DEVELOPMENT DOCUMENT FOR FINAL

EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS

FOR THE

PHARMACEUTICAL MANUFACTURING POINT SOURCE CATEGORY

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July 30, 1998

ACKNOWLEDGMENT AND DISCLAIMER

This report has been reviewed and approved for publication by the Engineering and Analysis Division, Office of Science and Technology. This report was prepared with the support of Eastern Research Group, Inc. (Contract No. 68-C5-0025), under the direction and review of the Office of Science and Technology. Neither the United States Government nor any of its employees, contractors, subcontractors, or their employees make any warrant, expressed or implied, or assume any legal liability or responsibility for any third party's use of or the results of such use of any information, apparatus, product, or process discussed in this report, or represents that its use by such party would not infringe on privately owned rights.

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SECTION 1

INTRODUCTION

1.1 Legal Authority

The Pharmaceutical Manufacturing Point Source Category Effluent Limitations Guidelines and Standards are being finalized under the authority of Sections 301, 304, 306, 307, 308, and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. 1251 et seq., as amended by the Clean Water Act of 1977, Pub. L. 95-217, and the Water Quality Act of 1987, Pub. L. 100-4), also referred to as "the Act."

1.2 Background

1.2.1 Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (101(a)). To implement the Act, EPA is to issue effluent limitations guidelines, pretreatment standards, and new source performance standards for industrial dischargers.

These guidelines and standards are summarized briefly below:

1. Best Practicable Control Technology Currently Available (BPT) (304(b)(1) of the Act).

   BPT effluent limitations apply to all discharges from existing direct dischargers. BPT effluent limitations guidelines are generally based on the average of the best existing performance by plants of various sizes, ages, and unit processes within the category or subcategory for control of pollutants.

   In establishing BPT effluent limitations guidelines, EPA considers the total cost of achieving effluent reductions in relation to the effluent reduction benefits, the age of equipment and facilities involved, the processes used, process changes required, engineering aspects of the control technologies, nonwater quality environmental

impacts (including energy requirements), and other factors as the EPA Administrator deems appropriate (304(b)(1)(B) of the Act). The Agency considers the category- or subcategory-wide cost of applying the technology in relation to the effluent reduction benefits. Where existing performance is uniformly inadequate within a category or subcategory, BPT may be transferred from a different subcategory or category.

2. Best Available Technology Economically Achievable (BAT) (304(b)(2) of the Act).

In general, BAT effluent limitations guidelines represent the best existing economically achievable performance of plants in the industrial subcategory or category, based upon available technology. The Act establishes BAT as the principal national means of controlling the direct discharge of toxic and nonconventional pollutants to navigable waters. The factors considered in assessing BAT include the age of equipment and facilities involved, the process employed, potential process changes, and nonwater quality environmental impacts (including energy requirements) (304(b)(2)(B)). The Agency retains considerable discretion in assigning the weight to be accorded these factors. As with BPT, where existing performance is uniformly inadequate within a category or subcategory, BAT may be transferred from a different subcategory or category. BAT may include process changes or internal controls, even when these technologies are not common industry practice.

3. Best Conventional Pollutant Control Technology (BCT) (304(b)(4) of the Act).

The 1977 Amendments to the Act established BCT for discharges of conventional pollutants from existing industrial point sources. 304(a)(4) designated the following as conventional pollutants: biochemical oxygen demand (BOD_5), total suspended solids (TSS), fecal coliform, pH, and any additional pollutants defined by the Administrator as conventional. The Administrator designated oil and grease as an additional conventional pollutant on July 30, 1979 (44 FR 44501).

BCT is not an additional limitation, but replaces BAT for the control of conventional pollutants. In addition to other factors specified in 304(b)(4)(B), the Act requires that BCT limitations be established in light of a two-part "cost-reasonableness" test. American Paper Institute v. EPA, 660 F.2d 954 (4th Cir. 1981). EPA's current methodology for the general development of BCT limitations was issued in 1986 (51 FR 24974, July 9, 1986).

4. New Source Performance Standards (NSPS) (306 of the Act).

NSPS are based on the best available demonstrated control technology. New plants have the opportunity to install the best and most efficient production processes and wastewater treatment technologies. As a result, NSPS should represent the most stringent numerical values attainable through the application of

the best available control technology for all pollutants (i.e., conventional, nonconventional, and toxic pollutants). In establishing NSPS, EPA is directed to take into consideration the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements.

5. Pretreatment Standards for Existing Sources (PSES) (307(b) of the Act).

PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of publicly owned treatment works (POTWs). The Act authorizes EPA to establish pretreatment standards for pollutants that pass through POTWs or interfere with POTWs' treatment processes or sludge disposal methods. The legislative history of the 1977 Act indicates that pretreatment standards are to be technology-based and analogous to the BAT effluent limitations guidelines for removal of toxic pollutants. For the purpose of determining whether to promulgate national category-wide pretreatment standards, EPA generally determines that there is pass through of a pollutant and thus a need for categorical standards if the nation-wide average percent removal of a pollutant removed by well-operated POTWs achieving secondary treatment is less than the percent removed by the BAT model treatment system.

The General Pretreatment Regulations, which set forth the framework for the implementation of categorical pretreatment standards, are found at 40 CFR Part 403. (Those regulations contain a definition of pass through that addresses localized rather than national instances of pass through and does not use the percent removal comparison test described above. See 52 FR 1586, January 14, 1987.)

6. Pretreatment Standards for New Sources (PSNS) (307(b) of the Act).

Like PSES, PSNS are designed to prevent the discharges of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. PSNS are to be issued at the same time as NSPS. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate into their plants the best available demonstrated technologies. The Agency considers the same factors in promulgating PSNS that it considers in promulgating NSPS.

1.2.2 304(m) Requirements

304(m) of the Clean Water Act (33 U.S.C. 1314(m)), added by the Water Quality Act of 1987, requires EPA to establish schedules for (I) reviewing and revising existing effluent limitations guidelines and standards ("effluent guidelines"), 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 industrial categories. One of the industries for which the Agency established a schedule was the Pharmaceutical Manufacturing Point Source Category.

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 304(m). A Consent Decree in this litigation was entered by the Court on January 31, 1992. The terms of the Consent Decree are reflected in the Effluent Guidelines Plan published on September 8, 1992 (57 FR 41000). This plan required, among other things, that EPA propose effluent guidelines for the pharmaceutical manufacturing category by January, 1994 and take final action on these effluent guidelines by August, 1995. Recently EPA filed an unopposed motion requesting an extension of time until July 30, 1998 for the Administrator to sign the final rule.

1.2.3 Pollution Prevention Act

The Pollution Prevention Act of 1990 (PPA) (42 U.S.C. 13101 et seq., Pub. L. 101-508, November 5, 1990), "declares it to be the national policy of the United States that pollution should be prevented or reduced whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner wherever feasible; and disposal or release into the environment should be chosen only as a last resort..." (See 6602; 42 U.S.C. 13101(b)).

1.2.4 Prior Regulation of the Pharmaceutical Manufacturing Category

EPA promulgated interim final BPT regulations for the Pharmaceutical Manufacturing Point Source Category on November 17, 1976 (41 FR 50676; 40 CFR Part 439 Subparts A - E). The BPT effluent guidelines established limitations for BOD_5, chemical oxygen demand (COD), TSS, and pH for wastewaters discharged by the extraction, the mixing/compounding and formulation, and the research subcategories and limitations for BOD_5, COD, and pH for wastewaters discharged by the fermentation and the chemical synthesis subcategories.

On November 26, 1982, EPA proposed regulations applicable to the Pharmaceutical Manufacturing Point Source Category (47 FR 53584) which proposed to modify and expand upon the November 17, 1976 regulations. EPA proposed the following:

- To modify the existing BPT TSS effluent limitations guidelines for the extraction, mixing, compounding and formulating, and research subcategories;
- To extend these revised BPT TSS effluent limitations guidelines to the fermentation and chemical synthesis subcategories;
- To modify the existing BPT COD effluent limitations guidelines for the fermentation, extraction, chemical synthesis, mixing/compounding and formulation, and research subcategories;
- To propose BPT cyanide effluent limitations guidelines for the fermentation, extraction, chemical synthesis, and mixing/compounding and formulation subcategories;
- To propose BAT COD and cyanide effluent limitations guidelines for the fermentation, extraction, chemical synthesis, and mixing/compounding and formulation subcategories;
- To propose BCT BOD_5, TSS and pH effluent limitations guidelines for the fermentation, extraction, chemical synthesis, and mixing/compounding and formulation subcategories;
- To propose BOD_5, COD, TSS, cyanide and pH NSPS for the fermentation, extraction, chemical synthesis, and mixing/compounding and formulation subcategories; and
- To propose cyanide PSES and PSNS for the fermentation, extraction, chemical synthesis, and mixing/compounding and formulation subcategories.

On October 27, 1983 (48 FR 49808), EPA promulgated portions of the November 26, 1982 proposal, proposed additional changes, and postponed portions of the proposed rule. This final rule included the following:

- Promulgation of BPT TSS limitations for all subcategories equal to a multiple of 1.7 times the existing BPT BOD_5 limitations;

- Promulgation of alternative BPT BOD_5 and COD concentration-based limitations for the extraction, mixing/compounding and formulation, and research subcategories (such alternative limitations were not deemed necessary for the fermentation and chemical synthesis subcategories because the available data indicated that raw loads were sufficiently high at these subcategory plants that limitations as low as the alternative limitations would not be required under BPT);

- Promulgation of BPT, BAT, NSPS, PSES, and PSNS for cyanide based on monitoring either in-plant after cyanide destruction or end-of-pipe after cyanide destruction and biological treatment for all but the research subcategory;

- Promulgation of pH NSPS for all but the research subcategory;

- Proposal of revised BOD_5 and TSS NSPS based on end-of-pipe filtration in combination with advanced biological treatment for all but the research subcategory;

- Postponement of a final decision on appropriate BAT limitations and NSPS for COD until a later date; and

- Postponement of BCT limitations until promulgation of the general methodology for determining appropriate levels of conventional pollutant control under BCT.

The October 27, 1983 preamble also included a discussion of BAT effluent limitations guidelines, NSPS, PSES, and PSNS for Toxic Volatile Organics (TVOs). The Agency decided, at that time, not to establish regulations controlling the discharge of volatile priority pollutants from pharmaceutical manufacturing plants based on certain provisions of the previous (1976) Settlement Agreement with NRDC, lack of data documenting harmful discharges or POTW pass-through of TVOs, and concern over the costs for treatment. However, the Agency obtained new data regarding the treatment of methylene chloride at a pharmaceutical manufacturing plant during a sampling study in which both the plant and EPA participated and began reconsidering its policy on regulating volatile priority pollutants. On September 9, 1985 (50 FR 36638), the Agency published a Notice of Availability and request for comments for the Pharmaceutical Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards (which included the new study data). This notice

requested comments on the treatment of TVOs by steam stripping, pretreatment of wastewaters, and any information about changes in solvent usage and facility flows and treatment operations.

On December 16, 1986 (51 FR 45094), the Agency published a final rule for BCT BOD_5, TSS, and pH effluent limitations guidelines for all but the research subcategory. This final rule set the BCT effluent limitations guidelines equal to the existing BPT BOD_5, TSS, and pH effluent limitations guidelines.

In 1989, EPA withdrew the proposed NSPS for BOD_5 and TSS over concern for the cost-effectiveness of TSS control for Subcategories B and D.

On May 2, 1995 (60 FR 21592), EPA proposed regulations applicable to the Pharmaceutical Manufacturing Point Source Category which proposed to modify and expand upon the 1983 and 1986 final regulations. EPA proposed the following:

- To revise the existing BPT BOD_5, TSS, and cyanide effluent limitations guidelines for the fermentation, extraction, chemical synthesis, and mixing/ compounding and formulation subcategories;
- To set BCT equal to the revised BPT for BOD_5 and TSS for the same set of subcategories;
- To propose BAT COD, cyanide, priority, and nonconventional pollutant effluent limitations guidelines for the fermentation, extraction, chemical synthesis, and mixing/compounding and formulation subcategories;
- To propose BOD_5, COD, TSS, cyanide, priority, and nonconventional NSPS for the fermentation, extraction, chemical synthesis, and mixing/ compounding, and formulation subcategories; and
- To propose cyanide, priority, and nonconventional PSES and PSNS for the fermentation, extraction, chemical synthesis, and mixing/compounding and formulation subcategories.

Based on comments on and data EPA received in response to the May 2, 1995 proposal, and subsequent follow-up analysis, the Agency presented potential revisions to the proposal

regulatory options under the CWA in the April 2, 1997 (62 FR 15753) Proposed Maximum Achievable Control Technology (MACT) Standards for the Pharmaceutical Manufacturing Industry. EPA published a Notice of Availability (NOA) on August 8, 1997 (62 FR 42732). EPA published this Notice in order to allow public comment on the data received since the May 2, 1995 CWA proposal, further develop and revise options for the control of the VOCs that were presented in the April 2, 1997 CAA MACT proposal, and to suggest responses to some comments on the 1995 CWA proposal.

1.3 Scope of Final Regulations

The final regulation covers the fermentation, extraction, chemical synthesis, and mixing, compounding and formulating subcategories of the pharmaceutical manufacturing industry. EPA is promulgating the following:

- Revised BPT effluent limitations guidelines for COD for Subcategories A, B, C and D;
- BCT effluent limitations guidelines for BOD_5 and TSS equal to the existing BPT limitations for BOD_5 and TSS;
- BAT effluent limitations guidelines for COD, ammonia, and 30 organic pollutants at Subcategories A and C;
- BAT effluent limitations guidelines for COD for Subcategories B and D;
- NSPS effluent limitations guidelines for BOD_5, COD, and TSS at Subcategories A, B, C, and D. Additionally, NSPS effluent limitations guidelines for ammonia and 30 organic pollutants at Subcategories A and C;
- PSES and PSNS effluent limitations guidelines for ammonia and 23 organic pollutants at Subcategories A and C; and
- PSES and PSNS effluent limitations guidelines for 5 organic pollutants at Subcategories B and D.

Additionally, EPA is clarifying the existing regulation for cyanide at Subcategories A and C, and withdrawing the existing regulation for cyanide at Subcategories B and D. These final effluent

limitations guidelines and standards do not cover discharges generated from the research subcategory of the Pharmaceutical Manufacturing Point Source Category.

SECTION 2

SUMMARY

2.1 Introduction

The final regulations for the pharmaceutical manufacturing industry include effluent limitations guidelines and standards for the control of wastewater pollutants. This document presents the information and rationale supporting the final effluent limitations guidelines and standards. 2.2 presents the final subcategorization scheme, 2.3 describes the scope of the final regulations, and 2.4 through 2.9 summarize the effluent limitations guidelines and standards.

2.2 Subcategorization

EPA is maintaining the existing subcategorization scheme for this industry (40 CFR Part 439). These subcategories are summarized in the following table:

Subcategory Code (Subpart)	Subcategory
A	Fermentation Operations
B	Biological and Natural Extraction Operations
C	Chemical Synthesis Operations
D	Mixing, Compounding, or Formulating Operations
E	Pharmaceutical Research Operations

2.3 Scope of Regulations

These regulations apply to Subcategories A through D of the pharmaceutical manufacturing industry. Subcategory E (Research) operations are not revised by these regulations. Subcategory E operations at stand-alone facilities or at manufacturing facilities with Subcategory A, B, C, and/or D operations are covered by the existing BPT effluent limitations guidelines for Subcategory E.

Pharmaceutical manufacturers use many different raw materials and manufacturing processes to create a wide range of products with therapeutic value. Pharmaceutical products are produced by chemical synthesis, fermentation, extraction from naturally occurring plant or animal substances, or by refining a technical grade product.

The pharmaceutical products, processes, and activities covered by this regulation include:

- Biological products covered by the U.S. Department of Commerce, Bureau of the Census Standard Industrial Classification (SIC) Code No. 2836, with the exception of diagnostic substances. (Products covered by SIC Code No. 2836 were formerly covered under the 1977 SIC Code No. 2831.)

- Medicinal chemicals and botanical products covered by SIC Code No. 2833.

- Pharmaceutical products covered by SIC Code No. 2834.

- All fermentation, biological and natural extraction, chemical synthesis and formulation products considered to be pharmaceutically active ingredients by the Food and Drug Administration that are not covered by SIC Code Nos. 2833, 2834, or 2836.

- Multiple end-use products derived from pharmaceutical manufacturing operations (e.g., components of formulations, intermediates, or final products, provided that the primary use of the product is intended for pharmaceutical purposes).

- Products not covered by SIC Code Nos. 2833, 2834, and 2836 or other categorical limitations and standards if they are manufactured by a pharmaceutical manufacturer by processes that generate wastewaters that in turn closely correspond to those of pharmaceutical products. (An example of such a product is citric acid.)

- Cosmetic preparations covered by SIC Code No. 2844 that contain pharmaceutically active ingredients or ingredients intended for treatment of some skin condition. (This group of preparations does not include products such as lipsticks or perfumes that serve to enhance appearance or to provide a pleasing odor, but do not provide skin care. In general, this also excludes deodorants, manicure preparations, shaving preparations and non-medicated shampoos that do not function primarily as a skin treatment.)

Products or activities specifically excluded from the pharmaceutical manufacturing category are:

- Surgical and medical instruments and apparatus reported under SIC Code No. 3841.
- Orthopedic, prosthetic, and surgical appliances and supplies reported under SIC Code No. 3842.
- Dental equipment and supplies reported under SIC Code No. 3843.
- Medical laboratories services reported under SIC Code No. 8071.
- Dental laboratories services reported under SIC Code No. 8072.
- Outpatient care facility services reported under SIC Code No. 8081.
- Health and allied services reported under SIC Code No. 8091, and not classified elsewhere.
- Diagnostic devices other than those reported under SIC Code No. 3841.
- Animal feeds that include pharmaceutical active ingredients such as vitamins and antibiotics, where the major portion of the product is non-pharmaceutical, and the resulting process wastewater is not characteristic of process wastewater from the manufacture of pharmaceutical products.
- Foods and beverage products fortified with vitamins or other pharmaceutical active ingredients, where the major portion of the product is non-pharmaceutical, and the resulting process wastewater is not characteristic of process wastewater from the manufacture of pharmaceutical products.
- Pharmaceutical products and intermediates subject to the provisions of 40 CFR part 414, provided their manufacture results in less than 50 percent of the total flow of process wastewater that is regulated by 40 CFR part 414 at the facility.

In addition, facilities regulated by the organic chemicals, plastics and synthetic fibers (OCPSF) effluent limitations guidelines and standards (40 CFR 414) that manufacture pharmaceutical products and intermediates, will be subject to the OCPSF effluent guidelines and standards provided that the wastewater generated as a result of the manufacture of pharmaceutical products and intermediates is less than 50% of the total process wastewater flow at the facility.

2.4 Best Practicable Control Technology Currently Available (BPT)

EPA is revising the BPT effluent limitations guidelines for chemical oxygen demand (COD) for Subcategories A, B, C, and D. Table 2-1 presents these final limitations, which are based on the application of advanced biological treatment. The existing BPT effluent limitations guidelines for pH, BOD_5 and TSS are being maintained for all subcategories. The existing BPT effluent limitations guidelines for cyanide are being refined; the compliance monitoring requirements for these limitations have been clarified. Limitations on cyanide for B and D Subcategories are being withdrawn.

2.5 Best Conventional Pollutant Control Technology (BCT)

Existing BCT effluent limitations guidelines are not being revised.

2.6 Best Available Technology Economically Achievable (BAT)

EPA is revising the BAT effluent limitations guidelines for Subcategories A and C. For Subcategories A and C, EPA is adding BAT effluent limitations for ammonia as nitrogen (N), COD, and 30 priority and nonconventional organic pollutants. For Subcategories B and D, EPA is setting a BAT effluent limitation for COD that is equivalent to the BPT limitation. No additional BAT effluent limitations are being set for Subcategories B and D. However, EPA is withdrawing the current BAT effluent limitations for cyanide for Subcategories B and D. Tables 2-2 and 2-3 present these final effluent limitations guidelines, which are based on the following: end-of-pipe advanced biological treatment with nitrification for Subcategories A and C, and end-of-pipe advanced biological treatment for Subcategories B and D.

2.7 New Source Performance Standards (NSPS)

EPA is setting NSPS for priority and nonconventional pollutants for Subcategories A and C. The NSPS for Subcategories A and C include ammonia (as N) and 30 priority and nonconventional organic pollutants, based on advanced biological treatment with nitrification.

EPA is also revising the NSPS controlling discharges of BOD_5, COD, and TSS for Subcategories A, B, C, and D based on advanced biological treatment. EPA is withdrawing cyanide standards for Subcategories B and D. Final NSPS for Subcategories A and C are presented in Table 2-4. Final NSPS for Subcategories B and D are presented in Table 2-5.

2.8 Pretreatment Standards for Existing Sources (PSES)

EPA is revising PSES for priority and nonconventional pollutants for Subcategories A, B, C, and D. For Subcategories A and C, EPA is setting PSES for ammonia (as N) and 23 priority and nonconventional organic pollutants based on steam stripping. For Subcategories B and D, EPA is setting PSES for 5 priority and nonconventional organic pollutants based on steam stripping. Revised PSES for Subcategories A, B, C, and D are presented in Tables 2-6 and 2-7.

2.9 Pretreatment Standards for New Sources (PSNS)

EPA is revising PSNS for priority and nonconventional pollutants for Subcategories A, B, C, and D equal to PSES. Revised PSNS for Subcategories A, B, C, and D are presented in Tables 2-8 and 2-9.

Table 2-1

BPT Effluent Limitations for Subcategories A, B, C, and D

Subcategory	Pollutant or Pollutant Property	BPT Effluent Limitation for End-of-Pipe Monitoring Points	
		Maximum for any one day (mg/L)	Monthly Average (mg/L)
A: Fermentation Operations	COD	1,675	856
B: Biological and Natural Extraction Operations	COD	228	86
C: Chemical Synthesis Operations	COD	1,675	856
D: Mixing, Compounding, or Formulating Operations	COD	228	86

Table 2-2

BAT Effluent Limitations for Subcategory A - Fermentation Operations and Subcategory C - Chemical Synthesis Operations

Pollutant or Pollutant Property	BAT Effluent Limitations for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	0.5	0.2
Acetonitrile	25.0	10.2
Ammonia as N	84.1	29.4
n-Amyl Acetate	1.3	0.5
Amyl Alcohol	10.0	4.1
Benzene	0.05	0.02
n-Butyl Acetate	1.3	0.5
Chemical Oxygen Demand (COD)	1,675	856
Chlorobenzene	0.15	0.06
Chloroform	0.02	0.01
o-Dichlorobenzene	0.15	0.06
1,2-Dichloroethane	0.4	0.1
Diethylamine	250.0	102.0
Dimethyl Sulfoxide	91.5	37.5
Ethanol	10.0	4.1
Ethyl Acetate	1.3	0.5
n-Heptane	0.05	0.02
n-Hexane	0.03	0.02
Isobutyraldehyde	1.2	0.5
Isopropanol	3.9	1.6
Isopropyl Acetate	1.3	0.5
Isopropyl Ether	8.4	2.6
Methanol	10.0	4.1
Methyl Cellosolve	100.0	40.6
Methylene Chloride	0.9	0.3
Methyl Formate	1.3	0.5
MIBK	0.5	0.2
Phenol	0.05	0.02
Tetrahydrofuran	8.4	2.6
Toluene	0.06	0.02
Triethylamine	250.0	102.0
Xylenes	0.03	0.01

Table 2-3

BAT Effluent Limitations for Subcategory B - Biological and Natural Extraction Operations and Subcategory D - Mixing, Compounding, or Formulating

Pollutant or Pollutant Property	BAT Effluent Limitations for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Chemical Oxygen Demand (COD)	228	86

Table 2-4

NSPS for Subcategory A - Fermentation Operations and Subcategory C - Chemical Synthesis Operations

Pollutant or Pollutant Property	NSPS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	0.5	0.2
Acetonitrile	25.0	10.2
Ammonia as N	84.1	29.4
n-Amyl Acetate	1.3	0.5
Amyl Alcohol	10.0	4.1
Benzene	0.05	0.02
n-Butyl Acetate	1.3	0.5
Chlorobenzene	0.15	0.06
Chloroform	0.02	0.01
o-Dichlorobenzene	0.15	0.06
1,2-Dichloroethane	0.4	0.1
Diethylamine	250.0	102.0
Dimethyl Sulfoxide	91.5	37.5
Ethanol	10.0	4.1
Ethyl Acetate	1.3	0.5
n-Heptane	0.05	0.02
n-Hexane	0.03	0.02
Isobutyraldehyde	1.2	0.5
Isopropanol	3.9	1.6
Isopropyl Acetate	1.3	0.5
Isopropyl Ether	8.4	2.6
Methanol	10.0	4.1
Methyl Cellosolve	100.0	40.6
Methylene Chloride	0.9	0.3
Methyl Formate	1.3	0.5
MIBK	0.5	0.2
Phenol	0.05	0.02
Tetrahydrofuran	8.4	2.6
Toluene	0.06	0.02
Triethylamine	250.0	102.0
Xylenes	0.03	0.01
BOD_5	267	111
COD	1,675	856
TSS	472	166

Table 2-5

NSPS for Subcategory B - Biological and Natural Extraction Operations and Subcategory D - Mixing, Compounding, or Formulating

Pollutant or Pollutant Property	NSPS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
BOD_5	35	18
COD	228	86
TSS	58	31

Table 2-6

PSES for Subcategory A - Fermentation Operations and Subcategory C - Chemical Synthesis Operations

Pollutant or Pollutant Property	PSES for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	20.7	8.2
Ammonia as N	84.1	29.4
n-Amyl Acetate	20.7	8.2
Benzene	3.0	0.6
n-Butyl Acetate	20.7	8.2
Chlorobenzene	3.0	0.7
Chloroform	0.1	0.03
o-Dichlorobenzene	20.7	8.2
1,2-Dichloroethane	20.7	8.2
Diethylamine	255.0	100.0
Ethyl Acetate	20.7	8.2
n-Heptane	3.0	0.7
n-Hexane	3.0	0.7
Isobutyraldehyde	20.7	8.2
Isopropyl Acetate	20.7	8.2
Isopropyl Ether	20.7	8.2
Methyl Cellosolve	275.0	59.7
Methylene Chloride	3.0	0.7
Methyl Formate	20.7	8.2
MIBK	20.7	8.2
Tetrahydrofuran	9.2	3.4
Toluene	0.3	0.1
Triethylamine	255.0	100.0
Xylenes	3.0	0.7

Table 2-7

PSES for Subcategory B - Biological and Natural Extraction Operations and Subcategory D - Mixing, Compounding, or Formulating

Pollutant or Pollutant Property	PSES for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	20.7	8.2
n-Amyl Acetate	20.7	8.2
Ethyl Acetate	20.7	8.2
Isopropyl Acetate	20.7	8.2
Methylene Chloride	3.0	0.7

Table 2-8

PSNS for Subcategory A - Fermentation Operations and Subcategory C - Chemical Synthesis Operations

Pollutant or Pollutant Property	PSNS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	20.7	8.2
Ammonia as N	84.1	29.4
n-Amyl Acetate	20.7	8.2
Benzene	3.0	0.6
n-Butyl Acetate	20.7	8.2
Chlorobenzene	3.0	0.7
Chloroform	0.1	0.03
o-Dichlorobenzene	20.7	8.2
1,2-Dichloroethane	20.7	8.2
Diethylamine	255.0	100.0
Ethyl Acetate	20.7	8.2
n-Heptane	3.0	0.7
n-Hexane	3.0	0.7
Isobutyraldehyde	20.7	8.2
Isopropyl Acetate	20.7	8.2
Isopropyl Ether	20.7	8.2
Methyl Cellosolve	275.0	59.7
Methylene Chloride	3.0	0.7
Methyl Formate	20.7	8.2
MIBK	20.7	8.2
Tetrahydrofuran	9.2	3.4
Toluene	0.3	0.1
Triethylamine	255.0	100.0
Xylenes	3.0	0.7

Table 2-9

PSNS for Subcategory B - Biological and Natural Extraction Operations and Subcategory D - Mixing, Compounding, or Formulating Operations

Pollutant or Pollutant Property	PSNS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	20.7	8.2
n-Amyl Acetate	20.7	8.2
Ethyl Acetate	20.7	8.2
Isopropyl Acetate	20.7	8.2
Methylene Chloride	3.0	0.7

SECTION 3

INDUSTRY DESCRIPTION

3.1 Introduction

This describes the pharmaceutical manufacturing industry by presenting a summary of the data and information EPA has gathered from previous EPA rulemaking efforts along with data collected as part of this effort to develop revised effluent limitations guidelines and standards for the pharmaceutical manufacturing industry. The following topics are discussed in this section:

- 3.2 discusses EPA's data collection methods and information sources;
- 3.3 presents an overview of the industry;
- 3.4 discusses pharmaceutical manufacturing processes; and
- 3.5 discusses trends in the industry.

3.2 Data Collection Methodology and Information Sources

In the course of developing effluent limitations guidelines and standards for the pharmaceutical manufacturing industry, EPA gathered and evaluated technical data from various sources to create an industry profile with respect to manufacturing processes, geographical distribution of facilities, and wastewater generation, treatment, and disposal. These data have also been used to characterize the pharmaceutical manufacturing industry's wastewater by evaluating the industry's water use, type of wastewater discharge, and occurrence of conventional, priority, and nonconventional pollutants in the wastewater. This summarizes the data collection efforts undertaken by EPA from 1975 to the present.

EPA announced it would collect additional information on this industry by publishing a Federal Register Notice (50 FR 36638, September 9, 1985) indicating its intent to reconsider whether or not to regulate methylene chloride and other volatile priority pollutants. In that Notice, EPA declared it had received new information indicating methylene chloride causes cancer in animals,

such that the effects of methylene chloride discharges from pharmaceutical manufacturing plants may be more harmful than previously believed. Additionally, the results of the 1986 Domestic Sewage Study (DSS) (1) identified pharmaceutical manufacturing facilities as a significant source of organic pollutants, and found that discharges of organic compounds from these facilities are largely unregulated. Based on these data, EPA ranked this industry relatively high with respect to other industries in EPA's 304(m) plan due to environmental need (volatile organic discharges) and utility to permits and pretreatment programs. Because of the DSS findings, EPA decided to expand its review beyond priority pollutants to include this industry's use and disposition of approximately 250 additional nonconventional pollutants.

Before introducing extensive new data collection efforts, EPA reviewed in 1986 available information and identified missing information that would need to be obtained for the review and revision of current effluent limitations guidelines and standards for this industry. 3.2.1 summarizes the data and information already available to EPA prior to 1986. Sections 3.2.2 through 3.2.13 describe EPA's new data collection efforts.

3.2.1 Summary of Data Collection Efforts

Data collection efforts conducted by EPA prior to 1986 provided substantial information regarding manufacturing processes, water use, wastewater characteristics, and treatment technologies in the pharmaceutical manufacturing industry. Documentation of these efforts was reviewed in 1986 to identify data and information that would be useful to the effort to develop revised effluent limitations guidelines and standards for the pharmaceutical manufacturing industry. This review identified the following major sources of information:

- 308 Portfolio Survey. The original 308 Portfolio Survey was an invaluable source of information for developing an industry profile and characterizing industry wastes. It provided the first detailed information on conventional pollutant parameters in the industry's wastewater and wastewater flow characteristics. It was also the first major data source on the use and/or generation of priority pollutants by this industry.

The 308 Portfolio Survey was conducted in two phases. In the fall of 1977, EPA distributed the original questionnaire to members of the Pharmaceutical Manufacturers' Association (PMA). (Now the Pharmaceutical Research and Manufacturers Association, PhRMA.) The Agency then distributed a second questionnaire to the remainder of the industry in the spring of 1979.

- PEDCo Reports. In the late 1970s, and concurrent with the data-gathering efforts of the 308 Portfolio Survey, PEDCo Environmental, Inc. (PEDCo), reviewed available literature to identify priority pollutants associated with the production of various pharmaceutical products.(2)(3)(4)

- OAQPS Study. EPA's Office of Air Quality Planning and Standards (OAQPS), with the assistance of the PMA, conducted a survey to determine the use and disposition of the 10 largest volume volatile organic pollutants that each member company purchased in 1975.(5)

  In 1985, OAQPS, with the assistance of the PMA, obtained updated purchase and disposition data for selected solvents from PMA member companies.(6) These data were added to the same type of industry data collected by OAQPS in 1975.

- Screening and Verification Sampling Program. Beginning in 1978, EPA initiated the Screening and Verification Sampling Program, under which wastewater samples were collected from plants with manufacturing operations representative of the industry. Process and end-of-pipe wastewater samples were collected and analyzed for priority, conventional, and nonconventional pollutants in a two-phase program. The first phase, called the screening phase, involved sampling and analyzing the effluent from 26 plants to determine the presence of conventional, priority, and nonconventional pollutants. This phase was followed by a verification phase, in which multiple samples were collected over several days at five facilities to verify the presence of the pollutants detected during the screening phase. Data from the Screening and Verification Sampling Program, augmented by data collected more recently, were used by EPA to characterize pharmaceutical industry wastewater.

- RSKERL/ADA Study. In 1979, the Robert S. Kerr Environmental Research Laboratory at Ada, Oklahoma (RSKERL/ADA) conducted an applied research study entitled "Industry Fate Study."(7) The purpose of this report was to determine the fate of specific priority pollutants within a biological treatment system. During the study, priority pollutants associated with the manufacture of pharmaceuticals were identified at two industrial facilities.

- Toxic Volatile Organics (TVO) Questionnaire. In 1982, EPA distributed a survey to 15 pharmaceutical manufacturing facilities requesting analytical information on TVO levels in their process wastewater. The survey was limited to volatile organic priority pollutants only.

- Steam Stripper Sampling. In May of 1983, EPA collected influent and effluent wastewater samples from a packed column steam stripper and a steam distillation flash tank at Plant 12003. The study was conducted over a five-day period, and provided EPA with analytical data documenting the performance of this technology treating pharmaceutical manufacturing industry wastewaters.

- Pilot-Plant Carbon Study. In 1984, U.S. EPA's Water Engineering Research Laboratory (WERL) conducted a pilot-plant carbon study to determine constituents contributing to high chemical oxygen demand (COD) in pharmaceutical manufacturing industry effluents, and to evaluate the ability of activated carbon adsorption technology to reduce COD levels.

- Domestic Sewage Study. In 1985, EPA sampled a pharmaceutical manufacturing facility as part of its efforts to evaluate the discharge of priority and hazardous pollutants to POTWs.(1) Samples of the raw wastewater discharge to the local POTW were taken at Plant 30767 during a 24-hour period.

Data from the above sources were evaluated and summarized in 1986. Additional data collection efforts were then undertaken to fill the data gaps identified during the analysis of the above data and to update or replace outdated information. These data collection efforts were:

- A follow-up (to the 1984 WERL study) pilot plant carbon study in 1987;

- Sampling and analysis of wastewater at 13 pharmaceutical manufacturing facilities between 1986 and 1991;

- A screener questionnaire distributed in May 1989 and a detailed questionnaire distributed in September 1991;

- Industry self-monitoring data submitted to EPA with the Detailed Questionnaire;

- EPA bench- and pilot-scale steam stripping, air stripping, and distillation treatability studies in 1991 and 1993;

- Product patent reviews for solvent usage;
- POTW Survey distributed in 1993 to nine POTWs receiving wastewater from pharmaceutical manufacturers; and
- Annual pollutant disposition data submitted by industry for the years 1987 through 1990 as part of their requirements under 313 of the Emergency Planning and Community Right to Know Act of 1986 [Toxic Release Inventory (TRI) data].

These data were presented in the record supporting the rulemaking proposed on May 2, 1995. In response to the proposal, EPA received additional data from industry which was described in a Notice Of Availability (NOA) published on August 8, 1997. EPA received additional data from industry in comments on the NOA. Additional data collected by EPA since the May 2, 1995 proposal are summarized below:

- Advanced biological treatment data submitted by industry to EPA in response to the May 2, 1995 proposal;
- Steam stripping performance data submitted by industry to EPA in response to the May 2, 1995 proposal;
- Technology performance data for cyanide submitted by industry to EPA in response to the May 2, 1995 proposal;
- Site visits conducted in 1996 at five pharmaceutical manufacturing facilities and three POTWs;
- Sampling and analysis of wastewater at the Barceloneta Regional Wastewater Treatment Plant (BRWTP) in August 1996 and subsequent visits in April and August 1997;
- Ammonia nitrification data submitted to EPA by industry in response to the August 8, 1997 NOA; and
- Additional BPT data submitted to EPA by industry in response to the August 8, 1997 NOA.

Discussions of these additional data are presented in Sections 3.2.2 through 3.2.13.

3.2.2 Follow-Up Pilot-Plant Carbon Study

EPA conducted a follow-up pilot-plant powdered activated carbon (PAC) study in 1987. The purpose of the study was to reduce COD concentrations by using PAC in pharmaceutical manufacturing wastewater biological treatment systems without creating additional mixed liquor suspended solids in the wastewater.

3.2.3 EPA's 1986 - 1991 Sampling at Selected Pharmaceutical Manufacturers

Between 1986 and 1991, EPA conducted sampling episodes at 13 pharmaceutical manufacturing facilities to: 1) characterize the pollutants in the wastewater being discharged at direct and indirect discharging facilities, 2) collect pollutant treatment system performance data from facilities with well-operated biological treatment systems (those systems attaining better than BPT annual average effluent levels), and 3) obtain treatability data from steam stripping and distillation.

Prior to 1986, the Agency had focused on 5 conventional pollutants and 126 priority pollutants identified in the 1977 Consent Decree. In 1986, the Agency expanded the analysis of pharmaceutical manufacturing wastewater and wastewater treatment sludges to determine the presence and levels of all the pollutants on the "Industrial Technology Division (ITD) List of Analytes" (hereinafter, the "List of Analytes").

The List of Analytes was derived from the "ITD/RCRA List of Lists" (8) using the following criteria:

- All analytes on the List of Lists were included on the List of Analytes, except:

  -- Analytes which only appear on the "Acutely Toxic Chemicals" List in EPA's Chemical Emergency Preparedness Program (VTOX list);

  -- Analytes which hydrolyze or are destroyed by water;

- -- Analytes which are designated for analysis solely by high performance liquid chromatography (HPLC);
- -- Analytes which must be analyzed by a subset of their chemical structure, or derivatized (except for the phenoxy acid herbicides which are analyzed by Method 615); and
- -- Analytes for which no analytical standard is available.

- For analytes which hydrolyze, the hydrolysis product is included (if an analysis type and standard are available).
- Metal salts are included as the metal (e.g., beryllium, iron, sodium) and as the anion (e.g., F-, S-, CN-).

When the List of Analytes was first assembled in 1986, it contained 377 analytes.(9) The List of Analytes was expanded as the need to identify different analytes in the wastewater of different industries increased. The most recent List of Analytes was published again in 1990 and included 458 analytes.(10)

The List of Analytes was modified in the 1986-1991 sampling programs conducted for the pharmaceutical manufacturing industry to account for two program-specific needs:

1. After the first two sampling episodes (Nos. 1108 and 1111), EPA determined that it was not necessary to continue analyzing pharmaceutical manufacturing wastewater and wastewater treatment plant sludges for pesticides/herbicides (Method 1618) and dioxins/furans (Method 1613) unless the presence of these analytes was known or suspected. Pesticides/herbicides and dioxins/furans were not detected during the first two sampling episodes.

2. Analysis of volatile organic pollutants not on the List of Analytes was conducted on a site-specific basis after an assessment of the pre-sampling site visit information (i.e., information on solvent use by the pharmaceutical manufacturing facility). Pharmaceutical manufacturing industry wastewaters were characterized for additional analytes such as: ethanol, ethyl acetate, formaldehyde, isopropanol, isopropyl acetate, methanol, methyl formate, and petroleum naphtha.

During the sampling program, EPA gathered analytical data to characterize the wastewater from five direct dischargers and eight indirect dischargers. Treatment system performance data were gathered from three advanced biological treatment systems and two biological pretreatment systems. Treatment unit performance data documenting the performance of five steam stripping columns were gathered. The performance of one resin adsorption column and one cyanide destruction unit was also documented. Table 3-1 summarizes the types of facilities sampled and types of information collected.

Prior to each sampling episode, a presampling site visit was conducted to gather information on manufacturing operations, solvent usage, wastewater treatment systems, and possible sample point locations. Following each visit, a site visit report was prepared which documented the information gathered and provided recommendations regarding sample point locations. These site visit reports are included in the Record of this rulemaking.

A draft sampling plan was prepared before each sampling episode to document the procedures to be followed by the sampling crew during that episode. Prior to the sampling event, EPA sent the sampling plan to plant personnel for their review and comment. During the sampling episodes, sampling teams collected, preserved, and shipped the samples to an EPA-contracted laboratory according to established protocols defined in the sampling plan. EPA offered to split samples with facility personnel during all episodes.

Following each sampling episode, a sampling episode report was prepared to document facility manufacturing operations, sampling procedures followed, and analytical results obtained (including a QA/QC evaluation of these results), and also to provide a discussion of wastewater treatment plant operation and performance. Sampling plans and reports are also included in the Record of this rulemaking.

QA/QC evaluations of analytical data began at EPA's Sample Control Center (SCC) when the data were received from the contract laboratories. The raw data from the laboratories were reviewed for acceptability based on predefined data quality objectives specified in the respective analytical methods. The following objectives were reviewed:

- Sample completeness;
- Holding times;
- Calibration verification;
- Blanks;
- Matrix spikes;
- Matrix spike duplicates;
- Laboratory control samples; and
- ICP serial dilution.

After the above-mentioned criteria were reviewed by SCC, a data quality report was issued for each dataset. Datapoints deemed unacceptable by SCC were deleted from the dataset. Once the analytical data review was completed, a review was conducted to determine the following:

- The relative percent differences between split sample results;
- The ability to reproduce blind field duplicates; and
- Any significant deviations or upsets in process operations during the sampling event that may have impacted the results obtained.

Data not meeting QA/QC objectives with respect to blind field duplicates established by EPA for the analytical methods used were discussed in the respective sampling episode reports, and the impacted data were identified and deleted from the final database as appropriate.

3.2.4 Pharmaceutical Industry Questionnaires

The Pharmaceutical Manufacturing Industry Questionnaire distributed by EPA under authority of 308 of the Clean Water Act is a major source of data and information used in the development of effluent limitations guidelines and standards for the pharmaceutical manufacturing industry. This questionnaire requested information on:

- Pharmaceutical products and production processes;
- Chemical use and disposition;
- Wastewater treatment system design and operation parameters;

- Waste minimization/pollution prevention techniques;
- Wastewater characterization, including long-term self-monitoring data; and
- Financial and economic data for use in assessing economic impact and achievability of regulatory options.

EPA used a two-phase questionnaire approach to collect industry information including a screener questionnaire and a detailed questionnaire. The industry trade association PMA (now known as PhRMA) participated in the development of these questionnaires and both questionnaires were submitted to OMB for clearance. The screener questionnaire was distributed by EPA in May 1989 to 1,163 known or suspected pharmaceutical manufacturers. The screener questionnaire mailing list was developed after an extensive review of these sources:

- EPA current list of pharmaceutical manufacturers (respondents of the 308 Portfolio Survey in 1977 and 1979);
- List of pharmaceutical manufacturers maintained by Noyes Data Corporation (11);
- List of pharmaceutical manufacturers presented in the Physician's Desk Reference (12);
- List of pharmaceutical manufacturers presented in the Merck Index (13);
- List of facilities classified under SIC codes 2831, 2833, and 2834 in Dunn and Bradstreet's "Electronic Yellow Pages" (14);
- List of facilities classified under SIC codes 2831, 2833, and 2834 in Dunn and Bradstreet's World Marketing Directory (15);
- List of facilities classified under SIC codes 2831, 2833, and 2834 in the EPA Permit Compliance System (PCS);
- List of facilities classified: 1) as pharmaceutical manufacturers, or 2) under SIC codes 2831, 2833, and 2834 by state and/or regional wastewater permitting authorities; and
- List of pharmaceutical manufacturers published in the American Medical Association's Drug Evaluations.(16)

The screener questionnaire was designed to identify those facilities that could possibly be subject to the revised BPT, BAT, BCT, and PSES effluent limitations guidelines and standards. Detailed Questionnaires were then sent to pharmaceutical manufacturing facilities that were identified as: 1) direct dischargers of process wastewater involved in fermentation, natural extraction, chemical synthesis, or mixing, compounding, or formulating operations, or 2) indirect dischargers of process wastewater that potentially use solvents in the manufacturing process. Indirect dischargers that indicated in the screener that they use fermentation, extraction, or chemical synthesis process operations were assumed to potentially use solvents and were sent detailed questionnaires. In addition, the Detailed Questionnaire was sent to indirect dischargers utilizing mixing/compounding/formulating operations if the facility indicated in the screener that they used solvents in these operations. The Detailed Questionnaire was not sent to facilities reporting zero discharge or research only operations in the screener questionnaire.

EPA wanted to ensure that the questionnaire was designed to collect representative data from the industry in the form that the industry maintains the data. Therefore, specific pharmaceutical manufacturers, as well as their trade association (PMA), were involved in the development of the Detailed Questionnaire. The PMA was given copies of the original draft of the survey, as well as subsequent drafts that included significant revisions or modifications.

In 1989, nine plants (six PMA members and three non-PMA members) were sent the Detailed Questionnaire as part of the pretest program. However, one facility closed prior to receiving the questionnaire, and a second declined to participate in the pretest program. Industry comments from the remaining seven facilities were incorporated into the survey, and a revised version was prepared.

As required by the Paperwork Reduction Act, (44 U.S.C. 3501 et seq.), EPA submitted the Detailed Questionnaire to the Office of Management and Budget (OMB) for review, and published a notice in the Federal Register that the questionnaire was available for review and comment.(17) In August 1990, OMB granted clearance of the technical (Part A) and company-level financial information (Part B) of the Detailed Questionnaire. OMB denied clearance of questions asking for facility-specific economic information. Industry representatives argued that

the industry should not be required to submit such information because it was not readily available because of standard accounting practices used by the industry, was highly sensitive, and in any case was not useful in developing effluent limitations guidelines. The Agency considered facility-level financial data critical to the economic analysis, and following discussions, OMB approved Part B of the questionnaire. Respondents to Part B had the option of certifying certain conditions about the economic impacts that will result from costs incurred to comply with the effluent limitations guidelines and standards that EPA ultimately promulgates pursuant to this rulemaking. This facility impact certification, signed by an official of the owner company with sufficient decision-making authority for this certification to be legally binding, could be submitted to EPA in lieu of completing the facility-level financial data in the Detailed Questionnaire.

In September 1991, EPA sent the Detailed Questionnaire to 280 facilities. This group included all direct dischargers involved in fermentation, extraction, chemical synthesis, or mixing, compounding, or formulating operations, all indirect dischargers involved in fermentation, extraction, and chemical synthesis operations, and a statistical sampling of indirect discharging facilities conducting mixing, compounding, or formulating operations that used solvents in their pharmaceutical manufacturing operations.

Not all indirect dischargers that performed mixing, compounding, or formulating operations were sent a Detailed Questionnaire. EPA determined this was unnecessary because the production methods, wastewater volume and strength, and treatment operations used among this group of facilities were similar. EPA expected the variation in the questionnaire responses from this group of facilities to be very small based on the information from the screener questionnaire supplied by this group of facilities. Consequently, a randomly selected subset of mixing, compounding, or formulating facilities that used solvents was surveyed. The random sample was developed using a methodology that ensured that the Detailed Questionnaire was distributed to facilities within four plant size groups, based on number of employees.(18)

Of the 280 facilities sent the Detailed Questionnaire, 245 were not closed or exempted and were deemed eligible to respond. Of the remaining 35 plants, 12 were closed and 23 were exempted

from completing the questionnaire by EPA because they certified that they no longer manufactured pharmaceutical products and they had no plans to manufacture them in the future. EPA received responses from 244 of the 245 eligible facilities (a 99.6% response rate).

The Detailed Questionnaire was designed to gather data and information to develop revised BAT, BPT, and BCT effluent limitations guidelines and pretreatment standards (PSES, PSNS) intended to control priority and nonconventional volatile organic pollutants and any other conventional, priority and nonconventional pollutants of concern found in significant quantities (i.e., treatable concentrations). The Detailed Questionnaire gathered information on pharmaceutical production, chemical use and disposition, waste minimization and pollution prevention, wastewater generation, collection, and conservation, wastewater treatment, steam stripping, wastewater characteristics and economic and financial data.(19)

The Agency required product-specific information to better understand the industry discharge pattern for individual pollutants.

The on chemical use and disposition focused on a specific list of chemicals and compounds identified as associated with the pharmaceutical manufacturing industry. The specific list of 139 pollutants was created after review of the data and information sources then available to determine all priority and nonconventional pollutants that were known or suspected to be used in the manufacture of pharmaceuticals. The list of 139 included pollutants meeting at least one of the following criteria:

- Identified by the 1975 and/or 1985 the Office of Air Quality Planning and Standards (OAQPS) solvent use and disposition data as being discharged in pharmaceutical manufacturing industry wastewaters;
- Identified by the pharmaceutical product patent search as potentially being used in pharmaceutical manufacture;
- Detected in the wastewaters of the pharmaceutical manufacturing industry;
- Identified as a volatile organic pollutant contained on the DSS list of analytes;

- Identified as a volatile organic pollutant on the ITD List of Analytes; or
- Identified as a volatile organic pollutant that was present in pharmaceutical manufacturing industry wastewaters according to the TRI database.

The Agency used the information on chemical use and disposition to provide wastewater loading estimates for various pollutants and to evaluate individual chemical usage by pharmaceutical manufacturers. In addition, OAQPS evaluated the chemical emission information in support of its development of emission standards for hazardous air pollutants as required by the Clean Air Act. The Agency's Office of Pollution and Prevention (OPP) also evaluated the responses to determine the extent to which individual chemicals are recycled and reused. Pollution prevention information on the extent to which source reduction and recycling is practiced in the pharmaceutical industry has been incorporated into EPA's regulatory development efforts to identify pollution prevention practices which have the potential for success.

Responses to questions pertaining to wastewater generation and collection have been used by EPA to characterize wastewater generation by the industry and to develop appropriate plant-by-plant treatment costs for process wastewater. EPA has used the information on wastewater treatment present at pharmaceutical facilities to determine the basis for revised regulations and to develop regulatory option costs. The information about the design and operating characteristics of in-place technology was also used for establishing the technology basis of the regulatory options considered and for cost estimating purposes. In addition, the existing wastewater treatment information was used to estimate air emissions from the treatment of pharmaceutical manufacturing wastewaters.

The Agency realizes that steam stripping technology is being used by some pharmaceutical manufacturing facilities primarily to recover volatile organic compounds from wastewater. Consequently, the Agency solicited data on steam strippers to categorize as accurately as possible those units in place at pharmaceutical manufacturing plants to identify their design and operating parameters. The information provided on steam stripping has been used by EPA to evaluate

what constitutes BAT level steam stripping under the Clean Water Act, as well as MACT level steam stripping under the Clean Air Act.

Conventional wastewater characteristics, including long-term performance averages supported by individual data points, were used by the Agency to develop revised limitations and standards for conventional pollutants. The Agency requested organics data to confirm the presence of priority and nonconventional pollutants that were expected in discharges of pharmaceutical manufacturing processes and to provide a source of treatment performance data for EPA's regulatory development.

The Agency used economic and financial data collected with the questionnaire to evaluate the economic impact of proposed regulations on the industry and to determine whether PSNS/NSPS would create a barrier to entry for facilities wishing to enter into pharmaceutical manufacturing.

3.2.5 Industry-Supplied Data

Facilities that discharge wastewater directly to surface waters of the United States must have a National Pollutant Discharge Elimination System (NPDES) permit, which establishes effluent limitations for various pollutants and requires the plants to monitor the levels of such pollutants in their effluent (see 402 CWA, as amended, implemented by 40 CFR 121-125). POTWs also require facilities to monitor pollutant levels in their wastewater prior to discharge. Additionally, some facilities with treatment systems monitor intermediate points within the systems to check the efficiency of the unit. EPA requested that copies of the effluent monitoring data collected by plants in 1990 be submitted as part of the response to the Detailed Questionnaire. Data from treatment systems using the technologies described in 7 were entered into a database to establish the treatment performance of those technologies.

Some facilities and POTWs provided additional data in response to a specific request by EPA or as follow-up to the data provided in their questionnaire or data gathered during a sampling episode. These additional data submittals are explained in the following paragraphs.

In addition to the data submitted by Plant 30701 in their Detailed Questionnaire response, an additional 20 months of self-monitoring data were submitted to EPA from that direct discharger. The data were submitted by plant personnel because they felt that the pharmaceutical production reported in their response to the 1988 pre-test questionnaire was below normal levels. EPA statisticians analyzed the original questionnaire data and the additional 20 months of data. Since no significant differences between the datasets were found, the two datasets were combined, and used in the wastewater characterization of the industry.

In 1991, under authority of 308 of the Clean Water Act, EPA requested that Facility 30542 provide six months' worth of data documenting the performance of their cyanide destruction unit. Personnel from Plant 30542 collected and analyzed influent and effluent samples from their batch cyanide destruction (hydrogen peroxide oxidation) unit for six months. These data were submitted to EPA in November of 1991, and were used in the evaluation of effluent limitations guidelines and standards for cyanide based on cyanide destruction technology.

In March of 1989, EPA conducted concurrent sampling episodes at Facility 30977 and the POTW to which they discharged. After those sampling episodes, POTW personnel provided EPA with additional priority and nonconventional pollutant data as well as data collected characterizing the wastewater discharged from Facility 30977. These data were ultimately used for wastewater characterization of the pharmaceutical manufacturing industry.

When personnel from Facility 30832 indicated that the data collected by EPA during a sampling episode in July of 1986 were not representative of their typical effluent, EPA requested from the POTW to which that facility discharged, copies of long-term data collected over a 12-month period. The data submitted by the POTW were added to EPA's database, and have been used to help characterize pharmaceutical manufacturing wastewaters. Based on comparison to the long-term data, the data collected during the sampling episode were judged not to be representative of typical operations at Facility 30832, and were not used in the development of effluent limitation guidelines and standards.

3.2.6 Air Stripping, Steam Stripping, and Distillation Pilot Studies

Between October and December 1991, bench-scale and pilot-scale tests were conducted by EPA to study: 1) air stripping technology for ammonia removal from pharmaceutical manufacturing plant final effluent, and 2) steam stripping technology for volatile organic pollutant removal from pharmaceutical manufacturing plant process wastewaters.

The air stripping and steam stripping pilot studies were conducted at a pharmaceutical manufacturing facility with fermentation, chemical synthesis, formulation, and research operations. The total facility effluent was used as the feed to the pilot-scale air stripping study. The objective of this study was to examine the feasibility of obtaining at least 90% ammonia removal using air stripping technology. The wastewater characterization and treatment performance from the pilot-scale study are described in more detail in Sections 5 and 8, respectively.

For the steam stripping study, three wastewater streams from the facility were selected for analysis. The objective of this study was to achieve the lowest practical concentrations of volatile organic contaminants in the treated effluent, and to collect sufficient data to document these concentrations. On-site pilot-scale testing was conducted for two of the three streams. Bench-scale testing of the third wastewater was conducted at a contractor's laboratory because there was insufficient wastewater volume available at the facility to run the steam stripping test on a pilot-scale basis. The wastewater characterization and treatment performance from the steam stripping study are described in more detail in Sections 5 and 8, respectively.

In September 1993, EPA conducted an on-site treatment performance study using a pharmaceutical manufacturing facility's existing distillation column that treated wastewaters containing methanol. The objective of the study was to define operating parameters which resulted in optimum removal of methanol and compounds with similar volatility from wastewater and to collect sufficient data to document this removal. Waste characterization and treatment performance of the distillation study are discussed in Sections 5 and 8, respectively.

3.2.7 Patent Reviews

To better characterize volatile organic pollutant usage in the pharmaceutical manufacturing industry, EPA reviewed all patents identified for the approximately 1,300 pharmaceutical active ingredients identified as being manufactured. In 1987 the patents were reviewed for solvents on the ITD List of Compounds. The patents were reviewed again in 1991 to identify all solvents potentially used by the industry (not just those on the ITD List of Compounds). These patent reviews provided information regarding which volatile organic pollutants were most likely used in the manufacture of pharmaceutical products, and identified the plants at which the volatile organic pollutants were being used. EPA used patent search information to support the development of the List of Pollutants analyzed for sampling efforts and for questionnaire development.

3.2.8 POTW Survey

In 1993 EPA surveyed nine POTWs to investigate the effect that indirect discharging pharmaceutical manufacturing facilities had on the POTWs that received the wastewater. This survey contained questions about local limits or special conditions which apply to pharmaceutical manufacturing facilities and volatile or semivolatile organics which caused problems for POTWs. The POTWs were also asked to explain problems connected with discharges from pharmaceutical manufacturing operations which they felt needed to be addressed in national regulations, and to supply other information regarding pharmaceutical manufacturing facility discharges within the sewer district that bears on the need for pretreatment standards.

Substantive responses were received from six of the surveyed POTWs. The responding POTWs provided EPA with a list of the pollutants frequently found in their wastewater, details of problems that result when wastewaters containing slug loads of pollutants are discharged, comments on the structure of PSES, and monitoring requirements which would be helpful to POTWs. The detailed responses to the POTW survey are included in the Record for this rulemaking.

3.2.9 Toxic Release Inventory (TRI) Data

Facilities which manufacture or use in their process at least 25,000 pounds of a listed toxic chemical must submit the Toxic Chemical Release Inventory (TRI) Reporting Form as required by 313 of the Emergency Planning and Community Right-to-Know Act. This form, known as Form R, provides the public with information on the releases of listed toxic chemicals in their communities and provides EPA with information to determine the need for future regulations.(20) The quantities of both routine and accidental releases of listed toxic chemicals must be reported, as well as the maximum amount of the listed toxic chemical on site during the calendar year and the amount contained in wastes transferred off site. The Agency reviewed the information provided by the TRIs for the years 1987 through 1990 and for 1994 to assist in characterizing the chemical use and wastewater discharges from the industry, and to investigate current trends in chemical use and disposition in the pharmaceutical manufacturing industry.

3.2.10 Industry Data in Response to Proposed Rulemaking

In response to the proposed rulemaking published on May 2, 1995, EPA has acquired a significant amount of additional data and information from the industry. The new data submitted include: 1) Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS) data for advanced biological treatment systems; 2) data on ammonia nitrification in advanced biological treatment systems; 3) advanced biological treatment systems data for organic pollutants; 4) steam stripping performance data for volatile organic pollutants; and 5) technology performance data for treatment of cyanide. Below are summaries of each type of new data provided by industry.

Advanced Biological Treatment Data (Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Ammonia)

Additional BOD_5, COD, and TSS data were submitted with comments on the proposed effluent limitations guidelines and standards from five facilities. The data from three of the facilities represents additional years of data that supplement the 1990 year data that were previously part of

the technology performance database for advanced biological treatment. Data from one other facility represents a new source of BOD_5, COD, TSS performance data which was also added to the advanced biological treatment technology performance database. Data from the fifth facility included only one data pair that was not included in technology performance database. A discussion of the review of these new data and the evaluation of whether to include them in the technology performance database is presented in 8.3.

Nitrification in Advanced Biological Treatment Data for Ammonia.

Performance data on ammonia nitrification from one facility were used as the basis of ammonia limitations at proposal. This facility provided additional ammonia data for a multi-year period. Three other facilities also submitted ammonia nitrification data in response to the proposed rulemaking. The other new ammonia data from biological treatment have been added to the existing ammonia database.

Advanced Biological Treatment Organics Data

New biological treatment performance data for organic pollutants were submitted with comments on the May 2, 1995 proposal by six facilities. Four of these facilities represented performance of advanced biological treatment.

Steam Stripping Performance Data

New data representing the performance of steam stripping technology in removing volatile organic pollutants were submitted with comments on the May 2, 1995 proposal by three facilities. The additional data reflect treatment by four stream strippers of 23 of the pollutants for which standards were proposed. In response to the comments on the May 2, 1995 proposal related to steam stripping of volatile organics, EPA has incorporated the newly submitted data with the data used at proposal and revised its pretreatment standards for the various parameters.

Technology Performance Data for Cyanide

EPA received additional cyanide treatment performance data from three facilities. Two of these facilities use alkaline chlorination treatment and one of these facilities uses hydrolysis treatment. For one facility, the new data include the individual effluent data points corresponding to the facility's 308 Questionnaire average 1990 effluent cyanide concentration. For the second facility, the new data include: 1) part of the raw 1990 data used in developing the facility's 308 Questionnaire average effluent cyanide concentration (the other part of the raw 1990 data used in the reported averages could not be located by the plant) and 2) additional 1994 cyanide destruction data. For the third facility, the new data include 1994 cyanide destruction data. In response to the May 2, 1995 proposal comments related to cyanide, EPA has incorporated the newly submitted data with the data used at proposal in its evaluation of cyanide.

3.2.11 Site Visits

Since the May 2, 1995, proposal, EPA has performed site visits at five facilities and three POTW's. The site visits were performed at four pharmaceutical manufacturers which discharge to a POTW and one pharmaceutical manufacturer which discharges directly to a surface water body. The respective POTW's were visited to collect information on the issues that affect indirect dischargers. A summary of the sites visited and the types of information collected are shown below:

Site	Date of Visit	Information Collected			
		WW Treatment	Mfg. Operations	Research/Pilot-Plant Operations	Indirects-Regulatory Issues
Abbott Laboratories	4/12/96 - 4/14/96	X	X	X	X
North Shore Sanitary District	4/12/96 - 4/14/96	X			X
Pfizer, Inc.	8/20/96 - 8/21/96	X	X	X	
Ganes Chemicals	11/19/96 + 11/22/96	X	X		X
Bergen County Utilities Authority	11/19/96 + 11/22/96	X			X
ISP Van Dyk	11/20/96 - 11/21/96	X	X		X
Penick Corp.	11/20/96 - 11/21/96	X	X		X
Passaic Valley Sewerage Commissioners	11/20/96 - 11/21/96	X			X

3.2.12 Barceloneta Regional Wastewater Treatment Plant (BRWTP) Sampling Effort

On May 24, 1996, an engineering site visit was conducted at the Barceloneta Regional Wastewater Treatment Plant (BRWTP) located in Barceloneta, Puerto Rico in preparation for sampling at this plant. A sampling episode was performed at the BRWTP from August 10 through August 16, 1996. The purpose of the sampling trip was to characterize the mass balance of specific organics around the primary treatment units and to characterize the treatment of COD and ammonia across the entire treatment plant.

A portion of the sampling episode, conducted jointly with representatives of PhRMA, also focused on determining the aerobic and anoxic biodegradation rates for the seven pollutants of concern in the primary treatment units. The quantity of mass reduction attributed to biodegration can be determined from the aerobic and anoxic biodegradation rates. The aerobic and anoxic rates were determined through lab studies conducted on samples taken during the sampling episode. The biodegradation rates were determined for each of the seven pollutants of concern across the grit chamber and the primary clarifier. A sampling episode by PhRMA was conducted in April 1997 to supplement the August 1996 anoxic biodegradation data. An additional sampling episode by PhRMA was conducted in August 1997 to enhance the mass balance data for alcohol losses through the primary clarifier.

3.2.13 Industry Data in Response to Notice of Availability

Lastly, since the August 8, 1997 Notice of Availability (NOA), EPA has received additional data from six facilities regarding nitrification/denitrification. Additional data were submitted with comments on the NOA. These data included a pilot-plant study on nitrification, data on two-stage nitrification from two facilities, and data on single-stage nitrification from two facilities. EPA also received operating data from one facility on a nitrification feasibility study. Data from influent and effluent sampling points as well as design data and operating specifications were provided.

EPA has also received data from three facilities regarding conventional pollutant treatment. Additional data were submitted in addition to comments on the NOA. The data from these facilities are supplemental to data previously provided. Data from influent and effluent sampling points were provided.

3.3 Overview of the Industry

This provides an overview of the pharmaceutical manufacturing industry by presenting general information on the geographical locations of facilities, Standard Industrial Classification (SIC) code distribution, value of shipments and number of employees in the industry, and age of facilities.

3.3.1 Geographical Location of Manufacturing Facilities

According to the 1989 Pharmaceutical Screener Questionnaire and the 1990 Detailed Questionnaire, there are 304 pharmaceutical facilities with solvent use which discharge wastewater in 34 states and the Commonwealth of Puerto Rico. This number includes the 244 facilities which completed the Detailed Questionnaire and the 60 indirect dischargers with mixing, compounding, or formulating operations which were not sent the Detailed Questionnaire. The majority of pharmaceutical manufacturing facilities are located in the eastern half of the United States, with the highest concentration of facilities in New Jersey, New York, Pennsylvania, and Puerto Rico. A map of the United States with the number of pharmaceutical manufacturing facilities in each state (or commonwealth) is presented in Figure 3-1. Table 3-2 presents the number of pharmaceutical manufacturing facilities by state and EPA region, along with the percentage of total facilities in each state and EPA region, and the total number of employees in each EPA region.

3.3.2 SIC Code Distribution

Standard Industrial Classification (SIC) codes, established by the U.S. Department of Commerce, are classifications of commercial and industrial establishments by the type of activity in which

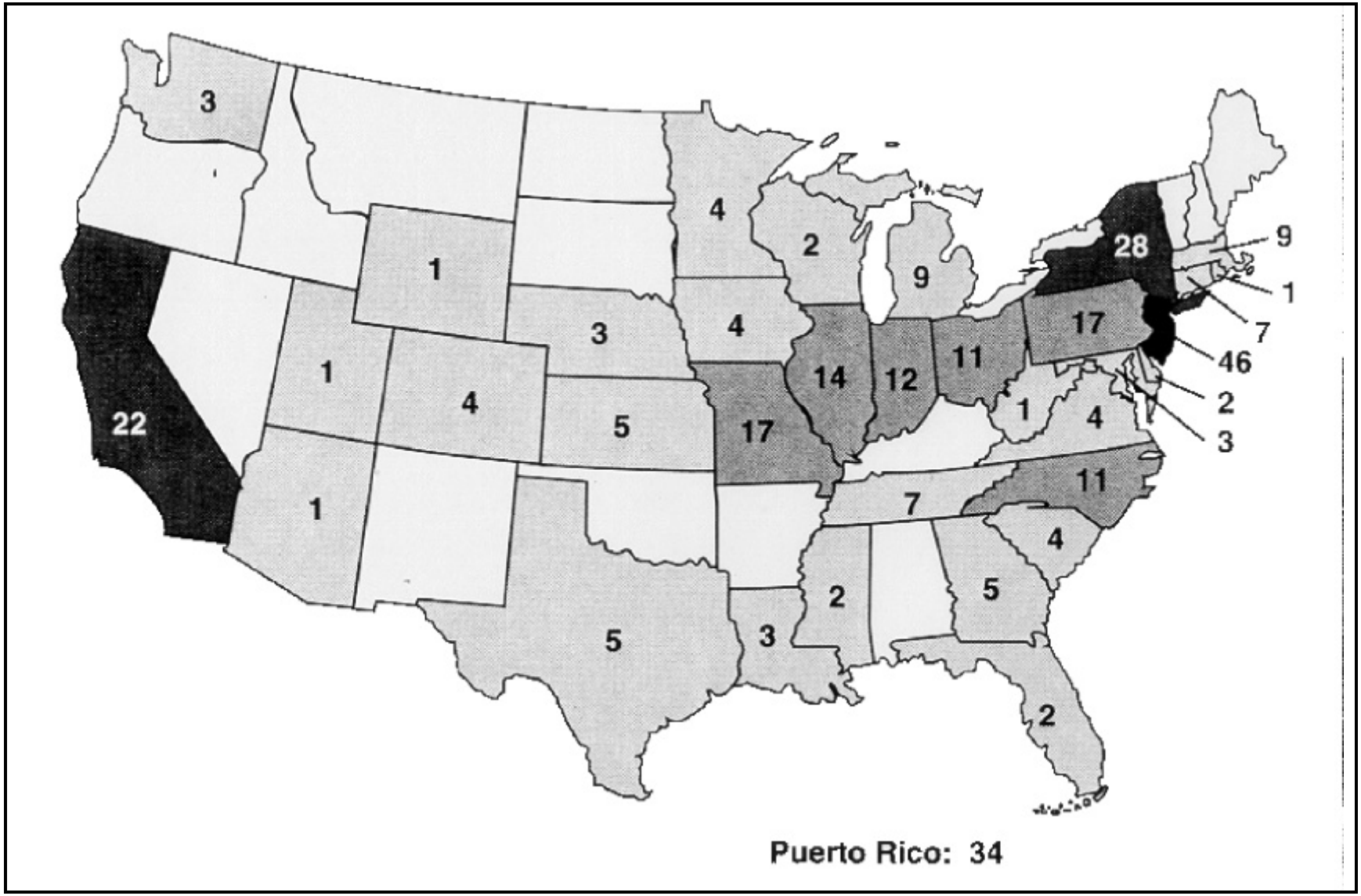

Figure 3-1. Location of Operating Pharmaceutical Facilities by State (304 Facilities)

they engage. The primary purpose of SIC codes is to classify the manufacturing industries for the collection of economic data. An operating establishment is assigned an industry code on the basis of its primary activity, which is determined by its principal product or group of products. The principal product of a manufacturing establishment is determined by the value of production. Pharmaceutical manufacturing facilities generally cover SIC codes 2833, 2834, and/or 2836 (formerly 2831). Other products included under the definition of pharmaceutical manufacturing facilities are discussed in 3.4.

3.3.3 Value of Shipments and Number of Employees in the Industry

The Department of Commerce provided information on the value of shipments and the number of total employees in the pharmaceutical manufacturing industry by SIC code.(21) In 1991, the value of product shipments for SIC codes 2833, 2834, and 2836 were $6.25 billion, $37.4 billion, and $2.84 billion, respectively. In 1991, the total number of employees in the pharmaceutical industry for SIC codes 2833, 2834, and 2836 were 12,500, 129,100, and 12,100, respectively.

3.3.4 Age of Facilities

Table 3-3 presents a distribution of pharmaceutical manufacturing facilities by decade when operations began at the facility and when pharmaceutical manufacturing operations began at the facility. The majority of facilities which currently manufacture pharmaceuticals began such operations after 1960. The oldest reported pharmaceutical manufacturing operation began in 1879, while the most recent operation reported began in 1991.

