling prices received by domestic producers of goods and services (Bureau of Labor Statistics, PPI Overview).

return on assets (ROA): The ratio of annual income to assets, a measure of profitability. In this analysis, measured as the ratio of pre-tax cash income divided by the book value of assets, as reported in the MP&M surveys.

specialization ratio: The ratio of primary product shipments to total product shipments (primary and secondary, excluding miscellaneous receipts) for the establishments classified in a particular industry (4-digit SIC code). An industry with a specialization ratio of 100 percent would, by definition, produce only its primary products. In contrast, a low specialization ratio indicates that much of an industry's output consists of secondary products.

sunk costs: The portion of fixed costs that is not recoverable.

vertical integration: Production by a single firm in different stages of production in the same industry. For example, a vertically-integrated petroleum company would explore for and extract crude oil, refine the oil, distribute the petroleum-based products, and sell gasoline and other products to end-users.

ACRONYMS

ECI: Employment Cost Index
PPI: Producer Price Index
ROA: return on assets
SIC: Standard Industrial Classification

REFERENCES

U.S. Bureau of Labor Statistics. *Producer Price Index Revision-Current Series*. On-line database at http://stats.bls.gov/ppihome.htm

U.S. Bureau of Labor Statistics. 2000. *Employment Cost Index - Historical Listing*. July 27. http://stats.bls.gov/ecthome.htm.

U.S. Department of Commerce (1997). Bureau of Economic Analysis, *The 1992 Benchmark Input-Output Accounts of the United States*.

Appendix C: POTW Administrative Costs

Introduction

Effluent guidelines and limitations are implemented by Federal, State and local government entities through the NPDES permit program (for direct dischargers) and the General Pretreatment Regulations (for indirect dischargers). A new effluent guideline rule may require that some facilities be permitted for the first time, may require that some facilities that already have permits be issued a different form of permit, and may require repermitting of facilities sooner than would otherwise be required. In these cases, the permitting authority will incur additional costs to implement the effluent guideline rule. This appendix provides information on the unit costs of these permitting activities, based on information reported by POTWs in the Metal Products and Machinery (MP&M) POTW Survey, and describes the calculation of government permitting costs for the proposed MP&M rule and regulatory alternatives.

The first section of this appendix provides an overview of permitting requirements under the NPDES Permit Program and the General Pretreatment Regulations. The second section describes the MP&M POTW Survey and the methods used to develop unit cost estimates from the survey responses. The third section presents the estimates of unit costs by permitting activity, and the final section lists the steps involved in applying these unit costs to calculate administrative costs for a particular regulatory option.

Appendix Contents:

C.1 Effluent Guidelines Permitting Requirements

Any facility that directly discharges wastewater to surface water is required to have a permit issued under the National Pollution Discharge Elimination System (NPDES) permit program. Facilities that discharge indirectly through a publicly-owned treatment works (POTW) are regulated by the General Pretreatment Regulations for Existing and New Sources of Pollution (40 CFR Part 403). The major portion of government administrative costs associated with implementing an effluent guidelines rule are the costs of managing the NPDES and Pretreatment programs for the regulated facilities. Permitting under these two programs is discussed below.

C.1.1 NPDES Basic Industrial Permit Program

Effluent guidelines Best Available Technology (BAT) and New Source Performance Standards (NSPS) regulations will be implemented through the NPDES industrial permit program. In general, EPA does not expect the administrative costs associated with the NPDES industrial permit program to increase as a result of the proposed MP&M rule. The Clean Water Act prohibits discharge of any pollutant to a water of the U.S. except as permitted by a NPDES permit. Therefore, every facility that discharges wastewater directly to surface water must hold a permit specifying the mass of pollutants that can be discharged to waterways. The proposed rule will affect the terms of the permits but is unlikely to increase the administrative costs associated with permitting.

In fact, the proposed rule may decrease the administrative burden of NPDES permits. The technical guidance provided by EPA as a component of rulemaking provides valuable information to permitting authorities that is likely to reduce the research required to develop Best Professional Judgment (BPJ) permits.[1] Further, establishing discharge

[1] Permits issued to facilities not covered by effluent guidelines or water quality-based standards are developed based on BPJ.

standards may reduce time spent by permitting authorities establishing limits and the frequency of evidentiary hearings. The promulgation of limitations may also enable EPA and the authorized States to cover more facilities under general permits. General permits are single permits covering a common class of dischargers in a specified geographic area.

C.1.2 Pretreatment Program

The General Pretreatment Regulations (40 CFR Part 403) establish procedures, responsibilities, and requirements for EPA, States, local governments, and industry to control pollutant discharges to POTWs. Under the Pretreatment Regulations, POTWs or approved States implement categorical pretreatment standards (i.e., PSES and PSNS).

Discharges from an MP&M facility to a POTW may be permitted in the baseline.[2] For example, industrial users subject to another Categorical Pretreatment Standard would have a discharge permit. Other significant industrial users (SIU) that are typically permitted by POTWs include industrial users that:

- discharge an average of 25,000 gallons per day or more of process wastewater to a POTW,
- contribute a process waste stream that makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant, or
- have a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard.

EPA does not expect the costs of administering the pretreatment program to increase due to the MP&M regulation for facilities that already hold a permit specifying the allowable mass of pollutant discharge to water. Governments will incur additional permitting costs, however, for unpermitted facilities and for any facilities currently with a concentration-based permit that will be issued a mass-based permit under the proposed rule instead. The remainder of this section estimates these cost increases. As with direct industrial dischargers, promulgation of the MP&M rule may cause some administrative costs to decrease. EPA has not estimated potential reductions in government administrative costs.

[2] Under the General Pretreatment Program, a facility's discharges may be controlled through a "permit, order or similar means". For simplicity, this document refers to the control mechanism as a permit

C.2 METHODOLOGY

C.2.1 Data Sources

EPA collected information from Publicly Owned Treatment Works (POTWs) to support development of the MP&M effluent guideline. Of 150 surveys mailed, EPA received responses to 147, for a 98 percent response rate. The POTW survey asked respondents to provide information on administrative permitting costs, sewage sludge use and disposal costs and practices, and general information (including number of permitted users and number of known MP&M dischargers). The administrative cost information included the number of hours required to complete specific permitting and repermitting, inspection, monitoring, and enforcement activities. Respondents were also asked to provide an average labor cost for all staff involved in permitting activities. EPA used the survey responses on administrative costs to estimate a range of costs incurred by POTWs to permit a single MP&M facility.

C.2.2 Overview of Methodology

EPA estimated increases in government administrative costs only for indirect discharging MP&M facilities. This section describes the steps used to develop these estimates.

a. Determine the number and characteristics of indirect dischargers that will be permitted under the proposed rule.

The cost of permitting a given MP&M facility varies depending on whether the facility is already permitted. EPA has information from the MP&M facility surveys on baseline permit status. Because costs differ by type of permit (mass-based versus concentration-based), EPA determined how many permits of each type would be issued. All Steel Forming & Finishing facilities will require mass-based permits under the proposed rule. Mass-based permits are not required for the other subcategories. Permit writers can determine what type of permit is appropriate for facilities in subcategories other than Steel Forming & Finishing. EPA is encouraging permit writers and control authorities to issue mass-based permits and control mechanisms, however, where appropriate and feasible. For costing purposes, the analysis of permitting costs assumes that one-third of the new or reissued permits in subcategories other than Steel Forming & Finishing will be mass-based. To the degree that POTWs do not require mass-based permits in subcategories other than Steel Forming & Finishing, this analysis will overestimate administrative costs.

b. Use the data from the POTW survey to determine a high, middle, and low hourly burden for permitting a single facility.

EPA defined the low and high estimates of hours such that 90% of the POTW responses fell above the low value and 90% of responses fell below the high value. The median value is used to define the middle hourly burden.

c. Use the data from the POTW survey to determine the average frequency of performing certain administrative functions.

For administrative functions that are not performed at all facilities, survey data were used to calculate the portion of facilities requiring these functions. For example, the survey data show that on average 38.5% of facilities submit a non-compliance report.

d. Multiply the per-facility burden estimate by the average hourly wage.

EPA determined a high, middle and low dollar cost of administering the rule for a single facility by multiplying the per-facility hour burden by the average hourly wage. The POTW survey reported an average hourly labor rate of $36.98 ($1999) for staff involved in permitting. This is a fully-loaded cost, including salaries and fringe benefits.

e. Calculate the annualized cost of administering the rule.

The number of facilities, hourly burden estimate, frequency estimates, and hourly wage estimates are all combined to determine the total cost of administering the rule. The type of administrative activities required varies over time and the total administrative cost is calculated over a 15 year time period. EPA calculated the present value of total costs using a seven percent discount rate, and then annualized the present value using the same seven percent discount rate.

C.3 Unit Costs of Permitting Activities

This section presents unit costs for the following permitting activities:

- ***Permit application and issuance***: developing and issuing concentration-based permits at previously unpermitted facilities; developing and issuing mass-based permits at previously unpermitted facilities; developing and issuing mass-based permits at facilities with concentration-based permits; providing technical guidance; and conducting public and evidentiary hearings;

- ***Inspection***: inspecting facilities both for the initial permit development and to assess subsequent compliance;

- ***Monitoring***: sampling and analyzing permittee's effluent; reviewing and recording permittee's compliance self-monitoring reports; receiving, processing, and acting on a permittee's non-compliance reports; and reviewing a permittee's compliance schedule report for permittees in compliance and permittees not in compliance;

- ***Enforcement***: issuing administrative orders and administrative fines; and

- ***Repermitting***.

EPA believes that these functions constitute the bulk of the required administrative activities. EPA recognizes that there are other relatively minor or infrequent administrative functions (e.g., identifying facilities to be permitted, providing technical guidance to permittees in years other than the first year of the permit, or repermitting a facility in significant non-compliance) but expects the associated costs to be insignificant compared to the estimated costs for the five major categories outlined above.

For each major administrative function, this section provides below: (1) a description of the activities involved, (2) the estimated percentage of facilities that require the administrative function; (3) the frequency with which the function is performed, and (4) high, medium and low estimates of per facility hours and costs.

C.3.1 Permit Application and Issuance

Before issuing a wastewater discharge permit to a facility, the permit authority typically inspects the facility, monitors the facility's wastewater, and completes pollutant limits calculations and permit paperwork. This section discusses the costs of completing limits calculations and paperwork; subsequent sections address inspection and monitoring costs. This section also discusses the costs of technical assistance that the control authority may provide facilities to facilitate compliance with new limits. Finally, this section includes the costs of public and evidentiary hearings that may be required for some permits.

a. Issue a concentration-based permit at a previously unpermitted facility

To issue a concentration-based permit, permit authorities first review permit applications for completeness. If an application is incomplete, the authorities notify the applicant and request the missing information. Completed applications are assigned to permit writers, who review the applications in more detail as they develop permit conditions. The effort required to complete these activities depends, in part, on the extent to which the permit authority has automated the permitting process.

EPA assumed that one-third of facilities are permitted in each of the three years following the rule's effective date because compliance is mandated within three years of the date the standard is effective (40 CFR Section 403.6). EPA further assumed that facilities are repermitted in five year cycles. (The administrative costs of repermitting are discussed separately below.) The actual number of facilities that are permitted each year is likely to differ somewhat from EPA's simplifying assumption. The Agency would prefer to receive baseline facility monitoring reports from all facilities early in the permitting process. Control authorities are then expected to place a priority on issuing mass-based permits. These minor differences in permit timing are not expected to significantly change the estimated administrative costs.

Table C.1: Administrative Activity: Develop and issue a concentration-based permit at a previously unpermitted facility

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
100% of unpermitted MP&M facilities that will be issued a concentration-based permit (for costing purposes, this is assumed to be 2/3 of all facilities being issued a permit for the first time)	One time	3.7 hours; $137	9.7 hours; $359	30.7 hours; $1,1345

b. Issue a mass-based permit for a previously unpermitted facility

The administrative activities required to issue a concentration-based permit are also required for a mass-based permit. In addition, for mass-based permits issued under the MP&M rule, the permit writer must determine whether the facility practices pollution prevention and water conservation methods equivalent to those specified as the basis for BPT. If so, the permitting authority must determine the facility's historical flow rate. If not, the authority must derive a mass-based limit based on other factors such as production rates. When a facility matches BPT water conservation practices and provides historic flow data, development of a mass-based permit is a relatively straight-forward process. However, the task will be more challenging at a facility practicing only limited water conservation, particularly if the facility has multiple production units and generates integrated process and sanitary wastewaters.

Table C.2: Administrative Activity: Develop and issue a mass-based permit at a previously unpermitted facility

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
100% of unpermitted MP&M facilities that will be issued a mass-based permit (for costing purposes, this is assumed to be 1/3 of all facilities being issued a permit for the first time)	One time	4.0 hours; $148	12.0 hours; $444	40.0 hours; $1,479

c. Issue a mass-based permit for a facility with a concentration-based permit

Some of the activities described above for issuing a mass-based permit will be simplified in cases where the facility already holds a concentration-based permit. For example, much of the basic information required in the permitting application will already be in the permitting authorities' records. However, the potentially labor-intensive task of determining the flow basis for the permit remains.

Table C.3: Administrative Activity: Develop and issue a mass-based permit at a facility holding a concentration-based permit				
Percent of facilities for which activity is required	**Frequency of activity**	**Typical costs**		
		Low	**Median**	**High**
100% of Steel Forming & Finishing facilities that currently have a concentration-based permit, plus 1/3 of all other MP&M facilities that currently hold a concentration-based permit	One time	2.0 hours; $74	8.0 hours; $296	21.0 hours; $777

d. Provide technical guidance to a permittee

Technical guidance is frequently provided by permit authorities to permittees concurrent with the issuance of a new permit. There are no legal requirements that a permit authority provide a permittee with technical guidance. However, such guidance is generally in the interest of all parties as it can expedite the permitting process, accelerate the permittee's compliance, and reduce the compliance burden. The extent of technical guidance provided varies dramatically among permit authorities. In some cases, a permit authority may hold a one-day workshop to provide information on a new pretreatment standard to facilities. In other cases, a permit authority may meet extensively with individual permittees to educate them regarding their responsibilities under pretreatment standards. The range of technical guidance appears to depend on whether the permittee already has a wastewater permit, whether the permittee is part of a multi-facility company, the resources of the permit authority, and the extent to which the permit authority has written or standardized guidance available for dissemination.

EPA assumed that permit authorities provide technical guidance to all facilities being issued a new mass-based or concentration-based permit under the MP&M pretreatment standards. Costs for technical guidance were estimated separately for facilities receiving a concentration-based permit and facilities receiving a mass-based permit. EPA assumed that technical guidance is provided in the year the initial permit is issued.

Table C.4: Administrative Activity: Provide technical guidance to permittee on permit compliance				
Percent of facilities for which activity is required	**Frequency of activity**	**Typical costs**		
		Low	**Median**	**High**
100% of MP&M facilities being issued a new concentration-based permit	One time	1.0 hour; $37	3.3 hours; $122	10.7 hours; $396
100% of MP&M facilities being issued a new mass-based permit	One time	2.0 hours; $74	3.7 hours; $137	13.0 hours; $481

e. Conduct a public or evidentiary hearing on a proposed permit

Federal regulations provide for a period during which the public may submit written comments on a proposed permit for direct dischargers and/or request that a public hearing be held. Permitting authorities for indirect dischargers may have the same requirements. Thus, proposed permits for indirect dischargers may be subject to public comments and hearings. Pretreatment public hearings are typically conducted at a scheduled local government (e.g., City Council) meeting. The meetings may require substantial preparation.

Federal regulations also provide for evidentiary hearings following final permit determination for direct dischargers. Again, permitting authorities for indirect dischargers may have these requirements as well. Thus, final permit determinations for indirect dischargers may be subject to evidentiary hearings.

Data from the POTW survey indicated that a public or evidentiary hearing would be required for 3.6% of indirect dischargers being issued a new mass-based or concentration-based permit, on average.

Table C.5: Administrative Activity: Conduct a public or evidentiary hearing				
Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
3.6% of MP&M facilities being issued a new mass-based or concentration-based permit	One time	2.3 hours; $85	8.0 hours; $296	33.3 hours; $1,231

C.3.2 Inspection

Permit authorities may choose to integrate their inspection and monitoring work force or to administer these functions separately. This discussion covers inspections only; monitoring is discussed below. Inspections are performed both to assess conditions for initial permitting and to evaluate compliance with permit requirements. Inspections involve record reviews, visual observations, and evaluations of the treatment facilities, effluents, receiving waters, etc. EPA assumed that the initial inspection would occur in the same year a new permit is issued, and that all permitted facilities would be inspected annually to assess compliance.

Table C.6: Administrative Activity: Inspect facility for permit development				
Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
100% of MP&M facilities being issued a new permit	One Time	2.3 hours; $85	4.7 hours; $174	12 hours; $444

Table C.7: Administrative Activity: Inspect facility for compliance assessment				
Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
100% of MP&M facilities being issued a new permit	Annual	1.8 hours; $67	3.7 hours; $137	10.0 hours; $370

C.3.3 Monitoring

Permitting authorities monitor facilities both to gather data needed for permit development and to assess compliance with permit conditions. Monitoring includes sampling and analysis of the permittee's effluent, review of the permittee's compliance self-monitoring reports, receipt of non-compliance reports, and review of compliance schedule reports. These activities are discussed below.

a. Sample and analyze permittee s effluent

As noted above, inspection and monitoring staff may be integrated or distinct. The costs of inspection were presented above. Federal regulations require that the permit authority "randomly sample and analyze the effluent from industrial users...independent of information supplied by industrial users" (40 CFR Part 403.8). The permit authority obtains samples required by the permit and performs chemical analyses. The results are used to verify the accuracy of the permittee's self-monitoring program and reports, determine the quantity and quality of effluents, develop permits, and provide evidence for enforcement proceedings where appropriate.

EPA estimated sampling costs for all facilities issued a new permit under the MP&M rule, and assumed annual monitoring. Although EPA requires only annual effluent sampling, some localities sample more frequently. EPA encourages this practice.

Table C.8: Administrative Activity: Sample and analyze permittee s effluent				
Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
100% of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	3.0 hours; $111	14.0 hours; $518

b. Review and record permittee s compliance self-monitoring reports

40 CFR Part 403.12 specifies that: "Any Industrial User subject to a categorical pretreatment standard...shall submit to the Control authority during the months of June and December...a report indicating the nature and concentration of pollutants in the effluent which are limited by such categorical pretreatment standards." The permit authority briefly reviews these submissions and may enter the information into a computerized system and/or file the data.

EPA estimated the costs of handling annual self-monitoring reports for all facilities being issued a new permit under the MP&M rule.

Table C.9: Administrative Activity: Review and enter data from permittee s compliance self-monitoring reports

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
100% of MP&M facilities being issued a new permit	Annual	0.5 hours; $18	1.0 hour; $37	3.5 hours; $129

c. Receive, process, and act on a permittee s non-compliance report

Generally, when a permittee violates a permit condition, it must submit a non-compliance report to the permit authority. Permittees report both unanticipated bypasses or upsets and violations of maximum daily discharge limits. The permit authority receives and processes both verbal and written non-compliance reports. In some cases, immediate action by the permit authority is required to mitigate the problem.

Data from the POTW survey indicate that 38.5 percent of all facilities submit at least one non-compliance report annually. Of facilities that submit at least one non-compliance report, the median number of reports filed per year is 5 reports.

Table C.10: Administrative Activity: Receive, process and act on a permittee s non-compliance reports

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
38.5% of all indirect dischargers receiving a new permit.	5 times per year	1.0 hour; $37	2.0 hours; $74	5.7 hours; $211

d. Review a permittee s compliance schedule report

Permittees submit reports to permit authorities that state whether compliance schedule milestones contained in their permits have been met. If the facility is in compliance, the permit authority reviews and files the report.

Data from the POTW survey indicate that approximately 17% of all facilities are issued compliance milestones. Of these facilities, 94% meet the milestones. Facilities submit an average of two compliance milestone reports per year. The cost of handling the report depends on whether the facility is in compliance with the schedule.

Table C.11: Administrative Activity: Review a compliance schedule report

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
Meeting milestones: 16.0% of all facilities issued a new permit (94% of the 17% who have compliance milestones).	2 reports per year	0.5 hours; $18	1.0 hour; $37	3.0 hours; $111
Not meeting milestones: 1% of all facilities issued a new permit (6% of the 17% who have compliance milestones).	2 reports per year	0.8 hours; $30	1.8 hours; $67	6.0 hours; $222

C.3.4 Enforcement

When a permitting authority identifies a permit violation, the authority determines and implements an appropriate enforcement action. Considerations when determining enforcement response include (1) the severity of the permit violation, (2) the degree of economic benefit obtained by the permittee through the violation, (3) previous enforcement actions taken against the violator, (4) the deterrent effect of the response on similarly situated permittees, and (5) considerations of fairness and equity. EPA estimated administrative costs for two levels of enforcement actions: (1) less severe actions such as issuing an administrative order, and (2) more severe activities such as levying an administrative fine.

EPA estimated that, annually, seven percent of facilities issued a new permit under the MP&M rule will require a minor enforcement action, such as issuing an administrative compliance order. In addition, EPA estimated that seven percent of facilities receiving a new permit will require more severe enforcement actions such as a fine or penalty.

Table C.12: Administrative Activity: Minor enforcement action e.g., issue an administrative order

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
Seven percent of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	3.7 hours; $137	13.3 hours; $492

Table C.13: Administrative Activity: Minor enforcement action, e.g., impose an administrative fine

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
Seven percent of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	5.3 hours; $196	24.7 hours; $913

C.3.5 Repermitting

The duration of permits cannot exceed five years. Renewing a permit for a facility in compliance with an existing permit is expected to be a relatively straightforward task. The data required in the permit application generally requires few changes, although pollutant limits may need to be recalculated in some cases. The labor required for repermitting depends, in part, on the extent to which the permit authority has automated the paperwork.

Table C.14: Administrative Activity: Repermit

Percent of facilities for which activity is required	Frequency of activity	Typical costs		
		Low	Median	High
100% of MP&M facilities being issued a new permit	every 5 years	1.0 hour; $37	4.0 hours; $148	17.0 hours; $629

C.4 POTW Administrative Costs by Option

Exhibits C.1 through C.7 at the end of this chapter present the calculation of POTW permitting costs for the proposed rule and the two regulatory alternatives considered by EPA.

Exhibit C1 provides an overview of the permitting activities, the estimated percentage of facilities that require the administrative function, the frequency with the function is performed, and per facility hours and costs for each function.

Exhibit C.2 contains the per facility hour burden and other assumptions described above for each of the three types of permitting (new concentration-based permit, new mass-based permit, and converting a concentration-based to a mass-based permit.)

Exhibits C.3 through C.5 show hours by type of permit for the low, medium, and high estimate of per-facility burden, respectively. These exhibits also summarize costs and dollars by year and permit type.

Exhibit C.6 presents the number of facilities requiring different types of permitting, for each of the regulatory options. The exhibit shows the total number of facilities that will be subject to requirements, the baseline permit status of those facilities, and the number of facilities by expected post-compliance permit status. These estimates are based on facility survey information about baseline permit status, the results of the facility impact analysis described in Chapter 5, and EPA's assumption for costing purposes that as many as one-third of all MP&M facilities (except Steel Forming & Finishing) could be issued mass-based permits by the permitting authority. The exhibit also shows the number of currently-permitted facilities that are projected to close as a result of the rule, and which will therefore no longer require permitting.

Finally, Exhibit C.6 shows the resulting calculation of POTW administrative hours and costs by year for each regulatory option. This exhibit also shows the present value of these costs, the annualized cost, and the maximum hours and costs incurred in any one year, for each option. These calculations reflect the incremental number of facilities requiring different types of permitting, inspection, monitoring, enforcement and repermitting in each year multiplied by the unit hours and cost per facility for those activities. All facilities are assumed to receive a permit under the proposed rule within the three-year compliance period. Some facilities with existing permits are repermitted sooner than they otherwise would be on the normal five-year permitting cycle. The cost analyses calculates incremental costs by subtracting the costs of repermitting these facilities on a five-year schedule from the costs of repermitting all such facilities within three years. EPA assumes that the required initial permitting activities will be equally divided over the three-year period. The analysis also calculates the net increase in the number of facilities requiring permitting by subtracting the number of facilities that close due to the rule from the number of facilities that will require new permits under the proposed rule.

More detailed information on these cost calculations is provided in the docket for the proposed rule.

APPENDIX C EXHIBITS

Exhibit C.1: Government Administrative Activities for Indirect Dischargers: Per Facility Hours and Costs

Administrative Activity	Percent of facilities for which activity is required	Frequency of activity	Typical hours and costs		
			Low	Median	High
Develop and issue a concentration-based permit at a previously unpermitted facility	100% of unpermitted facilities being issued a new concentration-based permit (2/3 of new permits)	One time	3.7 hours; $137	9.7 hours; $359	30.7 hours; $1,135
Develop and issue a mass-based permit at a previously unpermitted facility	100% of unpermitted MP&M facilities being issued a new mass-based permit (1/3 of new permits)	One time	4.0 hours; $148	12.0 hours; $444	40.0 hours; $1,479
Develop and issue a mass-based permit at a facility holding a concentration-based permit	All Steel Forming & Finishing facilities with a concentration-based permits and 1/3 of other facilities with a concentration-based permit	One time	2.0 hours; $74	8.0 hours; $296	21.0 hours; $777 year
Provide technical guidance to a permittee on permit compliance	100% of MP&M facilities being issued a new concentration-based permit	One time	1.0 hour; $37	3.3 hours; $122	10.7 hours; $396
	100% of MP&M facilities being issued a new mass-based permit	One time	2.0 hours; $74	3.7 hours; $137	13.0 hours; $481
Conduct a public or evidentiary hearing	3.2% of MP&M facilities being issued a new mass-based or concentration-based permit	One time	2.3 hours; $85	8.0 hours; $296	33.3 hours; $1,231
Inspect facility for permit development	100% of MP&M facilities being issued a new permit	One Time	2.3 hours; $85	4.7 hours; $174	12.0 hours; $444
Inspect facility for compliance assessment	100% of MP&M facilities being issued a new permit	Annual	1.8 hours; $67	3.7 hours; $137	10.0 hours; $370
Sample and analyze permittee's effluent	100% of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	3.0 hours; $111	14.0 hours; $518
Review and enter data from permittee's compliance self-monitoring reports	100% of MP&M facilities being issued a new permit	Annual	0.5 hours; $18	1.0 hour; $37	3.5 hours; $129
Receive, process and act on a permittee's non-compliance reports	38.5% of all indirect dischargers receiving a new permit.	5 times per year	1.0 hour; $37	2.0 hours; $74	5.7 hours; $211
Review a compliance schedule report	Meeting milestones: 16.0% of all facilities issued a new permit (94% of the 17% who have compliance milestones).	2 reports per year	0.5 hours; $18	1.0 hour; $37	3.0 hours; $111
	Not meeting milestones: 1% of all facilities issued a new permit (6% of the 17% who have compliance milestones).	2 reports per year	0.8 hours; $30	1.8 hours; $67	6.0 hours; $222
Minor enforcement action e.g., issue an administrative order	7% of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	3.7 hours; $137	13.3 hours; $492
Minor enforcement action, e.g., impose an administrative fine	7% of MP&M facilities being issued a new permit	Annual	1.0 hour; $37	5.3 hours; $196	24.7 hours; $913
Repermit	100% of MP&M facilities being issued a new permit	Every 5 years	1.0 hour; $37	4.0 hours; $148	17.0 hours; $629

Exhibit C.2: Per-Facility Hours and Assumptions

Activity	Low	Medium	High	% Facil	x/yr	Notes
New concentration-based permit						
develop and issue permit	3.7	9.7	30.7	100.0%	1	one-time
provide technical guidance	1.0	3.3	10.7	100.0%	1	one-time
conduct public or evidentiary hearings	2.3	8.0	33.3	3.2%	1	one-time, 3.2% of facilities
inspection for permit development	2.3	4.7	12.0	100.0%	1	one-time
inspection for compliance assessment	1.8	3.7	10.0	100.0%	1	annual
sample and analyze effluent	1.0	3.0	14.0	100.0%	1	annual
review & record self-monitoring reports	0.5	1.0	3.5	100.0%	1	annual
process & act on non-compliance reports	1.0	2.0	5.7	38.5%	5	5x/year, 38.5% of facilities
review compliance schedule report - in compliance with schedule	0.5	1.0	3.0	16.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 94% in compliance
review compliance schedule report - not in compliance with schedule	0.8	1.8	6.0	1.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 6% not in compliance
minor enforcement action (e.g., admin order)	1.0	3.7	13.3	7.0%	1	annual, 7% of facilities
minor enforcement action (e.g., admin fine)	1.0	5.3	24.7	7.0%	1	annual, 7% of facilities
repermit	1.0	4.0	17.0	100.0%	1	every three years
New mass-based permit						
develop and issue permit	4.0	12.0	40.0	100.0%	1	one-time
provide technical guidance	2.0	3.7	13.0	100.0%	1	one-time
conduct public or evidentiary hearings	2.3	8.0	33.3	3.2%	1	one-time, 3.2% of facilities
inspection for permit development	2.3	4.7	12.0	100.0%	1	one-time
inspection for compliance assessment	1.8	3.7	10.0	100.0%	1	annual
sample and analyze effluent	1.0	3.0	14.0	100.0%	1	annual
review & record self-monitoring reports	0.5	1.0	3.5	100.0%	1	annual
process & act on non-compliance reports	1.0	2.0	5.7	38.5%	5	5x/year, 38.5% of facilities
review compliance schedule report - in compliance with schedule	0.5	1.0	3.0	16.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 94% in compliance
review compliance schedule report - not in compliance with schedule	0.8	1.8	6.0	1.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 6% not in compliance
minor enforcement action (e.g., admin order)	1.0	3.7	13.3	7.0%	1	annual, 7% of facilities
minor enforcement action (e.g., admin fine)	1.0	5.3	24.7	7.0%	1	annual, 7% of facilities
repermit	1.0	4.0	17.0	100.0%	1	every three years
Converting concentration-based to mass-based						
develop and issue permit	2.0	8.0	21.0	100.0%	1	one-time
provide technical guidance						
conduct public or evidentiary hearings						
inspection for permit development						
inspection for compliance assessment	1.8	3.7	10.0	100.0%	1	annual
sample and analyze effluent	1.0	3.0	14.0	100.0%	1	annual
review & record self-monitoring reports	0.5	1.0	3.5	100.0%	1	annual
process & act on non-compliance reports	1.0	2.0	5.7	38.5%	5	5x/year, 38.5% of facilities
review compliance schedule report - in compliance with schedule	0.5	1.0	3.0	16.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 94% in compliance
review compliance schedule report - not in compliance with schedule	0.8	1.8	6.0	1.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 6% not in compliance
minor enforcement action (e.g., admin order)	1.0	3.7	13.3	7.0%	1	annual, 7% of facilities
minor enforcement action (e.g., admin fine)	1.0	5.3	24.7	7.0%	1	annual, 7% of facilities
repermit	1.0	4.0	17.0	100.0%	1	every three years

Source: estimates of hours by activity and average hourly rate from the 1996 MP&M POTW Survey.
Discount rate: *7%*
Average hourly rate: *$36.98* (1999$)

Exhibit C.3: Low Estimate of Hours and Costs per Facility (average considering frequency of activity and percent of facilities requiring activity)			
Activity	**Initial Year**	**Annual (non-permitting year)**	**Repermit Year**
New concentration-based permit			
develop and issue permit	4		
provide technical guidance	1		
conduct public or evidentiary hearings	0		
inspection for permit development	2		
inspection for compliance assessment	2	2	2
sample and analyze effluent	1	1	1
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	2	2	2
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			1
Total Hours by Year	*13*	*6*	*7*
Total Dollars by Year	*$466*	*$205*	*$242*
New mass-based permit			
develop and issue permit	4		
provide technical guidance	2		
conduct public or evidentiary hearings	0		
inspection for permit development	2		
inspection for compliance assessment	2	2	2
sample and analyze effluent	1	1	1
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	2	2	2
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			1
Total Hours by Year	*14*	*6*	*7*
Total Dollars by Year	*$515*	*$205*	*$242*
Upgrading from concentration-based to mass-based			
develop and issue permit	2		
provide technical guidance	0		
conduct public or evidentiary hearings	0		
inspection for permit development	0		
inspection for compliance assessment	2	2	2
sample and analyze effluent	1	1	1
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	2	2	2
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			1
Total Hours by Year	*8*	*6*	*7*
Total Dollars by Year	*$279*	*$205*	*$242*

annualized over 15 year period at 7 %

Exhibit C.4: Medium Estimate of Hours and Costs per Facility (average considering frequency of activity and percent of facilities requiring activity)			
Activity	**Initial Year**	**Annual (non-permitting year)**	**Repermit Year**
New concentration-based permit			
develop and issue permit	10		
provide technical guidance	3		
conduct public or evidentiary hearings	0		
inspection for permit development	5		
inspection for compliance assessment	4	4	4
sample and analyze effluent	3	3	3
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	4	4	4
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			4
Total Hours by Year	*30*	*13*	*17*
Total Dollars by Year	*$1,128*	*$464*	*$612*
New mass-based permit			
develop and issue permit	12		
provide technical guidance	4		
conduct public or evidentiary hearings	0		
inspection for permit development	5		
inspection for compliance assessment	4	4	4
sample and analyze effluent	3	3	3
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	4	4	4
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			4
Total Hours by Year	*33*	*13*	*17*
Total Dollars by Year	*$1,227*	*$464*	*$612*
Upgrading from concentration-based to mass-based			
develop and issue permit	8		
provide technical guidance	0		
conduct public or evidentiary hearings	0		
inspection for permit development	0		
inspection for compliance assessment	4	4	4
sample and analyze effluent	3	3	3
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	4	4	4
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			4
Total Hours by Year	*21*	*13*	*17*
Total Dollars by Year	*$759*	*$464*	*$612*

annualized over 15 year period at 7 %

Exhibit C.5: High Estimate of Hours and Costs per Facility
(average considering frequency of activity and percent of facilities requiring activity)

Activity	Initial Year	Annual (non-permitting year)	Repermit Year
New concentration-based permit			
develop and issue permit	31		
provide technical guidance	11		
conduct public or evidentiary hearings	1		
inspection for permit development	12		
inspection for compliance assessment	10	10	10
sample and analyze effluent	14	14	14
review & record self-monitoring reports	4	4	4
process & act on non-compliance reports	11	11	11
review compliance schedule report - in compliance with schedule	1	1	1
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	1	1	1
minor enforcement action (e.g., admin fine)	2	2	2
repermit			17
Total Hours by Year	*97*	*42*	*59*
Total Dollars by Year	*$3,575*	*$1,561*	*$2,190*
New mass-based permit			
develop and issue permit	40		
provide technical guidance	13		
conduct public or evidentiary hearings	1		
inspection for permit development	12		
inspection for compliance assessment	10	10	10
sample and analyze effluent	14	14	14
review & record self-monitoring reports	4	4	4
process & act on non-compliance reports	11	11	11
review compliance schedule report - in compliance with schedule	1	1	1
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	1	1	1
minor enforcement action (e.g., admin fine)	2	2	2
repermit			17
Total Hours by Year	*108*	*42*	*59*
Total Dollars by Year	*$4,004*	*$1,561*	*$2,190*
Upgrading from concentration-based to mass-based			
develop and issue permit	21		
provide technical guidance	0		
conduct public or evidentiary hearings	0		
inspection for permit development	0		
inspection for compliance assessment	10	10	10
sample and analyze effluent	14	14	14
review & record self-monitoring reports	4	4	4
process & act on non-compliance reports	11	11	11
review compliance schedule report - in compliance with schedule	1	1	1
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	1	1	1
minor enforcement action (e.g., admin fine)	2	2	2
repermit			17
Total Hours by Year	*63*	*42*	*59*
Total Dollars by Year	*$2,338*	*$1,561*	*$2,190*

annualized over 15 year period at 7 %

Exhibit C.6: Number of Facilities Requiring Additional Permitting

Proposed Rule	
Number of facilities operating post-regulation requiring a permit	**4,944**
Of facilities operating post-regulation:	
existing concentration-based	629
existing mass-based	3,667
no permit in baseline	648
concentration based to be converted to mass-based	223
new concentration-based	432
new mass-based	216
Number of currently permitted facilities closing (no longer requiring a permit)	**143**
Of facilities closing due to the rule:	
existing concentration-based	12
existing mass-based	131

Option 2/6/10	
Number of facilities operating post-regulation requiring a permit	**53,009**
Of facilities operating post-regulation:	
existing concentration-based	25,232
existing mass-based	3,764
no permit in baseline	24,013
concentration based to be converted to mass-based	8,424
new concentration-based	16,009
new mass-based	8,004
Number of currently permitted facilities closing (no longer requiring a permit)	**1,020**
Of facilities closing due to the rule:	
existing concentration-based	889
existing mass-based	131

Option 4/8	
Number of facilities operating post-regulation requiring a permit	**51,344**
Of facilities operating post-regulation:	
existing concentration-based	25,226
existing mass-based	3,440
no permit in baseline	22,678
concentration based to be converted to mass-based	8,422
new concentration-based	15,119
new mass-based	7,559
Number of currently permitted facilities closing (no longer requiring a permit)	**1,348**
Of facilities closing due to the rule:	
existing concentration-based	894
existing mass-based	454

Exhibit C.7: POTW Administrative Costs by Option (@ 7% discount rate)

Proposed Rule

	Year Relative to Promulgation of Rule														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Hours															
High	29,254	36,360	43,466	6,225	6,225	34,241	34,241	34,241	6,225	6,225	34,241	34,241	34,241	6,225	6,225
Medium	8,658	10,768	12,879	2,780	2,780	9,372	9,372	9,372	2,780	2,780	9,372	9,372	9,372	2,780	2,780
Low	3,173	4,106	5,038	1,910	1,910	3,558	3,558	3,558	1,910	1,910	3,558	3,558	3,558	1,910	1,910
Total Costs															
High	$1,081,831	$1,344,609	$1,607,388	$230,212	$230,212	$1,266,244	$1,266,244	$1,266,244	$230,212	$230,212	$1,266,244	$1,266,244	$1,266,244	$230,212	$230,212
Medium	$320,171	$398,209	$476,248	$102,791	$102,791	$346,563	$346,563	$346,563	$102,791	$102,791	$346,563	$346,563	$346,563	$102,791	$102,791
Low	$117,330	$151,823	$186,316	$70,649	$70,649	$131,592	$131,592	$131,592	$70,649	$70,649	$131,592	$131,592	$131,592	$70,649	$70,649

	High	Medium	Low
NPV	$8,310,860	$2,483,585	$1,047,744
Max One Year Hours	43,466	12,879	5,038
Max One Year Costs	$1,607,388	$476,248	$186,316
Annualized Cost	$912,488	$272,684	$115,037

Option 2/6/10

	Year Relative to Promulgation of Rule														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Hours															
High	863,939	1,187,479	1,511,019	868,565	868,565	1,168,950	1,168,950	1,168,950	868,565	868,565	1,168,950	1,168,950	1,168,950	868,565	$868,565
Medium	272,917	368,999	465,082	264,235	264,235	334,913	334,913	334,913	264,235	264,235	334,913	334,913	334,913	264,235	$264,235
Low	109,027	151,496	193,965	121,404	121,404	139,073	139,073	139,073	121,404	121,404	139,073	139,073	139,073	121,404	$121,404
Total Costs															
High	$31,948,466	$43,912,970	$55,877,474	$32,119,541	$32,119,541	$43,227,754	$43,227,754	$43,227,754	$32,119,541	$32,119,541	$43,227,754	$43,227,754	$43,227,754	$32,119,541	$32,119,541
Medium	$10,092,463	$13,645,595	$17,198,727	$9,771,403	$9,771,403	$12,385,100	$12,385,100	$12,385,100	$9,771,403	$9,771,403	$12,385,100	$12,385,100	$12,385,100	$9,771,403	$9,771,403
Low	$4,031,823	$5,602,326	$7,172,829	$4,489,511	$4,489,511	$5,142,936	$5,142,936	$5,142,936	$4,489,511	$4,489,511	$5,142,936	$5,142,936	$5,142,936	$4,489,511	$4,489,511

	High	Medium	Low
NPV	$357,680,237	$107,121,278	$45,719,037
Max One Year Hours	1,511,019	465,082	193,965
Max One Year Costs	$55,877,474	$17,198,727	$7,172,829
Annualized Cost	$39,271,367	$11,761,340	$5,019,704

Option 4/8

	Year Relative to Promulgation of Rule														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Hours															
High	812,714	1,112,853	1,412,992	798,371	798,371	1,089,320	1,089,320	1,089,320	798,371	798,371	1,089,320	1,089,320	1,089,320	798,371	798,371
Medium	257,134	346,267	435,400	243,389	243,389	311,847	311,847	311,847	243,389	243,389	311,847	311,847	311,847	243,389	243,389
Low	102,504	141,902	181,299	112,189	112,189	129,304	129,304	129,304	112,189	112,189	129,304	129,304	129,304	112,189	112,189
Total Costs															
High	$30,054,148	$41,153,303	$52,252,458	$29,523,746	$29,523,746	$40,283,052	$40,283,052	$40,283,052	$29,523,746	$29,523,746	$40,283,052	$40,283,052	$40,283,052	$29,523,746	$29,523,746
Medium	$9,508,810	$12,804,958	$16,101,105	$9,000,507	$9,000,507	$11,532,108	$11,532,108	$11,532,108	$9,000,507	$9,000,507	$11,532,108	$11,532,108	$11,532,108	$9,000,507	$9,000,507
Low	$3,790,616	$5,247,531	$6,704,445	$4,148,760	$4,148,760	$4,781,660	$4,781,660	$4,781,660	$4,148,760	$4,148,760	$4,781,660	$4,781,660	$4,781,660	$4,148,760	$4,148,760

	High	Medium	Low
NPV	$332,591,953	$99,684,264	$42,526,298
Max One Year Hours	1,412,992	435,400	181,299
Max One Year Costs	$52,252,458	$16,101,105	$6,704,445
Annualized Cost	$36,516,809	$10,944,796	$4,669,159

Appendix D: Baseline and Post-Compliance Pollutant Loads

INTRODUCTION

This appendix provides detailed information on baseline and post-compliance pollutant discharges by pollutant type, subcategory and discharge status. The reported loadings for indirect dischargers are facility discharges, and do not take account of POTW removals. The data include only loadings from water-discharging facilities potentially subject to the proposed MP&M regulation. They exclude discharges from facilities that are projected to close in the baseline, as described in Chapter 5 of the EEBA. Post-compliance discharges under the proposed rule include no change in loadings for facilities excluded under the rule by the subcategory exclusions or the low flow cutoffs, and include zero discharges for facilities that are projected to close due to the rule. Loadings are reported both as pounds of pollutant and as toxic-weighted pound-equivalents. The unweighted pounds are not summed across the types of pollutants to show total pollutant dischargers because some of the non-toxic pollutant categories overlap. These categories have zero toxic weights, so that the overlap does not cause double-counting when summing toxic-weighted pounds-equivalent.

APPENDIX CONTENTS:

Table D.1: Baseline Toxic-Weighted Discharges by Type of Pollutant for Facilities Regulated under the Proposed Rule Direct Dischargers[a] (Pounds Equivalent)

	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants			
Subcategory	Metals	Organics	Cyanide	Metals	Organics	COD	Oil & Gas	TSS	Total
General Metals	298,514	44,397	6,254	311,753	20,694	0	0	0	681,612
Metal Finishing Job Shop	3,897	410	6,288	4,364	193	0	0	0	15,152
Non-Chromium Anodizing									
Printed Wiring Board	21,484	717	1,809	29,310	6,020	0	0	0	59,340
Steel Forming & Finishing	50,190	7,529	2,496	61,415	3,342	0	0	0	124,972
Oily Waste	7,695	1,859	33	10,677	795	0	0	0	21,059
Railroad Line Maintenance	532	120	0	410	66	0	0	0	1,128
Shipbuilding Dry Dock	950	233	0	530	102	0	0	0	1,815
All Categories	383,262	55,265	16,880	418,459	31,212	0	0	0	905,078

a. Excludes discharges from facilities that are projected to close in the baseline.

Source: U.S. EPA analysis.

Table D.2: Post-Compliance Toxic-Weighted Discharges by Type of Pollutant: Proposed Rule Direct Dischargers[a] (Pounds Equivalent)

	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants			
Subcategory	Metals	Organics	Cyanide	Metals	Organics	COD	Oil & Gas	TSS	Total
General Metals	50,763	9,923	2,772	45,828	5,890	0	0	0	115,176
Metal Finishing Job Shop	401	47	41	508	191	0	0	0	1,188
Non-Chromium Anodizing									
Printed Wiring Board	3,761	564	331	4,192	3,075	0	0	0	11,923
Steel Forming & Finishing	16,039	4,655	1,268	17,333	1,957	0	0	0	41,252
Oily Waste	3,870	1,237	26	16,817	585	0	0	0	22,535
Railroad Line Maintenance	602	174	0	419	72	0	0	0	1,267
Shipbuilding Dry Dock	894	243	0	656	103	0	0	0	1,896
All Categories	76,330	16,843	4,438	85,753	11,873	0	0	0	195,237

a. Excludes discharges from facilities that are projected to close in the baseline.
Source: U.S. EPA analysis.

Table D.3: Baseline Pollutant Discharges by Type of Pollutant for Facilities Regulated under the Proposed Rule Direct Dischargers[a] (Pounds)

	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants		
Subcategory	Metals	Organics	Cyanide	Metals	Organics	COD	Oil & Gas	TSS
General Metals	766,448	286,837	5,686	4,331,006	4,782,918	176,757,897	5,392,931	9,407,387
Metal Finishing Job Shop	14,521	1,836	5,716	27,813	3,804	266,693	16,574	17,747
Non-Chromium Anodizing								
Printed Wiring Board	53,752	4,406	1,645	221,206	30,203	1,722,113	261,999	100,432
Steel Forming & Finishing	108,058	38,894	2,269	688,851	129,267	6,044,202	195,070	873,450
Oily Waste	9,170	9,406	30	599,419	125,673	6,406,304	964,705	413,961
Railroad Line Maintenance	455	604	0	54,261	988	169,844	51,978	18,180
Shipbuilding Dry Dock	2,466	1,875	0	86,024	4,524	976,452	8,496,729	18,402
All Categories	954,870	343,858	15,346	6,008,580	5,077,377	192,343,505	15,379,986	10,849,559

a. Excludes discharges from facilities that are projected to close in the baseline.
Source: U.S. EPA analysis.

Table D.4: Post-Compliance Pollutant Discharges by Type of Pollutant: Proposed Rule Direct Dischargers[a] (Pounds)

Subcategory	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants		
	Metals	Organics	Cyanide	Metals	Organics	COD	Oil & Gas	TSS
General Metals	47,761	66,405	2,520	1,118,109	114,424	5,220,923	298,025	313,681
Metal Finishing Job Shop	399	260	38	7,796	837	46,895	2,907	2,561
Non-Chromium Anodizing								
Printed Wiring Board	3,248	3,584	301	72,616	9,202	382,100	23,686	20,868
Steel Forming & Finishing	13,806	23,864	1,153	390,447	68,448	1,514,238	93,865	82,700
Oily Waste	3,434	8,476	23	621,142	55,322	5,626,916	123,264	233,648
Railroad Line Maintenance	513	859	0	176,677	1,229	129,791	6,767	9,254
Shipbuilding Dry Dock	1,813	2,345	0	87,112	4,782	1,224,437	46,242	56,260
All Categories	70,974	105,793	4,035	2,473,899	254,244	14,145,300	594,756	718,972

a. Excludes discharges from facilities that are projected to close in the baseline.
Source: U.S. EPA analysis.

Table D.5: Baseline Toxic-Weighted Discharges by Type of Pollutant for Facilities Regulated under the Proposed Rule Indirect Dischargers[a] (Pounds Equivalent)

	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants			
Subcategory	Metals	Organics	Cyanide	Metals	Organics	COD	Oil & Gas	TSS	Total
General Metals	13,665,657	207,071	542,448	5,004,316	111,124	0	0	0	19,530,616
Metal Finishing Job Shop	2,296,974	25,403	7,537,115	1,076,583	47,443	0	0	0	10,983,518
Non-Chromium Anodizing	20,090	4,701	0	15,749	2,171	0	0	0	42,711
Printed Wiring Board	909,088	12,091	860,587	908,363	27,378	0	0	0	2,717,507
Steel Forming & Finishing	248,286	3,873	1,239	142,400	1,446	0	0	0	397,244
Oily Waste	98,038	26,814	358	171,988	13,051	0	0	0	310,249
Railroad Line Maintenance	1,083	304	0	217	108	0	0	0	1,712
Shipbuilding Dry Dock	94	23	0	129	11	0	0	0	257
All Categories	17,239,310	280,280	8,941,747	7,319,745	202,732	0	0	0	33,983,814

a. Excludes discharges from facilities that are projected to close in the baseline. Discharges discussed in this table are total discharges from the facility, and do not account for POTW pollutant removals.
Source: U.S. EPA analysis.

Table D.6: Post-Compliance Toxic-Weighted Discharges by Type of Pollutant: Proposed Rule Indirect Dischargers[a] (Pounds Equivalent)

	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants			
Subcategory	Metals	Organics	Cyanide	Metals	Organics	COD	Oil & Gas	TSS	Total
General Metals	1,214,023	88,546	27,558	895,856	64,162	0	0	0	2,290,145
Metal Finishing Job Shop	66,434	12,693	5,036	70,283	37,185	0	0	0	191,631
Non-Chromium Anodizing	20,090	4,701	0	15,749	2,171	0	0	0	42,711
Printed Wiring Board	44,709	8,942	4,074	50,424	35,107	0	0	0	143,256
Steel Forming & Finishing	5,502	1,604	521	7,016	740	0	0	0	15,383
Oily Waste	105,183	29,250	360	175,617	14,110	0	0	0	324,520
Railroad Line Maintenance	1,083	304	0	217	108	0	0	0	1,712
Shipbuilding Dry Dock	94	23	0	129	11	0	0	0	257
All Categories	1,457,118	146,063	37,549	1,215,291	153,594	0	0	0	3,009,615

a. Excludes discharges from facilities that are projected to close in the baseline. Discharges discussed in this table are total discharges from the facility, and do not account for POTW pollutant removals.
Source: U.S. EPA analysis.

Table D.7: Baseline Pollutant Discharges by Type of Pollutant for Facilities Regulated under the Proposed Rule Indirect Dischargers[a] (Pounds)

	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants		
Subcategory	**Metals**	**Organics**	**Cyanide**	**Metals**	**Organics**	**COD**	**Oil & Gas**	**TSS**
General Metals	27,760,005	1,383,262	493,134	95,980,460	39,487,326	1,776,191,763	81,421,271	199,145,183
Metal Finishing Job Shop	5,543,839	147,997	6,851,923	14,358,652	492,517	60,965,863	11,454,626	8,757,513
Non-Chromium Anodizing	177,159	21,800	0	388,738	174,836	164,682,687	729,817	725,193
Printed Wiring Board	2,236,621	81,786	782,352	6,887,964	217,284	34,193,167	15,517,754	3,965,947
Steel Forming & Finishing	472,602	19,394	1,127	2,081,063	79,957	4,871,904	114,938	867,392
Oily Waste	137,453	167,038	326	2,127,850	5,173,619	239,789,613	11,582,618	11,306,816
Railroad Line Maintenance	1,124	1,513	0	10,599	2,872	670,587	27,504	43,632
Shipbuilding Dry Dock	256	124	0	25,432	199	72,786	364	4,992
All Categories	36,329,059	1,822,914	8,128,862	121,860,758	45,628,610	2,281,438,370	120,848,892	224,816,668

a. Excludes discharges from facilities that are projected to close in the baseline. Discharges discussed in this table are total discharges from the facility, and do not account for POTW pollutant removals.
Source: U.S. EPA analysis.

Table D.8: Post-Compliance Pollutant Discharges by Type of Pollutant: Proposed Rule Indirect Dischargers[a] (Pounds)

	Priority Pollutants			Nonconventional Pollutants		Conventional Pollutants		
Subcategory	**Metals**	**Organics**	**Cyanide**	**Metals**	**Organics**	**COD**	**Oil & Gas**	**TSS**
General Metals	1,543,930	591,995	25,053	16,822,356	3,429,204	163,208,391	8,068,222	13,314,727
Metal Finishing Job Shop	59,746	78,435	4,578	1,423,781	177,876	6,702,696	415,781	366,327
Non-Chromium Anodizing	177,159	21,800	0	388,738	174,836	164,682,687	729,817	725,193
Printed Wiring Board	40,640	65,697	3,704	971,318	179,122	4,682,307	290,422	255,937
Steel Forming & Finishing	6,017	9,119	474	158,675	46,752	733,041	40,820	42,272
Oily Waste	148,211	189,378	327	2,160,760	5,235,563	250,342,263	10,993,924	12,115,630
Railroad Line Maintenance	1,124	1,513	0	10,599	2,872	670,587	27,504	43,632
Shipbuilding Dry Dock	256	124	0	25,432	199	72,786	364	4,992
All Categories	1,977,083	958,061	34,136	21,961,659	9,246,424	591,094,758	20,566,854	26,868,710

a. Excludes discharges from facilities that are projected to close in the baseline. Discharges discussed in this table are total discharges from the facility, and do not account for POTW pollutant removals.
Source: U.S. EPA analysis.

Appendix E: Environmental Assessment

Introduction

This Environmental Assessment for the proposed rule estimates the environmental impact of MP&M discharges on waterbodies and POTWs under both current conditions and those corresponding to three regulatory options: the proposed option, Option 2/6/10, and Option 4/8. EPA estimates four types of environmental impacts:

- the occurrence of pollutant concentrations in excess of EPA ***ambient water quality criteria (AWQC)*** for protection of human health in waterways (e.g., streams, lakes, bays, and estuaries) receiving discharges from MP&M facilities;

- the occurrence of pollutant concentrations in excess of AWQC for protection of aquatic species in waterways receiving discharges from MP&M facilities;

- the occurrence of POTW inhibition problems resulting from MP&M facilities' discharges; and

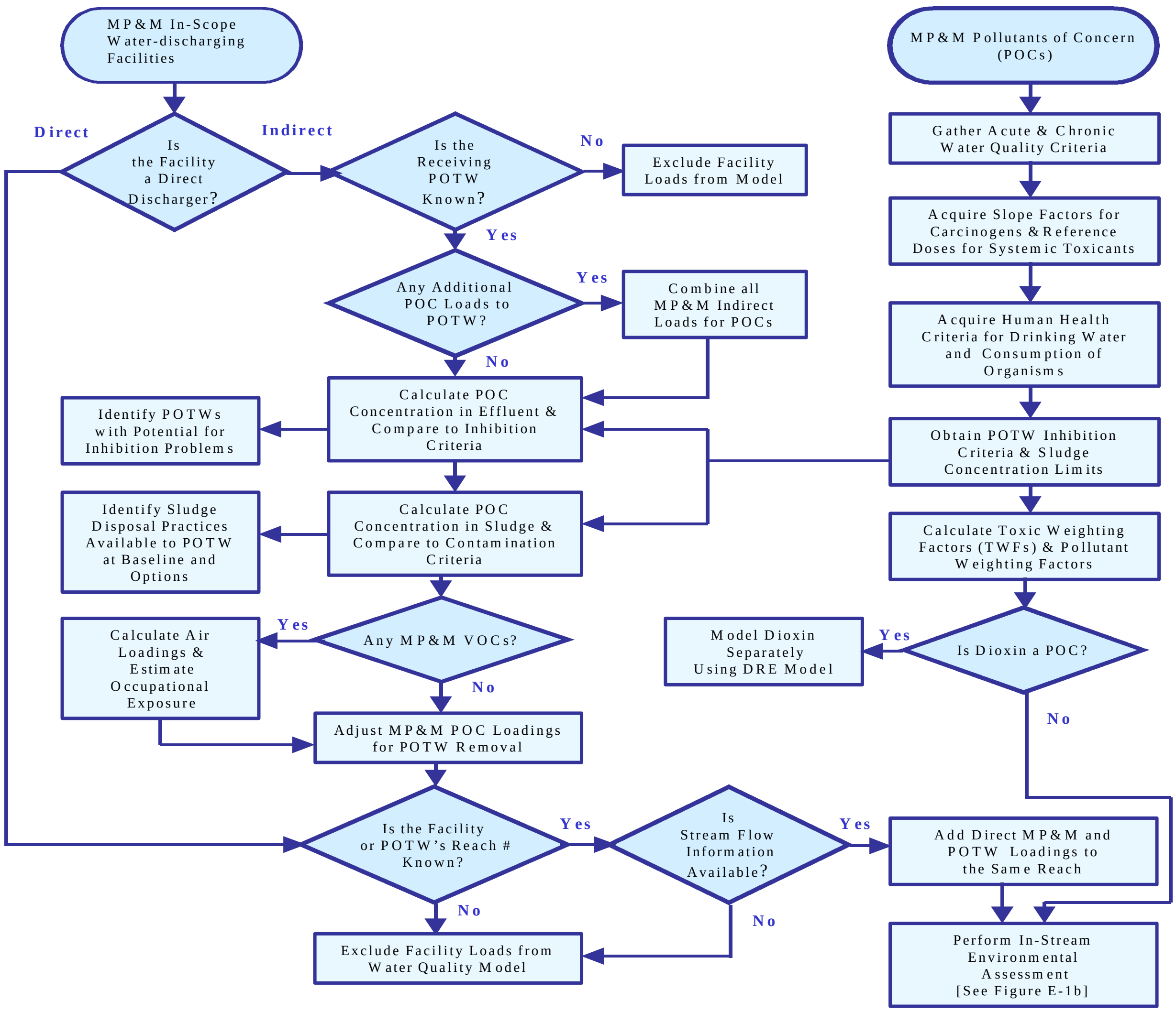
- barriers to POTWs' use of preferred sewage sludge management or disposal methods (i.e., beneficial land application or surface disposal), due to metals discharges from MP&M facilities.

EPA also estimated changes in human health risk from reduced exposure to MP&M pollutants via consumption of contaminated fish and drinking water. Chapters 13 and 14 of this EIA present both the methodology used to estimate human health impacts from exposure to MP&M pollutants and the results of this analysis.

EPA assessed potential environmental impacts of MP&M discharges on the receiving waterbodies and POTWs by using pollutant fate and toxicity data in conjunction with various modeling techniques. EPA quantified the releases of 132 pollutants of concern under both baseline conditions and the proposed rule. EPA then evaluated potential site-specific aquatic life and human health impacts resulting from the baseline and post-regulation pollutant releases. EPA compared projected water concentrations for each pollutant to either (a) EPA water quality criteria, or (b) toxic effect levels (i.e., lowest reported or estimated toxic concentration that cause a problem) in the absence of water quality criteria for a pollutant. Figure E-1 depicts steps used in the environmental assessment. The following sections detail these analytic steps.

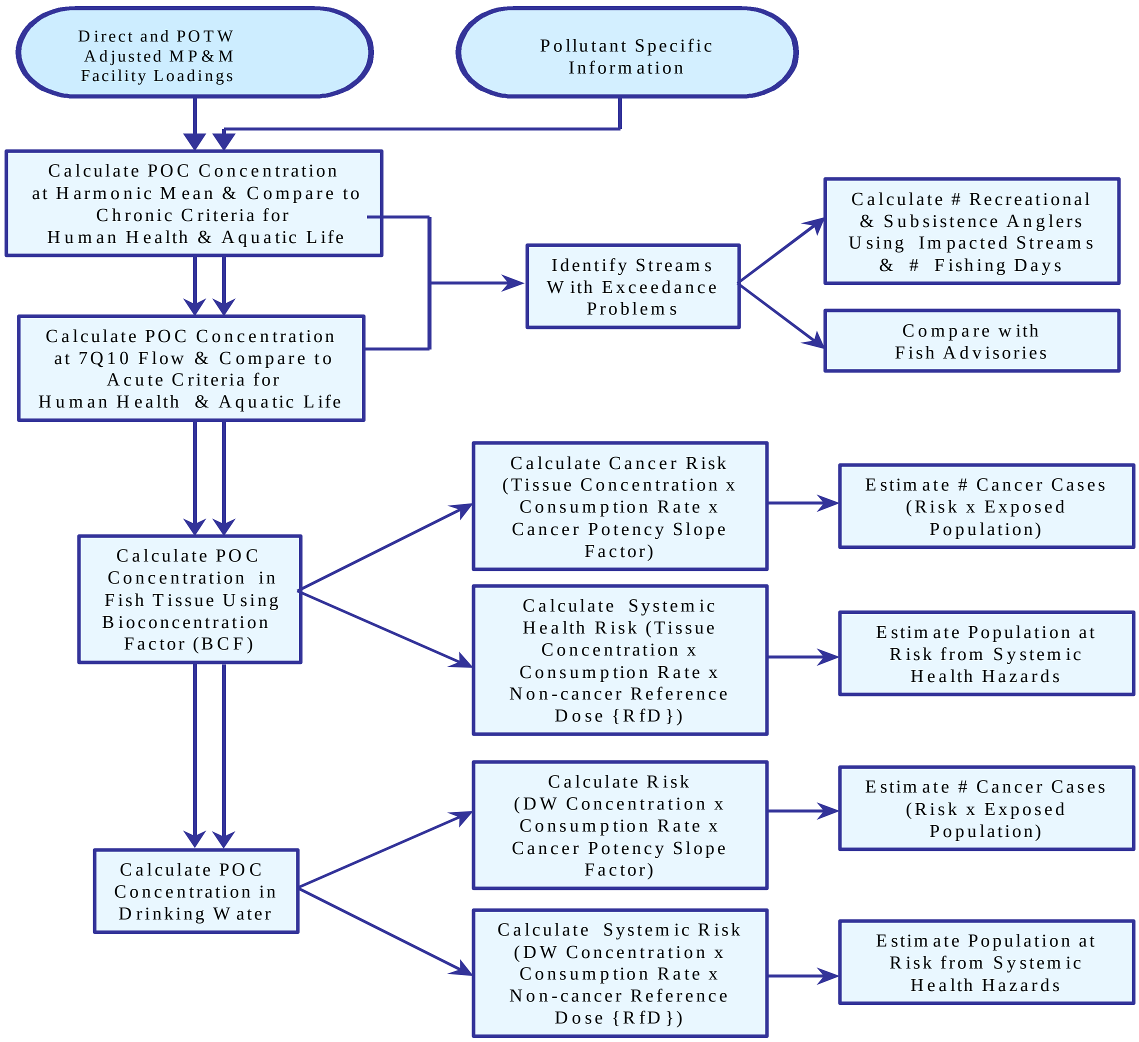
Appendix Contents:

Figure E.1a: MP&M Environmental Impact Assessment



Source: U.S. EPA analysis.

Figure E.1b: MP&M Environmental Impact Assessment (Continued)



Source: U.S. EPA analysis.

The remainder of this Appendix is organized as follows. Section E.1 provides information on the pollutants found in MP&M discharges. Section E.2 describes the methodology used to estimate environmental impacts, including extrapolation of sample sets to the national level and estimates of water quality impacts. Section E.3 describes data sources for both MP&M facilities and POTWs. Section E.4 presents the environmental assessment results.

E.1. MP&M Pollutant Characterization

The extent of human and ecological exposure and risk from environmental releases of toxic chemicals depends on chemical-specific properties, the mechanism and media of release, and site-specific environmental conditions. Chemical-specific properties include toxic effects on living organisms, and the fate of chemicals in the environment. EPA estimated the fate of MP&M pollutants based on their propensity to volatilize, adsorb onto sediments, bioconcentrate, and biodegrade.

EPA characterized the fate and toxicity of MP&M pollutants in three steps:

- identifying pollutants of concern in MP&M discharges,
- compiling physical-chemical and toxicity data for those pollutants, and
- grouping pollutants based on their characteristics.

The pollutant-specific fate and toxicity data were used in various portions of the quantitative benefits assessment. In addition, EPA summarized the distribution of MP&M pollutants based on their fate and toxicity properties using the groupings developed in the third step. This summary is presented in Chapter 12.

E.1.1 Identifying MP&M Pollutants

EPA sampled MP&M facilities nationwide to assess the concentrations of pollutants in MP&M effluents. The Agency collected samples of raw wastewater from MP&M facilities and applied standard water analysis protocols to identify and quantify the pollutant levels in each sample. EPA used these analytical data, along with selection criteria, to identify 132 contaminants of potential concern. MP&M pollutants of concern (POCs) include 43 priority pollutants (PP), 3 conventional pollutants, and 86 non-conventional pollutants.

EPA then evaluated the potential environmental fate of these pollutants and their toxicity to humans and aquatic receptors. EPA was able to assess the potential fate and toxicity of 119 of these pollutants, including 43 priority pollutants (33 priority organics, nine priority metals and one inorganic) and 75 non-conventional pollutants (50 non-conventional organics, 18 non-conventional metals, and seven non-conventional inorganics). Table E.1 presents the potential fate and toxicity, based on known characteristics of each chemical, of 132 pollutants of concern. Potential fate and toxicity data are not available for three conventional and eight bulk non-conventional pollutants (also listed in Table E.1) associated with adverse water quality impacts, as described in Section 12.1.3 of this report.