3.4 Pharmaceutical Manufacturing Processes

The pharmaceutical manufacturing industry encompasses the manufacture, extraction, processing, purification, and packaging of chemical materials to be used as medication for humans and animals. For this rulemaking, EPA has defined the pharmaceutical manufacturing industry to include the manufacture of any of the following products:

- Biological products covered by the U.S. Department of Commerce, Bureau of the Census Standard Industrial Classification (SIC) Code No. 2836, with the exception of diagnostic substances. (Products covered by SIC Code No. 2836 were formerly covered under the 1977 SIC Code No. 2831.)

- Medicinal chemicals and botanical products covered by SIC Code No. 2833.

- Pharmaceutical products covered by SIC Code No. 2834.

- All fermentation, biological and natural extraction, chemical synthesis and formulation products considered to be pharmaceutically active ingredients by the Food and Drug Administration that are not covered by SIC Code Nos. 2833, 2834, or 2836.

- Multiple end-use products derived from pharmaceutical manufacturing operations (e.g., components of formulations, intermediates, or final products, provided that the primary use of the product is intended for pharmaceutical purposes).

- Products not covered by SIC Code Nos. 2833, 2834, and 2836 or other categorical limitations and standards if they are manufactured by a pharmaceutical manufacturer by processes that generate wastewaters that in turn closely correspond to those of pharmaceutical products. (An example of such a product is citric acid.)

- Cosmetic preparations covered by SIC Code No. 2844 that contain pharmaceutically active ingredients or ingredients intended for treatment of some skin condition. (This group of preparations does not include products such as lipsticks or perfumes that serve to enhance appearance or to provide a pleasing odor, but do not provide skin care. In general, this also excludes deodorants, manicure preparations, shaving preparations and non-medicated shampoos that do not function primarily as a skin treatment.)

Products or activities specifically excluded from the pharmaceutical manufacturing category are:

- Surgical and medical instruments and apparatus reported under SIC Code No. 3841.

- Orthopedic, prosthetic, and surgical appliances and supplies reported under SIC Code No. 3842.

- Dental equipment and supplies reported under SIC Code No. 3843.

- Medical laboratories services reported under SIC Code No. 8071.
- Dental laboratories services reported under SIC Code No. 8072.
- Outpatient care facility services reported under SIC Code No. 8081.
- Health and allied services reported under SIC Code No. 8091, and not classified elsewhere.
- Diagnostic devices other than those reported under SIC Code No. 3841.
- Animal feeds that include pharmaceutical active ingredients such as vitamins and antibiotics, where the major portion of the product is non-pharmaceutical, and the resulting process wastewater is not characteristic of process wastewater from the manufacture of pharmaceutical products.
- Foods and beverage products fortified with vitamins or other pharmaceutical active ingredients, where the major portion of the product is non-pharmaceutical, and the resulting process wastewater is not characteristic of process wastewater from the manufacture of pharmaceutical products.
- Pharmaceutical products and intermediates subject to the provisions of 40 CFR part 414, provided their manufacture results in less than 50 percent of the total flow of process wastewater that is regulated by 40 CFR part 414 at the facility.

3.4.1 Types of Pharmaceutical Processes and Products

There are four general types of manufacturing processes used by pharmaceutical manufacturing facilities. The four process types are: fermentation, biological and natural extraction, chemical synthesis, and mixing, compounding, or formulating. Figure 3-2 presents a bar graph of the number of facilities which use each type of manufacturing process. Table 3-4 presents examples of typical products from each type of manufacturing process.

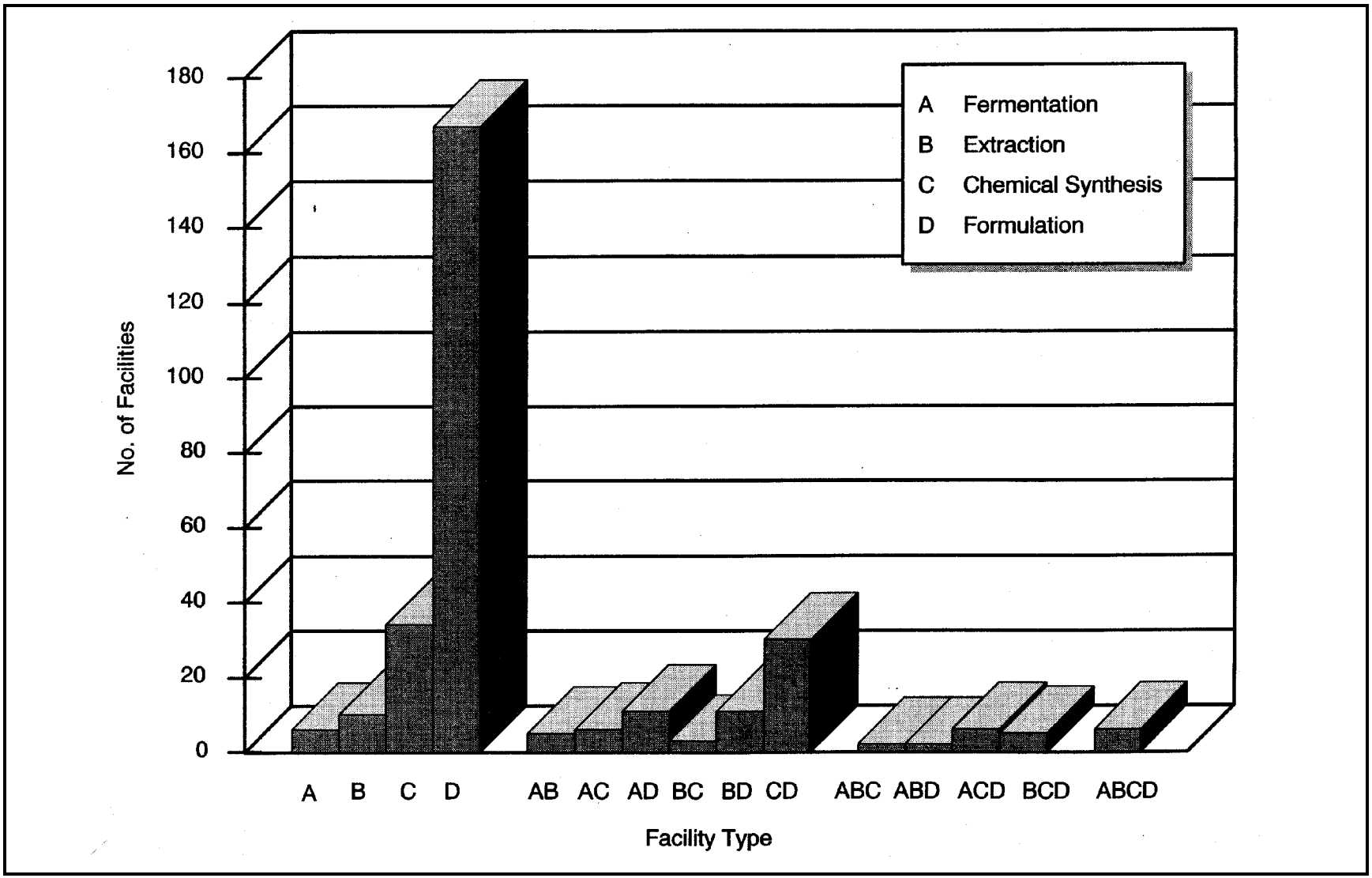

Figure 3-2. Number of Facilities in Each Combination of Pharmaceutical Manufacturing Process Types

3.4.2 General Process Descriptions

General process descriptions for each type of process operation are described in the following subsections. The specific processing steps on individual process lines may differ from these general descriptions as process operations will be tailored to the specific product being produced.

3.4.2.1 Fermentation

Most antibiotics and steroids are produced by the fermentation process, which involves three basic steps: inoculum and seed preparation, fermentation, and product recovery. Production of a fermentation pharmaceutical begins in the seed preparation step with spores from the plant master stock. The spores are activated with water, nutrients, and warmth; they are then propagated through the use of agar plates, test tubes, and flasks until enough mass is produced for transfer to the seed tank. In some fermentations, a single seed tank may provide inoculum for several fermentations. In this type of operation, the seed tank is never emptied completely, so the remaining seed serves as the inoculum for the next batch. The seed tank is emptied, sterilized, and reinoculated only when contamination occurs.

Fermentation is conventionally a large-scale batch process. The fermentation step begins with a water wash and steam sterilization of the fermenter vessel. Sterilized nutrient raw materials in water are then charged to the fermenter. Microorganisms grown from seed to aid in the fermentation process are transferred to the fermenter from the seed tank and fermentation begins. During fermentation, air is sparged into the batch and temperature is carefully controlled. After a period that may last from 12 hours to one week, the fermenter batch whole broth is ready for filtration. Filtration removes mycelia (i.e., remains of the microorganisms), leaving the filtered aqueous broth containing product and residual nutrients that are ready to enter the product recovery phase.

There are three common methods of product recovery: solvent extraction, direct precipitation, and ion exchange or adsorption. Solvent extraction is a recovery process in which an organic solvent is used to remove the pharmaceutical product from the aqueous broth and form a more

concentrated solution. With subsequent extractions, the product is separated from any contaminants. Further removal of the product from the solvent can be done by either precipitation, solvent evaporation, or further extraction processes. Normally, solvents used for product recovery are recovered and reused. However, small portions left in the aqueous phase during the solvent "cut" can appear in the plant's wastewater stream. Based on information from the Detailed Questionnaire, the solvents most often used in fermentation operations are acetone, methanol, isopropanol, ethanol, amyl alcohol, and MIBK. Table 3-5 lists solvents used in fermentation operations.

Direct precipitation using heavy metal precipitating agents is another common method of product recovery. The method involves first precipitating the product as a metal salt from the aqueous broth, then filtering the broth, and finally extracting the product from the solid residues. Copper and zinc are priority pollutant metals known to be used in the precipitation process.(2)

Ion exchange or adsorption involves removal of the product from the broth, using solid materials such as ion exchange resin, adsorptive resin, or activated carbon. The product is recovered from the solid phase using a solvent, then recovered from the solvent by evaporation.

Occasionally, a fermentation batch becomes infested with a phage, a virus that attacks microorganisms necessary to the fermentation process. Phage infection is rare in a well-operated plant, but when it occurs, the plant may discharge very large amounts of wastewater in a short period of time because of the decontamination process. Typically, the infested batch is discharged early, and its nutrient pollutant concentration is higher than that of spent broth.

Steam is the major sterilizing medium for most equipment. However, detergents and disinfectants, to the extent that they are used, can contribute to waste loads. An example of a commonly used chemical disinfectant is phenol, a priority pollutant. Air pollution control equipment sometimes installed to clean fermentation waste off-gas is another wastewater source. The air and gas vented from the fermenters usually contain odoriferous substances (e.g., oxides of nitrogen and sulfur) and large quantities of carbon dioxide. Treatment is often necessary to deodorize the gas before release to the atmosphere. Some plants use incineration methods; others

use liquid scrubbers. The blowdown from scrubbers may contain absorbed chemicals, soluble organic compounds, and insoluble organic oils and waxes.

Spent fermentation broth contributes pollutants to wastewater from the food materials contained in the broth, such as sugars, starches, protein, nitrogen, phosphate, and other nutrients. Fermentation wastes are very amenable to biological treatment. The spent broth can be satisfactorily handled by biological treatment systems in a concentrated form. Equalizing the broth prior to treatment helps avoid system upsets that may occur if the biota receive too high feed concentrations at one time.

Data from the Detailed Questionnaire generally show that process wastewater from fermentation plants is characterized by high BOD_5, COD, and TSS concentrations; relatively large flows; and a pH range of approximately 4.0 to 8.0.

3.4.2.2 Biological and Natural Extraction

Many materials used as pharmaceuticals are derived from such natural sources as the roots and leaves of plants, animal glands, and parasitic fungi. These products have numerous and diverse pharmaceutical applications, ranging from tranquilizers and allergy-relief medications to insulin and morphine. Also included in this group is blood fractionation, which involves the production of plasma and its derivatives.

Despite their diversity, all extractive pharmaceuticals have a common characteristic: they are too complex to synthesize commercially. They are either very large molecules, and/or their synthesis results in the production of several stereoisomers, only one of which has pharmacological value. Extraction is an expensive manufacturing process which requires collecting and processing large volumes of specialized plant or animal matter to produce small quantities of products. Facilities utilize extraction when there are no other reasonable alternatives for producing a desired active ingredient.

The extraction process consists of a series of operating steps beginning with the processing of a large quantity of natural or biological material containing the desired active ingredient. After almost every step, the volume of material being handled is reduced significantly. In some processes, reductions may be in orders of magnitude, and complex final purification operations may be conducted on quantities of materials only a few thousandths of the volume handled in earlier steps. Neither continuous processing methods nor conventional batch methods are suitable for extraction processing. Therefore, a unique assembly-line, small-scale batch processing method is used. Material is transported in portable containers through the plant in 75- to 100-gallon batches. A continuous line of containers is sent past a series of operating stations. At each station, operators perform specific tasks on each batch in turn. As the volume of material being handled decreases, individual batches are continually combined to maintain reasonable operating volumes, and the line moves more slowly. When the volume is reduced to a very small quantity, the containers also become smaller, with laboratory-size equipment used in many cases. An extraction plant may produce one product for a few weeks; then, by changing the logistical movement of containers and redefining tasks to be conducted at each station, the plant can convert to the manufacture of a different product.

Residual wastes from an extraction plant essentially will be equal to the weight of raw material, since the active ingredients extracted are generally present in the raw materials at very low levels. Solid wastes are the greatest source of the pollutant load; however, solvents used in the processing steps can cause both air and water pollution. Detergents and disinfectants used in equipment cleaning operations are normally found in the wastewater.

Priority pollutants, including methylene chloride, toluene, chloroform, 1,2-dichloroethane, and phenol, were identified as being used in the manufacturing of extractive pharmaceuticals in the Detailed Questionnaire. The cations of lead and zinc are known to be used as precipitating agents. Phenol was identified as a disinfecting chemical. The other priority pollutants found were used as processing solvents. The Detailed Questionnaire identified nonconventional pollutants most often used in the extractive manufacturing process as ethanol, methanol, n-amyl acetate, isopropanol, and acetone. These nonconventional pollutants may be used as processing solvents. Table 3-6 lists solvents used in biological or natural extraction operations.

Solvents are used in two ways in extraction operations. Some solvents are used to remove fats and oils that would contaminate the products. These "defatting" extractions use an organic liquid that dissolves the fat but not the product material. Solvents are also used to extract the product itself. For example, when plant alkaloids are treated with a base, they become soluble in such selected organic solvents as benzene, chloroform, and 1,2-dichloroethane.

Ammonia is used in many extraction operations because it is necessary to control the pH of water solutions from both animal and plant sources to separate valuable components from waste materials. Ammonium salts are used as buffering chemicals, and aqueous or anhydrous ammonia is used as an alkalinizing reagent. The high degree of water solubility of ammonium salts prevents unwanted precipitation of salt, and they do not react chemically with animal or plant tissue. Such basic materials as hydroxides and carbonates of alkali metals do not have these advantages.

The principal sources of wastewater from biological/natural extraction operations are: 1) spent raw materials (e.g., waste plasma fractions, spent media broth, plant residues); 2) floor and equipment wash water; 3) chemical wastes (e.g., spent solvents); and 4) cleanup of spills.

Wastewater from extraction plants is generally characterized by low BOD_5, COD, and TSS concentrations; small flows; and pH values of approximately 6.0 to 8.0.

3.4.2.3 Chemical Synthesis

Most of the active ingredients marketed and sold as drugs are manufactured by chemical synthesis. Chemical synthesis is the process of manufacturing pharmaceuticals using organic and inorganic chemical reactions. Since most of these compounds are produced in batch operations, the conventional batch reaction vessel is the major piece of equipment used on the process line.

The reaction vessel is one of the most standardized equipment designs in the industry. Generally, it is made of either stainless steel or glass-lined carbon-steel, and it contains a carbon-steel outer shell suitable for either cooling water or steam. Inside the vessel is a motor-driven agitator and a

baffle. Vessels of this type are made in many different sizes, with capacities ranging from 0.02 to 11.0 m^3 or more.

The basic vessels may be fitted with different attachments depending on the process needs of the product to be manufactured. Baffles usually contain sensors to measure the temperature of the reactor contents. Dip tubes may be used to introduce reagents into the vessels below the liquid surface. The vessel's agitators may be powered by two-speed motors or by variable-speed motor drives. The reactor may be mounted on load cells to accurately weigh the reactor contents. The batch reactors are typically installed with only the top heads extending above the plant operating floor to provide the operator with easy access for loading and cleaning. Also, one of the top nozzles may be fitted with a floodlight and another with a glass cover to enable an operator to observe the reactor contents.

The reactors can be modified for additional uses. By using heating or refrigeration devices, the chemicals may be boiled or chilled in them, according to process needs. By adding reflux condensation equipment, the vessel may perform complete reflux operations (i.e., recycling of condensed vapors). The vessels can also become evaporators if vacuum is applied. The reactors may also be used to perform solvent extraction operations and, by operating the agitator at a slow speed, the vessels can serve as crystallizers.

Synthetic pharmaceutical manufacture consists of using one or more of these reactor vessels to perform, in a step-by-step fashion, the various operations necessary to make the product. Following a definite recipe, the operator (or, increasingly, a programmed computer) adds reagents; increases or decreases the flow rate of cooling water, chilled water, or steam; and starts and stops pumps which transfer the reactor contents to another vessel. At appropriate steps in the process, solutions are pumped either through filters or centrifuges, or into solvent recovery headers or waste sewers.

The reactor vessels with an assembly of auxiliary equipment are usually arranged into independent process units, which are suitable for the complete or partial manufacture of many different pharmaceutical compounds. Only with the highest volume products is the process unit

"dedicated" to manufacturing only one product. Large pharmaceutical plants may have many such units, while smaller plants may have only one or two.

Each pharmaceutical product is usually manufactured in a "campaign," in which one or more process units are used for a few weeks or months to manufacture enough compound to satisfy the projected sales demand. Campaigns are usually tightly scheduled, with detailed coordination extending from procurement of raw materials to packaging and labeling of the product. For a variable period of time, a process unit actively manufactures a specific compound. At the end of the campaign for one product, another is scheduled to follow. After equipment cleaning, the same equipment is then used to make a completely different product, using different raw materials, executing a different recipe, and creating different wastes.

A variety of priority pollutants are used as reaction and purification solvents during chemical synthesis. According to the Detailed Questionnaire, priority pollutants used by facilities during the chemical synthesis process include benzene, chlorobenzene, chloroform, chloromethane, o-dichlorobenzene, 1,2-dichloroethane, methylene chloride, phenol, toluene, and cyanide.

The Detailed Questionnaire identified the top five nonconventional pollutants associated with chemical synthesis as methanol, acetone, isopropanol, ethyl acetate, and ethanol. Six-member ring compounds, such as xylene, pyridine, and toluene, are also widely used organic solvents because they are stable compounds that do not easily take part in chemical reactions. These compounds are used either in the manufacture of synthesized pharmaceuticals or are produced as the result of unwanted side reactions. Table 3-7 lists solvents used in chemical synthesis operations.

Solvents are used in chemical synthesis processes to dissolve gaseous, solid, or viscous reactants in order to bring all the reactants into close molecular proximity. Solvents also serve to transmit heat to or from the reacting molecules. By physically separating molecules from each other, solvents slow down some reactions that would otherwise take place too rapidly, resulting in unwanted side reactions and excessive temperature increases.

Some solvents are also used to control the reaction temperature. It is common practice in a batch-type synthesis to select a solvent which is compatible with the reaction and which has a boiling point the same as the desired reaction temperature. Heat is then applied to the reaction mass at a rate sufficient to keep the mixture boiling continuously. Vapors that rise from the reaction vessel are condensed, and the liquefied solvent is allowed to drain back into the reaction vessel. This refluxing prevents both overheating and overcooling of the reactor contents, and can automatically compensate for variations in the rate of release or absorption of chemical energy.

Many plants operate solvent recovery units that purify contaminated solvents for reuse. These units usually contain distillation columns, and may also include solvent/solvent extraction operations in which a second solvent is used to separate impurities. These operations may result in aqueous wastes that contain residues fully or partially saturated with residual solvent. Wastewater is generally produced with each chemical modification that requires filling and emptying the batch reactors. This wastewater can contain unreacted raw materials, as well as some solvents, along with a large number of compounds that differ due to the varied chemical reactions performed (e.g., nitration, amination, halogenation, sulfonation, alkylation). Chemical synthesis effluent generally has a high BOD_5 and COD waste load. The pollutants in chemical synthesis wastewater vary with respect to toxicity and biodegradability. The production steps may generate acids, bases, cyanides, metals, and other pollutants, while the waste process solutions and vessel wash water may contain residual organic solvents. Occasionally, chemical synthesis wastewater is incompatible with biological treatment systems because it is too concentrated or too toxic for the biomass in the treatment system. Thus, it may be necessary to equalize and/or chemically pretreat some chemical synthesis wastewater prior to biological treatment.

Primary sources of wastewater from chemical synthesis operations are: 1) process wastes such as spent solvents, filtrates, and concentrates; 2) floor and equipment wash water; 3) pump seal water; 4) wet scrubber wastewater; and 5) spills. Wastewater from chemical synthesis plants can be characterized as having high BOD_5, COD, and TSS concentrations; large flows; and extremely variable pH values, ranging from 1.0 to 11.0.

3.4.2.4 Mixing, Compounding, or Formulating

Pharmaceutically active ingredients are generally produced by batch processes in bulk form and must be converted to dosage form for consumer use. Common dosage forms for the consumer market are tablets, capsules, liquids, and ointments. In addition, active ingredients can also be incorporated into patches and time release capsules.

Tablets are formed in a tablet press machine by blending the active ingredient, filler, and binder. The filler (e.g., starch, sugar) is required to dilute the active medicinal ingredient to the proper concentration, and a binder (e.g., corn syrup or starch) is necessary to bind the tablet particles together. A lubricant (e.g., magnesium stearate) may be added for proper tablet machine operation. The dust generated during the mixing and tableting operation is collected and usually recycled directly to the same batch, while broken tablets generally are collected and recycled to the granulation operation in a subsequent lot. Some tablets are coated by tumbling with a coating material and then dried. After the tablets have been coated and dried, they are sent to the packaging unit where they are bottled. Tablet-coating operations can be a significant source of air emissions of solvents if solvent-based coatings are used, and can contribute solvents to the plant wastewater if certain types of air pollution control equipment (wet scrubbers or activated carbon) are used to capture solvent vapors from tablet-coating operations. Wastewater from the wet scrubber is likely to be sewered as is the condensate from the steam used to regenerate the activated carbon.

The first step in capsule production is to form a hard gelatine shell. The shells are produced by machines that dip rows of rounded metal dowels into a molten gelatine solution, and then strip the capsules from the dowels after the capsules have cooled and solidified. Imperfect capsules are remelted and reused, if possible, or sold for glue manufacture. Most pharmaceutical companies purchase empty capsules from a few specialty producers. The active ingredient and filler are mixed before being poured by machine into the empty gelatine capsules. The filled capsules are bottled and packaged. As in tablet production, some dust is generated, which is recycled to the production line. Liquid preparations are formulated for injection or oral use. In both cases, the liquid active ingredient is first weighed and then dissolved in water. Injectable solutions are

bulk-sterilized by heat or filtration and then poured into sterilized bottles. Oral liquid preparations can be bottled directly without the sterilization steps. Wastewater is generated by general cleanup operations, spills, and breakage.

Ointments are produced by blending an active ingredient(s) with an ointment base such as polyethylene glycol. The blended product is then poured into tubes by machine and packaged. Wastewater generated from these operations are all from equipment cleaning operations.

The primary objective of mixing, compounding, or formulating operations is to convert the manufactured products into a final, usable form. The necessary production steps typically have small wastewater flows because very few of the unit operations generate wastewater. The primary use of water is in the actual formulating process, where it is used for cooling and for equipment and floor washing.

Wastewater sources from mixing, compounding, or formulating operations are: 1) floor and equipment wash water, 2) wet scrubbers, and 3) spills. The use of water to clean out mixing tanks can periodically flush dilute wastewaters of unusual composition into the plant sewer system. The washouts from mixing tanks may be used to prepare the master batches of the pharmaceutical compounds and may contain inorganic salts, sugars, and syrup. Other sources of contaminated wastewater are dust and fumes from scrubbers, either in building ventilation systems or on specific equipment. In general, this wastewater is readily treatable by biological treatment systems.

An analysis of the pollutant information in the pharmaceutical manufacturing database shows that wastewater from mixing, compounding, or formulating plants normally has low BOD_5, COD, and TSS concentrations; relatively small flows; and pH values of 6.0 to 8.0.

3.4.3 Pharmaceutical Manufacturing Process Variability

The wastewater effluent flow and composition from a typical pharmaceutical manufacturing facility can be highly variable. Factors contributing to such variability are:

- Campaigning;
- Batch processing; and
- Wastewater commingling.

Because many pharmaceutical products are manufactured in campaigns, most wastewater is generated during product changeover. The process equipment must be cleaned out to avoid product contamination. The composition of the wastewater will vary according to the products that were manufactured on that process line.

Pharmaceuticals are manufactured by batch and continuous manufacturing operations. Batch-type production is by far the most common manufacturing technique, as presented in the production operation breakdown in Table 3-8. Many pharmaceutical facilities conduct multiple batch operations, some in series and some concurrently. Often several of the required batch processes are performed at the same time in separate reactors, each with its own schedule. Each batch may have unique waste stream characteristics. In fermentation operations, it can take a few days to several weeks to complete the ferment, during which little or no wastewater is generated. However, during product recovery operations, high-volume, high-strength wastewaters are generated.

It is also common practice in the pharmaceutical manufacturing industry to commingle organic-contaminated wastewaters. In many cases commingling is necessary to collect sufficient wastewater volume to properly operate an economically sized treatment unit such as a steam stripper. Commingled wastes may be added to the treatment unit feed tank on a variable schedule, thus altering the feed composition on a real-time basis. In other cases, segregating for purposes of recovery and treatment may be appropriate and cost effective.

A variety of solvents are used in the pharmaceutical manufacturing industry and end up in the industry's wastewater. Many solvents are process-specific and cannot be interchanged in other pharmaceutical processes. In addition, solvents must be approved by the FDA for each process. FDA regulations require that before a change can be made to an approved process, industry must meet the requirements of product purity and product efficacy as specified in the FDA approval.

Consequently, simplification of wastestream composition by chemical substitution to a common solvent may not be possible or desirable. Nonetheless, EPA has worked with the Food and Drug Administration (FDA) to encourage pollution prevention in the final guidelines and standards. See 7.2.1.2 for a more detailed discussion of EPA and FDA efforts towards pollution prevention in the pharmaceutical industry.

3.5 Trends in the Industry

The "Preliminary Data Summary for the Pharmaceutical Point Source Category" (22) gives a snapshot of the pharmaceutical manufacturing industry in the late 1970s and the early 1980s. By comparing these pre-1986 sources to the data available in the 1989 Pharmaceutical Screener Questionnaire and the 1990 Detailed Questionnaire, trends in the manufacturing process types used by pharmaceutical manufacturing facilities, the treatment technologies used at pharmaceutical manufacturing facilities, and the chemicals used in their manufacturing processes were observed. These trends are described in the following subsections.

3.5.1 Manufacturing Process Types

Since 1986, the number of pharmaceutical manufacturing facilities engaging in fermentation has increased, while those engaging in biological or natural extraction has decreased. These trends are shown in the following table.

Type of Facility	Percentage of Facilities Using Process Prior to 1986	Percentage of Facilities Using Process in 1989/1990
Fermentation	7.8	14.5
Biological or Natural Extraction	17.0	14.5
Chemical Synthesis	29.3	30.3
Mixing, Compounding, or Formulating	80.0	80.0

The total of the percentages is not 100 because any one facility may manufacture multiple process types.

3.5.2 Treatment Technologies in Use

Table 3-9 presents the trends in wastewater treatment technologies used by pharmaceutical manufacturing facilities. Since 1986, the use of neutralization, equalization, activated sludge, primary clarification, multimedia filtration, steam stripping, secondary clarification, granular activated carbon, and oxidation have all increased, while the use of aerated lagoons, chlorination, waste stabilization ponds, and trickling filters has decreased slightly. Upward or downward trends cannot be assessed for settleable solids removal, primary sedimentation, polishing ponds, evaporation, dissolved air floatation, pH adjustment, or phase separation since data were not available for both pre-1986 and post-1986 time frames.

3.5.3 Chemical Substitution

The pharmaceutical manufacturing industry has decreased its use of many chemicals because of their toxicity and contribution to air and water pollution. Use of chlorinated compounds has decreased the most. Based on a review of TRI data from pharmaceutical manufacturing facilities, the average annual discharge of chloroform, methylene chloride, carbon tetrachloride, benzene, methyl isobutyl ketone, pyridine, phenol, methyl cellusolve, and xylene has decreased between the years 1987 and 1994. Percent reductions in annual discharge vary from 26% (phenol) to 99% (carbon tetrachloride). Table 3-10 presents the total annual discharge for 1987 and 1994, and the percent reductions for each compound.

Table 3-1

Facilities Sampled As Part of the Pharmaceutical Manufacturing Industry Study

Plant Code	Sampling Dates	Subcategory	Days Sampled	Stream Characterization	Technology Sampled			
					Biological	Steam Stripping	Resin Adsorption	Cyanide Destruction
1. Indirect Dischargers								
30618	04/19/86-04/21/86	A,B,C,D,E	2	X	--	--	--	--
30832	07/16/86-07/18/86	A,C,D,E	2	X	--	--	--	--
30759	07/29/86-07/31/86	A,B,C,D,E	2	X	X	--	--	--
30022	03/11/87-03/13/87	A,B,C,D,E	2	X	X	--	--	--
30918	05/10/88-05/12/88	A,B,C,E	2	X	--	--	--	--
30329	09/12/88-09/16/88	A,C,D,E	3	X	--	PC, FT, DP	--	--
30977	03/28/89-03/30/89	A,B,C,E	2	X	--	--	--	--
30618	06/05/89-06/09/89	A,B,C,D,E	4	--	--	PC	X	--
2. Direct Dischargers								
30010	02/25/87-02/27/87	C	2	X	X	--	--	--
30487	09/19/88-09/23/88	C	4	--	--	PC	--	--
30542	03/13/89-03/17/89	A,C,E	4	--	--	--	--	X
30623	04/03/90-04/13/90	A,C	10	X	X	--	--	--
30540	06/03/91-06/13/91	A,B,C,D,E	10	X	X	--	--	--

Notes: PC = packed column; FT = flash tank; DP = distillation pot.
Subcategory refers to the type of manufacturing operations performed at the facility.

Subcategory A = Fermentation
Subcategory B = Extraction
Subcategory C = Chemical Synthesis
Subcategory D = Formulation
Subcategory E = Research and Development

Table 3-2

Pharmaceutical Industry Geographic Distribution(a)

Location	Number of Plants	Percentage of Total Plants	Total Number of Employees in Region
Eastern United States			
EPA Region I:			
Connecticut	7	2.3	
Maine	0	0.0	
Massachusetts	9	3.0	
New Hampshire	0	0.0	
Rhode Island	1	0.3	
Vermont	0	0.0	
EPA Region I Totals	17	5.6	7,025
EPA Region II			
New Jersey	46	15.1	
New York	28	9.2	
Puerto Rico	34	11.2	
Virgin Islands	0	0.0	
EPA Region II Totals	108	35.5	60,322
EPA Region III			
Delaware	2	0.7	
Maryland	3	1.0	
Pennsylvania	17	5.6	
Virginia	4	1.3	
West Virginia	1	0.3	
District of Columbia	0	0.0	
EPA Region III Totals	27	8.9	14,558

Table 3-2 (Continued)

Location	Number of Plants	Percentage of Total Plants	Total Number of Employees in Region
EPA Region IV			
Alabama	0	0.0	
Georgia	5	1.6	
Florida	2	0.7	
Mississippi	2	0.7	
North Carolina	11	3.6	
South Carolina	4	1.3	
Tennessee	7	2.3	
Kentucky	0	0.0	
EPA Region IV Totals	31	10.2	12,927
EPA Region V			
Illinois	14	4.6	
Indiana	12	4.0	
Ohio	11	3.6	
Michigan	9	3.0	
Wisconsin	2	0.7	
Minnesota	4	1.3	
EPA Region V Totals	52	17.1	37,235
Eastern U.S. Total (EPA Regions I-V)	**235**	**77.3**	**132,067**

Table 3-2 (Continued)

Location	Number of Plants	Percentage of Total Plants	Total Number of Employees in Region
Western United States			
EPA Region VI			
Arkansas	0	0.0	
Louisiana	3	1.0	
Oklahoma	0	0.0	
Texas	5	1.6	
New Mexico	0	0.0	
EPA Region VI Totals	8	2.6	2,121
EPA Region VII			
Iowa	4	1.3	
Kansas	5	1.6	
Missouri	17	5.6	
Nebraska	3	1.0	
EPA Region VII Totals	29	9.5	6,764
EPA Region VIII			
Colorado	4	1.3	
Utah	1	0.3	
Wyoming	1	0.3	
Montana	0	0.0	
North Dakota	0	0.0	
South Dakota	0	0.0	
EPA Region VIII Totals	6	2.0	1,252

Table 3-2 (Continued)

Location	Number of Plants	Percentage of Total Plants	Total Number of Employees in Region
EPA Region IX			
Arizona	1	0.3	
California	22	7.2	
Nevada	0	0.0	
Hawaii	0	0.0	
EPA Region IX Totals	23	7.6	9,520
EPA Region X			
Alaska	0	0.0	
Idaho	0	0.0	
Oregon	0	0.0	
Washington	3	1.0	
EPA Region X Totals	3	1.0	534
Western U.S. Total (EPA Regions VI-X)	**69**	**22.7**	**20,191**
U.S. Totals	**304**	**100**	**152,258**

(a) Employment obtained from the 1989 Screener Questionnaire. Facility locations obtained from the Detailed Questionnaire and the 1989 Screener Questionnaire.

Table 3-3

Distribution of Pharmaceutical Manufacturing Facilities by Date of Initiation of Operations(a)

Decade	Number of Facilities Reporting	
	Facility Operations Began	Pharmaceutical Manufacturing Operations Began
Prior to 1930s	19	10
1930s	6	5
1940s	14	14
1950s	17	18
1960s	26	27
1970s	47	46
1980s	50	57
1990s	4	5
No Response	61	62
Total	244	244

(a)Data obtained from 244 facilities responding to the Detailed Questionnaire.

Table 3-4

Example Pharmaceutical Products by Manufacturing Process and Classification

Fermentation Products	Extraction Products	Chemical Synthesis Products	Mixing/Compounding/ Formulating Products
Antibiotics	Antineoplastic Agents	Antibiotics	Cold Formulas
Amphotericin	Vinblastine	Aztreonam	Benedryl elixir
Chlortetracycline	Vincristine	Clindamycin	Dermatological Agents
Lincomycin	Enzymes and Digestive Aids	Antihistamines	Calamine
Nystatin	Pancreatin USP	Mecfizune dihydrochloride	Salicylic acid
Penicillin G	Papain	Cardiovascular Agents	Powders
Penicillin V	Central Depressants	Methyldopa	Desenex Powder
Streptomycin	Codeine	Central Stimulants	Mouthwash
Vancomycin	Morphine Sulphate	Amitriptyline	Listerine
Antineoplastic Agents	Noscapine	Caffeine	Tablets and Capsules
Dextran	Thebaine	Central Depressants	Contact
Therapeutic Nutrients	Hematological Agents	Acetaminophen	Di-gel tablets
Vitamins	Heparin	Aspirin (acetyl salicylic acid)	Accutane
Ascorbic acid (C)	Insulin	Hormones	Ointments
Riboflavin (B2)	Vaccines	Cortisone acetate	Absorbine Jr.
Steroids	Strepvax II	Dexamethasone acetate	Lubriderm
		Fluorometholone	Caladryl
		Hydrocortisone	Vicks Vaporrub
		Testosterone	
		Vitamins	
		Niacinamide	

Table 3-5

Solvents Used in Fermentation Operations

Acetone	n-Heptane
Acetonitrile	n-Hexane
Ammonia (aqueous)	Isopropanol
n-Amyl acetate	Isopropyl acetate
Amyl alcohol	Methanol
n-Butyl acetate	Methyl cellosolve
n-Butyl alcohol	Methylene chloride
Chloroform	Methyl isobutyl ketone (MIBK)
N,N-Dimethylformamide	Petroleum naphtha
Ethanol	Phenol
Ethyl acetate	Toluene
Formaldehyde	Triethylamine

Table 3-6

Solvents Used in Biological or Natural Extraction Operations

Acetone	Ethylene glycol
Acetonitrile	Formaldehyde
Ammonia (aqueous)	n-Heptane
n-Amyl acetate	n-Hexane
Amyl alcohol	Isopropanol
n-Butyl alcohol	Isopropyl acetate
Chloroform	Isopropyl ether
1,2-Dichloroethane	Methanol
Diethylmine	Methylene chloride
Diethyl ether	Petroleum naphtha
N,N-Dimethylformamide	Phenol
Dimethyl sulfoxide	n-Propanol
1,4-Dioxane	Pyridine
Ethanol	Tetrahydrofuran
Ethyl acetate	Toluene

Table 3-7

Solvents Used in Chemical Synthesis Operations

Acetone	Formaldehyde
Acetonitrile	Formamide
Ammonia (aqueous)	Furfural
n-Amyl acetate	n-Heptane
Amyl alcohol	n-Hexane
Aniline	Isobutyraldehyde
Benzene	Isopropanol
2-Butanone (MEK)	Isopropyl acetate
n-Butyl acetate	Isopropyl ether
n-Butyl alcohol	Methanol
Chlorobenzene	Methylamine
Chloroform	Methyl cellosolve
Chloromethane	Methylene chloride
Cyclohexane	Methyl formate
o-Dichlorobenzene (1,2-Dichlorobenzene)	Methyl isobutyl ketone (MIBK)
1,2-Dichloroethane	2-Methylpyridine
Diethylamine	Petroleum naphtha
Diethyl Ether	Phenol
N,N-Dimethyl acetamide	Polyethylene glycol 600
Dimethylamine	n-Propanol
N,N-Dimethylaniline	Pyridine
N,N-Dimethylformamide	Tetrahydrofuran
Dimethyl sulfoxide	Toluene
1,4-Dioxane	Trichlorofluoromethane
Ethanol	Triethlyamine
Ethyl acetate	Xylenes
Ethylene glycol	

Table 3-8

Production Operation Breakdown(a)

Type of Operation	Number of Operations					Percent of Total Operation
	Manufacturing Processes				Total	
	Fermentation	Biological Extraction	Chemical Synthesis	Mixing/ Compounding/ Formulating		
Batch	309	189	1,059	3,675	5,232	99
Continuous	16	1	16	8	41	1
Total Number of Operations	325	190	1,075	3,683	5,273	100
Percent of Total Operations	6	4	20	70	100	
Percent of Subcategory Operations which are Batch	95	99	99	100	99	

(a) Production data obtained from 244 facilities responding to the Detailed Questionnaire.

Table 3-9

Trends in Treatment Technologies Used at Pharmaceutical Manufacturing Facilities(a)

Treatment Technology	Percentage of Facilities Using This Type of Treatment Technology Prior to 1986	Percentage of Facilities Using This Type of Treatment Technology in 1989/1990
Neutralization	26.0	44.3
Equalization	20.1	28.6
Activated sludge	16.9	20.5
Settleable solids removal	13.3	NA
Primary sedimentation	12.0	NA
Aerated lagoon	7.5	4.9
Primary clarification	3.9	9.8
Chlorination	3.6	2.5
Polishing ponds	3.2	NA
Waste stabilization pond	2.9	2.5
Trickling filter	2.9	2.0
Multimedia filtration	2.3	6.1
Steam stripping	1.9	5.7
Evaporation	1.9	NA
Secondary clarification	1.6	20.9
Granular activated carbon	1.3	3.3
Oxidation	1.0	2.0
Dissolved air flotation	1.0	NA
pH adjustment	NA	50.0
Phase separation	NA	12.3

The total of the percentages is not 100 because any one facility may have multiple treatment technologies and some facilities do not have treatment in place.

NA - Not available.

(a) Data obtained from reference 22 and the responses to the Detailed Questionnaire.

Table 3-10

Trends in Average Annual Discharges of Compounds Between the Years 1987 and 1994

Compound	Total Annual Discharge 1987 (lbs)	Total Annual Discharge 1994 (lbs)	Percent Change
Benzene	136,600	46,116	-66
Carbon tetrachloride	125,982	1,710	-99
Chloroform	664,456	336,587	-49
Methyl isobutyl ketone	2,918,922	960,365	-67
Methyl cellusolve	77,887	12,990	-83
Mehylene chloride	25,262,249	9,071,052	-64
Phenol	73,502	54,360	-26
Pyridine	216,100	75,280	-65
Xylene	1,469,212	492,394	-66

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SECTION 4

INDUSTRY SUBCATEGORIZATION

4.1 Introduction

The purpose of subcategorization is to group together facilities of similar characteristics so that effluent limitations guidelines and standards representative of each group can be developed. This provides each subcategory with a uniform set of effluent limitations guidelines which take into account technological achievability and economic impacts unique to that subcategory.

For this final rulemaking, EPA considered the following factors in the subcategorization of the pharmaceutical manufacturing industry:

- Manufacturing processes;
- Wastewater characteristics and treatability;
- Product types;
- Raw materials;
- Plant size;
- Plant age;
- Plant location;
- Nonwater quality environmental impacts; and
- Treatment costs and energy requirements.

After evaluating the above factors, the Agency determined that subcategorization of the pharmaceutical manufacturing industry is necessary. The results of these evaluations are presented in the following sections:

- 4.2 discusses the regulatory background of subcategorization in the pharmaceutical manufacturing industry;
- 4.3 presents the final subcategorization basis; and
- 4.4 presents conclusions.

4.2 Background

The original subcategorization scheme for the pharmaceutical manufacturing industry was published in the November 17, 1976 Federal Register.(1) This subcategorization scheme was based on the operations listed below:

- Subcategory A - Fermentation Operations
- Subcategory B - Biological and Natural Extraction Operations
- Subcategory C - Chemical Synthesis Operations
- Subcategory D - Mixing, Compounding, or Formulating Operations
- Subcategory E - Pharmaceutical Research Operations.

Subsequently, EPA published proposed effluent limitations guidelines and standards for the pharmaceutical manufacturing industry in November 1982. As discussed in the preamble to the 1982 regulation, EPA proposed to combine Subcategories A through D above into a single subcategory.(2) Along with comments on the November 1982 proposal, EPA received additional influent and effluent conventional and nonconventional pollutant data. EPA statistically analyzed both new and existing influent and effluent conventional and nonconventional pollutant data for all direct dischargers to determine if the proposed change to create a single subcategory was appropriate. A detailed discussion of the data sources and the statistical comparisons used is presented in IV of the 1983 Final Development Document (3), and is summarized below.

The statistical comparisons of conventional pollutants and the nonconventional pollutant COD indicated that the subcategorization scheme should separate fermentation and chemical synthesis operations (Subcategory A and C) from extraction and mixing, compounding, or formulating operations (Subcategory B and D). The analyses showed that the influent and effluent conventional pollutant and COD concentrations, as well as discharge flows, of facilities with Subcategory A and C operations are similar and that these same characteristics are similar between facilities with Subcategory B and D operations. These characteristics are different, however, between the Subcategory A and C facility group and the Subcategory B and D facility group. These differences indicated that different effluent discharge levels of conventional pollutants and COD would be expected when facilities in both groups used the same control

technology. However, because the existing separate subcategories accommodated these differences and because permitting authorities and the regulated industry were familiar with that scheme, EPA decided to maintain the existing subcategorization scheme at that time.

In the May 2, 1995 proposal, EPA proposed to continue to maintain the existing subcategorization scheme. As part of this proposal, EPA also indicated that Subcategory E (research) was limited to bench-scale research operations and was not intended to cover pilot-plant development operations. The majority of commenters on the May 2, 1995 proposal supported the continuation of the existing subcategorization scheme. Several industry commenters, however, opposed limitations on the types of wastewaters included in the Subcategory E group and argued that pilot-plant operations have been and should continue to be included under the Subcategory E definition.

After considering the comments received concerning the regulation of wastewaters from pilot-scale operations, EPA has decided not to change the existing description of the research subcategory in the applicability section. EPA concluded that it did not have sufficient information concerning Subcategory E generated wastewaters to change the existing description. If pilot-scale manufacturing operations occur at stand-alone research facilities or during research operations at manufacturing facilities, then BAT and BCT limits for these wastewaters can be determined by permit writers on a best professional judgment (BPJ) basis. Similarly, such wastewater generated at indirect discharging facilities may be addressed by the regulations found at 40 CFR 403.5 and by local limits on a case-by-case basis.

EPA has reviewed the additional characterization data collected since the 1983 final rulemaking to determine if the previous subcategorization scheme is still appropriate. The results of that review are described in 4.3.

4.3 Final Subcategorization Basis

For this rulemaking, EPA is finalizing the following four subcategories:

1. Subcategory A - Fermentation Operations;
2. Subcategory B - Biological and Natural Extraction Operations;
3. Subcategory C - Chemical Synthesis Operations; and
4. Subcategory D - Mixing, Compounding, or Formulating Operations.

Where the subcategory operation definitions are as follows:

- Fermentation. A chemical change induced by a living organism or enzyme, specifically, bacteria, or the microorganisms occurring in unicellular plants such as yeast, molds, or fungi. Process operations that utilize fermentation to manufacture pharmaceutically active ingredients define Subcategory A.

- Biological and Natural Extraction. The chemical and physical extraction of pharmaceutically active ingredients from natural sources such as plant roots and leaves, animal glands, and parasitic fungi. The process operations involving biological and natural extraction define Subcategory B.

- Chemical Synthesis. The process(es) of using a chemical reaction or a series of chemical reactions to manufacture pharmaceutically active ingredients. The chemical synthesis process operations define Subcategory C.

- Mixing, Compounding, or Formulating. Processes through which pharmaceutically active ingredients are put in dosage forms. Processes involving mixing, compounding, or formulating define Subcategory D.

This subcategorization scheme is consistent with the conclusions drawn during the subcategorization analysis for the 1983 final rulemaking and with characterization data collected since 1983 and industry profile information gathered with the Detailed Questionnaire.

The following paragraphs discuss EPA's consideration of the nine factors listed in the beginning of this in determining appropriate subcategories for the pharmaceutical manufacturing industry.

The primary bases for subcategorization of facilities in this industry were found to be manufacturing processes and wastewater characteristics.

4.3.1 Manufacturing Processes

There are four basic manufacturing operations used in the pharmaceutical manufacturing industry: 1) fermentation, 2) biological or natural extraction, 3) chemical synthesis, and 4) mixing, compounding, and formulating. The following paragraphs present a brief overview of each of the manufacturing operations and the sources and characteristics of wastewater from each. A detailed discussion of these manufacturing operations is provided in 3.4.

Fermentation is the usual method for producing antibiotics and steroids. The process involves three basic steps: inoculum and seed preparation, fermentation, and product recovery. Most of the wastewater is generated from the fermentation and product recovery steps. Fermentation is typically a large-scale batch process. Product recovery is accomplished by solvent extraction, direct precipitation, ion exchange, and/or adsorption. Based on responses to the Detailed Questionnaire, the solvents most often used in fermentation operations are acetone, methanol, isopropanol, ethanol, and amyl alcohol. Priority pollutants used in fermentation operations include methylene chloride, toluene, and phenol. Copper and zinc are priority pollutant metals known to be utilized where precipitation is used for product recovery. Due to the food materials contained in spent fermentation broth, fermentation wastewaters are very amenable to biological treatment. Data from responses to the Detailed Questionnaire show that wastewater from fermentation plants is generally characterized by high BOD_5, COD, and TSS concentrations, large flows, and a pH range of approximately 4.0 to 8.0.

In biological and/or natural extraction manufacturing operations, pharmaceutical products are extracted from such natural sources as plant material, animal glands, and parasitic fungi through a series of volume reduction and chemical extraction steps. These operations are usually conducted on a much smaller scale than fermentation or chemical synthesis operations. The principal sources of wastewater from biological and natural extraction operations are spent raw materials (plant or animal tissue residue), floor and equipment washes, and spent solvents. Solvents used in

purification and extraction steps include the priority pollutants methylene chloride, toluene, chloroform, and 1,2 dichloroethane as well as the nonconventional pollutants ethanol, methanol, n-amyl acetate, isopropanol, and acetone. The priority pollutant phenol is used as a disinfecting chemical in this process. Ammonium salts are used for pH control during the extraction process. Data from responses to the Detailed Questionnaire show that wastewater from extraction operations is generally characterized by relatively low BOD_5, COD, and TSS concentrations, low flows, and pH values ranging from approximately 6.0 to 8.0.

Chemical synthesis is the process by which most drug compounds are manufactured. Chemical synthesis is generally a batch process using a conventional batch reaction vessel and involves techniques such as alkylations, carboxylation, esterifications, halogenations, and sulfonations. During chemical synthesis, wastewater is generally produced with each chemical modification that requires filling and emptying of the batch reactors. Primary sources of wastewater from chemical synthesis operations are process wastes (spent solvents, filtrates, and concentrates), floor and equipment washes, pump seal water, wet scrubber wastewater, and spills. A wide variety of priority pollutant and nonconventional chemicals are used as reaction and purification solvents during chemical synthesis. Priority pollutants used during chemical synthesis include several chlorinated alkanes and chlorinated aromatic compounds. The major nonconventional pollutants reported in the Detailed Questionnaire were methanol, acetone, isopropanol, ethyl acetate, ethanol, and the six-member ring compounds xylene, pyridine, and toluene. Wastewater from chemical synthesis operations is generally characterized by relatively high BOD_5, COD, and TSS concentrations, large flows, and a wide pH range.

Mixing, compounding, and formulating plants receive bulk pharmaceutical active ingredients as raw materials and subsequently manufacture final dosage forms for consumer use (tablets, liquids, capsules, ointments, etc.). Mixing, compounding, and formulating operations typically involve few production steps which generate wastewater. The primary wastewater sources from these operations are floor and equipment wash water, wet scrubbers, and spills. Wastewater from mixing, compounding, and formulating operations normally has low BOD_5, COD, and TSS concentrations, relatively small flows, and pH values ranging from 6.0 to 8.0.

Pilot-plant operations conducted at pharmaceutical manufacturing facilities can include biological studies, chemical research, and product development activities. Wastewaters from pilot-plant operations conducted in conjunction with and related to existing pharmaceutical manufacturing operations is covered by this final rule because these pilot plant operations would most likely generate wastewater with characteristics similar to the commercial manufacturing operations.

Each type of manufacturing operation in the pharmaceutical manufacturing industry is distinct. Fermentation and chemical synthesis manufacturing operations are typically large-scale batch processes characterized by large flows and relatively high BOD_5, COD, and TSS concentrations. Biological extraction and mixing, compounding, and formulating operations are characterized by low wastewater flows and relatively low BOD_5, COD, and TSS concentrations.

Because of these distinct manufacturing operations and the related wastewater characteristics, the Agency considered manufacturing processes as a basis for subcategorization of this industry.

4.3.2 Wastewater Characteristics and Treatability

As discussed in 4.3.1, each type of manufacturing process in the pharmaceutical manufacturing industry is distinct, and wastewaters are generated by differing unit operations and exhibit somewhat different characteristics. This summarizes discharge flow and wastewater characterization data submitted by the pharmaceutical manufacturing industry in the Detailed Questionnaire.

Tables 4-1 through 4-4 present flow, raw wastewater, and treated effluent characterization data from responses to the Detailed Questionnaire. The tables are arranged by subcategory (A, B, C, and D) and distinguish direct versus indirect dischargers. Because many facilities have operations from more than one subcategory, some data are presented for subcategory groups in the tables. Facilities with any manufacturing operations from Subcategories A or C, even those with manufacturing operations from Subcategory B and/or D, were included with the A, C, and A + C only facilities because most of the flow and pollutant load at these facilities comes from

Subcategory A or C manufacturing operations. Additional discussion of wastewater characterization data is presented in 5.0.

Table 4-1 presents discharge flow rate and BOD_5, COD, and TSS concentration averages and ranges in untreated wastewater. The table shows similar BOD_5, COD, and TSS average concentrations between facilities with Subcategory A and C operations and between facilities with Subcategory B and D operations. The table also shows that facilities with manufacturing operations from Subcategories A and/or C exhibit higher relative flows and BOD_5, COD, and TSS concentrations than those facilities with manufacturing operations from Subcategories B and/or D.

Tables 4-2 and 4-3 present low, high, and average priority and nonconventional organic pollutant concentration summary data for untreated wastewater. Organic pollutant data presented are the sums of individual pollutants reported as being present in the Detailed Questionnaire. These data do not indicate significant differences in pollutant concentrations for organics between Subcategory A and/or C wastewaters and Subcategory B and/or D wastewaters.

Table 4-4 presents low, high, and average pollutant concentration data for BOD_5, COD, and TSS in treated effluent from direct dischargers. These data do not represent the performance of any specific treatment technology, but are indicative of current overall treatment performance within the industry. These data indicate that BOD_5, COD, and TSS are generally treated to lower levels at the Subcategory B and/or D facilities. 8 discusses in detail the performance of specific wastewater treatment technologies in the pharmaceutical manufacturing industry. The data presented in 8 for advanced biological treatment systems, an important treatment technology commonly used in the pharmaceutical manufacturing industry, also indicate that Subcategory B and/or D facilities treat BOD_5, COD, and TSS to lower levels than can be achieved at the facilities with Subcategory A and/or C manufacturing operations.

The treatment performance data presented in 8 do not demonstrate any differentiation in treatment performance for priority and nonconventional organic pollutants among facilities with operations in different subcategories.

In summary, the distinctly different manufacturing operations identified in 4.2 result in distinctly different influent flow and pollutant concentrations between facilities with manufacturing operations from Subcategories A and/or C and facilities with manufacturing operations from Subcategories B and/or D. Facilities with manufacturing operations from Subcategories B and/or D are able to achieve lower treated effluent concentrations of BOD_5, COD, and TSS than facilities with operations from Subcategories A and/or C, using the same treatment technology.

4.3.3 Product Types

Manufacturing processes under the SIC code system in the pharmaceutical manufacturing industry are divided into the following:

- SIC 2833 Medicinal Chemicals and Botanical Products;
- SIC 2834 Pharmaceutical Preparations; and
- SIC 2836 Biological Products.

Medicinal chemicals and botanical products include three major product areas: fermentation products, chemical synthesis products, and natural extraction products. Fermentation products are primarily antibiotics and steroids. Chemical synthesis products include intermediates used to produce other chemical compounds as well as hundreds of bulk chemical products. Natural extraction products include such items as gland derivatives, animal bile salts and derivatives, and herb and tissue derivatives. Pharmaceutical preparations (formulation products) are formulated from bulk active ingredients prior to being marketed to the public. Biological products include materials extracted from biological materials such as vaccines, serums and various plasma derivatives.(4)

Because product types are a function of the manufacturing process used, the Agency concludes that the nature of the product manufactured is incorporated into the basis for subcategorization.

4.3.4 Raw Materials

The pharmaceutical manufacturing industry draws upon worldwide sources for the myriad of raw materials it needs to produce medicinal chemicals. Fermentation operations require many new raw materials falling into general chemical classifications such as carbohydrates, carbonates, steep liquors, nitrogen and phosphorus compounds, anti-foam agents and various acids and bases. These chemicals are used as carbon and nutrient sources (1), as foam control additives, and for pH adjustment in fermentation processes. Various solvents, acids, and bases are also required for extraction and purification processes. Hundreds of raw materials are required for the many batch chemical synthesis processes used by the industry. These include organic and inorganic compounds and are used in gas, liquid, and solid forms.(4)

Plant and animal tissues are also used by the pharmaceutical manufacturing industry to produce various biological and natural extraction products. The raw materials used in formulation operations are the products from other manufacturing operations. These include bulk chemicals from fermentation and chemical synthesis operations and such items as biles, blood fractions, salts, and various derivatives from biological and natural extraction operations.(4)

Because such a vast number and wide variety of raw materials are used within the industry, it is not practical to base subcategories directly on the raw materials used. In addition, the nature of raw materials used by the pharmaceutical manufacturing industry are related to the manufacturing process, and therefore, are indirectly accounted for in the final basis for subcategorization.

4.3.5 Plant Size

The Agency has determined that plant size in terms of production has no significant or consistent impact on the effectiveness of treatment technologies or wastewater characteristics and therefore did not consider plant size as a basis for subcategorization.

4.3.6 Plant Age

The age of a pharmaceutical manufacturing plant is an indefinite parameter primarily due to continual upgrading and modernization most facilities have undertaken in order to remain competitive. The cornerstone age (the age of the original facility) was evaluated relative to raw waste load and treated effluent load without any apparent relationship. The Agency therefore did not consider plant age as a basis for subcategorization.

4.3.7 Plant Location

The locations of pharmaceutical manufacturing facilities are typically based on a number of factors, including:

- Sources of raw materials;
- Proximity to markets for products;
- Availability of an adequate water supply;
- Cheap energy sources;
- Proximity to proper modes of transportation;
- Reasonably priced labor markets; and
- Tax considerations.

The majority of pharmaceutical manufacturing plants are located in New Jersey, New York, Pennsylvania, and Puerto Rico. Based on a review of available data, plant location does not affect the characteristics or treatability of process wastewater streams. The Agency therefore did not consider geographic location as a basis for subcategorization.

4.3.8 Nonwater Quality Environmental Impacts

Nonwater quality environmental impacts characteristics for the pharmaceutical manufacturing industry include:

- Sludge production;
- Waste solvent generation;

- Air pollution derived from wastewater generation and treatment; and
- Steam and electrical energy consumption due to wastewater treatment.

These factors all relate to the characteristics of the wastewater treated. Because wastewater characteristics are specifically accounted for in the final subcategorization approach, the Agency considers all non-water quality environmental impacts to be adequately addressed by the final subcategorization approach.

4.3.9 Treatment Costs and Energy Requirements

The same treatment unit operation, such as steam stripping to remove volatile organic pollutants, could be utilized to treat wastewater from a variety of sources. However, the cost of treatment and the energy required will vary depending on flow rates and wastewater characteristics. Because wastewater characteristics are specifically accounted for in the final subcategorization approach, treatment costs are adequately addressed. Therefore, while treatment costs, as discussed in 10, were considered by the Agency in selecting the technology bases for this final regulation, the Agency concludes that subcategorization based on treatment costs is not appropriate.

4.4 Conclusions

Based on EPA's review of industry data, as described earlier in this section, the Agency concludes that it is appropriate to maintain the four existing subcategories based on the different types of manufacturing operations used by the pharmaceutical manufacturing industry. The four subcategories for the pharmaceutical manufacturing industry covered by this final regulation are:

- Subcategory A - Fermentation Operations;
- Subcategory B - Biological and Natural Extraction Operations;
- Subcategory C - Chemical Synthesis Operations; and
- Subcategory D - Mixing, Compounding, or Formulating Operations.

Due to the similarities identified above between the characteristics and treatability of wastewater from fermentation and chemical synthesis operations, the Agency is establishing equivalent effluent limitations guidelines for Subcategories A and C. The Agency is also establishing equivalent effluent limitations guidelines for Subcategories B and D due to the similarity in characteristics and treatability of wastewater from biological extraction and mixing, compounding, and formulating operations.

At facilities that conduct fermentation and/or chemical synthesis operations, as well as biological extraction and/or mixing, compounding, or formulating operations, the vast majority of the wastewater discharge flow and pollutant load originates from the fermentation and chemical synthesis operations. Most facilities with fermentation and/or chemical synthesis operations conduct such operations at integrated facilities where other pharmaceutical manufacturing operations are also conducted, with discharges to a common wastewater treatment system. The Agency's treatment performance data reflect the integrated nature of such facilities.

For the purpose of analyzing and presenting data in subsequent sections of this development document, pharmaceutical manufacturing facilities are considered either Subcategory A and C facilities, or Subcategory B and D facilities. Due to the predominance of wastewater discharge flow and pollutant load from Subcategory A and C operations when these operations are conducted along with other pharmaceutical manufacturing operations at the same facility, and because of the integrated nature of such facilities, facilities with any Subcategory A or C operations are considered Subcategory A and C facilities. Subcategory B and D facilities are those facilities that have Subcategory B and/or D operations only.

Table 4-1

Summary of Discharge Flow Rate, Conventional Pollutants and COD Concentrations in Untreated Wastewater

Type of Discharge	1983 Subcategory	Pollutant	Untreated Wastewater Concentrations (mg/L)			Flow (1,000 gal/day)		
			Low	High	Ave.	Low	High	Ave.
Direct	A only	BOD_5	3,360	5,600	4,480	493	1,250	872
		COD	9,100	10,900	10,000	493	1,250	872
		TSS	264	2,490	1,380	493	1,250	872
	C only	BOD_5	0	812	218	<1	344	142
		COD	0	1,890	718	<1	344	142
		TSS	0	131	55	<1	344	142
	A and C only	BOD_5	22	2,620	975	202	73,300	21,000
		COD	216	5,280	2,410	202	73,300	21,000
		TSS	39	849	332	202	73,300	21,000
	A and/or C + Other(a)	BOD_5	11	9,700	2,230	51	2,000	1,010
		COD	123	16,500	4,050	51	2,000	1,010
		TSS	40	383	185	51	2,000	1,010
Indirect	A only	BOD_5	NA	NA	2,700	47	786	424
		COD	NA	NA	NA	47	786	424
		TSS	NA	NA	757	47	786	424
	C only	BOD_5	1,250	5,430	3,470	<1	1,620	169
		COD	1,200	22,200	7,980	<1	1,620	169
		TSS	19	1,000	265	<1	1,620	169
	A and C only	BOD_5	0	1,770	885	16	2,540	1,280
		COD	0	4,390	2,190	16	2,540	1,280
		TSS	0	888	444	16	2,540	1,280
	A and/or C + Other(a)	BOD_5	95	11,500	2,540	<1	7,310	494
		COD	152	19,700	4,750	<1	7,310	494
		TSS	14	6,070	820	<1	7,310	494

Table 4-1 (Continued)

Type of Discharge	1983 Subcategory	Pollutant	Untreated Wastewater Concentrations (mg/L)			Flow (1,000 gal/day)		
			Low	High	Ave.	Low	High	Ave.
Direct	B only	BOD_5	-	-	-	-	-	-
		COD	-	-	-	-	-	-
		TSS	-	-	-	-	-	-
	D only	BOD_5	0	328	117	2	692	110
		COD	0	1,140	271	2	692	110
		TSS	2	306	63	2	692	110
	BD only	BOD_5	NA	NA	53	NA	NA	63
		COD	NA	NA	27	NA	NA	63
		TSS	NA	NA	16	NA	NA	63
Indirect	B only	BOD_5	1,850	2,350	2,100	2	165	28
		COD	59	3,110	1,240	2	165	28
		TSS	81	552	250	2	165	28
	D only	BOD_5	0	4,650	601	<1	42,600	680
		COD	0	6,610	907	<1	42,600	680
		TSS	0	2,060	283	<1	42,600	680
	BD only	BOD_5	150	2,940	799	1	1,050	186
		COD	184	2,600	1,060	1	1,050	186
		TSS	24	743	265	1	1,050	186

(a) Facilities with combinations of manufacturing operations from other than Subcategories A, B, C, D, AC, and BD are included as other.

NA = Not available.

Table 4-2

Summary of Priority Pollutant Concentrations in Untreated Wastewater

Type of Discharge	Current Subcategory	Cyanide or Priority	# of Facilities Contributing Data	Untreated Wastewater Conc. (mg/L)		
				Low	High	Ave.
Direct	A only	C P	0 0			
	C only	C P	1 4	- 0.4	- 404	4,850 196
	A and C only	C P	1 4	- 20	- 657	1,730 306
	Other(a)	C P	1 6	- 0.3	- 11,900	38 2,860
Indirect	A only	C P	0 0			
	C only	C P	1 17	- 0.2	- 4,850	5 589
	A and C only	C P	0 1	-	-	619
	Other(a)	C P	2 32	229 0	850 79,900	539 3,630
Direct	B only	P	0			
	D only	P	3	0.2	30	10
	B and D only	P	0			
Indirect	B only	P	1	-	-	691
	D only	P	23	0.00	31,400	1,450
	B and D only	P	2	14.65	350	182

(a)"Other subcategory" denotes facilities which manufacture products in the following subcategories or subcategory combinations: ABD, ACD, AD, CD, ABCD, AB, BC, ABC, and BCD.
P - Priority organic pollutants.
C - Cyanide.
B/D facilities did not report any cyanide in their loads or waste streams.

Table 4-3

Summary of Nonconventional Pollutant Concentrations in Untreated Wastewater

Type of Discharge	1983 Subcategory	Ammonia or Other Nonconventionals	# of Facilities Contributing Data	Untreated Wastewater Concentrations (mg/L)		
				Low	High	Ave.
Direct	A only	N A	0 0			
	C only	N A	5 1	16 -	15,600 -	3,270 228
	A and C only	N A	4 1	282 -	7,450 -	3,030 21
	A and/or C + Other(a)	N A	8 5	114 0.05	39,500 842	9,930 332
Indirect	A only	N A	2 1	54 -	107 -	81 0.05
	C only	N A	21 12	0 10	54,100 948	7,530 354
	A and C only	N A	2 0	6,860	20,800	13,900
	A and/or C + Other(a)	N A	52 27	0 0	385,400 217,700	12,900 8,890
Direct	B only	N A	0 0			
	D only	N A	7 1	0 -	14,200 -	3,130 0.7
	B and D only	N A	1 0	-	-	6
Indirect	B only	N A	7 1	0 -	2,010 -	694 16
	D only	N A	54 4	0 0.5	492,400 348	12,900 99
	B and D only	N A	9 0	45 -	49,700	9,200

(a)Facilities with combinations of manufacturing operations from other than Subcategories A, B, C, D, AC, and BD are included as other.
N - Nonconventional.
A - Ammonia.

Table 4-4

Summary of Conventional Pollutants and COD Treated Effluent Concentrations

Type of Discharge	1983 Subcategory	Pollutant	Effluent Concentrations (mg/L)		
			Low	High	Ave.
Direct	A only	BOD_5	66	189	128
		COD	1,400	1,700	1,550
		TSS	97	264	180
	C only	BOD_5	0	15	8
		COD	0	923	268
		TSS	0	53	33
	A and C only	BOD_5	8	211	90
		COD	216	834	530
		TSS	9	232	122
	A and/or C + Other(a)	BOD_5	8	68	35
		COD	123	679	277
		TSS	12	143	71
Direct	B only	BOD_5	-	-	-
		COD	-	-	-
		TSS	-	-	-
	D only	BOD_5	0	145	17
		COD	0	1,140	123
		TSS	2	34	11
	B and D only	BOD_5	NA	NA	4
		COD	NA	NA	27
		TSS	NA	NA	16

(a)Facilities with combinations of manufacturing operations from other than Subcategories A, B, C, D, AC, and BD are included as other.

NA = Not available.

REFERENCES

1. U.S. EPA. Pharmaceutical Manufacturing Point Source Category; Interim Final Rulemaking, 41 Federal Register 50676 (November 17, 1976).

2. U.S. EPA. Pharmaceutical Manufacturing Point Source Category Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards; Proposed Regulation, 47 Federal Register 53584 (November 26, 1982).

3. U.S. EPA, Office of Water. Development Document for Effluent Limitations Guidelines and Standards for the Pharmaceutical Manufacturing Point Source Category. EPA 440/1-83/084, U.S. Environmental Protection Agency, Washington, D.C., September 1983.

4. U.S. EPA, Office of Water. Development Document for Interim Final Effluent Limitations and Proposed New Source Performance Standards for the Pharmaceutical Manufacturing Point Source Category. EPA 440/1-75/060, U.S. Environmental Protection Agency, Washington, D.C., December 1976.

SECTION 5

WATER USE AND WASTEWATER CHARACTERIZATION

5.1 Introduction

The 1990 Detailed Questionnaire and the 1989 Pharmaceutical Screener Questionnaire distributed by EPA identified 304 facilities which used solvents and discharged wastewater from pharmaceutical manufacturing processes. The following information, based on questionnaire and screener responses, is presented in this section:

- 5.2 discusses water use and sources of wastewater;
- 5.3 discusses wastewater volume by type of discharge;
- 5.4 presents water conservation measures;
- 5.5 discusses sources of wastewater characterization data; and
- 5.6 discusses wastewater characterization.

5.2 Water Use and Sources of Wastewater

As described in 3.4.1, there are four types of pharmaceutical manufacturing operations: fermentation; biological and natural extraction; chemical synthesis; and mixing, compounding, or formulating. Water use and sources of wastewater for each process are described in more detail below.

5.2.1 Pharmaceutical Process Wastewater Sources

Process wastewater is defined by 40 CFR 122.2 as "any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, or waste product."

Water is used and wastewater is generated in pharmaceutical manufacturing processes as follows:

- Water of reaction: water formed during the chemical reaction.
- Process solvent: water used to transport or support the chemicals involved in the reaction process; this water is usually removed from the process through a separation stage, such as centrifugation, decantation, drying, or stripping.
- Process stream washes: water added to the carrier, spent acid, or spent base which has been separated from the reaction mixture, in order to purify the stream by washing away the impurities.
- Product washes: water added to the reaction medium to purify an intermediate or final product by washing away the impurities (this water is subsequently removed through a separation stage); or water used to wash the crude product after it has been removed from the reaction medium.
- Spent Acid/Caustic: spent acid and caustic streams, which may be primarily water, discharged from the process during the separation steps which follow the reaction step in which acid and basic reagents are used to facilitate, catalyze, or participate.
- Condensed steam: steam used as a sterilizing medium and in steam strippers for solvent recovery and wastewater treatment.

Other sources of process wastewater associated with pharmaceutical manufacturing operations include:

- Air pollution control scrubber blowdown: water or acidic or basic compounds used in air emission control scrubbers to control fumes from reaction vessels, storage tanks, incinerators, and other process equipment.
- Equipment and floor washes: water used to clean process equipment between product campaigns and during unit shutdowns and floors during general housekeeping or for spill cleanup.
- Pump seal water: direct contact water used to cool packing and lubricate pumps.

The following materials are excluded from the definition of process wastewater, because of their significant potential to upset the normal operation of biological wastewater treatment plants:

- Trimthyl silanol;
- Any active anti-microbial materials;
- Wastewater from imperfect fermentation batches; and
- Process area spills.