Table E.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
O	Acenaphthene	83329	Moderate	Low	Moderate	Low	Moderate	Moderate	Moderate	Low	✓				✓
O	Acetone	67641	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓				
O	Acetophenone	98862	Low	Low	Unknown	Unknown	Low	Low	Low	Moderate	✓			✓	
O	Acrolein	107028	High	High	High	High	Moderate	Nonadsorptive	Moderate	Low	✓			✓	✓
O	Aniline	62533	Moderate	High	Low	Low	Low	Low	Low	Moderate		✓		✓	
O	Anthracene	120127	High	High	High	Moderate	Moderate	High	Moderate	Resistant	✓				✓
O	Benzoic acid	65850	Low	Low	Unknown	Unknown	Low	Low	Low	Moderate	✓				
O	Benzyl alcohol	100516	Low	Low	Low	Low	Low	Nonadsorptive	Insignificant	Moderate	✓				
O	Biphenyl	92524	Moderate	Low	Low	Low	Moderate	Moderate	Moderate	Moderate	✓			✓	
O	Bis(2-ethylhexyl) phthalate	117817	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Moderate	Moderate	✓	✓	M	✓	✓
O	Bromo-2-chlorobenzene, 1-	694804	Low	Low	Unknown	Unknown	Moderate	Moderate	Moderate	Low					
O	Bromo-3-chlorobenzene, 1-	108372	Low	Low	Unknown	Unknown	Moderate	Moderate	Moderate	Low					
O	Butyl benzyl phthalate	85687	Moderate	Low	Moderate	Low	Low	High	Moderate	Moderate	✓				✓
O	Carbon disulfide	75150	Low	High	Unknown	High	High	Low	Low	Unknown	✓			✓	
O	Chlorobenzene	108907	Low	Low	Low	Low	High	Low	Low	Low	✓		M	✓	✓
O	Chloroethane	75003	Low	Low	Unknown	Unknown	High	Low	Low	Low	✓	✓		✓	✓
O	Cresol, o-	95487	Low	Low	Low	Low	Low	Low	Low	Moderate	✓			✓	
O	Cresol, p-	106445	Low	Low	Unknown	Unknown	Low	Low	Low	High	✓			✓	
O	Cyanide	57125	High	High	High	High	Unknown	Low	Insignificant	Moderate	✓		M		✓
O	Cymene, p-	99876	Low	Low	Low	Low	High	Moderate	High	Low					
O	Decane, n-	124185	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Dibenzothiophene	132650	Moderate	Low	Unknown	Unknown	Moderate	High	High	Unknown					
O	Dichloroethene, 1,1-	75354	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Dichloromethane	75092	Low	Low	Low	Low	High	Low	Insignificant	Low	✓	✓	M	✓	✓
O	Dimethyl phthalate	131113	Low	Low	Low	Low	Nonvolatile	Low	Low	Moderate				✓	✓
O	Dimethylformamide, N,N-	68122	Low	Low	Unknown	Unknown	Nonvolatile	Nonadsorptive	Insignificant	Moderate	✓			✓	
O	Dimethylphenanthrene, 3,6-	1576676	Moderate	Moderate	Unknown	Unknown	Low	High	High	Moderate					
O	Dimethylphenol, 2,4-	105679	Low	Low	Unknown	Unknown	Low	Low	Moderate	Moderate	✓				✓
O	Di-n-butyl phthalate	84742	Moderate	Low	Moderate	High	Low	Moderate	Moderate	Moderate	✓			✓	✓
O	Dinitrophenol, 2,4-	51285	Low	Low	Low	Low	Low	Moderate	Insignificant	Resistant	✓			✓	✓
O	Dinitrotoluene, 2,6-	606202	Low	Moderate	Unknown	Unknown	Low	Low	Low	Resistant	✓				✓
O	Di-n-octyl phthalate	117840	Moderate	Moderate	Unknown	Unknown	Low	Moderate	High	Low	✓				✓
O	Dioxane, 1,4-	123911	Low	Low	Unknown	Unknown	Low	Low	Insignificant	Resistant		✓		✓	
O	Diphenylamine	122394	Low	Low	Unknown	Unknown	Low	Moderate	Moderate	Moderate	✓				
O	Diphenyl ether	101848	Moderate	Low	Low	Unknown	Moderate	Moderate	Moderate	Moderate					
O	Docosane, n-	629970	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Dodecane, n-	112403	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Eicosane, n-	112958	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Ethylbenzene	100414	Low	Low	Moderate	Moderate	High	Low	Low	Moderate	✓		M	✓	✓
O	Fluoranthene	206440	High	High	High	Moderate	Moderate	High	High	Resistant	✓				✓
O	Fluorene	86737	Moderate	High	Moderate	Moderate	Moderate	Moderate	Low	Low	✓				✓
O	Hexacosane, n-	630013	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Hexadecane, n-	544763	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Hexanoic acid	142621	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate					
O	Hexanone, 2-	591786	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate	✓				
O	Isobutyl alcohol	78831	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓				
O	Isophorone	78591	Low	Low	Low	Low	Low	Low	Insignificant	Low	✓	✓		✓	✓

Table E.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
O	Isopropylnaphthalene, 2-	2027170	Moderate	Moderate	Unknown	Unknown	Moderate	High	High	Unknown					
O	Methyl ethyl ketone	78933	Low	Low	Low	Low	Moderate	Nonadsorptive	Insignificant	Moderate	✓			✓	
O	Methyl isobutyl ketone	108101	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓			✓	
O	Methyl methacrylate	80626	Low	Low	Unknown	Unknown	Moderate	Low	Low	Low	✓			✓	
O	Methylfluorene, 1-	1730376	Moderate	Low	Unknown	Unknown	Moderate	High	High	Unknown					
O	Methylnaphthalene, 2-	91576	Low	Low	Moderate	Moderate	Moderate	Moderate	High	Moderate	✓				
O	Methylphenanthrene, 1-	832699	Moderate	Moderate	Unknown	Unknown	Low	High	High	Unknown					
O	Naphthalene	91203	Low	Low	Low	Low	Moderate	Low	Low	Moderate	✓			✓	✓
O	Nitrophenol, 2-	88755	Low	Low	Low	Low	Low	Low	Low	Low					✓
O	Nitrophenol, 4-	100027	Low	Low	Low	Low	Nonvolatile	Low	Moderate	Moderate	✓			✓	✓
O	Nitrosodimethylamine, N-	62759	Low	Low	Low	Low	Nonvolatile	Low	Insignificant	Resistant		✓		✓	✓
O	Nitrosodiphenylamine, N-	86306	Low	Low	Low	Low	Low	Moderate	Moderate	Low		✓			✓
O	Nitrosopiperidine, N-	100754	Low	Low	Unknown	Unknown	Nonvolatile	Nonadsorptive	Insignificant	Resistant					
O	Octacosane, n-	630024	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Octadecane, n-	593453	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Parachlorometacresol	59507	Low	Low	Unknown	Unknown	Low	Low	Moderate	Low	✓				✓
O	Phenanthrene	85018	Moderate	Moderate	Moderate	Moderate	Moderate	High	Moderate	Resistant					✓
O	Phenol	108952	Low	Low	Low	Low	Low	Low	Insignificant	High	✓			✓	✓
O	Pyrene	129000	Moderate	Moderate	Unknown	Unknown	Moderate	High	High	Resistant	✓				✓
O	Pyridine	110861	Low	Low	Unknown	Unknown	Low	Nonadsorptive	Insignificant	Moderate	✓				
O	Styrene	100425	Low	Low	Low	Low	High	Low	Low	Low	✓		M	✓	
O	Terpineol, alpha-	98555	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate					
O	Tetrachloroethene	127184	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Tetracosane, n-	646311	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Tetradecane, n-	629594	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Toluene	108883	Low	Low	Low	Low	High	Low	Low	Moderate	✓		M	✓	✓
O	Triacontane, n-	638686	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Trichloroethene	79016	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Trichlorofluoromethane	75694	Low	Low	Unknown	Unknown	High	Low	Low	Resistant	✓				
O	Trichloromethane	67663	Low	Low	Low	Low	High	Low	Insignificant	Resistant	✓	✓	THM	✓	✓
O	Tripropyleneglycolmethylether	20324338	Low	Low	Unknown	Unknown	Nonvolatile	Low	Insignificant	Moderate					
O	Xylene, m-	108383	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, m- & p-*	179601231	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, o-	95476	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, o- & p-*	136777612	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Ziram \ Cymate	137304	High	High	Low	Low	Nonvolatile	Nonadsorptive	Insignificant	Resistant	✓				
M	Aluminum	7429905	Moderate	Moderate	Unknown	Unknown	Nonvolatile	High	Moderate	Resistant	✓		SM		
M	Antimony	7440360	Low	Low	Low	Low	Nonvolatile	High	Insignificant	Resistant	✓		M		✓
M	Barium	7440393	Low	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓		M		
M	Beryllium	7440417	Moderate	High	Unknown	Unknown	Nonvolatile	High	Low	Resistant	✓		M		✓
M	Cadmium	7440439	High	High	High	High	Nonvolatile	High	Moderate	Resistant	✓		M		✓
M	Calcium	7440702	Unknown	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Chromium	7440473	Moderate	Moderate	Low	Moderate	Nonvolatile	High	Low	Resistant	✓		M		
M	Chromium hexavalent	18540299	High	Moderate	Low	Moderate	Nonvolatile	High	Low	Resistant	✓		M		
M	Cobalt	7440484	Low	Moderate	Unknown	Moderate	Nonvolatile	High	Unknown	Resistant	✓				
M	Copper	7440508	High	High	High	High	Nonvolatile	High	Moderate	Resistant	✓		TT		✓
M	Gold	7440575	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					

Table E.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC[f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
M	Iron	7439896	Unknown	Low	Low	Low	Nonvolatile	High	Unknown	Resistant	✓		SM		
M	Lead	7439921	High	High	Moderate	High	Nonvolatile	High	Low	Resistant			TT		✓
M	Magnesium	7439954	Low	Low	Unknown	Unknown	Nonvolatile	High	High	Resistant					
M	Manganese	7439965	Unknown	Low	Unknown	Moderate	Nonvolatile	High	Unknown	Resistant	✓		SM		
M	Mercury	7439976	High	High	High	High	High	High	High	Resistant			M		✓
M	Molybdenum	7439987	Unknown	Moderate	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Nickel	7440020	Moderate	Moderate	High	High	Nonvolatile	Low	Low	Resistant	✓		M		✓
M	Selenium	7782492	High	High	Moderate	Moderate	Nonvolatile	High	Insignificant	Resistant	✓		M		
M	Silver	7440224	High	High	High	High	Nonvolatile	High	Insignificant	Resistant	✓		SM		✓
M	Sodium	7440235	Low	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Thallium	7440280	Low	Moderate	Low	Low	Nonvolatile	High	Moderate	Resistant	✓		M		✓
M	Tin	7440315	Unknown	Moderate	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Titanium	7440326	Unknown	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Vanadium	7440622	Low	High	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Yttrium	7440655	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Zinc	7440666	Moderate	Low	High	Moderate	Nonvolatile	High	Low	Resistant	✓		SM		
OI	Ammonia as N	7664417	Low	Low	Low	Low	Moderate	Nonadsorptive	Unknown	Moderate					
OI	Arsenic	7440382	Moderate	Low	High	Moderate	Unknown	Unknown	Low	Unknown	✓	✓	M		✓
OI	Boron	7440428	Unknown	Moderate	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	✓				
OI	Chloride	16887006	Low	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown			SM		
OI	Fluoride	16984488	Low	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	✓		M		
OI	Phosphate	14265442	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown					
OI	Sulfate	14808798	Unknown	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown			SM		
OI	Sulfide	18496258	Unknown	High	Unknown	High	Unknown	Unknown	Unknown	Unknown					
OI	Phosphorus (as PO4)		Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown					
CP	BOD 5-day (carbonaceous)	C-003													
CP	Oil and Grease														
CP	Oil and Grease (as Hem)	C-036													
CP	Total Suspended Solids (TSS)	C-009													
BNCP	Amenable Cyanide	C-025													
BNCP	Chemical Oxygen Demand (COD)	C-004													
BNCP	Total Dissolved Solids (TDS)	C-010													
BNCP	Total Kjeldahl Nitrogen	C-021													
BNCP	Total Organic Carbon (TOC)	C-012													

Table E.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
BNCP	Total Petroleum Hydrocarbons (as Sgt-hem)	C-037													
BNCP	Total Recoverable Phenolics	C-020													
BNCP	Weak-acid Dissociable Cyanide	C-042													

Table Notes:

Unless indicated otherwise, all metals are assumed to be nonvolatile, to have high adsorption, and to be resistant to biodegradation.

a. Type
- O = Organic
- M = Metal
- OI = Other Inorganic
- CP = Conventional Pollutant
- BNCP = Bulk Non-Conventional Pollutant

b. BCF = Bioconcentration Factor

c. Biodeg = Biodegradation Potential

d. RfD = Reference Dose

e. SF = Slope Factor

f. DWC = Drinking Water Criteria

g. Drinking Water Criteria Codes
- M = Maximum Contaminant Level established for health-based effect
- SM = Secondary Maximum Contaminant Level (SMCL) established for taste or aesthetic effect
- THM = MCL established for trihalomethanes
- TT = Treatment technology action level established

h. HAP = Hazardous Air Pollutant

i. PP = Priority Pollutant

E.1.2 Physical-Chemical Characteristics and Toxicity Data of MP&M Pollutants

Pollutants present in MP&M effluents can have significant effects on human health and aquatic receptors. EPA used various data sources to evaluate both pollutant-specific fate and toxicity and potential human health effects, including:

- ***reference doses* (RfDs)**,
- ***cancer potency slope factors* (SFs)**,
- ***human health-based water quality criteria* (WQC)**,
- ***maximum contaminant levels* (MCLs)** for drinking water protection and other drinking water related criteria, and
- ***hazardous air pollutant* (HAP)** and ***priority pollutant* (PP)** lists.

To evaluate potential fate and effects in aquatic environments, the Agency relied on:

- measures of acute and chronic toxicity to aquatic species,
- bioconcentration factors for aquatic species,
- ***Henry's Law* (H)** constants (to estimate volatility),
- adsorption coefficients (to estimate association with bottom sediments), and
- biodegradation half-lives (to estimate the removal of chemicals via microbial metabolism).

The data sources used in the assessment include:

- EPA ambient WQC documents and updates;
- EPA's ***ASsessment Tools for the Evaluation of Risk* (ASTER)**;
- the ***AQUatic Information REtrieval System* (AQUIRE)** and the Environmental Research Laboratory-Duluth fathead minnow database;
- ***EPA's Integrated Risk Information System* (IRIS)**;
- ***EPA's Health Effects Assessment Summary Tables* (HEAST)**;
- EPA's 1991 and 1993 ***Superfund Chemical Data Matrix* (SCDM)**;
- Syracuse Research Corporation's ***CHEMFATE*** and ***BIODEG*** databases; and
- EPA and other government reports, scientific literature, and other primary and secondary data sources.

EPA also obtained information on chemicals for which the sources listed above did not provide physical-chemical properties and/or toxicity data, to ensure that the assessment be as comprehensive as possible. To the extent possible, EPA estimated values for the chemicals using the ***quantitative structure-activity relationship* (QSAR)** model incorporated in ASTER. The Agency also used published linear regression correlation equations to determine some physical-chemical properties.

a. Human health effects

EPA used various data sources to determine pollutant-specific toxicity to human health. EPA obtained RfDs and SFs from IRIS, HEAST, and EPA's Region II Risk-Based Concentration **(RBC)** table. EPA developed drinking water criteria and human health-based AWQC values for two exposure routes: (1) ingesting the pollutant via contaminated aquatic organisms only (carcinogens and noncarcinogens), and (2) ingesting the pollutant via both water and contaminated aquatic organisms (noncarcinogens only). Table E.2 summarizes pollutant toxicity data pertaining to human health. In addition to fate and toxicity data, Table E.1 also includes HAP and PP lists. Short descriptions and definitions for each of the measures of human health effects are provided below.

Table E.2: Human Health Data for 132 MP&M Pollutants of Concern

		Human Health AWQC Values				
CAS Number	Pollutant Name	Ingesting Water and Organisms (µg/l)	Ingesting Organisms Only (µg/l)	Slope Factor ([mg/kg-day]-1)	Reference Dose (mg/kg-day)	Drinking Water Criteria (µg/l)
51285	Dinitrophenol, 2,4-	70	14000		0.002	
57125	Cyanide	700	220000		0.02	200
59507	Parachlorometacresol	56000	270000		2	
62533	Aniline	5.8	95	0.0057		
62759	Nitrosodimethylamine, N-	0.00069	8.1	51		
65850	Benzoic acid	130000	2900000		4	
67641	Acetone	3500	2800000		0.1	
67663	Trichloromethane	5.7	470	0.0061	0.01	100
68122	Dimethylformamide, N,N-	3500	220000000		0.1	
75003	Chloroethane	12	520	0.0029	0.4	
75092	Dichloromethane	4.7	1600	0.0075	0.06	5
75150	Carbon disulfide	3400	94000		0.1	
75354	Dichloroethene, 1,1-	0.057	3.2	0.6	0.009	7
75694	Trichlorofluoromethane	9100	66000		0.3	
78591	Isophorone	36	2600	0.00095	0.2	
78831	Isobutyl alcohol	10000	1500000		0.3	
78933	Methyl ethyl ketone	21000	6500000		0.6	
79016	Trichloroethene	3.1	92	0.011	0.006	5
80626	Methyl methacrylate	48000	2300000		1.4	
83329	Acenaphthene	1200	2700		0.06	
84742	Di-n-butyl phthalate	2700	12000		0.1	
85018	Phenanthrene					
85687	Butyl benzyl phthalate	3000	5200		0.2	
86306	Nitrosodiphenylamine, N-	5	16	0.0049		
86737	Fluorene	1300	14000		0.04	
88755	Nitrophenol, 2-					
91203	Naphthalene	680	21000		0.02	
91576	Methylnaphthalene, 2-	75	84		0.02	
92524	Biphenyl	720	1200		0.05	
95476	Xylene, o-	42000	100000		2	10000
95487	Cresol, o-	1700	30000		0.05	
98555	Terpineol, alpha-					
98862	Acetophenone	3400	98000		0.1	
99876	Cymene, p-					
100027	Nitrophenol, 4-	220	1100		0.008	
100414	Ethylbenzene	3100	29000		0.1	700
100425	Styrene	6700	160000		0.2	100
100516	Benzyl alcohol	10000	810000		0.3	
100754	Nitrosopiperidine, N-					
101848	Diphenyl Ether					
105679	Dimethylphenol, 2,4-	540	2300		0.02	
106445	Cresol, p-	170	3100		0.005	
107028	Acrolein	410	1000		0.02	
108101	Methyl isobutyl ketone	2800	360000		0.08	
108372	Bromo-3-chlorobenzene, 1-					
108383	Xylene, m-	42000	100000		2	10000
108883	Toluene	6800	200000		0.2	1000
108907	Chlorobenzene	680	21000		0.02	100

Table E.2: Human Health Data for 132 MP&M Pollutants of Concern

		Human Health AWQC Values				
		Ingesting Water and Organisms	Ingesting Organisms Only	Slope Factor	Reference Dose	Drinking Water Criteria
CAS Number	Pollutant Name	(µg/l)	(µg/l)	([mg/kg-day]-1)	(mg/kg-day)	(µg/l)
108952	Phenol	21000	4600000		0.6	
110861	Pyridine	35	5400		0.001	
112403	Dodecane, n- (a)					
112958	Eicosane, n- (a)					
117817	Bis(2-ethylhexyl) phthalate	1.8	5.9	0.014	0.02	6
117840	Di-n-octyl phthalate	37	39		0.02	
120127	Anthracene	4100	6800		0.3	
122394	Diphenylamine	470	1000		0.025	
123911	Dioxane, 1,4-	3.2	2400	0.011		
124185	Decane, n-					
127184	Tetrachloroethene	320	3500	0.052	0.01	5
129000	Pyrene	230	290		0.03	
131113	Dimethyl phthalate	310000	2900000			
132650	Dibenzothiophene					
137304	Ziram \ Cymate	700	220000000		0.02	
142621	Hexanoic acid					
206440	Fluoranthene	300	370		0.04	
544763	Hexadecane, n- (a)					
591786	Hexanone, 2-	1400	65000		0.04	
593453	Octadecane, n- (a)					
606202	Dinitrotoluene, 2,6-	34	900		0.001	
629594	Tetradecane, n- (a)					
629970	Docosane, n-					
630013	Hexacosane, n- (b)					
630024	Octacosane, n- (b)					
638686	Triacontane, n- (b)					
646311	Tetracosane, n- (b)					
694804	Bromo-2-chlorobenzene, 1-					
832699	Methylphenanthrene, 1-					
1576676	Dimethylphenanthrene, 3,6-					
1730376	Methylfluorene, 1-					
2027170	Isopropylnaphthalene, 2-					
7429905	Aluminum	20000	47000		1	50
7439896	Iron	300			0.3	300
7439921	Lead					15
7439954	Magnesium					
7439965	Manganese	50	100		0.14	50
7439976	Mercury	0.05	0.051			2
7439987	Molybdenum				0.005	
7440020	Nickel	610	4600		0.02	100
7440224	Silver	170	110000		0.005	100
7440235	Sodium					
7440280	Thallium	1.8	6.5		0.00007	2
7440315	Tin				0.6	
7440326	Titanium				4	
7440360	Antimony	14	4300		0.0004	6
7440382	Arsenic	0.02	0.16	1.5	0.0003	50
7440393	Barium	1000			0.07	2000

Table E.2: Human Health Data for 132 MP&M Pollutants of Concern

		Human Health AWQC Values				
CAS Number	Pollutant Name	Ingesting Water and Organisms (µg/l)	Ingesting Organisms Only (µg/l)	Slope Factor ([mg/kg-day]-1)	Reference Dose (mg/kg-day)	Drinking Water Criteria (µg/l)
7440417	Beryllium	66	1100		0.002	4
7440428	Boron				0.09	
7440439	Cadmium	14	84		0.0005	5
7440473	Chromium	50000	1000000		1.5	100
7440484	Cobalt				0.06	
7440508	Copper	650	1200		0.04	1300
7440575	Gold					
7440622	Vanadium				0.007	
7440655	Yttrium					
7440666	Zinc	9100	69000		0.3	5000
7440702	Calcium					
7664417	Ammonia as N					
7782492	Selenium	170	11000		0.005	50
14265442	Phosphate					
14808798	Sulfate					250000
16887006	Chloride					250000
16984488	Fluoride				0.06	4000
18496258	Sulfide					
18540299	Chromium hexavalent	100	2000		0.003	100
20324338	Tripropyleneglycolmethyl ether					
136777612	Xylene, o- & p- (c)	42000	100000		2	10000
179601231	Xylene, m- & p- (c)	42000	100000		2	10000
C003	BOD 5-day (carbonaceous)					
C004	Chemical Oxygen Demand (COD)					
C009	Total Suspended Solids (TSS)					
C010	Total Dissolved Solids (TDS)					
C012	Total Organic Carbon (TOC)					
C020	Total Recoverable Phenolics					
C021	Total Kjeldahl Nitrogen					
C025	Amenable Cyanide					
C036	Oil And Grease (as Hem)					
C037	Total Petroleum Hydrocarbons (as Sgt-hem)					
C042	Weak-acid Dissociable Cyanide					
	Phosphorus (as PO4)					
	Oil and Grease					

Sources: U.S. EPA (1980), U.S. EPA (1984), U.S. EPA (1997), U.S. EPA (1998), U.S. EPA (1998/99), Worthing (1987).

❖ *Systemic toxicants*

Systemic toxicants are chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds. These effects may result from acute or chronic chemical exposures, and include:

systemic health effects (i.e., loss of one or more neurological, respiratory, reproductive, immunological, or circulatory functions);
organ-specific toxicity (e.g., liver and kidney effects);
developmental toxicity (e.g., reduced weight in newborns or loss of IQ); and
lethality.

EPA typically relies on animal toxicity data to develop RfDs for systemic toxicants that can enter the human body via ingestion. These values represent chemical concentrations expressed in mg of pollutant/kg body weight/day. Certain exposed populations are considered to be protected if these chemical concentrations are not exceeded. These populations include sensitive groups, such as young children or pregnant women. EPA included all available RfD data for the MP&M ***pollutants of concern* (POCs)** in the analysis.

❖ *Carcinogens*

Carcinogens are chemicals that EPA believes can cause or have the potential to cause cellular damage, which can lead to tumors or cancers in humans, either directly or indirectly. Unlike systemic toxicants, most carcinogens are not believed to have a toxicity threshold. Any amount of a carcinogen therefore has the potential to result in a cancer event, even though such a probability can be very small at low concentrations. The Agency has developed SFs, using animal or epidemiological data, that express the probability that a chemical will induce tumor or cancer development. EPA included all available SF data for the MP&M POCs in the analysis.

❖ *Drinking water criteria*

EPA developed human health-based drinking water criteria to assess the health hazards associated with the presence of certain toxic chemicals in drinking water. The criteria are usually presented as MCLs. MCLs for non-carcinogens represent chemical-specific concentrations (expressed in ***µg/l***) that are not expected to result in adverse health effects in exposed populations if not exceeded in drinking water. MCLs for carcinogens represent chemical-specific concentrations (expressed in µg/l) that are expected to result in less than one additional cancer case per million lifetime exposures if not exceeded in drinking water. The Agency also investigated additional drinking water criteria, including:

- ***Secondary Maximum Contaminant Levels* (SMCLs)** established for taste or aesthetic effects,
- MCLs established specifically for trihalomethanes, and
- ***action levels*** developed on the basis of treatment technology.

EPA included all the available primary and secondary drinking water criteria for the MP&M POCs in the analysis.

❖ *Pollutant uptake via water and/or organisms*

EPA has developed WQC for numerous priority toxic pollutants to protect the health of humans who consume water and organisms or only organisms obtained from aquatic habitats contaminated by those PPs. The criteria, expressed in µg/l, represent concentrations in surface waters that will cause adverse health effects in humans when exceeded. EPA obtained all available human health WQC for the MP&M POCs and included them in the analysis.

❖ *Priority pollutants (PPs)*

Priority pollutants are 126 individual chemicals, defined by the Agency as toxic, that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples. These chemicals are of particular concern to the Agency because of their high toxicity or persistence in the environment. EPA identified all MP&M PPs and included them in the analysis.

❖ *Hazardous air pollutants (HAPs)*

HAPs are compounds that EPA believes may represent an unacceptable risk to human health if present in the air. HAPs, expressed in $\mu g/m^3$, can be of particular concern to POTW workers if released into the air at high enough concentrations during the wastewater treatment cycle. EPA identified all HAPs among the MP&M POCs analyzed.

b. Aquatic receptor effects

The potential impact of chemicals on aquatic receptors can be assessed qualitatively based on five effect and fate parameters:

- aquatic toxicity (acute and chronic),
- bioconcentration,
- volatilization,
- adsorption, and
- biodegradation.

Site-specific risks require a measure of exposure and cannot be quantified using this approach. Chemicals can be classified and ranked in terms of their impacts on aquatic receptors, however, by using the five parameters discussed below. Table E.3 summarizes the measured or estimated values of these parameters for the MP&M POCs. Each effect and fate parameter is described below.

Biological oxygen demand* (BOD), *oil and grease* (O&G), *pH*, and *total suspended solids* (TSS)**: These fate/effect parameters are relevant only for specific chemicals. These parameters are not available for the conventional pollutants or bulk non-conventional pollutants, such as ***total petroleum hydrocarbons* (TPH)**, ***alkalinity, ***total organic carbon* (TOC)**, or ***total Kjeldahl nitrogen* (TKN)**. Most of these pollutants are responsible for significant environmental impacts, however. Section 12.2.4 outlines these impacts in greater detail.

❖ ***Aquatic toxicity data***

The Agency addressed two general classes of aquatic toxicity:

- ***Acute toxicity* (AT)** assesses the impacts of a pollutant after a relatively short exposure duration, typically 48 and 96 hours for invertebrates and fish, respectively. The endpoint of concern is mortality, reported as the ***LC50***. This value represents the concentration lethal to 50 percent of the test organisms for the duration of the exposure.

- ***Chronic toxicity* (CT)** assesses the impact of a pollutant after a longer exposure duration, typically from one week to several months. The endpoints of concern are one or more sublethal responses, such as changes in reproduction or growth in the affected organisms. The results are reported in various ways, including ***EC1*** or ***EC5*** (i.e., the concentration at which one percent or five percent of the test organisms show a significant sublethal response), **NOEC *(No Observed Effect Concentration)***, **LOEC *(Lowest Observed Effect Concentration)***, or **MATC *(Maximum Allowable Toxicant Concentration)***.

❖ ***Bioconcentration factor (BCF) data***

The ***bioconcentration factor*** (**BCF**, measured in ***l/kg***) is a good indicator of the potential for a chemical dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually fish gills. The BCF is defined as follows:

$$BCF = \frac{\text{equilibrium chemical concentration in target organism (mg/kg, wet weight)}}{\text{mean chemical concentration in surrounding water } (\mu g/L)}$$

EPA analyzes POCs with elevated BCF values because these pollutants can bioconcentrate in aquatic organisms and transfer up the food chain if they are not metabolized and excreted. This transfer can result in significant exposures to predators (including humans) consuming contaminated fish or shellfish.

❖ ***Volatilization data***

Volatilization is a process whereby chemicals dissolved in water escape into the air. Chemicals with higher volatilization potential are typically of less concern to aquatic receptors because they tend to be removed quickly from the water column. These volatile pollutants are a concern to human health when inhaled. For aquatic receptors, however, POCs with higher volatilization potential present lower hazards.

EPA used the air/water partitioning coefficient H to estimate a chemical's volatilization potential. H represents the ratio of a chemical's aqueous phase concentration to its equilibrium partial pressure in the gas phase (at 25°C); units are typically expressed as ***atm.m³/mole***. Metals do not have measurable partial pressures (with some notable exceptions, including several organic mercury compounds), and are therefore considered to be non-volatile unless otherwise indicated.

❖ ***Adsorption data***

Adsorption is a process whereby chemicals associate preferentially with the ***organic carbon* (OC)** found in soils and sediments. Highly-adsorptive compounds tend to accumulate in sludge or sediments. Such chemicals are also more likely to be taken up by ***benthic*** invertebrates and to affect local food chains. Both accumulation in sediment and the effect on local food chains make these chemicals more likely to impact higher predators including humans.

EPA used the ***adsorption coefficient* (K_{oc})** to assess the potential of organic MP&M POCs to associate with organic carbon. K_{oc} represents the ratio of the target chemical absorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium. Metals in the aquatic environment typically end up in the sediment phase but do not bind to the organic carbon (except for nickel). The Agency assumed that all metals show a high affinity for sludge and sediments independent of their negligible K_{oc} values.

❖ ***Biodegradation data***

Biodegradation is a process whereby organic molecules are broken down by microbial metabolism. Biodegradation represents an important removal process: compounds that are readily biodegraded generally represent lower intrinsic hazards because they can be eliminated rapidly. These compounds are therefore less likely to create long-term toxicity problems or to accumulate in sludge or sediments and organisms. Chemicals that biodegrade slowly or not at all can accumulate and linger for longer periods of time in sludge or sediments, and represent a higher hazard to aquatic receptors.

EPA used ***biodegradation half-life*** to estimate the potential for an organic chemical to biodegrade in the aquatic environment. Biodegradation half-life represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions. Metals do not biodegrade.

Table E.3 summarizes pollutant toxicity data pertaining to aquatic life.

Table E.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

		Freshwater Aquatic Life		Saltwater Aquatic Life		Bio-concentration Factor	Henry's Law Constant	Adsorption Coefficient (Koc)	Bio-degradation Half-Life
CAS Number	Pollutant Name	Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
51285	Dinitrophenol, 2,4-	1160	790	1500	940	1.51	0.000000443	2386	263
57125	Cyanide	22	5.2	1	1	1		45	16
59507	Parachlorometacresol	4050	1300			79	0.0000025	604	100
62533	Aniline	250	4	29400	2940	19.9	0.0000019	54	26
62759	Nitrosodimethylamine, N-	280000	4000	4300000	430000	0.026	0.000000263	12	180
65850	Benzoic acid	180000	17178			15	0.00000154	182	16
67641	Acetone	6210000	1866000	5640000	10000	0.39	0.00004	18	7
67663	Trichloromethane	13300	6300	19610	1961	3.75	0.00367	40	180
68122	Dimethylformamide, N,N-	7100000	710000			0.005	0.000000018	6.1	16
75003	Chloroethane	65614	21069			7.2	0.00882	37.6	28
75092	Dichloromethane	330000	82500	256000	2560	0.91	0.00219	28	28
75150	Carbon disulfide	2100	2		2	11.5	0.0303	89	
75354	Dichloroethene, 1,1-	11600	5114	224000	22400	5.6	0.0261	343	180
75694	Trichlorofluoromethane	17387	6412			49	0.097	93	360
78591	Isophorone	120000	11000	12900	1290	4.38	0.00000576	25	28
78831	Isobutyl alcohol	949000	4000	600000	60000	2.2	0.0000118	61.7	7.2
78933	Methyl ethyl ketone	3220000	233550	1287000	128700	1	0.00006	5.2	7
79016	Trichloroethene	40700	14850	14000	2000	10.6	0.0103	104	360
80626	Methyl methacrylate	191000	19100			6.6	0.00034	22	28
83329	Acenaphthene	580	208	970	710	242	0.00009	3890	102
84742	Di-n-butyl phthalate	850	500	450	3.4	89	0.00000181	6310	23
85018	Phenanthrene	180	19	110	11	486	0.00002	18800	200
85687	Butyl benzyl phthalate	820	260	510	400	414	0.00000126	17000	7
86306	Nitrosodiphenylamine, N-	5800	1000	3300000	33000	136	0.000005	1200	34
86737	Fluorene	212	8	1000	100	30	0.00006	2830	60
88755	Nitrophenol, 2-	160000	3451	32000	16000	13.5	0.00000947	114	28
91203	Naphthalene	1600	370	1200	120	10.5	0.00048	871	20
91576	Methylnaphthalene, 2-	1133	417	600	60	2566	0.00052	8500	20
92524	Biphenyl	360	230	4600	460	436	0.0003	1400	7

Table E.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life Acute Value (µg/l)	Freshwater Aquatic Life Chronic Value (µg/l)	Saltwater Aquatic Life Acute Value (µg/l)	Saltwater Aquatic Life Chronic Value (µg/l)	Bio-concentration Factor Value (l/kg)	Henry's Law Constant Value (atm/m^3-mole)	Adsorption Coefficient (Koc) Value	Bio-degradation Half-Life Value (days)
95476	Xylene, o-	3820	1332	6000	600	208	0.00519	129	28
95487	Cresol, o-	14000	2251	10200	1020	18	0.0000012	103	7
98555	Terpineol, alpha-	12742	4879			48	0.0000544	589	15
98862	Acetophenone	162000	31094			11	0.00001	45	16
99876	Cymene, p-	6500	237	4400	440	770	0.011	4000	100
100027	Nitrophenol, 4-	7680	1300	7170	1900	79	0.000000000415	236	7
100414	Ethylbenzene	9090	4600	430	43	37.5	0.00788	250	10
100425	Styrene	4020	402	9100	910	13.5	0.00283	920	28
100516	Benzyl alcohol	10000	1000	15000	1500	4	0.000000743	6.1	16
100754	Nitrosopiperidine, N-	1019538	282592				0.000000275	9	180
101848	Diphenyl Ether	780	213	2400		470	0.000448	4365	15
105679	Dimethylphenol, 2,4-	2120	1970			94	0.000002	18	7
106445	Cresol, p-	7500	2570			17.6	0.000000792	49	0.667
107028	Acrolein	14	5.8	55	5.5	215	0.00012	5	28
108101	Methyl isobutyl ketone	505000	50445	812000	81200	2.4	0.00014	19	7
108372	Bromo-3-chlorobenzene, 1-	1784	682			190	0.00078	1500	100
108383	Xylene, m-	16000	3900	12000	1200	208	0.00719	190	28
108883	Toluene	5500	1000	6300	5000	10.7	0.00664	95	22
108907	Chlorobenzene	2370	2100	10500	1050	10.3	0.00377	275	150
108952	Phenol	4200	200	5800	2410	1.4	0.000000333	30.2	3.5
110861	Pyridine	93800	25000			2	0.00000888	5	7
112403	Dodecane, n- (a)	18000	1300	500000	50000	14500		95000	17
112958	Eicosane, n- (a)	18000	1300	500000	50000	100000		30000000	17
117817	Bis(2-ethylhexyl) phthalate					130	0.0000001	87420	23
117840	Di-n-octyl phthalate	690	69			5460	0.000000445	2390	28
120127	Anthracene	2.78	2.2	40	16	478	0.00007	16000	460
122394	Diphenylamine	3790	734			269	0.000000496	1910	20
123911	Dioxane, 1,4-	9850000	1457300			0.4	0.0000048	17	180
124185	Decane, n- [a]	18000	1300	500000	50000	8800		58200	17

Table E.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

		Freshwater Aquatic Life		Saltwater Aquatic Life		Bio-concentration Factor	Henry's Law Constant	Adsorption Coefficient (Koc)	Bio-degradation Half-Life
CAS Number	Pollutant Name	Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
127184	Tetrachloroethene	4990	510	10200	450	30.6	0.0184	363	360
129000	Pyrene	591	61			1110	0.000011	62700	1900
131113	Dimethyl phthalate	33000	1700	58000	5800	36	0.000000105	40	7
132650	Dibenzothiophene	420	122			1100	0.00002	11000	
137304	Ziram \ Cymate	8	1.8	5200	520	0.001		0.4	
142621	Hexanoic acid	320000	15170			16	0.0000225	38	12
206440	Fluoranthene	45	7.1	40	16	1150	0.0000161	41700	440
544763	Hexadecane, n- (a)	18000	1300	500000	50000	32300		207000	17
591786	Hexanone, 2-	428000	38868			6.6	0.000113	12	16
593453	Octadecane, n- (a)	18000	1300	500000	50000	10100		66900	17
606202	Dinitrotoluene, 2,6-	18500	60			12	0.000000747	100	180
629594	Tetradecane, n- (a)	18000	1300	500000	50000	19500		126000	17
629970	Docosane, n- [b]	530000	68000	500000	50000	100000		110000000	17
630013	Hexacosane, n- (b)	530000	68000	500000	50000				17
630024	Octacosane, n- (b)	530000	68000	500000	50000				17
638686	Triacontane, n- (b)	530000	68000	500000	50000				17
646311	Tetracosane, n- (b)	530000	68000	500000	50000	100000		420000000	17
694804	Bromo-2-chlorobenzene, 1-	2942	1196			240	0.0006	1500	100
832699	Methylphenanthrene, 1-	555	54			4790	0.0000078	36000	
1576676	Dimethylphenanthrene, 3,6-	543	21			33000	0.0000053	330000	20
1730376	Methylfluorene, 1-	627	115			3300	0.00008	33000	
2027170	Isopropylnaphthalene, 2-	540	78			3200	0.00063	33000	
7429905	Aluminum	750	87			231			
7439896	Iron		1000	33000	3300				
7439921	Lead	65	2.5	210	8.1	49			
7439954	Magnesium	64700	6470			85215			
7439965	Manganese		388		10				
7439976	Mercury	1.4	0.77	1.8	0.94	5500	0.018	30000	
7439987	Molybdenum		27.8						

Table E.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern										
		Freshwater Aquatic Life		Saltwater Aquatic Life		Bio-concentration Factor	Henry's Law Constant	Adsorption Coefficient (Koc)	Bio-degradation Half-Life
CAS Number	Pollutant Name	Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
7440020	Nickel	470	52	74	8.2	47		300	
7440224	Silver	3.4	0.34	1.9	0.19	0.5			
7440235	Sodium	1640000	1020000						
7440280	Thallium	1400	40	2130	213	116			
7440315	Tin		18.6						
7440326	Titanium		191						
7440360	Antimony	3500	1600	4800	2900	1			
7440382	Arsenic	340	150	69	36	44			
7440393	Barium	410000	2813						
7440417	Beryllium	130	5.3			19			
7440428	Boron		31.6						
7440439	Cadmium	4.3	2.2	42	9.3	64			
7440473	Chromium	570	74	1100	50	16			
7440484	Cobalt	1620	49		10				
7440508	Copper	13	9	4.8	3.1	360			
7440575	Gold								
7440622	Vanadium	11200	9						
7440655	Yttrium								
7440666	Zinc	120	120	90	81	47			
7440702	Calcium		200000						
7664417	Ammonia as N	13300	2280	3800	570		0.00032	3.1	16
7782492	Selenium	12.83	5	290	71	4.8			
14265442	Phosphate								
14808798	Sulfate		1000000						
16887006	Chloride	860000	230000						
16984488	Fluoride	1600	160						
18496258	Sulfide		2		2				
18540299	Chromium hexavalent	16	11	1100	50	16			
20324338	Tripropyleneglycolmethylether	2484600	683870			0.2	0.0000000001	46	16

Table E.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio-concentration Factor	Henry's Law Constant	Adsorption Coefficient (Koc)	Bio-degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
136777612	Xylene, o- & p- [c]	2600	1205	6000	600	208	0.0076	260	28
179601231	Xylene, m- & p- [c]	2600	1205	6000	600	208	0.0076	260	28
C003	BOD 5-day (carbonaceous)								
C004	Chemical Oxygen Demand (COD)								
C009	Total Suspended Solids (TSS)								
C010	Total Dissolved Solids (TDS)								
C012	Total Organic Carbon (TOC)								
C020	Total Recoverable Phenolics								
C021	Total Kjeldahl Nitrogen								
C025	Amenable Cyanide								
C036	Oil And Grease (as Hem)								
C037	Total Petroleum Hydrocarbons (as Sgt-hem)								
C042	Weak-acid Dissociable Cyanide								
	Phosphorus (as PO4)								
	Oil and Grease								

Notes:
a. Aquatic toxicity data for n-decane are reported based on structural similarity
b. Aquatic toxicity data for n-docosane are reported based on structural similarity
c. Values for the most stringent isomer (p-Xylene) are assumed
Sources: Arthur D. Little (1983), Arthur D. Little (1986), Birge et al. (1979), Clay (1986), Holdway and Spraque (1979), ICF, Inc. (1985), Leblanc (1980), Lyman et al. (1981), U.S. Atomic Energy Commission (1973), U.S. EPA (1972), U.S. EPA (1976), U.S. EPA (1980), U.S. EPA (1993), U.S. EPA (1998/99a), U.S. EPA (1998/99b), Zhang and Zhang (1982).