The following waters and wastewaters are excluded from the definition of process wastewater:

- Non-contact cooling water;
- Utility wastewaters;
- General site surface runoff;
- Groundwater (e.g., contaminated groundwaters from on-site or off-site groundwater remediation projects); and
- Other waters generated on site that are not process wastewaters.

Permitting the discharge of such waters and wastewaters must be considered separately from pharmaceutical manufacturing industry process wastewater.

Table 5-1 presents the amount of process wastewater generated daily in the pharmaceutical manufacturing industry that contains the organic pollutants of concern in the pharmaceutical manufacturing industry (see Table 6-1). Table 5-2 presents the amount of process wastewater generated daily which does not contain organic pollutants of concern. Pharmaceutical manufacturing wastewater associated directly with the manufacturing process as well as pump seal water and water from equipment washes is considered process wastewater in Tables 5-1 and 5-2. Table 5-3 presents the amount of wastewater generated daily from the air pollution control devices.

5.2.2 Other Facility Wastewater Sources

In addition to process wastewater, other types of wastewater may be generated during pharmaceutical manufacturing. This wastewater may include noncontact cooling water (used in heat exchangers), noncontact ancillary water (boiler blowdown, bottle washing), sanitary wastewater, and wastewater from other sources (stormwater runoff). Tables 5-4 through 5-7 present the amount of wastewater generated from these sources. Table 5-8 presents the total amount of wastewater generated by pharmaceutical manufacturing facilities by subcategory.

5.3 Wastewater Volume by Type of Discharge

This discusses the types of wastewater discharges which apply to the pharmaceutical manufacturing industry, the discharge status of the pharmaceutical manufacturing facilities, and presents total industry discharge flow rates by type of discharge.

5.3.1 Type of Discharge Definitions

There are three types of discharge which apply to the pharmaceutical manufacturing industry: direct, indirect, and zero discharge. Definitions for these discharge types are listed below.

Direct discharge refers to the discharge of a pollutant or pollutants directly to waters of the United States (not to a publicly owned treatment works). Facilities that directly discharge wastewaters do so under the National Pollutant Discharge Elimination System (NPDES) permit program.

Indirect discharge refers to the discharge of pollutants indirectly to waters of the United States, through publicly owned treatment works (POTWs).

Zero discharge refers to no discharge of pollutants to waters of the United States, as a result of either reuse of process water back into the product, no water use, recycle off site or within the

plant in other processes, or disposal on or off site (e.g., by incineration, evaporation, or deep-well injection) that does not result in discharge to waters of the United States.

5.3.2 Discharge Status of Pharmaceutical Manufacturing Facilities

As discussed in 3.2.4, EPA received 244 responses to the Detailed Questionnaire. A breakdown of facility discharge status for facilities that responded to the Detailed Questionnaire and the 60 indirect discharging Subcategory D facilities with solvent use that were not sent a Detailed Questionnaire are presented in Table 5-9. Seven facilities changed discharge status in the time frame between the screener questionnaire and the Detailed Questionnaire. These facilities reported that they discharged wastewater in the screener questionnaire, but they reported zero discharge in the Detailed Questionnaire.

The flow rate and wastewater characterization data presented in this are representative of these 297 facilities.

5.3.3 Flow Rates by Type of Discharge

The total amount of process wastewater discharged from pharmaceutical manufacturing processes to waters of the United States in 1990 was approximately 104.2 MGD, compared to 105.5 MGD generated. Eighty-one percent of all process wastewater discharged was discharged directly to a receiving stream while 19% was discharged indirectly. Over 93% of the wastewater discharged in the pharmaceutical manufacturing industry is from facilities with fermentation and chemical synthesis operations. Table 5-10 presents the volumes of pharmaceutical process wastewater discharged by subcategory in 1990.

5.4 Water Conservation Measures

Water conservation measures were implemented with regard to process wastewater by 137 of the 244 respondents to the Detailed Questionnaire. Water conservation measures implemented include: careful monitoring of water use, installation of automatic monitoring and alarm systems

on in-plant discharges, implementation of alternative production processes requiring less water, conversion from barometric to surface condensers, reuse of wastewater from other manufacturing processes, reuse of noncontact water as process makeup water, and treatment of contact cooling water to allow reuse. Table 5-11 presents the number of facilities which implemented these water conservation measures.

Table 5-12, based on the responses to the waste minimization of the Detailed Questionnaire, presents the number of facilities reporting a reduction in wastewater generated (expressed as a range in gal/yr) between 1989 and 1990.

5.5 Sources of Wastewater Characterization Data

3.2 described the many wastewater data collection efforts undertaken for development of these final effluent limitations guidelines and standards. Sources that produced data on raw wastewater characteristics included the Detailed Questionnaire and EPA sampling at pharmaceutical manufacturing facilities. Results of these data-gathering efforts are described in more detail below.

5.5.1 Data from the Detailed Questionnaire

The Detailed Questionnaire was used to gather raw wastewater information from pharmaceutical manufacturing facilities for conventional, priority, and nonconventional pollutants. These data are presented in 5.6.

5.5.2 EPA Pharmaceutical Manufacturers Sampling Program

To expand and augment the wastewater characterization data obtained in previous data-gathering efforts, EPA conducted sampling episodes at 13 pharmaceutical manufacturing facilities between 1986 and 1991. Through this sampling effort, EPA verified the presence of many of the conventional, priority, and nonconventional pollutants that were indicated as known or believed to be present in pharmaceutical manufacturing wastewater based on earlier data-gathering efforts.

The sampling program was designed to characterize the wastewaters from both direct and indirect dischargers. Direct dischargers selected for participation in the sampling program were those that met the following criteria:

- The facility attained better than BPT-level annual average effluent concentrations for BOD_5, COD, and TSS with its biological treatment system, and
- The facility's raw wastewater discharge contained significant amounts of volatile organic pollutants.

Indirect dischargers selected for participation in the sampling program were those that discharged significant levels of volatile organic pollutants in their wastewater and/or operated a wastewater pretreatment facility. Because EPA concentrated its sampling efforts at facilities with many pollutants and high concentrations of pollutants, the facilities selected were all Subcategory A and C facilities. 5.6 presents wastewater characterization data from these sampling episodes.

5.6 Wastewater Characterization

The pharmaceutical manufacturing industry generates process wastewaters containing a variety of pollutants. Most of this process wastewater receives some treatment, either in-plant at the process unit prior to commingling with other facility wastewaters or in an end-of-pipe wastewater treatment system. This presents wastewater characterization data for pharmaceutical manufacturing facilities. Data from the Detailed Questionnaire are presented in Sections 5.6.1 through 5.6.3 and data from EPA's sampling program are presented in 5.6.4. 5.6.5 presents a discussion of sulfide and sulfate containing compounds in pharmaceutical wastewaters.

5.6.1 Conventional Pollutants and COD

The two conventional pollutants in pharmaceutical manufacturing wastewater characterized by data from the Detailed Questionnaire are BOD_5 and TSS.

BOD_5, the quantity of oxygen used in the aerobic stabilization of wastewater streams, is the most widely used measure of general organic pollution in wastewater. This analytical determination involves measuring dissolved oxygen used by microorganisms to biodegrade organic matter, and varies with the amount of biodegradable matter that can be assimilated by biological organisms under aerobic conditions. EPA Method 405.1 is used to measure BOD_5. The nature of specific chemicals discharged into wastewater affects the BOD_5 due to the differences in susceptibility of different molecular structures to microbiological degradation. Compounds with lower susceptibility to decomposition by microorganisms or that are toxic to microorganisms tend to exhibit lower BOD_5 values than compounds that biodegrade readily. Consequently, while BOD_5 can provide a gross indication of the presence of organic pollutants, it is not a good indicator for the presence of specific toxic organic pollutants.

Total solids in wastewater is defined as the residue remaining upon evaporation at just above the boiling point. Total Suspended Solids (TSS) consist of the non-filterable residues which are retained by a glass filter and dried to a constant weight at 103-105°C (as specified in EPA Method 160.2). Raw wastewater TSS content is a function of the manufacturing processes, as well as the manner in which fine solids may be removed during a processing step. The total solids are composed of matter which is settleable, in suspension or in solution, and can be organic, inorganic, or a mixture of both. Settleable portions of the suspended solids are usually removed in a primary clarifier. Finer materials are carried through the system, and in the case of an activated sludge system, become enmeshed with the biomass where they are then removed with the sludge during secondary clarification. Some manufacturing facilities may show an increase in TSS in the effluent from the treatment plant. This characteristic is usually associated with biological systems and indicates that secondary clarification may be inefficient in removing secondary solids. Treatment systems that include polishing ponds or lagoons may also exhibit this characteristic due to algae growth.

COD, a nonconventional pollutant, is also characterized in this because it is generally used with BOD_5 as a ratio to determine the amount of pollutants in the wastewater. COD is a measure of organic material in wastewater that can be oxidized as determined by subjecting the waste to a powerful chemical oxidizing agent (such as potassium dichromate or potassium permanganate) in

an acidic medium. COD can be analyzed by EPA Methods 410.1 and 410.2. The COD test can show the presence of organic materials that are not readily susceptible to attack by biological microorganisms. As a result of this difference, COD values are almost invariably higher than BOD_5 values for the same sample. The COD test cannot be substituted directly for the BOD_5 test because the COD/BOD_5 ratio is extremely variable and is dependent on the specific chemical constituents in the wastewater. In addition, the COD test measures refractory organics, which the BOD_5 test does not. A COD/BOD_5 ratio for the wastewater from a single manufacturing facility with a constant product mix or from a single manufacturing process may be established. This ratio is applicable only to the wastewater from which it was derived and cannot be used to estimate the BOD_5 of another facility's wastewater. It is often established by facility personnel to monitor process and treatment plant performance with a minimum of analytical delay.

Information gathered from the 1987 COD study described in 3.2.2 indicates that pharmaceutical manufacturing wastewaters contain COD which is comprised of many organic compounds (not all of which could be identified in the study). One of the objectives of the study was to evaluate the effectiveness of biological treatment and PAC in removing toxic organic compounds, which contribute to the COD effluent concentration. In order to accomplish this objective, aquatic bioassay tests were performed on both raw wastewater and treated effluents from pilot-scale units. Acute and chronic bioassay tests were performed. The acute bioassay tests performed used the median lethal concentration (LC_{50}) as the end point of the test. The LC_{50} value is the concentration of sample which results in the death of half of the test organisms over the duration of the test. The concentration of the sample is expressed in terms of percent effluent, (*i.e.*, 50 percent effluent contains half sample and half dilution water). The chronic bioassay tests performed included the no observed effect concentration (NOEC) and the lowest observed effect concentration (LOEC). The NOEC is the highest concentration of sample which caused no statistically significant adverse effect on the observed organism. The LOEC is the lowest concentration of sample which caused an adverse effect on the organism of interest.

Table 5-13 summarizes the acute bioassay test results. These test results show the raw waste acute toxicity (LC_{50}) is greatly reduced by biological treatment.

The chronic data from both test periods indicate that the raw waste exhibited very high chronic toxicity with respect to both reproduction and survival. Table 5-14 summarizes the chronic bioassay test results.

The results of these tests show that COD is a good measurement of the organic chemical content in wastewaters and thus can be used as a surrogate measurement for the pharmaceutical industry whose wastewaters are dominated by organics. Biological treatment can greatly reduce COD concentrations from raw wastewater and therefore reduce wastewater toxicity.

Untreated wastewater and final effluent wastewater characterization of COD, BOD_5, and TSS was obtained from a table in the Detailed Questionnaire requesting 1990 long-term averages (in mg/L) and flow (in GPD). Table 5-10 presents this information by subcategory and type of discharge. Final effluent data represent the characteristics of wastewater sent to a POTW or discharged to surface water, and do not represent any one level or type of treatment.

Untreated wastewater concentrations and final effluent concentrations reported are not paired data. Low and high concentrations for BOD_5, COD, and TSS presented in Table 5-15 represent the range of values reported and are not from a single facility. The average concentration in the table was calculated by adding the concentration data available from each facility and dividing by the number of facilities.

The summary data shown in Table 5-15 do not necessarily represent only pharmaceutical manufacturing process wastewater, and as a result, for some subcategories, such as the Subcategory C only direct dischargers, the untreated and final effluent wastewater concentrations are biased low. EPA expects the untreated wastewater characteristics of both direct and indirect discharging Subcategory C only facilities to be similar. The similarity in wastewater characteristics between direct and indirect discharging facilities is shown in Table 5-15 for the Subcategory A only, Subcategory A/C (only), and Subcategory A/C (other) facilities, where raw concentrations for BOD5, COD and TSS are similar between direct and indirect dischargers for each respective subcategory.

EPA concludes that the reason for the discrepancy between the direct and indirect discharging Subcategory C only facilities is that wastwater flows and pollutant concentrations do not solely represent flows and concentrations from pharmaceutical manufacturing process wastewater. Rather, they represent flows and concentrations that may include dilution water or water from other sources. Of the eight direct discharging Subcategory C only facilities, six dilute their pharmaceutical wastewater stream, sent through wastewater treatment, with water from other sources to some degree (ranging from 22 percent to greater than 99 percent). These additional water sources may be characterized by lower BOD_5 and COD concentrations, resulting in a low bias of raw wastewater and effluent concentrations for conventional and non-conventional parameters. EPA believes the reported concentrations for Subcategory C only direct discharging facilities represent other water in addition to pharmaceutical manufacturing process wastewater.

Therefore, EPA expects the untreated wastewater pollutant concentrations from Subcategory C only direct dischargers to be similar to wastewater pollutant concentrations from Subcategory C only indirect dischargers, and has determined these concentrations warrant regulation.

5.6.2 Priority Pollutants

Priority pollutants regulated by this final rule (listed in 6.6) were reported as used by 93 pharmaceutical manufacturing facilities in their responses to the Detailed Questionnaire. According to the Detailed Questionnaire, the list of priority pollutants used contained both volatile and semivolatile compounds. The priority pollutants used in the greatest quantities are methylene chloride, toluene, and chloroform. Table 5-16 presents untreated wastewater and final effluent wastewater characterization data for these priority pollutants. Concentrations of priority pollutants in untreated wastewater were calculated from pollutant discharge load information and influent flow rates to the wastewater treatment plant. The pollutant load in untreated wastewater was calculated as the sum of the following: air emissions from wastewater prior to discharge, the pollutant load in wastewater discharged to surface water and/or the sewer, and the pollutant load degraded and/or destroyed in the treatment process. Concentrations of priority pollutants in final effluent wastewater were calculated from the pollutant load in wastewater discharged to surface water and/or the sewer and effluent flow rates from the wastewater treatment plant. Final effluent

concentrations represent the concentration of priority pollutants in the wastewater sent to a POTW or discharged to surface water, and do not represent any one level or type of treatment.

The total mass of priority pollutants in untreated wastewater and final effluent was divided by the respective flow rate to calculate untreated wastewater and final effluent concentrations at each facility. Low and high concentrations presented in Table 5-16 represent the range of total concentration values from the facilities in the subcategory. Average concentrations were calculated by adding the total mass of priority pollutants from each facility with available data and dividing by the sum of the flows at these facilities. Discharge loads of specific priority pollutants are presented in 9.

5.6.3 Nonconventional Pollutants

Nonconventional pollutants regulated by this final rule (listed in 6.7) were reported as used by 225 pharmaceutical manufacturing facilities in their responses to the Detailed Questionnaire. According to the respondents, the nonconventional pollutants used in the largest quantities are methanol, ethanol, acetone, and isopropanol. Table 5-17 presents untreated wastewater and final effluent wastewater characterization data for these nonconventional pollutants.

The nonconventional pollutant COD is discussed in 5.6.1 because COD data were collected in the same manner as BOD_5 and TSS data. In addition, COD/BOD_5 ratios are used by facilities to monitor pharmaceutical manufacturing processes and treatment plant performance.

Ammonia is shown separately in Table 5-17 since it is not an organic compound and has rather distinct characteristics. Sampling data in the treatment performance database for ammonia are reported as ammonia as nitrogen (N) concentrations. Ammonia loads reported in the 1990 Detailed Questionnaire represent ammonium hydroxide load. To provide a consistent basis of comparison when examining ammonia discharge loads, the ammonium hydroxide loads were converted to ammonia as N loads, by multiplying the ammonium hydroxide load by 0.4. This multiplier accounts for the stoichiometric difference between nitrogen and ammonia and ammonium hydroxide.

In Table 5-17, concentrations of nonconventional pollutants in untreated wastewater were calculated from pollutant discharge load information and influent flow rates to the wastewater treatment plant reported in the 1990 Detailed Questionnaire. The pollutant load in untreated wastewater was calculated as the sum of the following: air emissions from wastewater prior to discharge, the pollutant load in wastewater discharged to surface water and/or the sewer, and the pollutant load degraded and/or destroyed in the treatment process. Concentrations of nonconventional pollutants in final effluent wastewater were calculated from the pollutant load in wastewater discharged to surface water and/or the sewer and effluent flow rates from the wastewater treatment plant. Final effluent concentrations represent the concentration of nonconventional pollutants in the wastewater sent to a POTW or discharged to surface water, and do not represent any one level or type of treatment.

The total mass of nonconventional pollutants in untreated wastewater and final effluent was divided by the respective flow rate to calculate untreated wastewater and final effluent concentrations at each facility. Low and high concentrations presented in Table 5-17 represent the range of concentration values from the facilities in the subcategory. Average concentrations were calculated by adding the total mass of nonconventional pollutants from each facility with available data and dividing by the sum of the flows at these facilities. Discharge loads of specific nonconventional pollutants are presented in 9.

5.6.4 Sampling Data

Table 5-18 summarizes untreated wastewater and final effluent wastewater characterization data from EPA sampling episodes. Priority and nonconventional pollutants in the table refer to pollutants proposed for regulation in Sections 6.6 and 6.7. Untreated wastewater data were collected from 11 of the 13 pharmaceutical facilities sampled. Final effluent data were collected from 8 of the 13 pharmaceutical facilities sampled. Final effluent wastewater characterization data do not represent any one level or type of treatment. Treatment performance data for specific treatment technologies are presented in 8.

Untreated wastewater concentrations and final effluent concentrations reported are not paired data. Low and high concentrations for ammonia as N, COD, nonconventional organics, and priority organics presented in Table 5-18 represent the range of values reported and are not from a single facility. The priority organic and nonconventional organic concentrations presented are the sum of the concentrations of individual organic constituents detected at the respective facilities. The average concentration was calculated by adding the concentration data available from each facility and dividing by the number of facilities. Full sets of sampling characterization data can be found in the sampling episode reports in the Record for this rulemaking.

5.6.5 Sulfide/Sulfate Containing Compounds

EPA has discussed with representatives of POTWs which receive pharmaceutical manufacturing wastewaters concerns related to sulfide/sulfate containing compounds discharged into POTW sewer systems. Sulfide and sulfate containing compounds discharged to POTW sewers are converted to hydrogen sulfide and released into the air under low pH conditions in the sewer lines or pumping stations leading to the POTW. The hydrogen sulfide that is produced has been measured at concentrations that create a worker safety concern and may also be an explosion concern. For example, EPA received comments from a POTW that documents on case of both worker health and safety problems along with corrosion problems as a result of pharmaceutical waste containing high sulfates converting to hydrogen sulfide in the collection system. Current treatment approaches that the Agency is aware of to reduce hydrogen sulfide emissions from POTW sewer lines include pH monitoring and the addition of ferrous chloride to sequester the sulfides in wastewater and also the addition of peroxide at pumping stations to oxidize hydrogen sulfide. Generation of hydrogen sulfide is a common concern related to the handling of untreated sewage. However, due to a lack of data specific to the discharge and treatment of these compounds in the pharmaceutical manufacturing industry, EPA did not further consider these pollutants in developing national standards. Specific problems related to sulfide/sulfate containing compounds discharged by pharmaceutical manufacturing facilities should be addressed on a case-by-case basis.

Table 5-1

Process Wastewater Generated Which Contains Organic Compounds

Subcategory and Discharge Mode	Average Quantity Generated (MGD)
A and/or C Direct	77.62
A and/or C Indirect	10.54
B and/or D Direct	0.15
B and/or D Indirect	3.12
Total	**91.43**

Table 5-2

Process Wastewater Generated Which Does Not Contain Organic Compounds

Subcategory and Discharge Mode	Average Quantity Generated (MGD)
A and/or C Direct	5.45
A and/or C Indirect	5.03
B and/or D Direct	1.29
B and/or D Indirect	2.31
Total	**14.08**

Table 5-3

Wastewater Resulting From Air Pollution Control

Subcategory and Discharge Mode	Average Quantity Generated (MGD)
A and/or C Direct	1.85
A and/or C Indirect	2.14
B and/or D Direct	0.01
B and/or D Indirect	0.33
Total	**4.33**

Table 5-4

Wastewater Resulting From Noncontact Cooling Water

Subcategory and Discharge Mode	Average Quantity Generated (MGD)
A and/or C Direct	55.71
A and/or C Indirect	42.36
B and/or D Direct	10.72
B and/or D Indirect	4.99
Total	**113.78**

Table 5-5

Wastewater Resulting From Noncontact Ancillary Water

Subcategory and Discharge Mode	Average Quantity Generated (MGD)
A and/or C Direct	16.72
A and/or C Indirect	4.24
B and/or D Direct	0.83
B and/or D Indirect	2.24
Total	**24.03**

Table 5-6

Sanitary Wastewater

Subcategory and Discharge Mode	Average Quantity Generated (MGD)
A and/or C Direct	1.10
A and/or C Indirect	4.46
B and/or D Direct	0.77
B and/or D Indirect	2.96
Total	**9.29**

Table 5-7

Wastewater From Other Sources

Subcategory and Discharge Mode	Average Quantity Generated (MGD)
A and/or C Direct	3.22
A and/or C Indirect	2.44
B and/or D Direct	0.48
B and/or D Indirect	3.34
Total	**9.48**

Table 5-8

Total Amount of Wastewater Generated from Pharmaceutical Manufacturing Facilities

Subcategory and Discharge Mode	Total Quantity Generated (MGD)
A and/or C Direct	161.67
A and/or C Indirect	71.21
B and/or D Direct	14.25
B and/or D Indirect	19.29
Total	**266.42**

Table 5-9

Facility Discharge Status by Subcategory

Subcategory	Number of Direct Discharge Facilities	Number of Indirect Discharge Facilities	Number of Facilities That Have Both Direct and Indirect Discharges	Total
A/C	23	88	1	112
B/D	12	171	2	185
Total	35	259	3	297[(a)]

(a) Seven facilities reported zero discharge in the Detailed Questionnaire.

Table 5-10

Volume of Process Wastewater Discharged by Subcategory

Subcategory	Volume of Process Wastewater Discharged to Surface Water (MGD)	Volume of Process Wastewater Discharged to POTW (MGD)	Total Process Water Discharged (MGD)
A/C	82.78	14.77	97.55
B/D	1.44	5.21	6.65
Total	84.20	19.98	104.20

Table 5-11

Water Conservation Measures Implemented For Process Wastewater[(a)]

Water Conservation Measure	Implemented Last 5 Years	Implemented Earlier	Total Responses
Careful monitoring of water use	79	58	137
Installation of automatic monitoring and alarm systems on in-plant discharges	36	20	56
Implementation of alternative production processes requiring less water	20	6	26
Conversion from barometric to surface condensers	6	12	18
Reuse of noncontact water as process makeup water	3	6	9
Reuse of wastewater from other manufacturing processes	6	3	9
Treatment of contact cooling water to allow reuse	4	4	8

(a)Of the 244 facilities completing the Detailed Questionnaire, 137 responded that water conservation measures were implemented with regard to process wastewater.

Table 5-12

Number of Facilities Reporting a Reduction in Wastewater Generated between 1989 and 1990

Reduction in Wastewater Quantity (gal/yr)	Number of Facilities
1 - 9,999	7
10,000 - 99,999	7
100,000 - 499,999	9
500,000 - 1,000,000	0
> 1,000,000	3
Total Number of Facilities	26

Table 5-13

COD Acute Bioassay Test Results

Acute Toxicity (48 Hours) using Ceriodaphia Dubia		
	Raw Waste LC_{50}[(a)]% (COD, mg/l)	Biological Treatment Effluent LC_{50}[(a)], % (COD, mg/l)
Test Period 1	0.81 (5,032)	46 (654)
Test Period 2	1.0 (5,694)	14 (532)

(a) LC_{50} - The concentration of sample (percent wastewater) which results in the death of half of the test organisms. Reported results are average values from four sets of daily tests for each test period.

Table 5-14

COD Bioassay Test Results

Chronic Toxicity (7 days) using Ceriodaphnia Dubia					
		Test Period 1 NOEC[(a)], %	Test Period 1 LOEC[(b)], %	Test Period 2 NOEC[(a)], %	Test Period 2 LOEC[(b)], %
Raw Waste	Survival	0.39	0.66	0.5	1
	Reproduction	<0.03	0.05	<0.01	0.01
Biological Treatment Effluent	Survival	33.3	>50.0	9.0	18.5
	Reproduction	<3.0	4.0	0.75	2.0

(a)NOEC = the highest concentration of sample which caused no statistically significant adverse effect on the observed organism. Reported results are average values from up to four sets of daily tests for each test period.
(b)LOEC = The lowest concentration of sample which caused an adverse effect on the organism of interest. Reported results are average values from up to four sets of daily tests for each test period.

Table 5-15

BOD_5, COD, and TSS Concentrations in Untreated Wastewater and Final Effluent

Type of Discharge	Current Subcategory	Pollutant	Untreated Wastewater Conc. (mg/L)			Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
			Low	High	Ave.	Low	High	Ave.	Low	High	Ave.
Direct	A only	BOD_5	3,360	5,600	4,480	66	189	128	493	1,250	872
		COD	9,100	10,900	10,000	1,400	1,700	1,550	493	1,250	872
		TSS	264	2,490	1,380	97	264	180	493	1,250	872
	C only	BOD_5	NA	812	218	0	15	8	0	344	142
		COD	NA	1,890	718	0	923	268	0	344	142
		TSS	NA	131	55	0	53	33	0	344	142
	A and C only(a)	BOD_5	22	2,620	975	8	211	90	202	73,300	21,000
		COD	216	5,280	2,410	216	834	530	202	73,300	21,000
		TSS	39	849	332	9	232	122	202	73,300	21,000
	Other(b)	BOD_5	11	9,700	2,230	8	68	35	51	2,000	1,000
		COD	123	16,500	4,050	123	679	277	51	2,000	1,000
		TSS	40	383	185	12	143	71	51	2,000	1,000
Indirect	A only(a)	BOD_5	NA	NA	2,690	300	2,690	1,500	47	786	424
		COD	NA	NA	NA	NA	NA	566	47	786	424
		TSS	NA	NA	757	757	1,560	1,160	47	786	424
	C only(a)	BOD_5	1,250	5,430	3,470	23	5,300	1,090	0	1,620	169
		COD	1,200	22,200	7,980	267	22,200	4,030	0	1,620	169
		TSS	19	1,000	265	14	2,110	254	0	1,620	169
	A and C only(a)	BOD_5	NA	1,770	885	0	1,770	885	16	2,540	1,280
		COD	NA	4,390	2,200	0	4,390	2,200	16	2,540	1,280
		TSS	NA	888	444	0	888	444	16	2,540	1,280
	Other(a,b)	BOD_5	95	11,500	2,540	0	32,800	2,400	0	7,310	494
		COD	152	19,700	4,750	282	19,700	3,030	0	7,310	494
		TSS	14	6,070	820	0	5,810	565	0	7,310	494

Table 5-15 (Continued)

Type of Discharge	Current Subcategory	Pollutant	Untreated Wastewater Conc. (mg/L)			Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
			Low	High	Ave.	Low	High	Ave.	Low	High	Ave.
Direct	B only	BOD_5	-	-	-	-	-	-	-	-	-
		COD	-	-	-	-	-	-	-	-	-
		TSS	-	-	-	-	-	-	-	-	-
	D only	BOD_5	NA	328	117	0	145	17	2	692	110
		COD	NA	1,140	271	0	1,140	123	2	692	110
		TSS	2	306	63	2	34	11	2	692	110
	B and D only	BOD_5	NA	NA	53	NA	NA	4	NA	NA	63
		COD	NA	NA	27	NA	NA	27	NA	NA	63
		TSS	NA	NA	16	NA	NA	16	NA	NA	63
Indirect	B only(a)	BOD_5	1,850	2,350	2,100	300	2,350	1,500	2	165	28
		COD	59	3,110	1,240	59	4,480	1,740	2	165	28
		TSS	81	552	250	9	552	209	2	165	28
	D only(a)	BOD_5	NA	4,650	601	0	4,950	580	0	42,600	680
		COD	NA	6,610	907	0	2,660	502	0	42,600	680
		TSS	NA	2,060	283	0	2,410	238	0	42,600	680
	B and D only(a)	BOD_5	150	2,940	800	10	307	140	1	1,050	186
		COD	184	2,600	1,070	184	413	282	1	1,050	186
		TSS	24	743	265	24	100	63	1	1,050	186

(a)Some of these facilities provided BOD_5, COD, and TSS loadings and flows by stream. The loadings and flows were summed for all streams in the facility, and the total concentration and flow were used in this average.

(b)"Other Subcategory" denotes facilities which manufacture products in the following subcategories or subcategory combinations: ABD, ACD, AD, CD, ABCD, AB, BC, ABC, and BCD.

NA - Not available.

Table 5-16

Cyanide and Total Priority Organic Pollutant Concentrations in Pharmaceutical Manufacturing Process Wastewater

Type of Discharge	Current Subcategory	Cyanide or Priority	# of Facilities Contributing Data	Untreated Wastewater Conc. (mg/L)			Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
				Low	High	Ave.	Low	High	Ave.	Low	High	Ave.
Direct	A only	C	0									
		P	0									
	C only	C	1	-	-	4,850	-	-	5	-	-	2
		P	4	0.4	404	196	0	5	2	3	1,340	389
	A and C only	C	1	-	-	1,730	-	-	0.4	-	-	3
		P	4	20	657	306	0	17	5	114	7,210	2,160
	Other(a)	C	1	-	-	38	-	-	0.2	-	-	3
		P	6	0.3	11,900	2,860	0	141	28	21	1,220	379
Indirect	A only	C	0									
		P	0									
	C only	C	1	-	-	5	-	-	0.4	-	-	1
		P	17	0.2	4,850	589	0	1,280	94	0	862	121
	A and C only	C	0									
		P	1	-	-	619	-	-	61	-	-	154
	Other(a)	C	2	229	850	539	0	1	0.5	0	30	15
		P	32	0	79,900	3,630	0	79,900	2,670	0	1,010	201
Direct	B only	P	0									
	D only	P	3	0.2	30	10	0	0	0	11	34	21
	B and D only	P	0									

Table 5-16 (Continued)

Type of Discharge	Current Subcategory	Cyanide or Priority	# of Facilities Contributing Data	Untreated Wastewater Conc. (mg/L)			Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
				Low	High	Ave.	Low	High	Ave.	Low	High	Ave.
Indirect	B only	P	1	-	-	691	-	-	0	-	-	11
	D only	P	23	0.00	31,400	1,450	0	31,400	1,380	0	278	28
	B and D only	P	2	14.65	350	182	2	15	8	13	676	345

(a)"Other subcategory" denotes facilities which manufacture products in the following subcategories or subcategory combinations: ABD, ACD, AD, CD, ABCD, AB, BC, ABC, and BCD. P - Priority organic pollutants.
C - Cyanide.
B and D facilities did not report any cyanide in their loads or waste streams.

Table 5-17

Ammonia and Total Nonconventional Organic Pollutant Concentrations in Pharmaceutical Manufacturing Process Wastewater

Type of Discharge	Current Subcategory	Ammonia or Nonconventional	# of Facilities Contributing Data	Untreated Wastewater Conc. (mg/L)			Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
				Low	High	Ave.	Low	High	Ave.	Low	High	Ave.
Direct	A only	N	0									
		A	0									
	C only	N	5	16	15,600	3,270	0.3	155	36	3	1,340	322
		A	1	-	-	91.2	-	-	15.6	-	-	1,340
	A and C only	N	4	282	7,450	3,030	0	138	35	114	7,210	2,160
		A	1	-	-	8.4	-	-	7.6	-	-	7,210
	Other(a)	N	8	114	39,500	9,930	0	432	110	21	1,220	298
		A	5	0.02	337	133	0	240	60.4	21	720	224
Indirect	A only	N	2	54	107	81	54	107	81	24	800	412
		A	1	-	-	0.02	-	-	0.02	-	-	24
	C only	N	21	0	54,100	7,530	0	20,800	2,760	0	862	99
		A	12	4	379	142	0	350	46.4	0	862	153
	A and C only	N	2	6,860	20,800	13,900	1,720	20,800	11,300	0	154	77
		A	0									
	Other(a)	N	52	0	385,000	12,900	0	366,000	10,200	0	1,010	134
		A	27	0	87,200	3,556	0	4,640	180	0	987	187
Direct	B only	N	0									
		A	0									
	D only	N	7	0	14,300	3,130	0	6,110	928	0	20	6
		A	1	-	-	0.3	-	-	0	-	-	13
	B and D only	N	1	-	-	6	-	-	6	-	-	63
		A	0									

Table 5-17 (Continued)

Type of Discharge	Current Subcategory	Ammonia or Nonconventional	# of Facilities Contributing Data	Untreated Wastewater Conc. (mg/L)			Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
				Low	High	Ave.	Low	High	Ave.	Low	High	Ave.
Indirect	B only	N	7	0	2,010	694	0	1,700	423	0	200	32
		A	1	-	-	6.4	-	-	0	-	-	1
	D only	N	54	0	492,000	12,900	0	492,000	10,600	0	309	23
		A	4	0.2	139	39.6	0	17.6	4.8	0	5	2
	B and D only	N	9	45	49,700	9,200	45	48,400	6,840	0	676	101
		A	0	-								

(a)"Other subcategory" denotes facilities which manufacture products in the following subcategories or subcategory combinations: ABD, ACD, AD, CD, ABCD, AB, BC, ABC, and BCD
A - Ammonia as N (where ammonium hydroxide x 0.4 (mg) = ammonia as N (mg))
N - Nonconventional organic pollutants

Table 5-18

Pharmaceutical Manufacturing Industry Wastewater Characterization Data Based on EPA Sampling Episodes

Type of Discharge	Sub-category	Pollutant	# of Data Points	Untreated Wastewater Conc. (mg/L)			Flow (1,000 GPD)			# of Data Points	Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
				Low	High	Ave.	Low	High	Ave.		Low	High	Ave.	Low	High	Ave.
Direct	C only	Ammonia as N	2	170	220	195	1,830	1,960	1,900	2	120	130	125	1,830	1,960	1,900
		COD	3	2,200	4,100	2,870	1,830	2,120	1,970	2	380	400	390	1,830	1,960	1,900
		Total non-conventional organics	3	18	190	104	1,960	2,120	2,070	2	0.1	0.2	0.1	1,830	1,960	1,900
		Total priority organics	6	1	12	6	1,830	2,120	2,050	3	0.04	0.2	0.1	1,830	1,960	1,920
	A and C only	Ammonia as N	20	0.5	100	24	950	32,500	4,450	24	0.5	160	58	950	50,000	12,000
		COD	17	63	10,000	3,940	950	32,500	4,320	18	63	2,200	567	950	50,000	6,850
		Total non-conventional organics	53	0.1	236	48	950	32,500	2,560	34	0.1	8	1	1,100	50,000	12,000
		Total priority organics	70	0.08	1,440	207	950	32,500	2,210	48	0.06	4	1	950	50,000	6,430
	Other(a)	Ammonia as N	6	23	49	42	920	1,120	1,030	10	1	4	3	860	1,090	1,020
		COD	6	4,800	6,500	5,450	920	1,120	1,030	11	400	550	482	860	1,210	1,040
		Total non-conventional organics	86	1,530	2,980	2,140	920	1,120	1,060	47	15	101	26	860	1,210	1,060
		Total priority organics	42	6	11	8	920	1,120	1,030	2	0.1	0.1	0.1	990	990	990

Table 5-18 (Continued)

Type of Discharge	Sub-category	Pollutant	# of Data Points	Untreated Wastewater Conc. (mg/L)			Flow (1,000 GPD)			# of Data Points	Final Effluent Conc. (mg/L)			Flow (1,000 GPD)		
				Low	High	Ave.	Low	High	Ave.		Low	High	Ave.	Low	High	Ave.
Indirect	A and C only	Ammonia as N	2	26	35	31	1,860	1,860	1,860	0	NA	NA	NA	NA	NA	NA
		COD	2	9,700	10,000	9,850	1,860	1,860	1,860	0	NA	NA	NA	NA	NA	NA
		Total non-conventional organics	2	1	2	2	1,860	1,860	1,860	0	NA	NA	NA	NA	NA	NA
		Total priority organics	4	0.06	0.6	0.4	1,860	1,860	1,860	0	NA	NA	NA	NA	NA	NA
	Other(a)	Ammonia as N	7	6	81	37	160	2,950	1,510	6	55	190	102	700	1,930	972
		COD	11	1,600	14,000	7,230	80	2,950	1,160	7	800	12,000	4,380	700	2,120	1,140
		Total non-conventional organics	22	2	1,910	412	80	2,950	1,310	9	0.1	2,160	691	700	2,120	1,360
		Total priority organics	24	8	312	62	80	2,950	1,410	13	0.2	13	5	700	2,120	1,470

(a)"Other subcategory" denotes facilities which manufacture products in the following subcategories or subcategory combinations: ABD, ACD, AD, CD, ABCD, AB, BC, ABC, and BCD.
NA - Not available.

REFERENCES

1. Memorandum: The COD of Pharmaceutical Wastewaters, from Frank Hund to the Public Record. April 1, 1988.

2. Memorandum from Alan Messing, DynCorp-Viar. April 4, 1994.

SECTION 6

POLLUTANTS SELECTED FOR REGULATION

6.1 Introduction

EPA has reviewed wastewater characterization data available from the Detailed Questionnaire responses and EPA sampling results to determine the presence or absence of conventional, nonconventional, and priority pollutants in pharmaceutical manufacturing process wastewaters. Using this information, EPA determined pollutants likely to be present and pollutants identified as being discharged by the pharmaceutical manufacturing industry. This presents the results of that study and identifies the pollutants and pollutant parameters the Agency is regulating under BPT, BCT, and BAT effluent limitations guidelines and NSPS, PSNS, and PSES, as appropriate.

EPA is authorized to regulate conventional and priority pollutants under Sections 304(a)(4) and 301(b)(2)(C) of the Clean Water Act (CWA), respectively. The list of toxic pollutants from 307 of the CWA has been expanded to include 126 priority pollutants identified in the Settlement Agreement of NRDC vs. Train.(1) In addition, the Agency may also regulate other nonconventional pollutants, taking into account factors such as treatable amounts, toxicity, analytical methods, frequency of occurrence, use of indicator pollutants, and the pass through of pollutants at Publicly Owned Treatment Works (POTWs).

The following information is discussed in these sections:

- 6.2 discusses the pollutants considered for regulation;
- 6.3 discusses the pollutants discharged by the pharmaceutical manufacturing industry;
- 6.4 presents the pollutant selection evaluation criteria;
- 6.5 discusses the conventional pollutants considered and selected for regulation;

- 6.6 discusses the priority pollutants considered and selected for regulation; and

- 6.7 discusses the nonconventional pollutants considered and selected for regulation.

6.2 Pollutants Considered for Regulation

Prior to 1986, the Agency's regulatory focus for the pharmaceutical manufacturing industry was on five conventional pollutants and 126 priority pollutants. In 1986, the Agency expanded the analysis of the industry's wastewater to determine the presence and levels of the Industrial Technology Division (ITD) List of Analytes, which was derived from the ITD List of Lists, as described in 3.2.3. The List of Analytes was revised in 1990 to include 458 analytes. EPA conducted a study to determine which of these 458 analytes could potentially be discharged in pharmaceutical manufacturing wastewaters in significant amounts. The study included a review of the prior pharmaceutical rulemaking and available literature, an evaluation of EPA and industry sampling data obtained prior to 1986, data reported in the Detailed Questionnaire, data submitted by the industry in connection with the Detailed Questionnaire, data obtained from EPA sampling at pharmaceutical manufacturing facilities, and industry-supplied corrections to the Detailed Questionnaire data.(2) These data-collection efforts were discussed in greater detail in 3.

The Agency's evaluation of the industry resulted in a list of 146 conventional, nonconventional, and priority pollutants and pollutant parameters which may be present in the industry's wastewater (see Table 6-1). The pollutants and pollutant parameters identified as likely to be present are predominantly volatile and semivolatile organic compounds. Other parameters which may be present are ammonia and cyanide. Although metals are used in some pharmaceutical manufacturing processes, they were not discharged at concentrations high enough to warrant control on an industry-wide basis. 3 describes in detail the criteria used by the Agency to identify those pollutants which may be present in the industry's wastewater.

6.3 Pollutants Discharged by the Pharmaceutical Industry

EPA requested discharge information on 143 of the 146 pollutants and pollutant parameters which may be present in the industry's wastewater in the Detailed Questionnaire sent to pharmaceutical manufacturing facilities in Subcategories A, B, C, and D. Discharge information was not collected on pH, oil and grease, and fecal coliform. Regulations governing control of pH in pharmaceutical manufacturing wastewater are not being revised. Oil and grease and fecal coliform are not significant pollutants in this industry. The Agency used the responses to this questionnaire to identify which of the pollutants likely to be present were being discharged by the industry.

Responses to 3-1 of the Detailed Questionnaire indicated that the following 17 priority pollutants and 36 nonconventional pollutants identified as potentially present in the industry's wastewater were not reported as discharged in pharmaceutical manufacturing wastewaters in 1990:

Priority Pollutants Not Reported as Discharged	
Acrolein	1,2-Dichloropropane
Acrylonitrile	Hexachlorocyclapentadiene
Benzidine	Hexachloroethane
Bromoform	Nitrobenzene
Bromomethane	2-Nitrophenol
Chloroethane	4-Nitrophenol
p-Dichlorobenzene	Trichloroethylene
1,1-Dichloroethane	Vinyl Chloride
1,1-Dichloroethene	
Nonconventional Pollutants Not Reported as Discharged	
Acetophenone	N-Dipropylamine
4-Aminobiphenyl	Epichlorohydrin
Benzotrichloride	Ethyl Cyanide
Benzyl Bromide	2-Hexanone
Biphenyl	Iodoethane
2-Bromo-Propanoylbromide	2-Methoxyaniline
N-Butylamine	Methyl Methacrylate

Nonconventional Pollutants Not Reported as Discharged	
sec-Butyl Alcohol	N-Nitrosomorpholine
Catechol	n-Pentane
2-Chloroacetophenone	B-Propiolactone
3-Chloro-4-Fluoroaniline	1,3-Propane Sulfone
Chloromethyl Methyl Ether	Propionaldehyde
Cresol (Mixed)	1,2-Propyleneimine
Cumene	Styrene
1,2-Dibromoethane	Tetrachloroethene
Diethyl Carbonate	1,2-trans-Dichloroethene
Diethyl-ortho Formate	2,4,5-Trichlorophenol
1,1-Dimethylhydrazine	Vinyl Acetate

These 17 priority and 36 nonconventional pollutants were excluded from consideration for regulation, leaving 90 conventional, priority, and nonconventional pollutants and pollutant parameters reported as discharged as potential candidates for regulation.

6.4 Pollutant Selection Evaluation Criteria

Having identified those pollutants of concern being discharged by the pharmaceutical manufacturing industry, the Agency next considered which of those pollutants should be controlled. The NRDC Consent Decree included a defined set of criteria for selecting pollutant parameters to be regulated.(1) While no longer bound by the conditions of the NRDC Consent Decree, the Agency used a similar screening protocol for selecting pollutants and pollutant parameters for this regulation. Pollutants were excluded from consideration for regulation based on the following criteria:

- The pollutant is discharged in relatively small amounts (<3,000 lbs per year) and is neither causing nor likely to cause toxic effects;
- The pollutant is not effectively treated by the use of treatment technologies selected under BAT or PSES;
- The pollutant is reported or detected in the effluent from a small number of sources, and is uniquely related to these sources;

- The pollutant cannot be analyzed by EPA-approved or other state-of-the-art established methods;
- Additionally, pollutants considered for regulation that were found to have minimal load reduction through implementation of BAT and PSES for A/C and B/D subcategories were not selected for regulation.

The Agency considered the available pollutant data (from existing rulemakings and available literature, evaluation of existing data, data obtained from the Detailed Questionnaire, data submitted by industry, and data obtained from EPA sampling at pharmaceutical manufacturing facilities) against the selection criteria cited above. Sections 6.4.1 through 6.4.4 summarize EPA's assessment of these evaluation criteria for 86 priority and nonconventional pollutants discharged by the pharmaceutical manufacturing industry. The other 4 of the 90 constituents identified as being discharged by the pharmaceutical manufacturing industry (cyanide, COD, and the conventional pollutants BOD_5 and TSS) are considered in Sections 6.5, 6.6, and 6.7. Table 6-2 summarizes the information obtained for each of the 86 priority and nonconventional pollutants identified as discharged by the pharmaceutical manufacturing industry.

6.4.1 Quantity Discharged

The quantity of each of the 86 priority and nonconventional pollutants discharged by the pharmaceutical manufacturing industry in 1990 ranged from 1 lb/yr to 13,200,000 lbs/yr. Table 6-2 lists these pollutants by total quantity discharged in process wastewaters. Table 6-2 also presents the percentage of total organic loading contributed by each constituent. Those pollutants discharged at 98,400 lbs/yr and above represent approximately 99% of the total organic loading discharged in 1990.

6.4.2 Treatability

Pollutant treatability was evaluated for the two main technologies utilized by the pharmaceutical manufacturing industry, biological treatment and steam stripping. Steam stripping treatability was evaluated using a pollutant's Henry's Law Constant. Biological treatability was evaluated by considering available biotreatability rate constants (Kmax) and/or the ratio of BOD to theoretical

oxygen demand (ThOD) (4,5). Henry's Law and Kmax constants, as well as the BOD/ThOD ratio, are general indicators of treatability. All pollutants were found to be treatable by either steam stripping or biological treatment.

6.4.3 Number of Facilities Discharging Pollutants

Table 6-2 lists the number of facilities reporting discharges of each pollutant and the number of facilities reporting a pollutant in their raw 1990 loads.

Some pollutants were found to be discharged by only one facility in 1990 and were unique to that one facility. Other pollutants such as benzene were reported as discharged by only one facility in 1990 but were present at more than one facility. Due to the variable nature of this industry, EPA has not excluded pollutants for regulation that may be present at more than one facility and are discharged in significant amounts. Benzene is a good case in point, since even though only one facility identified it as discharged in 1990 it was found to be present in 10 of the samples taken by EPA in August 1996 at the Barceloneta Regional Wastewater Treatment Plant which is a POTW that receives predominately pharmaceutical wastewaters along with domestic and food-processing wastewaters.

6.4.4 Load Removed

After identifying pollutants to be considered, EPA analyzed the load reduction of these pollutants. 9 provides specific information on calculation of pollutant loads and pollutant load reduction. Table 6-5 presents the pollutant load reductions expected through implementation of BAT and PSES regulations for A/C and B/D facilities.

6.5 Conventional Pollutants Considered and Selected for Regulation

Conventional pollutants include BOD_5, TSS, fecal coliform, pH, and oil and grease. These pollutants are general indicators of water quality rather than specific compounds. BOD_5, TSS,

and pH are regulated by current BPT limitations; with this final rule, EPA is retaining the existing BPT limitations for BOD_5, TSS, and pH.

Oil and grease and fecal coliform were not considered for regulation in the pharmaceutical manufacturing industry. Although oil and grease may appear in some plant process wastewater, it is not sufficiently widespread or discharged at concentrations high enough to justify regulation on an industry-wide basis. Fecal coliform is related to sanitary discharges and not discharges from specific pharmaceutical manufacturing process wastewaters and, therefore, was also not considered for regulation.

6.6 Priority Pollutants Considered and Selected for Regulation

6.6.1 Priority Pollutants Considered for Regulation

Thirty-two priority pollutants were considered for regulation in the pharmaceutical manufacturing industry (see Table 6-1). Seventeen of these were not reported as discharged in pharmaceutical manufacturing wastewaters based on the Detailed Questionnaire. Of the fifteen remaining, six were not selected for regulation because they were discharged on an industry-wide basis at less than 3,000 lbs/yr. A review of their treatability, treatment performance data availability, number of facilities discharging, analytical methods, and load discharged does not support the need for regulation. Table 6-3 lists these six priority pollutants and the reasons for their exclusion from the list of pollutants to regulate. The remaining 9 were identified as candidates for regulation:

Benzene
Chlorobenzene
Chloroform
Cyanide
o-Dichlorobenzene (1,2-Dichlorobenzene)
1,2-Dichloroethane
Methylene chloride
Phenol
Toluene

6.6.2 Priority Pollutants Selected for Regulation

EPA analyzed the load reduction of these nine priority pollutants expected through implementation of BAT and PSES for A/C and B/D subcategories. 9 provides specific information on calculation of pollutant loads and pollutant load reduction. Table 6-5 presents the expected pollutant load reductions. The Agency has previously regulated cyanide in the pharmaceutical manufacturing industry under BPT and is not revising those regulations for Subcategories A and C. The previous cyanide regulation is being withdrawn for Subcategories B and D, because EPA has determined that cyanide is neither used nor generated by facilities with these subcategory operations.

For A/C facilities, the remaining eight priority pollutants have been selected for regulation:

Benzene
Chlorobenzene
Chloroform
o-Dichlorobenzene (1,2-Dichlorobenzene)
1,2-Dichloroethane
Methylene chloride
Phenol
Toluene

For B/D facilities, seven of the remaining eight priority pollutants were found to have minimal load reduction under the selected regulatory options (in all cases less than 75 lbs/year), and therefore have not been selected for regulation.

Benzene
Chlorobenzene
Chloroform
o-Dichlorobenzene (1,2-Dichlorobenzene)
1,2-Dichloroethane
Phenol
Toluene

The remaining priority pollutant selected for regulation at B/D facilities is methylene chloride.

6.7 Nonconventional Pollutants Selected for Regulation

6.7.1 Nonconventional Pollutants Considered for Regulation

One hundred and nine nonconventional pollutants were considered for regulation in the pharmaceutical manufacturing industry (see Table 6-1). Thirty-six of these were not reported as discharged in pharmaceutical manufacturing wastewaters from process wastewaters based on the Detailed Questionnaire. Of the remaining 73 nonconventional pollutants considered, 34 were not selected for regulation for the following reasons:

- Twenty-seven pollutants were discharged on an industry-wide basis at less than 3,000 lbs/yr. A review of their treatability, treatment performance data availability, number of facilities discharging, analytical methods, and load discharged does not support the need for regulation.
- Acetic acid and formic acid were excluded due to their low toxicity and because they will be treated by normal pH control measures as required by the pH range specified within the regulation.
- Glycol ethers were excluded due to the lack of an available analytical method. Methyl cellosolve, the predominant glycol ether reported as being used by the industry, has been selected for regulation at subcategory A/C facilities, where it is found.
- Dimethyl carbamyl chloride and Bis(chloromethyl)ether were excluded because they hydrolize in water and therefore do not persist in water.
- 2-methylpyridine was excluded because the pollutant is reported or detected in the effluent from one source and is uniquely related to this source.
- Trichlorofluoromethane was excluded because the pollutant was detected in the effluent from one source and is uniquely related to this source.

Table 6-4 lists these 34 nonconventional pollutants and the reasons for their exclusion from the list of pollutants to regulate. The remaining 39 were identified by the Agency as candidates for regulation:

Acetone
Acetonitrile
Ammonia
n-Amyl acetate
Amyl alcohol
Aniline
2-Butanone (MEK)
n-Butyl acetate
n-Butyl alcohol
tert-Butyl alcohol
COD (Chemical Oxygen Demand)
Diethylamine
N,N-Dimethylacetamide
N,N-Diemethylaniline
N,N-Dimethylformamide
Dimethyl sulfoxide
1,4-Dioxane
Ethanol
Ethyl acetate
Ethylene glycol
Formaldehyde
Formamide
n-Heptane
n-Hexane
Isobutyraldehyde
Isopropanol
Isopropyl acetate
Isopropyl ether
Methanol
Methyl cellosolve
Methyl formate
Methyl isobutyl ketone (MIBK)
Petroleum naphtha
Polyethylene glycol 600
n-Propanol
Pyridine
Tetrahydrofuran
Triethylamine
Xylenes

EPA analyzed the load reduction of these 39 nonconventional pollutants expected through implementation of BAT and PSES for A/C and B/D subcategories. 9 provides specific information on calculation of pollutant loads and pollutant load reduction. Table 6-5 presents the expected pollutant load reduction for the subcategories.

For A/C facilities, the following 15 nonconventional pollutants considered for regulation were found to have minimal load reduction (less than 178 lbs/year) and therefore have not been selected for regulation.

Aniline
2-Butanone (MEK)
n-Butyl alcohol
tert-Butyl alcohol
N,N-Dimethylacetamide
N,N-Diemethylaniline
N,N-Dimethylformamide
1,4-Dioxane
Ethylene glycol
Formaldehyde
Formamide
Petroleum naphtha
Polyethylene glycol 600
n-Propanol
Pyridine

The remaining 24 nonconventional pollutants have been selected for regulation at A/C facilities:

Acetone
Acetonitrile
Ammonia
n-Amyl acetate
Amyl alcohol
n-Butyl acetate
COD (Chemical Oxygen Demand)
Diethylamine
Dimethyl sulfoxide
Ethanol
Ethyl acetate
n-Heptane
n-Hexane
Isobutyraldehyde
Isopropanol
Isopropyl acetate
Isopropyl ether
Methanol
Methyl cellosolve
Methyl formate
Methyl isobutyl ketone (MIBK)
Tetrahydrofuran
Triethylamine
Xylenes

For B/D facilities, the following 34 nonconventional pollutants were found to have low load reduction (less than 323 lbs/year), and therefore have not been selected for regulation:

Acetone
Ammonia
Amyl alcohol
Aniline
2-Butanone (MEK)
n-Butyl acetate
n-Butyl alcohol
tert-Butyl alcohol
Diethylamine
N,N-Dimethylacetamide
N,N-Diemethylaniline
N,N-Dimethylformamide
Dimethyl sulfoxide
1,4-Dioxane
Ethanol
Ethylene glycol
Formaldehyde
Formamide
n-Heptane
n-Hexane
Isobutyraldehyde
Isopropanol
Isopropyl ether
Methanol
Methyl cellosolve
Methyl formate
Methyl isobutyl ketone (MIBK)
Petroleum naphtha
Polyethylene glycol 600
n-Propanol
Pyridine
Tetrahydrofuran
Triethylamine
Xylenes

The remaining five nonconventional pollutants have been selected for regulation for B/D facilities:

Acetone
n-Amyl acetate
Chemical Oxygen Demand (COD)
Ethyl acetate
Isopropyl acetate

Table 6-1

Pollutants Which May be Present in Pharmaceutical Industry Wastewater

Conventional Pollutants		**Nonconventional Pollutants**
BOD_5	Oil & Grease	Acetaldehyde
pH	Fecal Coliform	Acetic acid
TSS		Acetone
		Acetonitrile
Priority Pollutants		Acetophenone
		Allyl chloride
Acrolein		4-Aminobiphenyl
Acrylonitrile		Ammonia
Benzene		n-Amyl acetate
Benzidine		Amyl alcohol
Bromoform		Aniline
Bromomethane		Benzaldehyde
Chlorobenzene		Benzotrichloride
Chloroethane		Benzyl alcohol
Chloroform		Benzyl chloride
Chloromethane		Benzyl bromide
Cyanide		Biphenyl
1,1-Dichloroethane		Bis(chloromethyl)ether
1,2-Dichloroethane		2-Bromo-Propanoylbromide
1,1-Dichloroethene		2-Butanone (MEK)
1,2-Dichloropropane		n-Butyl acetate
Ethylbenzene		n-Butyl alcohol
Hexachlorocyclopentadiene		tert-Butyl alcohol
Hexachloroethane		sec-Butyl alcohol
Methylene chloride		n-Butylamine
Nitrobenzene		Carbon disulfide
2-Nitrophenol		Catechol
4-Nitrophenol		Chloroacetic acid
o-Dichlorobenzene		2-Chloroacetophenone
p-Dichlorobenzene		3-Chloro-4-Fluoroaniline
Phenol		Chloromethyl methyl ether
1,1,2,2-Tetrachloroethane		COD (Chemical Oxygen Demand)
Tetrachloromethane		Cresol (Mixed)
Toluene		Cumene
1,1,1-Trichloroethane		Cyclohexane
Trichloroethylene		Cyclohexanone
1,1,2-Trichloroethane		Cyclopentanone
Vinyl chloride		

Table 6-1 (Continued)

Nonconventional Pollutants (Continued)	
Cyclohexylamine	Iodomethane
1,2-Dibromoethane	Isobutyraldehyde
1,2-trans-Dichloroethene	Isopropyl ether
Diethylaniline	Isopropanol
Diethyl ether	Isopropyl acetate
Diethylamine	Isobutyl alcohol
Diethyl carbonate	Methanol
Diethyl-ortho formate	Methyl cellosolve
Dimethylamine	Methyl amine
1,1-Dimethylhydrazine	Methyl formate
N,N-Dimethylacetamide	2-Methyl pyridine
N,N-Dimethylformamide	2-Methoxyaniline
N,N-Dimethylaniline	Methyl methacrylate
Dimethylcarbamyl chloride	Methyl-t-butyl-ether
Dimethyl sulfoxide	Methylal
1,4-Dioxane	Methyl isobutyl ketone (MIBK)
N-Dipropylamine	N-Nitrosomorpholine
Epichlorohydrin	n-Octane
Ethanol	n-Pentane
Ethylene oxide	Petroleum naphtha
Ethylamine	Polethylene glycol 600
Ethyl bromide	1,3-Propane sulfone
Ethyl cellosolve	n-Propanol
Ethyl acetate	B-Propiolactone
Ethylene glycol	Propionaldehyde
Ethyl cyanide	1,2-Propyleneimine
Formaldehyde	Propylene oxide
Formamide	Pyridine
Formic acid	Styrene
Furfural	Tetrachloroethene
Glycol ethers	Tetrahydrofuran
n-Heptane	Trichlorofluoromethane
2-Hexanone	2,4,5-Trichlorophenol
n-Hexane	Triethylamine
Hydrazine	Vinyl acetate
Iodoethane	Xylenes

Table 6-2
Pollutant Selection Evaluation Criteria for Pollutants Discharged by the Pharmaceutical Manufacturing Industry

Constituent Code	Constituent Name	Constituent Type (a)	Quantity Discharged (lbs/yr) (b)	Percent of Total Loading	# of Facilities Reporting Constituents in Raw Load	# of Facilities Reporting Constituents Discharged
97	Methanol (Methyl Alcohol)	N	13,204,311	33.145	91	75
70	Ethanol	N	5,864,800	14.722	111	92
2	Acetic Acid	N	3,306,442	8.300	44	44
94	Isopropanol	N	3,071,721	7.711	102	85
118	Acetone	N	3,069,840	7.706	63	53
102	Methylene chloride	P	1,257,644	3.157	54	45
60	N,N-Dimethylacetamide	N	1,046,104	2.626	8	7
9	Ammonium hydroxide	N	927,804	2.329	54	30
81	Formic Acid	N	821,154	2.061	9	9
66	Dimethyl sulfoxide	N	750,576	1.884	15	14
27	N-Butyl alcohol	N	666,324	1.673	20	18
105	Methyl isobutyl ketone (MIBK)	N	638,193	1.602	9	9
101	Methyl cellosolve	N	445,137	1.117	4	4
3	Acetonitrile	N	430,191	1.080	18	15
136	Triethylamine	N	418,697	1.051	22	13
26	N-Butyl acetate	N	415,426	1.043	2	2
64	N,N-Dimethylformamide	N	387,298	0.972	27	21
79	Formaldehyde	N	313,190	0.786	29	24
71	Ethyl acetate	N	273,627	0.687	35	26
130	Toluene	P	265,859	0.667	49	41
129	Tetrahydrofuran	N	264,875	0.665	21	16
113	Petroleum naphtha	N	260,583	0.654	5	2
55	Diethylamine	N	218,020	0.547	10	7
124	Pyridine	N	212,039	0.532	14	10
11	Amyl alcohol	N	196,554	0.493	6	6

Table 6-2 (Continued)

Constituent Code	Constituent Name	Constituent Type (a)	Quantity Discharged (lbs/yr) (b)	Percent of Total Loading	# of Facilities Reporting Constituents in Raw Load	# of Facilities Reporting Constituents Discharged
37	Chloroform	P	181,517	0.456	16	14
77	Ethylene glycol	N	165,860	0.416	13	12
15	Benzene	P	120,200	0.302	2	1
10	n-Amyl acetate	N	113,485	0.285	5	5
29	Tert-Butyl alcohol	N	98,408	0.247	7	5
106	2-Methylpyridine	N	48,800	0.122	1	1
95	Isopropyl acetate	N	47,924	0.120	10	9
93	Isobutyraldehyde	N	35,654	0.089	3	2
115	Polyethylene glycol 600	N	31,219	0.078	8	8
84	N-Heptane	N	27,894	0.070	12	11
139	Xylenes	N	27,361	0.069	14	13
67	1,4-Dioxane	N	24,422	0.061	5	5
48	o-Dichlorobenzene	P	21,499	0.054	2	2
62	N,N-Dimethylaniline	N	18,155	0.046	3	2
25	2-Butanone (MEK)	N	17,426	0.044	6	4
83	Glycol ethers	N	14,483	0.036	6	6
103	Methyl formate	N	12,616	0.032	4	3
117	N-Propanol	N	11,439	0.029	6	4
96	Isopropyl ether	N	11,314	0.028	4	4
22	Bis(Chloromethyl)ether	N	11,221	0.028	1	1
114	Phenol	P	10,919	0.027	18	12
87	N-Hexane	N	10,796	0.027	17	8
80	Formamide	N	7,184	0.018	5	4
35	Chlorobenzene	P	5,606	0.014	5	4
51	1,2-Dichloroethane	P	4,612	0.012	8	6
12	Aniline	N	4,603	0.012	4	4
63	Dimethylcarbamyl chloride	N	3,973	0.010	1	1

Table 6-2 (Continued)

Constituent Code	Constituent Name	Constituent Type (a)	Quantity Discharged (lbs/yr) (b)	Percent of Total Loading	# of Facilities Reporting Constituents in Raw Load	# of Facilities Reporting Constituents Discharged
134	Trichlorofluoromethane	N	3,850	0.010	2	1
132	1,1,2-Trichloroethane	P	2,954	0.007	2	2
111	n-Octane	N	2,200	0.006	1	1
56	Diethylaniline	N	1,703	0.004	1	1
58	Diethyl ether	N	1,350	0.003	13	8
45	Cyclohexylamine	N	1,250	0.003	1	1
31	Carbon disulfide	N	1,100	0.003	1	1
14	Benzaldehyde	N	886	0.002	3	3
91	Iodomethane	N	845	0.002	2	2
33	Chloroacetic acid	N	800	0.002	2	2
61	Dimethylamine	N	756	0.002	4	1
123	Propylene oxide	N	742	0.002	1	1
44	Cyclohexanone	N	738	0.002	1	1
46	Cyclopentanone	N	678	0.002	1	1
100	Methyl-t-butyl-ether	N	588	0.001	2	2
43	Cyclohexane	N	491	0.001	10	4
72	Ethylamine	N	466	0.001	1	1
18	Benzyl alcohol	N	401	0.001	16	16
99	Methylamine	N	310	0.001	9	2
98	Methylal	N	252	0.001	1	1
39	Chloromethane	P	204	0.001	2	2
126	1,1,2,2-Tetrachloroethane	P	120	0	1	1
78	Ethylene oxide	N	105	0	3	3
131	1,1,1-Trichloroethane	P	91	0	4	4
73	Ethylbenzene	P	90	0	1	1
92	Isobutyl alcohol	N	46	0	1	1
1	Acetaldehyde	N	33	0	1	1

Table 6-2 (Continued)

Constituent Code	Constituent Name	Constituent Type (a)	Quantity Discharged (lbs/yr) (b)	Percent of Total Loading	# of Facilities Reporting Constituents in Raw Load	# of Facilities Reporting Constituents Discharged
89	Hydrazine	N	17	0	2	2
75	Ethyl cellosolve	N	5	0	1	1
20	Benzyl Chloride	N	5	0	2	2
7	Allyl chloride	N	5	0	1	1
74	Ethyl bromide	N	5	0	2	2
82	Furfural	N	4	0	3	1
128	Tetrachloromethane	P	1	0	1	1

(a) N-Nonconventional Pollutant
P-Priority Pollutant
(b) Quantity discharged is equal to the discharge to surface water and/or sewer (1lbs) from Table 3-2 of the Detailed Questionnaire.

Table 6-3

Priority Pollutants Not Selected for Regulation in the Pharmaceutical Manufacturing Industry

Pollutant	Reason for Exclusion
Tetrachloromethane	Discharged in trace amounts from one facility (1 lb/yr)
Ethylbenzene	Discharged in trace amounts from one facility (90 lbs/yr), low toxicity
1,1,1-Trichloroethane	Discharged in trace amounts (91 lbs/yr), low toxicity
1,1,2,2-Tetrachloroethane	Discharged in low amounts from one facility (120 lbs/yr)
Chloromethane	Discharged in low amounts from two facilities (204 lbs/yr)
1,1,2-Trichloroethane	Discharged in low amounts from two facilities (2,954 lbs/yr)

Table 6-4

Nonconventional Pollutants Not Selected for Regulation in the Pharmaceutical Manufacturing Industry

Pollutant	Reason for Exclusion
Allyl chloride	Discharged in trace amounts from one facility (5 lbs/yr), low toxicity
n-Octane	Discharged in low amounts from one facility (2,200 lbs/yr), low toxicity
Diethylaniline	Discharged in low amounts from one facility (1,703 lbs/yr), low toxicity
Cyclohexylamine	Discharged in low amounts from one facility (1,250 lbs/yr), low toxicity
Carbon disulfide	Discharged in low amounts from one facility (1,100 lbs/yr), low toxicity
Propylene oxide	Discharged in low amounts from one facility (742 lbs/yr)
Iodomethane	Discharged in low amounts from two facilities (845 lbs/yr), low toxicity
Chloroacetic acid	Discharged in low amounts from two facilities (800 lbs/yr), low toxicity
Cyclohexanone	Discharged in low amounts from one facility (738 lbs/yr), low toxicity
Cyclopentanone	Discharged in low amounts from one facility (678 lbs/yr), low toxicity
Methyl-t-butyl-ether	Discharged in low amounts from two facilities (588 lbs/yr), low toxicity
Methylal	Discharged in low amounts from one facility (252 lbs/yr), low toxicity
Ethylamine	Discharged in low amounts from one facility (466 lbs/yr), low toxicity
Ethyl bromide	Discharged in trace amounts from two facilities (5 lbs/yr), low toxicity
Ethyl cellosolve	Discharged in trace amounts from one facility (5 lbs/yr)
Benzyl chloride	Discharged in trace amounts from two facilities (5 lbs/yr)
Isobutyl alcohol	Discharged in trace amounts from one facility (46 lbs/yr), low toxicity
Hydrazine	Discharged in trace amounts from two facilities (17 lbs/yr)
Acetaldehyde	Discharged in trace amounts from one facility (33 lbs/yr)
Acetic acid	Addressed by pH control under BPT
Formic acid	Addressed by pH control under BPT
Benzaldehyde	Discharged in low amounts (886 lbs/yr), low toxicity
Benzyl alcohol	Discharged in low amounts (401 lbs/yr), low toxicity
Ethylene oxide	Discharged in low amounts (105 lbs/yr)
Glycol ethers	No analytical method available
Dimethyl carbamyl chloride	Hydrolysis/does not persist in water
Bis(chloromethyl)ether	Hydrolysis/does not persist in water
Diethyl ether	Discharged in low amounts from eight facilities (1,350 lbs/yr)
Cyclohexane	Discharge in low amounts from four facilities (491 lbs/yr)
Dimethylamine	Discharged in low amounts from one facility (756 lbs/yr)

Table 6-4 (Continued)

Pollutant	Reason for Exclusion
Methylamine	Discharged in low amounts from two facilities (310 lbs/yr)
Furfural	Discharged in trace amounts from one facility (4 lbs/yr)
2-Methylpyridine	Discharged from one facility (48,800 lbs/yr), unique to one facility
Trichlorofluoromethane	Discharged in low amounts from one facility (13,850 lbs/yr), unique to one facility

REFERENCES

1. Natural Resources Defense Council, Inc, et al., v. Russel E. Train, 8 ERC 2120 (D.D.C. 1976) modified and Natural Resources Defense Council, Inc., et al., v. Douglas M. Costle, 12 ERC 1833 (D.D.C. 1979).

2. U.S. EPA, Office of Water Regulations and Standards. Preliminary Data Summary for the Pharmaceutical Manufacturing Point Source Category, EPA 440/1-89/084, U.S. Environmental Protection Agency, Washington, D.C. September 1989.

SECTION 7

DESCRIPTION OF THE CONTROL AND TREATMENT OPTIONS

7.1 Introduction

This describes the control and treatment options considered by the Agency for promulgation of BPT, BCT, BAT, NSPS, PSES and PSNS effluent limitations guidelines and standards for the pharmaceutical manufacturing industry. The following information is presented in this section:

- 7.2 discusses the pollution prevention measures and major wastewater treatment technologies used by the industry; and
- Section 7.3 discusses the development of control and treatment options.

7.2 Pollution Prevention Measures and Wastewater Treatment Technologies in the Pharmaceutical Manufacturing Industry

This describes pollution prevention practices and major wastewater treatment technologies used in the pharmaceutical manufacturing industry according to responses to the Detailed Questionnaire. 7.2.1 defines pollution prevention and describes how pollution prevention techniques are implemented in the industry. Sections 7.2.2 through 7.2.11 describe the major wastewater treatment technologies used in the industry based on responses to the Detailed Questionnaire. These treatment technologies include:

- Advanced biological treatment (7.2.2):
- Multimedia filtration (7.2.3);
- Polishing pond treatment (7.2.4);
- Cyanide destruction (7.2.5);
- Steam Stripping and Steam Stripping with Rectification (7.2.6);
- Granular activated carbon adsorption (7.2.7);
- pH adjustment/neutralization (7.2.8);
- Equalization (7.2.9);
- Air stripping (7.2.10); and
- Incineration (7.2.11).