E.1.3 Grouping MP&M Pollutants Based on Risk to Aquatic Receptors

The impact assessment for aquatic receptors looks at the six individual fate and effects parameters for each MP&M POC, including acute and chronic aquatic toxicities, bioconcentration factors, Henry's Law constants, adsorption coefficients, and biodegradation half-lives. EPA grouped POCs with similar attributes, and assigned qualitative descriptors of potential environmental behavior and impact to each group. This grouping was used to describe the range of MP&M pollutant characteristics in Chapter 12. The grouping described below focuses specifically on aquatic environments and their biological receptors; it does not cover the human health toxicity data discussed in the previous section.

Table E.4 provides a summary of the categorization scheme for the six fate and effects parameters.

Table E.4: Summary of Categorization Scheme For Six Fate and Effects Parameters

Parameter	High Hazard	Moderate Hazard	Low Hazard	Insignificant Hazard
Acute Toxicity (AT)	AT < 100µg/l	100 ≤ AT≤ 1,000µg/l	AT > 1,000µg/l	
Chronic Toxicity (CT)	CT < 10µg/l	10 ≤ CT ≤ 100µg/l	CT > 100µg/l	
Bioconcentration Factor (BCF)	BCF > 500	50 ≤ BCF ≤ 500	5 ≤ BCF < 50	BCF < 5
Henry's Law Constant (H)	$H > 10^{-3}$	$10^{-5} \le H \le 10^{-3}$	$3.0x10^{-7} \le H < 10^{-5}$	$H < 3.0x10^{-7}$
Adsorption Coefficient (K_{OC})	$K_{oc} > 10,000$	$1,000 \le K_{oc} \le 10,000$	$10 \le K_{oc} < 1,000$	$K_{oc} < 10$
Biodegradation Half-Life ($t_{1/2}$)	$t_{1/2} < 7$ d	$7 d \le t_{1/2} < 28$ d	$28 d \le t_{1/2} < 180$ d	$t_{1/2} \ge 180$ d

Source: U.S. EPA analysis.

a. Acute and chronic aquatic toxicity

EPA used the available AT data to group chemicals according to their relative short-term effects on aquatic organisms, using the following categories:

AT < 100µg/l	high acute toxicity
100µg/l ≤ AT ≤ 1,000µg/l	moderate acute toxicity
AT > 1,000 µg/l	low acute toxicity

These categories reflect the fact that acute toxicity decreases when higher concentrations of a pollutant are required to induce short-term mortality in the test organisms. EPA's Office of Pollution Prevention and Toxics (OPPT) uses this categorization as guidance to assess data submitted in ***Premanufacture Notices* (PMN)** (EPA, 1996).

EPA used the available CT data to group chemicals according to their relative long-term effects on aquatic organisms, based on the following categories:

CT < 10µg/l	High chronic toxicity
10µg/l ≤ CT ≤ 100µg/l	Moderate chronic toxicity
CT > 100 µg/l	Low chronic toxicity

These categories assume that CT occurs at a concentration averaging one tenth of that responsible for acute toxicity. They also reflect the fact that chronic toxicity decreases when higher concentrations of a pollutant are required to induce longer-term lethal or sublethal responses in the test organisms.

b. Bioconcentration factor (BCF)

EPA used the available BCF data to group chemicals according to their potential to bioconcentrate in aquatic organisms, based on the following categories:

BCF > 500	High potential to bioconcentrate
50≤BCF≤500	Moderate potential to bioconcentrate
5≤BCF≤50	Low potential to bioconcentrate
BCF<5	No significant potential to bioconcentrate

These categories reflect the fact that the decreased BCF reduces the intrinsic hazard of a chemical to aquatic receptors, because the chemical is less likely to accumulate in biological tissues.

c. Volatilization potential

EPA used available H data to group organic chemicals according to their potential to volatilize from water into air, based on the following categories:

$H > 10^{-3}$	High potential to volatilize
$10^{-5} \le H \le 10^{-3}$	Moderate potential to volatilize

$3.0{\times}10^{-7} \leq H \leq 10^{-5}$	Low potential to volatilize
$H < 3.0{\times}10^{-7}$	No potential to volatilize

Increased volatility decreases a chemical's hazard to aquatic receptors because the chemical is more likely to quickly move from the receiving water into the atmosphere. (The opposite is true for human health; hazard to human health *increases* with increased volatility because a volatile chemical is more available for intake by inhalation.)

d. Adsorption potential

EPA used the available K_{oc} to group the organic POCs according to their potential to adsorb to sediments, based on the following categories:

$K_{oc} > 10{,}000$	High potential for adsorption
$1{,}000 \leq K_{oc} \leq 10{,}000$	Moderate potential for adsorption
$10 \leq K_{oc} < 1{,}000$	Low potential for adsorption
$K_{oc} < 10$	No significant adsorption

A lower adsorption potential indicates a lower potential for a chemical to be a hazard to aquatic receptors. The lower the adsorption potential the less likely a chemical is to accumulate in sediments or to affect benthic invertebrates and be taken up into local food chains.

e. Biodegradation potential

EPA used biodegradation half-lives to group organic POCs according to their potential to biodegrade, based on the following categories:

$t_{1/2} < 7$ d	Rapid rate of biodegradation
7 d $\leq t_{1/2} < 28$ d	Moderate rate of biodegradation
28 d $\leq t_{1/2} < 180$ d	Slow rate of biodegradation
$t_{1/2} \geq 180$ d	Resistant to biodegradation

A faster rate of biodegradation by microbial metabolism decreases an organic chemical's hazard to aquatic receptors. The more rapid the rate of biodegradation, the more quickly a chemical will be removed from the aquatic environment. Most metals occur as inorganic compounds (notable exceptions include organic forms of certain metals, such as mercury, lead, or selenium), and are not removed by biodegradation. EPA assumes that all metals are resistant to biodegradation for the purposes of this assessment.

E.1.4 Assumptions and Limitations

The following are the major assumptions and limitations associated with the data compilation and categorization used in the MP&M analysis.

- Some data are estimated, and subject to uncertainty;
- Data are unavailable for some chemicals and parameters;
- The POCs considered in this study do not include all the constituents that may be present in MP&M pollutants;
- Data derived from laboratory tests may not accurately reflect conditions in the field; and
- Available aquatic toxicity and bioconcentration test data may not represent the most sensitive species.

E.2. METHODOLOGY

E.2.1 Sample Set Data Analysis and National Extrapolation

This analysis uses discharge information from 885 sample MP&M facilities (excluding two sample facilities in Puerto Rico) that discharge directly or indirectly to 627 receiving waterways (544 rivers/streams, 55 bays/estuaries, and 28 lakes). The in-stream water quality analysis excluded four of the 55 marine reaches due to data limitations. EPA extrapolated the environmental assessment results for the sample facilities to the entire population of MP&M facilities nationwide (approximately 62,752 facilities discharging to 58,530 waterbodies). This extrapolation uses sample facility weights developed as part of the data collection process. See the *Statistical Summary for the Metal Products & Machinery Industry Surveys* in the Administrative record for today's rule for additional information on sample design and facility level weights. Appendix F discusses the differential weighting technique used to extrapolate estimated sample facility results to the population level.

EPA evaluated the national level environmental impacts of reducing pollutant discharges from MP&M facilities to the nation's waterbodies for the proposed rule. EPA considered only pollutant loadings from MP&M facilities to particular waterbodies in the national analysis. With one exception, EPA did not take background loadings from other sources into account. For the analysis of sewage sludge quantity, EPA was able to use information from the Phase 2 Section 308 survey of POTWs to estimate total metal loadings from all sources to a POTW of a given size (i.e., small, medium, and large). The Agency based this estimate on survey estimates of the average number of small, medium, and large MP&M facilities discharging to a POTW in each size category and the percent contribution of total metal loadings discharged from MP&M facilities.

E.2.2 Water Quality Modeling

EPA used four different equations to model the impacts of MP&M discharges on receiving waterways. EPA used a simple stream dilution model for MP&M facilities that discharge into streams or rivers. This model does not account for fate processes other than complete immediate mixing.[1] EPA derived the facility-specific data (i.e., pollutant loading and facility flow) used in this equation from sources described in Sections 3.1 and 5.2 of this report.

The Agency used one of three receiving stream flow conditions (the lowest one-day average flow with a recurrence interval of 10 years (1Q10), the lowest consecutive seven-day average flow with a recurrence interval of 10 years (7Q10), and the harmonic mean flow), depending on the criterion or toxic effect level being considered.

The 1Q10 and 7Q10 flows are used in comparisons of in-stream concentrations with acute and chronic aquatic life criteria or toxic effect levels, respectively, as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991).

The harmonic mean flow, defined as the inverse mean of reciprocal daily arithmetic mean flow values, is used in comparisons of in-stream concentrations with human health criteria or toxic effect levels based on lifetime exposure. EPA recommends the long-term harmonic mean flow as the design flow for assessing potential long-term human health impacts. Harmonic mean flow is preferable to arithmetic mean flow because in-stream pollutant concentration is a function of, and inversely proportional to, the streamflow downstream of the discharge.

The event frequency represents the number of times an exposure event occurs during a specified time period. EPA set the event frequency equal to the facility operating days to assess impacts on aquatic life. The calculated in-stream concentration is thus the average concentration on days the facility is discharging wastewater. EPA set the event frequency at 365 days to assess long-term human health impacts. The calculated in-stream concentration is thus the average concentration on all days of the year. This frequency leads to a lower calculated concentration because of the additional dilution from days when the facility is not operating, but it is consistent with the conservative assumption that the target population is present to consume drinking water every day and contaminated fish throughout an entire lifetime. The following equation calculates in-stream concentration for streams and rivers:

$$C_{is} = \frac{L}{(OD \cdot FF) + (EF \cdot SF)} \qquad \text{(E.1)}$$

[1] EPA used an exponential decay model to estimate pollutant concentrations for the analysis of cancer risk from drinking water consumption for streams. This model is discussed in detail in Appendix G.

where:

C_{is} = in-stream pollutant concentration (µg/L);
L = facility pollutant loading (µg/yr); for indirect dischargers, $L = L_{\text{indirect facility}} * (1-TMT)$, where TMT is POTW treatment removal efficiency (unitless);
OD = facility or POTW operating days (days/yr);
FF = MP&M facility flow (L/day); for indirect dischargers, FF = POTW flow (L/day);
EF = event frequency (days/yr); and
SF = receiving stream flow (L/day).

EPA used the following simple steady-state model for facilities that discharge into lakes other than the Great lakes. This model takes into account pollutant degradation and the hydraulic residence time of the lake:

$$C_{lake} = \frac{C_i}{(1 + T_w \cdot k)} \qquad \text{(E.2)}$$

where:

C_{lake} = steady-state lake concentration of pollutant (µg/L),
C_i = steady-state inflow concentration of pollutant (µg/L),
T_w = mean hydraulic residence time (yr),
k = first-order pollutant decay rate (yr-1),

$$T_w = \frac{V}{Q} \qquad \text{(E.3)}$$

where:

V = lake volume (m^3), and
Q = mean total inflow rate (m^3/yr).

EPA used alternative means to predict pollutant concentrations suitable for comparison with ambient criteria or toxic effect levels for facilities discharging to hydrologically complex waters, such as bays and estuaries. Where possible, EPA employed site-specific ***critical dilution factors*** **(CDFs)** to predict the concentration at the edge of a mixing zone. Where CDFs were not available, EPA used available estuarine ***dissolved concentration potentials*** **(DCPs)**.

EPA obtained site-specific CDFs from a survey of states and regions conducted by EPA's Office of Pollution Prevention and Toxics (*Mixing Zone Dilution Factors for New Chemical Exposure Assessments*, U.S. EPA, 1992a). The dilution model for estimating estuary concentrations by using a CDF is presented below:

$$C_{es} = \frac{L}{EF \cdot FF \cdot CDF} \qquad \text{(E.4)}$$

where:

C_{es}	=	estuary pollutant concentration (µg/L);
L	=	facility pollutant loading (µg/yr); for indirect dischargers, $L = L_{\text{indirect facility}}$ * (1-TMT), where TMT is POTW treatment removal efficiency (unitless);
EF	=	event frequency (days/yr);
FF	=	facility flow (L/day); for indirect dischargers, FF = POTW flow (L/day); and
CDF	=	critical dilution factor (unitless).

EPA used acute CDFs to evaluate acute aquatic life effects and chronic CDFs to evaluate chronic aquatic life or adverse human health effects. EPA assumed that the drinking water intake and fishing location are at the edge of the chronic mixing zone. EPA set the event frequency equal to the facility operating days for comparison with aquatic life criteria or toxic effect levels, and equal to 365 days for comparison with human health criteria or toxic effect levels.

The ***National Oceanic and Atmospheric Administration*** **(NOAA)** has developed DCPs to predict pollutant concentrations in various salinity zones for each estuary in NOAA's ***National Estuarine Inventory*** **(NEI)**. A DCP represents the concentration of a nonreactive dissolved substance under well-mixed, steady-state conditions given an annual load of 10,000 tons. DCPs account for the effects of flushing by considering the freshwater inflow rate, and dilution by considering the total estuarine volume. DCPs reflect the predicted estuary-wide response, and may therefore not be indicative of concentrations at the edge of much smaller mixing zones. The dilution model used for estimating pollutant concentrations using a DCP is presented below:

$$C_{es} = \frac{L \cdot DCP}{BL \cdot CF} \qquad \text{(E.5)}$$

where:

C_{es}	=	estuary pollutant concentration (µg/L);
L	=	facility pollutant loading (kg/yr); for indirect dischargers, $L = L_{\text{indirect facility}}$ *(1-TMT), where TMT is POTW treatment removal efficiency (unitless);
DCP	=	dissolved concentration potential (µg/L);
BL	=	benchmark load (10,000 tons/yr); and
CF	=	conversion factor (907.2 kg/ton).

EPA determined potential water quality impacts by comparing projected waterway pollutant concentrations to EPA water quality criteria or toxic effect levels for the protection of aquatic life and human health. EPA determined water quality exceedences by dividing the projected waterway pollutant concentration by the EPA water quality criteria or toxic effect levels for the protection of aquatic life and human health. A value greater than one indicates an exceedance.

E.2.3 Impact of Indirect Discharging Facilities on POTW Operations

a. Analysis of biological inhibition

Inhibition of POTW operations occurs when high levels of toxics, such as metals or cyanide, kill the bacteria required for the wastewater treatment process. EPA analyzed inhibition of POTW operations by comparing calculated POTW influent concentrations with available inhibition levels. Exceedences are indicated by a value greater than one. POTW influent concentrations are estimated as:

$$C_{pi} = \frac{L}{OD \cdot PF} \qquad \text{(E.6)}$$

where:

C_{pi}	=	POTW influent concentration (µg/L),
L	=	facility pollutant loading (µg/yr),
OD	=	facility operating days (days/yr), and
PF	=	POTW flow (L/day).

b. Analysis of sludge disposal practices

EPA also analyzed the effects of MP&M discharges on POTW operations by comparing the estimated concentrations of metals in sewage sludge with the published metals concentration limits for preferable sewage sludge disposal or use practices. In particular, EPA examined:

- whether MP&M baseline discharges would prevent POTWs from being able to meet the metals concentration limits required for more favorable and lower-cost sewage sludge use/disposal practices (i.e., beneficial land application and surface disposal); and

- whether limitations on the selection of management practices would be removed under the proposed rule.

EPA estimated the sewage sludge concentrations of ten metals for sample facilities under baseline and post-regulatory option discharge levels. EPA compared these concentrations with the relevant metals concentration limits for three sewage sludge management options: Land Application-High (Concentration Limits), Land Application-Low (Ceiling Limits), and Surface Disposal. Metal concentrations in sewage sludge are estimated as:

$$C_{sp} = \frac{L \cdot TMT \cdot PART \cdot SGF}{OD \cdot PF} \qquad (E.7)$$

where:

C_{sp} = sewage sludge pollutant concentration (mg/kg),
L = facility pollutant loading (µg/yr),
TMT = POTW treatment removal efficiency (unitless),
PART = pollutant-specific sludge partition factor (unitless),
SGF = sludge generation factor (mg/kg per µg/L),
OD = POTW operating days (days/yr), and
PF = POTW flow (L/day).

EPA derived the facility-specific data to evaluate POTW operations from the sources described in Sections 3.1 and 5.2. EPA examined multiple MP&M facilities discharging to the same POTW by summing the individual loadings before calculating the POTW influent and sewage sludge concentrations.

The ***partition factor*** is a chemical-specific value representing the fraction of the load expected to partition to sewage sludge during wastewater treatment. EPA used 1988 data on volume of sewage sludge produced (Federal Register, February 19, 1993, p. 9257) and volume of wastewater treated (1988 Needs Survey, Table C-3) to predict sewage sludge generation, and found a sludge generation factor of 7.4 mg/kg per µg/L:

$$SGF = \frac{V_{WWT}}{V_{SSP}} = \frac{28.736 \times 10^9 gal/day}{5{,}357{,}200\ DMT/yr} \cdot \frac{365\ day}{1\ yr} \cdot \frac{1\ DMT}{1000\ kg} \cdot \frac{3.79\ L}{1\ gal} \cdot \frac{1\ mg\ chemical}{1000\ \mu g\ chemical}$$
$$= \frac{7.4\ mg\ chemical/kg\ sludge}{1\ \mu g\ chemical/L\ wastewater} \qquad (E.8)$$

where:

SGF = sludge generation factor µg/L,
V_{WWT} = volume of wastewater treated gal/day, and
V_{SSP} = volume of sewage sludge produced dry metric tons (DMT)/yr.

The resulting concentration in sewage sludge is 7.4 mg/kg dry weight for every 1 µg/L of pollutant removed from wastewater and partitioned to sewage sludge.

E.2.4 Assumptions and Limitations

The following discussion focuses on major assumptions and limitations associated with these in-stream water quality analyses.

a. Other source contributions

EPA did not account for "other source contributions" of MP&M pollutants to estimate in-stream concentrations of these pollutants. Accounting for the discharges from other sources is important because assessing benefits from reduced exceedance of AWQC limits depends on comparing concentrations of pollutants from all sources with applicable thresholds. Analyses must also identify situations in which threshold criteria are exceeded in the baseline case but met under a regulatory option. Failing to account for other source contributions has an uncertain effect on estimated benefits. For example, if non-sample MP&M facilities are major contributors to aggregate pollutant discharges to a receiving stream, then the analysis will likely understate the extent of aquatic habitat improvements that may be accomplished by reduced MP&M pollutant discharges. Conversely, if the total MP&M contribution to the aggregate pollutant discharges to a receiving stream is not significant, then reducing MP&M discharges may reduce but not eliminate AWQC exceedances, and the benefits of the MP&M regulation can be overstated. The net effect of the following are unknown:

- excluding other sources understates the number and extent of baseline exceedances;
- excluding non-sample MP&M facilities understates the reduction in MP&M pollutant discharges due to the rule; and
- the number of cases in which estimated baseline exceedances are eliminated may be either over- or understated, depending on the contribution of pollutants from non-MP&M sources.

b. Waterbody modeling

EPA made four major assumptions concerning all waterbody modeling, and two major assumptions specific to stream modeling. These assumptions are summarized below:

- Complete mixing of POTW discharge flow occurs immediately. This mixing results in the calculation of an "average" concentration, even though the actual concentration may vary across the width and depth of the waterbody.
- Pollutant loads to the receiving waterbody are continuous and representative of long-term facility operations. This assumption may overestimate long-term risks to human health and aquatic life, but may underestimate potential short-term effects.
- In the absence of data from EPA's ***Permit Compliance System* (PCS)** on specific individual POTW flow, POTW daily flow rates were set equal to the simple arithmetic mean flow among POTWs associated with sample MP&M facilities.
- EPA used 1Q10 and 7Q10 receiving stream flow rates to estimate aquatic life impacts, and harmonic mean flow rates to estimate human health impacts, when modeling stream reaches. EPA estimated 1Q10 low flows by using the results of a regression analysis conducted for OPPT of 1Q10 and 7Q10 flows from representative U.S. rivers and streams (Versar, 1992). EPA estimated harmonic mean flows from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991). These flows may not be the same as those used by specific states to assess impacts.

Where data on stream flow parameters were not available, EPA set mean and 7Q10 flow values equal to the corresponding mean values associated with reaches located upstream and downstream of the sample reach.

c. Exposure analyses

MP&M exposure assessment in freshwater locations uses two sets of human health-based AWQC:

- AWQC for the protection of human health from the consumption of organisms and drinking water, and
- AWQC for the protection of human health from consumption of organisms only.

MP&M exposure assessments in marine locations use AWQC for the protection of human health from the consumption of organisms only, because salt water is not used for drinking water supply.

d. Extrapolation from sample set to national level

Although the sample set should represent a national group of facilities discharging to waterways and POTWs, effluent from an individual sample facility may have a different potential environmental impact than effluent from the facilities it is assumed to represent. For example, a facility that discharges to a stream with a very low flow may be similar to the facilities it represents in all aspects except available dilution in the receiving stream. The sample frame used in the MP&M analysis was not designed to take receiving waterbody characteristics into account. Using sample weights to extrapolate environmental impacts may either under- or overstate estimated impacts.

E.3 Data Sources

The following three sections describe the various data sources used to evaluate water quality and POTW impacts.

E.3.1 Facility-Specific Data

Section E.2.1 provided detailed information on sample size and distribution, and on receiving waterways. The names, locations, and the flow data for the POTWs to which the MP&M facilities discharge were obtained from the MP&M facility level Surveys and EPA's PCS database. EPA took alternative measures to obtain a complete set of receiving POTWs if these sources did not yield information for a given facility. EPA used latitude/longitude coordinates (if available) to locate those POTWs that have not been assigned a reach number in PCS. EPA identified the nearest POTW in the case of facilities for which the POTW receiving the plant discharge could not be positively identified. EPA based its identification of the closest linear distance on the latitude/longitude coordinates of the MP&M facility or the city in which it was located. EPA then identified the corresponding reach in PCS, and obtained POTW flow from the Needs Survey or PCS.

EPA identified reaches to which direct MP&M facilities discharge by identifying the receiving reach in PCS or by identifying the nearest reach. EPA based its identification of the closest linear distance on the MP&M facility’s latitude/longitude coordinates.

E.3.2 Waterbody-Specific Data

a. Streams and rivers

EPA used 1Q10, 7Q10, and mean flow data for the 544 streams and rivers. EPA obtained 7Q10 and mean flow data from the W.E. Gates study data or from measured stream flow data, both of which are contained in EPA's ***GAGE*** file. The W.E. Gates study contains calculated average and low flow statistics based on the best available flow data and on drainage areas for reaches throughout the United States. The GAGE file also includes average and low flow statistics based on measured data from ***United States Geological Survey* (USGS)** gaging stations. In the absence of data on stream flow parameters, EPA set 7Q10 and mean flow values equal to the corresponding median values associated with the sample reaches. EPA used the results of a regression analysis conducted for OPPT of 1Q10 and 7Q10 flows from representative U.S. rivers and streams (Versar, 1992) to estimate 1Q10 flows. EPA estimated harmonic mean flows from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991).

b. Lakes

EPA used data on hydraulic residence time (i.e., the amount of time water remains in a lake) to analyze relatively small lakes, and CDFs (which describe dilution in a portion of a lake) to analyze large lakes.

The sample MP&M facilities discharged directly to two lake reaches and indirectly to 26 lake reaches: 19 to small lakes, 5 to sections of Lake Erie, and 4 to sections of Lake Michigan. EPA calculated the average hydraulic residence time for small lakes based on lake surface and drainage areas. EPA obtained data on lake surface and drainage area from the US Army Corps of Engineers, Major Dams: Map Layer Description File (USCE, 1999). CDFs were readily available for Lake Michigan, but not for the 5 sample reaches on Lake Erie. EPA arithmetically averaged the seven chronic CDFs available for reaches discharging to Lake Erie (1, 1, 4, 4, 10, 10, 4) (U.S. EPA, 1992a, p. A-4) for the five reaches being modeled.

c. Estuaries and bays

Fifty-five bays and estuaries receive discharges from sample MP&M facilities. Data necessary to support water quality modeling were not available for four of the 55 bays/estuaries. A dilution model predicted pollutant concentrations in the chronic and acute mixing zones, based on site-specific CDFs (U.S. EPA, 1992a and Versar, 1994), to estimate the pollutant concentrations in 23 of these complex waterbodies.

Both acute and chronic CDFs were available for 19 of the 55 bays/estuaries. EPA estimated acute and chronic CDFs for New York bays/estuaries by arithmetically averaging available values for nearby New Jersey sites discharging to the Arthur Kill (acute: 1.5, 4.0, 5.0; chronic: 5; 20; 10) and Upper New York Bay (acute: 8.0; chronic: 22.9). Acute and chronic CDFs for the Buzzards Bay in Massachusetts were estimated by arithmetically averaging values for nearby Massachusetts and Rhode Island sites discharging to the Atlantic Ocean.

EPA could not identify or approximate chronic CDFs for the remaining 28 sample reaches. Acute CDFs are available for 43 of the 55 bays/estuaries. EPA extrapolated acute CDFs for two bays/estuaries in Florida by using CDFs for another Florida bay. Likewise, EPA extrapolated acute CDFs for four bays/estuaries in California by using CDFs for another California bay.

EPA obtained DCP values for 11 of the 28 sample bays/estuaries for which CDFs were not available from the Development of Mixing Zone Dilution Factors report (Versar, 1994). EPA then used a dilution model that predicts pollutant concentrations in the estuarine environment using a site-specific DCP value.

E.3.3 Information Used to Evaluate POTW Operations

EPA used removal efficiency rates, inhibition values, and sewage sludge regulatory levels to evaluate POTW operations. EPA obtained POTW removal efficiency rates from several sources. The Agency developed rates from POTW removal data and pilot-plant studies or used removals for a similar pollutant when data were not available. Use of the selected removal rates assumes that the evaluated POTWs are well-operated and have at least secondary treatment in place (U.S. EPA, 2000).

EPA obtained inhibition values from the *Guidance Manual for Preventing Interference at POTWs* (U.S. EPA, 1987a) and from *CERCLA Site Discharges to POTWs: Guidance Manual* (U.S. EPA, 1990). EPA used the most conservative values for activated sludge (i.e., the lowest influent concentrations that would cause inhibition). The Agency used a value based on compound type (e.g., aromatics) for pollutants with no specific inhibition value.

EPA obtained sewage sludge regulatory levels from the Federal Register 40 CFR Part 257 et al., *Standards for the Use or Disposal of Sewage Sludge; Final Rules* (February 19, 1993) and from the Federal Register 59(38):9095-9099 (February 25, 1994) and 60(206):54,764-54,770 (October 25, 1995) for eight metals regulated in sewage sludge. EPA used pollutant limits established for the final use or disposal of sewage sludge when the sewage sludge is applied to agricultural and non-agricultural land or is applied to a dedicated surface disposal site.

Finally, EPA obtained sludge partition factors from the *Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works* (Domestic Sewage Study) (U.S. EPA, 1986).

Table E.5 lists POTW treatment removal efficiency rates, inhibition values, sewage sludge partition factors, and sewage sludge regulatory levels used in the evaluation of POTW operations.

Table E.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (µg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
51285	Dinitrophenol, 2,4-	1000	0.10000000149		77.51
57125	Cyanide	5000	1		70.44
59507	Parachlorometacresol	5000	0.07900000364		63
62533	Aniline	1000	0.1		93.41
62759	Nitrosodimethylamine, N-		0.1		77.51
65850	Benzoic acid	10000	0.1		80.5
67641	Acetone	120000	0.1		83.75
67663	Trichloromethane	500000	0.015		
68122	Dimethylformamide, N,N-	1000	0.1		87
75003	Chloroethane		0.0075		77.51
75092	Dichloromethane	150000	0.1395		54.28
75150	Carbon disulfide	50000	0.0075		84
75354	Dichloroethene, 1,1-	150000			77.51
75694	Trichlorofluoromethane	700			77.32
78591	Isophorone	120000	0.079		77.51
78831	Isobutyl alcohol	1000000	0.1		28
78933	Methyl ethyl ketone	120000	0.1		96.6
79016	Trichloroethene	20000	0.0578		77.51
80626	Methyl methacrylate	120000			99.96
83329	Acenaphthene	500000	0.366		98.29
84742	Di-n-butyl phthalate	10000	0.216		84.66
85018	Phenanthrene	500000	0.366		94.89
85687	Butyl benzyl phthalate	10000	0.452		81.65
86306	Nitrosodiphenylamine, N-				90.11
86737	Fluorene	500000	0.366		69.85
88755	Nitrophenol, 2-	50000			26.83
91203	Naphthalene	500000	0.275		94.69
91576	Methylnaphthalene, 2-	5000	0.079		28
92524	Biphenyl	5000	0.366		96.28
95476	Xylene, o-	5000	0.149		77.32
95487	Cresol, o-	90000	0.079		52.5
98555	Terpineol, alpha-	1000000	0.1		94.4
98862	Acetophenone	120000	0.1		95.34
99876	Cymene, p-	5000	0.0075		99.79
100027	Nitrophenol, 4-	50000	0.1		77.51
100414	Ethylbenzene	200000	0.06		93.79
100425	Styrene	500000	0.149		93.65
100516	Benzyl alcohol	1000000	0.1		78
100754	Nitrosopiperidine, N-	1000			77.32
101848	Diphenyl Ether	1000			77.32
105679	Dimethylphenol, 2,4-	40000	0.079		77.51
106445	Cresol, p-	90000	0.079		71.67
107028	Acrolein	50	0.10000000149		77.51
108101	Methyl isobutyl ketone	120000	0.1		87.87
108372	Bromo-3-chlorobenzene, 1-	100			77.32
108383	Xylene, m-	5000	0.149		95.07
108883	Toluene	200000	0.278		96.18
108907	Chlorobenzene	140000	0.154		96.37

Table E.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (μg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
108952	Phenol	90000	0.146		95.25
110861	Pyridine	1000	0.1		95.4
112403	Dodecane, n- (a)				
112958	Eicosane, n- (a)				
117817	Bis(2-ethylhexyl) phthalate	10000	0.728		59.78
117840	Di-n-octyl phthalate	10000	0.075		68.43
120127	Anthracene	500000	0.55		77.51
122394	Diphenylamine	1000	0.08		77.32
123911	Dioxane, 1,4-	120000	0.1		45.8
124185	Decane, n-				9
127184	Tetrachloroethene	20000	0.034		84.61
129000	Pyrene	500000	0.366		83.9
131113	Dimethyl phthalate		0.1		77.51
132650	Dibenzothiophene	5000	0.366		84.68
137304	Ziram \ Cymate	50			
142621	Hexanoic acid	10000			84
206440	Fluoranthene	5000	0.366		42.46
544763	Hexadecane, n- (a)				
591786	Hexanone, 2-	120000			77.32
593453	Octadecane, n- (a)				
606202	Dinitrotoluene, 2,6-	5000	0.1		77.51
629594	Tetradecane, n- (a)				
629970	Docosane, n-				88
630013	Hexacosane, n- (b)				
630024	Octacosane, n- (b)				
638686	Triacontane, n- (b)				
646311	Tetracosane, n- (b)				
694804	Bromo-2-chlorobenzene, 1-	100			77.32
832699	Methylphenanthrene, 1-	5000	0.366		84.55
1576676	Dimethylphenanthrene, 3,6-	500000	0.366		84.55
1730376	Methylfluorene, 1-	500000	0.366		84.55
2027170	Isopropylnaphthalene, 2-	500000	0.1		77.32
7429905	Aluminum		1		91.36
7439896	Iron	5000	1		81.99
7439921	Lead	100	1	300	77.45
7439954	Magnesium	1000000	1		14.14
7439965	Manganese	10000	1		35.51
7439976	Mercury	100	1	17	71.66
7439987	Molybdenum		1		18.93
7440020	Nickel	5000	1	420	51.44
7440224	Silver	30	1		88.28
7440235	Sodium	3500000	1		2.69
7440280	Thallium		1		71.66
7440315	Tin	9000	1		42
7440326	Titanium		1		91.82
7440360	Antimony		1		66.78
7440382	Arsenic	40	1	41	65.77
7440393	Barium		1		15.98

Table E.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (µg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
7440417	Beryllium		1		71.66
7440428	Boron	1000	1		30.42
7440439	Cadmium	500	1	39	90.05
7440473	Chromium	1000	1		80.33
7440484	Cobalt		1		6.11
7440508	Copper	1000	1	1500	84.2
7440575	Gold		1		32.52
7440622	Vanadium	20000	1		9.51
7440655	Yttrium		1		32.52
7440666	Zinc	5000	1	2800	79.14
7440702	Calcium	2500000	1		8.54
7664417	Ammonia as N	480000			38.94
7782492	Selenium		1	100	34.33
14265442	Phosphate				57.41
14808798	Sulfate				84.61
16887006	Chloride				57.41
16984488	Fluoride				61.35
18496258	Sulfide	25000			57.41
18540299	Chromium hexavalent	1000	1		57.41
20324338	Tripropyleneglycolmethylether	120000			52.4
136777612	Xylene, o- & p- (c)	5000	0.149		36832
179601231	Xylene, m- & p- (c)				
C003	BOD 5-day (carbonaceous)				89.12
C004	Chemical Oxygen Demand (COD)				81.3
C009	Total Suspended Solids (TSS)				
C010	Total Dissolved Solids (TDS)				
C012	Total Organic Carbon (TOC)				70.28
C020	Total Recoverable Phenolics				57.41
C021	Total Kjeldahl Nitrogen				57.41
C025	Amenable Cyanide				57.41
C036	Oil And Grease (as Hem)				86.08
C037	Total Petroleum Hydrocarbons (as Sgt-hem)				
C042	Weak-acid Dissociable Cyanide				
	Phosphorus (as PO4)				
	Oil and Grease				

Sources: U.S. EPA (1985), U.S. EPA (1987), U.S. EPA (1990).