Each technology includes a general description of how the technology works, what types of pollutants the technology treats, and how the pharmaceutical manufacturing industry currently uses the technology.

Table 7-1 presents the total number of facilities (out of the 244 facilities responding to the Detailed Questionnaire) that reported using each of these major technologies.

7.2.1 Pollution Prevention

The Agency examined pollution prevention practices in an effort to incorporate pollution prevention into the regulatory options developed. Although shown to be effective at reducing pollutant loadings and volumes of wastes generated at pharmaceutical manufacturing facilities, pollution prevention measures were not incorporated into the various technology options considered as bases for the final limitations and standards because of obstacles specific to the pharmaceutical manufacturing industry. However, the Agency believes that numerous facilities will choose to integrate pollution prevention practices into a cost-effective strategy to comply with the final effluent limitations guidelines and standards, where site-specific circumstances allow them to do so. This provides a general description of pollution prevention as it applies to the pharmaceutical manufacturing industry, and discusses the Agency's efforts to incorporate pollution prevention into the regulatory development process.

7.2.1.1 General Description

Pollution prevention is defined as the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. Also known as source reduction, pollution prevention includes practices that reduce the use of hazardous and nonhazardous materials, energy, water, or other natural resources. With the Pollution Prevention Act of 1990, Congress established pollution prevention as a national policy, declaring that the creation of pollutants should be prevented or reduced during the production cycle whenever feasible. (1)

Pollution prevention in the manufacturing community can be achieved by changing production processes to reduce or eliminate the generation of waste at the source. Pollution control and waste handling measures (including waste treatment, off-site recycling, volume reduction, dilution, and transfer of constituents to another environmental medium) are not considered pollution prevention because such measures are applied only after wastes are generated.(1)

The Pollution Prevention Act of 1990 and EPA's 1991 Pollution Prevention Strategy establish an environmental management hierarchy that includes (in order of highest priority): source reduction, recycling, treatment, and disposal or release.(1) Essentially, the environmental hierarchy establishes a set of preferences, rather than an absolute judgment, that source reduction is always the most desirable option. Adoption of the source reduction option, for example, depends on applicable regulatory requirements, achievable levels of risk reduction, and cost effectiveness. As it applies to industry, the environmental management hierarchy stipulates that:

- Pollution should be reduced at the source whenever feasible;
- Pollution that cannot be reduced should be recycled in an environmentally safe manner whenever feasible;
- Pollution that cannot be reduced or recycled should be treated in an environmentally safe manner whenever feasible; and
- Disposal or other release into the environment should be used only as a last resort and should be conducted in an environmentally safe manner.

Figure 7-1 outlines the environmental management hierarchy, as applied to industry.

Examples of current pollution prevention initiatives in the pharmaceutical manufacturing industry are documented in the U.S. EPA Pollution Prevention Information Clearinghouse (PPIC). Source reduction was achieved at one plant by substituting a water-based material for an organic solvent-based material used to coat tablets. This process change reduced organic air emissions by 24 tons/year, eliminated potential risks associated with solvent inhalation by workers, saved organic solvent purchase costs, avoided potential costs for complying with emission standards, and resulted in a payback period of less than one year.

I. Source Reduction

A. Product Changes
- Design for Less Environmental Impact
- Increase Product Life

B. Process Changes

1. Input Material Changes
   - Material Purification
   - Substitution of Less Toxic Materials

2. Technology Changes
   - Layout Changes
   - Increased Automation
   - Improved Operating Conditions
   - Improved Equipment
   - New Technology

3. Improved Operating Practices
   - Operating and Maintenance Procedures
   - Management Practices
   - Stream Segregation
   - Material Handling Improvements
   - Production Scheduling
   - Inventory Control
   - Training
   - Waste Segregation

II. Recycling

A. Reuse

B. Reclamation

III. Treatment

Reference: United States EPA, Office of Research and Development. Facility Pollution Prevention Guide, EPA/600/R-92/088, May 1992.

Figure 7-1. Environmental Management Options Hierarchy

In a similar case, another plant developed a process using a water-based solvent and new spray equipment for a tablet coating operation. By implementing these process changes, the plant avoided costs associated with purchasing and operating air pollution equipment and saved approximately $15,000 in annual solvent make-up cost. And at another tablet coating operation, a plant converted from conventional film coating to aqueous film coating, resulting in a reduction of methylene chloride usage from approximately 60 tons/year to approximately 8 tons/year. (2)

Another plant used conventional separation processes to recover and reuse 70% of the acetone contained in the plant wastewater. Prior to recycling, the plant discharged wastewater containing approximately 200,000 lb/yr of acetone to a POTW. By recycling the acetone, the facility saves approximately $70,000 in annual treatment costs, reduces the amount of acetone purchased, and reduces liabilities by generating less waste.

Additional examples of waste minimization and guidance on pollution prevention specific to the pharmaceutical manufacturing industry are provided in several documents published by the Agency, including *Guides to Pollution Prevention: The Pharmaceutical Industry* (EPA/625/7-91/017, October 1991) and *Pollution Prevention Assessment for a Manufacturer of Pharmaceuticals* (EPA/600/S-95/030, August 1995).

7.2.1.2 Efforts to Incorporate Pollution Prevention during the Regulatory Development Process

As demonstrated in the previous examples, pollution prevention initiatives can reduce the toxicity and volume of a pharmaceutical manufacturing facility's waste while lowering liability risk and operating costs. With such benefits in mind, EPA's Office of Water worked with the Food and Drug Administration (FDA) and EPA's Office of Pollution Prevention and Toxics (OPPT) to incorporate pollution prevention into the final pharmaceutical manufacturing industry effluent limitations guidelines and standards.

Prior to the implementation of a new drug manufacturing process the manufacturer must submit a new drug application to the FDA. During its review of a new drug application, the FDA assesses

the safety, efficacy, and quality of the drug. The FDA also examines the safety to the human environment from the manufacture and use of the drug. This examination includes an environmental assessment, review of clinical trials and animal trials of the drug. The FDA will also assess other factors such as the stability of the drug (shelf life) and the extent of drug absorption into the bloodstream.

Prior to the implementation of a change in a drug manufacturing process, that has already been approved by the FDA, a manufacturer must submit a supplement application to the FDA. During its review of a supplement application, the FDA assesses whether the proposed process change will produce a drug that equals or surpasses the efficacy and quality of the drug which was produced using the initial (unaltered) manufacturing process.

In the past, the length of time required by FDA to review and approve supplement applications (i.e., applications that propose changes to existing pharmaceutical manufacturing processes) has deterred the implementation of pollution prevention measures. However, since the enactment of the "Prescription Drug User Fee Act of 1992," 21 U.S.C. 379 et seq., Pub. L. 102-571, October 29, 1992, the FDA has committed to using the revenues generated under that Act to expedite the prescription drug review and approval process, including expediting decisions on supplements relating to pollution prevention-oriented process changes. EPA believes that such expeditious processing of supplements will eliminate impediments that presently discourage pharmaceutical plants from making process changes necessary to achieve source reductions. Additionally, EPA has transferred information collected from the pharmaceutical manufacturing industry via the Detailed Questionnaire to FDA, as stated in the August 23, 1993 Federal Register Notice (58 FR 44519). This information will enable FDA to develop a list of processes that could be the subject of supplement applications.

The Office of Water also worked with OPPT to develop 3b of the Detailed Questionnaire. This contains questions pertaining to waste minimization/pollution prevention efforts implemented at each facility in 1990. Two hundred and eighty Detailed Questionnaires were sent to pharmaceutical manufacturing facilities in 1991, and responses were received from 244 facilities. Three of the 244 facilities that responded to the questionnaire gave no response to 3b. Eighty-

nine of the 244 facilities indicated that they had no pollution prevention programs in place. One hundred and fifty-two of the 244 facilities claimed to have a pollution prevention program in place on site. Ninety of the 152 facilities with pollution prevention programs in place reported that their program did not include their pharmaceutical manufacturing processes. Sixty-two of the 152 facilities reported that the pollution prevention program implemented on site included their pharmaceutical manufacturing processes.

The 62 facilities that identified pollution prevention programs relevant to their pharmaceutical manufacturing processes reported 89 specific waste minimization/pollution prevention activities implemented at their facilities in 1990, and described these activities in the Detailed Questionnaire. The types of activities undertaken are summarized below.

Source Reduction					
	Number of Process Changes				
Number of Product Changes	Input Material Changes	Technology Changes	Improved Operating Practices	Number of Recycling Activities Reuse/Reclamation	Total Activities
3	22	16	16	32	89

Examples of pollution prevention activities reported by pharmaceutical manufacturing facilities include the following:

- **Product Changes** - Eliminate product packaging, and reformulate vitamin product filmcoats to remove volatile organic pollutants.
- **Input Material Process Changes** - Eliminate and/or reduce acetic acid, acetone, aerosols, chloroform, methanol, methylene chloride, toluene, and 1,1,1-trichloroethane from various production processes.
- **Technology Process Changes** - Install solvent recovery units; implement automated cleaning system for wastewater reduction; design closed-loop solvent recovery units for all new processes; and replace solvent-based cleaning units with water-based cleaning units.
- **Improved Operating Practices** - Separate nonquality products from batches earlier in production process; improve reclamation systems and

distillation capabilities; combine solvent waste streams to avoid need for multiple recovery systems; and reduce overall waste solvent generation.

- **Recycling/Reuse Activities** - Recycle/reuse alcohol, aqueous ammonia, dicyclohexylamine, dimethylaniline, freon, packaging materials, plastics, solvents, spent nickel catalyst wastes, steel drums, treated wastewater, 1,1,2-trichloroethane, triethylamine, and wooden pallets.

In addition to reporting pollution prevention activities, pharmaceutical manufacturing facilities reported quantities of chemicals that were recycled/reused. Table 7-2 summarizes the quantity of chemicals recycled/reused by pharmaceutical manufacturing facilities during 1990, as reported in the Detailed Questionnaire responses. As shown in the table, a total of approximately 335,000,000 pounds of 15 different chemicals were recycled/reused at the facilities during 1990.

The diversity of reported pollution prevention activities and recycled/reused chemicals demonstrate the facility-specific and/or process-specific nature of pollution prevention initiatives. Many of the examples listed are applicable to specific manufacturing processes and are not transferable to other operations. As reported in 3b of the Detailed Questionnaire, pollution prevention opportunities are generally site- and process-specific in the pharmaceutical manufacturing industry.

In the preamble to the proposed regulations, EPA discussed the possible pollution prevention alternatives available in pharmaceutical manufacturing. At that time, EPA indicated that pollution prevention opportunities were limited in the active ingredient manufacturing subcategories (namely, fermentation, natural extraction and chemical synthesis) but the use of water-based coatings in the formulation subcategory operations was a viable pollution prevention approach which eliminates the need for solvents in tablet coating operations. This approach may only be applicable to some and not most tablet coating operations, however. Since the proposal, EPA has received two suggestions for incorporation of pollution prevention into the final regulations which were discussed in the August 8, 1997 Notice of Availability at 62 FR 42720. One suggestion presented to the Agency was that Subcategories B and D dischargers that incorporate best management practices (BMPs), which reduce their discharge of any of the regulated pollutants should not have to monitor for the specific regulated pollutants, and possibly only monitor for the

conventional pollutants and COD. This pollution prevention approach is similar to the one adopted in the Pesticide Formulators, Packagers and Repackagers (PFPR) final regulation which was published in the Federal Register on November 6, 1996 at 61 FR 57518. (It should be noted that PFPR facilities that use the promulgated pollution prevention option have to assess their wastewater and may be required to treat wastewater prior to discharge). EPA evaluated this suggestion and decided that since EPA is not promulgating BAT limitations for specific organic pollutants (see 11.3), this pollution prevention suggestion was not relevant to compliance by subcategory B and D direct dischargers with final BAT limitations. For PSES, EPA believes the suggestion may be workable for indirect dischargers, since standards for specific organic pollutants are contained in the final rule, however, no information was submitted to identify the pollution prevention practices that would be incorporated into the rule, and EPA has been unable to identify any.

Another pollution prevention approach suggested to EPA was that Subcategories A and C facilities that can demonstrate a reduction in the use of a regulated pollutant and resultant lowered air emissions or water discharges should receive a higher effluent discharge limitation. As suggested, the higher effluent discharge limitation would be directly proportional to the amount of reduction achieved in the use of the regulated pollutant. Along with this suggestion, the commenters provided examples of how this pollution prevention suggestion could work in individual instances.

In evaluating this suggestion including the examples provided, EPA was concerned about the amount and type of process information that would have to be obtained from facilities and the methodology for estimating the pollutant reductions as the result of any pollution prevention practices. Another concern of the Agency had to do with the determination of when, in the new product development phase of work, the practice represents a pollution prevention activity or is just part of normal process development work in bringing a new product process to full scale production. EPA was also concerned that pollutant discharge or emission reductions achieved in the bench scale or pilot scale product development activities may not be realized during full scale production operations. In the period following publication of the NOA, the Agency did not

receive sufficient information relative to these concerns to enable it to develop a viable pollution prevention alternative based on this suggestion.

Furthermore, pollution prevention initiatives are not part of the technology basis of the final regulatory options for the pharmaceutical manufacturing industry because of several important constraints. First, Food and Drug Administration (FDA) review and approval is required before any modifications in manufactured pharmaceutical products or pharmaceutical manufacturing processes are permitted. EPA determined that it was not appropriate to include process modifications as part of the basis for regulatory options, when such modifications would need to be reviewed and approved by FDA on a case-by-case basis. Second, as discussed earlier in this section, the pharmaceutical manufacturing industry is complex and varied, and, therefore, EPA determined that the pollution prevention opportunities that exist are facility-, process-, and product-specific. EPA did not identify any specific pollution prevention techniques that could be incorporated into regulatory options and applied on a category- or subcategory-wide basis.

However, in addition to evaluating opportunities for reduced discharge and source reduction, EPA also examined potential treatment technologies to determine whether any might promote recovery, recycling, and reuse of process wastewater generated by pharmaceutical manufacturing operations, such as solvents. After evaluating the various technologies available to treat volatile-laden wastewaters, EPA concluded that for indirect discharging facilities, in-plant technologies such as steam stripping offered the best opportunity for recovery of solvents from wastewater. Steam stripping in plant not only avoids the dilution effects of commingling process wastewater streams and the transfer of volatile pollutants to air associated with other technologies, but it also allows the pharmaceutical manufacturing operation to recover the stripped solvents from the treatment process in an efficient and cost-effective manner from concentrated streams. These recovered solvents can then be recycled back into the process from which they were removed, reused in other manufacturing operations (e.g., in this industry or in other industries), or reused as "clean fuel" for boilers or other combustion devices. For a discussion of "clean fuels," see 12.4.3.

Thus, the Agency believes that the final regulation will foster the implementation of pollution prevention and recycle/reuse initiatives even though pollution prevention measures are not specifically part of the technologies upon which the final limitations and standards are based. Numerous facilities will use pollution prevention measures that reduce pollutant loadings and volumes of waste generated as part of a cost-effective strategy to comply with the final effluent limitations guidelines and standards.

7.2.2 Advanced Biological Treatment

7.2.2.1 General Description

Advanced biological treatment is used in the pharmaceutical manufacturing industry to treat BOD_5, COD, TSS, and to degrade various organic constituents. The term "advanced" is used to refer to treatment systems that consistently surpass, on a long-term basis, 90% BOD_5 reduction and 74% COD reduction in pharmaceutical manufacturing wastewater, as required by the existing BPT effluent limitations guidelines (40 CFR Part 439). To provide reduction of ammonia in the wastewater using advanced biological treatment, nitrification is necessary.

Biological systems can be divided into two basic types: aerobic (treatment takes place in the presence of oxygen) and anaerobic (treatment takes place in the absence of oxygen). According to responses to the Detailed Questionnaire, only two pharmaceutical manufacturing facilities reported using anaerobic biological treatment systems. The four most common aerobic treatment technologies in the industry are activated sludge systems, aerated lagoons, trickling filters, and rotating biological contactors (RBC).

In aerobic biological treatment processes, oxygen-requiring microorganisms decompose organic and nonmetallic inorganic constituents into carbon dioxide, water, nitrates, sulfates, organic byproducts, and cellular biomass. The microorganisms are maintained by adding oxygen and nutrients (usually nitrogen and phosphorous) to the system. Activated sludge and aerated lagoon processes are suspended-growth processes in which the microorganisms are maintained in suspension within the liquid being treated. The trickling filter and RBC processes are attached-

growth processes in which microorganisms grow on an inert medium (e.g., rock, wood, plastic). Three types of activated sludge processes were listed as choices in the Detailed Questionnaire: single, two-stage, and oxygen-activated sludge. Table 7-1 lists these processes under the heading "Biological Treatment." As can be seen in the table, the majority of biological treatment systems used in the industry are activated sludge systems.

An activated sludge treatment system normally consists of an equalization basin, a settling tank (primary clarifier), an aeration basin, a secondary clarifier, and a sludge recycle line. Equalization of flow, pH, temperature, and pollutant loads is necessary to perform consistent, adequate treatment. The settling tank is used to remove settleable solids prior to aeration. The aerobic bacterial population is maintained in the aeration basin, in which oxygen, recycled sludge, and nutrients are added to the system. Oxygen is normally supplied by aerators that also provide mixing to help keep microorganisms in suspension. Recycled sludge is added to keep an optimal concentration of acclimated microorganisms in the aeration basin. The secondary clarifier controls the amount of suspended solids discharged, as well as provides sludge for recycle to the aeration basin (3). Sludge produced by these systems generally consists of biological waste products and expired microorganisms. This sludge may accumulate under certain operating conditions and may therefore require periodic removal from the aeration basin.

Generated sludge will require some type of storage, handling, and disposal. Biological sludges are normally treated in a two-step process prior to disposal: thickening followed by dewatering. Other sludge treatment may also be performed, but these processes are the most common. The goal for each of these operations is to decrease the overall volume of sludge. Thickening of waste-activated sludge is normally performed in one of three ways: gravity separation, dissolved-air flotation, or centrifuging. Generally, thickeners will increase the solids content of sludge from 1% (typical from biological treatment) to 4 or 5%. Sludge dewatering is normally performed using some type of filter, including filter presses, vacuum filters, and belt filters. These units normally can increase the solids content in sludge from 5% up to 15 to 30%, which greatly reduces the shipping, handling and disposal costs associated with sludge generation from a biological treatment unit. (4)

Some key design parameters for activated sludge systems include nutrient-to-microorganism ratio, mixed liquor suspended solids (MLSS), sludge retention time, oxygen requirements, nutrient requirements, sludge production, substrate removal rate constant (K), and percent BOD_5 of effluent TSS. Pharmaceutical manufacturing industry averages for some of these parameters are presented in the following table.

Parameter	Subcategories A and C Average	Subcategories B and D Average
Food to Microorganism Ratio (lb/lb/day)	0.561	0.054
MLSS (mg/L)	5,521	3,443
Sludge Retention Time (hours)	33.0	22.9
K	11.14	2.06
%BOD_5 of TSS	23	24

Ammonia treatment by nitrification is achieved in biological treatment units by incorporating two additional sets of autotrophic microorganisms. The first set of microorganisms (Nitrosomonas bacteria) converts ammonia to nitrites and the second set (Nitrobacter bacteria) converts nitrites to nitrates. These microorganisms are maintained in the treatment tank in a similar fashion as the microorganisms described above (addition of oxygen, nutrients, etc). Nitrification can be accomplished in either a single or two-stage activated sludge system. Indicators of nitrification capability are 1) biological monitoring for ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) to determine if nitrification is occurring, and 2) analysis of the nitrogen balance to determine if nitrifying bacteria reduce the amount of ammonia and increase the amount of nitrite and nitrate. Common design criteria for single and two-stage systems with nitrification capability are:

Parameter	Single Stage	Two-Stage
Suspended growth Food/Microorganism ratio (g BOD_5/g MLVSS/d)	0.05-0.15	<0.15
Sludge retention time (days)	20-30	10-20
MLVSS (mg/L)	2,000 - 3,000	1,500 - 2,500
pH (standard units)	7.2 - 8.5	7.2 - 8.5

7.2.2.2 Industry Application

Based on responses to the Detailed Questionnaire, 58 of 244 responding facilities in the pharmaceutical manufacturing industry use some form of activated sludge treatment process, 12 use aerated lagoons, 5 use trickling filters, and 3 use RBC treatment. Most of these facilities are operated at or near the facility off-site wastewater discharge point (end-of-pipe). There are no specific data regarding whether the treatment units are used primarily to reduce concentrations of conventional pollutants or organic constituents in the wastewater. However, it is likely that these systems were initially designed to treat BOD_5 and COD.

7.2.3 Multimedia Filtration

7.2.3.1 General Description

Multimedia filtration is used in the pharmaceutical manufacturing industry to reduce TSS in wastewater. This technology may also serve to treat BOD_5 in wastewater by removing BOD_5 associated with particulate matter. A multimedia filtration system operates by introducing a wastewater to a fixed bed of inert granular media. Suspended solids are removed from the wastewater by one or more of the following processes: straining, interception, impaction, sedimentation, and adsorption. This operation is continued until there is either solids "breakthrough" (solids concentration increases to an unacceptable level in the discharge from the bed), or the head loss across the bed becomes too great (due to trapped solids) to operate the bed efficiently.

If either of these conditions occurs, the bed must be cleaned by backwashing before it can be operated effectively again. Backwashing usually is accomplished by reversing the flow to the bed and introducing a "clean" stream of wash water. Wash water is introduced until the bed becomes fluidized (expanded). At this point, the solids are washed from the bed and carried away from the unit. It is common to return the backwashed solids stream to the biological treatment system (if applicable).

In multimedia filtration, a series of layers, each with a progressively smaller grain size medium (traveling from inflow to outflow of the bed) are used in the filtration bed. This design allows solids to penetrate deeper into the bed before becoming fixed, thus increasing the capacity of the bed and decreasing the buildup of head loss in the unit. Typical filtration media include garnet, crushed anthracite coal, resin beads, and sand. Though downflow (gravity flow) systems are the most common, upflow and biflow (influent is introduced above and below the filter medium, and the effluent discharges from the center of the filter medium) filtration units can also be used. Figure 7-2 shows a cross-of a typical downflow, multimedia filtration bed. (4)

Some key design parameters associated with multimedia filtration units include wastewater flow rate, hydraulic loading rate, and filter medium depth. The following table shows ranges of values for each of these parameters for treatment units currently operated in the pharmaceutical manufacturing industry.

Parameter	Range	Units
Flow Rate	0.03 - 2.18	MGD
Hydraulic Loading Rate	2.0 - 5.0	gpm/ft^2
Depth of Medium	6 - 72	inches

7.2.3.2 Industry Application

Based on responses to the Detailed Questionnaire, 6 of 244 responding pharmaceutical manufacturing facilities use multimedia filtration treatment. This treatment is generally performed after biological treatment (if applicable) for additional TSS removal prior to wastewater discharge. Multimedia filtration can also provide limited treatment of BOD_5 by removing the BOD_5 load associated with suspended solids. The following is the breakdown of specific applications of multimedia filtration treatment in the industry: four facilities use multimedia filtration as a tertiary wastewater treatment, one facility uses it to treat noncontact cooling water prior to recycle, and one facility uses it as a treatment prior to granular activated carbon (GAC) treatment.

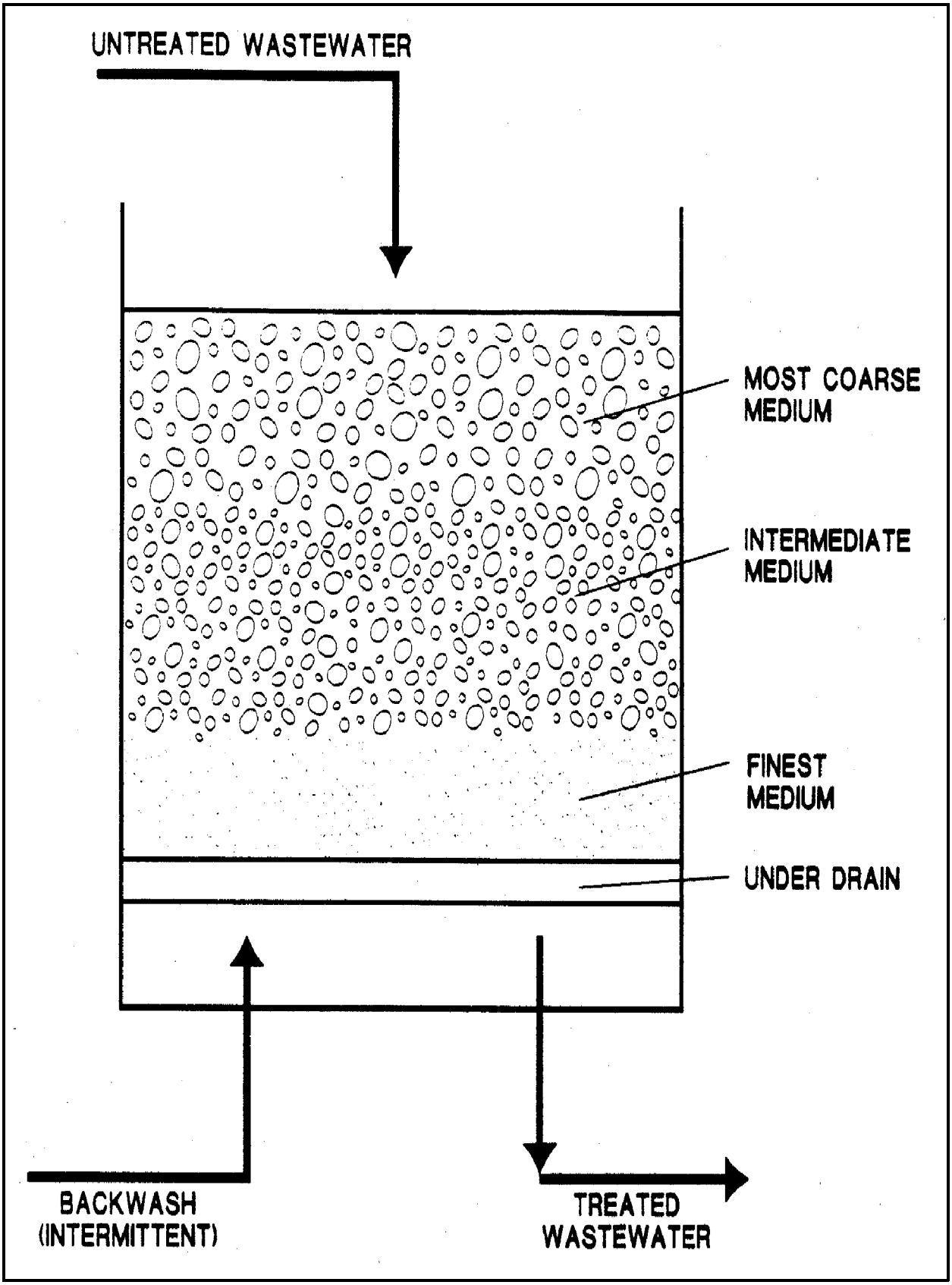

Figure 7-2. Typical Downflow Multimedia Filter Bed

7.2.4 Polishing Pond

7.2.4.1 General Description

Polishing ponds are used in the pharmaceutical manufacturing industry to remove TSS from wastewater using gravity settling. Some BOD_5 removal associated with the settling of suspended solids may also occur.

The wastewater is introduced at one end of the pond and ultimately flows out the other end. The pond is designed such that the water retention time is long enough and the water velocity is slow enough to allow solids to fall out of suspension. If the flow is too fast, or other mixing is added to the system, solids may be maintained in suspension and discharged from the pond.

To avoid anaerobic conditions in the bottom portion of the pond, these units must be designed to be shallow, which may require a large land area if flow to the unit is high. Depths of polishing ponds currently used in the industry range from 2.5 to 14 feet. Retention times range from 0.2 to 14.6 days. In the past, polishing ponds have been designed with an earthen liner only; however, current regulations require installation of a minimum of two liners and a leak detection system (40 CFR 264.221) for most new applications to this industry. Polishing ponds will accumulate solids over time and will therefore require periodic cleanout.

7.2.4.2 Industry Application

Based on responses to the Detailed Questionnaire, 8 of 244 responding pharmaceutical manufacturing facilities use polishing ponds to treat wastewater. This treatment is not currently common in the industry, and because of increasing regulatory requirements governing the use of ponds (surface impoundments), facilities have limited plans for installation of more of these units. For the facilities that use polishing ponds, this technology is generally used to treat wastewater just prior to discharge to the receiving stream or POTW.

7.2.5 Cyanide Destruction

7.2.5.1 General Description

Several cyanide destruction treatment technologies are currently used in the pharmaceutical manufacturing industry, including alkaline chlorination, hydrogen peroxide oxidation, and basic hydrolysis. The alkaline chlorination treatment process involves reacting free cyanide with hypochlorite (formed by reacting chlorine gas with an aqueous sodium hydroxide solution) to form nitrogen and carbon dioxide. The reaction is a two-step process and is normally performed separately in two reactor vessels. Because treatment is normally performed in batches, it is necessary to use an additional equalization tank to store accumulated wastewater during treatment. The reactors need to be equipped with agitators, and both reaction steps require close monitoring of pH and oxidation/reduction potential (ORP). These reactions are normally performed at ambient temperatures. (5)

Hydrogen peroxide treatment involves adding hydrogen peroxide to cyanide-bearing wastewater to convert free cyanide to ammonia and carbonate ions. This treatment is normally performed batch-wise in a reaction vessel or vessels. The treatment process consists of heating the wastewater to approximately 125°F and adjusting the pH in the reaction vessel to approximately 11. Hydrogen peroxide is added to the vessel and is allowed to react for approximately one hour. Required equipment for this process includes reaction vessel(s), storage vessels for hydrogen peroxide and a pH adjustment compound (typically sodium hydroxide), an equalization tank, and feed systems for hydrogen peroxide and sodium hydroxide.(5)

Hydrolysis treatment involves reacting free cyanide with water under basic conditions to produce formate and ammonia. This process requires approximately one hour to proceed and is typically performed at a temperature between 170 and 250°C, and at a pH of between 9 and 12. Hydrolysis is normally performed in a reactor vessel equipped with a heat exchanger and a system to store and deliver sodium hydroxide (or other basic compound).

7.2.5.2 Industry Application

Based on responses to the Detailed Questionnaire, 10 of 244 responding pharmaceutical manufacturing facilities use cyanide destruction treatment. Of these, six use alkaline chlorination, three use hydrogen peroxide oxidation, and one uses hydrolysis. Most of these facilities apply the cyanide destruction technologies in the process area that generates the cyanide-bearing wastewater, and most of the treatment units are operated in batch mode.

7.2.6 Steam Stripping and Steam Stripping with Rectification

Steam stripping and steam stripping with rectification are used both in industrial chemical production (for chemical recovery and/or recycle) and in industrial waste treatment to remove gases and/or organic chemicals from wastewater streams by providing steam to a tray or packed column. Under both technologies, differences in relative volatility between the organic chemicals and water are used to achieve a separation. The more volatile components of the feed mixture concentrate in the vapor, while the less volatile components concentrate in the liquid residue (bottoms). Steam stripping and steam stripping with rectification are effective treatment for a wide range of aqueous streams containing organics and ammonia. Appropriately designed and operated columns can treat a variety of waste streams ranging from wastewaters containing a single volatile constituent to complex organic/inorganic mixtures. Steam stripping and steam stripping with rectification can be used both as in-plant processes to recover concentrated organics from aqueous streams and as end-of-pipe treatment to remove organics from wastewaters prior to discharge or recycle. For most effective wastewater treatment, columns should be placed after the process generating the wastewater and before the wastewater is combined with other wastewater that does not contain the pollutants being treated. Wastewater with high concentration and low flow is easier and less expensive to treat than wastewater with high flow and/or low concentration. In addition, the amount of volatiles emitted to the air can be minimized if columns are placed prior to exposure of the wastewater stream to the atmosphere.

7.2.6.1 General Description

Steam stripping and steam stripping with rectification can be conducted as either a batch or continuous operation in a packed tower or fractionating column (sieve tray or bubble cap) with more than one stage of vapor-liquid contact. In a steam stripping column, the wastewater feed enters near the top of the column and then flows downward by gravity, countercurrent to the steam which is introduced at the bottom of the column. In a steam stripping with rectification column, the wastewater feed enters lower down the column to allow for a rectification above the feed. In the rectification section, a portion of the condensed vapors are refluxed to the column to countercurrently contact the rising vapors. This process concentrates the volatile components in the overhead stream.

Steam may either be directly injected or reboiled, although direct injection is more common. The steam strips volatile pollutants from the wastewater, which are then included in the upward vapor flow. As a result, the wastewater contains progressively lower concentrations of volatile compounds as it moves toward the bottom of the column. The extent of separation is governed by physical properties of the volatile pollutants being stripped, the temperature and pressure at which the column is operated, and the arrangement and type of equipment used.

The difference between steam stripping columns and steam stripping with rectification columns is the location of the feed stream. Stripping columns have a feed stream located near the top of the column while steam stripping with rectification columns have a feed stream located further down the column. Pollutants that phase separate from water can usually be stripped from the wastewater in a steam stripper (a column without rectifying stages). Pollutants that are not phase-separable, such as methanol, need a column with rectifying stages to achieve a high concentration of the pollutants in the overhead stream.

The ancillary equipment used in conjunction with steam stripping and steam stripping with rectification columns includes a condenser and subcooler, pumps for the feed, overhead, bottoms, and reflux streams, a feed preheater and bottoms cooler, a decanter, a storage tank, a distillate tank, and an air pollution control device to contain any vapors from the condenser. The

condenser and subcooler condense and cool the overhead stream to a temperature amenable for storage and disposal. The pumps supply the force to move the waste stream: either into the column at the feed position or at a point above the feed in the case of a reflux stream. The bottoms pump moves the bottoms from the stripping column to the bottoms cooler, and the overheads distillate pump moves the distillate from the decanter to the distillate receiver tank. The feed preheater/bottoms cooler is a heat exchanger that heats the feed before it enters the column at the same time it cools the bottoms stream so that it can be sent to a storage area or treatment system. The decanter separates the aqueous layer from the organic layer after the stream comes from the condenser and subcooler. The aqueous layer can be refluxed back to the column while the organic layer is usually disposed of or reused. The storage tank provides a steady feed for the steam stripper column, equalizing flow and waste variability. An air pollution control device may be needed to contain any pollutants that do not condense in the condenser and would otherwise escape to the air. Wet scrubbers, carbon adsorption devices, or venting to a combustion device may be used to control air emissions. Figure 7-3 shows a flow diagram of a typical steam stripping treatment system and Figure 7-4 shows a flow diagram of a typical steam stripping with rectification treatment system.

The typical construction material for steam stripping and steam stripping with rectification columns in the pharmaceutical manufacturing industry is stainless steel. If a wastewater stream is highly corrosive, a more corrosion-resistant material, such as Hastelloy or Teflon®-lined carbon steel, may be required for construction of the column. The majority of pharmaceutical manufacturing facilities which currently use steam stripping and/or steam stripping with rectification columns to treat their wastewater use stainless steel.

Salts and other pollutants may contribute to scaling and corrosion inside the column. Timely maintenance should be provided to deter scaling problems. Costs of these measures are discussed in 10.

The key design parameters for stripping columns are the steam-to-feed ratio and the number of trays or equilibrium stages in packed columns. These parameters are calculated using the

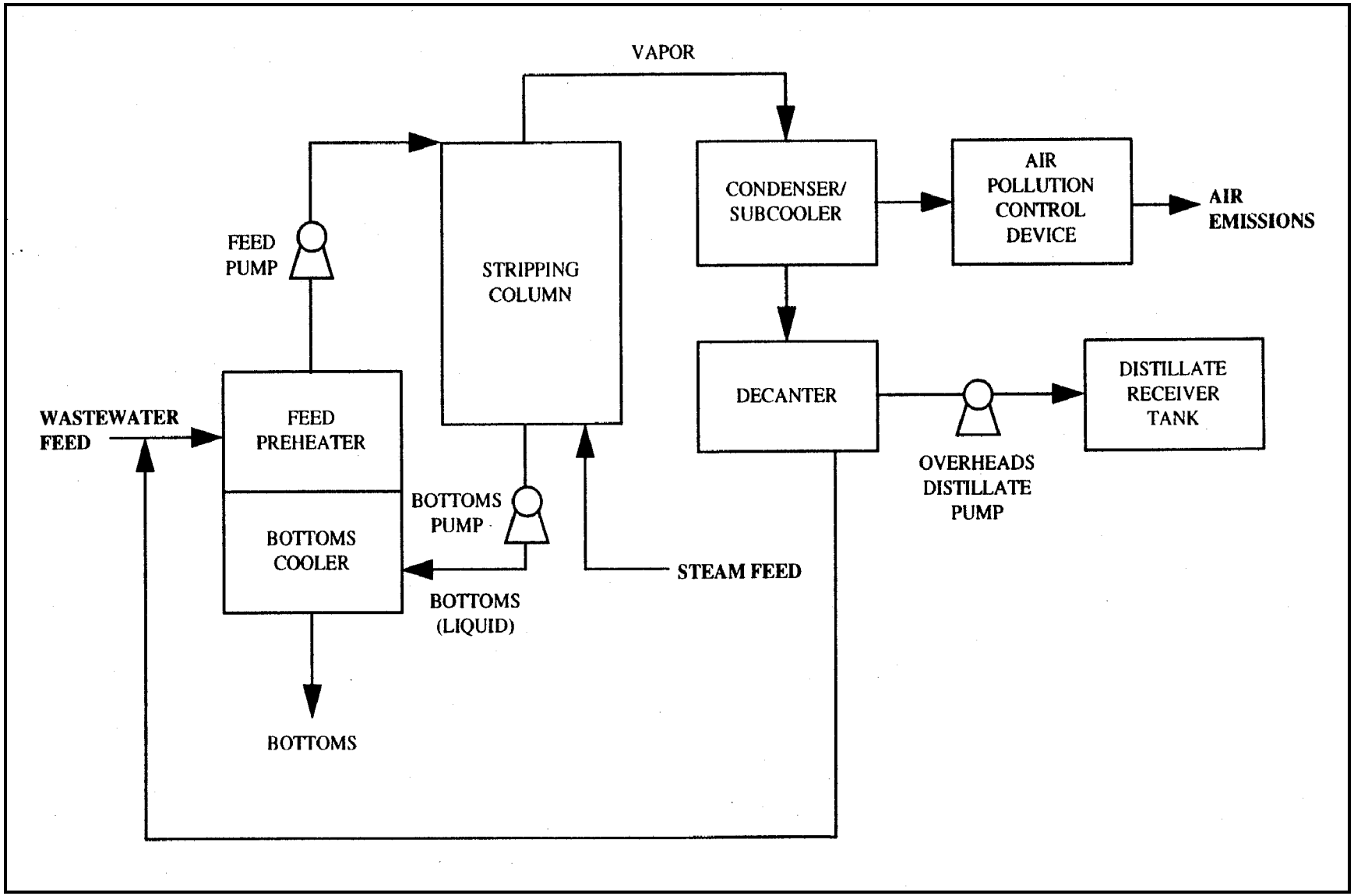

Figure 7-3. Steam Stripping Column Diagram

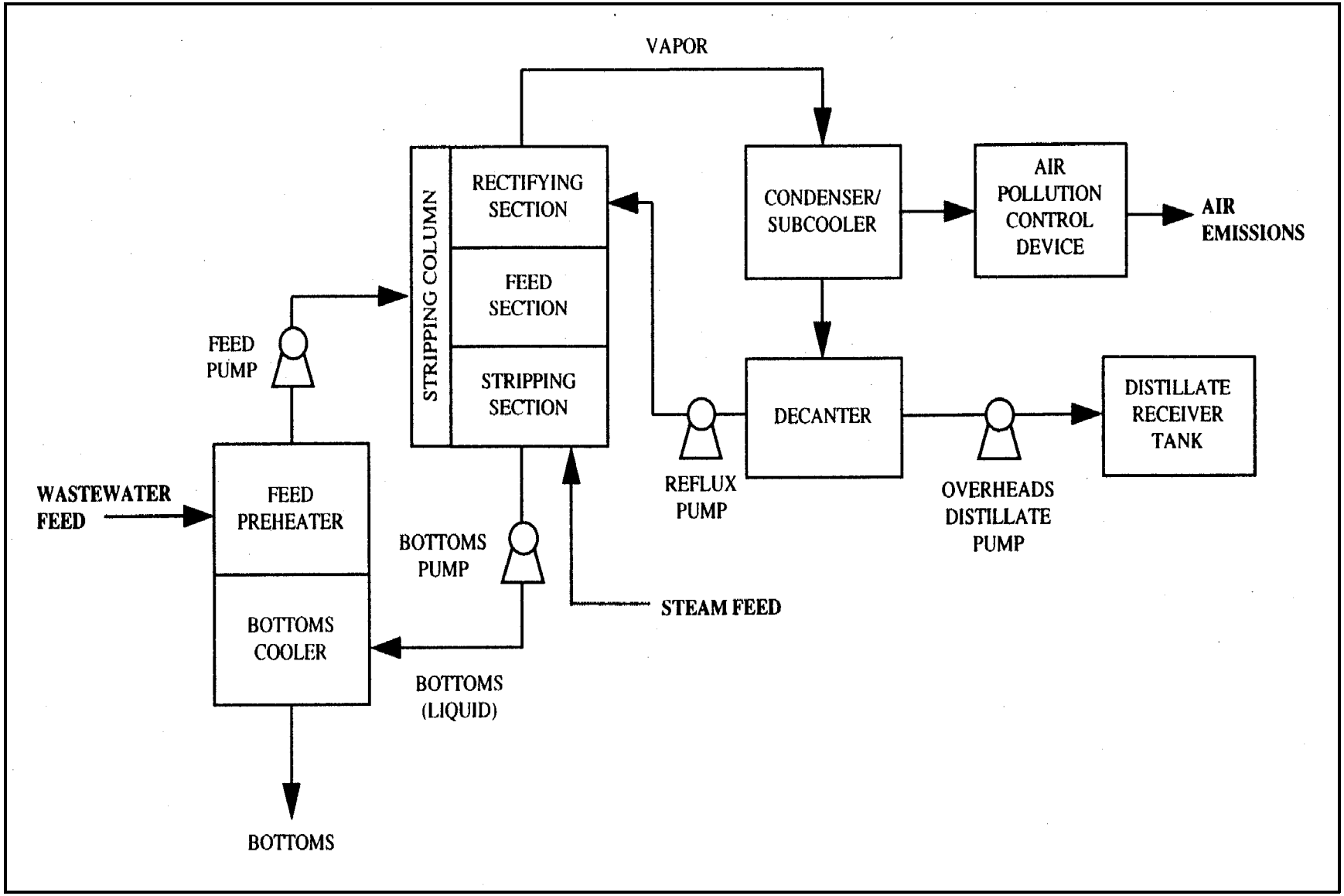

Figure 7-4. Steam Stripping and Rectification Column Diagram

equilibrium ratio of the least strippable contaminant in the wastewater stream and the removal efficiency required to treat the contaminant to the desired concentration. Typical ranges for steam-to-feed ratios vary from 1:3 to 1:35, and the typical number of trays or equilibrium stages vary from 2 to 20. Generally, columns with smaller diameters are packed while columns with larger diameters have trays. Typical column packings are Pall rings, Rashing rings, Berl saddles, and Intalox saddles.

7.2.6.2 Industry Application

In responses to the Detailed Questionnaire, 61 of 244 responding facilities in the pharmaceutical manufacturing industry reported using steam stripping with rectification for solvent recovery operations. Fourteen facilities reported using steam strippers for wastewater treatment. However, a review of these 14 facilities resulted in a determination by the Agency that only four were actually using the technology for wastewater treatment, while the other ten facilities were using the strippers for solvent recovery purposes. Steam stripping and steam stripping with rectification columns are currently used in this industry as stand-alone treatment or as pretreatment before biological treatment. They are also used to recover specific constituents from waste streams. Direct dischargers tend to use steam stripping or steam stripping with rectification as a pretreatment before biological treatment more frequently than as a stand-alone treatment, whereas indirect dischargers tend to use steam stripping or steam stripping with rectification more as a stand-alone treatment or to recover a specific constituent from the waste stream.

7.2.7 Granular Activated Carbon Adsorption

7.2.7.1 General Description

Granular activated carbon (GAC) adsorption is used in the pharmaceutical manufacturing industry to treat BOD_5, COD, or organic constituents in wastewater. Adsorption is a process in which soluble or suspended materials in water are bonded onto the surface of a solid medium. Activated carbon is an excellent medium for this process because of its high internal surface area, high

attraction to most adsorbates (the constituents to be treated), and the fact that it is hydrophobic (water will not occupy bonding sites and interfere with the adsorption process). Constituents in the wastewater bond onto the GAC grains until all surface bonding sites are occupied. At this point, the carbon is considered to be "spent", and requires regeneration, cleaning, or disposal.

Activated carbon is normally produced in two standard grain sizes: powdered activated carbon (PAC) with diameters less than a 200 mesh, and GAC with diameters greater than 0.1 mm. PAC is generally added to the wastewater, whereas GAC is normally used in flow-through fixed bed units.

For treatment units, GAC is packed into one or more beds or columns. Multiple beds are more common, and are normally operated in series because this design allows for monitoring between beds, and therefore minimizes the risk of discharging wastewater from the system with concentrations above acceptable levels. Wastewater flows through a bed and is allowed to come in contact with all portions of the GAC. The GAC in the upper layers of the bed is spent first as bonding sites are occupied, and the GAC in progressively lower regions is spent over time as the adsorption zone moves down through the unit. When contaminant concentrations begin to increase at the bottom of the bed above acceptable levels, the bed is considered to be spent and must be removed. The above description assumes that beds are operated in downflow mode; however, it is also possible to use an upflow design for GAC systems.

Once a bed is spent, the carbon can be treated in three ways: regeneration, backwash, or disposal. Normally, it is possible to use high heat (1,500 to 1,700° F), steam, or chemical treatment to regenerate the spent carbon. These processes remove contaminants from the carbon without significantly affecting the carbon itself; however, some carbon is lost each time this procedure is performed, and carbon performance decreases slightly with each regeneration. Because the bonds formed between the GAC and the adsorbate are not generally strong, it may also be possible to backwash the carbon bed as described in 7.2.3. If the carbon cannot be regenerated or backwashed, it must be disposed of as a solid waste.

The performance of GAC treatment units can be affected by several factors. Three important design criteria are saturation loading, wastewater TSS concentration, and hydraulic loading. Saturation loading is a treatment performance coefficient relating mass of contaminant adsorbed versus mass of carbon used. If this coefficient is very low (as is the case for highly soluble constituents), a GAC system will not perform efficiently. Parameters that effect solubility (i.e., pH and temperature) must also be considered when calculating a design saturation loading for a system. High TSS concentrations in wastewater will foul the GAC system. Solids will occupy bonding sites on the carbon and will get plugged in the pore spaces between GAC grains. If this happens, head loss may occur and a portion of the carbon bed will not be used for treatment. Flushing to remove solids can upset the mass flux zone in the GAC system. In some cases, it may be necessary to install some type of filtration prior to GAC treatment to keep TSS concentrations within acceptable limits. The effectiveness of GAC can only improve with lower TSS, and ideally, TSS levels in the influent should be as close to zero as possible. The amount of time the wastewater spends in contact with the GAC is directly related to hydraulic loading rate. If this time is not long enough, effluent contaminant concentrations will be higher than expected.(3)(4)

7.2.7.2 Industry Application

Based on responses to the Detailed Questionnaire, 10 of 244 responding pharmaceutical manufacturing facilities use GAC treatment to reduce concentrations of organic constituents (and BOD_5 and COD) in wastewater. This treatment is generally used to treat wastewater directly from a production area or somewhere prior to the facility treatment plant. GAC treatment can also be used to remove organics following biological treatment.

7.2.8 pH Adjustment/Neutralization

7.2.8.1 General Description

Because many treatment technologies used in the pharmaceutical manufacturing industry are sensitive to pH fluctuations, pH adjustment, or neutralization, may be required as part of an

effective treatment system. A pH adjustment system normally consists of a small tank (10 to 30 minutes retention time) with mixing and a chemical addition system. To adjust pH to a desired value, either acids or caustics can be added in the mixing tank. Some treatment technologies require a high or low pH to effectively perform treatment (e.g., air stripping of ammonia requires a pH of 10 to 11). pH is generally adjusted to between 6 and 9 prior to final discharge.

7.2.8.2 Industry Application

Based on responses to the Detailed Questionnaire, 126 of 244 responding facilities in the pharmaceutical manufacturing industry use pH adjustment or neutralization treatment of wastes. Retention times for these treatment units average approximately one hour.

7.2.9 Equalization

7.2.9.1 General Description

Because many of the treatment technologies listed in this are performed continuously and some are sensitive to spikes of high flow or high contaminant concentrations, it is necessary to include equalization as a part of most treatment systems. Equalization is normally performed in large tanks or basins designed to hold a certain percentage of a facility's daily wastewater flow. Equalization will equalize high- and low-flow portions of a typical production day by allowing wastewater to be discharged to downstream treatment operations at a constant flow rate. Equalization can also provide a continuous wastewater feed to operations such as biological treatment that perform more effectively under continuous load conditions.

The mixing that occurs in an equalization basin minimizes spikes of various contaminants in the discharged wastewater. This equalization will prevent loss of treatment effectiveness or treatment system failures associated with these spikes.

7.2.9.2 Industry Application

Based on responses to the Detailed Questionnaire, 70 of 244 responding facilities in the pharmaceutical manufacturing industry use equalization. Retention times for these treatment units average approximately 20 hours.

7.2.10 Air Stripping

7.2.10.1 General Description

Air stripping is used in the pharmaceutical manufacturing industry to remove volatile organic constituents from wastewater. Air stripping can also be used to remove ammonia from wastewater. Air stripping is normally performed in a countercurrent, packed tower or tray tower column. In these systems, the wastewater is introduced at the top of the column and allowed to flow downward through the packing material or trays. Air is simultaneously delivered at the bottom of the column and blows upward through the water stream. Volatile organics are stripped from the water stream, transferred to the air stream, and carried out of the system at the top of the column. Treated water discharges from the bottom of the column. If ammonia treatment is desired, the pH of the waste stream would be adjusted to between 10 and 11 prior to introduction to the column.

7.2.10.2 Industry Application

Based on responses to the Detailed Questionnaire, 2 of 244 responding pharmaceutical manufacturing facilities use air strippers to treat wastewater. This technology is not common in the industry, and its use has decreased due to increasingly strict air emission regulations. Because the standard air stripper design simply transfers pollutants from water to air, the Agency does not regard it as an acceptable treatment technology and is not including air stripping as part of the technology base of any of the regulatory options.

7.2.11 Incineration

7.2.11.1 General Description

Incineration is used in the pharmaceutical manufacturing industry to treat organic and inorganic constituents in wastewater. This treatment is typically performed in a fixed bed or multiple hearth incinerator equipped with an acid gas scrubber for control of generated hydrochloric acid. Contaminants in the wastewater are destroyed by combustion and the remaining water vapor is discharged to the atmosphere.

7.2.11.2 Industry Application

Based on responses to the Detailed Questionnaire, 12 of 244 responding pharmaceutical manufacturing facilities use incinerators to treat wastewater. Because incineration is costly and energy-intensive when used to treat high-water content streams and does not allow for direct recycle or reuse of constituents contained in wastewater, the Agency is not including incineration as part of the technology basis for any of the regulatory options.

7.3 Development of Control and Treatment Options

7.3.1 Introduction

This describes the combinations of treatment technologies that the Agency evaluated as technology options for the basis of the promulgated regulations:

- Best practicable control technology currently available (BPT);
- Best conventional pollutant control technology (BCT);
- Best available technology economically achievable (BAT);
- New source performance standards (NSPS);
- Pretreatment standards for existing sources (PSES); and
- Pretreatment standards for new sources (PSNS).

Treatment technologies for each option are selected from the list of technologies presented in 7.2, and include advanced biological treatment, advanced biological treatment with nitrification, cyanide destruction, and steam stripping. In addition, BCT was also evaluated for additional TSS removal using multimedia filtration and polishing pond treatment.

These promulgated regulations establish limits on the discharge of pollutants from industrial point sources. The regulations are based upon the performance of specific technologies, but do not require the use of any specific technology. The regulations applicable to direct dischargers (BPT, BCT, BAT, NSPS) are effluent limitations guidelines and standards that are applied to individual facilities through NPDES permits issued by EPA or authorized states under 402 of the CWA. The regulations applicable to indirect dischargers (PSES, PSNS) are standards, and are administered by local permitting authorities (i.e., the government entity controlling the POTW to which the industrial wastewater is discharged). The final pretreatment standards are designed to control pollutants that pass through or interfere with POTWs.

The treatment technologies that form the basis of the BPT options were selected to provide reduction of BOD_5, COD, and TSS, in pharmaceutical manufacturing wastewater. The treatment technologies that form the basis of the BCT options were selected to provide reduction of BOD_5 and TSS beyond the removals of these pollutants achieved by BPT effluent limitations guidelines. The treatment technologies that form the basis of BAT, PSES, NSPS, and PSNS options were selected to provide reduction of organic constituents, COD, ammonia, and cyanide. 6 identifies the list of organic constituents regulated by these options.

Sections 7.3.2 through 7.3.7 provide discussions of each of the regulatory options described above, including the treatment technologies that form the basis of each option, and the rationale for the development of each of the options. Technologies included under each regulatory option may vary by subcategory and are therefore presented in separate subsections for Subcategories A and C and Subcategories B and D, respectively. Table 7-3 summarizes the regulatory options, identifying the treatment technologies included under each one.

7.3.2 Best Practicable Control Technology Currently Available (BPT)

Effluent limitations guidelines based on the best practicable control technology currently available establish quantitative limits on the direct discharge of pollutants from existing industrial point sources. BPT effluent limitations guidelines are based upon the average of the best existing performance, generally in terms of treated effluent discharged by facilities of various sizes, ages, and unit processes within an industry or subcategory. BPT effluent limitations guidelines are most commonly developed for the control of conventional and nonconventional pollutants, but also may be used for the control of priority pollutants.

In developing BPT, the Agency considers the total cost of applying the technology in relation to the effluent reduction benefits to be achieved from the technologies; the size and age of equipment and facilities; the processes used; the engineering aspects of applying various types of control techniques; process changes; and nonwater quality environmental impacts, including energy requirements.

7.3.2.1 Subcategories A and C

EPA considered five regulatory options as BPT for Subcategories A and C as part of the development of the proposed effluent limitations guidelines for the pharmaceutical manufacturing industry. These options are discussed in detail in the technical development document supporting the proposed rule, and are not discussed further in this section. In the May 2, 1995 proposal, the selected options were based on the application of advanced biological treatment. After gathering additional data after proposal and reviewing comments on the proposed rule and the supplemental Notice of Availability to the proposed rule, the Agency considered four options for the final BPT limitations for Subcategories A and C. Under the first option, EPA would not revise the existing BPT limitations for BOD_5, TSS, COD and cyanide. Under the second option, EPA would revise the BPT limitations based on advanced biological treatment only for COD, and revise the monitoring requirements for the existing cyanide limitations. Under option three, EPA would revise BPT limitations for BOD_5 and TSS based on advanced biological treatment and revise the monitoring requirements for the existing cyanide limitations. Under the fourth option, EPA

would revise BPT limitations for BOD_5, TSS, and COD based on advanced biological treatment, and revise the monitoring requirements for the existing cyanide limitations. The three options with advanced biological treatment are based on a system installed immediately prior to the off-site wastewater discharge point (end-of-pipe). As discussed in 8, advanced biological treatment provides significant removal of BOD_5, COD, and TSS and is widely used in the pharmaceutical manufacturing industry.

7.3.2.2 Subcategories B and D

EPA considered three regulatory options as BPT for Subcategories B and D as part of the development of the proposed effluent limitations guidelines for the pharmaceutical manufacturing industry. These options are discussed in detail in the technical development document supporting the proposed rule, and are not discussed further in this section. In the May 2, 1995 proposal, the selected options were based on the application of advanced biological treatment. After gathering additional data after proposal and reviewing comments on the proposed rule and the supplemental Notice of Availability to the proposed rule, the Agency considered four options for the final BPT limitations for Subcategories B and D. Under the first option, EPA would not revise the existing BPT limitations for BOD_5, TSS, COD and withdraw the existing cyanide limitations. Under the second option, EPA would revise the BPT limitations based on advanced biological treatment only for COD, and withdraw the existing cyanide limitations. Under option three, EPA would revise BPT limitations for BOD_5 and TSS based on advanced biological treatment and withdraw the existing cyanide limitations. Under the fourth option, EPA would revise BPT limitations for BOD_5, TSS, and COD based on advanced biological treatment, and withdraw the existing cyanide limitations.

7.3.2.3 Rationale

Advanced biological treatment is the basic treatment in each of the technology options described above. Biological treatment is a well-established method for treating BOD_5 and COD in wastewater and is the most common method in the pharmaceutical manufacturing industry for treating BOD_5. Of the facilities in the industry that reported using biological treatment, 74% use

the activated sludge process. The secondary clarifier, which is a standard component of the biological treatment system, provides TSS treatment of the wastewater prior to discharge from the system.

The treatment performance of these regulatory options considered for promulgation is discussed in 8.

7.3.3 Best Conventional Pollutant Control Technology (BCT)

Effluent limitations guidelines based on the best conventional pollutant control technology establish quantitative limits on the direct discharge of conventional pollutants from existing industrial point sources. In contrast to BPT guidelines that are devised as the average of the best existing performance by a group of like facilities, BCT guidelines are developed by identifying candidate technologies and evaluating their cost-reasonableness. Effluent limitations guidelines based upon BCT may not be less stringent than BPT effluent limitations guidelines. As such, BPT effluent limitations are a "floor" below which BCT effluent limitations guidelines cannot be established. EPA uses a BCT cost test methodology in determining whether it is "cost-reasonable" for industry to control conventional pollutants at a level more stringent than would be required by BPT effluent limitations. This methodology is fully described in 14.

In performing the BCT cost test, a BPT baseline must be developed to serve as the starting point against which more stringent technologies are analyzed. In each subcategory at proposal, EPA conducted the BCT analysis assuming the baseline was the proposed BPT level of advanced biological treatment. EPA received comments that this was not an appropriate choice for the BPT baseline, and that instead the level of control associated with the existing BPT effluent limitations guidelines should be used as the BPT baseline in the cost test. In consideration of these comments, EPA has modified the BPT baseline in the cost test to be equal to the level of control associated with the existing BPT effluent limitations guidelines.

7.3.3.1 Subcategories A and C

The BCT treatment options for Subcategories A and C are the same as the BCT options considered at proposal: a no revision option; revision of BOD_5, TSS and COD based on advanced biological treatment; revision of BOD_5 and TSS based on advanced biological treatment and effluent filtration; revision of BOD_5 and TSS based on advanced biological treatment and polishing ponds; and revision of BOD_5 and TSS based on advanced biological treatment and effluent filtration and polishing ponds.

7.3.3.2 Subcategories B and D

The BCT treatment options for Subcategories B and D are the same as the BCT options considered at proposal: a no revision option; revision of BOD_5 and TSS based on advanced biological treatment; and revision of BOD_5 and TSS based on advanced biological treatment and effluent filtration.

7.3.3.3 Rationale

The rationale for the use of advanced biological treatment under BCT is the same as that presented for BPT. EPA also evaluated whether additional TSS control using effluent filtration and/or polishing ponds was cost reasonable under the BCT cost test. TSS is a conventional pollutant present at significant levels and effluent filtration and polishing ponds provide a greater degree of control of TSS than advanced biological treatment.

7.3.4 Best Available Technology Economically Achievable (BAT)

Effluent limitations guidelines based on the best available technology economically achievable establish quantitative limits on the direct discharge of priority and nonconventional pollutants to waters of the United States. These limits are based upon the performance of specific technologies, but they do not require the use of any specific technology. BAT effluent limitations guidelines are applied to individual facilities through NPDES permits issued by EPA or authorized

states under 402 of the CWA. The facility then chooses its own approach to complying with its permit limitations.

The technology selected by the Agency to define the BAT performance may include end-of-pipe treatment, process changes, and internal controls, even when these technologies are not common industry practice. BAT performance is established for groups of facilities with shared characteristics. Where a group of facilities demonstrates uniformly inadequate performance in controlling pollutants of concern, BAT may be transferred from a different subcategory or industrial category.

A primary consideration in selecting BAT is the effluent pollutant reduction capability of the available technologies. Implementation of the best available technology must be economically achievable by the industry, so the cost of applying the technology is also considered. Other factors considered in establishing BAT include:

- The processes used;
- Engineering aspects of the application of various types of control techniques;
- Potential process changes;
- Age and size of equipment and facilities; and
- Nonwater quality environmental impacts, including energy requirements.

7.3.4.1 Subcategories A and C

EPA considered four regulatory options as BAT for Subcategories A and C as part of the development of the proposed effluent limitations guidelines for the pharmaceutical manufacturing industry. These options are discussed in detail in the technical development document supporting the proposed rule, and are not discussed further in this section. In the May 2, 1995 proposal, the selected options were based on the application of in-plant steam stripping and hydrogen peroxide

oxidation followed by end-of-pipe advanced biological treatment for Subcategories A and C, and application of end-of-pipe advanced biological treatment for Subcategories B and D.

After proposal, the Agency gathered additional data and reviewed comments on the proposed rule and the Supplemental Notice of Availability to the proposed rule. The Agency also considered the regulatory effects of the Maximum Achievable Control Technology (MACT) standards for the Pharmaceutical Manufacturing Industry, which were proposed on April 2, 1997, to control emissions of Hazardous Air Pollutants (HAPs) from storage tanks, process vents, equipment leaks, and wastewater. The MACT standards, for releases from wastewater, provide for in-plant control, or equivalent control of the wastestreams that contain sufficient quantities of volatile organic pollutants. Since the wastestreams that require control by in-plant steam stripping will receive that control under MACT, the Agency has decided to change its model BAT technology basis for VOCs to avoid duplicative regulations. As a result of this additional data and associated analyses, EPA considered three options as the basis of promulgated regulations. All three options modify the existing BAT regulations to parallel the BPT regulations and to clarify the compliance monitoring point for the existing cyanide limitations. The first option is a no cost revision which includes revised limitations for COD equal to the final BPT limitations and clarifies the monitoring requirements for cyanide. The second option adds limitations for 30 organic pollutants based on advanced biological treatment, revised limitations for COD equal to the final BPT limitations and clarifies the monitoring requirements for cyanide. The third option adds limitations for 30 organic pollutants based on advanced biological treatment, ammonia limitations based on one or two stage biological nitrification technology, incorporates the revised COD limitations and clarifies the monitoring requirements for cyanide.

7.3.4.2 Subcategories B and D

EPA considered two final BAT regulatory options. The first option is a no cost option consisting of the withdrawal of the existing cyanide limitations and the addition of the BPT revised COD limitations. The second option includes the withdrawal of the existing cyanide limitations and the addition of the BPT revised COD limitations and limitations based only on advanced biological

treatment for the same organic pollutants selected for regulation at the Subcategory A and C facilities.

7.3.4.3 Rationale

Advanced biological treatment is the basic treatment operation in the technology options described above. Advanced biological treatment is a proven method for treating COD and organic constituents in pharmaceutical manufacturing industry wastewater. Treatment performance data for advanced biological treatment and the other technologies included in the BAT options are provided in 8. Of the facilities in the industry that reported using biological treatment, 74% use the activated sludge process. Biological treatment systems, including activated sludge systems, can achieve significant ammonia removal through nitrification. Nitrification can be achieved through adjusting the operating parameters of a single stage system or by using a two stage system.

In-plant steam stripping, which was considered as a treatment technology in the effluent guidelines proposal, was not included in the list of BAT regulatory options for promulgation. Steam stripping was originally included to control highly volatile components that would not be treated, but would be air stripped. EPA has determined that MACT standards will provide this control, and these standards have been promulgated concurrently. The inclusion of steam stripping treatment beyond what is currently provided under the MACT standards for BAT would be unnecessary and duplicative.

Because cyanide and ammonia are not present at concentrations of concern in Subcategory B and D wastewaters, cyanide destruction and ammonia treatment are not included under the Subcategory B and D options.

7.3.5 New Source Performance Standards (NSPS)

The basis for new source performance standards under 306 of the CWA is the best available demonstrated technology. Industry has the opportunity to design and install the best and most

efficient processes and wastewater treatment facilities at new facilities. Accordingly, Congress directed EPA to consider the best demonstrated alternative processes, process changes, in-plant control measures, and end-of-pipe wastewater treatment technologies that reduce pollution to the maximum extent feasible. In response to that directive, and as with the development of options for the BAT effluent limitations guidelines, EPA considered effluent reductions attainable by the most advanced and demonstrated process and treatment technologies at pharmaceutical manufacturing facilities.

7.3.5.1 Subcategories A and C

EPA considered two regulatory options as the basis of NSPS for Subcategories A and C as part of the development of the proposed effluent limitations guidelines for the pharmaceutical manufacturing industry. These options are discussed in detail in the technical development document supporting the proposed rule. In the May 2, 1995 proposal, the selected option was based on the application of in-plant steam stripping with rectification and hydrogen peroxide oxidation followed by end-of-pipe biological treatment to a treatment level achieved by the best performing facility for Subcategories A and C. After proposal, the Agency gathered additional data, reviewed comments on the proposed rule and the Supplemental Notice of Availability to the proposed rule, and considered the regulatory effects of the MACT standards for the industry. The MACT standards for releases from wastewater provide for in-plant control (or equivalent) of the wastestreams that contain sufficient quantities of volatile organic pollutants. Since the wastestreams that require control by in-plant steam stripping will receive this control under MACT, the Agency has decided to remove this component of its NSPS technology basis for VOCs to avoid duplicative regulations.

EPA evaluated technology options capable of achieving greater pollutant removal of conventional pollutants (BOD_5 and TSS), COD, organics, cyanide, and ammonia than those selected as the basis for existing source limitations (BPT, BCT, and BAT). The only option potentially capable of achieving additional removals involves the use of granular activated carbon (GAC) absorption technology. This technology is capable of reducing the COD from some direct discharging A and C Subcategory facilities. However, there is only limited GAC performance data available, from

one pilot study. EPA ultimately concluded that this study did not provide a sufficient basis to develop NSPS limitations.

Therefore, EPA considered a single NSPS option based on the best available demonstrated control technologies, which include advanced biological treatment with nitrification and cyanide destruction. NSPS under this option are the same as BAT effluent limitations for 30 organic pollutants, cyanide, and ammonia. EPA is also promulgating revised NSPS for BOD_5, COD, and TSS at a level equal to the discharge characteristics of the best performing BPT plants. For COD this is equivalent to the BAT/BPT level of control.

7.3.5.2 Subcategories B and D

Similar to Subcategories A and C, for Subcategories B and D EPA considered a single NSPS option based on the best available demonstrated control technology, which is advanced biological treatment. The revised NSPS for BOD_5, COD, and TSS associated with this option is at a level equal to the discharge characteristics of the best performing BPT plants. For COD this is equivalent to the BAT/BPT level of control.

7.3.5.3 Rationale

Because new plants have the opportunity to install the best and most efficient wastewater treatment technologies, NSPS should be based on the most stringent control technology demonstrated for all pollutants of concern (conventional, nonconventional, and priority pollutants). The NSPS options include the most advanced wastewater treatment technologies demonstrated to effectively treat pharmaceutical manufacturing industry wastewater. The NSPS options address the treatment of conventional, nonconventional, and priority pollutants in Subcategory A and/or C and Subcategory B and/or D wastewaters. Because cyanide and ammonia are not present in wastewaters at concentrations of concern at existing Subcategory B and D facilities, cyanide destruction and ammonia treatments are not included under the NSPS option for Subcategories B and D.

7.3.6 Pretreatment Standards for Existing Sources (PSES)

Pretreatment standards for existing sources establish quantitative limits on industrial discharges to POTWs. PSES are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. The CWA requires pretreatment for pollutants that pass through POTWs in amounts that would exceed direct discharge effluent limitations or limit POTW sludge management alternatives, including the beneficial use of sludges on agricultural lands. The transfer of a pollutant to another media (air) through volatization does not constitute treatment. Pretreatment standards are to be technology-based and analogous to BAT for removal of priority and nonconventional pollutants. Like effluent guidelines limitations and standards based on BPT, BCT, BAT, and NSPS, PSES do not require the use of any specific technology.

7.3.6.1 Subcategories A and C

In developing the final PSES for Subcategories A and C, EPA considered three options. The first option was not to develop pretreatment standards for ammonia or any of the VOC pollutants, and to modify the monitoring requirements for the existing cyanide standards. The second option builds on compliance with the MACT standard with additional pretreatment standards for VOC's based on steam stripping technology and ammonia based on steam stripping or nitrification. The second option also includes modification of the existing cyanide monitoring requirements. The third option is the same as the second option, with the addition of revised pretreatment standards for cyanide based on an in-plant technology unit consisting of either hydrogen peroxide oxidation technology or alkaline chlorination technology, depending on individual facility conditions.

7.3.6.2 Subcategories B and D

For Subcategories B and D, EPA considered two options. The first option was not to add regulated pollutants to the existing PSES and, since cyanide is not present in wastewaters for these subcategory facilities, to withdraw the existing cyanide standards. Thus, compliance with the MACT standard would be the only requirement for controlling VOC pollutants. The second

option was to add pretreatment standards for VOCs based on steam stripping in addition to withdrawing the existing cyanide standards. No ammonia standards were considered since facilities in these subcategories do not generate significant levels of ammonia in their wastewaters.

7.3.6.3 Rationale

Steam stripping is an effective technique for the removal of priority and nonconventional pollutants of concern in pharmaceutical manufacturing wastewater. Steam stripping provides effective pretreatment of wastewater that is further treated off-site by biological treatment at a POTW. The regulatory options beyond no revision use steam stripping to control the additional discharge of VOCs not controlled by the MACT standards.

Cyanide and ammonia are not present at concentrations of concern in Subcategory B and D wastewaters; therefore, cyanide destruction and ammonia treatment are not included under the Subcategory B and D options. It was also determined that biological treatment beyond what is currently provided at the POTW would not be appropriate treatment of wastewater from all pharmaceutical facilities. Therefore, the PSES regulatory options for Subcategories A, B, C, and D include in-plant steam stripping without any end-of-pipe biological treatment.

7.3.7 Pretreatment Standards for New Sources (PSNS)

Pretreatment standards for new sources establish quantitative limits on the indirect discharge of priority and nonconventional pollutants to waters of the United States. 307(c) of the CWA requires EPA to promulgate PSNS at the same time it promulgates NSPS. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies, including process changes, in-plant controls, and end-of-pipe treatment technologies.

As discussed in 17, EPA determined that a range of priority and nonconventional organic pollutants, ammonia, and cyanide pass through POTWs. PSNS are applicable to these pollutants.

7.3.7.1 Subcategories A, B, C, and D

For all subcategories, EPA considered the same technology options under PSNS as under PSES. For the final rule, EPA was not able to identify a technology option that would achieve greater removal of pollutants than the PSES technology options.

7.3.7.2 Rationale

New indirect dischargers, like new direct dischargers, have the opportunity to incorporate into their plants the best available wastewater treatment technologies. Therefore, the treatment technologies included in the PSNS options are the most advanced wastewater treatment technologies demonstrated to effectively treat pharmaceutical manufacturing industry wastewater. The PSNS technology options address the treatment of organics, ammonia, and cyanide in Subcategory A and C wastewater and organics in Subcategory B and D wastewater in a manner similar to the PSES technology options. Since cyanide and ammonia are not present in wastewater at concentrations of concern at Subcategory B and D facilities, cyanide destruction and ammonia treatment are not included under the Subcategory B and D options. EPA did not consider a technology option employing advanced biological treatment for the same reasons EPA rejected end-of-pipe advanced biological treatment as part of the PSES technology options.

Table 7-1

Summary of Major Treatment Technologies Used in the Pharmaceutical Manufacturing Industry

Technology	Number of Facilities Using the Technology[a]	
	Subcategories A and C	Subcategories B and D
pH Adjustment/Neutralization	81	45
Equalization	44	26
Biological Treatment		
Single-Stage Activated Sludge	31	21
Two-Stage Activated Sludge	2	2
Oxygen Activated Sludge	1	1
Aerated Lagoons	7	5
Trickling Filters	4	1
Rotating Biological Contactors	2	1
Multimedia Filtration	3	3
Cyanide Destruction		
Alkaline Chlorination	6	0
H_20_2 Oxidation	3	0
Hydrolysis	1	0
Distillation Technologies		
Solvent Recovery		
Distillation	12	3
Distillation with reflux	28	5
Rectification	12	1
Wastewater treatment		
Steam stripping	4 [b]	0
Carbon Adsorption	6	4
Polishing Pond	2	6
Air Stripping	2	0
Incineration	10	1

(a)Data based on responses from the Detailed Questionnaire (244 responding facilities).
(b)In their Detailed Questionnaire responses, 14 facilities reported using steam stripping for wastewater treatment; however, based on a review of each of these facilities, EPA determined that only four facilities were actually using the technology for wastewater treatment.

Table 7-2

Pharmaceutical Manufacturing Facilities Quantity of Chemicals Recycled/Reused (1990)

Chemical Name	Number of Facilities Reporting	Total Quantity Recycled/Reused (lbs)
Acetone	2	17,107,958
Acetonitrile	2	10,518,000
n-Butyl acetate	1	37,302,726
1,2-Dichloroethane	2	187,020
Ethyl acetate	1	10,243,000
Ethyl alcohol	1	122,304,000
Heptane	1	5,680,400
Hexane	1	248,082
Isopropanol	1	27,441
Methanol	7	19,027,784
Methylene chloride	7	92,599,587
Pyridine	1	451,000
Tetrahydrofuran	1	76,666
Toluene	6	19,185,893
Triethylamine	1	29,534
TOTAL		**334,989,091**

Table 7-3

Summary of Regulatory Options

Regulation	Option Name	Technology Basis	
		Subcategory A and C Facilities	**Subcategory B and D Facilities**
BPT	No Revision (MACT Only)	Current Treatment Technology	Current Treatment Technology and Withdraw Cyanide
	Clarify Cyanide, Revise COD Only	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Clarify Cyanide, Revise BOD_5 and TSS Only	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Clarify Cyanide and Revise BOD_5, TSS, & COD	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
BCT	No Revision	Current BPT	Current BPT
	Revise BOD_5 & TSS	Advanced Biological Treatment	Advanced Biological Treatment
	Revise BOD_5 & TSS	Advanced Biological Treatment and Effluent Filtration	Advanced Biological Treatment and Effluent Filtration
	Revise BOD_5 & TSS	Advanced Biological Treatment and Polishing Pond	--
	Revise BOD_5 & TSS	Advanced Biological Treatment and Effluent Filtration and Polishing Pond	--
BAT	Revise COD to BPT Limits and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Add Organics Only, Revise COD to BPT Limits, and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Add Organics and Ammonia, Revise COD to BPT Limits, and Clarify Cyanide	Advanced Biological Treatment with Nitrification, and Revised Monitoring Requirements for Cyanide	*Ammonia and cyanide limits do not apply for B/D facilities*

Table 7-3 (Continued)

Regulation	Option Name	Technology Basis	
		Subcategory A and C Facilities	**Subcategory B and D Facilities**
NSPS	Revise Equal to Promulgated Level of BPT/BAT Control	Advanced Biological Treatment with Nitrification, and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
PSES	No Revision (MACT Only) and Clarify Cyanide	Current Treatment Technology and Revised Monitoring Requirements for Cyanide	Current Treatment Technology and Withdraw Cyanide
	Organics Only and Withdraw Cyanide	*This option was not considered for A/C Facilities*	In-Plant Steam Stripping for Organic Compounds and Withdraw Cyanide
	Organics and Ammonia, and Clarify Cyanide	In-Plant Steam Stripping for Organic Compounds and Ammonia, and Revised Monitoring Requirements for Cyanide (Nitrification may be used for Ammonia)	*Ammonia and Cyanide limits do not apply for B/D Facilities*
	Organics and Ammonia, and Revise Cyanide	In-Plant Steam Stripping for Organic Compounds and Ammonia, and In-Plant Cyanide Destruction (Nitrification may be used for Ammonia)	*Ammonia and Cyanide limits do not apply for B/D Facilities*
PSNS	Revise Equal to Promulgated PSES Limits	PSES Treatment Technology	PSES Treatment Technology

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SECTION 8

PERFORMANCE OF THE CONTROL AND TREATMENT OPTIONS

8.1 Introduction

This discusses the treatment performance data collected and available to the Agency for the treatment technologies discussed in 7 and for the constituents and pollutant parameters to be regulated discussed in 6. The subsections below list, by technology, criteria applied to available datasets to determine which data corresponded to well-designed/well-operated treatment units that are used in developing long-term mean (LTM) performance levels. Those data meeting the criteria are presented in this section.

The following information is presented in this section:

- 8.2 provides an overview of the treatment performance databases developed by the Agency and their sources.
- 8.3 provides a technology-by-technology evaluation of treatment performance data, lists the criteria used to identify data associated with well-designed/well-operated systems, and summarizes those datasets that meet the well-designed/well-operated criteria.
- 8.4 presents the Agency's rationale for the data transfers developed for this regulation, including process simulation modeling conducted by EPA to support transfers.
- 8.5 discusses the development of LTMs for conventional pollutants and COD.
- 8.6 discusses the development of the LTM for cyanide.
- 8.7 discusses the development of LTMs for priority and nonconventional pollutants.
- 8.8 discusses the development of the LTM for ammonia.

8.2 Treatment Performance Databases

There are four main sources of treatment performance data available to the Agency: EPA sampling data; industry-supplied self-monitoring data; data gathered from EPA-sponsored treatability studies; and data collected as part of other research efforts. These sources are described in detail in 3.2. The treatment performance data used from these sources are discussed in greater detail below.

8.2.1 EPA Pharmaceutical Manufacturers Sampling Program Data

Beginning in 1978, EPA conducted the Screening and Verification Sampling Programs. Under these programs, wastewater samples were collected from plants with manufacturing operations representative of the pharmaceutical manufacturing industry. In the screening program, in-plant and end-of-pipe wastewater samples from 26 plants were screened for the presence of 129 priority pollutants. Typical sample collection periods were 24 hours during the screening phase. The Agency conducted follow-up sampling (referred to as the verification phase) at five facilities to verify the presence, levels, frequency of discharge, and treatability of the pollutants detected during the screening program. The typical verification sampling program was three days in length.

Between 1983 and 1991, EPA also conducted 15 different sampling episodes at 13 pharmaceutical manufacturing facilities. Data were collected for all pollutants on the List of Analytes during these sampling efforts. These data were used to characterize the pollutants in the wastewater discharged by direct and indirect facilities, to generate pollutant treatment system performance data from facilities with well-operated biological treatment systems, and to obtain treatability data characteristic of the operation of steam stripping columns.

The treatment performance data collected from these sampling episodes were incorporated into a sampling database. These data were evaluated against the criteria defined in 8.3 to establish data representative of well-designed/well-operated steam stripping, and biological treatment systems for priority and nonconventional pollutants.

8.2.2 Industry-Supplied Self-Monitoring Data

Self-monitoring data were supplied by pharmaceutical manufacturers to the Agency as part of their response to the Detailed Questionnaire (self-monitoring data were also submitted by the seven facilities that participated in the 1989 pretest questionnaire). In addition, the Agency requested self-monitoring data from Facility 30542 on the performance of their cyanide destruction unit, which employs in-plant hydrogen peroxide oxidation treatment. Several pharmaceutical facilities also submitted self-monitoring data with their comments on the Proposed Pharmaceutical Effluent Guidelines and Limitations and the Notice of Availability. All self-monitoring treatment performance data were evaluated against the criteria defined in 8.3 to establish data representative of well-designed/well-operated treatment units. Data that conformed to the criteria were placed into the Self-Monitoring Database. This database includes biological treatment performance data for conventional, priority, and nonconventional pollutants as well as cyanide treatment performance data. EPA also has TSS industry-supplied self-monitoring data in connection with multi-media filtration and polishing pond treatment.

8.2.3 EPA Treatability Studies Data

In 1984, the Agency collected granular activated carbon treatability data for total COD. The data collected as part of this treatability study were evaluated to establish data representing well-designed/well-operated GAC treatment for COD.

In late 1991, the Agency collected steam stripping treatability data for several volatile organic pollutants generated at a pharmaceutical manufacturing facility using a pilot-scale and bench-scale steam stripper. Additionally, the Agency collected distillation treatability data in September of 1993 for methanol, using an existing full-scale distillation column in operation at a pharmaceutical manufacturing facility. The data collected as part of these treatability studies were evaluated against the criteria defined in 8.3 to identify data representative of well-designed/well-operated steam stripping and distillation treatment for priority and nonconventional pollutants.

8.2.4 Other Research Sources

In 1979, the Robert S. Kerr Environmental Research Laboratory at Ada, Oklahoma conducted an applied research study to determine the fate of specific priority pollutants within a biological treatment system.(1) In the course of the study, priority pollutants associated with the manufacture of pharmaceuticals were identified at two industrial facilities. The data collected as part of this study were evaluated against the criteria defined in 8.3 to identify data representative of well-designed/well-operated biological treatment for priority pollutants.

8.3 Evaluation of Treatment Performance Data

This subpresents the criteria used to evaluate well-designed/well-operated performance for each technology. The treatment performance data that meet these editing criteria are also presented below.

8.3.1 Advanced Biological Treatment

The Agency has defined "advanced" biological treatment at pharmaceutical manufacturing facilities as those with existing BPT-level performance or better, for treating BOD_5 and COD. Advanced biological treatment performance was defined in 7.2.2.1 as systems that consistently surpass, on a long-term basis, 90% BOD_5 reduction and 74% COD reduction from raw waste levels in pharmaceutical manufacturing wastewater, as required by the existing BPT effluent limitations guidelines (40 CFR Part 439).

These reductions in BOD_5 and COD represent the initial criteria used to identify best performer datasets for advanced biological treatment. For BOD_5, COD, and TSS, an additional criteria established for best performer datasets was that the treatment system represented by the data treat a predominant amount (49% or more by volume) of pharmaceutical process wastewater in relation to other process wastewaters treated by the system. In response to comments on the proposed rulemaking, EPA has used only treatment performance data collected from biological treatment systems that contain less than 25% nonprocess water to calculate long-term mean

performance. This data exclusion is based on the previous EPA effluent limitations guidelines and standards rulemaking for the Organic Chemicals, Plastics and Synthetic Fibers (OCPSF) industry (52 FR 42522) and ensures that the data used are representative of process wastewater treatment without undue dilution from nonprocess water sources.

Table 8-1 presents the BOD_5, COD, and TSS datasets that meet the criteria listed above for best performance. A review of these datasets shows that each is consistently achieving far greater reductions in BOD_5, COD, and TSS discharges than the other plants subject to the existing BPT regulations. Facilities 30010, 30540, and 30623 represent best treatment performance for conventional pollutants and COD for Subcategory A and C facilities. Facility 30637 represents best treatment performance for conventional pollutants and COD for Subcategory B and D facilities.

For the identification of applicable datasets for organic pollutants, the facility must achieve BOD_5 and COD removal representative of "advanced" biological treatment. Additional review criteria included:

- The treatment facility must process a predominant amount of pharmaceutical process wastewater compared to other process wastewater. A predominate amount is defined as $\geq$49%;
- The data should be for a constituent or pollutant parameters selected for regulation or to be used as a data transfer;
- The data must be representative of advanced biological treatment technology (e.g., datasets representing biological treatment plus powdered activated carbon adsorption were removed from consideration);
- The data from facilities that supplied influent data only should be excluded;
- The data must be from facilities where the average influent pollutant concentration was at least 10 times greater than the analytical detection limit so that treatment being achieved could be measured;
- The facility must treat less than 25% nonprocess water through the biological treatment facility; and

- The data must be from sampling events consisting of three or more data points.

Table 8-2 presents the organic constituent datasets that meet the criteria listed above for best performance. For organic constituents, treatment performance data do not demonstrate a difference in treatment based on subcategory, and were considered together. These data are considered representative of treatment performance for all subcategories.

8.3.2 Nitrification

The Agency has evaluated single and two-stage biological treatment at pharmaceutical manufacturing facilities to identify nitrification performance data. Nitrification can be accomplished in either a single or two-stage activated sludge system. Two indicators of nitrification are the presence of ammonia oxidizing bacteria and nitrite oxidizing bacteria, and analysis of the nitrogen balance to determine if nitrifying bacteria reduce the amount of ammonia and increase the amount of nitrite and nitrate. 7.2.2.1 identified common design criteria for single and two-stage systems with nitrification capability. In EPA's evaluation of its one stage biological treatment data, some systems were found to nitrify part of the time. In these cases, EPA considered in its nitrification database those data points associated with nitrification behavior. The treatment performance demonstrated by the edited data sets closely resembles the treatment performance of the data sets which exhibited consistent nitrification. Table 8-3 presents the nitrification treatment performance data that represent nitrification. All of this performance data is taken from biological treatment systems achieving at least 90% BOD_5 removal and 74% COD removal.

8.3.3 Multimedia Filtration

The Agency has obtained industry-supplied self-monitoring treatment performance data for tertiary filtration from one Subcategory A and C pharmaceutical manufacturing facility (Facility 50007) and from two Subcategory B and D pharmaceutical manufacturing facilities (Facilities 12053 and 12317). TSS reductions through treatment were calculated using these data; datasets

that did not include influent concentrations were not included in the calculations. Table 8-4 presents the data that describe the treatment performance of these tertiary filters.

8.3.4 Polishing Ponds

The Agency has obtained industry-supplied self-monitoring treatment performance data describing polishing pond treatment from one Subcategory A and C pharmaceutical manufacturing facility. TSS reductions through treatment were calculated using these data. The calculated reductions were used in developing the TSS LTM representing polishing pond treatment. Table 8-5 presents the polishing pond treatment performance data.

8.3.5 Cyanide Destruction

The Agency requested cyanide destruction data in the Detailed Questionnaire. Ten facilities reported using cyanide destruction systems, including the following types of treatment: hydrogen peroxide oxidation (at 3 facilities), alkaline chlorination (at 6 facilities), and hydrolysis (at 1 facility). EPA considered all of the individual datasets representative of the various cyanide destruction technologies in use. EPA considered two different technologies to represent achievable cyanide reduction: hydrogen peroxide oxidation and alkaline chlorination. Two technologies were considered because of the potential safety hazard hydrogen peroxide oxidation may cause when used to treat pharmaceutical cyanide wastewaters with high organic content. Hydrogen peroxide may be highly reactive with organic chemicals and may release oxygen in the chemical process which may combust causing unsafe working conditions. Alkaline chlorination on the other hand, does not release oxygen in the chemical process of converting cyanide to a nitrogen gas and carbonate.

As discussed in 3.2.5, EPA requested Facility 30542 to develop a long-term database documenting the performance of their hydrogen peroxide oxidation cyanide destruction unit. The facility submitted six months of data to EPA in November 1991. EPA also sampled the cyanide destruction unit of this facility during an on-site sample episode. The dataset that represents the performance of hydrogen peroxide oxidation was obtained from treatment batches with analytical

sampling of each treated batch to achieve a treated cyanide concentration ≤1mg/L. Facility 30567 developed a long-term database documenting the performance of their alkaline chlorination unit. The facility submitted 1990 data with their detailed questionnaire. The dataset that represents the performance of alkaline chlorination was obtained from treatment batches with analytical sampling of each treated batch. This dataset achieved on average a 99.9% cyanide removal. The self-monitoring data submitted by Facility 30542 along with EPA-collected sampling data from this facility's system were used to develop the LTMs for cyanide based on hydrogen peroxide oxidation. The self-monitoring data submitted by Facility 30567 were used to develop the LTMs for cyanide based on alkaline chlorination.

Hydrogen Peroxide Oxidation treatment performance data from Facility 30542 were evaluated and those data points which represent an effluent cyanide concentration in excess of 1.0 mg/L were removed from the dataset that represents best performance. Four of 36 effluent data points were removed based on this criterion. These batches should have been recycled to cyanide destruction treatment but were discharged at the time of the data collection due to a false negative result from the facility's internal test procedure for cyanide which did not identify the effluent concentrations above the 1.0 mg/L target.

Alkaline Chlorination treatment performance data from Facility 30567 were evaluated. Only the datasets that showed 99% or more removal of cyanide were used as BAT treatment performance data. There were 256 datasets included in the treatment performance database and 46 effluent data points were removed based on this criterion. These batches should have been recycled to cyanide destruction treatment because they are not representative of BAT treatment performance. Table 8-6 presents the cyanide destruction treatment performance data.

8.3.6 Steam Stripping

The Agency collected steam stripping performance data from four EPA sampling episodes and from one EPA-sponsored pilot study.(5)(6)(7)(8)(9) The Agency also collected distillation performance data from one EPA-sponsored study.(10) In addition, the Agency received industry supplied steam stripping monitoring data from multiple facilities.

The data from these sampling episodes and treatability studies were evaluated against steam stripping treatment performance criteria. (32)

Only those constituents to be regulated were included in the database. All data points that were collected from a flash tank or distillation pot were excluded since these technologies are not considered "equivalent" to the BAT technology. Influent and effluent datasets where the influent concentration was not detected, showed a negative percent removal or that showed no removal after treatment were excluded. Data were excluded if collected while a stripper was not at steady state, because these data would not be representative of BAT performance. Steady state for the purpose of this comparison was defined as the point where temperatures and flow rates are constant. All data point pairs with an influent concentration lower than the long-term means shown in Table 8-19 were deleted. All data point pairs collected from a steam stripper with inadequate steam to feed ratios or an inadequate number of equilibrium stages in the stripper were deleted (see Table 10-7). Data which came from a single wastewater stream at one facility that was deemed to have an atypical matrix, i.e., did not lend itself to BAT performance, and were reported at a detection limit an order of magnitude or more than EPA's promulgated method minimum level, were not used.

The Agency received several comments arguing against the use of the distillation performance data collected by the Agency at proposal. The Agency performed an alcohol distillation pilot study at a pharmaceutical facility to represent optimum performance for the removal of alcohols and other compounds with similar strippability. Commenters argued that the wastewater stream evaluated in that study was not representative of "typical" pharmaceutical industry wastewater since it did not contain a mix of organic solvents, rather it was predominantly a methanol and water stream. In response to these comments, the Agency has not used this dataset in the determination of the final limitations and standards.

All other treatment performance data were then evaluated against the criteria listed above. Table 8-7 presents the data meeting these criteria for the steam stripping options. For organic constituents, treatment performance data do not indicate a difference in treatment based on

subcategory, and were considered together. These data are considered representative of treatment performance for all subcategories.

The Agency has also evaluated the use of air stripping for the removal of ammonia.(9) Since the average ammonia concentration of the plant wastewater stream for the air stripping study was significantly less than that expected, the Agency made three test runs at varying V/L ratios with plant wastewater spiked with ammonia. The optimum V/L ratio for ammonia stripping in these runs was found to be 510 cfm/gpm and the treatment performance data from this run represent well-designed/well-operated treatment performance for ammonia removal. The treatment performance data from this run are presented below. The Agency is transferring this air stripping treatment performance data to represent treatment achievable by steam stripping. Each of these technologies are based on the same mass transfer principals and steam stripping is a more effective treatment technology than air stripping since it is conducted at elevated temperatures at which ammonia is more volatile. Therefore, steam stripping will be as or more effective than air stripping in removing ammonia from wastewater. Table 8-8 presents the air stripping treatment performance data which are being used to represent treatment performance achievable by steam stripping.

The Agency received several comments arguing against the use of the ammonia air stripping pilot study performance data. EPA disagrees with these comments and maintains that the data collected from the air stripping study can be extrapolated to steam stripping limitations, since steam stripping will produce better removals than air stripping. The study was performed on-site at a pharmaceutical plant that produces a variety of products including products in the A, C, and D Subcategories.

EPA agrees that steam stripping performance is highly dependent on wastewater pH. The pilot study was performed for pH ranges between 10 and 12. The results of the pilot study show optimal air stripping performance between these levels. EPA expects that comparable ammonia removals from steam stripping at a lower pH will result in similar effluent concentrations as air stripping at a higher pH.

Additional steam stripping data from industry submitted after proposal show that under appropriate operating conditions (proper pH, steam to feed ratio, equilibrium temperatures, and sufficient stages) ammonia concentrations lower than the promulgated long-term mean can be achieved. In one data submittal from full-scale steam stripping operating data, the average influent ammonia concentration was 129 mg/L with effluent ammonia concentrations ranging from non-detect (<5 mg/L) to 5 mg/L. In a pilot steam stripping study data submittal, effluent ammonia concentration values were all non-detect.

8.4 Evaluation of Treatment Performance Data Transfers

The Agency does not have treatment performance data for all constituents and pollutant parameters promulgated for regulation. The Agency has transferred treatment performance data from constituents with data to constituents without data that are deemed to be treated similarly. The transferred data are being used to develop limitations and standards for pollutants for which EPA does not have data. This discusses the treatment performance data transfers used by the Agency.

8.4.1 Advanced Biological Treatment Performance Data Transfers

As shown in Table 8-2, EPA has performance data from advanced biological treatment for 24 organic constituents. To develop a basis of transfer for the 25 organic constituents considered for regulation for which EPA does not have sufficient performance data, the Agency grouped the organic constituents by structural and biodegradability groups and identified data transfers within these groups.

The organic constituents selected for regulation were grouped by biodegradability, including "high", "medium", and "low" biodegradability. These biodegradability groups were developed using Kmax values and the ratio of BOD_5 to theoretical oxygen demand (BOD_5/ThOD). The Kmax biodegradation rate is based on Monod-type kinetics, which assumes that biodegradation of any one constituent is independent of the concentrations of other constituents as long as no constituents are inhibitory or toxic to the microorganisms. Inhibition or toxicity by one

constituent may slow or halt the degradation of other constituents. As the Kmax value increases, biodegradability increases. Large values of the ratio BOD_5/ThOD (e.g., >50%) indicate that the compound is readily biodegradable. Low ratios (e.g., < 20%) indicate that the compound is either slowly biodegradable or only partially biodegradable.(13)

Constituents were placed in the "high" biodegradability group if the Kmax value was greater than 4.00 E-06 or the BOD_5/ThOD ratio was greater than 50%. Because neither a Kmax value nor a BOD_5/ThOD ratio were found for methyl formate, this constituent was placed in the "high" group due to its similar structure to ethyl acetate which is in the "high" group.

Constituents were placed in the "medium" biodegradability group if there was a broad range of BOD_5/ThOD ratios (e.g., a BOD_5/ThOD ratio between 20% and 70%). Constituents were also placed in the "medium" biodegradability group if the Kmax value was greater than 1.00 E-07 and less than 4.00 E-06. Because Kmax values and BOD_5/ThOD ratios were not found for diethylamine, 2-methylpyridine, and triethylamine, these constituents were placed in the "medium" group, based on the following information:

- Literature suggests biodegradability of diethylamine, but reports it is inhibitory to bacterial and algal cell division (14);
- 2-methylpyridine is very similar in structure to pyridine, which is in the "high" group; however, 2-methylpyridine was placed in the "medium" group because the extra methyl group of this constituent makes it less biodegradable (16); and
- A 200 mg/L solution of triethylamine is 100% biodegraded but triethylamine is also reported to be 50% inhibitory to nitrifying bacteria.(15)

Constituents were placed in the "low" biodegradability group if the Kmax value was less than 1.00 E-07 or BOD_5/ThOD ratios were less than 20%. Because Kmax values and BOD_5/ThOD ratios were not found for amyl alcohol, formamide, and N,N-dimethylacetamide, these constituents were placed in the "low" group, based on the following information:

- Very slow biodegradation has been shown for amyl alcohol. An activated sludge unit demonstrated only 3.7% removal of ThOD of this compound in 24 hours.(15)

- Very slow biodegradation has been shown for formamide. An activated sludge unit demonstrated only 11.8% removal of ThOD of this compound in 24 hours.(15)

- N,N-Dimethylacetamide was placed in the "low" group due to its structural similarity to formamide.(15)

Table 8-9 presents the structural and biodegradability groups for the organic constituents and ammonia for which EPA has best performance data and for the other organic constituents selected for regulation without best performance data.

8.4.1.1 Data Transfer Methodology

Once the biodegradability groups were assigned, appropriate data transfers were identified whereby treatment performance data were transferred from constituents with data to constituents for which the Agency did not have treatment performance data. Transfers were made between structurally similar constituents from within the same structural group (with the exception of the amines and those constituents without treatment performance data in the miscellaneous group). Transfers were made from less treatable to more treatable constituents, based on their biodegradability groupings and general guidelines regarding biological treatability (i.e., decreasing biodegradability with increased branching or shortening of carbon chains).(16) Table 8-9 presents the biological treatment performance data transfers. For some of the constituents listed in Table 8-9, treatment performance data were not available, and transfers of long-term means were not identified using the general methodology outlined above. Treatment performance data transfers were developed for these constituents based on the following methodology: transfers were still based on structural similarity, although a few of the transfers were not between constituents from the same structural group. Where more than one constituent was a candidate from which to transfer a long-term mean performance level, the constituent with the higher long-term mean was chosen. All of these transfers were between constituents that are similar in terms of relative biodegradability. The specific rationale supporting each data transfer is discussed below.

8.4.1.2 Alcohol Structural Group

The data transfers within the alcohol structural group are from ethanol to ethylene glycol, tert-butyl alcohol, n-butyl alcohol, n-propanol, and amyl alcohol. In addition to having similar structures, ethylene glycol was included in the high biodegradability group while ethanol was included in the medium biodegradability group, suggesting a transfer of data from a more treatable to a less treatable constituent. Both n-propanol and amyl alcohol have similar structures to ethanol and have longer carbon chains, suggesting easier biodegradability. The transfer from ethanol to tert-butyl alcohol and n-butyl alcohol is based on structural similarity.

8.4.1.3 Aldehyde Structural Group

The data transfer within the aldehyde structural group is from formaldehyde to isobutyraldehyde. Isobutyraldehyde has a longer carbon chain attached to the carbonyl group, which should enhance its biodegradability. The ratio of BOD_5 to ThOD is 65% for isobutyraldehyde compared to 60% for formaldehyde, indicating isobutyraldehyde is as biodegradable as formaldehyde, thereby supporting this transfer.

8.4.1.4 Amide Structural Group

Within the amide structural group, the data transfers are from N,N-dimethylformamide to N,N-dimethylacetamide and formamide. For N,N-dimethylacetamide, the additional methyl group attached to the acetamide should make it more biodegradable than N,N-dimethylformamide. For formamide, N,N-dimethylformamide is the most structurally similar constituent to this amide for which data are available.

8.4.1.5 Amine Structural Group

The amide, N,N-dimethylformamide, is used as the source of data transfer for diethylamine and triethylamine, since their structures are very similar. Both amines are less branched than N,N-dimethylformamide and, therefore, predicted to be more biodegradable than N,N-dimethylformamide.

8.4.1.6 Aromatic Structural Group

Within the aromatic structural group, data transfers are from 2-methylpyridine to aniline, N,N-dimethylaniline, chlorobenzene, pyridine, and o-dichlorobenzene. Aniline and pyidine, which are in the high biodegradability group, are predicted to be more biodegradable than 2-methylpyridine, which is in the medium biodegradability group. o-Dichlorobenzene and chlorobenzene, which are in the medium biodegradability group, are predicted to be as biodegradable as 2-methylpyridine, which is also in the medium biodegradability group. The other data transfer is based on the fact that N,N-dimethylaniline is closest in structure to 2-methylpyridine, an aromatic constituent for which treatment performance data are available.

8.4.1.7 Ester Structural Group

Data transfers in the ester structural group are from isopropyl acetate to n-butyl acetate and from ethyl acetate to n-amyl acetate and methyl formate. For all three transfers, the constituent transferred to is less complex and/or has a longer carbon chain attached to the ester group, making it easier to biodegrade.

8.4.1.8 Ether Structural Group

In the ether structural group, data transfers are from tetrahydrofuran to polyethylene glycol 600, 1,4-dioxane, and isopropyl ether. The transfer from tetrahydrofuran to 1,4-dioxane is based on the structural similarity of these constituents and the more highly branched structure of tetrahydrofuran. Both constituents have the same Kmax value, also supporting the rationale that

1,4-dioxane should be at least as biodegradable as tetrahydrofuran. Tetrahydrofuran was chosen as the transfer basis for the other ethers without available treatment performance data since these constituents have similar structures.

8.4.1.9 Ketone and Alkane Structural Groups

In the ketone and alkane structural groups, data transfers are from acetone to methyl isobutyl ketone (MIBK) and from n-hexane to petroleum naphtha. MIBK and acetone are in the same structural group and both are considered highly biodegradable. Also MIBK has a greater Kmax value than acetone, suggesting easier biodegradability for MIBK. N-hexane, an alkane, is the most structurally similar compound with performance data to petroleum naphtha. Petroleum naphtha is actually a petroleum distillate fraction containing a mixture of aromatic and straight chain hydrocarbons, with characteristics similar to both alkanes and aromatics.

8.4.1.10 Miscellaneous Structural Group

From the miscellaneous structural group, treatment performance data transfers are from ethanol to methyl cellosolve and from chloromethane to dimethyl sulfoxide. In each case, data were transferred from the most structurally similar constituent or group of constituents for which performance data are available.

8.4.2 Steam Stripping Treatment Performance Data Transfers

The Agency has treatment performance data from well-designed/well-operated steam stripping units for ten potentially regulated organic constituents. The ten candidate pollutants for regulation were used to develop a basis of performance data transfer for the other 27 potentially regulated organic constituents, by grouping all organic constituents into strippability groups based on their Henry's Law Constant. Data transfers were then made within each group from the least strippable compound to more strippable compounds.

Long term means were calculated for the ten potentially regulated pollutants from well-designed/well-operated steam stripping data. The calculated long-term means were then transferred to other pollutants within strippability groups. The Agency assigned long-term means for every potentially regulated pollutant; although, not every pollutant with a steam stripping long-term mean is necessarily being regulated under the promulgated steam stripping option. The POTW pass-through analysis precluded some of the pollutants with well-designed/well-operated steam stripping performance data from regulation. These pollutants are discussed within the context of steam stripping treatment performance data even though they are not regulated pollutants by the selected steam stripping option.

Henry's Law is used to relate the equilibrium of the vapor-phase concentration of a solute to its liquid-phase concentration. In its traditional formulation, shown in Equation 8-1, Henry's Law expresses vapor-liquid equilibrium when the total pressure is low (less than 2 atm) and when the solute concentration is also low (less than 1 mol%).(19)

$$Xi \times H = Yi \times P \qquad (8\text{-}1)$$

Where:

Xi	=	solute liquid-phase mole fraction
H	=	Henry's Law Constant
Yi	=	solute vapor-phase mole fraction
P	=	pressure.

While the solute concentration in the wastewater from facilities in the pharmaceutical manufacturing industry may be more than 1 mol%, Henry's Law Constants still provide a good measure of relative strippability, and can be used to rank the constituents and place them in strippability groups.

In environmental applications, Henry's Law is often used to relate the equilibrium vapor-phase concentration of a contaminant to its concentration in water. For a given contaminant in water, the Henry's Law Constant is directly proportional to the contaminant's vapor pressure and inversely proportional to its solubility. A contaminant with a high vapor pressure and low solubility in water has a high Henry's Law Constant. Conversely, a contaminant that has a low

vapor pressure and/or is very soluble in water has a low Henry's Law Constant. For all contaminants, the Henry's Law Constant is a function of temperature and pressure.

These fundamental relationships allow Henry's Law Constants to be used to judge how effective treatment technologies that rely on liquid-to-vapor mass transfer will be and to judge the relative effectiveness of these technologies on different constituents. For example, constituents with high Henry's Law Constants are easily removed from water by steam stripping, while constituents with low Henry's Law Constants are not.

Table 8-10 presents, for each potentially regulated organic constituent and ammonia, the Henry's Law Constant (presented in decreasing order), the structural group, and the transfer group for the steam stripping option. In many cases, differing Henry's Law Constants for the same constituent were reported in differing data sources. In cases where different values were reported, those values presented in the EPA literature sources (20) or values from EPA's Surface Impoundment Modeling System (SIMS) database (18) were generally chosen as the preferred values. If no values were listed in any of these sources, then values were chosen from other sources based on best engineering judgment. All reported values for Henry's Law Constant are at 25°C and 1 atm (760 mmHg).

No Henry's Law Constants were found for polyethylene glycol 600 (PEG 600) and petroleum naphtha. PEG 600 is a mixture of condensation polymers of ethylene glycol with an average molecular weight of 600. The Henry's Law Constant for ethylene glycol, the "building block" of this polymer, was transferred to PEG 600 due to structural similarity. Petroleum naphtha is not a specific compound but a cut of petroleum that distills within a certain temperature range. Based on best engineering judgment, petroleum naphtha was placed in the "low" strippability group. The Henry's Law Constant for petroleum naphtha was transferred from the constituent with the lowest Henry's Law Constant in the "low" strippability group.

EPA has determined based on the Henry's Law constants and physical properties that eight of the constituents listed in Table 8-10 are not strippable. These constituents cannot be effectively treated by steam stripping and, therefore, do not have treatment performance data associated with

stripping treatment. These constituents may be regulated under regulatory options which include biotreatment but will not be regulated under regulatory options that include only steam stripping.

Sections 8.4.2.1 through 8.4.2.3 describe the steam stripping option treatment performance data transfers within each treatability group and the basic rationale behind each data transfer.

8.4.2.1 High Treatability Group

Three constituents with treatment performance data are included in the high treatability group, containing constituents which are easiest to strip. These constituents are chloroform, methylene chloride, and toluene. The long-term mean treatment performance level for methylene chloride, the least strippable of the constituents in the high treatability group, was transferred to the other, more strippable constituents in the high treatability group without treatment performance data. The long-term mean treatment performance level for methylene chloride is 0.20 mg/L.

8.4.2.2 Medium Treatability Group

Three constituents with treatment performance data, acetone, 2-butanone (also referred to as methyl ethyl ketone), and tetrahydrofuran are included in the medium treatability group. The long-term mean treatment performance level for acetone, the least strippable of the constituents in the medium treatability group, was transferred to the other, more strippable constituents in the medium treatability group without treatment performance data. The long-term mean treatment performance level for acetone is 4.1 mg/L under the steam stripping option.

8.4.2.3 Low Treatability Group

Treatment performance data are available for four constituents in the low treatability group: isopropanol, ethanol, pyridine, and methanol. The treatment performance data for isopropanol was transferred to more strippable constituents in the low treatability group for which treatment performance data are not available. The long-term mean treatment performance level for isopropanol is 11.8 mg/L. The treatment performance data for ethanol was transferred to n-

propanol. The long-term mean treatment performance data for ethanol is 355 mg/L. Treatment performance data for methanol were transferred to the remaining constituents in the low treatability group for which no data were available. The long-term mean treatment performance level for methanol is 1,240 mg/L.

8.4.3 ASPEN Simulation Modeling to Support Steam Stripping Treatment Performance Data Transfers

This provides technical support for the data transfers made in developing the long-term mean treatment performance levels for the steam stripping treatment option. In particular, this focuses on how process modeling was used to support the data transfers. 8.4.3.1 provides a general overview of the ASPEN simulation model. 8.4.3.2 describes the methodology used for supporting data transfers for steam stripping. The results of the ASPEN simulations are presented in 8.4.3.3. ASPEN simulations were performed using a steam stripping design similar to the designs forming the basis of the final regulations. The relative behavior demonstrated in these simulations document that constituents within the same stripping group can achieve equivalent or similar effluent concentrations.

8.4.3.1 Overview of ASPEN

Since the 1970s, the process industries (chemical, petroleum, pharmaceutical, etc.) have increasingly relied on computer models to design and predict the performance of process equipment. The types of models typically used in these industries for this task are not statistical or empirical, but rely on engineering fundamentals such as the principles of thermodynamics and unit operations.

Two process models (also called process simulators) were used to support the development of the pharmaceutical manufacturing effluent guidelines: ASPEN/SP™ (Version 7.0) and ASPEN Plus™ (Version 8.5), commercial process design programs available respectively from Simulation Sciences, Inc. and Aspen Technologies, Inc. Both programs are descendants of the original ASPEN program which was developed at MIT during the period of 1976-1981 under the

sponsorship of the Department of Energy and 55 industrial participants. Both programs give similar results and are widely accepted in industry for modeling chemical, petroleum, and environmental processes.

Key features of process simulation packages like ASPEN/SP™ and ASPEN Plus™ include the following:

- A large database of compounds and their properties which allow for modeling a wide range of processes;
- An extensive library of thermodynamic models (equations of state and activity coefficient models) for calculating the properties of mixtures; and
- A wide range of computer algorithms for modeling unit operations such as mixers, reactors, absorbers, strippers, and distillation columns.

8.4.3.2 Methodology for Data Transfer Simulations

As discussed previously, effluent data were collected on actual operating columns and pilot columns treating pharmaceutical manufacturing wastewater. For those pollutants where treatment performance data were not available, data were transferred from pollutants for which data were collected. The approach to making data transfers was two-part:

1) Transfers were made based on the physical properties that determine strippability, and
2) The proposed transfers were checked by simulating typical stripping systems using the ASPEN process simulators.

In using the ASPEN programs to support the data transfers, a five-step methodology was followed:

1) Each of the pollutants to be regulated was placed in one of seven strippability categories, with Group 1 representing pollutants that are most strippable and Group 7 representing pollutants that are not strippable.

2) Simple flowsheets for typical stripping systems were developed and the appropriate unit-operations models were selected.

3) Values were assumed for the key process variables (number of equilibrium stages and liquid to vapor (L/V) ratio). These key inputs vary among strippability groups because less strippable pollutants will operate at lower L/V ratios and require more stages. Influent concentrations for each pollutant were based on the maximum and average loadings reported in the Detailed Questionnaire.

4) The thermodynamic models for liquid-vapor equilibrium calculations were selected. To model the nonideal nature of most pollutants in water, an activity coefficient model was used.

5) The results of steps 1 through 4 were developed into simulation input files. Simulations were then run to determine if the transferred long-term mean performance level could be met by each pollutant assuming it was present at its maximum and average loading. If the long-term mean performance level could be met with either the maximum or average influent loading, the data transfer was considered acceptable. Note that in all cases the long-term mean performance level could be met at the maximum influent loads by increasing the number of stages or decreasing the L/V ratio assumed under step 3 (thus, ability to achieve performance levels is independent of feed concentrations for a given constituent).

8.4.3.3 Strippability Groups

As discussed above, each of the pollutants proposed for regulation was placed in one of seven strippability groups. Placement was based on published Henry's Law Constants at 25°C and 1 atm. Table 8-11 presents these categories and the pollutants in each group. Note that these groups are different than the data transfer groups presented in Table 8-10, as they have been established for a different purpose. The data transfer groups presented in Table 8-10 were established for the purpose of transferring direct measurement data. The strippability groups discussed here were established for the purpose of assigning key process design variables for simulation purposes, and for cost estimating purposes, as discussed in 10.3.5. However, the grouping presented in Table 8-10 and these presented here share two important characteristics: 1) both grouping systems are based on a ranking of pollutants by Henry's Law constant from

highest to lowest, and 2) pollutants considered not strippable are the same under both grouping systems.

8.4.3.4 Flowsheet Development

Two examples of typical steam stripping/distillation systems were identified: a stripper/decanter system for treating contaminants that have low water solubility and will form a phase-separable overhead product, and a distillation column with reflux for treating contaminants that are highly water soluble and will not likely form a phase-separable overhead product. Figures 8-1 and 8-2 illustrate these process configurations.

Process simulation flowsheets were developed for these configurations. For modeling contaminants that form a phase-separable overhead product, the flowsheet in Figure 8-3 was used. In this flowsheet, the stripper was modeled using the equilibrium-stage distillation algorithm in ASPEN, RADFRAC. The decanter was modeled using the three-phase flash algorithm, FLASH3, and the feed/effluent exchanger was modeled with the heater algorithm, HEATER.

For modeling situations where the contaminants are highly water soluble, the flowsheet shown in Figure 8-4 was used. A reflux ratio high enough to achieve a concentrated overhead product (contaminant weight percent $\geq$ 33) was assumed.

The key part of the ASPEN simulations is the column calculations. The RADFRAC model, which makes these calculations, is a general distillation model which uses the equilibrium-stage concept.(30) The required inputs to model a distillation column using the RADFRAC model are the feed wastewater flow rate, the steam flow rate, the pressure drop across the column, and the number of equilibrium stages. The algorithm used in RADFRAC makes simultaneous mass and energy balances at each stage. This algorithm is based on the "inside-out" concept developed by Boston.(30) The distillation, absorption, and stripping models used in most process simulators utilize this approach.

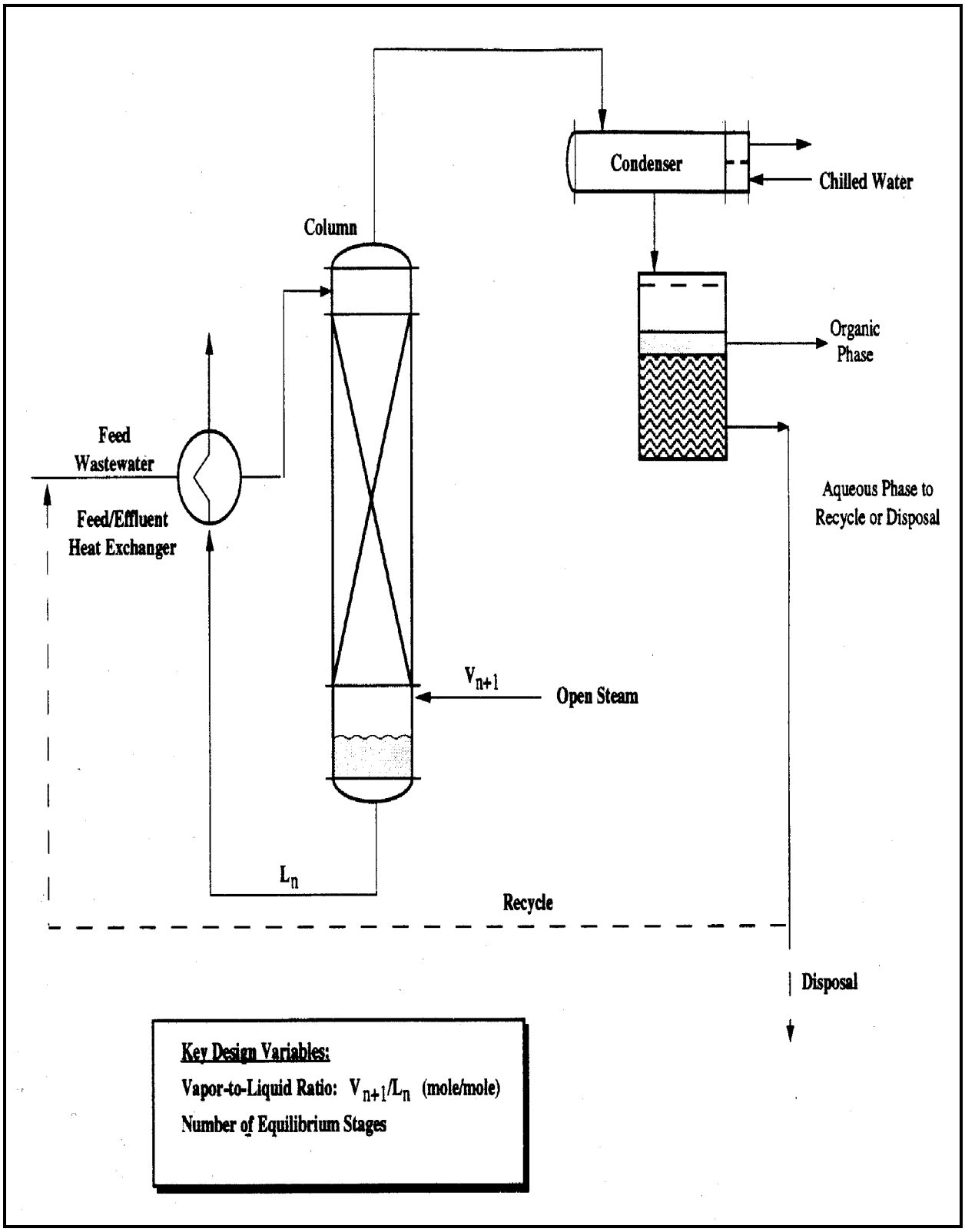

Figure 8-1. Process Schematic for a Steam Stripper with Open Steam

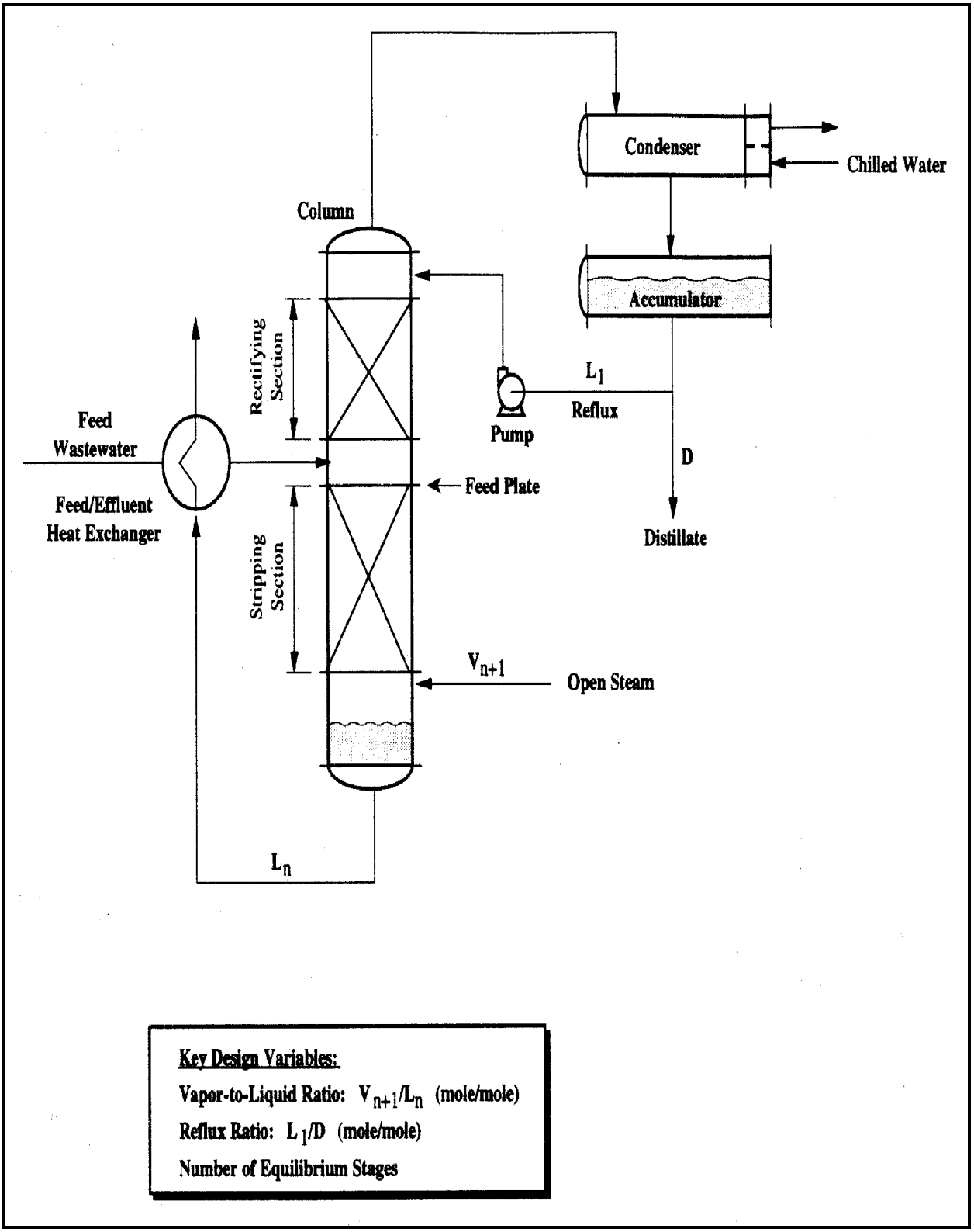

Figure 8-2. Process Schematic for a Distillation Column with Open Steam

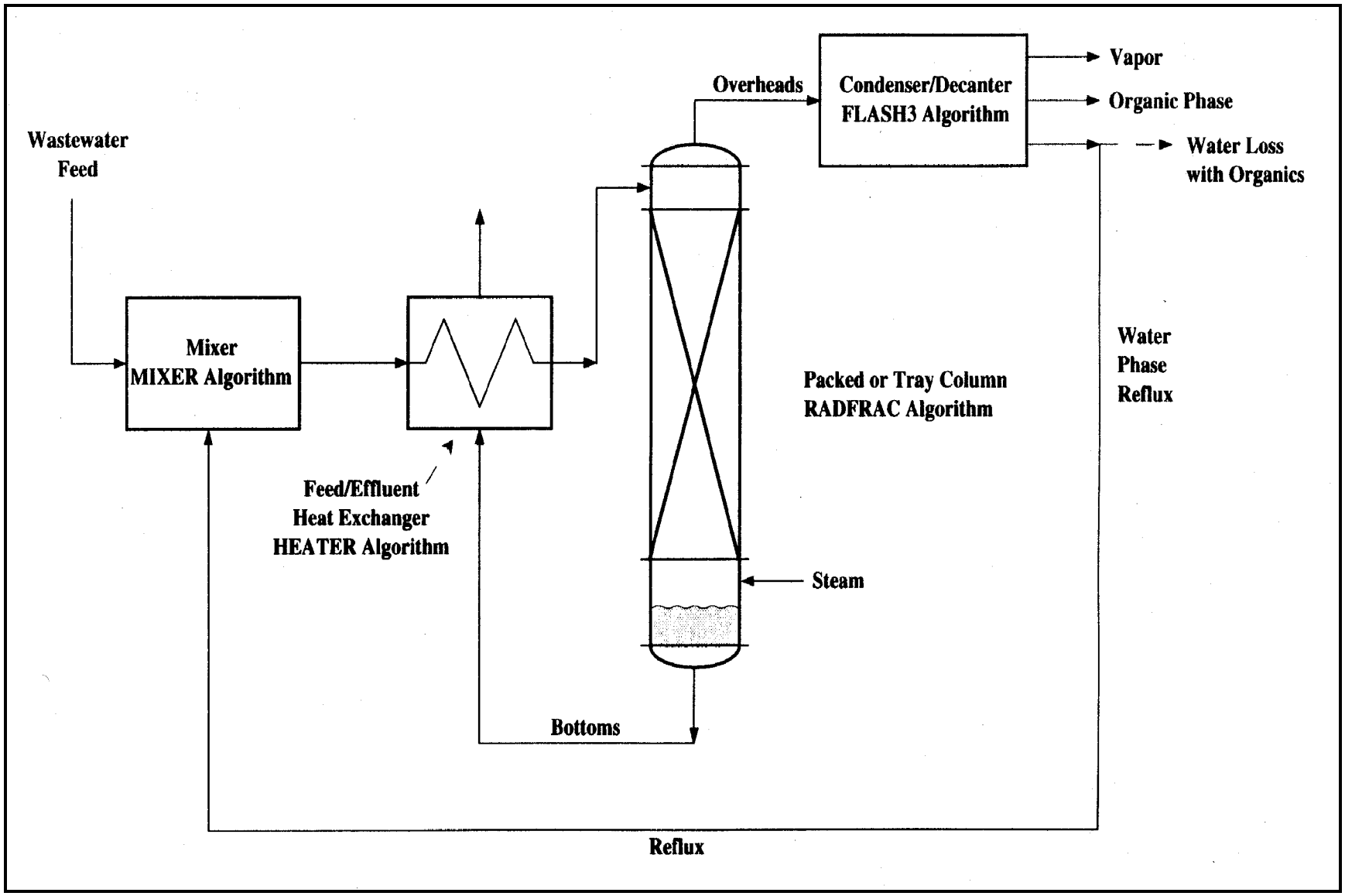

Figure 8-3. Simulation Block Diagram for Steam Stripper with Decanter

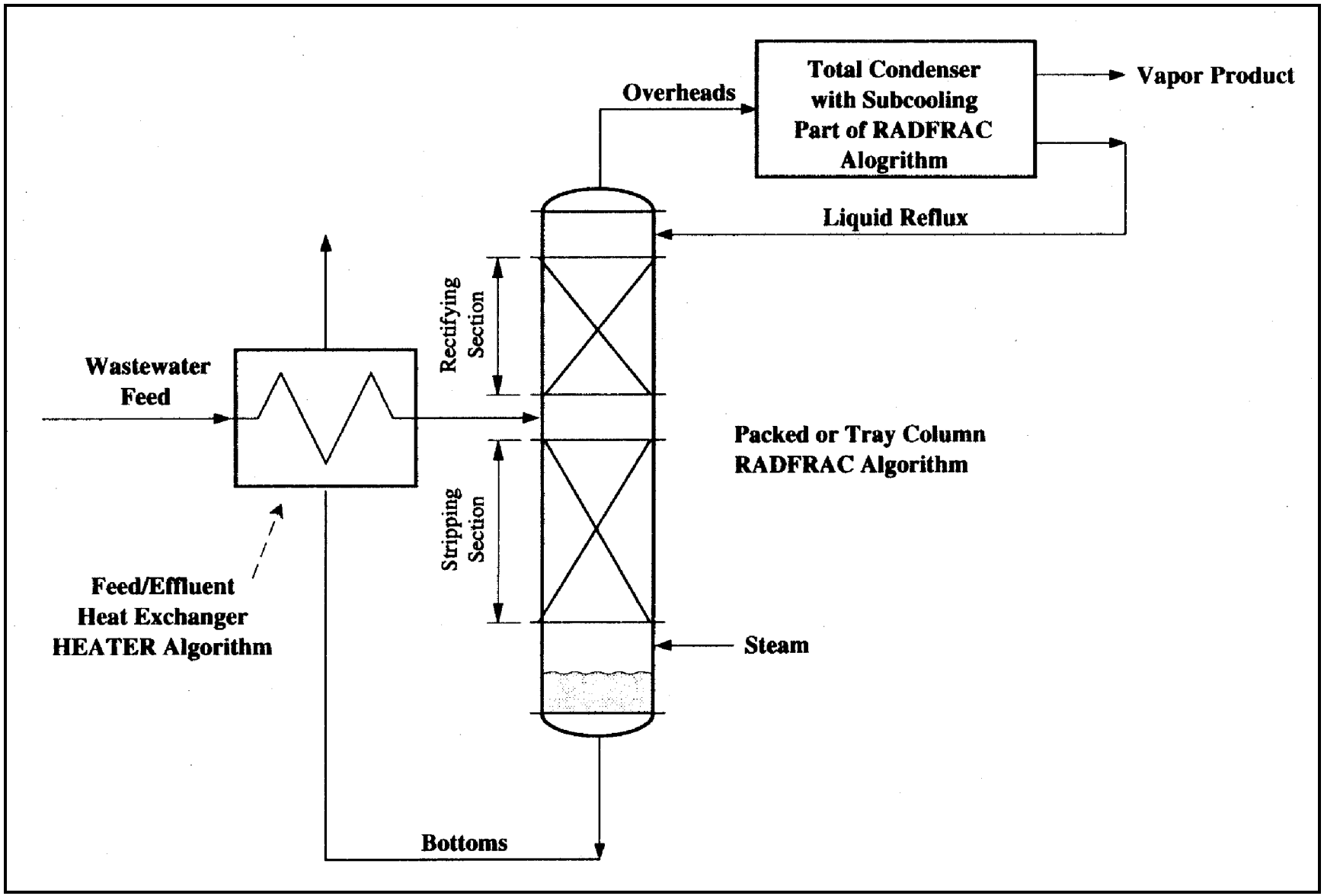

Figure 8-4. Simulation Block Diagram for Distillation Column with Open Steam

8.4.3.5 Estimation of Key Input Variables

As previously noted, the two most important process variables which determine the removal efficiency of a steam stripper or a distillation column are: 1) the number of equilibrium stages, and 2) the L/V ratio in the column. Table 8-12 presents the number of equilibrium stages and L/V ratios assumed for each strippability group. The assumed stages were chosen so that the total column height would be reasonable for a packed column assuming a height equivalent to one theoretical plate (HETP) of 2 to 3 feet. Two rectifying stages were assumed for strippability groups 3 through 6. The L/V ratios were then chosen to ensure high pollutant removal efficiencies. Other process inputs (feed water temperature, column pressure, condenser temperature, etc.) were based on typical industry values and are shown in Table 8-12. The values selected for these inputs will have less impact on the simulation results than the assumed number of stages or L/V ratio.

8.4.3.6 Selection of Thermodynamic Models

Since pharmaceutical manufacturing waste streams are generally nonideal mixtures, the liquid-vapor equilibrium calculations in the steam stripper simulations were performed using the UNIversal QUAsi Chemical (UNIQUAC) activity coefficient model. The UNIQUAC model is one of many commonly used activity coefficient models. It is a widely accepted tool for modeling nonideal solutions.

The UNIQUAC model uses binary interaction parameters in its calculations. These parameters can be determined from experimental vapor-liquid equilibrium data or they can be estimated using the UNIFAC group contribution method. With the UNIFAC method, the binary interaction between two compounds is estimated from the interactions between the different functional groups that make up the two compounds. The UNIFAC database, which consists of values for the interaction parameters between different functional groups, is available in several references.(24,27) For the ASPEN/SP™ simulations performed, the binary interaction parameters for the UNIQUAC model were taken either from the DECHEMA data series (26) or generated using UNIFAC. The validity of using UNIFAC was confirmed by comparing calculated

K-values (estimated with ASPEN/SP™ using UNIFAC) to published K-values for several contaminants. Table 8-14 summarizes these results.

8.4.3.7 Summary of Simulation Results

Tables 8-15 and 8-16 present the results of the treatment performance data transfer simulation runs for Subcategory A and/or C facilities and Subcategory B and/or D facilities, respectively. These results show that simulating the average pollutant loading will result in an effluent concentration from steam stripping with distillation less than the pollutant's proposed long-term mean performance level for steam stripping with distillation. The Agency also found that in almost all cases simulating the maximum pollutant loading would also result in effluent concentrations less than the proposed long-term mean performance levels. Although ASPEN simulations were performed prior to proposal and were based on the proposed long-term mean performance levels for steam stripping with distillation, the methodology for determining pollutant transfers has not been modified for the final rule. Since transfers of experimental data were made from pollutants that are less strippable (i.e., a lower Henry's Law Constant) to pollutants that are more strippable, the effluent limitations guidelines should be attainable for all pollutants where well-designed, well-operated steam stripping and distillation columns are installed.

8.5 Long-Term Mean Development for Conventional Pollutant Parameters and COD

The conventional pollutants BOD_5 and TSS along with the nonconventional pollutant COD are controlled using advanced biological treatment under the regulatory options considered for the pharmaceutical manufacturing industry, as described in 7.

Using the treatment performance data presented in 8.3.1, a statistical analysis of the data was conducted to develop a long-term mean concentration and variability factors for BOD_5, TSS, and COD for advanced biological treatment. The results of this analysis are presented in Table 8-17. A detailed description of the statistical analysis and the results from this analysis are presented in

the Statistical Support Document for the Final Effluent Limitations Guidelines for the Pharmaceutical Manufacturing Industry (EPA-821-B-98-007) (hereafter referred to as the Statistical Support Document).

To develop the concentration-based long-term means and variability factors for each pollutant parameter, EPA modeled the concentration data using a modification of the delta-lognormal distribution. The modified delta-lognormal distribution model assumes that all nondetects occur at the detection limit and that the measured concentrations follow a lognormal distribution (i.e., the logarithms of the measured data are normally distributed). The modified delta-lognormal distribution is identical to a lognormal distribution if there are no nondetects in the data.

8.6 Long-Term Mean Development for Cyanide

For most of the regulatory options considered, as described in 7, cyanide limitations would not be revised, but the monitoring requirements would be clarified in Subcategories A and C and cyanide limitations would be withdrawn in Subcategories B and D.

For one of the PSES options considered, revised cyanide limitations were developed using the treatment performance data presented in 8.3.5. A statistical analysis of this data was conducted to develop a long-term mean concentration and variability factors for cyanide. For facilities using hydrogen peroxide oxidation, the long-term mean concentration developed for cyanide is 0.24 mg/L. For facilities using alkaline chlorination, the long term mean concentration developed for cyanide is 4.8 mg/L. A detailed description of the statistical analysis and the results from this analysis are presented in the Statistical Support Document.

EPA is not revising existing cyanide limitations or standards for Subcategories A and C because the new cyanide performance data indicate there would not be a large enough cyanide load removal to warrant changing the existing standard. EPA is clarifying that the existing cyanide limitations or standards must be met in-plant unless a facility can show a measurable cyanide load at end-of-pipe. The final regulation withdraws cyanide limitations or standards for subcategories B and D because cyanide is not present in the wastewaters of those subcategories.

8.7 Development of Long-Term Mean Concentrations for Priority and Nonconventional Pollutants

Sections 6.6 and 6.7 list the priority and nonconventional pollutants selected for regulation in the pharmaceutical manufacturing industry. Priority and nonconventional pollutants are controlled under the regulatory options considered for the pharmaceutical manufacturing industry described in 7, using either advanced biological treatment or steam stripping.

Using the treatment performance data presented in Sections 8.3.1 and 8.3.6, the Agency conducted a statistical analysis of the data to develop a long-term mean and variability factors for those priority and nonconventional pollutants with advanced biological and steam stripping treatment performance data. A detailed description of the statistical analysis and the results from this analysis are presented in the Statistical Support Document. Table 8-18 presents the long-term mean treatment performance concentrations developed for these pollutants using the datasets identified in Tables 8-2 and 8-7.

For priority and nonconventional pollutants without advanced biological or steam stripping treatment performance data, a transfer was applied as discussed in Section 8.4. Table 8-19 presents the long-term mean treatment performance concentrations for priority and nonconventional pollutants after application of the treatment performance data transfers.

8.8 Long-Term Mean Development for Ammonia

Ammonia is controlled under the regulatory options considered for the pharmaceutical manufacturing industry described in 7.

Advanced biological treatment with nitrification performance data for ammonia are presented in 8.3.2. Air stripping treatment performance data for ammonia are presented in 8.3.6; the air stripping data are being used to represent treatment achievable by steam stripping. A detailed description of the statistical analysis of these data and the results from this analysis are presented in the Statistical Support Document. EPA is not regulating ammonia for Subcategories B and D

because ammonia is not present in Subcategory B and D wastewaters at concentrations of concern.

The long-term mean treatment performance concentration developed for ammonia through advanced biological treatment with nitrification is 12.5 mg/L. The long-term mean treatment performance concentration for ammonia applicable to steam stripping treatment is 9.91 mg/L.

Table 8-1

Advanced Biological Treatment Performance Data for BOD_5, COD, and TSS

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30010	BOD_5	10	2,080	971	3.0	695	47.6	600	SMD
	COD	157	3,750	2,030	31.0	1,904	296	951	SMD
	TSS	-	-	-	1.0	604	55.3	694	SMD
30540*	BOD_5	230	9,730	2,440	11.0	528	98.4	1756	SMD
	COD	526	12,000	4,960	197	10,100	744	365	SMD
	TSS	-	-	-	16.3	2,710	155	365	SMD
30623	BOD_5	566	5,880	2,520	0.8	19.7	4.7	356	SMD
	COD	986	11,600	5,080	27.9	189	98.3	51	SMD
	TSS	-	-	-	0.5	254	18.7	356	SMD
30637	BOD_5	566	5,880	2,620	16.0	660	77.8	366	SMD
	COD	986	11,600	5,280	108.0	1,700	883	366	SMD
	TSS	-	-	-	8.0	577	106	366	SMD

* Data from facility 30540 has been corrected to account for the nonprocess water discharge after treatment.

Source:
SMD - Self-Monitoring Database, Reference (2).

Table 8-2

Advanced Biological Treatment Performance Data for Priority and Nonconventional Pollutants

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30540	Acetone	38.5	112	61.8	0.05	0.800	0.137	10	I
30540	Acetone	12.0	100	38.1	0.01	0.10	0.061	8	N
30623	Acetone	1.30	14.9	6.78	0.05	0.130	0.066	19	I
30623	Acetone	11.4	44.3	21.2	0.05	0.97	0.220	6	N
30540	Acetonitrile	2.0	8.80	4.06	0.050	0.10	0.090	5	N
30623	Acetonitrile	0.005	1.62	0.337	0.005	0.005	0.005	19	I
30623	Benzene	1.0	41.0	14.3	0.002	0.002	0.002	3	P
30623	2-Butanone (MEK)	13.7	107	35.7	0.050	0.065	0.051	19	I
30623	2-Butanone (MEK)	5.53	15.3	8.50	0.010	0.10	0.035	7	N
30050	Chloroform	0.554	1.62	1.09	0.001	0.001	0.001	3	V
30540	Chloroform	1.47	5.51	3.18	0.010	0.010	0.010	10	I
30540	Chloroform	0.840	3.40	1.92	0.0016	0.005	0.003	8	N
30623	Chloroform	1.00	16.0	6.3	0.009	0.018	0.013	3	P
30623	Chloroform	0.202	55.3	7.62	0.010	0.024	0.013	19	I

Table 8-2 (Continued)

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30010	Chloromethane (Methyl chloride)	8.00	13.0	10.1	0.10	0.41	0.29	3	V
30540	Chloromethane (Methyl chloride)	4.70	5.33	5.03	0.010	0.124	0.053	10	I
30540	Chloromethane (Methyl chloride)	0.500	6.50	2.93	0.001	0.010	0.007	8	N
30540	Cyclohexane	0.100	5.00	1.52	0.005	0.010	0.0075	8	N
30623	1,2-Dichloroethane	0.132	24.8	13.0	0.010	0.263	0.071	19	I
30623	1,2-Dichloroethane	1.00	5.00	2.67	0.002	0.110	0.038	3	P
30623	N,N-Dimethylformamide	0.10	113	49.8	0.010	0.035	0.011	20	I
30010	Ethanol	21.7	320	160	1.00	1.77	1.10	8	N
30540	Ethanol	124	209	161	0.500	5.51	1.00	10	I
30540	Ethanol	68.1	420	181	1.00	5.00	3.00	8	N
30623	Ethanol	10.6	1,320	253	0.500	0.800	0.530	20	I
30540	Ethyl acetate	40.0	77.1	57.9	0.500	0.600	0.510	10	I

Table 8-2 (Continued)

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30540	Ethyl acetate	0.18	50.0	11.0	0.005	0.010	0.0075	8	N
30623	Formaldehyde	0.300	6.50	1.75	0.120	0.800	0.343	19	I
30010	Formaldehyde	0.124	3.21	0.647	0.049	0.321	0.193	3	N
30623	Heptane	0.005	3.25	0.921	0.005	0.005	0.005	19	I
30623	Hexane	0.046	1.43	0.444	0.005	0.005	0.005	19	I
30623	Hexane	0.284	2.50	1.66	0.014	0.034	0.023	7	N
30540	Isopropanol	112	152	136	0.500	0.500	0.500	10	I
30540	Isopropanol	33.0	126	87.8	0.100	2.000	1.050	8	N
30540	Isopropyl acetate	26.4	112	68.1	0.500	0.500	0.500	10	I
30540	Isopropyl acetate	2.50	66.0	32.2	0.010	0.010	0.010	4	N
30010	Methanol	115	370	211	0.500	0.500	0.500	8	N
30540	Methanol	165	1,100	592	2.26	14.1	5.34	9	I
30540	Methanol	11.3	1,700	539	0.500	5.000	2.750	8	N
30623	Methanol	8.50	16,000	1,900	0.300	3.70	0.650	20	I

Table 8-2 (Continued)

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30623	Methylene chloride	1.00	264.0	91.0	0.004	0.110	0.069	3	P
30623	Methylene chloride	36.9	1,340	416	0.010	1.10	0.110	19	I
30623	Methylene chloride	0.431	6.11	1.94	0.010	0.68	0.097	8	N
30540	2-Methylpyridine	0.941	4.08	2.83	0.050	0.050	0.050	10	I
30540	2-Methylpyridine	0.161	1.60	0.643	0.010	0.011	0.011	8	N
30623	Phenol	0.010	0.651	0.169	0.010	0.022	0.011	7	I
30623	Tetrahydrofuran	1.59	75.0	25.4	0.005	3.48	1.22	9	I
30623	Tetrahydrofuran	1.68	7.88	5.35	0.007	1.36	0.048	8	N
30010	Toluene	56.0	71.0	61.3	0.010	0.010	0.010	3	V
30050	Toluene	0.078	0.193	0.131	0.001	0.001	0.001	3	V
30540	Toluene	0.146	0.484	0.311	0.010	0.010	0.010	10	I
30540	Toluene	0.410	3.00	1.26	0.005	0.006	0.0055	8	N
30623	Toluene	1.21	38.0	10.4	0.010	0.010	0.010	10	I
30623	Toluene	1.0	4.0	2.33	0.002	0.053	0.019	3	P
30623	Toluene	14.5	39.8	24.4	0.010	0.110	0.029	7	N

Table 8-2 (Continued)

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30540	Trichlorofluoromethane	1.32	2.25	1.77	0.010	0.043	0.018	10	I
30540	Total Xylenes	37.0	170	94.5	0.005	0.005	0.005	4	N

Sources:
I - EPA (List of Analytes) Sampling Program.
P - Facility Self-Monitoring Data from 1989 Pretest Questionnaires.
V - Verification Sampling Program.
N - Facility Sampling Program Submitted in Response to the Proposed Effluent Limitations and Guidelines.