In the absence of data on POTW flow rates, EPA set the POTW flow rate equal to the arithmetic mean flow among POTWs associated with the sample MP&M facilities, using the following steps:

1. Calculate arithmetic mean flow among POTWs associated with the sample MP&M facilities. The estimated arithmetic mean flow for POTWs associated with the sample MP&M facilities is 61.4 million gallons per day (MGD).
2. Set POTW flow rate equal to the relevant arithmetic mean flow. For all POTWS with missing flow data, EPA set their flow rates equal to the arithmetic mean flow rate for sample POTWs, 61.4 MGD.

E.4 Results

MP&M facilities nationwide currently discharge an estimated 5,025 million pounds of pollutants per year to publicly-owned treatment works (POTWs) and approximately 410 million pounds of pollutants directly to surface waters. MP&M facility effluents contain 43 priority or toxic pollutants, 86 non-conventional pollutants, and three conventional pollutants (BOD, TSS, and O&G).

EPA estimates that the proposed rule would reduce pollutant discharges to the waters of the U.S. substantially, as shown by the loadings estimates in Table E.6 for five categories of pollutants. The regulation would result in total removals of 3,872 million pounds per year. These removals include a 30 million pound per year reduction in eight sewage sludge contaminants and a 703 million pound per year reduction in 89 pollutants causing inhibition of sewage sludge. The regulation would reduce discharges of 35 HAPs by about one million pounds per year. The regulation would also reduce discharges of pollutants with acute and chronic effects on aquatic life by 823 and 1,035 million pounds per year, respectively. These reductions result from increased wastewater treatment, pollution prevention, and regulatory closures. EPA evaluated the national environmental impacts of reducing pollutant discharges from MP&M facilities to the nation's waterbodies for the proposed rule. The following sections present results of this analysis.

Table E.6 National MP&M Facility Discharges

Category	POTW Impacts: Activated Sludge Inhibition	POTW Impacts: Biosolids Contaminants	POTW Impacts: HAP	Receiving Stream Impacts: Aquatic Life Toxicity: Acute	Receiving Stream Impacts: Aquatic Life Toxicity: Chronic
Baseline Loadings[a]					
# of Pollutants	89	8	35	107	116
Million lbs/yr	1,031	31.7	2.1	1,252	1,758
Remaining with the Proposed Option					
Million lbs/yr	328	1.61	1.11	430	723
Remaining with Option 2/6/10					
Million lbs/yr	266	0.54	0.89	364	647
Remaining with Option 4/8					
Million lbs/yr	484	0.43	1.05	595	895

a. Excludes loadings from facilities projected to close in the baseline. See Chapter 5.
Source: U.S. EPA analysis.

E.4.1 Human Health Impacts

This analysis compares the estimated baseline and post-compliance in-stream pollutant concentrations with AWQC. The comparison included AWQC both for protection of human health through consumption of organisms and for consumption of organisms and water. Pollutant concentrations in excess of these values indicate potential risks to human health.

EPA extrapolated the findings from the analysis of reaches affected by sample facility discharges to national estimates using facility sample weights, as described in Appendix F. EPA's modeling results estimate that baseline in-stream concentrations of 18 pollutants exceed human health criteria for consumption of water and organisms in 10,310 receiving reaches nationwide (Table E.7). The total number of estimated baseline exceedences is 11,341. The proposed rule eliminates concentrations in excess of the criteria for consumption of water and organisms on 1,105 of these reaches. EPA also estimates that the proposed rule eliminates the occurrence of concentrations exceeding human health criteria only for consumption of organisms on 121 of the 192 reaches on which EPA estimates baseline discharges cause concentrations exceeding AWQC values. Results also show that 382 receiving reaches will experience partial water quality improvements from reduced occurrence of some pollutant concentrations exceeding AWQC limits for consumption of water and organisms. The total number of exceedences is reduced to 9,789.

Table E.8 presents results for individual pollutants estimated to affect water quality in the receiving stream.

Table E.7: Summary of Projected National Criteria Exceedences for MP&M Dischargers

Policy Option	Human Health Water and Organisms	Human Health Organisms Only
Baseline		
Streams (No.)	10,310	192
Pollutants (No.)	18	6
Total Exceedences	11,341	256
Proposed Option		
Streams (No.)	9,205	71
Pollutants (No.)	11	5
Total Exceedences	9,789	107
Option 2/6/10		
Streams (No.)	4,151	71
Pollutants (No.)	11	5
Total Exceedences	4,720	107
Option 4/8		
Streams (No.)	4,160	65
Pollutants (No.)	13	5
Total Exceedences	4,711	100

Source: U.S. EPA analysis.

Table E.8: National Summary of Pollutants Projected to Exceed Human Health-Based AWQC

	Human Health Water and Organisms (# of reaches)				Human Health Organisms Only (# of reaches)			
Pollutant	**Baseline**	**Proposed Option**	**Option 2/6/10**	**Option 4/8**	**Baseline**	**Proposed Option**	**Option 2/6/10**	**Option 4/8**
Aniline	12	12	12	12	0	0	0	0
Arsenic	474	433	433	372	117	50	50	44
Bis (2-ethylhexyl) phthalate	59	15	15	15	26	12	12	12
Chloroethene	9	9	9	9	0	0	0	0
Cresol, p-	9	0	0	9	0	0	0	0
Dichloroethene, 1,1-	143	57	42	67	12	12	12	12
Dichloromethane	12	12	12	12	0	0	0	0
Dinitrophenol, 2,4-	9	0	0	0	0	0	0	0
Dinitrotoluene, 2,6-	9	0	0	0	0	0	0	0
Dioxane, 1,4-	12	12	12	12	0	0	0	0
Iron	7	0	0	0	0	0	0	0
Isophorone	9	0	0	0	0	0	0	0
Manganese	224	0	0	0	72	0	0	0
Nitrosodimethylamine, n-	10,310	9,205	4,151	4,160	20	20	20	20
Nitrosodiphenylamine, N-	12	12	12	12	9	12	12	12
Pyridine	9	0	0	9	0	0	0	0
Trichloroethene	12	12	12	12	0	0	0	0
Tricoloromethane	12	12	12	12	0	0	0	0
Total Exceedences	11,343	9,791	4,722	4,713	256	106	106	100

Source: U.S. EPA analysis.

The alternative options would eliminate instances of in-stream pollutant concentrations exceeding AWQC limits for consumption of water and organisms in 6,159 (Option2) and 6,150 (Option 4/8) reaches. Options 2/6/10 and 4/8 would eliminate occurrence of pollutant concentrations in excess of AWQC values for organism consumption in 121 and 127 reaches nationwide. The total number of exceedences is reduced to 4,827 and 4,811 under Option 2/6/10 and Option 4/8, respectively.

E.4.2 Aquatic Life Effects

EPA evaluated the effects of wastewater discharges on receiving stream water quality under the baseline and the proposed option. The analysis compared baseline and post-compliance exceedances of aquatic life AWQC to determine the effects of the rule. Table E.9 summarizes the results extrapolated to the national level. Results show that baseline pollutant concentrations exceed acute AWQC in 878 reaches and chronic AWQC in 2,466 reaches nationally at baseline discharge levels. The total number of exceedences at the baseline is 6,452.

Table E.9: Summary of Projected Criteria Exceedences for MP&M Dischargers (National Basis)

Policy Option	Acute Aquatic Life	Chronic Aquatic Life
Baseline		
Streams (No.)	878	2,466
Pollutants (No.)	10	31
Total Exceedences	1,152	6,452
Proposed Option		
Streams (No.)	103	1,437
Pollutants (No.)	11	25
Total Exceedences	188	2,307
Option 2/6/10		
Streams (No.)	61	1,394
Pollutants (No.)	8	20
Total Exceedences	72	2,003
Option 4/8		
Streams (No.)	52	1,310
Pollutants (No.)	6	17
Total Exceedences	62	1,730

Source: U.S. EPA analysis.

Table E.10 presents results for individual pollutants estimated to affect water quality in the receiving reaches. EPA estimates that the proposed option will eliminate concentrations in excess of acute and chronic criteria in 775 and 1,029 reaches, respectively. Results also show that an additional 903 receiving reaches will experience partial water quality improvements from reduced occurrence of some pollutant concentrations in excess of acute and/or chronic AWQC limits for protection of aquatic life. The proposed rule reduces the total number of exceedences to 2,495 nationwide. Options 2 and 4 would eliminate exceedances of chronic AWQC values on 1,072 and 1,156 reaches. The alternative options would also eliminate in-stream pollutant concentrations in excess of acute AWQC value on 817 (Option 2/6/10) and 826 reaches (Option 4/8). The total number of exceedences will be reduced to 2,075 and 1,792 under Option 2/6/10 and 4/8 respectively.

Table E.10: Summary of Pollutants Projected to Exceed Aquatic Life Based AWQC (National Basis)

Pollutant	Acute Aquatic Life (# of reaches)				Chronic Aquatic Life (# of reaches)			
	Baseline	Proposed Option	Option 2/6/10	Option 4/8	Baseline	Proposed Option	Option 2/6/10	Option 4/8
Acrolein	13	12	12	12	103	39	39	39
Aluminum	0	0	0	0	40	22	13	0
Ammonia as N	9	0	0	9	12	12	12	12
Aniline	0	0	0	0	19	15	15	15
Anthracene	76	15	15	15	92	24	15	15
Benzoic Acid	0	0	0	0	33	33	0	0
Boron	0	0	0	0	946	400	366	317
Butyl benzyl phthalate	0	0	0	0	9	0	0	0
Cadmium	0	9	9	9	75	9	9	9
Carbon disulfide	0	0	0	0	11	3	3	7
Chromium hexavalent	33	33	0	0	33	33	0	0
Copper	783	31	13	0	926	31	13	0
Cyanide	62	9	9	9	165	16	16	16
Di-n-butyl phthalate	0	0	0	0	8	0	0	0
Dimethylphenanthrene,3,6-	0	0	0	0	3	0	0	3
Fluoranthene	0	3	3	0	24	24	15	15
Fluorene	0	0	0	0	15	15	15	15
Fluoride	0	0	0	0	109	22	22	22
Iron	0	0	0	0	39	0	0	0
Lead	0	9	9	9	372	50	9	9
Manganese	0	0	0	0	17	0	0	0
Molybdenum	0	0	0	0	241	154	130	0
Nickel	39	0	0	0	300	9	0	0
Phenanthrene	0	0	0	0	12	3	3	12
Phenol	0	0	0	0	9	0	0	0
Selenium	33	33	0	0	93	36	3	0
Silver	7	3	3	0	166	87	78	45
Sulfide	0	0	0	0	1,621	1,218	1,218	1,178
Tin	0	0	0	0	793	9	0	0
Vanadium	0	0	0	0	70	12	12	3
Zinc	98	33	0	0	98	33	0	0
Total Exceedences	**1,153**	**190**	**73**	**63**	**6,454**	**2,309**	**2,008**	**1,732**

Source: U.S. EPA analysis.

E.4.3 POTW Effects

EPA evaluated the effects of indirect MP&M dischargers on POTW operations for the baseline and the proposed option. 726 sample MP&M facilities discharge 132 pollutants to 524 POTWs. Of these, EPA evaluated 89 pollutants for potential inhibition of POTW operations and 8 pollutants for potential sludge contamination. The 726 indirect sample MP&M facilities discharge 278.5 million pounds per year of priority and non-conventional pollutants to the receiving POTWs. EPA estimates that the proposed regulation would reduce the MP&M loadings to the receiving POTWs to 71.6 million pounds per year. EPA extrapolated sample-level results to the national level by using sample facility weights and the differential weighting technique (see Appendix F for details). At the national level, 57,707 MP&M facilities discharge 5,025 million pounds of priority and non-conventional pollutants. EPA estimates that the proposed regulation would reduce the MP&M loadings to the receiving POTWs to 1,463 million pounds per year at the national level.

a. Biological inhibition

EPA estimated inhibition of POTW operations by comparing predicted POTW influent concentrations to available inhibition levels for 89 pollutants.

National results show that POTW influent concentrations of 18 pollutants exceed biological inhibition criteria at 515 POTWs in the baseline (see Table E.11). The proposed regulation would eliminate potential inhibition problems at 306 POTWs and reduce occurrence of pollutant concentrations in excess of inhibition criteria at 82 POTWs. Options 2/6/10 and 4/8 would eliminate influent concentrations in excess of POTW inhibition criteria at 392 POTWs. Table E.12 presents the 18 individual pollutants that are projected to impact POTWs because their influent concentrations exceed biological inhibition criteria.

Table E.11: National Summary of Projected Inhibition and Sludge Contamination Problems

Policy Option	Biological Inhibition (# of POTWs)	Sludge Contamination (# of POTWs)
Baseline:		
POTWs (No.)	515	6,953
Pollutants (No.)	18	8
Total Exceedences	1695	18,782
Proposed Option		
POTWs (No.)	209	6,889
Pollutants (No.)	12	8
Total Exceedences	676	18,434
Option 2/6/10		
POTWs (No.)	123	5,574
Pollutants (No.)	11	8
Total Exceedences	563	16,934
Option 4/8:		
POTWs (No.)	123	5,574
Pollutants (No.)	10	8
Total Exceedences	479	16,510

Source: U.S. EPA analysis.

Table E.12: National Summary of Pollutants Projected to Impact POTWs (National basis)

	Biological Inhibition (# of POTWs)				Sludge Contamination (# of POTWs)			
Pollutant	**Baseline**	**Proposed Option**	**Option 2/6/10**	**Option 4/8**	**Baseline**	**Proposed Option**	**Option 2/6/10**	**Option 4/8**
Acrolein	82	82	82	82				
Arsenic	85	85	85	82	1,553	1,553	1,553	1,553
Benzoic acid	48	31	0	0				
Boron	240	149	123	123				
Bromo-2-chlorobenzene, 1-	93	36	36	36				
Bromo-3-chlorobenzene, 1-	93	36	36	36				
Cadmium	0	0	0	0	2,159	2,086	2,079	2,046
Chromium	85	24	24	0				
Chromium hexavalent	24	0	0	0				
Copper	269	24	24	0	3,804	3,688	3,626	3,626
Dinitrophenol, 2,4-	24	0	0	0				
Iron	97	11	11	11				
Lead	236	91	36	36	2,515	2,480	2,465	2,465
Mercury	0	0	0	0	130	130	130	130
Nickel	82	0	0	0	3,080	2,964	2,964	2,964
Selenium	0	0	0	0	1,410	1,410	1,402	1,360
Silver	82	82	82	24				
Sodium	24	0	0	24				
Sulfide	82	24	24	24				
Tin	23	0	0	0				
Zinc	24	0	0	0	3,194	3,146	2,995	2,995
Total Exceedences	1,693	675	563	478	17,845	17,457	17,214	17,139

Source: U.S. EPA analysis.

b. Sewage sludge

EPA estimated that baseline concentrations of eight metals at the national level would fail to meet Land Application-High limits for sludge disposal at 6,953 POTWs. These concentrations were compared with the relevant metals concentration limits for the following sewage sludge management options: Land Application-High (Concentration Limits), Land Application-Low (Ceiling Limits), and Surface Disposal. The Agency estimates that the proposed regulation will eliminate metal concentrations in excess of sludge contamination criteria at 64 POTWs. EPA estimated that an additional 1,378 POTWs would meet all Land Application-High limits as a result of the regulatory Options 2/6/10 or 4/8. The proposed regulation would cause an estimated 1.7 million additional DMT of annual disposal of sewage sludge to qualify for beneficial use under the Land Application-High limits (see Tables E.11 and E.12).

GLOSSARY

action levels: the existence of a contaminant concentration in the environment high enough to warrant implementation of drinking water treatment technology.

acute toxicity (AT): the ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance. (See also: chronic toxicity, toxicity.) (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption: removal of a pollutant from air or water by collecting the pollutant on the surface of a solid material; an advanced method of treating waste in which activated carbon removes organic matter from wastewater. (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption coefficient (K_{oc}): represents the ratio of the target chemical absorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium.

alkalinity: the capacity of bases to neutralize acids (e.g., adding lime to lakes to decrease acidity). (http://www.epa.gov/OCEPAterms/aterms.html)

ambient water quality criteria (AWQC): Levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

atm/m^3-mole: atmosphere per cubic meter mole (see also mole).

benthic: relating to the bottom of a body of water; living on, or near, the bottom of a waterbody. (http://www.ucmp.berkeley.edu/glossary/gloss5ecol.html)

bioconcentration factor (BCF): indicator of the potential for a chemical dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually gills.

BIODEG: a web-based biodegradation database developed by Syracuse Research Corporation (http://esc.syrres.com/efdb/biodgsum.htm).

biodegradation: a process whereby organic molecules are broken down by microbial metabolism.

biodegradation half-life: represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions.

biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in an aquatic environment.

cancer potency slope factors (SFs): a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

carcinogens: chemicals that EPA believes can cause or have the potential to cause tumors or cancers in humans, either directly or indirectly.

CHEMFATE: a web-based chemical fate database developed by Syracuse Research Corporation (http://esc.syrres.com/efdb/Chemfate.htm).

chronic toxicity (CT): the capacity of a substance to cause long-term toxic or poisonous health effects in humans, animals, fish, and other organisms (see also: acute toxicity). (http://www.epa.gov/OCEPAterms/cterms.html)

critical dilution factors (CDFs): express the relationship between a point source loading and the resulting concentration at the edge of the mixing zone. Typically, this is expressed as a ratio of parts receiving water to one part effluent.

dissolved concentration potentials (DCPs): represents the concentration of a nonreactive dissolved substance under well-mixed, steady-state conditions given an annual load of 10,000 tons.

dry metric tons (DMT): dry measure is a system of units for measuring dry commodities. 1 DMT=1,000 kilogram.

EC1: the concentration at which one percent of the test organisms show a significant sublethal response.

EC5: the concentration at which five percent of the test organisms show a significant sublethal response.

Environmental Research Laboratory-Duluth fathead minnow database: a data base developed by EPA's Mid-Continent Ecology Division (MED) which provides data on the acute toxicity of hundreds of industrial organic compounds to the fathead minnow (http://www.eoa.gov/med/databases/fathead_minnow.html)

GAGE: a U.S. Geological Survey streamflow database. The database contains stream flow data and drainage area measurement from all U.S. Geological Survey flow gages.

hazardous air pollutant (HAP): air pollutants that are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects (e.g., beryllium, mercury, ethylbenzene, chloroethane, and doxane). (http://www.epa.gov/OCEPAterms/hterms.html)

Health Effects Assessment Summary Tables (HEAST): a comprehensive listing of provisional human health risk assessment data relative to oral and inhalation routes for chemicals of interest to EPA. Unlike data in IRIS, HEAST entries have received insufficient review to be recognized as high quality, Agency-wide consensus information (U.S. EPA. 1997. Health Effects Assessment Table; FY 1997 Update. EPA-540-R-97-036).

Henry's Law (H): chemical law stating that the amount of a gas that dissolves in a liquid is proportional to the partial pressure of the gas over the liquid, provided no chemical reaction takes place between the liquid and the gas. The law is named after William Henry (1774–1836), the English chemist who first reported the relationship. (www.infoplease.com)

human health-based water quality criteria (WQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/wterms.html)

Integrated Risk Information System (IRIS): IRIS is an electronic data base with information on human health effects of various chemicals. IRIS provides consistent information on chemical substances for use in risk assessments, decision-making, and regulatory activities.

LC50 (Lethal Concentration): a standard measure of toxicity that tells how much of a substance is needed to kill half of a group of experimental organisms in a given time (see: LD 50). (http://www.epa.gov/OCEPAterms/lterms.html)

LD50 (Lethal Dose): the dose of a toxicant or microbe that will kill 50 percent of the test organisms within a designated period. The lower the LD 50, the more toxic the compound.

l/kg: liter per kilogram

Lowest Observed Effect Concentration (LOEC): the lowest level of pollutant concentration that causes statistically and biologically significant differences in test samples as compared to other samples subjected to no stressor. (http://www.epa.gov/OCEPAterms)

Maximum Allowable Toxicant Concentration: (MATC): for a given ecological effects test, the range (or geometric mean) between the No Observable Adverse Effect Level and the Lowest Observable Adverse Effects Level. (http://www.epa.gov/OCEPAterms/mterms.html)

maximum contaminant levels (MCLs): the maximum permissible level of a contaminant in water delivered to any user of a public system. MCLs are enforceable standards. (http://www.epa.gov/OCEPAterms/mterms.html)

mg/kg: milligram per kilogram

µg/l: microgram per liter

mole: the amount of substance that contains Avogardo’s number of atoms, molecules or other elementary units.

National Estuarine Inventory (NEI): The National Estuarine Inventory is a series of inter-related activities that define, characterize, and assess the Nation's estuarine systems. NEI data are compiled in a systematic and consistent manner that enables the Nation's estuaries to be compared and assessed according to their environmental quality, economic values, and resource uses. A principal feature of the NEI is the determination of the physical dimensions and hydrologic features of estuarine systems of the United States which are primary determinants of estuarine processes and ultimately affect the ecology of a system.

National Oceanic and Atmospheric Administration (NOAA): Organization within the Bureau of Commerce that conducts research and gathers data about the global oceans, atmosphere, space, and sun.

No Observed Effect Concentration (NOEC): Exposure level at which there are no statistically or biologically significant differences in the frequency or severity of any effect in the exposed or control populations. (http://www.epa.gov/OCEPAterms/nterms.html)

oil and grease (O&G): organic substances that may include hydrocarbons, fats, oils, waxes, and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

organic carbon (OC): carbon in compounds derived from living organisms.

partition factor: a chemical-specific value representing the fraction of the load expected to partition to sewage sludge during wastewater treatment.

Permit Compliance System (PCS): a computerized database of information on water discharge permits, designed to support the National Pollutant Discharge Elimination System (NPDES). (http://www.epa.gov/ceisweb1/ceishome/ceisdocs/pcs/pcs-exec.htm)

pH: an expression of the intensity of the basic or acid condition of a liquid; Natural waters usually have a pH between 6.5 and 8.5. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutants of concern (POCs): are the 150 contaminants identified by EPA as being of potential concern for this rule and which are currently being discharged by MP&M facilities.

Premanufacture Notices (PMN): a notice, required by Section 5 of TSCA, that must be submitted to EPA by anyone who plans to manufacture or import a new chemical substance for a non-exempt commercial distribution. The notice must be submitted at least 90 days prior to the manufacture or import of the chemical. (http://www.epa.gov/oppt/newchems/index.htm)

priority pollutant (PP): 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples. These chemicals are also known as toxic pollutants.

quantitative structure-activity relationship (QSAR): an expert system that uses a large database of measured physicochemical properties, such as melting point, vapor pressure, and water solubility, to estimate the fate and effect of a specific chemical based on its molecular structure (http://www.epa.gov/med/databases/aster.html)

reference doses (RfDs): RfDs represent chemical concentrations - expressed in mg of pollutant/kg body weight/day - which, if not exceeded, are expected to protect an exposed population, including sensitive groups such as young children or pregnant women.

Secondary Maximum Contaminant Levels (SMCLs): non-enforceable water treatment levels applying to public water systems and specifying the maximum contamination levels that, in the judgment of EPA, are required to protect the public welfare. These treatment levels apply to any contaminants that may adversely affect the odor or ap- pearance of such water and consequently may cause people served by the system to discontinue its use.

suspended solids: small particles of solid pollutants that float on the surface of, or are suspended in, sew- age or other liquids. They resist removal by conventional means.

Superfund Chemical Data Matrix (SCDM): a source for factor values and benchmark values applied when evaluating potential National Priorities List (NPL) sites using the Hazard Ranking System (HRS). (http://www.epa.gov/superfund/resources/scdm/index.htm).

systemic toxicants: chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds.

total Kjeldahl nitrogen (TKN): TKN is defined as the total of organic and ammonia nitrate. It is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

total organic carbon (TOC): a measure of the suspended solids in wastewater, effluent, or waterbodies, determined by tests for "total suspended non-filterable solids" (see also: suspended solids).

total petroleum hydrocarbons (TPH): a general measure of the amount of crude oil or petroleum product present in an environmental media (e.g., soil, water, or sediments). While it provides a measure of the overall concentration of petroleum hydrocarbons present, TPH does not distinguish between different types of petroleum hydrocarbons.

total suspended particles (TSP): A method of monitoring airborne particulate matter by total weight. (http://www.epa.gov/OCEPAterms/tterms.html)

total suspended solids (TSS): a measure of the suspended solids in wastewater, effluent, or waterbodies, determined by tests for "total suspended non-filterable solids" (see also: suspended solids).

United States Geological Survey (USGS): a governmental organization that provides reliable scientific information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. (www.noaa.gov)

volatilization: a process whereby chemicals dissolved in water escape into the air.

ACRONYMS

AQUIRE: AQUatic Information REtrieval System
ASTER: ASsessment Tools for the Evaluation of Risk
AT: acute toxicity
AWQC: ambient water quality criteria
BCF: bioconcentration factor
BOD: biological oxygen demand
CDF: critical dilution factor
CT: chronic toxicity
DCP: dissolved concentration potential
DMT: dry metric tons
H: Henry's Law
HAP: hazardous air pollutant
HEAST: Health Effects Assessment Summary Tables
IRIS: Integrated Risk Information System
K_{oc}: adsorption coefficient
LOEC: Lowest Observed Effect Concentration
MATC: Maximum Allowable Toxicant Concentration
MCL: maximum contaminant level
NEI: National Estuarine Inventory
NOAA: National Oceanic and Atmospheric Administration
NOEC: No Observed Effect Concentration
O&G: oil and grease
OC: organic carbon
PCS: Permit Compliance System
PMN: Premanufacture Notices
POC: pollutant of concern
PP: priority pollutant
QSAR: quantitative structure-activity relationship
RBC: EPA's Region III Risk-Based Concentration Table
RfD: reference dose
SCDM: Superfund Chemical Data Matrix
SF: cancer potency slope factor
SMCL: Secondary Maximum Contaminant Level
TKN: total Kjeldahl nitrogen
TOC: total organic carbon
TPH: total petroleum hydrocarbons
TSP: total suspended particulates
TSS: total suspended solids
USGS: United States Geological Survey
WQC: water quality criteria

REFERENCES

Arthur D. Little. 1983. *Evaluation of waterborne exposure pathways to paragraph 4(c) pollutants.* Draft Report, April 28. Also: Paragraph 4(c) list of detected chemicals.

Arthur D. Little. 1986. *Bioaccumulation Study*.

Birge, W.J. et al. 1979. *Aquatic toxicity tests on inorganic elements occurring in oil shale.* Oil Shale Symposium - Sampling, Analysis and Quality Assurance, March. EPA-600/9-80-022.

Clay, D.R. 1986. Office of Toxic Substances, U.S. Environmental Protection Agency. Memorandum to J.M. Conlon, OWRS, U.S. Environmental Protection Agency.

Holdway, D.A. and J.B. Spraque. 1979. "Chronic toxicity of vanadium to flagfish." *Water Research* 13:905-910.

Howard, P.H., Ed. 1991. *Handbook of Environmental Degradation Rates*. Chelsea. MI: Lewis Publishers, Inc.

ICF, Inc. 1985. *Superfund Public Health Evaluation Manual* - Draft.

Leblanc, G.A. 1980. "Acute toxicity of priority pollutants to water flea" (Daphnia magna). *Bull Environmental Contamination Toxicology* 24:684-691.

Lyman, W.J.; W.F. Reehl, and D.H. Rosenblatt. 1981. *Handbook of Chemical Property Estimation Methods - Environmental Behavior of Organic Compounds*. New York, NY: McGraw-Hill Book Company. 960 pp. (reported or estimated using methods outlined).

Syracuse Research Corporation. 1997. CHEMFATE Datafile within the Environmental Fate Database. Syracuse, NY: Syracuse Research Corporation.

U.S. Atomic Energy Commission. 1973. *Toxicity of power plant chemicals to aquatic life*. Washington, DC: U.S. Atomic Energy Commission.

U.S. Environmental Protection Agency (U.S. EPA). 1972. "Blue Book", NAS-NAE (Water Quality Criteria - 1972). Washington, DC: U.S. EPA. EPA-R3-73-033. If the code @ AA is provided with this reference, the value is an estimate based on application factors described in the "Blue Book."

U.S. Environmental Protection Agency (U.S. EPA). 1976. "Red Book" (Quality Criteria For Water). Washington, DC: US Environmental Protection Agency.

U.S. Environmental Protection Agency (U.S. EPA). 1980. Ambient water quality criteria documents. Washington, DC: Office of Water, U.S. EPA. EPA 440/5-80 Series. Also refers to any update of criteria documents (EPA 440/5-85 and EPA 440/5-87 Series) or any Federal Register notices of proposed criteria or criteria corrections. The most recent National Recommended Water Quality Criteria used in this report were published in the Federal Register on December 10, 1998.

U.S. Environmental Protection Agency (U.S. EPA). 1984. *Summary of current oral Acceptable Daily Intakes (ADIs) for systemic toxicants*. Cincinnati, Ohio: Environmental Criteria and Assessment Office, U.S. EPA, May. 19 pp.

U.S. Environmental Protection Agency (U.S. EPA). 1985. *Report to Congress on the Discharge of Hazardous Wastes to Publicly-owned Treatment Works (Domestic Sewage Study)*. Office of Water Regulations and Standards. Washington, DC: U.S. EPA.

U.S. Environmental Protection Agency (U.S. EPA). 1987. *Guidance Manual for Preventing Interference at POTWs.* Washington, DC: U.S. EPA

U.S. Environmental Protection Agency (U.S. EPA). 1990. *CERCLA Site Discharges to POTWs: Guidance Manual*. Washington, DC: Office of Emergency and Remedial Response EPA/540/G-90/005.

U.S. Environmental Protection Agency (U.S. EPA). 1997. Health Effects Assessment Summary Tables (HEAST). Office of Research and Development and Office of Emergency and Remedial Response, Washington, DC: U.S. EPA.

U.S. Environmental Protection Agency (U.S. EPA). 1998. Risk-Based Concentration Table, October. Philadelphia, PA: Region III, U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency (U.S. EPA). 1998/99. QSAR. Duluth, MN: Environmental Research Laboratory, U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency (U.S. EPA). 1998/99a. Aquatic Toxicity Information Retrieval (AQUIRE) Data Base. Duluth, MN: Environmental Research Laboratory, U.S. Environmental Protection Agency. 1998 Database retrieval.

U.S. Environmental Protection Agency (U.S. EPA). 1998/99b. Assessment Tolls for Evaluation of Risk (ASTER) Data Base. Duluth, MN: Environmental Research Laboratory, U.S. Environmental Protection Agency. 1998 Database retrieval.

U.S. Environmental Protection Agency (U.S. EPA). 1998/99c. Integrated Risk Information System (IRIS) Retrieval. Washington, DC: U.S. EPA. 1998 Data Base retrieval.

U.S. Environmental Protection Agency (U.S. EPA). 2000. *Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products and machinery Point Source Category*. Washington, DC: U.S. EPA.

Versar. 1992. *Upgrade of Flow Statistics Used to Estimate Surface Water Chemical Concentrations for Aquatic and Human Exposure Assessment*. Prepared for the Office of Pollution Prevention and Toxics, U.S. EPA.

Versar. 1994. *Development of Mixing Zone Dilution Factors. Preliminary Draft, Progress Report*. Prepared for U.S. EPA, Office of Pollution Prevention and Toxics, Economics, Exposure, and Technology Division. October 27. EPA Contract No. 68-D3-0013.

Worthing, C.R. 1987. *The Pesticide Manual - a world compendium*, Eighth Edition. Surry, UK: The British Crop Protection Council. ISBN 0-948404-42-6.

Zhang, R. and Zhang, S. 1982. “Toxicity of fluorides to fishes.” C.A. Selects - *Environm Pollut* 24,97:176354k.

Appendix F: Differential Sample Weighting Technique

Introduction

EPA used two methods in the benefit analysis to extrapolate sample facility results to the national level.

- a ***standard linear weighting technique***; and
- a ***differential sample weighting technique***.

The choice of the weighting method depends on the additivity of the effects being considered. In some cases, effects are additive across facilities regardless of their location relative to each other. In other cases, effects depend on how many facilities discharge to the same waterbody. The choice of sample weight used differs for the two situations.