Note: Values that were not detected were set at the detection limit.

Table 8-3

Nitrification Treatment Performance Data for Ammonia

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
Two-Stage System									
31040	Ammonia as N	1.0	533.0	166.0	1.0	167.0	15.2	529	A
30759	Ammonia as N	2.2	166.0	58.0	1.4	94.8	13.0	937	A
Single-Stage System									
30540	Ammonia as N	23.0	47.5	40.7	1.4	3.7	2.53	10	I
30669	Ammonia as N	33.0	338	181.28	1.0	155.0	15.05	115	N
30542	Ammonia as N	0.28	101	29.48	0.09	46.4	2.96	124	N

Sources: A = new data (post-NOA); I = EPA (List of Analytes) sampling; N= new data (post-proposal)

Table 8-4

Multimedia Filtration Treatment Performance Data for TSS

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
50007	TSS	4.0	110	24.2	2.0	60.0	12.8	466	SMD
12053	TSS	5.5	106	26.2	0.40	35.0	6.84	84	SRI
12317	TSS	1.0	83.0	18.8	1.0	41.0	5.87	248	SRI

SMD - Self-Monitoring Database, Reference (2).
SRI - Self-Monitoring Database from the 10/27/83 NSPS proposed rule containing facility self-monitoring data from 1982 and 1983, Reference (4).

Note: Values that were not detected were set at the detection limit.

Table 8-5

Polishing Pond Treatment Performance Data for TSS

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
50007	TSS	4.0	158.0	30.4	4.0	110.0	24.2	462	SMD

SMD - Self-Monitoring Database, Reference (2).

Table 8-6

Cyanide Destruction Treatment Performance Data

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
Hydrogen Peroxide Oxidation									
30542	Cyanide	160.0	3,700.0	1,937.4	0.005	0.720	0.25	32	SMD/I
Alkaline Chlorination									
30567	Cyanide	6.0	28,568	7,307.94	0.02	26	4.767	210	SMD

SMD/I - Combined datasets from the Self-Monitoring Database and the EPA (List of Analytes) Sampling Program at Facility 30542, References (2), (3).
SMD - Self-Monitoring Database, Reference (2).

Table 8-7

Well-Designed/Well-Operated Steam Stripping Treatment Performance Data for Priority and Nonconventional Pollutants

Facility-Stream	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30329-C	Acetone	977	20,000	3,750	0.730	103	32.3	20	N
30487-A	Acetone	59.1	151	89.0	0.818	5.84	2.65	23	I
30832-B	Acetone	1,800	9,700	5,220	7.80	1,800	732	5	N
31105-A	Acetone	78	78	78	0.050	0.050	0.050	5	N
31105-B	Acetone	340	340	340	0.069	16.0	4.07	4	N
60000-A	Acetone	731	769	746	0.197	0.769	0.389	8	I
60000-B	Acetone	1,100	1,570	1,290	1.22	9.68	5.61	8	I
30329-B	2-Butanone (MEK)	2,670	35,300	17,500	4.70	392	121	11	I
30329-C	Chloroform	42.1	1,000	330	0.040	0.091	0.046	16	N
60000-A	Chloroform	1,110	1,170	1,150	0.010	0.010	0.010	8	I
60000-B	Chloroform	228	600	370	0.010	0.010	0.010	8	I
60000-D	Chloroform	80.5	85.0	82.7	0.010	0.010	0.010	8	I
30329-B	Ethanol	1,190	28,100	13,400	102	1,330	693	11	I
30329-C	Ethanol	676	87,100	16,900	54.4	62,600	4,810	27	N
60000-A	Ethanol	345	660	479	0.500	0.500	0.500	8	I
60000-B	Ethanol	280	440	358	3.00	36.0	16.0	8	I

Table 8-7 (Continued)

Facility-Stream	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30329-C	Isopropanol	230	4,990	1,640	47.5	345	155	20	N
60000-A	Isopropanol	1,800	2,000	1,980	0.500	0.500	0.500	8	I
60000-B	Isopropanol	950	1,300	1,060	2.10	21.9	11.8	8	I
30329-C	Methanol	60,200	750,000	265,000	28,200	241,000	96,900	30	N
31105-A	Methanol	3,000	3,000	3,000	50.0	50.0	50.0	5	N
60000-A	Methanol	2,500	3,700	2,900	46.0	95.8	60.4	8	I
60000-B	Methanol	1,450	2,900	1,960	260	1,300	888	8	I
60000-D	Methanol	100,000	240,000	194,000	60,000	120,000	83,900	7	I
60000-E	Methanol	5,300	7,000	6,660	720	3,900	1,590	5	I
30329-C	Methylene chloride	83.8	10,000	2,510	0.060	4.60	0.329	25	N
30487-A	Methylene chloride	8.63	55.7	21.0	0.100	0.101	0.100	23	I
30618-A	Methylene chloride	9,060	12,800	10,300	1.00	1.00	1.00	13	I
30832-B	Methylene chloride	9,900	14,000	11,500	0.010	4.90	2.01	4	N
60000-A	Methylene chloride	17.1	19.0	18.3	0.010	0.398	0.106	8	I
60000-B	Methylene chloride	41.4	54.0	47.1	0.010	0.010	0.010	8	I
30329-C	Pyridine	1.20	760	118	0.790	180	43.1	9	N
30329-C	Tetrahydrofuran	1,000	9,000	3,290	0.700	1.40	0.750	14	N
30832-B	Tetrahydrofuran	5,300	13,000	9,230	0.500	130	66.2	3	N

Table 8-7 (Continued)

Facility-Stream	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Effluent Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
60000-E	Tetrahydrofuran	7,500	8,550	8,340	0.220	2.57	1.54	5	I
30329-B	Toluene	253	253	253	0.124	2.41	1.25	3	I
30329-C	Toluene	221	70,000	13,500	0.260	1,400	70.9	29	N
30487-A	Toluene	15.2	82.6	35.2	0.100	0.100	0.100	23	I
30832-A	Toluene	130	120,000	46,700	0.140	0.370	0.240	3	N
30832-B	Toluene	37	190	102	0.070	9.50	3.15	5	N
31105-A	Toluene	420	420	420	0.010	0.010	0.010	5	N
31105-B	Toluene	93	93	93	0.002	0.002	0.002	4	N
60000-A	Toluene	16.7	19.1	18.0	0.010	0.010	0.010	8	I
60000-B	Toluene	18.0	21.3	19.2	0.027	0.042	0.034	8	I
60000-D	Toluene	237	668	494	0.010	0.012	0.010	8	I
60000-E	Toluene	515	580	528	0.333	0.630	0.473	5	I

Sources:
I - EPA (List of Analytes) Sampling Program, Reference (3).
N - Facility Sampling Program submitted in response to the Proposed Effluent Limitations and Guidelines.

Note: Values that were not detected were set at the detection limit.

Table 8-8

Air Stripping Treatment Performance Data for Ammonia

Facility	Pollutant	Influent Conc. (mg/L)			Effluent Conc. (mg/L)			# of Data Points	Source
		Min.	Max.	Avg.	Min.	Max.	Avg.		
30329	Ammonia (aqueous)	123.0	128.0	125.0	8.1	11.2	9.9	7	PILOT

PILOT - EPA-sponsored pilot study of air stripping, Reference (9).

Table 8-9

Advanced Biological Treatment Performance Data Transfers

Constituent Code	Constituent Name	Kmax Value (a)	BOD_5/ThOD Ratio	Structural Group	Biodegradability Group	Constituent Transferred From
94	Isopropanol	4.89E-06	54%-83%	alcohol	high	Data available
70	Ethanol	2.45E-06	37%-74%	alcohol	medium	Data available
77	Ethylene glycol		63%	alcohol	high	Ethanol
114	Phenol	2.70E-05	70%	alcohol	high	Data available
29	tert-Butyl alcohol		0.8%	alcohol	medium	Ethanol
97	Methanol (Methyl alcohol)	5.00E-06	51%-75%	alcohol	high	Data available
27	n-Butanol	4.89E-06	33%-58%	alcohol	high	Ethanol
117	n-Propanol		20%-44%	alcohol	medium	Ethanol
11	Amyl alcohol			alcohol	low	Ethanol
79	Formaldehyde	1.39E-06	60%	aldehyde	high	Data available
93	Isobutyraldehyde		65.6%	aldehyde	high	Formaldehyde
60	N,N-Dimethylacetamide			amide	low	N,N-Dimethylformamide
80	Formamide			amide	low	N,N-Dimethylformamide
64	N,N-Dimethylformamide	2.70E-06		amide	medium	Data available
55	Diethylamine			amine	medium	N,N-Dimethylformamide
136	Triethylamine			amine	medium	N,N-Dimethylformamide
15	Benzene	5.28E-06	70%	aromatic	high	Data available
12	Aniline	1.97E-06	62%	aromatic	high	2-Methylpyridine

Table 8-9 (Continued)

Constituent Code	Constituent Name	Kmax Value (a)	BOD_5/ThOD Ratio	Structural Group	Biodegradability Group	Constituent Transferred From
62	N,N-Dimethylaniline		9.5%	aromatic	low	2-Methylpyridine
139	Xylenes	8.65E-06		aromatic	high	Data available
106	2-Methylpyridine			aromatic	medium	Data available
35	Chlorobenzene	1.10E-07	1%	aromatic	medium	2-Methylpyridine
124	Pyridine	4.89E-06	52%	aromatic	high	2-Methylpyridine
130	Toluene	2.04E-05	5%-69%	aromatic	high	Data available
48	o-Dichlorobenzene (1,2-Dichlorobenzene)	7.00E-07		aromatic	medium	2-Methylpyridine
51	1,2-Dichloroethane	5.83E-07	7%	chlorinated alkane	medium	Data available
39	Chloromethane (Methyl chloride)	8.30E-08		chlorinated alkane	low	Data available
134	Trichlorofluoromethane	3.00E-06		chlorinated alkane	medium	Data available
102	Methylene Chloride	6.11E-06		chlorinated alkane	high	Data available
37	Chloroform	8.20E-07	6%	chlorinated alkane	medium	Data available
26	n-Butyl acetate		7%-46%	ester	medium	Isopropyl acetate
71	Ethyl acetate	4.89E-06	16%-68%	ester	high	Data available
95	Isopropyl acetate		12.7%	ester	low	Data available
10	N-Amyl acetate	4.89E-06	38%	ester	high	Ethyl acetate
103	Methyl formate			ester	high	Ethyl acetate
115	Polyethylene glycol 600		0.6%	ether	low	Tetrahydrofuran
67	1,4-Dioxane	4.89E-06		ether	high	Tetrahydrofuran

Table 8-9 (Continued)

Constituent Code	Constituent Name	Kmax Value (a)	BOD_5/ThOD Ratio	Structural Group	Biodegradability Group	Constituent Transferred From
129	Tetrahydrofuran	4.89E-06		ether	high	Data available
96	Isopropyl ether		6.7%	ether	low	Tetrahydrofuran
105	Methyl isobutyl ketone (MIBK)	4.89E-06	4.4%-79%	ketone	high	Acetone
118	Acetone	3.61E-07	50%	ketone	high	Data available
25	2-Butanone (MEK)	5.60E-07	46%	ketone	medium	Data available
84	n-Heptane	4.25E-06		alkane	high	Data available
87	n-Hexane	4.25E-06	63%	alkane	high	Data available
43	Cyclohexane	4.25E-06		alkane	high	Data available
113	Petroleum naphtha			alkane		n-Hexane
3	Acetonitrile	5.00E-06		misc.	high	Data available
101	Methyl cellosolve		7.1%	misc.	low	Ethanol
9	Ammonia (aqueous)	2.70E-06		misc.	medium	Data available
66	Dimethyl sulfoxide			misc	low	Chloromethane

(a) Units for Kmax values are (gram constituent/gram biosludge/second)
Kmax values: Reference (18).
BOD_5/ThOD ratios: References (14), (15), (16), and (17).

Table 8-10

Steam Stripping Treatment Performance Data Transfers

Constituent Code	Constituent Name	Henry's Law Constant (atm/gmole/m3)	Source	Structural Group	Transfer Group	Constituent Transferred From
84	N-Heptane	2.85E+00	(a)	n-alkane	high	Methylene chloride
87	N-Hexane	1.55E+00	(a)	n-alkane	high	Methylene chloride
130	Toluene	5.93E-03	(a)	aromatic	high	Data available
15	Benzene	5.55E-03	(c)	aromatic	high	Methylene chloride
139	Xylenes	5.10E-03	(a)	aromatic	high	Methylene chloride
35	Chlorobenzene	3.93E-03	(b)	aromatic	high	Methylene chloride
37	Chloroform	3.39E-03	(b)	chlorinated alkane	high	Data available
101	Methyl cellosolve	2.90E-03	(a)	misc.	high	Methylene chloride
102	Methylene chloride	2.68E-03	(a)	chlorinated alkane	high	Data available
96	Isopropyl ether	2.24E-03	(c)	ether	medium	Acetone
48	o-Dichlorobenzene (1,2-Dichlorobenzene)	1.94E-03	(b)	aromatic	medium	Acetone
51	1,2-Dichloroethane	1.10E-03	(c)	chlorinated alkane	medium	Acetone
26	N-Butyl acetate	4.68E-04	(a)	ester	medium	Acetone
10	N-Amyl acetate	3.91E-04	(a)	ester	medium	Acetone
9	Ammonia (aqueous)	3.28E-04	(b)	misc.	medium	Data available
95	Isopropyl acetate	3.17E-04	(e)	ester	medium	Acetone
93	Isobutyraldehyde	1.47E-04	(e)	aldehyde	medium	Acetone
136	Triethylamine	1.38E-04	(a)	amine	medium	Acetone
71	Ethyl acetate	1.20E-04	(c)	ester	medium	Acetone

Table 8-10 (Continued)

Constituent Code	Constituent Name	Henry's Law Constant (atm/gmole/m3)	Source	Structural Group	Transfer Group	Constituent Transferred From
55	Diethylamine	1.10E-04	(a)	amine	medium	Acetone
129	Tetrahydrofuran	1.10E-04	(f)	ether	medium	Data available
105	MIBK	9.40E-05	(a)	ketone	medium	Acetone
103	Methyl formate	8.10E-05	(g)	ester	medium	Acetone
25	2-Butanone (MEK)	4.36E-05	(b)	ketone	medium	Data available
118	Acetone	3.67E-05	(a)	ketone	medium	Data available
11	Amyl alcohol	2.23E-05	(a)	alcohol	low	Isopropanol
80	Formamide	1.92E-05	(g)	amide	low	Isopropanol
62	N,N-Dimethylaniline	1.75E-05	(a)	aromatic	low	Isopropanol
29	tert-Butyl alcohol	1.17E-05	(a)	alcohol	low	Isopropanol
94	Isopropanol	8.07E-06	(a)	alcohol	low	Data available
117	n-Propanol	6.85E-06	(a)	alcohol	low	Ethanol
70	Ethanol	6.26E-06	(a)	alcohol	low	Data available
27	n-Butyl alcohol	5.57E-06	(a)	alcohol	low	Methanol
124	Pyridine	5.30E-06	(g)	aromatic	low	Data available
67	1,4-Dioxane	4.88E-06	(a)	ether	low	Methanol
12	Aniline	2.90E-06	(b,g)	aromatic	low	Methanol
113(I)	Petroleum naphtha	2.70E-06	(g)	misc.	low	Methanol
97	Methanol	2.70E-06	(b)	alcohol	low	Data available
114	Phenol	3.97E-07	(a)	alcohol	not strippable	-
79	Formaldehyde	3.27E-07	(a)	aldehyde	not strippable	-
3	Acetonitrile	2.01E-07	(a)	misc.	not strippable	-

Table 8-10 (Continued)

Constituent Code	Constituent Name	Henry's Law Constant (atm/gmole/m3)	Source	Structural Group	Transfer Group	Constituent Transferred From
64	N,N-Dimethylformamide	1.29E-07	(g,h)	amide	not strippable	-
115(j)	Polyethylene glycol 600	1.08E-07	(g)	alcohol	not strippable	-
77	Ethylene glycol	1.08E-07	(e)	alcohol	not strippable	-
60	N,N-Dimethylacetamide	4.55E-08	(g,h)	amide	not strippable	-
66	Dimethyl sulfoxide	6.00E-09	(g,h)	misc.	not strippable	-

Sources:

(a) EPA Literature Values, Reference (20).
(b) SIMS Model Database, Reference (18).
(c) Alternate EPA Literature Values, References (21), (22), and (23).
(d) UNIFAC Value, Reference (24).
(e) TSDF Air Emission Model, Reference (25).
(f) Toxics Database.
(g) Best Engineering Judgement.
(h) DECHEMA, Reference (26).

Notes: All values for Henry's Law Constant are at 25°C and 1 atm.
The LTM for constituents without data was transferred from the constituent with the lowest Henry's Law Constant in the transfer group except where noted.
Ammonia data are from air stripping treatment performance.

Table 8-11

Strippability Groups for Potentially Regulated Compounds Established for Assigning Process Design Variables for Steam Stripping Technology

Compound/Group	Henry's Law Constant ($atm/gmole/m^3$)
Group 1	
n-Heptane	2.85E+00
n-Hexane	1.55E+00
Group 3	
Toluene	5.93E-03
Benzene	5.55E-03
Xylenes	5.10E-03
Chlorobenzene	3.93E-03
Chloroform	3.39E-03
Methyl cellosolve	2.90E-03
Methylene chloride	2.68E-03
Isopropyl ether	2.24E-03
o-Dichlorobenzene (1,2-Dichlorobenzene)	1.94E-03
1,2-Dichloroethane	1.10E-03
Group 4	
N-Butyl acetate	4.68E-04
N-Amyl acetate	3.91E-04
Ammonia (aqueous)	3.28E-04
Isopropyl acetate	3.17E-04
Isobutyraldehyde	1.47E-04
Triethylamine	1.38E-04
Ethyl acetate	1.20E-04
Diethylamine	1.10E-04
Tetrahydrofuran	1.10E-04
Methyl isobutyl ketone (MIBK)	9.40E-05
Methyl formate	8.10E-05
Group 5	
2-Butanone (MEK)	4.36E-05
Acetone	3.67E-05
Amyl alcohol	2.23E-05
Formamide	1.92E-05
N,N-Dimethylaniline	1.75E-05
tert-Butyl alcohol	1.17E-05
Isopropanol	8.07E-06

Table 8-11 (Continued)

Compound/Group	Henry's Law Constant (atm/gmole/m^3)
n-Propanol	6.85E-06
Ethanol	6.26E-06
n-Butyl alcohol	5.57E-08
Pyridine	5.30E-06
1,4-Dioxane	4.88E-06
Aniline	2.90E-06
Group 6	
Methanol	2.70E-06
Petroleum naphtha	2.70E-06
Group 7	
Phenol	3.97E-07
Formaldehyde	3.27E-07
Acetonitrile	2.01E-07
N,N-Dimethylformamide	1.29E-07
Polyethylene glycol 600	1.08E-07
Ethylene glycol	1.08E-07
N,N-Dimethylacetamide	4.55E-08
Dimethyl sulfoxide	6.00E-09

Table 8-12

Key Process Inputs for Data Transfer Simulations

Strippability Group	Equilibrium Stages Total	Stripping Stages	L/V	V/L
1	4	4	12.0	0.083
2	4	4	12.0	0.083
3	6	4	10.0	0.100
4	10	8	7.5	0.133
5	14	12	4.0	0.250
6	14	12	3.0	0.333

Table 8-13

Secondary Process Inputs for Data Transfer Simulations

Input	Value	Basis
Thermodynamics	Calculated	UNIQUAC/UNIFAC
Mass & Energy Balances	Calculated	Inside/Outside Algorithm by Boston
Steam Pressure	40 psig	Field Test Experience
Column Pressure Drop (includes delta P across condenser)	4 psig	Field Test Experience
Approach for Feed/Effluent HX[(a)] (Feed temperature of approximately 200°F)	20°F	Field Test Experience

(a) Approach for Feed/Effluent HX is the temperature difference between the inlet bottom temperature and the outlet temperature of the feed to the column.

Table 8-14

Comparison of UNIFAC K-Values and Literature K-Values At 25°C In Water

Chemical	K-Values[a]		Reference
	Estimated with UNIFAC	Literature Values	
Acetone	2.2	2.0	29
Chloroform	221.0	188.	25
Ethanol	0.5	0.3, 1.7	30/29
Isopropyl alcohol	2.1	0.4, 8.3	30/29
Methanol	0.1	0.2, 7.5	30/29
Methylene chloride	140.0	177.2	25
Methyl isobutyl ketone (MIBK)	3.4	2.8, 5.2	30/29
Tetrahydrofuran (THF)	6.4	6.1	30
Toluene	436.7	377.8	18

(a)The K-value of a compound in water at infinite dilution is referred to as the Henry's Law Constant of that compound.

Table 8-15

Simulation Results Supporting Steam Stripping with Distillation Treatment Performance Data Transfers for Subcategory A and C Facilities

Compound Strippability Group	Estimated Influent[a] (mg/L)	ASPEN Simulated Effluent[b] (mg/L)	Proposed Long-Term Mean Performance Level (mg/L)
Group 1			
n-Heptane	242	<0.005	0.10
n-Hexane	16,600 (c)	<0.005	0.10
Group 3			
Toluene	4,760	<0.010	0.1
Benzene	46.2	<0.010	0.10
Xylenes	328	<0.010	0.10
Chlorobenzene	106	<0.010	0.10
Chloroform	257	<0.010	0.01
Methylene chloride	3,380 (c)	<0.010	0.10
Isopropyl ether	19.2	<0.050	0.39
1,2-Dichloroethane	575	<0.010	0.39
Group 4			
Tetrahydrofuran	1,820	<0.005	1.54
n-Butyl acetate	828	<0.500	0.39
n-Amyl acetate	2,870	<0.500	0.39
Isopropyl acetate	966	<0.500	0.39
Isobutyraldehyde	67.3	<0.180	0.39
Triethylamine	3,240	<0.050	0.39
Ethyl acetate	16,300	<0.500	0.39
Diethylamine	1,440	<0.010	0.39
Methyl isobutyl ketone (MIBK)	9,780	<0.005	0.39
Methyl formate	276	<0.500	0.50
Group 5			
Pyridine	1,110	0.247	1.00
2-Butanone	262	<0.050	25.8
Acetone	3,680	<0.050	0.39
Amyl alcohol	486	<0.500	1.52
N,N-Dimethylaniline	1,670	<0.050	1.52
tert-Butyl alcohol	254	<0.500	1.52
Isopropanol	3,190	<0.050	1.52
n-Propanol	261	<0.050	1.52

Table 8-15 (Continued)

Compound Strippability Group	Estimated Influent[a] (mg/L)	ASPEN Simulated Effluent[b] (mg/L)	Proposed Long-Term Mean Performance Level (mg/L)
Ethanol	28,900	0.697	1.52
n-Butyl alcohol	37,900	0.159	1.52
1,4-Dioxane	180	<0.050	1.52
Aniline	22.8	<0.010	1.52
Group 6			
Methanol	20,000 (d) (e)	1.040	1.52

(a) All estimated influents are industry average unless otherwise noted.
(b) The < sign indicates estimated concentration is below detection limit.
(c) Simulated with concentration at solubility limit.
(d) Approximate concentration during field test.
(e) Influent is not an industry average.

Note: Simulations were not run for methyl cellosolve, formamide, and petroleum naphtha, since appropriate physical property data were not available.

Table 8-16

Simulation Results Supporting Steam Stripping with Distillation Treatment Performance Data Transfers for Subcategory B and D Facilities

Compound/Group	Estimated Influent (mg/L)	Estimated Influent is an Industry Average (A)	ASPEN Simulated Effluent(a) (mg/L)	Proposed Long-Term Mean Performance Level (mg/L)
Group 1				
n-Hexane	423	A	<0.005	0.10
Group 3				
Toluene	66.1	A	<0.010	0.10
Chloroform	7.8	A	<0.010	0.01
Methylene chloride	3,380	A (b)	<0.010	0.10
Isopropyl ether	28.3	A	<0.050	0.10
Group 4				
N-Amyl acetate	400	A	<0.500	0.39
Isopropyl acetate	110	A	<0.500	0.39
Triethylamine	<0.1	A	<0.050	0.39
Ethyl acetate	1,070	A	<0.500	0.39
Group 5				
Pyridine	45.0	A	0.2	1.00
Acetone	42,700	A	<0.050	0.39
Isopropanol	2,650	A	<0.050	1.52
Ethanol	2,920	A	0.7	1.52
n-Butyl alcohol	7.3	A	0.2	1.52
Group 6				
Methanol	20,000	(b)	1.0	1.52

(a) The < sign indicates estimated concentration is below detection limit.
(b) Simulated with concentration at solubility limit.
(c) Approximate concentration during field test.

Note: Simulations were run for those regulated constituents with raw loads reported in the Detailed Questionnaire.

Table 8-17

Long-Term Mean Treatment Performance Concentrations for BOD_5, COD, and TSS in Advanced Biological Treatment

Subcategory Discharge Status	Long-Term Mean Concentration (mg/L)		
	BOD_5	COD	TSS
A and C/Direct	74.3*	637	105*
B and D/Direct	13.5*	55.4	23.4*

*Only applicable to NSPS

Table 8-18

Long-Term Mean Treatment Performance Concentrations for Priority and Nonconventional Pollutants with Available Data

Pollutant Code	Pollutant	Long-Term Mean Concentration (mg/L)	
		Adv. Biological Treatment	Steam Stripping
118	Acetone	0.101	4.1
003	Acetonitrile	0.048	-
009	Ammonia (aqueous)	12.5	9.9
015	Benzene	0.002	-
025	2-Butanone (MEK)	0.043	121
037	Chloroform	0.010	0.010
039	Chloromethane (Methyl chloride)	0.053	-
043	Cyclohexane	0.008	-
051	1,2-Dichloroethane	0.055	-
064	N,N-Dimethylformamide	0.011	-
070	Ethanol	1.10	355
071	Ethyl acetate	0.259	-
079	Formaldehyde	0.268	-
084	n-Heptane	0.005	-
087	n-Hexane	0.014	-
094	Isopropanol	0.775	11.8
095	Isopropyl acetate	0.255	-
097	Methanol	1.70	0.218
102	Methylene chloride	0.097	0.20
106	2-Methylpyridine	0.030	
114	Phenol	0.011	-
124	Pyridine	-	43.1
129	Tetrahydrofuran	0.784	1.5
130	Toluene	0.010	0.100
134	Trichlorofluoromethane	0.018	-
139	Xylenes	0.005	-

A dash indicates treatment performance data for a specific technology is not available.

Table 8-19

Long-Term Mean Treatment Performance Concentrations for Priority and Nonconventional Pollutants (Including Treatment Performance Data Transfers)

Pollutant Code	Pollutant	Long-Term Mean Concentration (mg/L)	
		Adv. Biological Treatment	Steam Stripping
118	Acetone	0.101	4.1
003	Acetonitrile	5.0*	NS
009	Ammonia (aqueous)	12.5	9.9
010	n-Amyl acetate	0.259	4.1
011	Amyl alcohol	2.0	11.8
012	Aniline	0.030	1,240
015	Benzene	0.010*	0.218
025	2-Butanone (MEK)	0.05*	121
026	n-Butyl acetate	0.255	4.1
027	n-Butyl alcohol	2.0	1,240
029	tert-Butyl alcohol	2.0	11.8
035	Chlorobenzene	0.030	0.218
037	Chloroform	0.010	0.010
048	o-Dichlorobenzene (1,2-Dichlorobenzene)	0.030	4.1
051	1,2-Dichloroethane	0.055	4.1
055	Diethylamine	50*	50*
060	N,N-Dimethylacetamide	0.05*	NS
062	N,N-Dimethylaniline	0.030	11.8
064	N,N-Dimethylformamide	0.011	NS
066	Dimethyl sulfoxide	20*	NS
067	1,4-Dioxane	0.784	1,240
070	Ethanol	2.0*	355
071	Ethyl acetate	0.259	4.1
077	Ethylene glycol	2.0	NS
079	Formaldehyde	0.268	NS
080	Formamide	100*	100*
084	n-Heptane	0.010*	0.218
087	n-Hexane	0.014	0.218

Table 8-19 (Continued)

Pollutant Code	Pollutant	Long-Term Mean Concentration (mg/L)	
		Adv. Biological Treatment	Steam Stripping
093	Isobutyraldehyde	0.268	4.1
094	Isopropanol	0.775	11.8
095	Isopropyl acetate	0.255	4.1
096	Isopropyl ether	0.784	4.1
097	Methanol	2.0*	1,240
101	Methyl cellosolve	20*	20*
102	Methylene chloride	0.097	0.218
103	Methyl formate	0.259	4.1
105	Methyl isobutyl ketone (MIBK)	0.101	4.1
113	Petroleum naphtha	0.03*	1,240
114	Phenol	0.011	NS
115	Polyethylene glycol 600	1.0*	NS
117	n-Propanol	2.0	355
124	Pyridine	0.030	43.1
129	Tetrahydrofuran	0.784	1.5
130	Toluene	0.010	0.100
136	Triethylamine	50*	50*
139	Xylenes	0.005	0.218

NS - Constituent is not strippable.

* - Long-term mean concentration set at ML for pollutant.

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SECTION 9

POLLUTANT REDUCTION ESTIMATES

9.1 Introduction

EPA obtained data on pollutant loads generated by pharmaceutical manufacturing processes and the ultimate fate of these loads from Detailed Questionnaire responses. Using these data and the treatment performance data presented in 8, the Agency has developed estimates of raw and current pollutant discharge loads from the pharmaceutical manufacturing industry. The Agency also calculated the pollutant discharge loads that would remain after implementation of each of the regulatory options considered.

The following information is presented in this section:

- 9.2 presents the estimated raw loads of regulated pollutants in process wastewaters based on responses to the Detailed Questionnaire;
- 9.3 presents the loads of regulated pollutants currently being discharged based on responses to the Detailed Questionnaire;
- 9.4 discusses estimated end-of-pipe discharge loads for each regulatory option; and
- 9.5 discusses the pollutant load reductions expected through steam stripping and advanced biological treatment.

9.2 Raw Loads

The Agency estimated raw loads, by potentially regulated pollutant, which are generated by pharmaceutical manufacturing processes based on responses to the Detailed Questionnaire. The raw load was estimated as the sum of the discharge load, air emissions from wastewater load, and degraded/destroyed load. These loads from the detailed questionnaire for each facility were summed by pollutant across all facilities within a subcategory group. Table 9-1, located at the end

of this section, lists the estimated raw loads for each pollutant by subcategory and type of discharge.

The raw loads for the Subcategory D indirect dischargers were scaled up according to the methodology discussed in 3.2.4 and presented in Reference (1). This scale-up was used to estimate the total amount of pollutants for all Subcategory D indirect dischargers, including the facilities which were not sent a Detailed Questionnaire. Table 9-2 summarizes the total amount of pollutant load in untreated wastewater from Subcategory B and D indirect dischargers.

9.3 Current Baseline Loads

The current baseline loads are those loads, by potentially regulated pollutant, which are currently discharged by pharmaceutical manufacturing processes to a POTW or to surface water based on responses to the Detailed Questionnaire. Those discharge loads, available from the Detailed Questionnaire for each facility, were summed by pollutant across all facilities within a subcategory group. Table 9-3 lists the current baseline loads for each pollutant by subcategory group and type of discharge.

The current baseline loads for the Subcategory D indirect dischargers were scaled up according to the methodology discussed in 3.2.4 and presented in Reference (1). This scale-up was used to estimate the total amount of pollutants for all Subcategory D indirect dischargers, including the facilities which were not sent a Detailed Questionnaire. Table 9-4 summarizes the total amount of pollutants currently discharged by Subcategory B and D indirect dischargers.

9.4 End-of-Pipe Discharge Loads for Each Regulatory Option

End-of-pipe discharge loads for the BPT, BAT, and PSES regulatory options are presented by subcategory and pollutant in this section. These loads were calculated in the following manner. For each facility, current discharge loads were converted to an estimated current effluent concentration using the pollutant discharge load, facility process wastewater flow, and a conversion factor. For each facility, current estimated effluent concentrations were then

compared to the long term mean concentrations at the end of the treatment train for a particular regulatory option. The lower of these concentrations was used along with the facility flow and an appropriate conversion factor to determine facility specific end-of-pipe discharge loads (2), (3). Loads from all facilities within a subcategory group were then summed to provide the subcategory-wide estimates.

9.4.1 BPT

The regulatory options under BPT address the loads and concentrations of BOD_5, COD, and TSS at Subcategory A, B, C, and D direct discharger facilities. Indirect dischargers are not regulated under BPT.

The regulatory options beyond no revision considered under BPT for Subcategories A, B, C and D direct discharger facilities incorporate advanced biological treatment. Options considered include: 1) no revisions to the existing BPT, 2) revise COD only and clarify cyanide, 3) revise BOD_5 and TSS only and clarify cyanide, and 4) revise BOD_5, COD, and TSS and clarify cyanide. Estimated end-of-pipe discharge loads are presented in Table 9-5 for BOD_5, COD, and TSS removed by advanced biological treatment and the options considered.

9.4.2 BAT

The regulatory options considered under BAT beyond no revision address the loads and concentrations of priority and nonconventional pollutants, including ammonia and cyanide where appropriate.

The regulatory options considered under BAT beyond no revision for Subcategory A and C direct discharging facilities incorporate advanced biological treatment and advanced biological treatment with nitrification. Options considered include: 1) revise COD and clarify cyanide, 2) add organics only, revise COD, and clarify cyanide, and 3) add organics and ammonia, revise COD, and clarify cyanide. Table 9-6 presents estimated end-of-pipe discharge loads for these options. COD end-

of-pipe discharge loads are equivalent to the BPT end-of-pipe discharge loads presented in Table 9-5.

The regulatory option considered under BAT beyond no revision for Subcategory B and D direct discharging facilities incorporates advanced biological treatment. Options considered include: 1) revise COD and withdraw cyanide, and 2) add organics only, revise COD, and withdraw cyanide. Because ammonia is not present at concentrations of concern in Subcategory B and D wastewaters, ammonia nitrification is not included as part of the technology basis for these subcategories. Also, because cyanide is not present at concentrations of concern in Subcategory B and D wastewaters, the regulatory options withdraw the existing cyanide limitations. Table 9-7 presents estimated end-of-pipe discharge loads for this option. COD end-of-pipe discharge loads are equivalent to the BPT end-of-pipe discharge loads presented in Table 9-5.

9.4.3 PSES

The regulatory options considered under PSES beyond no revision address the loads and concentrations of priority and nonconventional organic pollutants and where appropriate, ammonia and cyanide. PSES is being revised for Subcategory A, B, C, and D indirect discharging facilities. Direct dischargers are not regulated under PSES.

The regulatory options beyond no revision considered under PSES for Subcategory A and C indirect discharging facilities include: 1) in-plant steam stripping for organic compounds and ammonia, and clarify cyanide, and 2) in-plant steam stripping for organic compounds and ammonia, plus in-plant cyanide destruction. Table 9-8 presents end-of-pipe discharge loads for these options.

The regulatory option beyond no revision considered under PSES for Subcategory B and D indirect discharging facilities is in-plant steam stripping for organic compounds. Because ammonia is not present at concentrations of concern in Subcategory B and D wastewaters, ammonia is not included as part of the technology option. Also, because cyanide is not present at concentrations of concern in Subcategory B and D wastewaters, the regulatory options withdraw

the existing cyanide limitations. Table 9-9 presents estimated end-of-pipe discharge loads for this option at Subcategory B and D indirect dischargers.

The end-of-pipe loads for the Subcategory D indirect discharging facilities were scaled up according to the methodology discussed in 3.2.4 and in Reference (1). An estimate of the total end-of-pipe discharge loads for the Subcategory D indirect discharging facilities including those not sent a Detailed Questionnaire are presented in Table 9-10.

9.5 Pollutant Load Reduction Estimates

Pollutant load reductions through each regulatory option are discussed in this section. The regulatory options are summarized in Table 7-3 of 7.

9.5.1 BPT

Load reductions through advanced biological treatment for three options are shown in Table 9-11: COD revised; BOD_5 and TSS revised; and BOD_5, COD, and TSS revised.

9.5.2 BAT

Table 9-12 presents load reductions through advanced biological treatment and advanced biological treatment with nitrification for organic pollutants and ammonia under BAT for Subcategories A and C and load reductions through advanced biological treatment for organic pollutants under BAT for Subcategories B and D. These load reductions correspond to the load reduction between current baseline loads and BAT end-of-pipe loads for both A and C; and B and D direct dischargers.

Under BAT, there is also removal of BOD_5 and COD associated with the organics treatment upgrades. The load removals for BOD_5 and COD under BAT are listed in Table 9-13. The first set of removal numbers assume revision of BPT limitations for BOD_5 and COD, with additional incidental COD removal associated with the organics treatment. The second set of removal

numbers assumes no revision of BPT limitations for BOD_5 and COD, and compliance at BAT with a COD limitation equivalent to the BPT COD limitation. Under this approach, there is also incidental BOD_5 removals associated with the COD treatment.

9.5.3 PSES

As discussed in 7 of this document, EPA considered multiple regulatory options of PSES for the four manufacturing subcategories. One option is current treatment (i.e., no revision); this option results in no additional load reductions under PSES. The remaining options are based on in-plant steam stripping. Table 9-14 presents load reductions through in-plant steam stripping for organic compounds and ammonia. These load reductions include the regulated pollutant load reductions achievable by in-plant steam stripping where the in-plant steam strippers see a raw pollutant load prior to air emissions or current on-site treatment.

For the Subcategory A and C PSES option that includes in-plant cyanide destruction, there would be an additional reduction of 1,024 lbs/yr of cyanide.

Load reductions for the Subcategory D indirect dischargers were scaled up according to the methodology discussed in 3.2.4 and presented in Reference (1). An estimate of the total load reductions for the Subcategory D indirect dischargers including those not sent a Detailed Questionnaire are presented in Table 9-15.

Table 9-1

Estimated Raw Loads by Subcategory Group and Discharge Mode (lbs/yr)

Pollutant	A and C Direct Dischargers	B and D Direct Dischargers	A and C Indirect Dischargers	B and D Indirect Dischargers
Conventionals and COD				
BOD_5	90,653,469	1,411,645	NA	NA
COD	197,712,617	2,757,315	NA	NA
TSS	26,416,318	581,627	NA	NA
Priority Organics				
Benzene	1,700	0	121,400	0
Chlorobenzene	10,959	0	84,710	0
Chloroform	404,213	0	488,980	77
o-Dichlorobenzene (1,2-Dichlorobenzene)	0	0	21,499	0
1,2-Dichloroethane	482,499	0	6,552	0
Methylene chloride	7,972,997	25	7,170,355	780,865
Phenol	364,720	1,811	6,693	714
Toluene	3,518,302	0	2,964,665	2,276
Priority Organics Subtotal	**12,755,390**	**1,836**	**10,864,854**	**783,932**
Cyanide	25,651	0	75,065	0
Priority Pollutant Total	**12,781,041**	**1,836**	**10,939,919**	**783,932** [(a)]
Nonconventional Organics				
Acetone	5,079,688	154	13,490,007	1,607,106
Acetonitrile	918,854	0	2,545,953	0
n-Amyl acetate	330,293	0	717,685	824,830
Amyl alcohol	54,000	0	144,619	0
Aniline	0	0	30,551	0
2-Butanone (MEK)	12,868	0	19,578	0
n-Butyl acetate	0	0	415,426	0
n-Butyl alcohol	0	0	977,029	109
tert-Butyl alcohol	86,997	0	212,508	0

Table 9-1 (Continued)

Pollutant	A and C Direct Dischargers	B and D Direct Dischargers	A and C Indirect Dischargers	B and D Indirect Dischargers
Diethylamine	0	0	325,570	0
N,N-Dimethylacetamide	7,460	0	1,379,516	0
N,N-Dimethylaniline	0	0	131,174	0
N,N-Dimethylformamide	4,572,206	0	801,666	0
Dimethyl sulfoxide	87,992	0	819,972	355
1,4-Dioxane	0	0	69,039	0
Ethanol	4,100,897	67,674	8,847,220	2,525,138
Ethyl acetate	3,369,005	0	2,957,822	14,675
Ethylene glycol	41,699	0	326,623	18,061
Formaldehyde	147,220	230	783,013	2,418
Formamide	3,337	0	352,661	0
n-Heptane	0	0	74,346	0
n-Hexane	1,833,105	0	1,566,893	14,624
Isobutyraldehyde	8,501	0	36,479	0
Isopropanol	4,625,059	38,672	9,095,624	853,366
Isopropyl acetate	527,801	0	249,114	225,593
Isopropyl ether	78	0	16,730	350
Methanol	29,442,300	458	21,638,898	99,880
Methyl cellosolve	0	0	1,755,690	0
Methyl formate	607,950	0	28,689	0
Methyl isobutyl ketone (MIBK)	75,130	0	2,416,611	0
Petroleum naphtha	728	0	578,795	146
Polyethylene glycol 600	0	200	37,707	181
n-Propanol	0	0	19,326	0
Pyridine	617,929	0	321,010	1,803
Tetrahydrofuran	135,157	0	816,347	0
Triethylamine	454,280	0	1,693,165	2
Xylenes	724,406	0	153,563	0

Table 9-1 (Continued)

Pollutant	A and C Direct Dischargers	B and D Direct Dischargers	A and C Indirect Dischargers	B and D Indirect Dischargers
Nonconventional Organics Subtotal	**58,256,989**	**107,388**	**75,846,619**	**6,188,637**
Ammonia as N	819,153	28	1,979,257	302
Nonconventional Total	**59,076,142**	**107,416**	**77,825,876**	**6,188,939[a]**

(a) Untreated load for facilities for which questionnaire data were available. Estimated total priority and nonconventional pollutant load for all facilities is 7,452,000 lbs/yr.

NA - Not available

Table 9-2

Total Pollutant Load in Untreated Wastewater from Band D Indirect Dischargers

	Subcategory B and D Indirect Dischargers from the Detailed Questionnaire	Subcategory D Indirect Dischargers Without Questionnaire	Total Subcategory B and D Indirect Dischargers
Total Raw Load for Priority and Nonconventional Pollutants (lbs/yr)	6,991,000	461,000	7,452,000

Table 9-3

Current Pollutant Discharge Loads by Subcategory Group and Discharge Mode (lbs/yr)

Pollutant	A and C Direct Dischargers	B and D Direct Dischargers	A and C Indirect Dischargers	B and D Indirect Dischargers
Conventionals and COD				
BOD_5	2,981,441	145,753	NA	NA
COD	29,345,638	544,204	NA	NA
TSS	5,538,216	149,383	NA	NA
Priority Organics				
Benzene	0	0	120,200	0
Chlorobenzene	0	0	5,606	0
Chloroform	4,198	0	177,287	32
o-Dichlorobenzene (1,2-Dichlorobenzene)	0	0	21,499	0
1,2-Dichloroethane	318	0	4,294	0
Methylene chloride	43,518	0	1,198,531	15,595
Phenol	9,000	0	1,206	714
Toluene	8,169	0	257,662	5
Priority Organics Subtotal	**65,203**	**0**	**1,786,285**	**16,346**
Cyanide	42	0	1,084	0
Priority Pollutant Total	**65,245**	**0**	**1,787,369**	**16,346** [(a)]
Nonconventional Organics				
Acetone	21,727	8	3,004,969	43,136
Acetonitrile	6,370	0	423,821	0
n-Amyl acetate	2,493	0	28,509	82,483
Amyl alcohol	53,000	0	143,554	0
Aniline	0	0	4,600	0
2-Butanone (MEK)	143	0	17,283	0
n-Butyl acetate	0	0	415,426	0

Table 9-3 (Continued)

Pollutant	A and C Direct Dischargers	B and D Direct Dischargers	A and C Indirect Dischargers	B and D Indirect Dischargers
n-Butyl alcohol	0	0	664,561	108
tert-Butyl alcohol	2,844	0	95,564	0
Diethylamine	0	0	218,020	0
N,N-Dimethylacetamide	746	0	1,045,358	0
N,N-Dimethylaniline	0	0	18,155	0
N,N-Dimethylformamide	174	0	387,124	0
Dimethyl sulfoxide	5,040	0	745,181	355
1,4-Dioxane	0	0	24,422	0
Ethanol	204,601	7,854	4,368,801	1,283,544
Ethyl acetate	107,183	0	164,241	3
Ethylene glycol	39	0	147,760	18,061
Formaldehyde	1,201	229	310,677	1,083
Formamide	109	0	7,075	0
n-Heptane	0	0	27,894	0
n-Hexane	2,247	0	8,449	100
Isobutyraldehyde	0	0	35,654	0
Isopropanol	181,581	14,841	2,785,586	88,285
Isopropyl acetate	10,556	0	14,809	22,559
Isopropyl ether	1	0	10,963	350
Methanol	725,851	98	12,433,615	44,747
Methyl cellosolve	0	0	445,137	0
Methyl formate	9,843	0	2,773	0
Methyl isobutyl ketone (MIBK)	15,000	0	623,193	0
Petroleum Naphtha	0	0	260,583	0
Polyethylene Glycol 600	0	200	30,839	181
n-Propanol	0	0	11,439	0
Pyridine	50	0	210,186	1,803
Tetrahydrofuran	38,708	0	226,167	0
Triethylamine	11,000	0	407,696	1

Table 9-3 (Continued)

Pollutant	A and C Direct Dischargers	B and D Direct Dischargers	A and C Indirect Dischargers	B and D Indirect Dischargers
Xylenes	2,642	0	24,969	0
Nonconventional Organics Subtotal	**1,403,149**	**23,230**	**29,795,053**	**1,586,799**
Ammonia as N [(b)]	1,128,044	0	433,505	25
Nonconventional Total	**2,531,193**	**23,230**	**30,228,558**	**1,586,824** [(a)]

(a) Load for facilities for which questionnaire data were available. Estimated total priority and nonconventional pollutant load for all facilities is **2,063,000** lbs/yr.

(b) Load for facilities based on detailed questionnaire loadings, DMR reports, sampling, and self-monitoring data (4).

NA - Not available

Table 9-4

Total Pollutant Load Currently Discharged from B and D Indirect Dischargers

	Subcategory B and D Indirect Dischargers from the Detailed Questionnaire	Subcategory D Indirect Dischargers Without Questionnaire	Total Subcategory B and D Indirect Dischargers
Total Current Baseline Loads for Priority and Nonconventional Pollutants (lbs/yr)	1,603,000	460,000	2,063,000

Table 9-5

Estimated End-of-Pipe BPT Discharge Load

Pollutant	Subcategory A and C BPT Discharge Load (lbs/yr)	Subcategory B and D BPT Discharge Loads (lbs/yr)
No Revisions Option		
BOD_5	2,981,441	145,753
TSS	5,538,216	149,383
COD	29,345,638	544,204
Revise COD Only Option		
BOD_5*	423,766	44,113
TSS	5,538,216	149,383
COD	17,551,857	107,097
Revise BOD_5 and TSS Option		
BOD_5	1,636,442	22,999
TSS	2,945,822	35,861
COD*	28,591,100	192,065
Revise BOD_5, COD and TSS Option		
BOD_5	423,766	22,999
TSS	2,945,822	35,861
COD	17,551,857	107,097

* - These pollutants are incidentally removed under the option.

Table 9-6

End-of Pipe Discharge Loads for Subcategory A and C Facilities Under BAT Options (lbs/yr)

Pollutant	Discharge Loads (lbs/yr)	
	Advanced Biological Treatment	Advanced Biological Treatment with Nitrification
Priority Organics		
Chloroform	118	118
1,2-Dichloroethane	171	171
Methylene chloride	1,663	1,663
Phenol	5	5
Toluene	127	127
Priority Organics Subtotal	**2,084**	**2,084**
Priority Pollutants		
Cyanide	42	42
Priority Pollutant Total	**2,116**	**2,116**
Nonconventional Organics		
Acetone	1,349	1,349
Acetonitrile	5,224	5,224
n-Amyl acetate	877	877
Amyl alcohol	826	826
2-Butanone (MEK)	14	14
tert-Butyl alcohol	2,844	2,844
N,N-Dimethylacetamide	135	135
N,N-Dimethylformamide	35	35
Dimethyl sulfoxide	3	3
Ethanol	10,163	10,163
Ethyl acetate	3,803	3,803
Ethylene glycol	39	39
Formaldehyde	1,038	1,038

Table 9-6 (Continued)

Pollutant	Discharge Loads (lbs/yr)	
	Advanced Biological Treatment	Advanced Biological Treatment with Nitrification
Formamide	12	12
n-Hexane	128	128
Isopropanol	9,940	9,940
Isopropyl acetate	894	894
Isopropyl ether	1	1
Methanol	12,920	12,920
Methyl formate	957	957
Methyl isobutyl ketone (MIBK)	533	533
Pyridine	14	14
Tetrahydrofuran	5,307	5,307
Triethylamine	53	53
Xylenes	60	60
Nonconventional Organics Subtotal	**57,169**	**57,169**
Ammonia	1,128,044	327,130
Nonconventional Pollutant Total	**1,185,213**	**384,299**

Table 9-7

End-of-Pipe Discharge Loads for Subcategory B and D Facilities Under BAT Options (lbs/yr)

Pollutant	Advanced Biological Treatment
Acetone	8
Ethanol	377
Formaldehyde	58
Isopropanol	195
Methanol	98
Polyethylene Glycol 600	154
Nonconventional Pollutant Total [(a)]	**890**

(a) There are no priority pollutant end-of-pipe discharge loads for Subcategory B and D direct discharging facilities.

Table 9-8

End-of-Pipe Discharge Loads for Subcategory A and C Facilities Under PSES Options (lbs/yr)

Pollutant	In-Plant Steam Stripping for Organics	In-Plant Steam Stripping for Organics plus In-Plant Cyanide Destruction
Priority Organics		
Benzene	504	504
Chlorobenzene	473	473
Chloroform	52	52
o-Dichlorobenzene (1,2-Dichlorobenzene)	5,123	5,123
1,2-Dichloroethane	1,767	1,767
Methylene chloride	2,847	2,847
Phenol	1,206	1,206
Toluene	1,358	1,358
Priority Organics Subtotal	**13,330**	**13,330**
Priority Pollutants		
Cyanide	1,084	60
Priority Pollutant Total	**14,414**	**13,390**
Nonconventional Organics		
Acetone	57,617	57,617
Acetonitrile	330,127	330,127
n-Amyl acetate	1,430	1,430
Amyl alcohol	47,093	47,093
Aniline	4,600	4,600
2-Butanone (MEK)	12,452	12,452
n-Butyl acetate	2,008	2,008
n-Butyl alcohol	420,012	420,012
tert-Butyl alcohol	89,831	89,831
Diethylamine	26,816	26,816

Table 9-8 (Continued)

Pollutant	In-Plant Steam Stripping for Organics	In-Plant Steam Stripping for Organics plus In-Plant Cyanide Destruction
N,N-Dimethylacetamide	1,045,358	1,045,358
N,N-Dimethylaniline	1,898	1,898
N,N-Dimethylformamide	387,124	387,124
Dimethyl sulfoxide	745,181	745,181
1,4-Dioxane	24,308	24,308
Ethanol	3,973,339	3,973,339
Ethyl acetate	9,511	9,511
Ethylene glycol	147,760	147,760
Formaldehyde	310,677	310,677
Formamide	1,356	1,356
n-Heptane	612	612
n-Hexane	392	392
Isobutyraldehyde	5,917	5,917
Isopropanol	2,170,103	2,170,103
Isopropyl acetate	4,073	4,073
Isopropyl ether	1,381	1,381
Methanol	9,711,783	9,711,783
Methyl cellosolve	9,577	9,577
Methyl formate	2,773	2,773
MIBK	11,637	11,637
Petroleum Naphtha	260,583	260,583
Polyethylene Glycol 600	30,839	30,839
n-Propanol	6,525	6,525
Pyridine	86,620	86,620
Tetrahydrofuran	6,113	6,113
Triethylamine	21,051	21,051
Xylenes	173	173
Nonconventional Organics Subtotal	**19,968,650**	**19,968,650**

Table 9-8 (Continued)

Pollutant	In-Plant Steam Stripping for Organics	In-Plant Steam Stripping for Organics plus In-Plant Cyanide Destruction
Ammonia	169,164	169,164
Nonconventional Pollutant Total	**20,137,814**	**20,137,814**

Table 9-9

End-of-Pipe Discharge Loads for Subcategory B and D Facilities Under PSES Option (lbs/yr)

Pollutant	In-Plant Steam Stripping for Organics
Priority Pollutants	
Chloroform	0
Methylene chloride	594
Phenol	713
Toluene	5
Priority Pollutant Total	**1,312**
Nonconventional Organics	
Acetone	8,748
n-Amyl acetate	1,385
n-Butyl alcohol	108
Dimethyl sulfoxide	355
Ethanol	1,283,544
Ethyl acetate	1
Ethylene glycol	18,061
Formaldehyde	1,083
n-Hexane	2
Isopropanol	87,985
Isopropyl acetate	786
Isopropyl ether	27
Methanol	44,747
Polyethylene Glycol 600	181
Pyridine	1,803
Triethylamine	1
Nonconventional Organics Subtotal	**1,448,817**
Ammonia	25
Nonconventional Pollutant Total	**1,448,842**

Table 9-10

Total Estimated End-of-Pipe Discharge Loads for Subcategory B and D Indirect Dischargers

	Subcategory B and D Indirect Dischargers With the Detailed Questionnaire	Subcategory D Indirect Dischargers Without Questionnaire	Total Subcategory B and D Indirect Dischargers
Total Priority and Nonconventional Pollutant Discharge Loads under PSES Based on In-Plant Steam Stripping (lbs/yr)	1,450,000	448,000	1,898,000

Table 9-11

Estimated BPT Load Reduction

Pollutant	Subcategory A and C Load Reduction through Advanced Biological Treatment (lbs/yr)	Subcategory B and D Load Reduction through Advanced Biological Treatment (lbs/yr)
Revise COD Only Option		
Incidental BOD_5	2,558,000	102,000
Incidental TSS	0	0
COD	11,794,000	437,000
Revise BOD_5 and TSS Option		
BOD_5	1,345,000	123,000
TSS	2,592,000	113,000
Incidental COD	754,000	352,000
Revise BOD_5, COD and TSS Option		
BOD_5	2,558,000	123,000
TSS	2,592,000	113,000
COD	11,794,000	437,000

Table 9-12

Pollutant Load Reduction Through Advanced Biological Treatment Under BAT for Subcategory A and C and B and D Direct Dischargers (lbs/yr)

Pollutant	Load Reduction for A and C Direct Dischargers	Load Reduction for B and D Direct Dischargers
Priority Organics		
Benzene	0	0
Chlorobenzene	0	0
Chloroform	4,080	0
o-Dichlorobenzene (1,2-Dichlorobenzene)	0	0
1,2-Dichloroethane	147	0
Methylene chloride	41,905	0
Phenol	8,995	0
Toluene	8,042	0
Priority Organics Subtotal	**63,169**	**0**
Priority Pollutant		
Cyanide	0	0
Priority Pollutant Total	**63,169**	**0**
Nonconventional Organics		
Acetone	17,832	0
Acetonitrile	1,146	0
n-Amyl acetate	1,616	0
Amyl alcohol	52,174	0
Aniline	0	0
2-Butanone (MEK)	0	0
n-Butyl acetate	0	0
n-Butyl alcohol	0	0
tert-Butyl alcohol	0	0
Diethylamine	0	0
N,N-Dimethylacetamide	0	0
N,N-Dimethylaniline	0	0
N,N-Dimethylformamide	136	0
Dimethyl sulfoxide	3,712	0
1,4-Dioxane	0	0
Ethanol	195,517	7,477

Table 9-12 (Continued)

Pollutant	Load Reduction for A and C Direct Dischargers	Load Reduction for B and D Direct Dischargers
Ethyl acetate	87,223	0
Ethylene glycol	0	0
Formaldehyde	178	171
Formamide	0	0
n-Heptane	0	0
n-Hexane	241	0
Isobutyraldehyde	0	0
Isopropanol	165,987	14,646
Isopropyl acetate	286	0
Isopropyl ether	0	0
Methanol	712,931	0
Methyl cellosolve	0	0
Methyl formate	8,437	0
Methyl isobutyl ketone (MIBK)	14,462	0
Petroleum Naphtha	0	0
Polyethylene Glycol 600	0	46
n-Propanol	0	0
Pyridine	36	0
Tetrahydrofuran	31,821	0
Triethylamine	0	0
Xylenes	2,582	0
Total Nonconventional Organics Subtotal	**1,296,317**	**22,339**
Ammonia [(a)]	800,913	0
Total Nonconventional Pollutant Total	**2,097,230**	**22,339**

(a) Ammonia is only removed under the BAT option that includes nitrification. Removals for other BAT options are 0 lbs/yr.

Table 9-13

Estimated BAT Load Reduction Under BPT Options

Pollutant	Load Reduction through Advanced Biological Treatment for Subcategory A and C Direct Dischargers (lbs/yr)	Load Reduction through Advanced Biological Treatment for Subcategory B and D Direct Dischargers (lbs/yr)
BPT Revised		
Incidental BOD_5	0	0
Incidental COD	1,215,000	7,000
BPT Not Revised		
Incidental BOD_5	2,558,000	102,000
COD	13,009,000	444,000

Table 9-14

PSES Pollutant Load Reduction Through In-plant Steam Stripping and Cyanide Destruction (lbs/yr)

Pollutant	Load Reduction for A and C Indirect Dischargers	Load Reduction for B and D Indirect Dischargers
Priority Organics		
Benzene	120,896	0
Chlorobenzene	84,094	0
Chloroform	45,219	77
o-Dichlorobenzene (1,2-Dichlorobenzene)	16,376	0
1,2-Dichloroethane	546	0
Methylene chloride	677,934	754,985
Phenol	0	1
Toluene	640,348	1
Priority Organics Subtotal	**1,585,413**	**755,064**
Priority Pollutant		
Cyanide [(a)]	1,024	0
Priority Pollutant Total	159,567	755,064
Nonconventional Organics		
Acetone	2,234,971	1,517,984
Acetonitrile	0	0
n-Amyl acetate	294,153	810,977
Amyl alcohol	0	0
Aniline	0	0
2-Butanone (MEK)	0	0
n-Butyl acetate	412,547	0
n-Butyl alcohol	0	0
tert-Butyl alcohol	0	0
Diethylamine	61,645	0
N,N-Dimethylacetamide	0	0
N,N-Dimethylaniline	0	0
N,N-Dimethylformamide	0	0

Table 9-14 (Continued)

Pollutant	Load Reduction for A and C Indirect Dischargers	Load Reduction for B and D Indirect Dischargers
Dimethyl sulfoxide	0	0
1,4-Dioxane	0	0
Ethanol	110	0
Ethyl acetate	1,693,800	11,639
Ethylene glycol	0	0
Formaldehyde	0	0
Formamide	0	0
n-Heptane	17,502	0
n-Hexane	1,133,860	108
Isobutyraldehyde	29,737	0
Isopropanol	11	300
Isopropyl acetate	9,426	217,732
Isopropyl ether	9,280	323
Methanol	22	0
Methyl cellosolve	978,931	0
Methyl formate	23,283	0
Methyl isobutyl ketone (MIBK)	254,906	0
Petroleum Naphtha	0	0
Polyethylene Glycol 600	0	0
n-Propanol	0	0
Pyridine	0	0
Tetrahydrofuran	91,063	0
Triethylamine	374,837	0
Xylenes	22,140	0
Nonconventional Organics Subtotal	**7,642,224**	**2,559,063**
Ammonia	1,424,865	0
Nonconventional Pollutant Total	**9,067,189**	**2,559,063**

(a) Cyanide is only removed under the PSES option that includes in-plant cyanide destruction. Removals for other PSES options are 0 lbs/yr.

Table 9-15

Total Pollutant Load Reductions from B and D Indirect Dischargers

	Subcategory B and D Indirect Dischargers Submitted in Detailed Questionnaire	Subcategory D Indirect Dischargers Without Questionnaire	Total Subcategory B and D Indirect Dischargers
Total Load Reduction Through In-Plant Steam Stripping for Organic Compounds (lbs/yr)	3,314,000	44,500	3,358,500

REFERENCES

1. Memorandum: Subcategory D Indirect Scale-Up Methodology, from K. Mahsman, Radian Corporation, to the Public Record, September 1994.

2. Memorandum: Final Pollutant Loading Estimates for the Pharmaceutical Manufacturing Industry - Subcategory A/C and B/D Direct and Indirect Discharging Facilities, from K. Mahsman and M. Willett, Radian Corporation, to F. Hund, USEPA/EAD, August 31, 1994.

3. Letter from M. Willett, Radian Corporation, to K. Koon, Versar, December 15, 1994.

4. Memorandum: Ammonia Data Used for Subcategory A/C Direct Facility Loadings, from T. Brenza, Eastern Research Group, to the Public Record, March 1998.

SECTION 10

COSTS OF TECHNOLOGY BASES OF REGULATIONS

10.1 Introduction

Previous sections have described the respective BPT, BCT, BAT, NSPS, PSES, and PSNS technology options that were considered as the bases of regulations for the pharmaceutical manufacturing industry. This presents the estimated engineering costs associated with installing and operating each of these technology bases. These costs are calculated to determine the overall economic impact on the industry of complying with each regulatory option.

The following information is discussed in this section:

- 10.2 discusses the costing methodology;
- 10.3 discusses cost modeling and summarizes cost estimating assumptions and design bases of the technologies that make up the regulatory options; and
- 10.4 presents the cost estimates by regulatory option.

10.2 Costing Methodology

To accurately determine the impact of the effluent limitations guidelines and standards on the pharmaceutical manufacturing industry, it is necessary to calculate costs associated with regulatory compliance. A cost model was developed to represent each of the regulatory options under BPT, BCT, BAT, PSES, PSNS, and NSPS. The cost model is used to calculate costs for each option based on the treatment technologies used as the basis for that option. These costs are estimates of actual compliance costs; however, the regulations do not require that a facility install or possess the technologies specified as the bases, but only that the appropriate limitations be met.

The Agency has selected a facility-by-facility approach to costing as opposed to a model facility approach, because of the variability of processes and resultant wastewaters among pharmaceutical manufacturing facilities. Detailed facility information was available from responses to the Detailed Questionnaire and comments on the proposed regulations, which was used to characterize the wastewater and assess existing treatment technologies at each facility. It should be noted, however, that in certain instances, engineering assumptions regarding facility operations were made, or industry average data were used when facility-specific information were not available. Thus, for any given facility, the costs estimated may deviate from those that would actually be experienced by the facility. However, since these assumptions were based on industry-wide data, the resulting estimates are considered accurate when evaluated on an industry-wide, aggregate basis.

When practical and appropriate, facilities were given credit for existing treatment on site, based on an evaluation of the following criteria:

- Biological treatment system aeration capacity (in million gallons);
- Clarifier overflow rate (in gallons per minute per square foot);
- Presence of adequate equalization treatment;
- Presence of steam stripping or steam stripping with distillation treatment that achieved adequate removal of organic compounds; and
- Presence of cyanide destruction treatment - this credit was given wholly or partially based on comparison to the treatment systems selected as the technology bases.

These treatment credits were used to develop cost estimates for system upgrades instead of new systems where appropriate. At facilities that currently meet the limitations associated with a regulatory option, no compliance costs beyond necessary additional monitoring were estimated.

10.2.1 Cost Model Structure

The model used to calculate wastewater treatment costs was developed based on research into various existing costing approaches and use of customized computer software tools. The model consists mainly of a series of technology modules, each of which calculates the costs associated with a particular treatment technology. These modules can be combined as appropriate to assemble each of the various regulatory options. A more detailed discussion of the cost model and its origins is given in Section 10.3.

Operation and maintenance (O&M) and capital costs were calculated by the model for each technology and then summed for all technologies at each facility. The facility capital and O&M costs were combined and totaled by subcategory and discharge type (e.g. Subcategory A and C - indirect discharger).

Annual O&M costs consist of all costs related to operating and maintaining the treatment system for a period of one year. Sources for O&M costs primarily included literature references and engineering judgement (typically used in the case of estimating required operator hours). O&M costs typically include the following:

- Chemical usage;
- O&M labor;
- Removal, transportation, and disposal of any waste solids, sludges, solvents, or other waste products generated by the treatment system; and
- Utilities, such as electricity and steam, required to run the treatment system.

Table 10-1 presents the O&M unit costs most commonly used by the model and includes references for the origin of each cost.

Capital costs consist of direct and indirect costs associated with purchase and installation of wastewater treatment equipment. Primary sources for the capital costs were vendor quotes and literature references. Table 10-2 presents the unit capital costs most commonly used by the model and includes references for the origin of each cost. Typically, direct capital costs include the following:

- Purchase and installation of treatment equipment;
- Purchase and installation of piping, instrumentation, pumps, and other ancillary equipment;
- Electrical hookups;
- Any required site preparation (e.g., excavation);
- Construction of buildings or other structures.

In addition to direct capital costs, indirect costs are also included in the estimate of total capital cost. Indirect capital costs typically include engineering costs and contractor's fees.

For each technology, it is assumed that ancillary direct capital costs and required indirect capital costs can be accounted for by using a factor related to purchased and installed capital cost. Table 10-3 lists these factors for all applicable treatment technologies.

Because all facility-specific information in the questionnaire database is from 1990, all costs are adjusted to 1990 dollars. This adjustment allows direct comparison between reported financial data and costs for each facility. Costs are adjusted using the Marshall and Swift 1990 annual index (915.1) and the index value for the year in which the costs were originally reported using the following formula:

$$AC = OC(915.1/OCI) \qquad (10\text{-}1)$$

where:
AC = Adjusted cost, $
OC = Original cost, $
OCI = Original cost year index

The wage rate for all required labor to properly operate and maintain the systems associated with the technology bases was based on a weighted average, where data were obtained from two sources: (1) the U.S. National Bureau of Labor Statistics, and (2) industry supplied wage rates. In 1990, the U.S. National Bureau of Labor Statistics reported that the average wage rate for all production workers in the Drug Manufacturing industry was $12.90 per hour. This rate was then increased by 115% to account for supervision (15%), and overhead (100%) to arrive at a total rate of $27.74 per hour. This cost was assumed for the entire industry except where industry supplied wage rates. The weighted average wage rate for the entire industry was $27.89 per hour.

The cost for electricity used by various treatment technologies was obtained from two sources: (1) 1990 U.S. Department of Energy Statistics for Investor-Owned Utilities for Commercial Facilities and (2) industry supplied energy costs. The U.S. Department of Energy rate was given as $0.048 per kilowatt-hour. This cost was averaged with industry supplied costs for a rate of $0.059 per kilowatt-hour for facilities in the United States. The rate of $0.080 per kilowatt-hour for facilities in Puerto Rico was derived from an industry supplied rate.

The cost for steam usage was based on a weighted average, where data were obtained from two sources (1) Plant Design & Economics for Chemical Engineers, Peters and Timmerhaus, Fourth Edition, and (2) industry supplied steam costs. The unit cost obtained from source (1) was $3.20 per 1,000 pounds of 100 psig steam, and represents the high end of the range of costs given for 100 psig steam. This cost was assumed for the entire industry (U.S.) except where industry supplied steam costs. The weighted average steam cost for facilities in the United States was $4.20 per 1000 pounds of 100 psig steam. The steam cost of $6.91 per 1000 pounds of 100 psig steam for facilities in Puerto Rico was derived from industry supplied costs. These unit costs are listed along with other O&M unit costs in Table 10-1.

For the cost estimating effort, it was assumed that all Subcategory A and C facilities and Subcategory B and D direct discharger facilities operate 350 days per year, and that Subcategory B and D indirect discharger facilities operate 250 days per year. These assumptions are based on operating modes observed during engineering site visits. If a facility supplied the actual number

of operating days per year, this number was used. It is also assumed, because of the nature of the technology, that all biological treatment systems operate 365 days per year, regardless of subcategory.

10.3 Cost Modeling

10.3.1 Evaluation of Existing Cost Models

Before a costing methodology could be developed, existing cost models were researched and evaluated to determine which, if any, existing algorithms for costing various treatment technologies could be used to develop costs for wastewater treatment systems and treatment system upgrades in the pharmaceutical manufacturing industry. The following models were initially considered for potential use:

- The Wastewater Treatment System Design and Cost Model (WTSDCM) developed by EPA in the early 1980s for various metal manufacturing-related industries;
- The Cost of Remedial Action model (CORA);
- The Remedial Action Cost Engineering and Requirements (RACER) model;
- The Advanced System for Process Engineering (ASPEN);
- The Computer Assisted Procedure for the Design and Evaluation of wastewater Treatment systems (CAPDET); and
- The pesticide industry models developed by EPA for pesticide chemicals manufacturers and pesticide formulators, packagers, and repackagers, respectively.

The WTSDCM model was eliminated because of the lack of similarity between pharmaceutical and metal manufacturing industry wastewaters and related treatment techniques. The CORA model was also eliminated because it had been superseded by the more recently developed RACER model. The remainder of the cost models were considered further.

The RACER model was determined not to be applicable because it was designed to address remedial treatment activities associated with cleanup of contaminated sites, and not industrial wastewater treatment. ASPEN was also determined not to be applicable because, while serving as an excellent process simulation tool, it is not set up to serve the cost estimating purposes required. It also models only the steam stripping treatment technology included in the basis for the regulatory options.

The remaining models (CAPDET and the pesticide industry models) were determined to have some appropriate design and costing information, but were not configured properly to be used directly to cost the pharmaceutical manufacturing industry. Based on this conclusion, it was determined that the most effective way to model costs for the industry would be through development of a new cost model.

The resulting cost model is an integrated computer model that uses design and costing information taken from many sources, including CAPDET and the pesticides industry models. The cost model includes program files that design and cost all technologies included as bases for the regulatory options discussed in 7, and data files that include all pertinent facility data.

10.3.2 Model Driver

Because the pharmaceutical manufacturing industry cost model (hereafter referred to as the cost model) is basically a collection of computer "modules" designed to calculate costs for each of the basic technologies, it was necessary to include a program to organize the modules and track the costs for the entire industry. This program has been designated as the model "driver". The model driver performs the following major functions associated with generating industry costs for each of the regulatory options:

- Locate and open all necessary input data files;
- Store input data entered by a user of the model;
- Open and run each of the technology modules in the appropriate order;

- Track all costs and pollutant concentrations generated by the technology modules; and

- Send tracked costs by subcategory, discharge type, and regulatory option to a storage file which may be printed or maintained in electronic form.

The following sections list the major technologies included as modules within the cost model, and describe the major assumptions and costing methodology used for each.

10.3.3 Advanced Biological Treatment

Advanced biological treatment is used to control BOD_5, COD, and TSS and to degrade various organic pollutants. The biological treatment systems are designed based on COD loads, or BOD_5 and TSS loads, and desired removal efficiency. Organic pollutant reduction also occurs through well-operated biological treatment systems. The installation of extended aeration activated sludge biological treatment was assumed for cost estimating purposes for BOD_5, COD, TSS and organics. For ammonia the installation of a second stage activated sludge nitrification system was assumed for cost estimating purposes. As shown in Table 7-1, activated sludge treatment is the most common biological treatment used in the pharmaceutical manufacturing industry. All of the facilities that form the bases for the limitations based on biological treatment use activated sludge biological treatment on site.

Typically, an extended aeration activated sludge biological treatment system consists of the following major equipment:

- An equalization basin;
- An aeration basin;
- A secondary clarifier; and
- A sludge handling system, if necessary.

10.3.3.1 Overview of Costing Methodology

Facilities requiring additional treatment of BOD_5, COD, TSS, or organics were costed for installing a biological treatment system capable of removing these pollutants down to the long-term mean performance concentrations for this technology that are discussed in 8.5. If a facility had no biological treatment on site, a new treatment system was costed. If a facility had biological treatment on site, an upgrade to the existing system was costed.

Various types of upgrades were possible for a facility with existing treatment on site. If additional BOD_5, COD, or organics removal was required, an additional aeration basin was installed in parallel with the existing treatment unit. If additional TSS treatment was also required, additional clarifiers were installed in parallel with the existing clarifiers. If the costed biological treatment system, whether an upgrade or new system, was determined to generate excess biological solids, a new sludge handling system was installed. If ammonia removal was required, an additional aeration basin was installed as a second stage nitrification system with clarifiers.

10.3.3.2 Design Bases and Assumptions

The design of the aeration basin for biological treatment of BOD_5, COD, TSS and organic pollutants, and secondary clarifier are based on a combination of relationships and equations developed by Eckenfelder and from field data for suspended growth biological treatment. The design of the aeration basin for biological treatment of ammonia through nitrification are based on relationships and equations developed by Metcalf and Eddy. Costing equations were taken from CAPDET for equalization basins, package extended aeration activated sludge units (facility flows less than 0.5 MGD), full-size extended aeration activated sludge units (flows greater than 0.5 MGD), and circular secondary clarifiers.

Design equations for biological treatment systems were similar for new units and for upgrades. The following is a list of key design assumptions for costing biological treatment for pharmaceutical manufacturing facilities:

- Values for key design parameters associated with biological treatment were established based on subcategory-specific information obtained from the Detailed Questionnaire Responses. These values are listed in Table 10-3.

- The retention time for designed clarifiers is 5 hours.

- The retention time for designed equalization basins is 24 hours (if a new equalization basin is necessary).

- The sludge generated by the biological treatment unit has the following characteristics:

  - 1% solids in the sludge from the clarifier to the sludge thickener;
  - 5% solids in the sludge from the thickener to the filter press;
  - 13% solids in filter press cake; and
  - Sludge density equal to 80 lbs/ft^3.

- Generated sludge is thickened, dewatered, and hauled off site for incineration as a nonhazardous waste.

- Installation of any of the equipment associated with biological treatment will not require purchase of additional land. In response to concern about this assumption, the agency solicited information from facilities documenting the need for the purchase of additional land for upgrades to their biological treatment system. Commenters which responded to the solicitation all have the land available on-site. Therefore, this assumption has been maintained.

- One or more floating surface mixers are necessary for operation of the equalization basin. (It is assumed that 30 horsepower per million gallons are required for mixing in the equalization basin.)

- Fix-mounted surface aerators will be used for treatment of BOD_5, COD, organics, and ammonia.

10.3.3.3 Costing Methodology

Cost equations for purchase and installation of equipment associated with equalization, aeration, and secondary clarification were obtained from CAPDET. The costs for the following standard-sized equipment were also obtained from CAPDET: package aeration plant (100,000 gal/day) and

clarification tank (90-foot diameter). The following costs were obtained from vendors or costing references: chemical unit costs, excavation unit cost, reinforced concrete installation unit cost, floating surface aerator costs, fixed-mounted surface aerator costs, sludge thickening tank costs, sludge filter press costs, and sludge hauling and disposal costs. Tables 10-1 and 10-2 presents all unit costs listed above.

The following are included in the total capital cost calculated for each facility requiring biological treatment (all equipment costs include purchase and installation):

- A reinforced, concrete equalization basin (if not already existing at the facility);
- Floating surface mixers for the equalization basin, if necessary;
- A reinforced concrete aeration basin, with associated fixed-mounted surface aerators, if necessary (aeration basins are provided at facilities with no existing biological treatment, at those needing ammonia nitrification, or where existing treatment is not adequate);
- A reinforced concrete clarifier, if necessary (clarifiers are provided at facilities with no existing biological treatment, or where existing suspended solids removal is not adequate);
- Any earthwork required for site preparation prior to installing the equalization basin, aeration basin, or clarifier (earthwork includes the construction of curbs and dikes for secondary containment);
- A platform and pedestrian bridge over the aeration basin;
- Sludge thickening tank(s); and
- Filter press(es) for sludge dewatering.

Table 10-4 presents the factors that are used by the cost model to account for ancillary direct and all indirect capital costs.

The following are included in the total O&M costs calculated for each facility:

- O&M labor;
- Electricity usage;
- Chemical purchases;
- Miscellaneous O&M materials and supplies; and
- Sludge hauling and incineration.

Table 10-5 lists operation and maintenance labor hour requirements for various activities associated with biological treatment.

All operation and maintenance hour requirement calculations except those used for sludge handling were based on assumptions and equations from CAPDET. Sludge handling labor hour requirements were developed based on engineering judgement regarding the labor required for operation and maintenance of the filter press or presses.

Electricity usage was calculated using relationships provided in CAPDET. Table 10-6 presents the electricity requirement equations that are used by the cost model for each portion of the biological treatment system. Miscellaneous O&M material and supply costs are based on factors provided in CAPDET. Table 10-7 presents the operation and maintenance material and supply factors that are used by the cost model for biological treatment operations.

Table 10-1 lists unit costs for chemical purchases and sludge hauling and incineration.

10.3.4 Cyanide Destruction Treatment

There are two technologies that are used as the basis for cyanide destruction: hydrogen peroxide treatment and alkaline chlorination treatment. Hydrogen peroxide technology would be used by the majority of facilities while facilities with a potential safety hazard would be required to comply with limitations based on alkaline chlorination. Hydrogen peroxide destruction is used by Facility 30542 and represents the basis of the treatment performance data used by EPA to develop the limitation for cyanide for facilities currently using hydrogen peroxide destruction. The system designed and costed by the cost model has a greater degree of control than the system used by Facility 30542, in that laboratory analysis of treated batches of wastewater for cyanide is required

prior to discharge. This approach minimizes the potential for releases of wastewater with cyanide concentrations above the proposed limitations. Facility 30542 currently uses a qualitative field technique to measure cyanide after treatment which does not provide the same level of precision and accuracy as the EPA-approved analytical method.

Alkaline chlorination is used by Facility 30567 and represents the basis of the treatment performance data used by EPA to develop the limitation for cyanide for facilities currently using alkaline chlorination or hydrolysis technologies. The equipment designed and costed is the same as that designed and costed for hydrogen peroxide destruction.

The cyanide destruction treatment system costed for the pharmaceutical manufacturing industry includes the following equipment: four pumps (influent, effluent, sodium hydroxide, and either hydrogen peroxide or sodium hypochlorite feed pumps), five tanks (pH adjustment, reactor, either hydrogen peroxide or sodium hypochlorite feed, sodium hydroxide feed, and treated wastewater storage), two agitators (for the reactor and pH adjustment tanks), and a pre-engineered building to house the treatment unit. If the required volumes of the chemical additives were less than 5.7 gal/day, 55-gallon drums are used for storage instead of storage tanks.

10.3.4.1 Overview of Costing Methodology

Costs for in-plant cyanide destruction treatment were included for all facilities that reported the presence of cyanide in their wastewater in the Detailed Questionnaire and who discharged in 1990 cyanide concentrations above the long-term mean treatment performance concentrations provided in 8. In-plant streams are defined as cyanide-bearing wastewater streams prior to dilution with non-cyanide-bearing wastewater. Facilities that had portions of the technology bases for this treatment already on site were given credit for these elements, and therefore did not incur costs associated with a complete, new treatment system.

10.3.4.2 Design Bases and Assumptions

Cyanide destruction treatment using hydrogen peroxide is based on the reaction of cyanide with hydrogen peroxide under basic conditions to form ammonia and carbonate ions. Cyanide destruction treatment using alkaline chlorination is based on the reaction of cyanide with sodium hypochlorite under basic conditions to form sodium chloride and carbonate ions. Facilities with high organic concentrations may not be able to use hydrogen peroxide oxidation because of potential safety hazards the reaction may cause. Components that comprise the treatment system were selected based on the system used by Facility 30542. The cost estimates generated by the cost model are based on the following treatment steps:

- Collection of the wastewater in the pH adjustment tank.
- Addition of sodium hydroxide to raise the pH in the tank.
- Transfer of wastewater to the reactor vessel.
- Addition of either hydrogen peroxide or sodium hypochlorite to the reactor to treat cyanide, followed by field cyanide analysis.
- If the batch fails the field analysis, it is reacted again with either additional hydrogen peroxide or sodium hypochlorite. If it passes, the wastewater is transferred to the storage tank for laboratory analysis.
- If the batch fails laboratory analysis, it is returned to the hydrogen peroxide reaction vessel for additional treatment. If it passes, it is discharged to the end-of-pipe treatment system (if applicable).

Costs for equipment and chemicals are based on vendor information.

The following key assumptions and design bases were used to cost cyanide destruction treatment:

- There is adequate land to install the treatment unit at each facility requiring cyanide destruction;
- All equipment is sized based on in-plant flow rate reported for waste streams containing cyanide; and

- Cyanide destruction treatment is operated in a batch mode, with up to three batches treated per day.

10.3.4.3 Costing Methodology

The treatment system components were chosen based on the system used by Facility 30542. Unit costs for the following were obtained from vendors or costing reference manuals: spill containment drum pallets, pumps, tanks, agitators, earthwork for building installation, pre-engineered building purchase and installation, chemical purchases, and laboratory and field monitoring. Tables 10-1 and 10-2 present these unit costs.

The following are included in the direct capital cost calculated for each facility requiring cyanide destruction treatment:

- Tanks for pH adjustment, reaction, storage of either hydrogen peroxide or sodium hypochlorite, storage of sodium hydroxide, and storage of treated wastewater prior to discharge;
- For smaller volumes (less than 5.7 gal/day), 55-gallon drums to store chemicals used for cyanide destruction, instead of tanks (if drums are used, drum spill containment pallets are included);
- Pumps for delivering influent wastewater to the system, removing effluent from the system, delivering either hydrogen peroxide or sodium hypochlorite to the reaction tank, and delivering sodium hydroxide to the pH adjustment tank;
- Agitators in the reaction and pH adjustment tanks;
- Earthwork to prepare the site for installation of a pre-engineered building (earthwork includes the construction of curbs and dikes for spill containment); and
- A building to house the cyanide destruction treatment system.

Table 10-4 presents the factors for calculating ancillary direct and all indirect capital costs.

The following are included in the total O&M costs calculated for each facility:

- O&M labor (assumed to be 1 hour per day);
- Materials and supplies;
- Chemical purchases;
- Field monitoring for cyanide concentration;
- Laboratory monitoring for cyanide concentration; and
- Electricity usage.

Maintenance material and supply costs are calculated based on the following relationships to installed equipment costs: 1% is used for pumps, 2% is used for storage tanks, and 5% is used for reaction tanks and agitators. Maintenance of pumps is also assumed to require one hour per day of operator labor.

Field and laboratory monitoring are assumed to occur once per batch for cyanide destruction treatment. Table 10-1 lists unit costs for cyanide monitoring. Electricity costs are based on pump usage.

10.3.5 Steam Stripping

Steam stripping is used to treat organic pollutants and ammonia in wastewater. In a steam stripping column, the wastewater to be treated is introduced near the top of the column and is allowed to flow downward through the column by gravity. Steam is simultaneously introduced at the bottom of the column, and flows countercurrently to the wastewater. In steam stripping columns, organic compounds and ammonia enter the vapor phase as the steam contacts the wastewater, and are carried out of the top of the column with the steam. The column overheads are condensed from vapor to liquid. A portion of the condensed overheads are returned to the top of the column as reflux, the remaining portion is disposed of off-site. If the condensed overheads form an aqueous and organic layer, a decanter is used so that the portion returned to the column is the aqueous layer, while the portion disposed of is the organic layer. Treated wastewater exits the column from the bottom.

The following equipment is assumed to be required to perform steam stripping: stripping column, feed preheater/bottoms cooler, steam condenser, subcooler, decanter, air pollution control device, feed collection and storage tank, distillate receiver tank, feed pump, reflux pump, distillate pump, bottoms pump, spare pump, piping, and instrumentation. Multiple units may be required for any or all of the equipment listed above, due to high facility flow rates or if multiple process streams requiring steam stripping exist at a facility. The air pollution control device is costed as an acid scrubber if ammonia is present in the waste stream; otherwise it is costed as a carbon canister. Facilities may find that it is cost effective to route vents from the steam stripper unit to an existing incinerator or other air pollution control system. This approach was not costed as part of this effort because information on existing air pollution control systems was not available.

10.3.5.1 Overview of Costing Methodology

Data supplied by the pharmaceutical industry to EPA's Office of Air Quality Planning and Standards (OAQPS) were used to develop assumptions regarding facility process wastewater stream flow and load distributions. Every facility was assigned four theoretical waste streams. Relative flows and stream loads are consistent among all facilities. Stream 1 for each facility represents 44 percent of the total facility wastewater flow as reported in the Detailed Questionnaire, and it comprises 1 percent of its total pollutant load (in pounds). Stream 2 represents 9 percent of the flow, and comprises 2 percent of the total pollutant load. Stream 3 represents 19 percent of the flow, and 6 percent of the total load. Stream 4 represents 28 percent of the total flow, and contains 91 percent of the pollutant load.

Facilities were costed for steam stripping of all process wastewater streams with concentrations of regulated pollutants above the long-term mean treatment performance concentrations for the steam stripping options, provided in 8. Cost estimates are based on the installation of the technology at an in-plant location. An in-plant location is defined as prior to dilution by non-process wastewater, commingling with other process wastestreams not containing regulated pollutants at treatable levels, and any conveyance, equalization, or other treatment units which are open to the atmosphere.

Facilities were given credit for steam stripping on site if an existing column was used to treat organic pollutants in wastewater to concentrations below the long-term mean treatment performance concentrations for steam stripping. If steam stripping treatment existed on site that did not treat organics to these levels, effluent from the existing column was considered as influent to the new column to be costed. It may be possible for facilities to improve performance of existing steam stripping columns to meet the required levels. However, the facility-specific information provided in responses to the Detailed Questionnaire was not adequate to determine if this would be possible for individual cases. Therefore, new columns were costed for all facilities not meeting the long-term mean treatment performance concentrations. The modeled compliance costs for facilities able to optimize their existing steam stripping column performance will be higher than actual compliance costs.

Facilities were also given credit for steam strippers to be put in place to meet the upcoming maximum achievable control technology (MACT) standards. These strippers were assumed to be in place on streams that EPA's Office of Air Quality Planning and Standards (OAQPS) deemed cost effective. If these strippers could treat organic pollutants in wastewater to concentrations below the long-term mean treatment performance concentrations, no additional steam strippers were costed. Otherwise, steam strippers were costed to treat the effluent from the OAQPS strippers down to the long-term mean treatment performance concentrations, provided in 8.

10.3.5.2 Design Bases and Assumptions

The steam stripping systems designed and costed by the cost model are based on achieving sufficient treatment of the least strippable compound present in the process wastewater stream being treated. Strippability groups were created for the purpose of establishing the design bases for steam stripping treatment. The strippability groups contain all regulated compounds and range from most easily stripped (Group 1) to not strippable at all (Group 8). Table 10-8 lists all potentially regulated compounds by these strippability groups.

The least strippable compound is selected for a particular stream based on the following criteria:

- Only compounds with concentrations above the steam stripping long-term mean treatment performance concentration are considered;
- Only compounds in the least strippable group (excluding the nonstrippable group) of any compounds at the facility are considered; and
- Within the least strippable group, the compound with the lowest Henry's Law Constant is selected.

Design parameters for the steam stripping column are selected based on the least strippable compound and its concentration in the process wastewater to be treated. Key steam stripping design parameters are:

- K value - the volatility or equilibrium ratio for a contaminant in a vapor/liquid system at the temperature and pressure of the column.
- Number of equilibrium stages - the number of contact units in a column within which the concentration of components in the liquid phase is in equilibrium with the concentration of components in the vapor phase.
- Steam-to-feed ratio - the volume of steam required to treat a given volume of wastewater.

Table 10-9 lists the steam stripping design parameters for constituents in Groups 1 through 7 (no values are given for compounds in Group 8 because they are not considered treatable by steam stripping).

Process simulations were used to assist in establishing the cost module design basis in two ways:

1. Process simulations were used to develop process designs that would achieve the long-term steam stripping performance levels for each of the strippability groups, typical numbers of equilibrium stages and feed/steam (L/V) ratios were determined using process simulations discussed in 8 for pollutants in each of the strippability groups; and

2. Simulations were also used to help estimate a typical K value for pollutants in each strippability group.

The model scans all pollutants in each stream at each facility for strippability group and for concentration. If any regulated pollutants are above the steam stripping long-term mean treatment performance concentration and are considered strippable, then treatment is costed for the stream. EPA evaluated each of the four process desegregated streams separately; therefore, a facility might have four steam stripping systems costed. The largest allowable diameter column designed by the model is 15 feet. This limitation is based on the difficulty associated with transporting larger columns. If a column larger than 15 feet is required, multiple columns are costed.

It is assumed that facilities requiring steam stripping treatment will have adequate space within existing enclosed process buildings.

10.3.5.3 Costing Methodology

Design equations were obtained from engineering texts, ASPEN methodology, and input from design engineers. Most unit costs were obtained from algorithms found in Peters and Timmerhaus, Fourth Edition (12). Others were obtained from vendor quotes. Unit costs were included in the cost model for the following: packed and tray columns, storage tanks, condensers, decanters, subcoolers, pumps, air pollution control devices, and feed preheaters. These unit costs were developed using algorithms dependent on multiple variables, and are presented in the Pharmaceuticals Manufacturing Industry Cost Documentation Report, which can be found in the Administrative Record of this rulemaking. Table 10-10 provides the purchase costs for the smallest and largest size of each major component of the steam stripping treatment unit, as designed and costed for all pharmaceutical manufacturing facilities that responded to the Detailed Questionnaire.

These costs are for individual components only, some systems may require the installation of multiple components. Pump costs and chemical additive costs were obtained from vendor quotes. These unit costs are presented in Tables 10-1 and 10-2.

The following are included in the total capital cost calculated for each facility requiring steam stripping treatment:

- Stainless steel column(s), including either packing or trays (packing was used for columns with diameters less than 48 inches; trays were used for larger diameter columns);
- Stainless steel feed preheater(s)/bottoms cooler(s) to prepare influent wastewater for treatment and to maintain an acceptable temperature in the effluent from the column;
- Stainless steel steam condenser(s)/subcooler(s) to convert overheads from vapor to liquid;
- Decanter(s) to separate distilled organic compounds from water to be returned to the column;
- Air pollution control device(s) to remove noncondensible organics or ammonia from the vent stream;
- Stainless steel feed collection and storage tanks with capacity to 24 hours;
- Stainless steel distillate collection tank with capacity to 24 hours; and
- Pumps to deliver influent wastewater to the column, refluxed wastewater back to the column inlet, effluent bottoms to storage tank, distillate to collection tank, and sodium hydroxide to the feed storage tank if pH adjustment is necessary (pH adjustment is required for streams that contain ammonia; stripping is performed at a pH of 9 for ammonia-bearing streams).

Stainless steel components were costed because of the corrosion potential of pharmaceutical manufacturing wastewater. Hastelloy was considered as a construction material, and may be necessary on a site-specific basis. However, for the purpose of calculating industry-wide costs, stainless steel was considered the most appropriate construction material.

Table 10-4 lists the factors that are used by the model to account for ancillary direct and all indirect capital costs.

The following are included in the O&M costs calculated for each facility:

- O&M labor;
- Steam usage;
- Chilled water usage for the condenser and subcooler;
- Hydrochloric acid addition to the ammonia scrubber (if necessary) or carbon canister replacement for air pollution control;
- Sodium hydroxide addition, if pH adjustment is necessary;
- Hauling and disposing of waste hydrochloric acid (if any) and waste solvents decanted from the column overhead stream;
- Miscellaneous O&M materials and supplies (assumed to be equal to 4% of the total capital cost); and
- Electricity usage.

O&M labor requirements are based on 12 labor hours per day to properly operate and maintain the steam stripping unit. Steam usage is calculated based on the facility flow rate and the selected steam-to-feed ratio.

Hydrochloric acid usage in the ammonia scrubber is calculated based on the amount of ammonia in the overhead stream from the column. It is assumed that 20% of the ammonia removed from the waste stream will be vented to the air pollution control device, and that the mass (pounds) of hydrochloric acid required will be 2.12 times the mass of the removed ammonia. The value 2.12 is based on the reaction of hydrochloric acid with ammonia in the air pollution control device. Carbon canister usage is based on the total mass of organic compounds removed from the waste stream. Based on ASPEN simulations, it is assumed that 0.29% of the overheads from the column will be vented to the air pollution control device. Based on EPA data from air emission

studies at Superfund sites, it is assumed that 10 pounds of carbon will be required for each pound of organics removed in the air pollution control device.

Sodium hydroxide usage is calculated based on the presence of ammonia in the waste stream and the flow rate of the stream. Hauling and disposing of waste hydrochloric acid and waste solvents is based on unit costs displayed in Table 10-1. Electrical usage is calculated based on pump usage and pump horsepower.

10.3.6 Contract Hauling

Cost estimates for contract hauling of wastewater were developed for facilities with low flows. The treatment consists of storing untreated wastewater at the current end-of-pipe discharge point, and then hauling it off site for incineration. It has been determined that this approach is more cost-effective than other in-plant or end-of-pipe treatments for flows below 30 gallons per day.

The equipment required to perform this treatment depends on whether drums or a storage tank are used to store the wastewater. For drum storage, the only equipment required is the drums. If a storage tank is used, the equipment includes the tank and a discharge pump. It is assumed that for each scenario, the facility will have enough existing space for wastewater storage, requiring no additional land or facility improvement costs.

10.3.6.1 Overview of Costing Methodology

No credit was given to facilities for existing treatment on site. It was assumed that contract hauling would be performed at facilities with discharge flows below 30 gal/day and regulated pollutants at concentrations above the long-term mean treatment performance, regardless of the existing level of treatment.

10.3.6.2 Design Bases and Assumptions

The following assumptions were made for costing contract hauling:

- Facilities with zero wastewater discharge, no regulated pollutants reported, or no concentrations of regulated constituents above limitations did not incur any costs.
- Wastewater from all facilities requiring contract hauling required incineration.
- Any facility with a flow rate greater than 30 gal/day was not considered.
- The incineration facility was assumed to be 500 miles from the generating facility.

The selection of drums versus a storage tank for on site storage prior to disposal is based on the on-site storage time required to generate 5,000 gallons of wastewater. If it takes longer than 45 days to accumulate 5,000 gallons on site (approximately 110 gal/day), drums are used to store the wastewater. If it takes less than 45 days to generate 5,000 gallons, a storage tank is used instead.

Spill prevention for the drum storage system is provided by including spill prevention drum pallets for the storage area. These pallets provide a contained space beneath the drums to collect any leakage or spills.

10.3.6.3 Cost Methodology and Assumptions

Required costs for the following were obtained from vendor information: tanks, pumps, hauling, incineration, drums, and spill prevention pallets. Tables 10-1 and 10-2 present these unit costs.

The following were included in the total capital cost for each facility requiring contract hauling:

- Storage tank purchase and installation, if necessary (assumed to be an 11,000-gallon tank); and

- Discharge pump purchase and installation (assumed to be a 70-gpm pump), if necessary.

The following items are included as O&M costs for contract hauling:

- Drum purchase, if necessary;
- Spill prevention pallet purchase, if necessary;
- Electricity requirements for the pump, if necessary;
- Tank or drum area daily inspection (15 minutes per day);
- Loading and unloading of wastewater for transport;
- Transport of wastewater to the disposal facility (assumed to be 500 miles); and
- Incineration of the wastewater.

10.3.7 Compliance Monitoring

Compliance monitoring costs were calculated for all pharmaceutical manufacturing facilities that discharge wastewater. Costs represent analytical analysis costs based on which pollutants were reported in 1990 to be discharged in a facility's wastewater. Monitoring is required at the end of pipe for all regulatory options.

Costs for monitoring the discharge levels of BOD_5, COD, and TSS have not been included, as no incremental costs above those which the plants are presently incurring are anticipated. Cyanide monitoring costs are included as part of the cyanide treatment cost module and are not calculated in the monitoring module. It is assumed that no additional physical equipment is required to perform monitoring.

10.3.7.1 Overview of Costing Methodology

For purposes of estimation, facilities were costed for weekly end-of-pipe (EOP) monitoring for compounds that were reported in 1990 to be discharged in a facility's wastewater, and one annual EOP full analytical scan for all regulated pollutants. Permit writers or pretreatment authorities will determine the frequency of monitoring on a per facility basis. All facilities will be required to perform the annual EOP full analytical scan.

10.3.7.2 Cost Methodology

There are no capital items associated with compliance monitoring. The only O&M costs included for this activity are the laboratory analytical costs. It is assumed that the labor required to perform monitoring sampling is negligible compared to labor requirements already existing at each facility. It is also assumed that any materials required for monitoring are already present at the facility or are provided by the laboratory performing the analyses. All analytical cost information was provided by vendors of analytical services.

10.4 Engineering Costs by Regulatory Option

Table 10-11 presents a summary of estimated BPT, BCT, BAT, and PSES engineering costs, broken down by subcategory, discharge type, and regulatory option. Costs shown include capital and operation and maintenance (including energy usage) costs totaled for each group of applicable facilities.

It should be noted that advanced biological treatment costs are incorporated into both the BPT and BAT costs for direct dischargers. Facilities would install only one treatment system adequate to comply with both BPT and BAT limitations.

Table 10-12 presents a summary of estimated NSPS and PSNS engineering costs on an amortized yearly basis.

For NSPS and PSNS, costs were developed using the existing facility information to model potential new source facilities. NSPS and PSNS costs were developed on an annualized basis using amortized yearly costs and assuming a Subcategory A and/or C facility flow rate of 1 MGD and a subcategory B and/or D facility flowrate of 0.1 MGD.

The amortized yearly costs are equal to the sum of amortized capital costs and the yearly operation and maintenance costs. The capital costs are amortized using the following equation:

$$\text{Amortized Capital Cost (\$/yr)} = \text{Capital Cost (\$)}\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

where: I = Interest rate of .07

n = Equipment depreciation period of 16 years.

Table 10-1

Operation and Maintenance Unit Costs Used By the Cost Model

Unit Disposal Costs			
Activity	**Cost (1990 $)**	**Units**	**Reference**
Incinerate drums of liquid waste	480.10	55-gallon drum	2
Dispose of bulk wastewater	5.02	gallon	2
Incinerate solvents in bulk	280.00	ton	3,4,36
Incineration of waste HCL	280.00	ton	4
Dispose of biological treatment sludge	50.00	ton	5 (a)
Unit Hauling Costs			
Activity	**Cost (1990 $)**	**Units**	**Reference**
Haul solvents	29.02	ton	4
Haul drums/bulk wastewater	2,626.00	full load (80 drums or 5,000 gallons bulk liquid)	2
Haul biological treatment sludge	4.05	loaded mile	6
Unit Chemical Costs			
Chemical	**Cost (1990 $)**	**Units**	**Reference**
NaOH (50%)	310.00	ton	7
H_2O_2 (50%)	0.495	pound	7
NaOCL (10%)	1.17	gallon	35
Nitrogen (Ammonium Sulfate)	0.013	pound	7
Phosphorous (Phosphoric Acid)	0.199	pound	7
Hydrochloric acid	395.77 - 482.65	drum (500 lbs)	8
Polymer	2.25	pound	9
Miscellaneous Unit Costs			
Item	**Cost (1990 $)**	**Units**	**Reference**
O&M labor rate	27.89	hour	10, 37
Electricity usage fee (US/PR)	0.059/0.080	kilowatt-hour	11, 37
Steam (US/PR)	4.20/6.91	1000 lbs	12, 37

Table 10-1 (Continued)

Miscellaneous Unit Costs			
Item	**Cost (1990 $)**	**Units**	**Reference**
Sample fee (for off-site disposal)	322.22	per load of wastewater	2
Drum purchase	43.66	drum	13
Field cyanide analysis	0.50	per sample	14
Laboratory cyanide analysis	27.50	per sample	15

(a) Unit cost was calculated by taking the median of costs reported by pharmaceutical manufacturing facilities for disposing of similar wastes.

Table 10-2

Capital Unit Costs Used by the Cost Model

Construction Unit Costs			
Activity	**Cost (1990 $)**	**Units**	**Reference**
Excavation	4.81	cubic yard	16
Concrete wall installation	547.69	cubic yard	17
Concrete slab installation	120.51	cubic yard	18
Prefabricated building installation	19.51	square foot of floor space	18
Impermeable, double liner installation	3.58	square foot	19
Crane rental	98.15	hour	20
Handrail installation	46.91	linear foot	21
Purchased, Installed Treatment Equipment Unit Cost			
Item	**Cost (1990 $)**	**Standard Size**	**Reference**
Package biological treatment plant	67,944	100,000 gal/day	22
Clarifier	139,610	90 ft diameter	22
Filtration unit	307,143	784 ft^2 of filter surface area	22
Fix-mounted surface aerator	33,080	20 HP	22
Pump station pump (large applications)	32,110	3,000 gpm	22
Filter press (1 ft^3 to 20 ft^3)	6,119 to 30,992	per press	23
Sludge Thickening Tank (100 gal to 500,000 gal)	1,270 to 79,062	per tank	24
Miscellaneous Unit Capital Costs			
Activity/Item	**Cost (1990 $)**	**Units/Standard Size**	**Reference**
Drum pallet (spill preventative)	338.64	4-drum pallet	25
Monitoring well installation	4,444	per well	26

Table 10-2 (Continued)

Miscellaneous Unit Capital Costs			
Activity/Item	**Cost (1990 $)**	**Units/Standard Size**	**Reference**
Groundwater background concentration determination	114,868	per acre of polishing pond	27
Unit Capital Costs Using Curves or Ranges			
Item/Activity	**Range/Equation**	**Units**	**Reference**
Small pumps (3 - 27 gpm)	Cost = 45.705 (Q) + 615.24 (Q= flow in gpm)	per pump	27
Larger pumps (50 - 900 gpm)	Cost= 6.09 (Q) + 2,485 (Q = flow in gpm)	per pump	23
Carbon steel tanks (11,000 to 150,600 gal)	Cost = 0.1935(V) + 8814 (V = volume in gallons)	per tank	28
Floating aerators (20 HP to 100 HP)	11,698 to 42,662	per aerator	29
Package filtration unit (SA < 400 ft^2)	Cost = $60{,}034(SA)^{0.3203}$ (SA = filter surface area in square feet)	per filter unit	22
Reaction vessel agitator (0.25 to 5.0 HP)	1,210 to 2,614	per agitator	30

Table 10-3

Constants and Values Used to Model Biological Treatment

Parameter	Subcategory A and C Value	Subcategory B and D Value	Units
Temperature	24.56	24.56	°C
Synthesis oxygen coefficient	1.05	1.05	lb O_2/lb BOD_5
Influent VSS/TSS ratio	0.65	0.65	NA
Nondegradable influent VSS	0.70	0.70	NA
Clarifier hydraulic loading	400	400	gal/day/ft^2
Clarifier solids loading	20	20	lb/day/ft^2
Clarifier polymer addition	1.5	1.5	mg/L
Field oxygen transfer	3.0	3.0	lb/HP-hr
Substrate removal rate constant (K)	11.14	2.06	NA
Synthesis yield coefficient	0.36	0.78	NA
Endogenous decay rate constant	0.0	0.0	NA
BOD_5 associated with effluent TSS	0.23	0.24	mg/mg
COD removed to BOD_5 removed ratio	0.615	0.52	NA

NA - Not applicable.
Source: Mean values based on information provided in the Detailed Questionnaire.

Table 10-4

Factors Used To Calculate Indirect and Ancillary Direct Capital Costs As a Percentage of Total Purchased and Installed Capital Cost

Technology	Factor (%)	Reference
Equalization	5	22
Package aeration (flow ≤ 0.5 MGD)	11	22
Full-size aeration (flow > 0.5 MGD)	11	22
Clarification	18	22
Cyanide destruction	35	31
Steam stripping	62.5	12

Table 10-5

Operation and Maintenance Labor Hour Calculations for Biological Treatment

Activity	Type of Labor	Minimum hours (per year)	Equation(s) for calculating hours per year
Package aeration	Operation	1200	$1683\ (FLOW)^{0.1469}$
	Maintenance	640	$1143\ (FLOW)^{0.2519}$
Full-size aeration	Operation	NA	$242.4\ (TICA)^{0.3731}$ (TICA < 200) $100\ (TICA)^{0.5425}$ (TICA $\geq$ 200)
	Maintenance	NA	$106.3\ (TICA)^{0.4031}$ (TICA < 100) $42.6\ (TICA)^{0.5956}$ (TICA $\geq$ 100)
Clarification	Operation	350	$37.1(SA)^{0.3247}$ (1,000 $\leq$ SA $\leq$ 3,000) $4.0\ (SA)^{0.6020}$ (SA > 3,000)
	Maintenance	200	$30.3\ (SA)^{0.2733}$ (1,000 $\leq$ SA $\leq$ 3,000) $2.05\ (SA)^{0.6098}$ (SA > 3,000)
Sludge Handling	Operation	NA	1 hour per batch per press for presses < 6 ft^3 2 hours per batch per press for presses between 6 ft^3 and 12 ft^3 3 hours per batch per press for presses larger than 12 ft^3 The maximum number of operation hours per day at any one facility is 27.
	Maintenance	NA	2 hours per year per press

FLOW - Facility end-of-pipe wastewater treatment flow (MGD).
TICA - Total installed capacity of aeration (horsepower).
SA - Clarifier surface area (ft^2).
NA - Not applicable.

Table 10-6

Electricity Requirement Equations for Biological Treatment

Activity	Electricity Usage Equation (a)
Package aeration	75,000 (FLOW)
Full-scale aeration	6701.4 (TICA) (b)
Clarification	7500 (SA $\leq$ 1670) 2183.3 $(SA)^{0.1663}$ (1670 < SA $\leq$ 16,700) 38.4 $(SA)^{0.5818}$ (SA > 16,700)
Sludge Handling	None

(a) All equations yield values in kilowatt-hours.
(b) This equation represents operating aerators 90% of the time, every day, year-round.
FLOW - Facility flowrate (MGD).
TICA - Total installed capacity of aeration (horsepower).
SA - Clarifier surface area (ft^2).

Table 10-7

Operation and Maintenance Material and Supply Cost Factors for Biological Treatment

Activity	Miscellaneous O&M Cost
Package aeration	$1.74\ (FLOW)^{-0.2497}$
Full-size aeration	4.225 - 0.975log (TICA)
Clarification	1 percent of total clarification purchased and installed equipment costs

FLOW - Facility flowrate (MGD)
TICA - Total installed capacity of aeration (horsepower)

Table 10-8
Steam Stripping Strippability Groups for All Regulated Compounds

Compound	Strippability Group	Compound	Strippability Group
n-Heptane	1	Acetone	5
n-Hexane	1	Amyl alcohol	5
Benzene	3	2-Butanone (MEK)	5
Chlorobenzene	3	tert-Butyl alcohol	5
Chloroform	3	N,N-Dimethylaniline	5
o-Dichlorobenzene	3	Formamide	5
1,2-Dichloroethane	3	Isopropanol	5
Isopropyl Ether	3	Methyl Formate	5
Methyl Cellosolve	3	MIBK	5
Methylene Chloride	3	Ethanol	6
Toluene	3	n-Propanol	6
Xylenes	3	Aniline	7
Ammonia	4	n-Butyl alcohol	7
n-Amyl Acetate	4	1,4-Dioxane	7
n-Butyl Acetate	4	Pyridine	7
Diethylamine	4	Methanol (Methyl alcohol)	7
Ethyl Acetate	4	Petroleum naphtha	7
Isobutyraldehyde	4	Acetonitrile	8
Isopropyl Acetate	4	N,N-Dimethylacetamide	8
Tetrahydrofuran	4	N,N-Dimethylformamide	8
Triethylamine	4	Dimethyl sulfoxide	8
		Ethylene glycol	8
		Formaldehyde	8
		Phenol	8
		Polyethylene glycol 600	8

Table 10-9

Steam Stripping Design Parameters Established by Strippability Group

Strippability Group	Concentration of Least Strippable Contaminant	K Value	Number of Equilibrium Stages	Feed-to- Steam Ratio
1	ALL	10,219	4	12.0
2	ALL	1874.2	4	12.0
3	ALL	400	6	12.0
4	< 2,000	44.5	8	12.0
	> 2,000	44.5	10	12.0
5	≤ 1,000	21.6	10	12.3
	1,000 < conc. ≤ 5,000	21.6	14	12.9
	5,000 < conc. ≤ 10,000	21.6	14	12.1
	10,000 < conc. ≤ 50,000	21.6	14	10.9
	> 50,000	21.6	14	9.7
6	< 1,000	11.5	14	12.0
	1,000 < conc. ≤ 5,000	11.5	14	8.8
	5,000 < conc. ≤ 10,000	11.5	14	7.9
	> 10,000	11.5	14	6.8
7	< 5,000	7.8	14	7.8
	5,000 < conc. ≤ 10,000	7.8	14	6.3
	10,000 < conc. ≤ 20,000	7.8	14	5.5
	20,000 < conc. ≤ 30,000	7.8	14	5.1
	> 30,000	7.8	14	4.6
8	NA	NA	NA	NA

conc. - Concentration in mg/L.
ALL - Compounds in Groups 1, 2, and 3 are considered very strippable; therefore, all expected influent concentrations can be treated to limitations using the design criteria listed.
NA - Compounds in Group 8 are not considered strippable; therefore, no design parameters are listed.

Table 10-10

Purchase Cost Range for the Major Component of the Steam Stripping Treatment Unit

Component	Smallest Unit		Largest Unit	
	Cost	Size	Cost	Size
Packed Column	$17,552	Diameter = 10 in.	$141,724	Diameter = 32 in.
Tray Column	$67,710	Diameter = 14 in.	$208,528	Diameter = 35 in.
Condenser and Subcooler	$4,430	Surface area = 52 ft^2	$34,439	Surface area = 1,327 ft^2
Decanter	$1,763	Volume = 8.2 ft^3	$8,284	Volume = 210.3 ft^3
Acid Scrubber	$16,507	Diameter = 10 in.	$16,507	Diameter = 10 in.
Feed Preheater	$3,583	Surface area = 21.4 ft^2	$24,245	Surface area = 900 ft^2

Table 10-11

Summary of BPT, BCT, BAT, and PSES Engineering Costs

Regulation	Option	Subcategory A and C Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)	Subcategory B and D Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)
BPT	No Revision (MACT Only)	Current Treatment Technology	0	0	Current Treatment Technology	0	0
	Clarify cyanide, revise COD only	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	2,422,401	1,825,252	Advanced Biology Treatment Withdraw Cyanide	1,785,771	966,863
	Clarify cyanide and revise BOD, TSS, & COD	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	2,402,354	1,936,759	Advanced Biology Treatment Withdraw Cyanide	3,318,455	1,226,850
	Clarify cyanide and revise BOD, TSS, & COD	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	2,878,502	2,292,158	Advanced Biology Treatment Withdraw Cyanide	3,839,905	1,400,438
BCT	No Revision	Current BPT	0	0	Current BPT	0	0
	Revise BOD & TSS	Advanced Biological Treatment	2,402,354	1,936,759	Advanced Biological Treatment	3,318,455	1,226,850
	Revise BOD & TSS	Advanced Biological Treatment and Effluent Filtration	9,572,354	2,896,759	Advanced Biological Treatment and Effluent Filtration	5,689,455	1,461,850
	Revise BOD & TSS	Advanced Biological Treatment and Polishing Pond	25,072,354	16,436,759	--	--	--
	Revise BOD & TSS	Advanced Biological Treatment and Effluent Filtration Polishing Pond	31,872,354	19,036,759	--	--	--
BAT	Revise COD to BPT Limits and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	0	0	Advanced Biological Treatment and Withdraw Cyanide	0	0
	Add Organics Only, Revise COD to BPT Limits and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	1,440,154*	1,775,563*	Advanced Biological Treatment and Withdraw Cyanide	887,021*	248,325*
	Add Organics and Ammonia, Revise COD to BPT Limits, and Clarify Cyanide	Advanced Biological Treatment with Nitrification, and Clarify Cyanide	5,569,135	2,423,725	***Ammonia limits do not apply for B/D facilities***	NA	NA

Table 10-11 (Continued)

Regulation	Option	Subcategory A and C Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)	Subcategory B and D Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)
PSES	No Revision (MACT Only) and Clarify Cyanide	Current Treatment Technology and revised monitoring requirements for Cyanide	0	0	Current Treatment Technology and Withdraw Cyanide	0	0
	Organics Only and Withdraw Cyanide	***This option was not considered for A/C facilities***	NA	NA	In-Plant Steam Stripping for Organic Compounds and Withdraw Cyanide	17,880,239	4,643,632
	Organics and Ammonia, and Clarify Cyanide	In-Plant Steam Stripping for Organic Compounds and Ammonia (and revised monitoring requirements for Cyanide (nitrificationing be used for ammonia))	80,864,749	28,597,243	***Ammonia and Cyanide limits do not apply for B/D facilities***	NA	NA
	Organics and Ammonia and Revise Cyanide	In-Plant Steam Stripping for Organic Compounds and ammonia and in-plant cyanide destruction (nitrification may be used for ammonia)	81,192,219	28,839,569	***Ammonia and cyanide limits do not apply for B/D facilities***	NA	NA

* Costs for this option were calculated based on the list of pollutants considered for regulation, rather than the list selected for regulation. Actual costs would be slightly less due to reduced monitoring requirements.

Table 10-12

Summary of NSPS and PSNS Engineering Costs

Regulation	Option	Subcategory A and C Facilities	Annualized Cost ($/yr)	Costs at Set Flowrate (MGD)	Subcategory B and D Facilities	Annualized Cost ($/yr)	Costs at Set Flowrate (MGD)
NSPS	Revise Equal to Promulgated Level of BPT/BAT	Advanced Biological Treatment with Nitrification, and Revised Monitoring Requirements for Cyanide	$225,189	1	Advanced Biological Treatment	$70,218	0.1
PSNS	Revise Equal to Promulgated PSES Limits	PSES Treatment Technology	$1,620,852	1	PSES Treatment Technology	$306,300	0.1

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SECTION 11

REGULATORY OPTIONS SELECTION

11.1 Introduction

This presents the final selected regulatory options for the pharmaceutical manufacturing industry and discusses the factors considered in determining the selected options for BPT, BAT, NSPS, PSES, and PSNS. Factors considered included: reduction in pollutant discharges to the environment, costs to the industry, age of the equipment and facilities involved, the manufacturing processes used, process changes required, nonwater quality environmental impacts, engineering aspects of the control technologies, and energy requirements.

The regulatory options selected provide the technology basis of the effluent limitations guidelines and standards presented in Sections 13 (BPT), 15 (BAT), 16 (NSPS), and 17 (PSES and PSNS). Selection of the BCT option is determined by the BCT cost test analysis, which is discussed in 14. Owners or operators of facilities subject to these regulations would not be required to use the specific wastewater treatment technologies selected by EPA to establish the limitations and standards. Rather, a facility could choose to use any combination of process changes, water use changes, and wastewater treatment to comply with the limitations and standards provided that the limitations and standards are not achieved through prohibited dilution.

Sections 11.2 through 11.6 provide an overview of the regulatory options considered, the options selected as the bases of the final regulation, and the rationale for options selected under BPT, BAT, NSPS, PSES, and PSNS, respectively.

11.2 BPT

Effluent limitations guidelines based on the best practicable control technology currently available apply to direct discharges and are generally based on the average of the best existing performance, in terms of treated effluent discharged by facilities in a subcategory. BPT focuses on end-of-pipe

treatment technology and such process changes and internal controls that are common industry practice. Based on 304(b)(1)(B) of the CWA, the factors considered in assessing BPT include:

- The cost of achieving effluent reductions in relation to the effluent reduction benefits;
- The age of equipment and facilities involved;
- The process used;
- Process changes required;
- Engineering aspects of the control technologies;
- Nonwater quality environmental impacts (including energy requirements); and
- Other factors the Administrator deems appropriate.

The Agency is not changing the current BPT effluent limitations set for pH in the November 17, 1976 interim final regulation for the pharmaceutical manufacturing industry.

Table 11-1 lists the BPT regulatory options considered by the Agency as discussed in 7.3.2.

EPA has determined to revise BPT effluent limitations only for COD for Subcategories A, B, C, and D. EPA is also clarifying the compliance monitoring requirements for the existing BPT limitations for cyanide for Subcategories A and C, and withdrawing the existing cyanide limitations for Subcategories B and D. By revising BPT (and BAT) for COD, plants will not only remove large amounts of COD, but also achieve significant incidental removals of BOD_5 and TSS. For this reason, EPA has determined that it is not necessary to separately revise the BPT limits for BOD_5 and TSS in this case.

EPA has determined to revise BPT for COD because the biological treatment technology used as a basis for the limitations really represents BPT technology and is widely used in the industry. 31

of 38 direct discharging pharmaceutical manufacturing facilities currently use on-site activated sludge biological treatment as part of their wastewater treatment systems.

The bulk parameter and nonconventional pollutant COD is an indicator of organic matter in the wastestream that is susceptible to strong oxidation, and as such would also contain much of the BOD_5 that would be measured. In addition, limited studies and discharge monitoring data have identified toxicity associated with the COD levels contained in effluents from pharmaceutical manufacturing facilities.

With regard to cyanide, EPA is retaining the existing BPT limitations for the A and C subcategories. EPA did not revised the BPT cyanide limitations because the removal achievable by the limitations was estimated to be less than 38 pounds per year and was deemed to be not significant in relation to the annualized costs.

However, EPA is modifying the requirements for compliance monitoring (for Subcategories A and C). The current limitations require compliance monitoring after cyanide treatment and before dilution with other wastestreams, or in the alternative, monitoring after mixing with other wastestreams based on a standard dilution factor. The modified monitoring requirements do not change the prohibition on dilution to meet the effluent limitations for cyanide. Monitoring for compliance with the existing limitations is required in-plant, prior to the commingling of cyanide-bearing wastestreams with non-cyanide-bearing wastestreams for those facilities where the cyanide levels would be below the level of detection at the end-of-pipe monitoring location. The only change in the monitoring requirements is to eliminate the current dilution standard that applied industry-wide, and to allow individual facilities to demonstrate that end-of-pipe monitoring for cyanide is feasible (*i.e.*, cyanide is detectable once dilution effects are accounted for); those facilities may continue to monitor at the end-of-pipe. EPA is withdrawing the cyanide limitations for Subcategories B and D, as cyanide is not used or generated in these subcategories.

11.3 BAT

Effluent limitations guidelines based on the best available technology economically achievable represent the best existing economically achievable performance of plants in the industrial subcategory. The CWA establishes BAT as the principal national means of controlling the direct discharge of priority pollutants and nonconventional pollutants to waters of the United States. Based on 304(b)(2)(B) of the CWA, the factors considered in assessing BAT include:

- The age of equipment and facilities involved;
- The process used;
- Process changes required;
- Engineering aspects of control technologies;
- The cost of achieving effluent reduction;
- Nonwater quality environmental impacts (including energy requirements); and
- Other factors the Administrator deems appropriate.

The Agency retains considerable discretion in assigning the weight to be accorded these factors. BAT may include process changes or internal controls, even when these technologies are not common industry practice.

Table 11-1 lists the BAT regulatory options considered by the Agency as discussed in 7.3.4. Analysis of the impacts of these options in terms of reduction in pollutant discharges to the environment, costs to industry, and nonwater quality environmental impacts (including energy impacts) are described in 9, 10, and 12, respectively.

For Subcategories A and C, EPA evaluated the costs and economic impacts associated with each option and determined that all the options were economically achievable. After considering the pollutant load removals, the costs, as well as the non-water quality environmental impacts

associated with the options, EPA selected the third option which adds effluent limitations for 30 organic pollutants, ammonia and COD and clarifies the cyanide monitoring requirements. EPA believes that this option is economically achievable and there are no significant adverse non-water quality impacts associated with it. In addition, EPA believes the discharge loadings of ammonia, COD and the organic pollutants are significant from Subcategory A and C facilities, and that limitations on these discharges are appropriate. EPA has also evaluated the technology bases of the final BAT limitations in the context of the BAT statutory factors, *i.e.*, the age of equipment and facilities involved, the process(es) employed, potential process changes and non-water quality impacts such as energy requirements. EPA believes the final BAT limitations are appropriate based on its assessment of these factors in relation to A and C subcategory facilities.

For Subcategories B and D, EPA has identified only the pollutant COD for control by BAT limitations based on advanced biological treatment (the technology selected as the basis for the BPT limitations). As discussed under BPT, cyanide is not a pollutant of concern for Subcategory B and D operations and EPA is withdrawing the current BAT cyanide limitations for facilities with subcategories B and D operations. EPA also has determined that ammonia is not a pollutant of concern for these subcategories since ammonia is not found in significant amounts in wastewaters from these operations.

EPA has evaluated the discharge loadings of organic pollutants from Subcategory B and D facilities and has determined that 95 percent of the discharge of organic pollutants is from two facilities. Most direct discharging Subcategory B and D facilities do not discharge any organic pollutants. EPA believes these organic pollutant discharges are not sufficient to justify national regulations for these subcategories. If permit writers determine the need to further control the organic pollutants from the two facilities, the appropriate limits contained in the Subcategory A and C BAT regulations may be used. EPA has selected the first option, which is to only add the BPT revised COD limitations to BAT for Subcategory B and D facilities, and to withdraw the existing cyanide limitations.

11.4 NSPS

The basis for new source performance standards under 306 of the CWA is the best available demonstrated technology. Industry has the opportunity to design and install the best and most efficient pharmaceutical manufacturing processes and wastewater treatment systems at new plants. Accordingly, Congress directed EPA to consider the best demonstrated alternative processes, process changes, in-plant control measures, and end-of-pipe wastewater treatment technologies that reduce pollution to the maximum extent feasible. In response to that directive, and as with the development of options for the BAT effluent limitations guidelines, EPA considered effluent reductions attainable by the most advanced and demonstrated process and treatment technologies at pharmaceutical manufacturing facilities.

The general approach followed by the Agency for developing NSPS options was, where appropriate, to evaluate the best demonstrated processes for control of priority and nonconventional pollutants at the process level and best demonstrated end-of-pipe treatment for control of conventional pollutants and additional control of certain nonconventional pollutants. The factors considered in assessing NSPS include:

- The demonstration status of the process and wastewater treatment technologies;
- The cost of achieving effluent reductions;
- Nonwater quality environmental impacts; and
- Energy requirements.

For Subcategories A, B, C, and D, EPA evaluated technology options capable of achieving greater pollutant removal of conventional pollutants (BOD_5 and TSS), COD, organics, cyanide and ammonia than the selected bases for existing source limitations (BPT, BCT, and BAT). The only option potentially capable of achieving additional removals involves the use of granular activated carbon (GAC) adsorption technology. This technology is capable of reducing the COD

from some direct discharging A and C subcategory facilities. However, there is only limited GAC performance data available, from one pilot study.

Therefore, EPA is promulgating NSPS equal to the final BAT effluent limitations for organic pollutants, cyanide, and ammonia. EPA is also promulgating revised NSPS for BOD_5, COD and TSS for all four subcategories at a level equal to the discharge characteristics of the best performing BPT plants. For COD this is equivalent to the BAT/BPT level of control. These final standards are based on the best available demonstrated control technologies, which include advanced biological treatment for all four subcategories, and cyanide destruction and nitrification for Subcategories A and C. In developing these final standards, the Agency considered factors including the cost of achieving effluent reductions, non-water quality environmental impacts, and energy requirements. EPA finds that the final standards represent the best available demonstrated control technologies, are economically achievable and have acceptable non-water quality environmental impacts.

11.5 PSES

Pretreatment standards for existing sources are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. The CWA requires pretreatment for pollutants that interfere with or pass through POTWs in amounts that would exceed direct discharge effluent limitations or limit POTW sludge management alternatives, including the beneficial use of sludges on agricultural lands. The Agency is also requiring pretreatment for pollutants that pass through POTWs due to the pollutant exhibiting significant volatilization prior to treatment by a POTW. The transfer of a pollutant to another media (air) through volatilization does not constitute treatment. PSES are to be technology-based and analogous to BAT for removal of priority and nonconventional pollutants.

Table 11-1 lists the PSES regulatory options considered by the Agency as discussed in 7.3.6.

For Subcategory A and C facilities, due to the low pollutant removals achievable by the revised cyanide standards (approximately 1,000 lbs. Per year with 97 percent of the removals coming from one facility) in relation to the compliance costs, EPA has decided not to revise the existing cyanide standards, and has selected the option to add organics and ammonia only and modify the current cyanide monitoring requirements. The selected option adds standards for ammonia and the 23 organic pollutants determined to pass through (see 17), and modifies the monitoring point for the current cyanide pretreatment standards for Subcategories A and C.

EPA is setting pretreatment standards for ammonia for Subcategories A and C because of the high loads of ammonia currently being discharged by a number of pharmaceutical facilities to POTWs that do not have nitrification capability and receive wastewaters from Subcategory A and C facilities. However, EPA is aware that some POTWs treating pharmaceutical wastewaters from these subcategories have nitrification capability, and EPA has made a determination of no pass through for ammonia at these POTWs. Thus, PSES ammonia limitations will not apply to Subcategory A and C facilities discharging to POTWs with nitrification capability.

The pollutants regulated under the selected PSES option of Subcategories A and C have been determined to pass through and the pollutant removals are high with respect to the compliance costs. The costs for this option are economically achievable and the nonwater quality environmental impacts are acceptable.

For PSES for Subcategories B and D, EPA has selected the second option (organics only and withdraw cyanide). EPA is basing this selection on the fact that the five pollutants regulated under this option have been determined to pass through, and the pollutant removals are high with respect to the compliance costs. EPA has decided to withdraw the existing cyanide standards, since cyanide is not present in wastewaters for these subcategory facilities. The costs for this option are economically achievable, and the nonwater quality environmental impacts are acceptable.

11.6 PSNS

Pretreatment standards for new sources are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. The CWA requires pretreatment for pollutants that pass through POTWs or limit POTW sludge management alternatives, including the beneficial use of sludges on agricultural lands.

The development of regulatory options for PSNS is analogous to the development of options for NSPS, in that the new source has the opportunity to design and install the best and most efficient pharmaceutical manufacturing processes and wastewater treatment facilities. Accordingly, Congress directed EPA to consider the best demonstrated alternative processes, process changes, in-plant control measures, and end-of-pipe wastewater treatment technologies that reduce pollution to the maximum extent feasible. In response to that directive, EPA considered effluent reductions attainable by the most advanced and demonstrated process and treatment technologies at pharmaceutical manufacturing facilities. The factors considered in assessing PSNS include:

- The demonstration status of the process and wastewater treatment technologies;
- The cost of achieving effluent reductions;
- Nonwater quality environmental impacts; and
- Energy requirements.

EPA selected PSNS limits equal to PSES for Subcategories A, B, C, D. EPA was unable to identify a technology that would achieve greater removal of the pollutants to be controlled by the PSES being promulgated and is therefore promulgating PSNS equal to PSES for all four Subcategories.

Table 11-1

Summary of BPT, BAT, and PSES Regulatory Options

Regulation	Option Name	Technology Basis	
		Subcategory A and C Facilities	**Subcategory B and D Facilities**
BPT	No Revision (MACT Only)	Current Treatment Technology	Current Treatment Technology and Withdraw Cyanide
	Clarify Cyanide, Revise COD Only	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Clarify Cyanide, Revise BOD_5 and TSS Only	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Clarify Cyanide and Revise BOD_5, TSS, & COD	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
BAT	Revise COD to BPT Limits and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Add Organics Only, Revise COD to BPT Limits, and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	Advanced Biological Treatment and Withdraw Cyanide
	Add Organics and Ammonia, Revise COD to BPT Limits, and Clarify Cyanide	Advanced Biological Treatment with Nitrification, and Revised Monitoring Requirements for Cyanide	*Ammonia and cyanide limits do not apply for B/D facilities*
PSES	No Revision (MACT Only) and Clarify Cyanide	Current Treatment Technology and Revised Monitoring Requirements for Cyanide	Current Treatment Technology and Withdraw Cyanide
	Organics Only and Withdraw Cyanide	*This option was not considered for A/C Facilities*	In-Plant Steam Stripping for Organic Compounds and Withdraw Cyanide
	Organics and Ammonia, and Clarify Cyanide	In-Plant Steam Stripping for Organic Compounds and Ammonia, and Revised Monitoring Requirements for Cyanide (Nitrification may be used for Ammonia)	*Ammonia and Cyanide limits do not apply for B/D Facilities*
	Organics and Ammonia, and Revise Cyanide	In-Plant Steam Stripping for Organic Compounds and Ammonia, and In-Plant Cyanide Destruction (Nitrification may be used for Ammonia)	*Ammonia and Cyanide limits do not apply for B/D Facilities*

SECTION 12

NONWATER QUALITY ENVIRONMENTAL IMPACTS

12.1 Introduction

Sections 304(b) and 306 of the CWA require EPA to consider the nonwater quality environmental impacts associated with effluent limitations guidelines and standards. In accordance with these requirements, EPA has considered the potential effect of the final regulatory options for the pharmaceutical manufacturing industry on energy consumption, air emissions, and solid waste generation. Sections 12.2, 12.3, and 12.4, respectively, discuss these nonwater quality environmental impacts. The Agency's development of air emission standards is discussed in 12.5.

12.2 Energy Impacts

Energy impacts to the pharmaceutical manufacturing industry from the final regulatory options will include increased electrical usage and increased energy usage in the generation of steam for steam stripping. These energy impacts are discussed below in Sections 12.2.1 and 12.2.2.

12.2.1 Electrical Usage

According to the Department of Energy, the pharmaceutical manufacturing industry purchased approximately $5{,}404 \times 10^6$ kWh of electrical energy in 1990, accounting for 0.7% of the total U.S. industrial electrical energy purchase ($756{,}646 \times 10^6$ kWh) in 1990.(1) The Agency evaluated the annual incremental increase in electrical power consumption expected under each regulatory option for direct dischargers. These estimated annual incremental increases (in kWh) are shown in Table 12-1.

For Subcategory A and C operations, the Agency is promulgating the second BPT Option (clarify CN and revise COD only) and the third BAT Option (Add Organics and Ammonia). Taken

together, these options would increase the electrical power consumption by less than 0.1 percent of the total electrical power purchased in 1990 by the pharmaceutical manufacturing industry.

For Subcategory B and D operations, the Agency is promulgating the second BPT Option (clarify CN and revise COD only) and the first BAT Option (No revision). Taken together these options would increase the electrical power consumption by less than 0.02 percent of the total electrical power purchased in 1990 by the industry.

For indirect dischargers regulated under PSES, changes in electrical energy consumption are shown in Table 12-2.

For Subcategory A and C operations, the Agency is promulgating the third PSES Option (add Organics and Ammonia, and clarify CN) and would increase the electrical power consumption by less than 0.1 percent of the total electrical power purchased in 1990 by the industry. For Subcategory B and D operations, the Agency is promulgating the second PSES Option (add Organics and withdraw CN) and would increase the electrical power consumption by less than 0.01 percent of the total electrical power purchased in 1990 by the industry.

12.2.2 Energy Usage in the Generation of Steam

Of greater impact is the energy usage required to generate steam under the regulatory options that include steam stripping. Steam stripping is part of PSES options considered for Subcategory A and C indirect dischargers and Subcategory B and D indirect dischargers. The impacts of steam usage under BAT and BPT options are negligible. The Agency evaluated the annual incremental increase in energy usage from steam generation expected under each of the PSES options. These estimated annual incremental increases (in kWh/yr) are shown in Table 12-3.

According to the Department of Energy (1), the pharmaceutical manufacturing industry purchased approximately $6{,}953 \times 10^6$ kWh of fuel and electric energy in 1990. For Subcategory A and/or C operations at indirect dischargers, the Agency is promulgating the third PSES Option (Add Organics and Ammonia, and clarify CN) which would increase the energy consumption for steam

generation by about 7 percent of the total fuel and electrical power purchased in 1990. For Subcategory B and/or D operations at indirect dischargers, the Agency is promulgating the second PSES Option (Add Organics and withdraw CN) which would increase the energy consumption for steam generation by an amount less than one percent of the total fuel and electrical power purchased in 1990.

It should be noted that since proposal, EPA has modified its steam stripping module to incorporate a revised approach for determining stream characteristics, resulting in a better estimation of the energy consumption for steam generation associated with steam stripping options. At proposal, EPA assumed from the detailed questionnaire responses that wastewater streams containing high concentrations of volatile organic pollutants could not be segregated from streams containing minimal or no concentrations of these pollutants. The Agency has since revised its methodology to distribute the process wastewater flow and load according to the disaggregation approach used in the MACT Standards, which assumes that pharmaceutical process wastewaters can be represented by four streams. Using this disaggregation approach has provided a better estimate of the volume of wastewater that is subject to steam stripping, and, therefore, a better estimate of the energy demand related to steam usage.

Table 12-4 summarizes the estimated increase in energy usage (including electrical power and steam generation) associated with the final regulations. Compliance with the final regulations is estimated to increase the industry's energy usage by approximately 7.6 percent. While the steam generation required under the final regulations requires increased energy consumption, the Agency notes that the potential for solvent recovery and reuse will help to offset these energy expenditures. The Agency concludes that the effluent reduction benefits from the final regulation exceed the potential adverse impacts from the increase in energy consumption that is projected.

12.3 Air Emission Impacts

Pharmaceutical manufacturing facilities generate wastewaters that contain varying concentrations of organic compounds, some of which are listed as Hazardous Air Pollutants (HAPs) in Title 3 of the Clean Air Act Amendments (CAAA) of 1990. Table 12-5 lists the HAPs and volatile organic

pollutants present in pharmaceutical manufacturing wastewaters, as reported by facilities responding to the Detailed Questionnaire (volatile organic pollutants were identified as those constituents that could be analyzed by standard EPA methods for volatile organics such as gas chromatography mass spectrometry (GCMS) by analytical method 1624 (40 CFR Part 136) or GC by analytical method 8015.(2)). Prior to discharge, pharmaceutical manufacturing wastewaters typically pass through a series of collection and treatment units that are open to the atmosphere. Atmospheric exposure of organic-containing wastewaters can result in significant volatilization of HAPs, volatile organic pollutants, and other organic pollutants to the air.

Air emissions of HAPs, volatile organic pollutants, and other organic pollutants may occur from wastewater collection units such as process drains, manholes, trenches, sumps, and junction boxes, and from wastewater treatment units such as neutralization and equalization basins, settling basins, clarifiers, biological treatment units, air and steam strippers lacking air pollution control devices, and other units that expose wastewater to the air.

To determine the impact of the final regulation on air emissions, the Agency had to first determine the current amount of organic constituents emitted into the air from pharmaceutical manufacturing wastewaters. 12.3.1 describes the air emissions estimated by facilities responding to the Detailed Questionnaire. 12.3.2 discusses the regulatory impact on air emissions based on a comparison of current air emissions from pharmaceutical manufacturing wastewaters to projected air emissions from pharmaceutical manufacturing wastewaters of facilities complying with the final regulation.

This also discusses the estimated impact on criteria pollutant emissions in the generation of steam for regulatory options which include steam stripping.

12.3.1 Current Air Emissions Based on Detailed Questionnaire Responses

In response to 3a of the Detailed Questionnaire, entitled "Compound or Chemical Usage and Disposition," facilities estimated the quantities of virgin chemicals used and disposed of during manufacturing of pharmaceutical products in calendar year 1990. As part of the chemical usage

and disposition reporting, facilities were asked to estimate the amount of virgin chemicals used in pharmaceutical manufacturing operations that were: 1) emitted into the air from wastewater prior to discharge, 2) degraded and/or destroyed, and 3) discharged to a surface water and/or a POTW. These three disposition methods summarize the fate, or disposal pathways, of organic constituents present in pharmaceutical manufacturing wastewaters. Overall, a total of 8.5 million pounds of organic pollutants were reported as emitted into the air in 1990 from pharmaceutical manufacturing wastewaters based on summarized Detailed Questionnaire responses.

Upon examining responses to the Detailed Questionnaire regarding the fate of wastewater organic constituents, the Agency suspected that a greater percentage of wastewater organic constituents are emitted to the air than most facilities reported. The Agency noted that several indirect dischargers that had no on-site wastewater treatment systems reported a large percentage of wastewater organic constituents degraded and/or destroyed on site. It is improbable that such high rates of degradation and/or destruction could be achieved in the absence of any wastewater treatment system, such as biological treatment or incineration. In addition, some plants with open impoundments or basins with mechanical agitators or aerators, reported relatively small percentages of air emissions from wastewater in Table 3-2 of the Detailed Questionnaire. The responses to the Detailed Questionnaire also lacked in most cases an indication of the estimation method used in determining the load discharged as air emissions from wastewater.

Because of these deficiencies in the Detailed Questionnaire responses, EPA believes that the industry reported data provides a minimum estimate of air emissions. The Agency believes that the actual amount of air emissions from pharmaceutical manufacturing wastewaters is greater than the total described above.

12.3.2 Regulatory Impact on Air Emissions

Air emissions from pharmaceutical manufacturing facilities will be controlled by the MACT Standards and the effluent limitations guidelines and standards described in this document. For indirect dischargers, these regulations share the common technology basis of in-plant steam stripping.

The use of in-plant steam stripping as part of the Agency's promulgated regulatory options will impact air emissions in two ways. First, priority and nonconventional pollutants that are currently released as air emissions from wastewater at pharmaceutical manufacturing facilities will be removed and condensed by in-plant steam stripping for recycle, reuse, or disposal. Second, the generation of steam for steam stripping will result in increased emissions of criteria pollutants (CO, NO_x, VOC, SO_2, and particulate matter). A brief description of the regulatory impact of the MACT standards is provided in 12.3.2.1, and EPA's evaluation of these air emission impacts are described in Sections 12.3.2.2 and 12.3.2.3 below.

12.3.2.1 Regulatory Impact of the MACT Standards on Air Emissions

The MACT Standards that are being promulgated in conjunction with these effluent standards will control HAP emissions from wastewater treatment and wastewater collection devices at major source pharmaceutical plants using steam stripping as the reference control technology. The final MACT Standards for the pharmaceutical industry will reduce emissions of many of the HAPs listed in 112(b)(1) of the CAAA. The alternatives considered in the development of this regulation, including those alternatives selected as standards for new and existing sources, are based on process and emissions data received from the existing facilities known by EPA to be in operation. The major HAPs emitted by facilities covered by the MACT standards include methylene chloride, methanol, toluene, and hydrogen chloride. The significant reductions in HAP emissions required by the final MACT standards will also result in incidental reductions in nonHAP air emissions because many nonHAPs are found in the same wastewater streams as the HAPs, and thus will be steam stripped along with the HAPs. Further description of the reduction in air emissions resulting from the promulgated MACT Standards is provided in the next section.

12.3.2.2 Reduction in Air Emissions Due to Promulgated Effluent Standards

As discussed in 11, the Agency is promulgating effluent limitations guidelines and standards for ammonia and organic pollutants based on the following in-plant and end-of-pipe treatment technologies, as shown in Table 12-6.

For Subcategory A and/or C direct and indirect dischargers, there are significant air emissions which the MACT controls are designed to address. As a result of the application of these MACT controls, the load of VOCs to POTWs from pharmaceutical manufacturing plants would be reduced by approximately 48 percent. The Agency estimates that these MACT strippers will provide HAP and nonHAP load removals, as shown in Table 12-7.

For Subcategory A and/or C direct dischargers, the BAT treatment technology (advanced biological treatment plus ammonia nitrification) applied at the end-of-pipe location will result in the removal of some additional HAP and nonHAP load. In addition, for Subcategory A and/or C and Subcategory B and/or D indirect dischargers, the PSES treatment technology (in-plant steam stripping) applied to streams that are not already controlled by the application of MACT wastewater strippers will also result in the removal of additional HAP and nonHAP load. Some of this load may also have been air emissions from wastewater. The Agency estimates that the wastewater strippers costed to achieve compliance with the options beyond no revision put forward by the Office of Water will provide HAP and nonHAP load removals, as shown in Table 12-8.

12.3.2.3 Criteria Pollutant Air Emissions

EPA evaluated the impact of steam generation requirements, under regulatory options that include in-plant steam stripping, on criteria pollutant emissions. To develop this estimate, total steam generation requirements were estimated using the pharmaceutical cost model and it was assumed that the steam would be generated in industrial boilers with no emission controls. Ninety-five percent of the required boiler fuel is assumed to be natural gas and the remaining 5% supplied by low sulfur Number 6 fuel oil.(3) The calculation of criteria pollutant air emissions is presented in the calculation package entitled Calculation of Air Emissions Related to Steam Generation, dated May 19, 1998.(4) Table 12-9 presents an estimate of the resultant criteria pollutant emissions.