The standard linear weighting technique is used where the effects being considered (e.g., compliance costs) are linearly additive over facilities. EPA used this extrapolation method in the economic impact analysis to calculate national compliance costs, and in the cost-effectiveness and benefit analyses to estimate changes in pollutant loadings. This approach was also used in the benefits analysis to calculate changes in cancer risk, because pollutant exposures have marginal effects on cancer risk. These marginal effects are linearly additive over the facilities, chemicals, and human populations affected by changes in MP&M pollutant discharges.

EPA used a differential sample weighting technique for all threshold value-based analyses, such as the lead-related benefits analysis. Threshold based analyses include comparisons of the estimated baseline and post-compliance POTW influent flow concentrations, sludge concentrations, or in-waterway concentrations with the relevant threshold values.

The differential weighting technique is identical to the standard linear weighting method for POTWs or reaches to which only one MP&M sample facility discharges. If a POTW or reach receives discharges from only one sample facility, the number of POTWs or reaches expected to benefit in a similar fashion at the national level is simply the sample weight of the single facility discharging to the POTW or reach. Approximately 22.6 percent of the reaches that have a MP&M sample facility and 18.4 percent of POTWs that have a sample MP&M facility receive discharges from more than one sample facility. EPA used a different method for developing national estimates of benefits to account for the presence of more than one facility with different sample weights discharging to POTWs or reaches affected by multiple MP&M dischargers. This appendix describes this method for extrapolating sample results to the national level.

Appendix Contents:

F.1 Methodology for Developing Sample-Weighted Estimates for Sites with more than One MP&M Facility

The MP&M analysis is based on a random stratified sample of MP&M facilities, while the unit of environmental assessment and analyses is a reach. It is possible to use facility sample weights to estimate the number of similar facilities on similar reaches nationwide with some adjustments. These facility sample weights are designed to provide facility characteristics. They are not reach-specific sample weights designed to estimate reach characteristics, however, and therefore cannot be used directly to estimate the national occurrence of reaches associated with a specific characteristic of MP&M discharges. For example, the sum of MP&M sample facility weights discharging to one reach is an accurate estimate of the number of national *facilities* similar to the sample facilities, but is not a valid national estimate of the number of *reaches* identically similar to that reach.

It is not valid to assume that the co-location of sample facilities is similar to the co-location characteristics of all

MP&M facilities. This point is illustrated by the case in which two sample facilities with different weights discharge to the same reach. Assume that one of these two sample facilities has a sample weight of 5 and the other has a sample weight of 200. The sample weights indicate that there are four additional facilities in the US that are economically and technically similar to the facility with the weight of five. It is also correct to estimate that the other four facilities will discharge the same volume of the same pollutants as the other four facilities. Now let us assume that there are 199 other facilities nationwide similar to the facility with the weight of 200. The more numerous facilities represented by the facility with a weight of 200 could only rarely be co-located with one of the four facilities represented by the sample facility with a weight of 5.

EPA developed a method that takes into consideration the joint occurrence of facilities with different statistical weights on reaches to estimate the number of reaches affected by MP&M facilities nationwide. EPA created a series of new discharge variables (a discharge event) for each reach affected by MP&M sample facilities, and assigned weights for the discharge events that provide a national estimate of pollutant discharges across all reaches. The sample discharge events (flows and pollutant loadings) are calculated based on the sum of the flows and pollutant loadings for subsets of the MP&M sample facilities that discharge to that reach. The weights for the discharge events are developed from the facility weights for those subsets of facilities. The calculation includes direct MP&M facility discharges and indirect discharges from POTWs after considering pollutant removals from POTW treatment.

The number of discharge events on a sample reach equals the number of unique sample weights for the facilities on the reach. EPA calculated a sample weight for each discharge event based on the sample weights of the facilities contributing loadings and flows to the event. Table F-1 illustrates discharge event calculations and corresponding sample weights. Steps for calculating the relevant parameters for discharge events on reaches affected by multiple discharges are as follows:

- Rank pollutant loadings (or discharge flows) in ascending order of facility sample weight for each pollutant of concern discharged by one or more of those facilities.
- Generate the first discharge event loadings (or flows) as the total loadings (or flows) from all sample facilities on the reach. Assign the smallest sample weight to the first discharge event (Wt_1 in Table F-1) among the facilities discharging to the reach. A smaller sample weight relative to the others means that this facility represents no other population facilities that could occur jointly with the other facilities. The weight of the first facility is therefore considered as "used up," and that facility's loadings (or flows) are not included in subsequent discharge events defined for the reach.
- Generate subsequent discharge events by removing the loadings (or flows) of facilities with the smallest sample weight from a running sum of loadings (or flows) of all facilities in the ranking. The weight assigned to each subsequent event is the remaining *unused* weight of the facility with the smallest weight among the facilities remaining in the particular discharge event. Calculate this weight as the difference between the weight of the next facility in the ranking and the weight of the previous facility (Wt_2-Wt_1).

EPA avoids double-counting indirect dischargers by including the discharge flow of any given POTW into a reach only once in any given discharge event, even when multiple sample facilities discharge indirectly into one POTW.

This methodology generates a set of discharge events (loadings or flows) for each pollutant discharged to the reach. The following steps illustrate application of the differential weighting technique to estimating the national number of reaches on which ***ambient water quality criteria* (AWQC)** are exceeded:

- Assign a weight to each discharge event based on the weights of the facilities discharging to the reach;
- Combine the effluent flow with the stream flow of the reach;
- Divide the pollutant loading into the stream flow to determine the pollutant concentration caused by the event;
- Compare pollutant concentration to AWQC values to determine whether the concentration exceeds those values;
- Identify an estimated AWQC "exceedence" if the concentration is greater than a criterion; and
- Give the AWQC exceedence event the weight of the discharge event, to establish national estimates of the number of reaches on which an AWQC is exceeded.

Table F.1: Construction of Discharge Events for Any Pollutant Discharged to Any Reach

Event Number	Loadings and Flows Assigned to Event	Weight Assigned to Event
One	$\sum_{i=1}^{N} Load_i \text{ or } Flow_i$	Wt_1
Two	$\sum_{i=2}^{N-1} Load_i \text{ or } Flow_i$	$Wt_2 - Wt_1$
N - 2	$Load_{N-2} + Load_{N-1} + Load_N$ $Flow_{N-2} + Flow_{N-1} + Flow_N$	$Wt_{N-2} - Wt_{N-3}$
N - 1	$Load_{N-1} + Load_N$ $Flow_{N-1} + Flow_N$	$Wt_{N-1} - Wt_{N-2}$
N	$Load_{N+}Flow_N$	$Wt_N - Wt_{N-1}$

Notes: N sample facilities discharge to the reach and are ranked in ascending order of sample weight and indexed by i (1 = facility with smallest weight, N = facility with largest weight); $Load_i$ = Loading from facility i; $Flow_i$ = Flow from facility i or the POTW associated with facility i; Wt_i = Sample weight of facility i; and A POTW's flow is included only once per event, even if multiple facilities in that event discharged through that POTW, to avoid over-counting the POTW's flow.
Source: U.S. EPA analysis.

This weighting method is a relatively simplistic approach to a complex analytic issue, and does not provide a precise estimate of the national distribution of in-stream MP&M pollutant concentrations that reflects the true co-location characteristics of MP&M facilities. A statistically-valid estimate of that distribution is not possible given the design of the Section 308 surveys. However, the differential weighting technique does correct for the significant overstatement of benefits that would result from using a simple weighting approach to estimate national reach characteristics. The Agency believes that this method is a reasonable approach to addressing this issue, given time and resource constraints. Approaches that are both more sophisticated and more expensive might not yield significantly different aggregate findings.

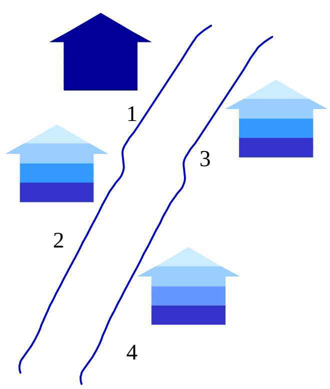
Figure F.1 provides a graphic example of a hypothetical reach to which three known sample facilities discharge. Table F.2 provides a numeric example of this calculation for a hypothetical reach to which three known sample facilities discharge.

Figure F.1a: Estimating MP&M Pollutant Loadings to Receiving Streams When Using a Random Sample of MP&M Facilities

Problem:	**Lack of Information on the Occurrence of Joint Discharges**
	Geographic Discharge Location of Non-Sample Facilities is Unknown
Result:	**Underestimation of Baseline MP&M Discharges and MP&M Contribution to Problem**
Solution:	**None Known at this Time**

MP&M sample facilities
Sample Weight $_1$=1
Produces Chemical X
Produces Chemical Y

MP&M non-sample facilities
Sample Weight1=Sample Weight2=Sample Weight3=1



If Only Sample Facility Discharges Are Considered:

Facility 1, Chemical X

In-stream concentration (X) = 30 g/l,
which is greater than AWQC(X) = 20 g/l .
Number of Exceedence Events = 5

Facility 1, Chemical Y

In-stream concentration (Y) = 40 g/l,
which is less than AWQC(Y)= 50 g/l.
Number of Exceedence Events = 0

If All MP&M Discharges Are Considered (Chemical Y)

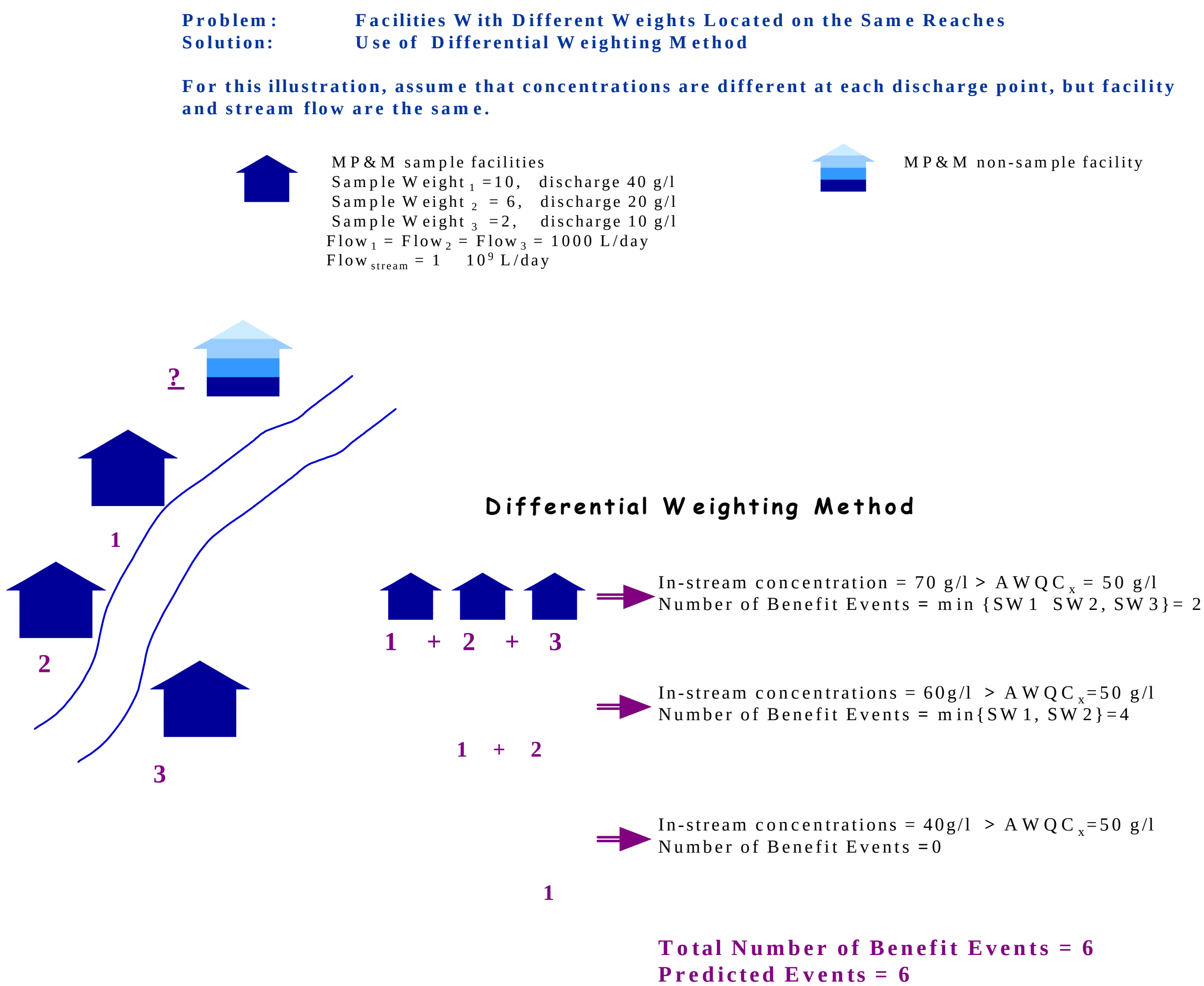
1 + 2,3,4

In-stream concentrations (Y) = 70 g/l,
which is greater than AWQC(Y)=50 g/l.
Number of Actual Exceedence Events =1

Number of Estimated Exceedence Events =0
Underestimation of Events =1

Source: U.S. EPA analysis.

Figure F.1b: Estimating MP&M Pollutant Loadings to Receiving Streams When Using a Random Sample of MP&M Facilities



Note: The situation may be further complicated by actually having a non-sampled MP&M facility on the same reach. The differential weighting method does not address this issue.

Source: U.S. EPA analysis.

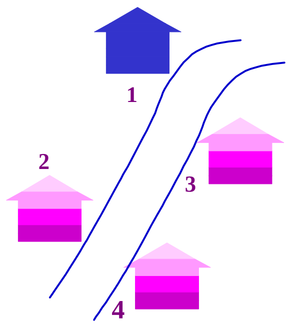
Figure F.1c: Estimating MP&M Pollutant Loadings to Receiving Streams When Excluding Background Concentrations

Problem 3: **Omitting Discharges from Non-MP&M Facilities**
Results: **Uncertainty, May Underestimate or Overestimate Benefits**

MP&M sample facilities
Sample Weight $_1$=15

Non-MP&M facilities

Case I: Underestimation of Benefits When all Discharges are Considered



If Only Sample Facility Discharges Are Considered:

Baseline
In-stream concentration (X) = 30 g/l <AWQC(X) = 40 g/l
Number of Baseline Exceedence Events = 0.

Post Compliance
In-stream concentration (X) = 15 g/l<AWQC(X)= 40 g/l
Number of Postcompliance Exceedence Events = 0
Number of Benefit Events = 0

If Non-MP&M Discharges Are Considered

Baseline 1 + 2,3,4
In-stream concentrations (X) = 50g/l >AWQC(X)=40 g/l
Number of Exceedence Events =15

Post Compliance 1 + 2,3,4
In-stream concentrations (X) = 35 g/l <AWQC(X)=40 g/l
Number of Exceedence Events = 0
Number of Benefit Events = 15

Case 2: Overestimation of Benefits When all Discharges are Considered

If Only Sample Facility Discharges Are Considered

Baseline
In-stream concentration (X) = 30 g/l >AWQC(X) = 20 g/l
Number of Baseline Exceedence Events = 15.

Post Compliance
In-stream concentration (X) = 15 g/l<AWQC(X)= 20 g/l
Number of Postcompliance Exceedence Events = 0
Number of Benefit Events =15

If Non-MP&M Discharges Are Considered

Baseline 1 + 2,3,4
In-stream concentrations (X) = 95g/l >AWQC(X)=20 g/l
Number of Exceedence Events =15

Post Compliance 1 + 2,3,4
In-stream concentrations (X) = 80 g/l >AWQC(X)=20 g/l
Number of Exceedence Events = 15
Number of Benefit Events = 0

Source: U.S. EPA analysis.

Table F.2: Example of Differential Sample Weighting Technique

Facility	Weight	Pollutant A lbs/yr	Flow gal/year
Raw data:			
1	10	5	2,000,000
2	3	2	4,000,000
3	1	12	10,000,000
Total	14	19	16,000,000
Reach flow (gal/year):			100,000,000
Calculating flow and pollutant loadings for the reach:			
1. Rank facilities in ascending order of weights			
3	1	12	10,000,000
2	3	2	4,000,000
1	10	5	2,000,000
2. Calculate flow and pollutant loadings for discharge event 1 with weight = 1			
Facility	**Pollutant A lbs/yr**	**Flow gal/year**	**Remaining Weight**
3	12	10,000,000	0
2	2	4,000,000	2
1	5	2,000,000	9
Event 1	19	16,000,000	
3. Eliminate the facility with the lowest weight and calculate flow and pollutant loadings for discharge event 2 with weight = 2 (3-1)			
2	2	4,000,000	0
1	5	2,000,000	7
Event 2	7	6,000,000	
4. Eliminate the facility with the next lowest weight and calculate and pollutant loadings for discharge event 3 with weight = 7 (10-3)			
1	5	2,000,000	0
Event 3	5	2,000,000	

5. Estimate national in-stream concentrations based the flows, loadings, and weights for each discharge event and the reach flow

Discharge Event	Pollutant A Loading lbs/yr	Facility Flow gal/year	Stream Flow gal/year	Total Flow gal/year	In-stream Concentration ppb	Weight
1	19	16,000,000	100,000,000	116,000,000	0.0955	1
2	7	6,000,000	100,000,000	106,000,000	0.0385	2
		2,000,000	100,000,000	102,000,000	0.0286	7
Total Affected Reaches:						10

Source: U.S. EPA analysis.

GLOSSARY

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

differential sample weighting technique: weighting method for all threshold value-based analyses, such as the lead-related benefits analysis.

standard linear weighting technique: weighting method used where the effects being considered (e.g., compliance costs) are linearly additive over facilities.

reach: a specific length of river, lake, or marine shoreline

Appendix G: Fate and Transport Model for DW and Ohio Analyses

Appendix Contents:

Introduction

EPA used a simplified fate and transport model to quantify the fate and transport of MP&M pollutant releases to surface waters in the drinking water and Ohio analyses. This model estimates pollutant concentrations at the initial point of discharge and below the initial discharge ***reach***.

The national MP&M analysis considered pollutant concentrations only at the point of discharge (see Appendix E.2.2). The drinking water and Ohio analyses account for the in-stream concentrations of pollutants at the initial point of discharge and in reaches downstream from the initial discharge reach.

This appendix describes the equations characterizing the model, its underlying assumptions, and the data sources used in model estimation. EPA combined the equations defining the model with geographic information (reach flow, velocity, length, etc.) to estimate pollutant concentrations at the initial point of discharge and below the initial discharge reach.

The estimation of pollutant concentrations below the initial discharge reach includes several factors that reduce the in-stream pollutant concentrations with the passage of time. These factors include: ***volatilization***, ***sedimentation***, and chemical decay from ***hydrolysis*** and ***microbial degradation***. EPA adjusted concentrations for changes in stream flow volume in downstream reaches. The discussion below outlines the main assumptions of this analysis. Although more advanced models are available that account for time-variable flow, sediment transport, channel geometry changes within a reach, and detailed simulation of all in-stream processes, these models will not necessarily produce more accurate results without sufficient data to support the input parameters. Estimates of the input parameters required by these models are subject to a high degree of uncertainty when applied on a national scale, and gathering such data is beyond the scope of this study.

EPA has previously applied the approach used in this analysis. For example, the first-order contaminant degradation relationship described below in Equation G.1 is currently being used by the Office of Pollution Prevention and Toxics for exposure analysis in the ReachScan computer program.

G.1 Model Equations

The total pollution concentration in the water columns for each reach included in the analysis is calculated by the following equation expressed in generic terms of mass (M), length (L), and time (T):

$$C_T = \frac{W_T}{Q} x\, e^{\left[-\left(\frac{V_T}{H}\right)\left(\frac{x}{U}\right)\right]} \tag{G.1}$$

where:

C_T = total toxicant concentration in the water column (M/L^3),
W_T = mass input rate of toxicant (M/T),
Q = river flow (L^3/T),
V_T = overall net loss rate of chemical (L/T),
H = flow depth (L),

x = distance downstream from the point of release (L), and
U = flow velocity (L/T).

In reaches where more than one facility is discharging, or where pollutant loadings occur from upstream reaches, the mass input rate (W_T) represents a combined input rate from all relevant industrial facilities affecting the reach. The relevant industrial facilities in the drinking water risk analysis are all MP&M sample facilities (see Chapter 13). The relevant industrial facilities in the Ohio case study analysis include:[1]

- all sample MP&M facilities,
- non-sample MP&M facilities, and
- non-MP&M facilities.

The overall net loss rate of chemical (V_T) is given by:

$$V_T = V_{Td} + V_{Ts} = (k_l + K_d H) \times f_d + v_n f_p \quad \text{(G.2)}$$

where:
V_T = overall net loss rate of chemical (L/T),
V_{Td} = dissolved chemical loss rate (L/T),
V_{Ts} = loss of chemical due to sediment interaction (L/T),
k_l = volatilization transfer coefficient (L/T),
K_d = dissolved chemical decay rate (hydrolysis and microbial degradation) (1/T),
H = flow depth (L),
f_d = dissolved fraction of toxicant (unitless),
v_n = net loss of solids (L/T), and
f_p = particulate fraction of toxicant (unitless).

The dissolved and particulate fractions of the pollutant, f_d, and f_p , respectively, are estimated by:

$$f_d = \frac{1}{1 + K_p S} \quad \text{(G.3)}$$

and

$$f_p = \frac{K_p S}{1 + K_p S} \quad \text{(G.4)}$$

where:
K_p = partition coefficient [L^3/M], and
S = suspended solids [M/L^3].

The dissolved concentration of ***metals*** and most other pollutants in the water column is generally considered a more accurate expression than the total concentrations of the toxic or bioavailable fraction. For this reason, EPA modified Equation (G.1) to express the pollutant concentrations in terms of dissolved concentration. The dissolved fraction of a pollutant is estimated as:

$$C_d = f_d \times C_T \quad \text{(G.5)}$$

Substituting equation (G.2) for C_T results in the dissolved pollutant concentration being expressed as:

[1] See Chapter 22 for detail.

$$C_d = \frac{\frac{W_T}{Q} \times e\left[-\left(\frac{K_d^{\,H} + k_l}{(1 + K_p^{\,S})^H} + \frac{v_N\, K_p^{\,S}}{(1 + K_p^{\,S})^H}\right) \times \left(\frac{x}{U}\right)\right]}{1 + K_p^{\,S}} \tag{G.6}$$

G.2 MODEL ASSUMPTIONS

The following three principal assumptions underlie Equation G.5:

G.2.1 Steady Flow Conditions Exist Within the Stream or River Reach

This assumption is necessary due to this study's broad geographical coverage. This assumption significantly reduces the computational effort and input parameter requirements and still produces a good first fate and transport modeling of pollutants in surface waters.

The pollutant concentration is completely mixed, both laterally (across the stream) and vertically (with depth) within each reach. The approach involves a two-dimensional model in which the concentration is uniform over the entire cross-section of the stream reach but varies with the distance of the reach. EPA assumed that the contaminant completely mixes at the point of release. This assumption will likely underestimate the concentration of a contaminant release in areas where mixing is incomplete (e.g., shore-hugging plume) and overestimate concentrations in areas beyond the point showing incomplete mixing (e.g., in areas beyond a shore-hugging plume).

G.2.2 Longitudinal Dispersion of the Pollutant Is Negligible

The model does not account for mixing outside the plane of discharge along the river reach, although it predicts variation in pollutant concentrations over distance due to both pollutant fate and decay and the differing hydrology of downstream reaches. In natural streams, longitudinal velocity gradients due to channel irregularities can cause mixing, thereby decreasing the peak concentrations as the contaminant moves downstream from the point of release. Under steady-state situations, however, the longitudinal dispersion of the pollutant is assumed to be negligible. The solution of the dispersion equation approximates a first-order decay function such as the one shown in Equations G.1 and G.5 under steady flow conditions and complete lateral and vertical mixing.

G.2.3 Flow Geometry, Suspension of Solids, and Reaction Rates Are Constant Within a River Reach

EPA assumes the data that describe a river reach and that are calculated for a reach to be constant for the full extent of the reach.

G.3 HYDROLOGIC LINKAGES

EPA modeled pollutant concentrations for a distance of 500 km downstream from the discharge point in the drinking water risk analysis. In the Ohio case study analysis, EPA used the lesser of 500 km or the distance to the Ohio border from the initial discharge point to identify reaches potentially affected by pollutant discharges from this discharge point. The Agency obtained Information on the hydrologic linkages between reaches from the REACH2 file of EPA's ***Graphical Exposure Modeling System* (GEMS)**. The GAGE file in GEMS provided flow (mean flow, 7Q10) and velocity (mean, low) data for each reach.

EPA used the process equations listed above to estimate both the initial pollutant concentrations at the beginning of each reach and the changes in concentrations as pollutants traveled to the end of the reach. The concentration at the end of each reach served as the value for the beginning of the next reach.

G.4 ASSOCIATING RISK WITH EXPOSED POPULATIONS

The number of individuals served by each drinking water intake is an output of the fate and transport model described in this Appendix. If a drinking water intake exists on the initial reach or any downstream reach, then the model calculates the in-stream pollutant concentration at that intake. Data on the population served by the intake is saved with the concentration for further analysis (see Chapter 13 for a discussion of the cancer risk assessment).

G.5 Data Sources

Data sources used for the fate and transport model are discussed briefly in the section below, by categories of information.

G.5.1 Pollutant Loading Data Used in the Drinking Water Risk Analysis

EPA estimated annual pollutant loadings (kg/yr) for the direct and indirect sample MP&M facilities analyzed under the various regulatory options. The Agency first adjusted pollutant loadings for indirect dischargers to reflect POTW treatment, and then divided annual pollutant loadings by the number of days in one year (365) to establish daily pollutant loadings.

G.5.2 Pollutant Loading Data Used in the Ohio Case Study Analysis

EPA estimated pollutant discharges from both MP&M and significant non-MP&M sources at the reaches included in the Ohio case study analysis. Consumer perception and valuation of enhanced water-based recreational opportunities depend on the absolute level of pollutant contamination at recreation sites, and on the change in contamination from the baseline to the post-compliance cases. For this reason, capturing the effect of concurrent discharges from all MP&M and other pollutant sources is particularly important for the recreational benefits analysis.

EPA used the Office of Water's ***BASINS*** software package to identify all possible point source dischargers contributing to ambient pollutant concentrations at a given reach. BASINS is a GIS-based system that serves as a database management system for water quality monitoring, point-source pollutant discharge, and various geo-technical data. Several sources provide information on point source discharges to BASINS, including the ***Permit Compliance System* (PCS)** and ***Toxic Release Inventory* (TRI)** databases. Version 2.0 includes data reported through 1996. Preprogrammed queries in BASINS generate information on various point source discharge variables at either the state or watershed level. BASINS data on point source dischargers include:

- location information on major industrial dischargers, including PCS facilities and facilities reporting under TRI;
- SIC codes;
- flow volume; and
- discharge characteristics for up to 50 pollutants or parameters for PCS facilities.

The following sections describe steps used to characterize both MP&M and non-MP&M discharges in Ohio.

a. Characterize MP&M facility discharges

EPA used different approaches to assign discharge characteristics to MP&M facilities in Ohio, based on the level of information available for each facility. The Agency divided all MP&M facilities into three groups, based on the level of information provided by different sources:

❖ ***Facilities covered by the detailed Phase 1 and 2 questionnaire (hereafter, sampled MP&M facilities)***

The detailed surveys contain data on:

- discharge status;
- discharge volume;
- industrial processes used;
- pollution prevention activities;
- employment, revenue, and costs.

EPA engineers estimated loadings of 131 MP&M pollutants using information on facilities' processes and pollution prevention activities. All MP&M facilities in this group therefore have extensive data on their location, size, and discharge characteristics.

❖ ***Facilities covered by the detailed Iron and Steel questionnaire (hereafter sampled I&S facilities)***

The detailed I&S survey contained data similar to the detailed MP&M survey. EPA engineers used data on I&S facilities' processes and pollution prevention activities to estimate pollutant loadings from these facilities.

❖ ***Facilities covered by the Phase 2 screener questionnaire or that were covered by the Phase 1 mini-DCP (hereafter, MP&M screener facilities).***

The screener surveys contain significantly fewer data on MP&M facilities. The data collected from the screener survey recipients include:

- facility location, which can be used to assign the facilities to receiving waterways or receiving POTWs;
- SIC codes;
- discharge status (i.e., whether the facility discharges process wastewater and the approximate amount);

- employment and revenue data;
- whether the facility is engaged in manufacturing, maintenance or repairing activities; and
- data on MP&M unit operations (including type of MP&M unit operations performed at the site, and whether process wastewater is discharged as a result of each operation).

The project engineers used these data to estimate pollutant loadings for these facilities. Loading estimates for the screener facilities, which are based on less comprehensive information, involve greater uncertainty.

❖ ***Facilities that respond to neither the screener nor detailed questionnaires (hereafter referred to as non-sampled MP&M facilities)***

To address the problem of omitted discharge information on non-sampled MP&M facilities, EPA used information from the 1600 screener MP&M facilities and a random draw approach to assign the relevant characteristics for non-sampled MP&M facilities. Each screener facility represents *n* non-sampled facilities, where *n* is determined by the screener facility sample weight. All non-sampled facilities are smaller indirect dischargers because all direct MP&M facility dischargers and large indirect discharging facilities in Ohio are covered by the long, short, or screener questionnaire.

The exact location of non-sampled facilities is unknown. All non-sampled facilities discharge to one of the Ohio's POTWs because they are indirect dischargers. The Agency assigned *n* facilities represented by each screener facility to the receiving POTWs by drawing a random sample of *n* POTWs from the universe of POTWs in Ohio.[2] The Agency assigned screener facility characteristics (i.e., pollutant loadings) to all *n* facilities represented by the screener facility.

EPA used a random draw procedure for all observations from the screener survey that have a sample weight greater than one.

b. Characterize non-MP&M point source discharges

EPA used preprogrammed queries in BASINS to obtain information on all non-MP&M point source discharges in Ohio. BASINS data on non-MP&M point source dischargers include:

- location,
- SIC codes,
- flow volume, and
- discharge characteristics for up to 50 pollutants or parameters for PCS facilities.

The Agency assigned discharge characteristics to all non-MP&M industrial direct discharges based on the information provided in BASINS. POTW effluent may contain pollutants from both MP&M and non-MP&M discharges. The Agency combined information from BASINS with loading estimates provided by the project engineers to estimate total pollutant loadings from a given POTW. This analysis used the following assumptions to estimate total POTW pollutant loadings under the baseline discharge levels:

- If a POTW was not estimated to receive discharges from the MP&M facilities, then the analysis used POTW loadings reported in BASINS.
- If a pollutant or a parameter was not reported in BASINS, then the analysis used aggregate loadings from all MP&M facilities discharging to a given POTW to calculate total POTW loadings of a given pollutant.
- If a POTW was estimated to receives discharges from MP&M facilities and a given pollutant was reported in BASINS, then the analysis used the greater of the aggregate loadings from all MP&M facilities or POTW loadings reported.

EPA estimated post-compliance pollutant loadings from each POTW by subtracting the estimated reduction in the MP&M facility loadings for a given pollutant from its total baseline loadings for a given POTW.

c. Characterize nonpoint source discharges

The water quality analysis in Ohio used empirical data on ***Total Kjeldahl Nitrogen*** (TKN) concentrations to characterize the baseline water quality conditions. Empirical data on in-stream concentrations captured TKN contribution from both point and nonpoint sources under baseline conditions. EPA estimated changes in TKN concentrations resulting from the proposed rule by using the estimated pollutant loading reductions from MP&M sources and the water quality model described above. The Agency assumed that the non-point source contribution of toxic pollutants found in MP&M effluent to ambient concentrations of these pollutants in Ohio's streams and lakes is negligible.

[2] The Agency was unable to validate random assignments because POTWs do not know all of their MP&M dischargers. For the final rule, the Agency will perform a sensitivity analysis based on alternative draws to test the stability of the results.

GLOSSARY

BASINS: a software package that serves as a database management system for water quality monitoring, point-source pollutant discharge, and various geo-technical data, and also provides an analytic platform for modeling in-stream pollutant concentrations over an entire watershed based on multiple sources of pollutants withing the watershed. (http://www.epa.gov.OST/BASINS)

Graphical Exposure Modeling System (GEMS): A computer system designed for exposure modeling and assessment.

hydrolysis: the decomposition of organic compounds by interaction with water. (http://www.epa.gov/OCEPAterms)

metals: inorganic compounds, generally non-volatile, and which cannot be broken down by biodegradation processes. They are a particular concern because of their prevalence in MP&M effluents. Metals can accumulate in biological tissues, sequester into sewage sludge in POTWs, and contaminate soils and sediments when released to the environment. Some metals are quite toxic even when present at relatively low levels.

microbial degradation: a process whereby organic molecules are broken down by microbial metabolism.

Permit Compliance System (PCS): a computerized database of information on water discharge permits, designed to support the National Pollutant Discharge Elimination System (NPDES). (http://www.epa.gov/ceisweb1/ceishome/ceisdocs/pcs/pcs-exec.htm)

MP&M reach: a reach to which an MP&M facility discharges.

sedimentation: : letting solids settle out of wastewater by gravity. (http://www.epa.gov/OCEPAterms)

Total Kjeldahl Nitrogen (TKN): the total of organic and ammonia nitrogen. TKN is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

Toxic Release Inventory (TRI): database of toxic releases in the United States compiled from SARA Title III Section 313 reports. (http://www.epa.gov/OCEPAterms)

volatilization: a process whereby chemicals dissolved in water escape into the air. (http://www.epa.gov/OCEPAterms)

ACRONYMS

GEMS: Graphical Exposure Modeling System
IFD: Industrial Facility Discharge
MMR: manufacturing, maintenance or repairing activities
PCS: Permit Compliance System
TKN: Total Kjeldahl Nitrogen
TRI: Toxic Release Inventory

Appendix H: Spacial Distribution of Benefiting Reaches, MP&M Facilities, and Benefiting Populations

INTRODUCTION

This appendix presents six maps showing a distribution, by geographic location and population, of the sample discharge reaches estimated to benefit from reduced MP&M discharges. EPA used a U.S. Counties data layer developed by the Environmental System Research Institute (ESRI) as a base map. The Agency then used ESRI's ArcView 3.2 to display the benefiting reaches and the sample MP&M facilities data layers.

The Benefiting Reaches data layer depicts all reaches in which at least one MP&M pollutant exceeding the AWQC limits for human health or aquatic species fell below the AWQC limit as a result of the proposed rule. EPA used the Office of Water's BASINS software package to identify locations of the sample benefiting reaches.

The Agency geocoded the sample MP&M facilities to display their locations by county and population, in two ways:

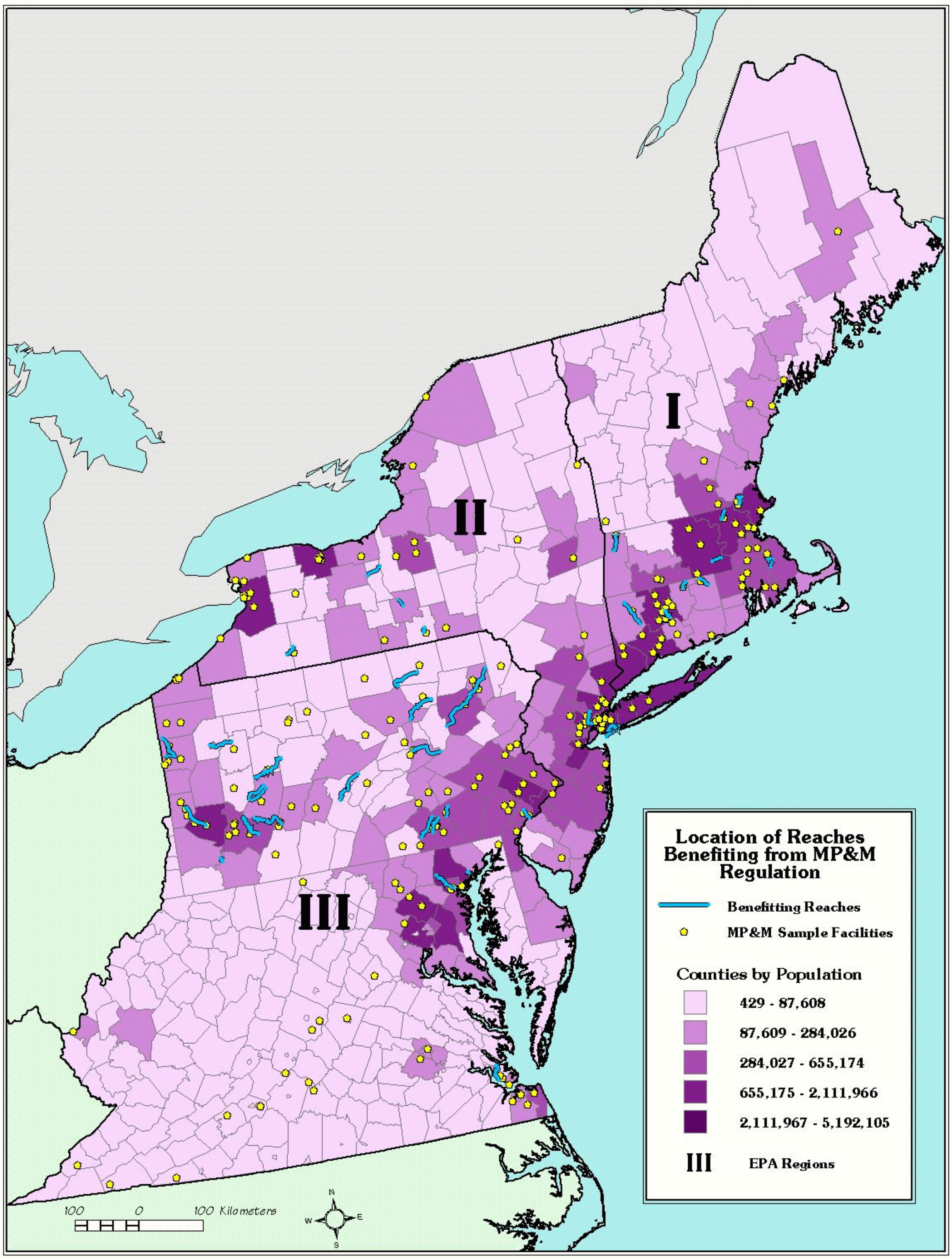
- by using latitude and longitude coordinates gathered during Phase I; or
- in the absence of those coordinates, by matching the reported ZIP code of the facility to the ZIP code centroid data layer provided by ESRI.

ESRI provided information on the 1999 county population estimates. EPA then estimated population categories for each map using a least-squares process. The least-squares process minimizes the differences within groups while maximizing the differences between them. The Agency applied this process to the population ranges of only those counties found within the regions depicted on the map.

APPENDIX CONTENTS:

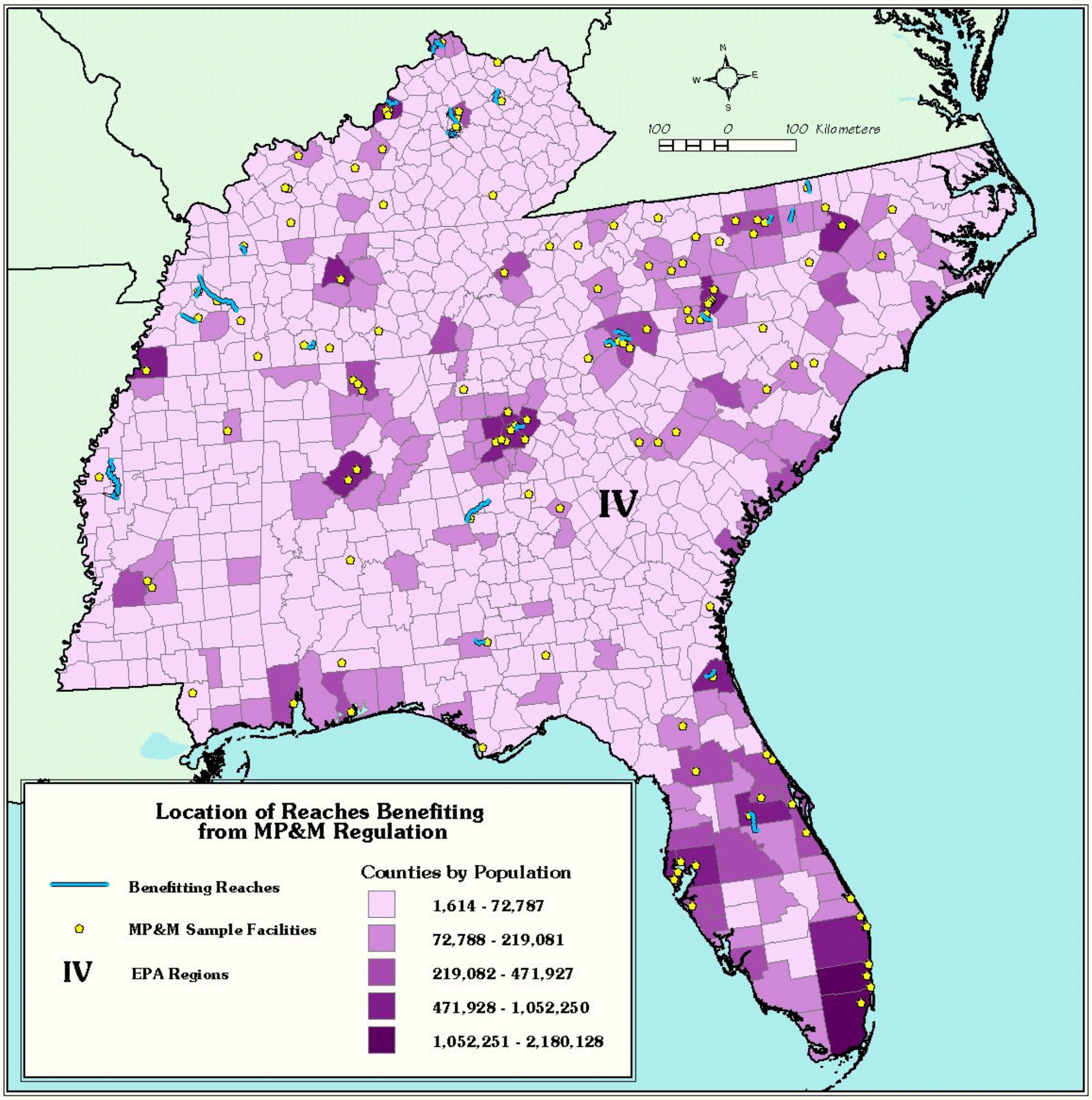
This appendix also compares the national distribution of all MP&M facilities by state and the national distribution of recreational participants by state (see Table H.1 and Figure H.7). EPA based the distribution of MP&M facilities by state on Census data on total numbers of facilities in the SICs that make up the MP&M industries, not just water dischargers. This comparison assumes that the state distribution of water-discharging MP&M facilities is the same as the overall distribution of MP&M facilities. EPA based the distribution of recreational participants by state and by type of recreation activity on information provided by the National Demand Study data. This comparison suggests that the reaches that benefit from the proposed rule are also those where a very large percentage of all recreational participants reside and recreate.

Figure H.1: Location of Benefiting Reaches in Relation to Sample MP&M Facilities by County and Population Reaches Benefiting from MP&M Regulation (EPA Regions I, II, and III)



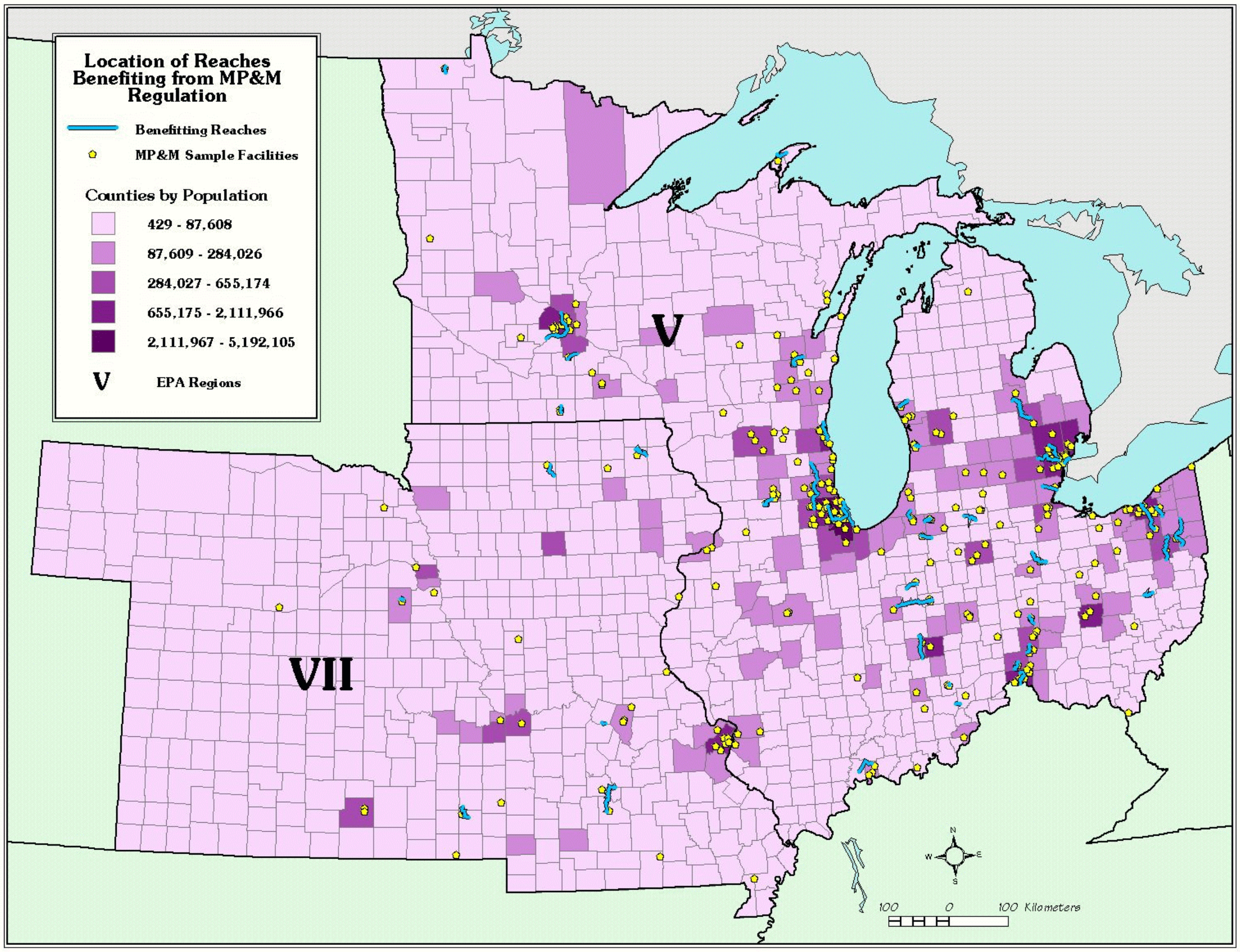
Source: U.S. EPA analysis.

Figure H.2: Location of Benefiting Reaches in Relation to Sample MP&M Facilities by County and Population Reaches Benefiting from MP&M Regulation (EPA Region IV)



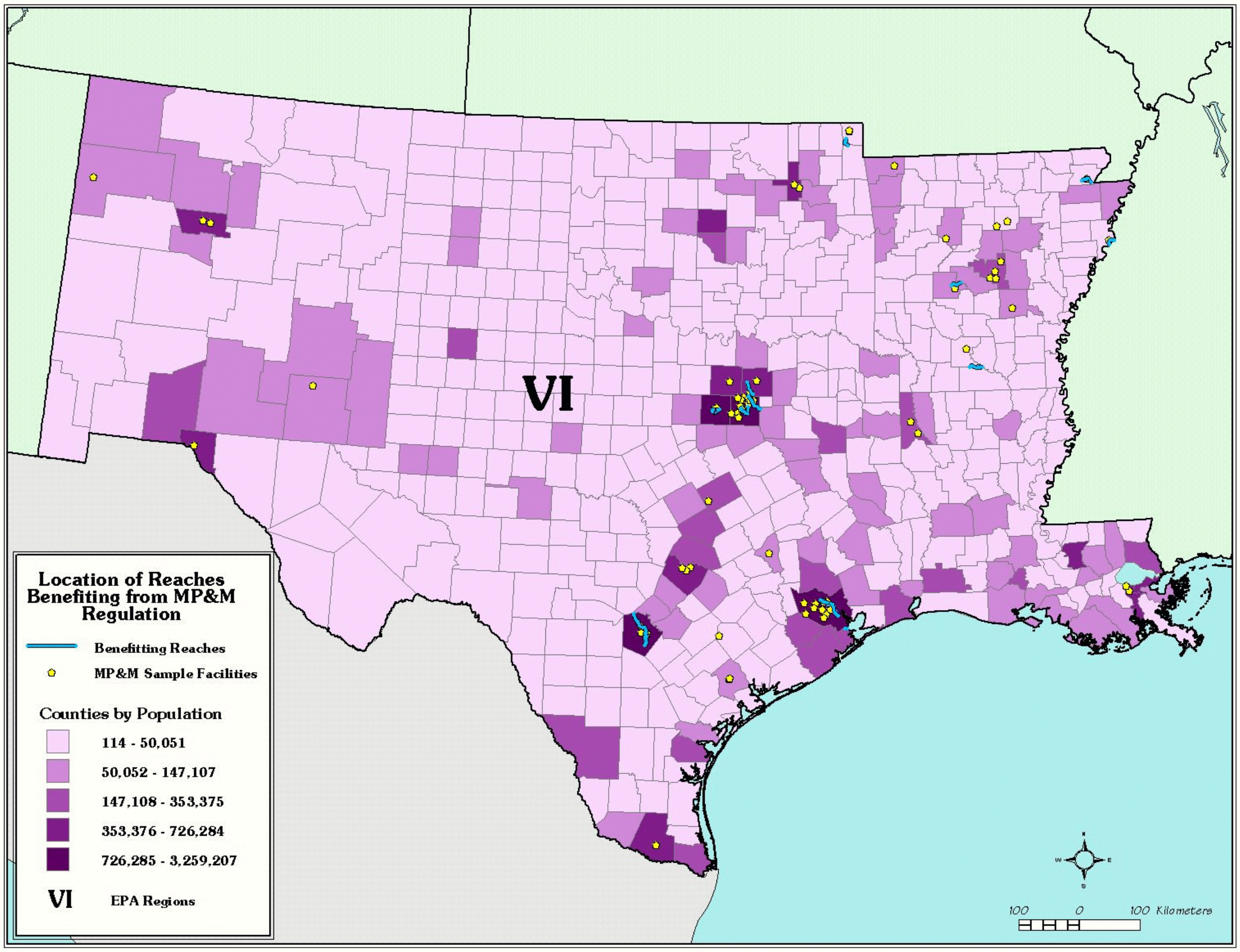
Source: U.S. EPA analysis.

Figure H.3: Location of Benefiting Reaches in Relation to Sample MP&M Facilities by County and Population Reaches Benefiting from MP&M Regulation (EPA Region V and VII)



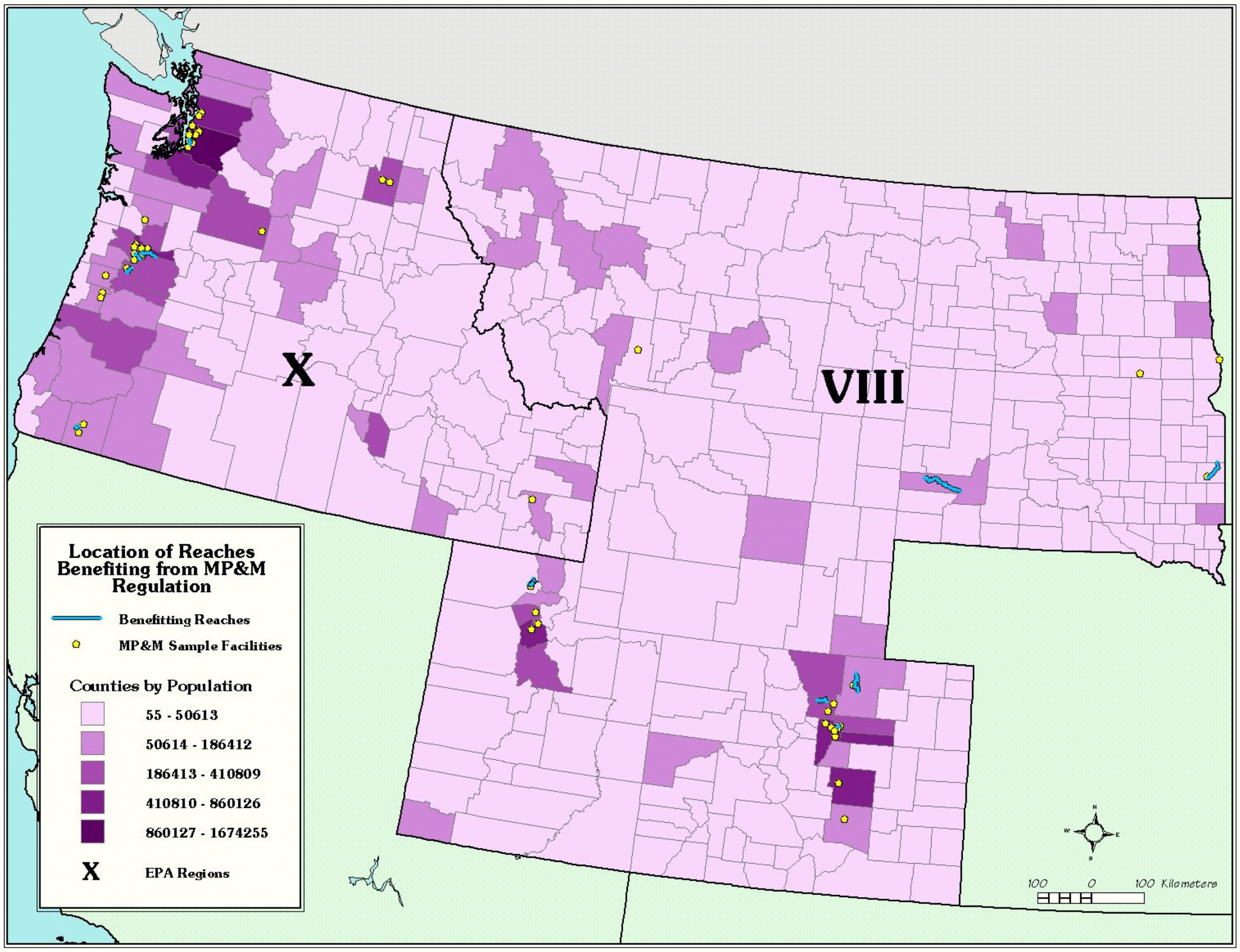
Source: U.S. EPA analysis.

Figure H.4: Location of Benefiting Reaches in Relation to Sample MP&M Facilities by County and Population Reaches Benefiting from MP&M Regulation (EPA Region VI)



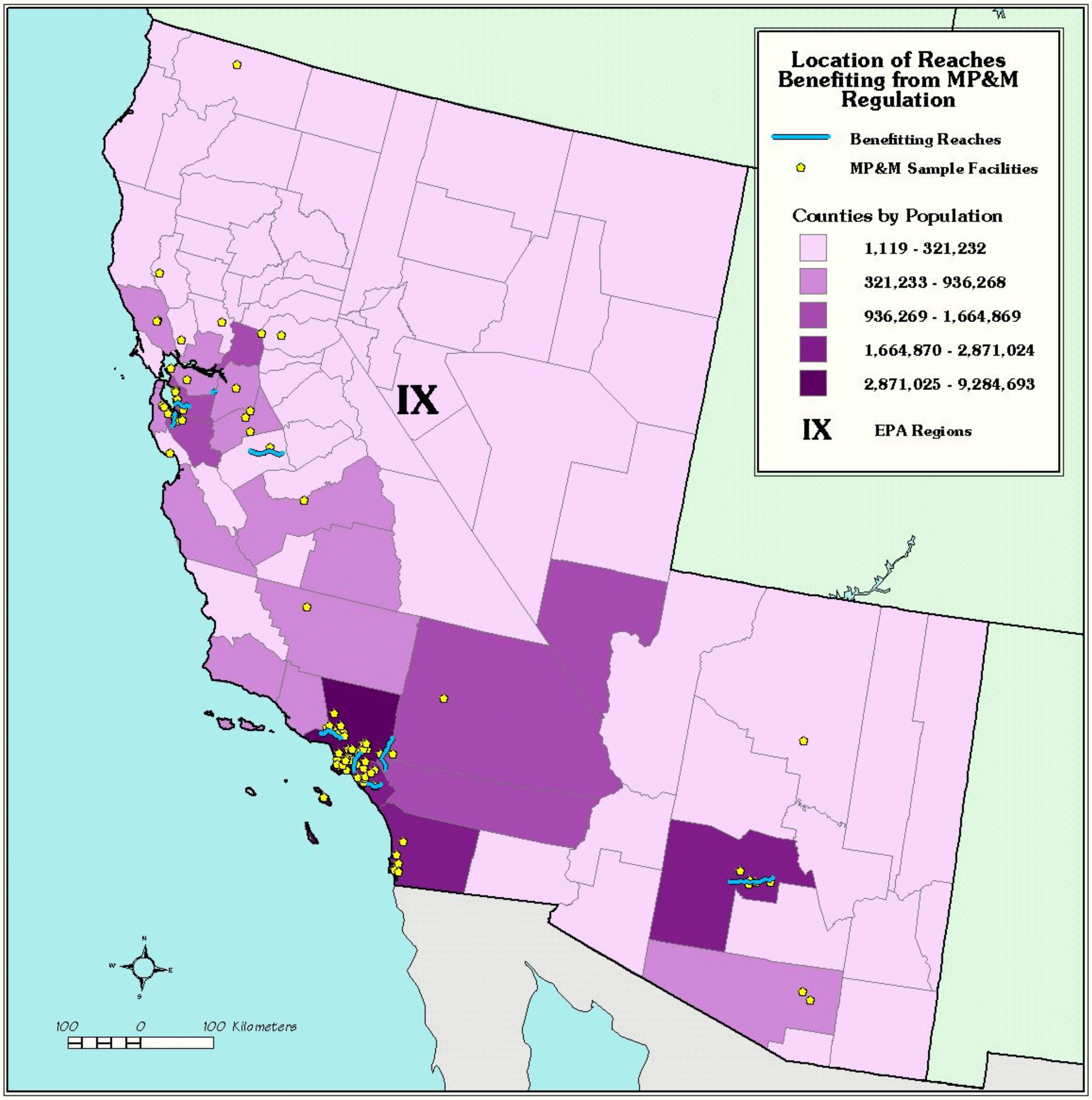
Source: U.S. EPA analysis.

Figure H.5: Location of Benefiting Reaches in Relation to Sample MP&M Facilities by County and Population Reaches Benefiting from MP&M Regulation (EPA Regions VIII and X)



Source: U.S. EPA analysis.

Figure H.6: Location of Benefiting Reaches in Relation to Sample MP&M Facilities by County and Population Reaches Benefiting from MP&M Regulation (EPA Region IX)



Source: U.S. EPA analysis.

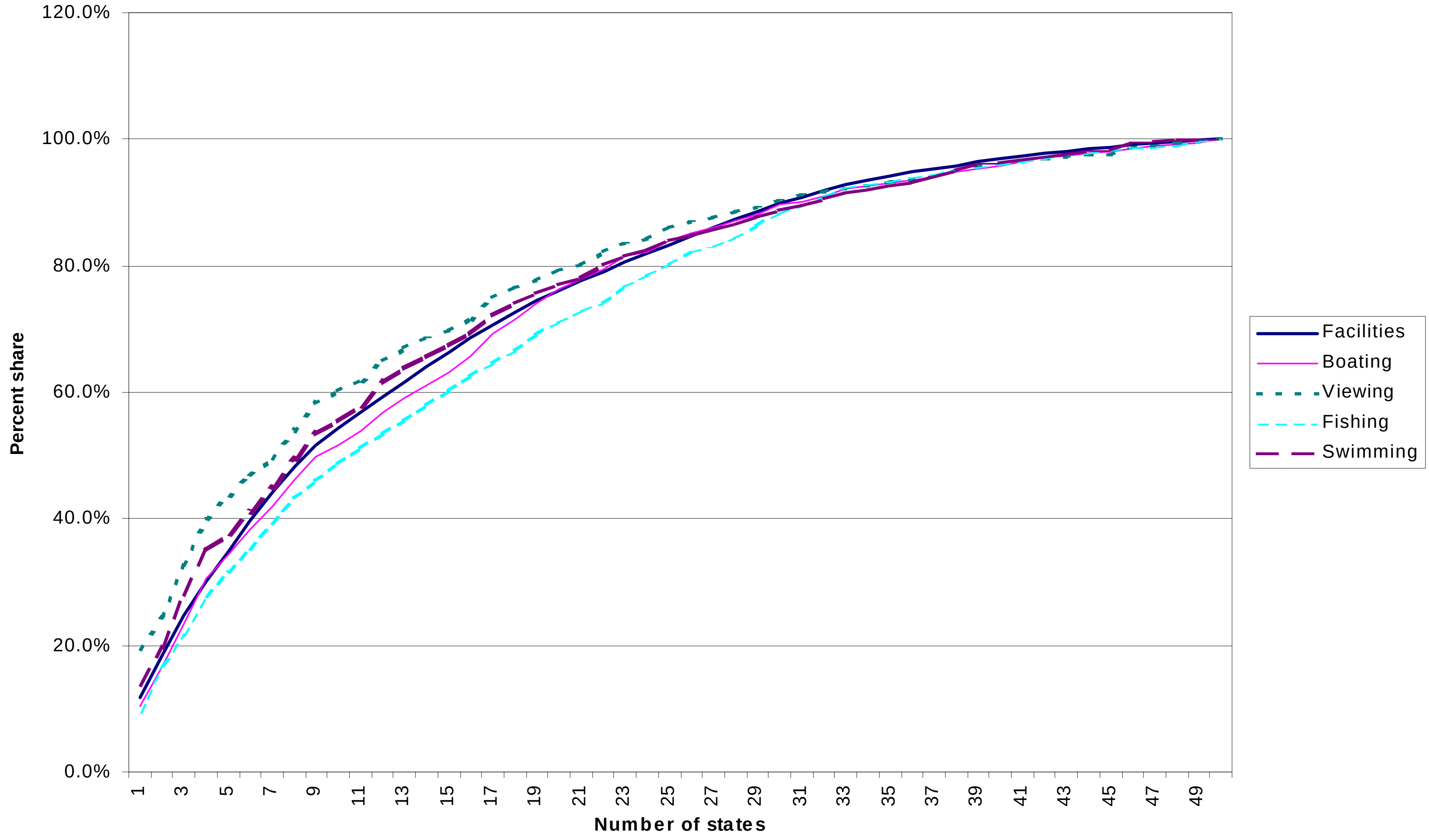
Table H.1: Distribution of MP&M Facilities and Participants of Water Based Recreation by State

State	Percent of State Population Participating by Activity				Average # of Per Person Trips per Season by Activity				Total State Pop. (1990) (Millions)	Potential (Extrapolated) # Participants Based on State Population				Nat.'l # of MP&M Facilities	State %of National Facilities	Cum. ST % of Facilities	Cumulative Percent Distribution of Participants by State			
	Boat	View	Fish	Swim	Boat	View	Fish	Swim		Boat	View	Fish	Swim				Boat	View	Fish	Swim
CA	11.7%	36.9%	13.6%	20.1%	5.4	14	7.1	11.7	29.8	3,490,513	10,992,849	4,057,154	5,983,736	68,359	11.9%	11.9%	10.3%	19.5%	9.4%	13.8%
TX	12.8%	16.4%	18.9%	14.5%	7.2	5	10.6	6.5	17.0	2,171,791	2,792,303	3,205,978	2,456,192	38,176	6.6%	18.5%	16.7%	24.5%	16.8%	19.4%
NY	12.4%	25.6%	11.2%	20.5%	7.9	5.7	9.2	8.7	18.0	2,231,374	4,602,209	2,022,183	3,695,714	36,329	6.3%	24.8%	23.3%	32.6%	21.5%	27.9%
FL	18.7%	32.6%	20.5%	24.2%	10.1	17.9	17.1	15.4	12.9	2,423,418	4,221,438	2,657,943	3,126,991	30,198	5.2%	30.0%	30.5%	40.1%	27.7%	35.1%
IL	11.8%	17.2%	14.6%	9.4%	9.6	9	13.7	5.7	11.4	1,349,105	1,962,335	1,667,985	1,079,284	28,343	4.9%	34.9%	34.5%	43.6%	31.5%	37.6%
OH	11.5%	15.8%	14.2%	14.0%	8	8.2	13.1	8.8	10.8	1,251,590	1,718,851	1,535,284	1,518,596	26,460	4.6%	39.5%	38.2%	46.6%	35.1%	41.1%
PA	10.5%	14.4%	15.2%	13.7%	9.4	7.4	10.9	8	11.9	1,249,014	1,713,391	1,809,469	1,633,326	26,237	4.6%	44.1%	41.9%	49.7%	39.3%	44.8%
MI	16.0%	24.8%	18.4%	20.8%	8.6	9.4	12	8.5	9.3	1,484,665	2,307,687	1,710,593	1,936,520	23,662	4.1%	48.2%	46.3%	53.8%	43.2%	49.3%
NJ	15.9%	32.3%	15.9%	23.9%	10.9	6.4	6.3	7.3	7.7	1,225,246	2,495,046	1,225,246	1,849,008	19,805	3.4%	51.6%	49.9%	58.2%	46.1%	53.5%
NC	8.8%	17.9%	16.5%	13.5%	7.7	5.2	13.6	7.4	6.6	586,317	1,188,920	1,091,201	895,762	15,158	2.6%	54.3%	51.6%	60.3%	48.6%	55.6%
IN	14.3%	15.0%	20.3%	16.3%	7.7	9	11.8	5.5	5.5	794,663	831,624	1,127,312	905,546	14,656	2.5%	56.8%	54.0%	61.8%	51.2%	57.7%
MA	15.7%	30.9%	15.7%	28.9%	8.7	11.6	14.3	9.5	6.0	942,332	1,860,501	942,332	1,739,689	13,915	2.4%	59.2%	56.8%	65.1%	53.4%	61.7%
WI	15.7%	22.1%	18.1%	19.7%	10	6.1	11.5	6.2	4.9	768,940	1,079,788	883,463	965,266	13,845	2.4%	61.6%	59.0%	67.0%	55.4%	63.9%
GA	11.5%	13.9%	16.6%	11.5%	11.4	4.1	10.3	7.4	6.5	746,819	903,129	1,076,808	746,819	13,747	2.4%	64.0%	61.2%	68.6%	57.9%	65.6%
MO	13.0%	12.6%	18.8%	15.2%	5.2	4	5	8	5.1	665,035	646,562	960,606	775,874	13,395	2.3%	66.3%	63.2%	69.8%	60.1%	67.4%
VA	13.4%	17.0%	16.2%	13.4%	9	4.2	8.4	6.1	6.2	827,102	1,049,783	1,002,066	827,102	12,829	2.2%	68.6%	65.7%	71.6%	62.5%	69.3%
WA	25.0%	39.2%	18.8%	25.9%	5.8	11.7	18.2	5.8	4.9	1,216,673	1,907,623	916,260	1,261,735	11,991	2.1%	70.6%	69.3%	75.0%	64.6%	72.2%
MN	17.6%	19.6%	19.6%	17.6%	5.4	16.5	11.5	6.8	4.4	767,875	857,162	857,162	767,875	11,272	2.0%	72.6%	71.5%	76.5%	66.6%	73.9%
TN	17.9%	13.5%	22.6%	14.5%	7.5	3.7	15.1	6.7	4.9	873,280	659,079	1,103,957	708,510	10,808	1.9%	74.5%	74.1%	77.7%	69.1%	75.6%
MD	14.8%	18.7%	17.1%	12.1%	8.8	12.1	13.2	8.4	4.8	706,988	893,037	818,617	576,753	8,993	1.6%	76.0%	76.2%	79.3%	71.0%	76.9%
AL	14.7%	11.9%	20.6%	13.8%	7.5	9.2	18.6	10.6	4.0	593,114	481,905	834,066	556,044	8,825	1.5%	77.6%	77.9%	80.1%	72.9%	78.2%
CT	16.4%	37.1%	14.5%	27.0%	7.7	6.8	7.7	12.3	3.3	537,516	1,219,747	475,495	888,969	8,593	1.5%	79.1%	79.5%	82.3%	74.0%	80.2%
LA	16.4%	15.3%	27.0%	13.8%	4	3.4	13.4	4.4	4.2	692,165	647,509	1,138,723	580,525	8,500	1.5%	80.5%	81.6%	83.4%	76.7%	81.5%
CO	6.6%	13.2%	25.9%	11.3%	17.2	14.8	13.1	5.2	3.3	217,554	435,109	854,678	372,950	8,231	1.4%	82.0%	82.2%	84.2%	78.7%	82.4%
OR	20.3%	37.8%	24.9%	23.0%	8.8	7.2	13.2	7.4	2.8	576,323	1,074,057	707,306	654,913	7,978	1.4%	83.3%	83.9%	86.1%	80.3%	83.9%
KY	11.9%	12.3%	22.4%	10.0%	6.5	3	9.4	17.5	3.7	437,524	454,352	824,564	370,212	7,822	1.4%	84.7%	85.2%	86.9%	82.2%	84.8%
AZ	7.3%	11.2%	11.8%	10.7%	7.2	8	8.3	5.7	3.7	267,685	411,823	432,415	391,232	7,799	1.4%	86.1%	86.0%	87.7%	83.2%	85.7%

Table H.1: Distribution of MP&M Facilities and Participants of Water Based Recreation by State

State	Percent of State Population Participating by Activity				Average # of Per Person Trips per Season by Activity				Total State Pop. (1990) (Millions)	Potential (Extrapolated) # Participants Based on State Population				Nat.'l # of MP&M Facilities	State %of National Facilities	Cum. ST % of Facilities	Cumulative Percent Distribution of Participants by State			
	Boat	View	Fish	Swim	Boat	View	Fish	Swim		Boat	View	Fish	Swim				Boat	View	Fish	Swim
IA	13.5%	16.4%	18.7%	13.5%	5	4.4	13.8	2.7	2.8	373,482	454,673	519,627	373,482	7,661	1.3%	87.4%	87.1%	88.5%	84.4%	86.5%
OK	11.2%	12.6%	25.2%	14.0%	4.9	3.4	14.6	4.2	3.1	351,954	395,948	791,896	439,942	6,972	1.2%	88.6%	88.2%	89.2%	86.2%	87.5%
SC	13.8%	19.9%	26.0%	15.5%	9.8	8.5	16.2	7.5	3.5	481,589	693,488	905,387	539,380	6,907	1.2%	89.8%	89.6%	90.4%	88.3%	88.8%
KS	6.7%	17.0%	18.5%	13.3%	17.6	9	12.9	6.2	2.5	165,172	422,105	458,810	330,343	6,370	1.1%	90.9%	90.1%	91.1%	89.4%	89.5%
AR	14.1%	12.5%	28.1%	18.0%	4.6	10.2	13.3	7.3	2.4	330,571	293,841	661,141	422,396	5,825	1.0%	91.9%	91.1%	91.7%	90.9%	90.5%
MS	13.6%	12.1%	23.6%	15.7%	6.3	24.2	17.4	12.9	2.6	349,222	312,462	606,544	404,363	5,165	0.9%	92.8%	92.1%	92.2%	92.3%	91.4%
NE	10.7%	15.5%	10.7%	15.5%	3.9	2.1	13.9	3.9	1.6	169,113	244,274	169,113	244,274	4,424	0.8%	93.6%	92.6%	92.7%	92.7%	92.0%
UT	8.1%	17.1%	13.5%	12.6%	6.6	3.5	3.6	6.8	1.7	139,691	294,902	232,818	217,296	3,633	0.6%	94.2%	93.0%	93.2%	93.3%	92.5%
WV	9.5%	10.3%	18.3%	15.9%	6.6	4.6	17.2	6.7	1.8	170,807	185,041	327,381	284,679	3,442	0.6%	94.8%	93.5%	93.5%	94.0%	93.1%
RI	15.8%	40.4%	19.3%	36.8%	6.9	4.6	8.3	7	1.0	158,442	404,907	193,651	369,697	3,106	0.5%	95.3%	94.0%	94.2%	94.5%	94.0%
ME	22.2%	44.4%	27.8%	37.5%	7.6	5.7	10.5	10.3	1.2	272,873	545,746	341,091	460,473	2,980	0.5%	95.9%	94.8%	95.2%	95.3%	95.1%
NH	18.8%	31.2%	14.1%	34.4%	3.3	14.9	13.2	15.7	1.1	207,985	346,641	155,989	381,305	2,960	0.5%	96.4%	95.4%	95.8%	95.6%	95.9%
NM	6.7%	8.6%	12.4%	9.5%	3.7	5.6	9.8	3.8	1.5	101,005	129,863	187,580	144,292	2,927	0.5%	96.9%	95.7%	96.0%	96.1%	96.3%
ID	24.1%	25.3%	20.5%	20.5%	5.8	4.3	13.4	9.5	1.0	242,590	254,720	206,202	206,202	2,572	0.4%	97.3%	96.4%	96.5%	96.5%	96.7%
NV	17.3%	21.3%	13.3%	12.0%	4.8	7.3	15.4	6.3	1.2	208,318	256,391	160,244	144,220	2,406	0.4%	97.7%	97.0%	96.9%	96.9%	97.1%
MT	14.5%	20.0%	34.5%	29.1%	7.8	15.6	20.7	8.3	0.8	116,228	159,813	276,041	232,455	2,204	0.4%	98.1%	97.4%	97.2%	97.5%	97.6%
SD	16.7%	21.4%	16.7%	21.4%	2.3	1.8	6	7	0.7	116,001	149,144	116,001	149,144	2,049	0.4%	98.5%	97.7%	97.5%	97.8%	97.9%
ND	15.0%	15.0%	25.0%	15.0%	3.7	3	4.5	11.5	0.6	95,820	95,820	159,700	95,820	1,749	0.3%	98.8%	98.0%	97.7%	98.2%	98.2%
HI	16.4%	58.2%	18.2%	47.3%	6.7	33.9	6.6	15.5	1.1	181,347	644,788	201,496	523,890	1,677	0.3%	99.1%	98.5%	98.8%	98.7%	99.4%
VT	20.6%	17.6%	8.8%	20.6%	7.1	5.5	8.7	10.4	0.6	115,862	99,310	49,655	115,862	1,488	0.3%	99.3%	98.9%	99.0%	98.8%	99.6%
DE	15.7%	41.2%	15.7%	13.7%	6.4	11	11.5	6.9	0.7	104,497	274,305	104,497	91,435	1,379	0.2%	99.6%	99.2%	99.5%	99.0%	99.8%
WY	19.4%	16.1%	48.4%	6.5%	6.3	4.6	8.1	8	0.5	87,791	73,159	219,478	29,264	1,309	0.2%	99.8%	99.4%	99.6%	99.5%	99.9%
AK	34.5%	41.4%	37.9%	6.9%	5.4	7.1	17.4	2	0.6	189,670	227,604	208,637	37,934	1,156	0.2%	100.0%	100.0%	100.0%	100.0%	100.0%

Figure H.7: Cumulative Distribution of Facilities and Participants



Note: The numbers refer to States in the order they appear in the above table. Therefore, 1 is California, 2 is Texas, 3 is New York, etc.
Sources: Information on total MP&M facilities by State is from Census Data; information on where recreating people live is from NDS data.

Appendix I: Selecting WTP Values for Benefits Transfer

Introduction

EPA identified eight surface water evaluation studies that quantified the effects of water quality improvements on various water-based recreational activities. As noted in Chapter 15 of this report, the Agency selected these studies based on the technical criteria for evaluating study transferability (Desvousges et al., 1987; and Boyle and Bergstrom, 1990):

- The environmental change valued at the study site must be the same as the environmental quality change caused by the rule (e.g., changes in toxic contamination vs changes in nutrient concentrations);
- The populations affected at the study site and at the policy site must be the same (e.g., recreational users vs nonusers);
- The assignment of property rights at both the study and policy sites must lead to the same theoretically appropriate welfare measure (e.g., willingness to pay (WTP) vs willingness to accept compensation); and
- The candidate studies should be based on defensible research methods. Six of the eight studies are published in peer reviewed journals. One study, Tudor et al. (2000), was presented at the annual American Agricultural Economic Association and the Northeastern Resource and Environmental Economic meetings. The eighth study, Lyke (1989), is an unpublished Ph.D. dissertation.

In addition to the above criteria, the Agency considered authors' recommendations regarding the robustness and theoretical soundness of various estimates in selecting point estimates for benefits transfer.

The rest of this appendix presents welfare estimates from seven studies used in estimating recreational benefits from the proposed regulation and provides EPA's reasons for selecting specific values from each study. The study by Tudor et al. (2000) is discussed in detail in Chapter 21. All welfare estimates from this study are eligible for use in benefits transfer, because the study is based on the policy scenarios specific to the MP&M regulation.

Appendix Contents:

I.1 Desvousges et al., 1987. Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River

This study used findings from a ***contingent valuation (CV)*** survey to estimate WTP for improved recreational fishing from enhanced water quality in the Pennsylvania portion of the Monongahela River. In a hypothetical market, each survey respondent was asked to provide an option price for different water quality changes, such as "raising the water quality from suitable for boating (hereafter, 'boatable' water) to a level where gamefish would survive (hereafter, 'fishable' water)." Table I.1 lists water quality changes evaluated in the study and the corresponding WTP estimates. The following discussion provides justification for selecting the point estimates EPA used in the benefits transfer analysis in Chapter 15.

Table I.1: Changes in the Resource Value from a Specified Water Quality Improvement from Desvousges et al. (1987)

	Adjusted to 1999$			Original Estimates (1981$)		
Water Quality Change Valued	**User**	**Nonuser**	**Combined**	**User**	**Nonuser**	**Combined**
Iterative Bidding: $25 starting point						
Unsuitable to Boatable	$50.2	$54.4	$53.1	$27.4	$29.7	$29.0
Boatable to Fishable[a]	**$34.6**	$26.6	$29.1	**$18.9**	$14.5	$15.9
Fishable to Swimmable	$21.6	$13.2	$15.9	$11.8	$7.2	$8.7
Boatable to Swimmable	$58.8	$39.7	$46.0	$32.1	$21.7	$25.1
Unsuitable to Swimmable	$109.0	$94.1	$99.1	$59.5	$51.4	$54.1
Iterative Bidding: $125 starting point						
Unsuitable to Boatable	$173.5	$71.1	$105.1	$94.7	$38.8	$57.4
Boatable to Fishable	$106.4	$48.2	$67.6	$58.1	$26.3	$36.9
Fishable to Swimmable	$60.6	$21.2	$34.4	$33.1	$11.6	$18.8
Boatable to Swimmable	$182.6	$74.2	$110.3	$99.7	$40.5	$60.2
Unsuitable to Swimmable	$356.1	$145.1	$215.4	$194.4	$79.2	$117.6
Direct Question: no payment card						
Boatable to Unsuitable	$83.0	$26.0	$44.9	$45.3	$14.2	$24.5
Boatable to Fishable	$57.3	$19.8	$32.2	$31.3	$10.8	$17.6
Fishable to Swimmable	$37.0	$15.6	$22.7	$20.2	$8.5	$12.4
Boatable to Swimmable	$96.9	$37.2	$57.1	$52.9	$20.3	$31.2
Unsuitable to Swimmable	$179.9	$63.2	$102.0	$98.2	$34.5	$55.7
Direct Question: payment card						
Boatable to Unsuitable	$85.7	$97.1	$93.4	$46.8	$53.0	$51.0
Boatable to Fishable	$83.0	$40.1	$53.7	$45.3	$21.9	$29.3
Fishable to Swimmable	$41.9	$14.1	$22.9	$22.9	$7.7	$12.5
Boatable to Swimmable	$130.4	$54.8	$78.6	$71.2	$29.9	$42.9
Unsuitable to Swimmable	$216.0	$151.7	$172.0	$117.9	$82.8	$93.9

Location: Pennsylvania portion of the Monongahela River
Estimating Approach: CV
Survey Population : Recreational Users and Nonusers
a. The value selected for benefits transfer is given in bold.

EPA judged that only one value from this study met the requirements for the quality of research methods and was compatible with the environmental changes and population characteristics considered in the analysis of recreational benefits from the MP&M rule. EPA selected this value for the following reasons:

- **Environmental quality change**. The Desvousges et al. (1987) study derived WTP values for five different changes in water quality, as shown in Table I.1 above. EPA judged that only one of these improvements, from "boatable" to "fishable," is compatible with the changes in water quality expected under the MP&M rule. Streams unsuitable for recreational activities such as boating are likely to be affected by multiple environmental stressors from many sources including many that are not related to MP&M discharges (e.g., severe oxygen depletion.) In these cases it is reasonable to assume that changes in concentrations of MP&M pollutants would reduce or eliminate one of the stressors on the reach, but would be unlikely to change the designation of the reach.

The analysis in Chapter 15 assumes that reaches with ***ambient water quality criteria*** (AWQC) exceedances under the baseline conditions are boatable and likely to support rough fishing, but may not be clean enough to support game fishing. AWQC are set at a level below which pollutant concentrations are not expected to cause significant harm to human health or aquatic life. Exposure to pollutant concentrations above the AWQC levels are expected to have a harmful effect. Therefore, by definition, water with pollutant levels that exceed criteria set to protect human health or aquatic life are not suitable waters for sensitive aquatic species or ideal as a sources of fish for consumption.

Removing AWQC exceedances is therefore comparable to shifting water quality from "boatable"to "fishable." The Agency did not use the boatable to swimmable designation because a more limited number of reaches are suitable for swimming nationally due to reasons not related to MP&M discharges (e.g., amenities, pathogens). Determining national level locations affected by MP&M pollutants that are suitable for swimming required more resources than were available for the national analysis, but may be done in the future analyses.

- **Research methods**. The authors used four different payment vehicles in their CV study. For the recreational benefits analysis, EPA decided to use the WTP estimates derived from the "***iterative bidding***" **(IB)** payment vehicle, because it is universally preferred to the "***direct question/open-ended***" format for eliciting option price bids.

  Survey respondents in the direct question format are asked to state the most that they would be willing to pay for the program or policy. This format confronts respondents with an unfamiliar choice. Studies that use this approach usually have high non-response rates.

  Respondents in the IB format are asked whether they would be willing to pay a given amount. If the answer is yes, then this amount is raised in pre-set increments until the respondent says that he or she will not pay the last amount given. If the answer is no, then the amount is decreased until the respondent indicates WTP the stated amount. Some studies found that the respondent's final WTP amount depends on the initial amount offered (e.g., Boyle and Bishop, 1988). This problem is referred to in economic literature as starting point bias. The Agency selected the WTP estimates derived using the $25 starting point IB process to avoid upward starting point bias. Table I.1 shows that the selected estimates are the most conservative among all the payment vehicles used.

- **Population characteristics**. EPA selected WTP values for the user population to match population characteristics considered in our analysis (i.e., recreational anglers, boaters, and wildlife viewers).

I.2 Farber and Griner, 2000. Valuing Watershed Quality Improvements Using Conjoint Analysis

Farber and Griner (2000) used a CV study to estimate changes in water resource values to users from various improvements in Pennsylvania's water quality. The study defines water quality as "polluted," "moderately polluted," and "unpolluted" based on a water quality scale developed by EPA Region III. "Polluted" streams are unable to support aquatic life, "moderately polluted" streams are somewhat unable to support aquatic life, and "unpolluted" streams adequately support aquatic life. Farber and Griner developed WTP estimates for water quality improvements for the following three water quality changes:

- From "moderately polluted" to "unpolluted,"
- From "severely polluted" to "moderately polluted," and
- From "severely polluted" to "unpolluted."

The authors used six different model variations to estimate the WTP for the three improvements scenarios for various population groups (e.g., users, nonusers, and a mix of users and nonusers). Table I.2 presents the estimated WTP values. The following discussion provides EPA's reasons for selecting point estimates for the use in benefits transfer.

Table I.2: Estimate WTP for Specified Water Quality Improvements from Farber and Griner (1999$)

	Binary Choice Model			Intensity of Preference Model		
Water Quality Change Valued	**User**	**Nonuser**	**Combined**	**User**	**Nonuser**	**Combined**
Basic						
Moderately Polluted to Unpolluted	$46.77	$5.95	$38.04	$52.85	$13.13	$51.02
Severely Polluted to Moderately Polluted	$62.91	$5.50	$52.30	$69.42	$48.36	$66.70
Severely Polluted to Unpolluted	$110.35	$42.20	$90.01	$121.90	$54.26	$109.92
Interactive						
Moderately Polluted to Unpolluted	$45.36	$3.05	$35.76	$53.56	$12.55	$51.35
Severely Polluted to Moderately Polluted	$61.29	$1.39	$49.62	$70.63	$47.61	$67.64
Severely Polluted to Unpolluted	$108.68	$38.87	$87.43	$125.25	$54.22	$112.44
Fixed Effects						
Moderately Polluted to Unpolluted [a]	**$23.09**	$15.45	$26.63	**$39.34**	$5.17	$38.59
Severely Polluted to Moderately Polluted	$39.93	$10.01	$35.90	$59.67	$28.50	$55.46
Severely Polluted to Unpolluted	$81.42	$45.51	$75.63	$103.93	$29.15	$92.76

Location: Lower Allegheny Watershed in Western Pennsylvania
Estimating Approach: Conjoint Analysis
Survey Population: Recreational users and nonusers
a. Values selected for the use in benefits transfer are given in bold.

The Agency selected only two values from this study based on their compatibility with the environmental changes and population characteristics considered in both the original study and the analysis of recreational benefits from the MP&M rule. The following discussion summarizes EPA's reasons used in the selection process:

- **Environmental quality change**. EPA judged that only one water quality improvement scenario — change from "moderately polluted" to "unpolluted" — is compatible with the environmental quality change expected from the proposed regulation

  AWQC are set at a level below which pollutant concentrations have not been demonstrated to cause significant harm to human health or aquatic life. Exposure to pollutant concentrations above the AWQC levels are expected to have a harmful effect. Therefore, by definition, water with pollutant levels that exceed criteria set to protect human health or aquatic life are polluted waters.

  EPA chose the case where the policy variable changed from moderately polluted to unpolluted because this is likely to be the most frequently occurring scenario for reaches with MP&M discharges. Streams unable to support any aquatic life (i.e., "severely polluted") are likely to be affected by numerous environmental stressors, in addition to MP&M discharges. Eliminating MP&M related AWQC exceedences would eliminate or reduce one of the stressors, but is unlikely to change the quality of the water from severely polluted to unpolluted. It is more realistic to assume that most streams affected by MP&M facility discharges are moderately polluted, i.e., these streams support some aquatic life; but sensitive species are adversely affected by MP&M pollutants exceeding AWQC values protective of aquatic life. Removing all AWQC exceedances would make such streams unpolluted.

- **Research methods**. EPA considered only two of the six versions of the benefits transfer model based on the authors' recommendations. The authors appear to prefer the "fixed effects" versions of both the ***binary choice*** (BC) and ***intensity of preference*** (IP) models. Specifically, they note that, "A likelihood ratio test, with degrees of freedom being the number of individuals in the estimating sample, can be used to test the superiority of the fixed effects model. Such a test shows the fixed effects model to be a statistical improvement over either the basic or interactive models" (see Table I.2). In addition, they state that, "the purpose of estimating a fixed effects model was to account for the possibility that some respondents may approve of all changes, regardless of price and quality. If this behavior existed in the sample, not controlling for it would result in overestimates of marginal valuations for each type of quality change. This expectation is supported by the fact that the fixed effects valuation estimates are lower than the others."

- **Population characteristics**. EPA selected WTP values for the user population to match population characteristics considered in our national analysis (i.e., recreational anglers, boaters, and wildlife viewers).

I.3 Jakus et al., 1997. Do Sportfish Consumption Advisories Affect Reservoir Anglers Site Choice?

Jakus et al. (1997) used a repeated discrete choice ***travel cost* (TC)** model to examine the impacts of ***fish consumption advisories* (FCA)** in eastern and middle Tennessee. The estimated consumer surplus from recreational fishing in middle and east Tennessee is $24.48 and $49.45 per angler per day, respectively, under the baseline water quality conditions. The estimated welfare gain from removing FCAs is $1.92 and $2.97 per angler per day , respectively. Table I.3 summarizes the study's estimates.

Table I.3: Consumer Surplus from Recreational Fishing from Jakus et al. (1997)[a]

Water Quality Change Valued	Consumer Surplus Adjusted to 1999$	Consumer Surplus ($1997)
Site Choice Model -- multinomial logit		
Average surplus per trip in middle TN (baseline water quality conditions)	**$24.48**	**$23.60**
Benefit per trip from removing all advisories in middle TN	**$1.92**	**$1.85**
Average surplus per trip in East TN (baseline water quality conditions)	**$49.45**	**$47.67**
Benefit per trip from removing all advisories in east TN	**$2.97**	**$2.86**
Benefit per trip from removing Watts Bar advisory	$1.65	$1.59
Repeated Discrete Choice Model -- repeated nested logit model		
Seasonal benefit from removing all advisories in middle TN	$22.78	$21.96
Seasonal benefit from removing all advisories in east TN	$49.17	$47.40
Seasonal benefit from removing Watts Bar advisory	$28.63	$27.60

Location: Tennessee
Estimating Approach: TC
Survey Population: Tennessee residents; anglers and non-anglers
a. Values selected for the use in benefits transfer are given in bold.

EPA selected two values from this study for use in benefits transfer, based on their compatibility with the environmental quality change and population characteristics at both the original study and policy sites, for the following reason:

- **Environmental quality change**. FCAs are usually triggered by the presence of toxic pollutants in fish tissue. EPA expects the proposed regulation to reduce discharges of toxic pollutants, including those linked to FCAs (e.g., mercury and lead). The Agency therefore assumed that the removal of FCAs is compatible with water quality improvement expected from the proposed regulation.

The recreational benefits analysis uses consumer surplus estimates for both regions studied by the authors, because MP&M facilities are located in these regions as well as throughout heavily populated regions of the U.S. EPA did not include the value corresponding to the Watts Bar lake in the benefit transfer analysis because this lake is included in the set of fishing areas for east Tennessee.

I.4 Lant and Roberts, 1990. Greenbelts in the Cornbelt: Riparian Wetlands, Intrinsic Values, and Market Failure

Lant and Roberts (1990) used a CV study to estimate the recreational and nonuse benefits of improved water quality in selected Iowa and Illinois river basins. River quality was defined by means of an interval scale of "poor," "fair," "good," and "excellent." The authors defined the four water quality intervals as follows:

- "poor" water quality is inadequate to support any recreation activity,
- "fair" water quality is adequate for boating and rough fishing,
- "good" water quality is adequate for gamefishing, and
- "excellent" is adequate to support swimming and exceptional fishing.

Table I.4 summarizes WTP values for specified water quality improvements from this study.

Table I.4: WTP Values for a Specified Water Quality Improvement from Lant and Roberts (1990)

	Adjusted to 1999$		Original Study Values $1987	
Water Quality Change Valued	**Use Value**	**Nonuse Value**	**Use Value**	**Nonuse Value**
Poor to Fair	$44.70	$55.12	$30.50	$37.61
Fair to Good [a]	**$54.38**	$69.12	**$37.10**	$47.16
Good to Excellent	$60.84	$63.35	$41.51	$43.22

Location: Selected Iowa and Illinois river basins
Estimating Approach: CV
Survey Population: Recreational users and nonusers
a. The values given in bold were selected for the use in benefits transfer.

The Agency judged that only one value from this study is compatible with the environmental changes and population characteristics considered in the analysis of recreational benefits from the MP&M rule, for the following reasons:

- **Environmental quality change**. The Agency judged that only one of the three possible water quality changes considered in this study — "fair" to "good" — was compatible with the water quality change expected under the MP&M rule. EPA assumed in its analysis of recreational benefits expected from the MP&M rule that reaches with AWQC exceedances under the baseline conditions are may support rough fishing, but may not be clean enough to support more sensitive species such as those desired for game fishing. Removing AWQC exceedances will shift water quality from "fair"to "good."
- **Population characteristics**. EPA selected WTP values for the user population only to match population characteristics considered in our analysis (i.e., recreational anglers, boaters, and wildlife viewers).

I.5 Audrey Lyke, 1993. Discrete Choice Models to Value Changes in Environmental Quality: A Great Lakes Case Study

Lyke's (1993) study of the Wisconsin Great Lakes open water sport fishery showed that anglers may place a significantly higher value on a contaminant-free fishery than on one with some level of contamination. Lyke estimated the value of the fishery to Great Lakes trout and salmon anglers if it was improved enough to be "completely free of contaminants that may threaten human health." The author also estimated various policy scenarios that affect the value of recreational fishing in the Wisconsin Great Lakes, including reducing the daily bag limit for lake trout and restoring naturally reproducing populations of lake trout. Table I.5 presents welfare estimates from this study.

Table I.5: WTP Estimates for a Specified Water Quality Improvements from Lyke (1993)

Water Quality Change Valued	Adjusted to 1999$: Value of WI Fishing	Adjusted to 1999$: Change in Value	Original Study Value (1989$): Value of WI Fishing	Original Study Value (1989$): Change in Value
CV -- linear logit model				
1990 fishing conditions remain the same as 1989	**$89,426,613**		**$66,600,000**	
WI daily bag limit for lake trout reduced to one a day	$41,356,452	-$48,070,161	$30,800,000	-$35,800,000
Great Lakes fish are free of pollutants affecting human health	$99,362,903	**$9,936,290**	$74,000,000	**$7,400,000**
Restoring naturally reproducing populations of lake trout	$16,247,177	$16,247,177	$12,100,000	$12,100,000
WI inland fishing conditions remain the same as 1989	$907,156,452		$675,600,000	
Restoring naturally reproducing populations of lake trout in WI waters of Great Lakes (inland anglers only)	$0	$0	$0	$0
CV -- constant elasticity of substitution model (mean)				
1990 fishing conditions remain the same as 1989	**$111,850,403**		**$83,300,000**	
Great Lakes fish are free of pollutants affecting human health	$146,761,694	**$34,911,290**	$109,300,000	**$26,000,000**
CV -- constant elasticity of substitution model (median)				
1990 fishing conditions remain the same as 1989	$25,243,548		$18,800,000	
Great Lakes fish free of pollutants that affect human health	$38,133,871	$12,890,323	$28,400,000	$9,600,000

Location: Wisconsin
Estimating Approach: TC and CV
Survey Population: Wisconsin Great Lakes and inland anglers
a. The values selected for the use in benefits transfer are given in bold.

EPA selected two WTP values from this study for use in benefits transfer for the following reasons:

- **Environmental quality change**. EPA judged that only one policy scenario — Great Lakes fish that are free from contaminants harmful to human health — is compatible with water quality improvements expected under the proposed regulation (i.e., removal of AWQC exceedances). Other scenarios, such as reducing daily bag limit for lake trout to one per day and restoring naturally reproducing populations of lake trout, are irrelevant to the MP&M regulation. The Agency used estimates from the "no change in 1990 fishing conditions compared to 1989" scenario as an estimate of the baseline value of recreational fishing in Wisconsin.

- **Research methods**. The Agency did not consider estimates from the TC model because the author noted that "the nested logit travel cost model results seem too high."

I.6 Montgomery and Needelman, 1997. The Welfare Effects of Toxic Contamination in Freshwater Fish

Montgomery and Needelman (1997) estimated benefits from removing "toxic" contamination from lakes and ponds in New York State. They used a binary variable as their primary water quality measure, which indicates whether the New York Department of Environmental Conservation considers water quality in a given lake to be impaired by toxic pollutants. Their model controls for major causes of impairments other than "toxic" pollutants, to separate the effects of various pollution problems that affect the fishing experience. Table I.6 lists environmental quality changes considered in the study and the WTP values corresponding to a specified water quality change.

Table I.6: Welfare Estimates from Montgomery and Needelman (1997)

Water Quality Change Valued	Compensating Variation per Capita per Season (1999$)	Compensating Variation per Capita per Season (1989$)
Eliminate toxic contamination in all lakes [a]	**$84.93**	**$63.25**
All toxic lakes are closed to fishing	$116.94	$87.09
Raise pH in acidic lakes (none are threatened or impaired)	$18.56	$13.82
Close all acidic lakes to fishing	$19.94	$14.85
Eliminate toxic contamination and raise pH in acidic lakes	$106.67	$79.44

Location: New York State
Estimating Approach: TC -- Repeated discrete choice model
Survey Population: New York State residents; anglers and non-anglers
a. The values selected for the use in benefits transfer are given in bold.

The Agency selected only one value from this study for use in the benefits transfer based on its compatibility with environmental quality changes at both the original study and the MP&M sites, for the following reason:

- **Environmental quality change**. Only one of the five policy scenarios considered — removing toxic contamination in all lakes — is directly compatible with the potential changes brought about by the MP&M rule. The MP&M rule is unlikely to significantly affect the acidity in lakes and streams affected by MP&M discharges. The last three policy scenarios in Table I.6 involve changes in pH levels, and are therefore not included in the benefits transfer. The Agency also did not consider the estimate from the second scenario in table I,6 — closing all toxic lakes to fishing — in benefits transfer, because it does not consider water quality improvement per se.

I.7 Phaneuf et al., 1998. Valuing Water Quality Improvements Using Revealed Preference Methods When Corner Solutions are Present

Phaneuf et al. (1998) studied angling in Wisconsin Great Lakes. They estimated changes in recreational fishing values resulting from a 20 percent reduction of toxin levels in lake trout flesh. The study uses a TC model to value water quality improvements when ***corner solutions*** are present in the data. Corner solutions arise when consumers visit only a subset of the available recreation sites, setting their demand to zero for the remaining sites. Phaneuf et al. found that improved industrial and municipal waste management results in general water quality improvement. Table I.7 presents findings from this study based on two policy scenarios and four different model specifications.

Table I.7: Welfare Estimates from Phaneuf et al. (1998)

	Adjusted to 1999$				Study Values (1989$)			
Water Quality Change Valued	**RNL**	**RPRNL**	**KT**	**System**	**RNL**	**RPRNL**	**KT**	**System**
20% reduction in toxins	$39.15	$11.79	**$156.36**	$14.76	$29.16	$8.78	**$116.45**	$10.99
Loss of South Lake Michigan	$218.42	$132.05	$1,140.11	$415.19	$162.67	$98.34	$849.09	$309.21

Location: Wisconsin Great Lakes
Estimating Approach: TC models, including:
RNL: Repeated Nested Logit Model;
RPRNL: Random Parameters Repeated Nested Logit Model;
KT: Kuhn-Tucker Model; and
System: Systems of Demands Model
Survey Population: Wisconsin anglers; Great Lakes and inland anglers

The Agency selected only one value for use in benefits transfer for the following reasons:

- **Environmental quality change**. Only one policy scenario evaluated in this study — a 20 percent reduction in the toxin levels in fish tissue — is compatible with the water quality changes expected from the MP&M regulation (i.e., removal of aquatic life-based AWQC exceedances. The second scenario — loss of South Lake Michigan — is irrelevant to the proposed regulation.

- **Research methods**. Phaneuf et al. estimated four different models and provided WTP estimates based on each of them. The authors indicated, however, that " the KT model comes closest to matching the ideal theoretical model" (see authors conclusions, page 1030). Other models either rely on more restrictive assumptions or require additional research. The Agency chose the value from the KT model based on the authors' recommendation, which is one of the selection criteria for values used in the benefits transfer.

GLOSSARY

ambient water quality criteria (AWQC): Levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

binary choice (BC): offers respondents to a contingent valuation survey specific dollars and cents choices, for example, would you be willing to pay between $10 and $20 per year to improve visibility at the Grand Canyon.

conjoint analysis: CJ is defined as "any decompositional method that estimates the structure of consumer's preferences…given his or her overall evaluations of a set of alternatives that are prespecified in terms of levels of different attributes. Price typically is included as an attribute." (Green and Srinivasan, 1990).

contingent valuation (CV): a method used to determine a value for a particular event, where people are asked what they are willing to pay for a benefit and/or are willing to receive in compensation for tolerating a cost. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids that are close to what would be revealed if an actual market existed. (http://www.damagevaluation.com/glossary.htm)

corner solutions: a corner solution arise when a consumer who has a choice of two goods, x_1 and x_2, chooses to consume no x_1 at the utility maximum.

direct question/open-ended (OE): in the OE approach, respondents are asked the most they would be willing to pay for the program or policy. This approach has a virtue of not providing any hints about what might be a reasonable value. This approach, however, confronts respondents with an unfamiliar choice (i.e., placing a price on environmental commodities). Studies that use the OE approach have high item non-response rates.

fish consumption advisory (FCA): an official notification of the public about specific areas where fish tissue samples have been found to be contaminated by toxic chemicals which exceed FDA action limits or other accepted guidelines. Advisories may be species specific or community wide.

intensity of preference (IP): the experimental design allows individuals to state an intensity of preferences for or against the alternative to the status quo. For example, the individual designates they would "probably yes" or "definitely yes" prefer the alternative to the status quo.

iterative bidding (IB): with IB, respondents are asked whether they would be WTP a given amount. If the answer is yes, this amount is raised in pre-set increments until the respondent says that he will not pay the last amount given. If the answer is no, then the amount is decreased until the respondent indicates a willingness to pay the stated amount.

starting point bias: because survey interviewers suggest the first bid this can influence the respondents answer and cause the respondent to agree too readily with bids in the vicinity of the initial bid. (http://www.damagevaluation.com/glossary.htm)

travel cost (TC): method to determine the value of an event by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site. (http://www.damagevaluation.com/glossary.htm)

willingness to pay (WTP): maximum amount of money one would be willing to pay or give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

AWQC: ambient water quality criteria
BC: binary choice
CV: contingent valuation
FCA: fish consumption advisory
IB: iterative bidding"
IP: intensity of preference
TC: travel cost
WTP: willingness to pay

REFERENCES

Boyle, K. J. and J.C Bergstrom. 1992. "Benefit Transfer Studies: Myths, Pragmatism and Idealism." *Water Resources Research,* Vol. 28, No.3 pages 657-663, March.

Desvousges, W. H. et al. 1987. "Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River." *Journal of Environmental Economics and Management*, 14, pages 248-267.

Desvousges, W. H. et al. 1992. "Benefit Transfer: Conceptual Problems in Estimating Water Quality Benefits Using Existing Studies." *Water Resources Research,* Vol. 28, No.3 pages 675-683, March.

Farber, S. and B. Griner. 2000. *Valuing Watershed Quality Improvements Using Conjoint Analysis.* University of Pittsburgh, PA.

Fisher, A. and R. Raucher. 1984. "Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives." In: *Advances in Applied Microeconomics*, Vol. 3, V.K. Smith, editor, JAI Press.

Jakus, P.M., M. Downing, M.S. Bevelhimer, and J.M. Fly. 1997. "Do Sportfish Consumption Advisories Affect Reservoir Anglers' Site Choice?" *Agricultural and Resource Economic Review*, 26(2).

Lant, C. L. and R.S. Roberts. 1990. "Greenbelts in the Cornbelt: Riparian Wetlands, Intrinsic Values, and Market Failure." *Environment and Planning A*, Vol. 22, pages 1375-1388.

Lyke, A.J. 1993. "Discrete Choice Models to Value Changes in Environmental Quality: A Great Lakes Case Study." PhD dissertation, University of Wisconsin, Department of Agricultural Economics, Madison.

Montgomery, M. and M. Needelman. 1997. "The Welfare Effects of Toxic Contamination in Freshwater Fish." *Land Economics* 73(2): 211-223.

Phaneuf, D. J., C. L. Kling, and J.A. Herriges. 1998. "Valuing Water quality Improvements Using Revealed Preference Methods When Corner Solutions are Present." *American Journal of Agricultural Economics* 80, pages 1025-1031.