For those PSES options selected as the basis of regulation (organics and ammonia, clarify cyanide for A/C indirects; organics only, withdraw cyanide for B/D indirects), the resultant criteria

pollutant emission total is 308 tons/yr or 0.62 x 10^6 lbs/yr. The Agency concludes that the air emission and effluent reduction benefits of hazardous air pollutants, priority, nonconventional, and conventional pollutants outweigh the potential negative impacts of increased emissions of criteria air pollutants.

12.4 Solid Waste Impacts

The Agency has evaluated the following solid waste impacts which would be expected due to the application of the final BPT, BCT, BAT, and PSES effluent limitations guidelines and standards:

- The increase in dry sludge generation due to the application of advanced biological treatment;
- The increase in waste solvent generation due to the application of in-plant steam stripping; and
- The increase in waste hydrogen chloride (HCl) due to scrubber liquor generated by facilities with wastewaters containing ammonia.

These impacts are discussed below in Sections 12.4.1, 12.4.2, and 12.4.4, respectively. 12.4.3 presents an overview of EPA's waste minimization and combustion strategy including EPA's approach for clean fuels.

12.4.1 Dry Sludge Generation

Based on the responses to the Detailed Questionnaire, pharmaceutical manufacturers generated approximately 112,000 tons of dry sludge in 1990. Table 12-10 presents the amount of sludge (dry basis) generated in 1990 by Subcategory A and/or C and Subcategory B and/or D direct and indirect dischargers as well as the estimated amount of additional dry sludge that would be generated by Subcategory A and/or C and Subcategory B and/or D direct and indirect dischargers facilities complying with the final effluent limitations guidelines. On an industry-wide basis, some sludge generated may be hazardous because it may contain hazardous constituents. For purposes of estimating compliance costs, all sludge generated was assumed to require disposal as hazardous

waste, so that the cost of such disposal was accounted for where it was required. Not all facilities actually generate sludge that is considered hazardous, so the cost of sludge disposal may be overestimated for these facilities.

Compliance with BPT/BCT is expected to increase the mass of wastewater treatment sludge generated by Subcategory A and/or C direct dischargers by 343 tons/yr, a result of increased solids generation and removal at facilities upgrading to advanced biological treatment systems. This represents approximately a 1% increase in the current sludge generation rate of 36,400 tons/yr for Subcategory A and/or C direct dischargers.

Compliance with BPT/BCT is expected to increase the mass of wastewater treatment sludge generated by Subcategory B and/or D direct dischargers by 194 tons/yr, a result of increased solids generation and removal at facilities upgrading to advanced biological treatment systems. This represents less than a 7% increase in the current sludge generation rate of 2,760 tons/yr for Subcategory B and/or D direct dischargers.

Compliance with BAT is expected to increase the mass of wastewater treatment sludge generated by Subcategory A and/or C direct dischargers by 308 tons/yr, a result of increased solids generation and removal at facilities upgrading to advanced biological treatment systems including nitrification. This represents approximately a one percent increase in the current sludge generation rate of 36,400 tons/yr for Subcategory A and/or C direct dischargers.

BAT is not being revised for Subcategory B and/or D direct dischargers and therefore will not increase the mass of wastewater treatment sludge generated.

Compliance with BAT/BPT/BCT is anticipated to improve the quality of wastewater treatment sludge by reducing mass loadings of pollutants exported in sludge through conversion to organic material. The Agency concludes that there will be no adverse non-water quality environment impacts regarding sludge management.

No additional sludge is expected to be generated by facilities that discharge indirectly as a result of the final regulations.

12.4.2 Waste Solvent Generation

Compliance with PSES for Subcategory A and/or C and Subcategory B and/or D indirect dischargers is expected to increase the amount of waste solvents generated by pharmaceutical manufacturing facilities as a result of in-plant steam stripping. The amount of waste solvents recovered as a result of steam stripping by Subcategory A and/or C and Subcategory B and/or D indirect dischargers would be approximately 10,600 and 3,310 tons/yr, respectively. As discussed previously, the use of in-plant steam stripping would remove a significant amount of organic pollutants from the wastewater prior to atmospheric exposure of the wastewater and the subsequent emission of pollutants into the air.

Organic solvent overheads generated under the promulgated PSES options will create the opportunity for additional solvent recovery or reuse in the pharmaceutical manufacturing industry. For example, the Agency is aware of at least one pharmaceutical manufacturer that is currently distilling methanol from a process wastewater stream and recycling the concentrated methanol overheads back into their process operation. The Agency is also aware of at least two other pharmaceutical manufacturers that steam strip their process wastewaters and sell the solvent overheads for profit. Where possible, facilities would be expected to recover solvents for reuse within the process or for use in other industrial processes.

The solvent overheads will also have a value associated with their energy content. The Agency has estimated that the energy value of the solvent overheads generated under the promulgated options will be 14.3 million kWhr/yr for Subcategory A and/or C indirect dischargers and 4.4 million kWh/yr for Subcategory B and/or D indirect dischargers.

12.4.3 Waste Minimization and Combustion Strategy

In May 1994, the EPA Administrator announced a Draft Hazardous Waste Minimization and Combustion Strategy that is pertinent to the pharmaceutical manufacturing industry. The Draft Strategy provides the central framework for EPA's federal effort to maximize the source reduction and recycling of hazardous wastes under RCRA. The Draft Strategy focuses on a number of specific goals, including reducing the amount and toxicity of hazardous waste that is generated, particularly when such reductions would benefit more than one environmental medium. The Draft Strategy also encompasses a number of other features, including public outreach, public involvement and environmental justice, permitting, enforcement, risk assessments, and good science.(5)

In April 1996, EPA proposed Revised Standards for Hazardous Waste Combustors (61 FR 17358). In June 1998, the Revised Standards for Hazardous Waste Combustors Final Rule - Part 1 was published. This final rule addresses four elements of the April 1996 proposal: RCRA comparable fuel exclusion; permit modifications for hazardous waste combustion units; notification of intent to comply; and waste minimization and pollution prevention criteria for compliance extensions.

12.4.3.1 Waste Minimization

The Draft Strategy has both short-term and a longer-term phases. In the short-term, EPA will address the source reduction and environmentally sound recycling of halogenated (and metal-bearing) combustible wastes. The longer-term effort will encompass all RCRA hazardous wastes, taking a more comprehensive approach to how wastes are generated and managed, and the role waste minimization can play as a preferred "mode of management" over other forms of waste management (e.g., treatment, storage, and disposal). This source reduction (waste minimization) strategy should reduce the long-term demand for combustion and other waste management facilities.(6) 7.2 presents EPA's efforts toward increasing opportunities for source reduction (e.g., process changes) in the pharmaceutical manufacturing industry.

The Agency also has released a draft report by the EPA Office of Solid Waste's Definition of Solid Waste Task Force. This report, Reengineering RCRA for Recycling(6), presents recommendations of the Task Force to improve the regulation of hazardous waste recycling under RCRA. One of the recommendations of the Task Force was that provision should be made to exempt "clean" waste-derived fuels from the regulatory requirements of RCRA for hazardous wastes. "Clean fuels" are fuels with "*de minimis*" levels of halogens (primarily chlorine in this case) or toxic metals, especially fuels that are characteristically hazardous only because of ignitability.

Under the final rule, EPA is excluding from the regulatory definition of solid waste, hazardous waste-derived fuels that meet specification levels comparable to fossil fuels for concentrations of hazardous constituents and for physical properties that affect burning. Specific waste codes that EPA expects to contain only those constituents for which the final rule sets maximum allowable concentrations include ignitable solvent wastes (F003 and F005). All wastes consisting primarily of alcohols, petroleum distillates, oils, or other ignitable organic liquids are the most likely candidates for applying to this rule.

In the case of the pharmaceutical manufacturing industry, the volatile organic pollutants that are generated in the largest quantities are non-halogenated volatile organic pollutants, including methanol, toluene, xylene, and acetone. In the final rule methanol, xylene, and acetone are listed V wastes with no corresponding constituent limit in regards to the RCRA comparable fuel exclusion. Implementation of in-plant steam stripping technology affords the opportunity to recover these pollutants and reuse them for their solvent properties. In situations where reuse of solvents is not practical, these non-halogenated pollutants can potentially be used as comparable fuel as defined in the Final Revised Standards for Hazardous Waste Combusters.

Implementation of in-plant steam stripping also affords the opportunity to recover halogenated volatile organic pollutants (e.g., methylene chloride) for recycle in the pharmaceutical manufacturing process. Recovered chlorinated solvents that are not of sufficient quality for reuse in pharmaceutical manufacturing processes may be sold for reuse in other industries.

12.4.3.2 Combustion

The Draft Strategy also addresses rigorous controls on hazardous waste combustion facilities using best available technologies to ensure that these facilities do not impose unacceptable risk to human health and the environment. EPA's regulatory activities are scheduled to be directed toward upgrading technical standards for residual wastes and emissions from hazardous waste combustion facilities, including incinerators, cement kilns, light-weight aggregate kilns, and smelter furnaces, as well as boilers and industrial furnaces.

EPA estimates that approximately 13,900 tons per year or 12,600 metric tons per year of solvent waste (halogenated and nonhalogenated) would be recovered from in-plant steam stripping at pharmaceutical manufacturing facilities. Currently there is RCRA-permitted capacity at commercially available facilities to incinerate in excess of 1 million metric tons per year of solvents. Therefore, there is adequate capacity at commercial incinerators to combust the entire mass of solvents assuming that none would be recovered and recycled. Again, however, it is the Agency's policy that the most appropriate mode of management for solvents removed from pharmaceutical manufacturing wastewaters by steam stripping is recycle in the process, recycle at other facilities, or use as comparable fuels.

12.4.4 Waste Hydrogen Chloride Scrubber Liquor

Compliance with PSES for Subcategory A and/or C indirect dischargers is expected to increase the amount of waste hydrogen chloride (HCl) scrubber liquor recovered by pharmaceutical manufacturing facilities that generate wastewaters containing ammonia. HCl wet scrubbers are used to control air emissions from steam strippers used to remove ammonia from the wastewater. The amount of waste scrubber liquor generated by Subcategory A and/or C indirect dischargers from the regulation of ammonia and organics, would be approximately 283 tons/yr.

12.5 Development of Air Emission Standards

Title III of the 1990 Clean Air Act Amendments was enacted to reduce the amount of nationwide emissions of hazardous air pollutants. It comprehensively amended 112 of the Clean Air Act (CAA).

112(b) lists the 189 chemicals, compounds, or groups of chemicals deemed by Congress to be hazardous air pollutants (HAPs). These toxic air pollutants are to be regulated by national emission standards for hazardous air pollutants (NESHAP). 112(c) requires the Administrator to use this list of HAPs to develop and publish a list of source categories for which NESHAP will be developed. EPA must list all known categories and subcategories of "major sources."

The term major source is defined in paragraph 112(a)(1) to mean any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit, considering controls, in the aggregate 10 tons per year (tons/yr) or more of any HAP or 25 tons/yr or more of any combination of HAPs. The term stationary source, from 111 of the CAA, means any building, structure, facility, or installation that emits or may emit any air pollutant. The term area source, as defined in 112(a)(2), means any stationary source of HAPs that is not a major source.

Notice of the initial list of categories of major and area sources of HAPs was published on July 16, 1992 (57 FR 31576), under authority of 112(c). This notice listed pharmaceutical manufacturing as a category of major sources of HAPs. Notice of the schedule for the promulgation of emission standards for the listed categories, under authority of 112(e), was given on December 3, 1993 (58 FR 63941). Under this notice, emission standards for the pharmaceutical production industry would be promulgated no later than November 15, 1997. This promulgation deadline has been extended to July 1998.

112(d) of the CAA directs the Administrator to promulgate emission standards for each category of HAP sources listed under 112(c). Such standards are applicable to both new and existing sources and must require the maximum degree of reduction in emissions of the hazardous air

pollutants subject to this (including a prohibition on such emissions, where achievable) that the Administrator, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements, determines is achievable for new and existing sources in the category or subcategory to which such emission standard applies. See 42 U.S.C. 7412(d)(2).

112(d)(3) provides that the maximum degree of reduction in emissions that is deemed achievable for new sources shall not be any less stringent than the emission control that is achieved in practice by the best controlled similar source. For existing sources, the standards may not be less stringent than the average emission limitation achieved by the best performing 12 percent of existing sources in each category of 30 or more sources.

Once this minimum control level (referred to as the floor) has been determined for new or existing sources for a category, the Administrator must set a standard based on maximum achievable control technology (MACT) that is no less stringent than the floor. The Administrator may set MACT standards that are more stringent that the floor if such standards are achievable considering the cost, environmental, and other impacts listed in 112(d)(2). Such standards must then be met by all sources within the category.

EPA is finalizing the MACT standard for pharmaceutical facilities concurrently with the effluent limitations guidelines and standards for this industry. The MACT standards will require the control of several different emission points, including storage tanks, equipment leaks, vents, and organic air emissions from wastewater operations. The area of overlap between the OAQPS Pharmaceutical MACT and the pharmaceutical effluent guidelines is process wastewater from manufacturing operations.

The control approach that EPA OAQPS is promulgating for the pharmaceutical manufacturing industry wastewater emissions source consists first of identifying a subset of wastewater streams that require control through a combination of wastewater flow rate and concentration action levels, and second, the control requirements for these affected streams. Table 12-11 summarizes the wastewater flow rate and concentration action levels and the control requirements for these

affected streams. The flow rate and concentration of each wastewater stream are then determined to reflect the characteristics at the point of determination (POD) of the wastewater stream.

The point of determination is defined to be where each individual wastewater stream exits production process equipment (defined after the last collection device) prior to any form of wastewater treatment. The characteristics of a wastewater stream at the point of determination are used to determine which streams to control because this is where the organic concentration is the highest and the flow is the lowest. The use of the point of determination in this way results in the identification of the most cost effective streams for control. If the characteristics of the streams were determined at some point downstream of the point of determination, there would be losses of organics due to air emissions and an increase in the wastewater flow rate due to mixing with other wastewater streams, both of which would result in the subsequent control of the stream being less cost effective. In addition, if wastewater treatment were allowed before the point of determination, the treatment unit, such as an air stripper, would not be required to have air emission control.

The concentration action level is based on the "volatile organic" concentration of the wastewater stream rather than the total concentration. EPA has developed a test method, Method 305 in Appendix A of 40 CFR Part 63, to determine the volatile organic HAP concentration for use with wastewater MACT standards. The purpose of this test method is to determine a relative measure of the emission potential of a typically controlled wastewater stream by measuring essentially all of an organic HAP compound that is likely to be emitted in significant quantities while measuring essentially none of an organic HAP compound that is unlikely to be emitted.

The control requirements for affected wastewater streams include managing the identified wastewater streams in controlled units during collection and treatment to remove or destroy the organics. This control approach includes: 1) suppression or control of air emissions from the point of wastewater determination to the treatment device by installing controls on the sewer system, tanks, and containers used to transport the wastewater; 2) treatment of the wastewater to remove or destroy the organics; 3) control of air emissions from the treatment device (e.g., the non-condensible air emissions from the stripper condenser); and 4) control or recycling of the

organics removed by the treatment device (e.g., the condensed residuals collected by the stripper condenser).

The treatment device used as the basis for control of air emissions from the pharmaceutical manufacturing industry is the steam stripper. The pharmaceutical manufacturing industry requirements are performance standards, so that any device that achieves the desired performance can be used. In addition, the regulation allows several compliance alternatives including the use of open biological treatment units to treat the wastewater if a controlled (*i.e.*, covered) collection and treatment system is used up to the unit and the biological treatment (*e.g.*, aeration basin) unit can be demonstrated to achieve the required level of biological degradation. The regulation requires the use of the procedures outlined in Appendix C of 40 CFR Part 63 to demonstrate that the organics are being degraded by the biological treatment unit and not emitted to the air.

The CAA also requires EPA to establish Control Techniques Guideline (CTG) documents for the states to use to develop volatile organic pollutant emissions control plans for ozone nonattainment areas. Industrial wastewater, which includes the pharmaceutical manufacturing industry, is one of the source categories for which EPA is developing a CTG document (see the draft document entitled "Control of Volatile Organic Compound Emissions from Industrial Wastewater," EPA-453/D-92-056, September 1992; available in the record). Based on this guidance, certain states will write rules for volatile organic pollutant emissions from wastewater operations at pharmaceutical facilities located in ozone nonattainment areas. These rules are expected to be similar to the MACT standards, except they would control additional wastewater streams based on their potential for volatile organic pollutant emissions rather than HAP emissions. The concentration action level used in the draft CTG is based on the volatile organic concentration, which is determined by Method 25D in Appendix A of 40 CFR part 60.

Table 12-1

Estimated Annual Electrical Energy Consumption for Direct Increase Dischargers

Option	Increase in Electrical Energy Consumption (kWh/yr)	
	Subcategory A and C Direct Dischargers	Subcategory B and D Direct Dischargers
BPT No Revision and Clarify CN	NA	NA
BPT Clarify CN, Revise COD Only	2,110,000	1,070,000
BPT Clarify CN, Revise BOD_5 and TSS Only	274,000	4,090,000
BPT Clarify CN and Revise BOD_5, TSS and COD	2,150,000	261,000
BAT Revise COD to BPT Limits and Clarify CN	NA	NA
BAT Add Organics Only, Revise COD to BPT Limits, and Clarify CN	1,100,000	242,000
BAT Add Organics and Ammonia, Revise COD to BPT Limits, and Clarify CN	3,770,000	NA

Table 12-2

Estimated Annual Electrical Energy Consumption Increase for Indirect Dischargers

PSES Options	Increase in Electrical Energy Consumption (kWh/yr)	
	Subcategory A and C Indirect Dischargers	Subcategory B and D Indirect Dischargers
No Revision and Clarify CN	NA	NA
Add Organics and Withdraw CN	NA	0.459×10^6
Add Organics and Ammonia, and Clarify CN	5.94×10^6	NA
Add Organics and Ammonia, and Revise CN	5.94×10^6	NA

Table 12-3

Estimated Annual Energy Demand Related to Steam Usage Increase for Indirect Dischargers

PSES Options	Increase in Energy Demand Related to Steam Usage (kWh/yr)	
	Subcategory A and C Indirect Dischargers	Subcategory B and D Indirect Dischargers
No Revision and Clarify CN	NA	NA
Add Organics and Withdraw CN	NA	58.8×10^6
Add Organics and Ammonia, and Clarify CN	454×10^6	NA
Add Organics and Ammonia, and Revise CN	454×10^6	NA

Table 12-4

Regulatory Impact on Energy Usage

Facility Subcategories	Regulation	Source of Increased Energy Usage	Amount of Increase in Energy Usage (1×10^6 kWh)
Subcategory A and C Direct Dischargers	BPT	Advanced Biological Treatment	2.11
Subcategory B and D Direct Dischargers	BPT	Advanced Biological Treatment	1.07
Subcategory A and C Direct Dischargers	BAT	Advanced Biological Treatment with nitrification	3.77
Subcategory A and C Indirect Dischargers	PSES	In-plant Steam Stripping + Steam Usage	460
Subcategory B and D Indirect Dischargers	PSES	In-plant Steam Stripping + Steam Usage	59
		Total	526

Table 12-5

HAPs and Volatile Organic Pollutants Present in Pharmaceutical Manufacturing Wastewaters

HAPs		Volatile Organic Pollutants	
Const. Code	**Chemical Name**	**Const. Code**	**Chemical Name**
3	Acetonitrile	3	Acetonitrile
12	Aniline	10	n-Amyl acetate
15	Benzene	11	Amyl alcohol
22	Bis(chloromethyl)ether	15	Benzene
25	2-Butanone (MEK)	25	2-Butanone (MEK)
35	Chlorobenzene	26	n-Butyl acetate
37	Chloroform	27	n-Butyl alcohol
39	Chloromethane	29	tert-Butyl alcohol
62	N,N-Dimethylaniline	35	Chlorobenzene
64	N,N-Dimethylformamide	37	Chloroform
67	1,4-Dioxane	39	Chloromethane
77	Ethylene glycol	43	Cyclohexane
79	Formaldehyde	51	1,2-Dichloroethane
83	Glycol ethers	58	Diethyl ether
87	n-Hexane	66	Dimethyl sulfoxide
97	Methanol (Methyl alcohol)	67	1,4-Dioxane
102	Methylene chloride	70	Ethanol
105	Methyl isobutyl ketone (MIBK)	71	Ethyl acetate
114	Phenol	77	Ethylene glycol
130	Toluene	84	n-Heptane
136	Triethylamine	87	n-Hexane
139	Xylenes	94	Isopropanol
		97	Methanol
		101	Methyl cellosolve
		102	Methylene chloride
		103	Methyl formate

Table 12-5 (Continued)

HAPs		Volatile Organic Pollutants	
Const. Code	**Chemical Name**	**Const. Code**	**Chemical Name**
		105	Methyl isobutyl ketone (MIBK)
		117	n-Propanol
		118	Acetone
		130	Toluene
		134	Trichlorofluoromethane
		139	Xylenes

Table 12-6

Treatment Technologies Selected as the Bases of Regulations

Subcategory	BAT Treatment Technologies for Organic Pollutants	PSES Treatment Technologies for Organic Pollutants
A and C	End-of-pipe advanced biological treatment with Nitrification	Compliance with MACT Standards and In-Plant steam stripping for organic compounds and Ammonia.
B and D	No additional control required	Compliance with MACT Standards and In-Plant steam stripping for organic compounds.

Table 12-7

Estimated HAP and nonHAP Load Removals for MACT Wastewater Strippers

Subcategory	Discharge Status	HAP and nonHAP Load Removals for MACT Wastewater Strippers (lbs/yr)
A and C	Direct	14.1×10^6
A and C	Indirect	41.4×10^6
B and D	Direct	0
B and D	Indirect	0

Table 12-8

Estimated HAP and nonHAP Load Removals for PSES Options Based on Steam Stripping

Subcategory	Discharge Status	HAP and NonHAP Load Removals for PSES Options Based on Steam Stripping
A and C (a)	Indirect	10.7×10^6
B and D	Indirect	3.3×10^6

(a) For Subcategories A and C the PSES option includes regulation of ammonia.

Table 12-9

Increase in Criteria Pollutant Emissions from Steam Generation (tons/year)

Criteria Pollutant	Subcategory A and C Indirects	Subcategory B and D Indirects
	Add Organics and Ammonia	Add Organics
CO	38	5
NO_x	164	21
VOC	6	1
SO_2	47	6
PM	18	2
Total	273	35

Source: Reference 4.

Table 12-10

Regulatory Impact on Solid Waste Generation

	Subcategory A and C Direct Dischargers	Subcategory B and D Direct Dischargers	Subcategory A and C Indirect Dischargers	Subcategory B and D Indirect Dischargers
Current dry sludge generated (tons/yr)	36,400	2,760	68,500	4,630
BPT/BCT Increase in dry sludge generation (tons/yr)	343	194	--	--
BAT Increase in dry sludge generation (tons/yr)	308	--	--	--
PSES Increase in waste solvent generation (tons/yr)	--	--	10,600	3,310
PSES Increase in waste HCl generation (tons/yr)	--	--	283	--

-- = No impact on solid waste generation

Table 12-11

Summary of MACT Standards for New and Existing Sources of Process Wastewater

Emission Source	New or Existing?	Applicability Requirement	Cutoff	Control Efficiency
Wastewater	New and Existing	>1 Mg/yr total HAP load from all POD within a process or any single POD	1,300 ppmw at POD of partially soluble HAPs	99% reduction of partially soluble HAPs
			5,200 ppmw at POD of total HAP load	99% reduction of partially soluble HAPs 90% reduction of soluble HAPs 95% reduction of total HAP using biotreatment
		>1 Mg/yr total HAP load from facility	10,000 ppmw at POD of total HAP load	99% reduction of partially soluble HAPs 90% reduction of soluble HAPs 95% reduction of total HAP using biotreatment
	New	>1 Mg/yr total HAP load from all POD within a process or any single POD	110,000 ppmw at POD of soluble HAPs	99% reduction of soluble HAPs

POD: Point of determination

REFERENCES

1. U.S. Department of Commerce. 1990 Annual Survey of Manufacturers, Statistics for Industry Groups and Industries. M90(AS)-1, March 1992.

2. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition, may 1991.

3. U.S. Department of Energy. Annual Energy Review 1996. DOE Report No. DOE/EIA-0384(96).

4. Calculation of Air Emissions Related to Steam Generation. Prepared by R. Sieber, Radian Corporation. December 15, 1994. Updated May 19, 1998.

5. U.S. EPA. Draft Hazardous Waste Minimization and Combustion Strategy. EPA Report No. 530-D-94-002, U.S. Environmental Protection Agency, Washington, D.C., May 1994.

6. U.S. EPA, Office of Solid Waste. Reengineering RCRA for Recycling. U.S. Environmental Protection Agency, Washington, D.C., April 22, 1994.

SECTION 13

BEST PRACTICABLE CONTROL TECHNOLOGY (BPT)

13.1 Introduction

Effluent limitations guidelines based on the best practicable control technology currently available establish quantitative limits on the direct discharge of pollutants from existing industrial point sources. BPT effluent limitations guidelines are based upon the average of the best existing performance, in terms of treated effluent discharged by facilities of various sizes, ages, and unit processes within a category or subcategory. BPT effluent limitations guidelines most commonly focus on the control of conventional and nonconventional pollutants, but can also control priority pollutants, such as cyanide.

BPT effluent limitations guidelines are based upon the performance of specific technologies, but do not require the use of any specific technology. BPT effluent limitations guidelines are applied to individual facilities through NPDES permits issued by EPA or authorized states under Section 402 of the CWA. The facility then chooses its own approach to comply with its permit limitations.

In developing BPT, the Agency considered the total cost of applying the technologies in relation to the effluent reduction benefits achieved from the technologies; the size and age of equipment and facilities; the processes used; the engineering aspects of applying various types of control techniques; process changes; and nonwater quality environmental impacts, including energy requirements.

The BPT effluent limitations are based on advanced biological treatment for Subcategories A, B C, and D, as discussed in Section 11.

The following information is discussed in this section:

- Section 13.2 reviews the subcategories and the pollutants to be regulated by BPT and presents the final BPT effluent limitations guidelines; and
- Section 13.3 discusses BPT effluent limitations guidelines implementation with regard to NPDES permits, point of application, and monitoring and compliance issues.

13.2 Summary of the BPT Effluent Limitations Guidelines

13.2.1 Regulated Subcategories

BPT effluent limitations guidelines, as discussed in Section 7.3, are for Subcategories A, B, C, and D direct dischargers. As discussed in Section 4.3, Subcategories A, B, and C include wastewater discharges resulting from the manufacture of pharmaceuticals by fermentation, biological or natural extraction processes, and chemical synthesis processes, respectively. Subcategory D includes wastewater discharges resulting from mixing, compounding, and formulating of pharmaceutical products.

13.2.2 Regulated Pollutants

Since the BPT guidelines were last revised in 1983, there have been significant improvements in secondary treatment. Therefore, it is appropriate to revise the BPT limitations to reflect the best practicable control technology currently available.

The BPT effluent limitations guidelines revise COD effluent limitations for Subcategories A, B, C, and D. Raw wastewaters from pharmaceutical facilities are characterized by high COD concentrations. EPA found a correlation between effluent COD and aquatic toxicity in the 1987 pilot-plant carbon study which was conducted on pharmaceutical industry wastewaters. Also, COD loads can deplete oxygen levels in the water resulting in adverse health effects in fish, including mortality, and reduction in biological diversity. EPA previously promulgated COD

limits of minimum 74% removal, however, facilities can meet this limitation while still discharging effluents with high COD levels.(3)

Under the revised BPT COD regulations, facilities must comply with the new COD concentration limitations, promulgated with this rulemaking, or the 74% reduction of COD, whichever is more stringent.

The revised BPT in this rulemaking clarifies existing in-plant cyanide limitations for Subcategory A and C facilities. Compliance monitoring for cyanide should occur immediately after cyanide destruction, before commingling cyanide-bearing wastestreams with non-cyanide-bearing wastestreams, unless a facility can demonstrate that cyanide is detectable at end-of-pipe. The 1983 cyanide limitations for Subcategory B and D direct dischargers are being withdrawn; these subcategories do not use or generate cyanide.

The BPT effluent limitations guidelines for BOD_5 and TSS have not been revised, however, revision of the BPT effluent limitations guidelines for COD will achieve incidental removals of BOD_5 and TSS. However, the incidental removal of TSS is expected to be significantly less than the incidental removal of BOD_5 as a result of the new COD limitations. The BOD_5 effluent limitations, expressed as mass loading, require a minimum 90% reduction in the long-term average daily BOD_5 load of the raw (untreated) process wastewater, multiplied by a variability factor of 3.0. The effluent limitation for TSS, expressed as a mass loading, must be calculated as 1.7 times the BOD_5 limitation. The pH effluent limit, established in the 1976 Final Rule (41 FR 50676) to be the range of 6.0 to 9.0 standard units for all subcategories, will not be amended. As discussed in Section 6.5, other conventional pollutants, such as fecal coliform and oil and grease, will not be regulated under BPT, because they are not pollutants of concern for this industry.

13.2.3 The BPT Effluent Limitations Guidelines

The BPT effluent limitations guidelines for each subcategory are based on a combination of long-term mean effluent concentrations and variability factors that account for day-to-day variation in

measured treated effluent concentrations. Long-term means, discussed in Section 8, are target values that a facility's treatment system should achieve on a long- term, average basis. The variability factors, discussed in the Statistical Support Document(1), located in the Administrative Record for this rulemaking, represent the ratio of an elevated value, expected to occur only rarely, to the long-term mean. The purpose of the variability factor is to allow for variations in effluent concentrations that comprise the long-term mean. A facility that designs and operates its treatment system to achieve a long-term mean on a consistent basis should be able to comply with the daily and monthly limitations in the course of normal operations.

Table 13-1 presents the maximum daily and monthly average BPT effluent limitations guidelines for end-of-pipe monitoring points for Subcategories A, B, C, and D based on long-term mean treatment performance concentrations and associated variability factors.

The limitations for COD were calculated using available data sets from best-performing advanced biological treatment systems. The long-term mean concentration was multiplied by the 1-day and 30-day variability factors for each data set. This resulted in data set specific limitations. The mean value of the dataset specific limitations based on the 1-day variability factor is the BPT maximum limitation for any one day; the mean value based on the 30-day variability factor is the BPT monthly average limitation.

13.3 Implementation of the BPT Effluent Limitations Guidelines

13.3.1 NPDES Permit

BPT effluent limitations guidelines are applied to individual facilities through NPDES permits issued by EPA or authorized states under Section 402 of the CWA.

The effluent limitations guidelines are concentration-based and, as such, do not regulate wastewater flow. For end-of-pipe effluent limitations, permit writers will use a reasonable estimate of process wastewater discharge flow allowing for up to 25 percent non-process water

through treatment. The flow estimates and the concentration-based limitations are used to develop mass-based limitations for the NPDES permit.

"Process wastewater" discharge is defined by 40 CFR 122.2 to include wastewaters resulting from manufacture of pharmaceutical products that come in direct contact with raw materials, intermediate products, and final products, and surface runoff from the immediate process area that has the potential to become contaminated. Noncontact cooling waters, utility wastewaters, general site surface runoff, groundwater, and other nonprocess water generated on site are specifically excluded from this definition. The end-of-pipe limitations are developed from performance data at facilities which contain less than 25 percent nonprocess water through their biological treatment facility. Therefore, the end-of-pipe limitations for BPT apply to the pharmaceutical process wastewater allowing for up to 25 percent nonprocess wastewater. Nonprocess flow in excess of 25 percent should be handled separately in establishing permit limits.

Using current facility information provided by the permit applicant, the permitting or control authority must determine the appropriate wastewater discharge flow to use when developing mass based limitations. In cases where the permit writer deems the wastewater discharge flow claimed by industry to be excessive, he/she may develop a more appropriate process wastewater discharge flow for use in computing the mass effluent limitations. The permit writer should review the following items to evaluate whether process wastewater discharge flow is excessive.

- Component flows, to ensure that the claimed flows are, in fact, process wastewater discharge flows as defined by 40 CFR 122.2.
- Plant operations, to ensure that sound water conservation practices are being followed. Examples include minimization of process water uses and reuse or recycle of intermediate process waters or treated wastewaters at the process area and in wastewater treatment operations (pump seals, equipment and area washdowns, etc.).
- Barometric condenser use at the process level. Often, barometric condensers will generate relatively large volumes of slightly contaminated water. Replacing barometric condensers with surface condensers can

reduce wastewater volumes significantly and result in collection of condensates that may be returned to the process.

To establish an NPDES permit for a direct discharger, the permit writer should determine the facility's subcategorization and use the corresponding concentration-based effluent limitations as a basis for developing the mass-based limitations. The permit writer should then use best professional judgment to determine the facility's annual average wastewater discharge flow (i.e., the permit writer should consider only the sources of "process wastewater discharge," as defined previously, when determining the annual average process wastewater discharge flow, allowing for up to 25 percent nonprocess wastewater). The annual average flow is defined as the average of daily flow measurements calculated over at least a year; however, if available, three to five years of data are preferable to obtain a representation of average daily flow.(2)

If no historical or actual process wastewater flow data exist, the permitting authority is advised to establish a reasonable estimate of the facility's projected flow representative of the entire term of the permit. This may include a request for the facility to measure process wastewater flows for a representative period of time to establish a flow basis. If a plant is planning significant changes in production during the effective period of the permit, the permitting authority may consider establishing multiple tiers of limitations as a function of these production changes. Alternatively, a permit may be modified during its term, either at the request of the permittee or another interested party, or on EPA's initiative, to increase or decrease the flow basis in response to a significant change in production (40 CFR 124.5, 122.62). A change in production may be an "alteration" of the permitted activity or "new information" that could provide the basis for a permit modification (40 CFR 122.62(a)).

The permit writer should use the facility’s annual average process wastewater discharge flow and no more than 25 percent additional flow contributed by existing nonprocess wastewater discharges to convert the end-of-pipe concentration-based limitations into mass-based limitations.

13.3.2 Point of Application

The BPT effluent limitations guidelines at Subcategory A, B, C, and/or D direct dischargers would be applicable to the final effluent at the point of discharge to waters of the United States and before dilution with significant amounts of nonprocess waters (i.e., end-of-pipe).

13.3.3 Monitoring and Compliance

The monitoring frequency for BPT effluent limitations guidelines for Subcategory A, B, C, and/or D direct dischargers should be determined by the permit authority.

Compliance with the end-of-pipe effluent limitations guidelines should be determined by multiplying the regulated pollutant concentration, measured in the effluent sample, by a conversion factor and by the total applicable wastewater flow discharged during the effluent sampling period, which is typically 24 hours. Thus, the mass compliance value should be based on the applicable flow discharged on the day of sampling, not on the long-term average flow rate used to establish the permit limitations and standards.

Table 13-1

BPT Effluent Limitations Guidelines for Direct Dischargers

Subcategory	Pollutant or Pollutant Property	BPT Effluent Limitation for End-of-Pipe Monitoring Points	
		Maximum for any one day (mg/L)	Monthly Average (mg/L) [(a)]
A - Fermentation Operations	COD	1,675	856
B - Biological and Natural Extraction Operations	COD	228	86
C - Chemical Synthesis Operations	COD	1,675	856
D - Mixing, Compounding, or Formulating Operations	COD	228	86

(a) If these COD concentrations are higher than concentration values reflecting a reduction in the long-term average daily COD load in the raw (untreated) process wastewater of 74 percent multiplied by a variability factor of 2.2, then effluent limitations for COD corresponding to the lower concentration values must be applied.

REFERENCES

1. U.S. EPA, Office of Water. Statistical Support Document for the Effluent Limitations Guidelines for the Pharmaceutical Manufacturing Industry. EPA-821-B-98-007, U.S. Environmental Protection Agency, Washington, D.C., 1998.

2. U.S. EPA, Office of Water. Training Manual for NPDES Permit Writers. EPA 833-B-93-003, U.S. Environmental Protection Agency, Washington, D.C., 1993.

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SECTION 14

BEST CONVENTIONAL TECHNOLOGY

14.1 Introduction

Effluent limitations guidelines based on best conventional technology establish quantitative limits on the direct discharge of conventional pollutants from existing industrial point sources. In contrast to BPT guidelines, which are based on the average of the best existing performance by a group of facilities, BCT guidelines are developed by identifying candidate technologies and evaluating their cost-reasonableness. Effluent limitations guidelines based upon BCT may not be less stringent than BPT effluent limitations guidelines. As such, BPT effluent limitations are a "floor" below which BCT efficient limitations guidelines cannot be established. As discussed below, EPA has developed a BCT cost test methodology to assist the Agency in determining whether it is "cost-reasonable" for industry to control conventional pollutants at a level more stringent than would be required by BPT effluent limitations.

The following information is presented in this section:

- Section 14.2 discusses the Agency's general methodology for determining BCT effluent limitations for industry;
- Section 14.3 reviews the subcategories and pollutants proposed to be regulated by BCT, describes the application of the general BCT methodology to the pharmaceutical manufacturing industry, and presents the proposed BCT effluent limitation guidelines; and
- Section 14.4 discusses BCT effluent limitations guideline implementation.

14.2 General Methodology for BCT Effluent Limitations Development

The July 9, 1986 Federal Register (51 FR 24974) presents the Agency's general methodology for developing BCT effluent limitations guidelines. BCT effluent limitations guidelines are based on the performance of the pollution control technology selected as BCT. As noted in 51 FR 24974,

the first step in determining BCT is to establish that a BCT option is technologically feasible (defined as providing conventional pollutant control beyond the level of control provided by application of BPT). If a BCT option is found to be technologically feasible, the Agency applies a two-part BCT cost test to evaluate the "cost-reasonableness" of the BCT option. The BCT cost test consists of a POTW test and an industry cost-effectiveness test that the BCT option must pass to be considered as a basis for BCT effluent limitations guidelines. The results of these tests along with other industry-specific factors are evaluated to determine BCT. The POTW cost test, the industry cost-effectiveness test, and the process of BCT determination are discussed below.

14.2.1 POTW Cost Test

The POTW cost test compares the cost-effectiveness of an industrial treatment system upgrade to meet the BCT requirements to the benchmark cost-effectiveness of a POTW upgrade. For a BCT option to pass the POTW cost test, the cost per pound of conventional pollutant removed by upgrading from BPT to the BCT option at industrial direct dischargers must be less than the cost per pound of conventional pollutant removed by upgrading POTWs from secondary treatment to advanced secondary treatment. Specifically, the upgrade cost to industry must be less than the POTW benchmark of $0.25 per pound (in 1976 dollars) for industries whose cost per pound is based on long-term performance data (Tier I POTW benchmark), or must be less than $0.14 (in 1976 dollars) per pound for industries whose cost per pound is not based on long-term performance data (Tier II POTW benchmark).

As noted in 51 FR 24974, the conventional pollutants measured for removal during the two-part BCT cost test are BOD_5 and TSS. Oil and grease may be used along with BOD_5 and TSS to calculate pollutant removal for BCT options when deemed appropriate for the industry and technology being evaluated. Fecal coliform and pH are not included in the calculations because control of these pollutants is not measurable as "pounds removed". An acceptable interval for controlling pH is evaluated with respect to the particular processes of a BCT option. Generally, the acceptable pH interval for BCT will be the same as that for BPT. Maintaining the acceptable interval is an inherent cost of the BCT option and must be economically achievable and cost-reasonable (51 FR 24974).

14.2.2 Industry Cost-Effectiveness Test

To remain a viable option, a BCT option must also pass an industry cost-effectiveness test which consists of computing a ratio of two incremental costs. The first increment is the cost per pound of pollutant load removed by the BCT option relative to BPT; the second increment is the cost per pound of pollutant load removed by BPT relative to no treatment (i.e., raw wastewater). The ratio of the two incremental costs (first cost divided by the second cost) is compared to an industry benchmark. The industry benchmark is a ratio of two POTW incremental costs: 1) the cost per pound of pollutant removed for a POTW to upgrade from secondary treatment to advanced secondary treatment, and 2) the cost per pound of pollutant removed for a POTW to upgrade from no treatment to secondary treatment. If the first ratio (BCT option to BPT) is lower than the industry benchmark, the BCT option passes the industry cost-effectiveness test. The Tier I industry benchmark, for industries whose ratio is based on long-term performance data, is 1.29. The Tier II industry benchmark, for industries whose ratio is not based on long-term performance data, is 0.68.

In calculating the ratio of a BCT option to BPT, the Agency will consider any BCT option cost per pound less than $0.01 to be equivalent to zero costs. The Agency believes that a BCT option with zero cost per pound of pollutant removed satisfies the Congressional intent for cost-reasonableness.

14.2.3 BCT Determination

BCT is determined by evaluating results of both the POTW test and the industry cost-effectiveness test as measures of cost-reasonableness. In addition, Section 304 (b)(4)(B) of the CWA instructs the Agency to consider "other factors deemed appropriate" when making BCT determinations; other factors are considered on an industry-specific basis. Generally, BCT is the most stringent technology option (i.e., the technology option that achieves the greatest pollutant reduction) to pass both parts of the cost test. If all BCT options for an industry category or subcategory fail either or both of the tests, or if no BCT option more stringent than BPT is identified, then BCT is set equal to BPT.

The owners or operators of facilities subject to BCT are not required to use the specific technologies selected by EPA to establish BCT, but may choose to use any combination of process technologies and wastewater treatment to comply with NPDES permit limitations derived from BCT effluent limitations guidelines.

14.3 BCT Effluent Limitations Guidelines Development for the Pharmaceutical Manufacturing Industry

14.3.1 Regulated Subcategories

BCT effluent limitations guidelines, as discussed in Section 7.3, are being promulgated for Subcategories A, B, C, and D.

14.3.2 Regulated Pollutants

The final BCT effluent limitations guidelines establish BOD_5 and TSS effluent limitations. The pH effluent limitation under BCT will be the equivalent of the pH limitation established by BPT.

14.3.3 Application of General BCT Methodology to the Pharmaceutical Manufacturing Industry

The Agency applied the general methodology for BCT effluent limitations guidelines development to the pharmaceutical manufacturing industry subcategories. First, technologically feasible BCT options that provide a greater degree of conventional pollutant control than BPT were identified. Section 7.3.3 describes the BCT options evaluated by the BCT determination process. After determining that the BCT options were technologically feasible, the Agency applied the two-part BCT cost test. The results of the BCT cost test were used to establish the technology basis for the final BCT effluent limitations guidelines.

The following subsections discuss the BPT baseline established for the two-part BCT cost test, the BCT options evaluated, the use of the pharmaceutical cost model to generate costs for this analysis, the two-part BCT cost test results, and the final BCT effluent limitations guidelines for the pharmaceutical manufacturing industry subcategories.

14.3.3.1 BCT Cost Test Baseline

To apply the two-part BCT cost test to the pharmaceutical manufacturing industry, a baseline technology representing the current BPT limitations (before any revision) was defined to serve as the comparison point for the more stringent BCT options. The methodology for BCT determination (as documented in 51 FR 24974) requires that this point of comparison is BPT. Thus, the baseline technology used in the two-part BCT cost test is the current (1990) treatment level.

14.3.3.2 BCT Options

Subcategories A and C

As described in Section 7.3.3, there are four BCT technology options for Subcategories A and C beyond current treatment:

- Advanced Biological Treatment;
- Advanced Biological Treatment and Effluent Filtration;
- Advanced Biological Treatment and Polishing Pond; and
- Advanced Biological Treatment and Effluent Filtration and Polishing Pond.

Subcategories B and D

As described in Section 7.3.3, there are two BCT technology option for Subcategories B and D beyond current treatment:

- Advanced Biological Treatment; and
- Advanced Biological Treatment and Effluent Filtration.

14.3.3.3 Pharmaceutical Manufacturing Cost Model

The Agency used the pharmaceutical manufacturing cost model (described in Section 10) to calculate baseline conventional pollutant control costs and corresponding costs for the BCT options. The annualized conventional pollutant control costs for the baseline and BCT options are calculated in 1990 dollars.

14.3.3.4 BCT Cost Test Results

Table 14-1 summarizes the results of the two-part BCT cost test for Subcategory A and C direct dischargers. Table 14-2 summarizes the results of the two-part BCT cost test for Subcategory B and D direct dischargers. All results are based on the use of long-term performance (i.e., Tier I) data. Results of the POTW cost test and the industry cost-effectiveness test are discussed below.

POTW Cost Test Results

Results of the POTW cost test are summarized in the upper portion of Tables 14-1 and 14-2. For Subcategory A and C direct dischargers, one BCT option passed the POTW cost test (BPT baseline to advanced biological treatment). For Subcategory B and D direct dischargers, all BCT options failed the POTW cost test.

As an example of POTW test application, consider the first BCT option for Subcategory A and C direct dischargers. The cost of upgrading from the BPT baseline (current treatment) to the BCT

option (advanced biological treatment) is $2,190,000 per year (in 1990 dollars). The load reduction of BOD_5 and TSS achieved by upgrading to the BCT option is 3,940,000 lbs/yr. Thus, upgrading from the BPT baseline to the BCT option results in a ratio of 0.557 $/lb (dollars expended to pounds of BOD_5 and TSS removed). This ratio is less than the Tier I POTW benchmark (in 1990 dollars) of 0.56 $/lb. (The POTW benchmark of 0.56 $/lb, expressed in 1990 dollars, was calculated using the May 1986 promulgated methodology entitled BCT Benchmarks: Methodology, Analysis and Results for Calculating and Indexing BCT POTW Benchmarks to Various Years' Dollars (1).) Since the cost per pound of pollutant removed is less than the POTW benchmark, this BCT option for Subcategory A and C direct dischargers passed the POTW cost test.

Industry Cost-Effectiveness Test Results

Results of the industry cost-effectiveness test are presented in the lower portion of Tables 14-1 and 14-2. For Subcategory A and C direct dischargers, all BCT options failed the industry cost-effectiveness test. For Subcategory B and D direct dischargers, all BCT options failed the industry cost-effectiveness test.

As an example of industry cost-effectiveness test application, consider the first BCT option for Subcategory A and C direct dischargers. From the POTW test, the incremental cost per pound of pollutant removed associated with upgrading from the BPT baseline to the BCT option was 0.557 $/lb. The cost of upgrading from no treatment (i.e., raw wastewater) to the BPT baseline is $25,800,000 per year (in 1990 dollars). The load reduction of BOD_5 and TSS achieved by upgrading from no treatment to the BPT baseline is 97,800,000 lbs/yr. Thus, the incremental cost per pound of pollutant load removed for Subcategory A and C direct dischargers upgrading from no treatment to the BPT baseline is 0.264 $/lb. The ratio of these two incremental costs is 2.11 (i.e., 0.557 divided by 0.264). Since this ratio (2.11) is greater than the industry benchmark of 1.29, the BCT option failed the industry cost-effectiveness test.

14.3.3.5 Conclusions

Based on the results of the two-part BCT cost test and the criteria discussed in Section 14.1.3 for BCT determination, the final BCT effluent limitations guidelines for Subcategory A and C and Subcategory B and D direct dischargers are equal to BPT limitations for BOD_5 and TSS for those subcategories.

Table 14-1

Summary Results of BCT Cost Test for Subcategory A and C Direct Dischargers (Monetary Values are 1990 $)

	POTW Cost Test			
	BPT Baseline to Advanced Biological Treatment	**BPT Baseline to Advanced Biological Treatment and Effluent Filtration**	**BPT Baseline to Advanced Biological Treatment and Polishing Pond**	**BPT Baseline to Advanced Biological Treatment and Effluent Filtration and Polishing Pond**
Annualized Cost for BOD & TSS Reduction ($/yr.)	2,190,000	4,060,000	19,700,000	23,000,000
BOD & TSS Load Red. (lbs./yr.)	3,940,000	4,860,000	5,400,000	7,060,000
($/lb.)	0.557	0.836	3.64	3.27
POTW Benchmark ($/lb.) 1990 $	0.56	0.56	0.56	0.56
Pass/Fail	Pass	Fail	Fail	Fail
	Industry Cost - Effectiveness Test			
	Raw WW to BPT Baseline	**Raw WW to BPT Baseline**	**Raw WW to BPT Baseline**	**Raw WW to BPT Baseline**
Annualized Cost for BOD & TSS Reduction ($/yr.)	25,800,000	25,800,000	25,800,000	25,800,000
BOD & TSS Load Red. (lbs./yr.)	97,800,000	97,800,000	97,800,000	97,800,000
($/lb.)	0.264	0.264	0.264	0.264
Ratio	2.11	3.17	13.8	12.4
Ratio Benchmark	1.29	1.29	1.29	1.29
Pass/Fail	Fail	Fail	Fail	Fail

Notes:

Baseline is set equivalent to current Treatment. The raw to baseline and baseline to BCT option costs and load reductions were developed using the pharmaceutical manufacturing cost model. These costs do not include costs for COD removal.

To adjust the POTW benchmark to 1990 dollars, the Agency used the promulgated methodology, BCT Benchmarks: Methodology, Analysis and Results, May 1986, for calculating and indexing BCT POTW benchmarks to various years' dollars (1).

Table 14-2

Summary Results of BCT Cost Test for Subcategory B and D Direct Dischargers (Monetary Values are 1990 $)

	POTW Cost Test	
	BPT Baseline to Advanced Biological Treatment	**BPT Baseline to Advanced Biological Treatment and Effluent Filtration**
Annualized Cost for BOD & TSS Reduction ($/yr.)	1,580,000	2,120,000
BOD & TSS Load Red. (lbs./yr.)	236,000	267,000
($/lb.)	6.68	7.93
POTW Benchmark ($/lb.) 1990 $	0.56	0.56
Pass/Fail	Fail	Fail
	Industry Cost - Effectiveness Test	
	Raw WW to BPT Baseline	**Raw WW to BPT Baseline**
Annualized Cost for BOD & TSS Reduction ($/yr.)	2,110,000	2,110,000
BOD & TSS Load Red. (lbs./yr.)	1,300,000	1,300,000
($/lb.)	1.63	1.63
Ratio	4.10	4.87
Ratio Benchmark	1.29	1.29
Pass/Fail	Fail	Fail

Notes:

Baseline is set equivalent to current Treatment. The raw to baseline and baseline to BCT option costs and load reductions were developed using the pharmaceutical manufacturing cost model. These costs do not include costs for COD removal.

To adjust the POTW benchmark to 1990 dollars, the Agency used the promulgated methodology, BCT Benchmarks: Methodology, Analysis and Results, May 1986, for calculating and indexing BCT POTW benchmarks to various years' dollars (1).

REFERENCES

1. U.S. EPA. BCT Benchmarks: Methodology, Analysis, and Results for Calculating and Indexing BCT POTW Benchmarks to Various Year's Dollars. U.S. Environmental Protection Agency, Washington, D.C., May 1986.

SECTION 15

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

15.1 Introduction

Effluent limitations guidelines based on the best available technology economically achievable establish quantitative limits on the direct discharge of priority and nonconventional pollutants to waters of the United States. These limits are based upon the performance of specific technologies, but do not specify which technologies must be used to achieve compliance. BAT effluent limitations guidelines are applied to individual facilities through NPDES permits issued by EPA or authorized states under Section 402 of the CWA. Each facility then chooses its own approach to comply with its permit limitations.

The technology selected by the Agency to define the BAT performance may include end-of-pipe treatment, process changes, and internal controls, even when these technologies are not common industry practice. Section 7 provides an overview of the technologies assessed by the Agency.

BAT performance is established for groups of facilities (subcategories) with shared characteristics. Where a group of facilities demonstrates uniformly inadequate performance in controlling pollutants of concern, BAT may be transferred from a different subcategory or industrial category.

For Subcategory A and C facilities, EPA chose the BAT regulatory option to add organics and ammonia, revise COD to BPT limits, and clarify the monitoring requirements for cyanide. The Agency selected end-of-pipe advanced biological treatment with nitrification of ammonia as the technology basis for the BAT effluent limitations guidelines for Subcategory A and/or Subcategory C direct dischargers. The Agency chose to revise COD to BPT limits and withdraw cyanide limitations for Subcategory B and D facilities. The Agency selected BPT treatment technology (advanced biological treatment) as the basis for the BAT effluent limitations guidelines

for Subcategory B and/or Subcategory D direct dischargers. The rationale behind these selections is discussed in Section 11.

The following information is presented in this section:

- Section 15.2 reviews the subcategories and the pollutants to be regulated by BAT and presents the BAT effluent limitations guidelines; and
- Section 15.3 discusses BAT effluent limitations guidelines implementation with regard to point of application, NPDES permits, and monitoring and compliance issues.

15.2 Summary of the BAT Effluent Limitations Guidelines

15.2.1 Regulated Subcategories

Revised BAT effluent limitations guidelines are for Subcategories A, B, C, and D. As discussed in Section 4.3, Subcategories A, B, and C include wastewater discharges resulting from the manufacture of pharmaceuticals by fermentation, biological or natural extraction processes, and chemical synthesis processes, respectively. Subcategory D includes wastewater discharges resulting from mixing, compounding, and formulating of pharmaceutical products.

15.2.2 Regulated Pollutants

The BAT guidelines establish effluent limitations for the priority and nonconventional pollutants listed in Table 15-1 for direct dischargers in Subcategories A and C. EPA is not establishing BAT effluent limitations guidelines for Subcategory B and D operations except to set BAT COD limitations equivalent to the BPT COD limitations. Conventional pollutants are regulated under BPT and BCT and are not discussed here.

The revised BAT in this rulemaking clarifies existing in-plant cyanide limitations for Subcategory A and C facilities. Compliance monitoring for cyanide should occur immediately after cyanide

destruction, before commingling cyanide-bearing waste streams with non-cyanide bearing waste streams, unless a facility can demonstrate that cyanide is detectable at end-of-pipe. The 1983 cyanide limitations for Subcategory B and D direct dischargers are being withdrawn; these subcategories do not use or generate cyanide.

15.2.3 The BAT Effluent Limitations Guidelines

The BAT effluent limitations guidelines for each subcategory are based on a combination of long-term mean treatment performance concentrations and variability factors that account for day-to-day variation in measured treated effluent concentrations. Long-term mean treatment performance concentrations, discussed in Section 8, are target values that a facility's treatment system should achieve on a long-term, average basis. The variability factors, discussed in the Statistical Support Document(1), which is located in the Record for this rulemaking, represent the ratio of an elevated value, expected to occur only rarely, to the long-term mean. The purpose of the variability factor is to allow for variations in effluent concentrations that comprise the long-term mean. A facility that designs and operates its treatment system to achieve a long-term mean on a consistent basis should be able to comply with the daily and monthly limitations in the course of normal operations.

Table 15-2 presents the maximum daily and monthly average BAT effluent limitations guidelines for Subcategory A and C operations. These limitations were determined by multiplying the long-term means for each subcategory by the respective pollutant's 1-day and 4-day variability factors. A 4-day variability factor was used to develop the BAT monthly average limitations, with the exception of COD for which a 30-day variability factor was used. Table 15-3 presents the maximum daily and monthly average BAT COD effluent limitations guidelines for Subcategory B and D operations.

The BAT effluent limitations guidelines for acetonitrile, benzene, diethylamine, dimethyl sulfoxide, ethanol, n-heptane, methanol, methyl cellosolve, and triethylamine are based on the analytical method minimum level. The minimum level for a pollutant is the level at which an analytical system gives recognizable signals and an acceptable calibration point. For pollutants

with a long-term mean below the minimum level, typically in cases where treatment performance was established through data transfer, the final long-term mean was set at a value no lower than the minimum level for the pollutant. The final effluent limitations are determined by applying 1-day and 4-day variability factors to the final long-term means.

The BAT cyanide effluent limit, established in the 1983 Final Rule to be a daily maximum of 33.5 mg/L and a maximum monthly average of 9.4 mg/L for all subcategories, is not being revised for Subcategories A and C. The cyanide effluent limit is being withdrawn for Subcategories B and D because EPA has determined that cyanide is neither used nor generated by facilities with these subcategory operations.

15.3 Implementation of the BAT Effluent Limitations Guidelines

The BAT effluent limitations guidelines for Subcategory A and C operations are presented in Table 15-2. EPA is not establishing BAT effluent limitations guidelines for Subcategory B and D operations except to set a BAT COD limitation equivalent to the BPT COD limitation.

15.3.1 Establishing List of Pollutants for Compliance Monitoring

Permitting authorities should establish permit limitations and compliance monitoring requirements for each regulated pollutant, listed in Table 15-1, generated or used at a pharmaceutical manufacturing facility with Subcategory A and/or C operations. Limitations and routine compliance monitoring should not be required for regulated pollutants not generated or used at a facility. A determination that regulated pollutants are not generated or used should be based on a review of all raw materials and chemical processes used, considering resulting products and by-products. The determination that a regulated pollutant is not generated or used would need to be confirmed by annual chemical analyses of wastewater from each monitoring location. Such confirmation would be provided by an analytical measurement of a non-detect value.

Facilities discharging more than one regulated organic pollutant may monitor for a single surrogate pollutant to demonstrate an appropriate degree of control for a specified group of pollutants. For the purpose of identifying surrogates, pollutants are grouped according to treatability classes; Table 15-4 presents the treatability classes identified for advanced biological treatment, which is the BAT technology basis for organic pollutant limitations. For treatability classes with more than one possible surrogate pollutant, the analyte with the highest concentration or loadings should be chosen as the surrogate pollutant. Plants may monitor for a surrogate pollutant(s) only if they demonstrate that all other pollutants receive the same degree of treatment.

An individual plant may choose to demonstrate by selecting a monitoring pollutant for a given treatability class and maintaining documentation, including flow information and sampling results, that all pollutants in that treatability class receive equivalent treatment. The documentation is then submitted to the permit authority for approval.

15.3.2 Point of Application

The BAT effluent limitations for ammonia, COD, and the organic pollutants listed in Table 15-2 are end-of-pipe limitations and applicable to the final effluent at the point of discharge to waters of the United States, prior to non-process dilution waters. This compliance point is identical to the point used to demonstrate compliance with the BPT effluent limitations guidelines. Compliance monitoring for cyanide should occur in-plant, unless a facility can show a measurable amount of cyanide at end-of-pipe, instead of a non-detect in accordance with 40 CFR 403.6 (e)(2) and 403.6 (e)(4).

15.3.3 Permit Limitations

End-of-pipe permit limitations based on the BAT limitations for ammonia, COD, and organic constituents will be mass-based. Permit writers should use a reasonable estimate of process wastewater discharge flow and the concentration-based limitations listed in Table 15-2 to develop mass-based limitations for the NPDES permit.

"Process wastewater discharge" is defined by 40 CFR 122.2 to include wastewaters resulting from pharmaceutical products manufacturing that come in direct contact with raw materials, intermediate products, and final products, and surface runoff from the immediate process area that has the potential to become contaminated. Noncontact cooling waters, utility wastewaters, general site surface runoff, groundwater, and other nonprocess water generated on site are specifically excluded from this definition. The end-of-pipe limitations are developed from performance data at facilities which contain less than 25 percent nonprocess water through their biological treatment facility. Therefore, the end-of-pipe limitations for BAT apply to the pharmaceutical process wastewater allowing for up to 25 percent nonprocess wastewater. Non process flow in excess of 25 percent should be handled separately in establishing permit limits.

Using current facility information provided by the permit applicant, the permitting or control authority must determine the appropriate process wastewater discharge flow to use when developing mass-based limitations. In cases where the permit writer deems the process wastewater discharge flow claimed by industry to be excessive, he/she may develop a more appropriate process wastewater discharge flow for use in computing the mass-based limitations. The permit writer should review the following items to evaluate whether process wastewater discharge flow is excessive:

- Component flows, to ensure that the claimed flows are, in fact, process wastewater discharge flows as defined by 40 CFR 122.2.
- Plant operations, to ensure that sound water conservation practices are being followed. Examples include minimizing process water uses and reusing or recycling intermediate process waters or treated wastewaters at the process area and in wastewater treatment operations (pump seals, equipment and area washdowns, etc.).
- Barometric condenser use at the process level. Often, barometric condensers will generate relatively large volumes of slightly contaminated water. Replacing barometric condensers with surface condensers can reduce wastewater volumes significantly and result in collection of condensates that may be returned to the process.

Once the permit writer has reviewed the permit application, best professional judgment should be used to determine the facility's annual average wastewater discharge flow (i.e., the permit writer should consider only the sources of "process wastewater discharge," as defined previously, when determining the annual average process wastewater discharge flow allowing for up to 25 percent nonprocess wastewater). The annual average flow is defined as the average of daily flow measurements calculated over at least a year; however, if available, three to five years of data are preferable to obtain a representation of average daily flow(2).

If no historical or actual process wastewater flow data exist, the permitting authority is advised to establish a reasonable estimate of the facility's projected flow expected to be representative during the entire term of the permit. If a plant is planning significant production changes during the effective period of the permit, the permitting authority may consider establishing multiple tiers of limitations as a function of these production changes. Alternatively, a permit may be modified during its term, either at the request of the permittee or another interested party, or on EPA's initiative, to increase or decrease the flow basis in response to a significant change in production (40 CFR 124.5, 122.62). A change in production may be an "alteration" of the permitted activity or "new information" that could provide the basis for a permit modification (40 CFR 122.62(a)).

After determining the facility's annual average process wastewater flow, the permit writer would use this flow and not more than 25 percent nonprocess wastewater to convert the concentration-based limitations into mass-based limitations for ammonia, COD, and organic constituents for control at the end-of-pipe.

Additional detailed guidance on the establishment of permit limitations, including examples, is available in the Guidance for Implementing the Pharmaceutical Manufacturing Industry Regulations.

In-plant permit limitations for cyanide, based on the 1983 BAT limitations, will be concentration-based, and not converted to a mass basis. A concentration basis for cyanide offers a direct benchmark to assess whether the in-plant control technology is achieving the intended level. In-

plant wastestreams that require control may be generated or treated on a variable, batch basis, causing difficulty in establishing accurate mass-based permit limitations. Also, compliance is hindered, because the permitted facility cannot make a direct measurement to determine if its control technology is performing at the required level. Concentration-based permit limitations eliminate these problems and offer a direct measure of cyanide to both the permitting authority and the permitted facility that BAT performance levels are being achieved.

15.3.4 Monitoring and Compliance

Compliance monitoring for ammonia, COD, and all regulated organic constituents should be performed on a frequency basis established by the permit authority. EPA's monitoring costs for this regulation assumed compliance monitoring for ammonia and all regulated organic constituents on a weekly basis for Subcategory A and C facilities, and monitoring for COD on a daily basis for Subcategory A, B, C, and D facilities. The list of pollutants for which monitoring would be required at Subcategory A and C facilities includes all regulated constituents listed in Table 15-1 generated or used in pharmaceutical manufacturing processes at the facility. Based on the limitations, monitoring of ammonia, COD, and organic constituents generated or used in pharmaceutical manufacturing processes would occur prior to discharge to waters of the United States and before dilution with significant amounts of nonprocess waters.

Compliance with mass-based permit limitations is determined by multiplying the measured concentration of a regulated pollutant in the effluent sample by a conversion factor and by the total wastewater flow at the monitoring location during the effluent sampling period. Thus, the mass compliance value should be based on the total flow discharged on the day of sampling, not on the long-term average process water flow rate that provided the basis for establishing the permit limitations and standards.

Compliance monitoring for cyanide should occur in-plant, prior to commingling or dilution with non-cyanide-bearing wastewater, unless a facility can show end-of-pipe monitoring for cyanide is feasible. To show that end-of-pipe monitoring is feasible, the facility would need to demonstrate

compliance with cyanide limitations, adjusted as necessary to account for dilution with non-cyanide-bearing wastewater, at a level above the detection limit for cyanide.

The list of pollutants for which monitoring would be required should be updated based on consideration of raw material and process changes throughout the facility and an annual scan for all pollutants listed in Table 15-1. The annual scan should be performed at the compliance monitoring point(s) to identify any regulated pollutants in the wastewater. Permit monitoring and compliance should be required at all monitoring locations for all pollutants detected at any locations.

Dischargers must use the test methods promulgated at 40 CFR Part 136.3 or incorporated by reference in the tables of that part, when available, to monitor pollutant discharges from the pharmaceutical manufacturing industry, unless specified otherwise in part 439 (see 40 CFR 401.13) or by the permitting authority.

As a part of the final rule, EPA promulgated additional test methods for the pollutants to be regulated under Part 439 for which there are no test methods listed at 40 CFR Part 136.3. To support the Part 439 regulations at the time of proposal, EPA published test methods developed specifically for the pharmaceutical industry in a compendium entitled, "Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewater," EPA-821-B-94-001. These test methods were discussed in the proposed rule and have been revised in response to public comment. The revised test methods are available for monitoring some pollutants covered by today's final rule. The revised test methods have been published in a revised compendium (the "Pharmaceutical Methods Compendium, Revision A;" EPA-821-B-98-016, 1998), with the same title as the proposed compendium.

In addition, EPA is allowing use of applicable drinking water methods that have been promulgated at 40 CFR Part 141 and use of ASTM Methods D3371, D3695, and D4763, for monitoring of the pollutants included in this rulemaking. The final rule allows for use of these additional test methods for several reasons: (1) it allows greater flexibility in monitoring; (2) it conforms use of methods in EPA's drinking water and wastewater programs; (3) it moves toward

a performance-based measurement system; and (4) it allows use of technical standards as contemplated by the National Technology Transfer and Advancement Act of 1995 (NTTAA).

Table 15-1

Pollutants Regulated Under BAT for Subcategories A and C

Priority Pollutants	
Benzene	Methylene chloride
Chlorobenzene	Phenol
Chloroform	Toluene
o-Dichlorobenzene (1,2-Dichlorobenzene)	Cyanide [(a)]
1,2-Dichloroethane	
Nonconventional Pollutants	
Ammonia	n-Hexane
Chemical Oxygen Demand (COD)	Isobutyraldehyde
Acetone	Isopropanol
Acetonitrile	Isopropyl acetate
n-Amyl acetate	Isopropyl ether
Amyl alcohol	Methanol
n-Butyl acetate	Methyl cellosolve
Diethylamine	Methyl formate
Dimethyl sulfoxide	Methyl isobutyl ketone (MIBK)
Ethanol	Tetrahydrofuran
Ethyl acetate	Triethylamine
n-Heptane	Xylenes

(a) Retaining cyanide effluent limits established in the 1983 final rule.

Table 15-2

BAT Effluent Limitations for Subcategory A and C Operations

Pollutant or Pollutant Property	BAT Effluent Limitations for In-Plant Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Cyanide [(a)]	33.5	9.4

(a) Cyanide effluent limit established in the 1983 final rule.

Pollutant or Pollutant Property	BAT Effluent Limitations for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L [(a)]
COD	1,675	856

(a) If these COD concentrations are higher than concentration values reflecting a reduction in the long-term average daily COD load in the raw (untreated) process wastewater of 74 percent multiplied by a variability factor of 2.2, then effluent limitations for COD corresponding to the lower concentration values must be applied.

Pollutant or Pollutant Property	BAT Effluent Limitations for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Ammonia as N	84.1	29.4
Acetone	0.5	0.2
Acetonitrile	25.0	10.2
n-Amyl Acetate	1.3	0.5
Amyl Alcohol	10.0	4.1
Benzene	0.05	0.02
n-Butyl Acetate	1.3	0.5
Chlorobenzene	0.15	0.06
Chloroform	0.02	0.01
o-Dichlorobenzene	0.15	0.06
1,2-Dichloroethane	0.4	0.1
Diethylamine	250.0	102.0
Dimethyl Sulfoxide	91.5	37.5
Ethanol	10.0	4.1
Ethyl Acetate	1.3	0.5
n-Heptane	0.05	0.02

Table 15-2 (Continued)

Pollutant or Pollutant Property	BAT Effluent Limitations for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
n-Hexane	0.03	0.02
Isobutyraldehyde	1.2	0.5
Isopropanol	3.9	1.6
Isopropyl Acetate	1.3	0.5
Isopropyl Ether	8.4	2.6
Methanol	10.0	4.1
Methyl Cellosolve	100.0	40.6
Methylene Chloride	0.9	0.3
Methyl Formate	1.3	0.5
MIBK	0.5	0.2
Phenol	0.05	0.02
Tetrahydrofuran	8.4	2.6
Toluene	0.06	0.02
Triethylamine	250.0	102.0
Xylenes	0.03	0.01

Table 15-3

BAT Effluent Limitations for Subcategory B and D Operations

Pollutant or Pollutant Property	BAT Effluent Limitations for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L [(a)]
Chemical Oxygen Demand (COD)	228	86

(a) If these COD concentrations are higher than concentration values reflecting a reduction in the long-term average daily COD load in the raw (untreated) process wastewater of 74 percent multiplied by a variability factor of 2.2, then effluent limitations for COD corresponding to the lower concentration values must be applied.

Table 15-4

Surrogates for Subcategory A/C Direct Dischargers (Biotreatment)

Group	Compound	Surrogate (yes/no)
Alcohols	Ethanol	Yes
	Isopropanol	Yes
	Methanol	Yes
	Phenol	No
	Amyl alcohol	No
Aldehydes	Isobutyraldehyde	No
Alkanes	n-Heptane	Yes
	n-Hexane	Yes
Amides & Amines	Triethylamine	No
	Diethylamine	No
Aromatics	Toluene	Yes
	Xylenes	Yes
	Chlorobenzene	No
	o-Dichlorobenzene	No
	Benzene	No
Chlorinated Alkanes	Methylene chloride	Yes
	Chloroform	Yes
	1,2-Dichloroethane	Yes
Esters & Ethers	Ethyl acetate	Yes
	Tetrahydrofuran	Yes
	Isopropyl acetate	No
	n-Amyl acetate	No
	Isopropyl ether	No
	n-Butyl acetate	No
	Methyl formate	No
Ketones	Acetone	Yes
	MIBK	No
Miscellaneous	Ammonia (aqueous)	No
	Acetonitrile	No
	Dimethyl sulfoxide	No
	Methyl cellosolve	No

Yes - Surrogate pollutant for that group.
No - Not a surrogate pollutant for that group.

REFERENCES

1. U.S. EPA, Office of Water. Statistical Support Document for the Effluent Limitations Guidelines for the Pharmaceutical Manufacturing Industry. EPA-821-B-98-007. U.S. Environmental Protection Agency, Washington, D.C., 1998.

2. U.S. EPA, Office of Water. Training Manual for NPDES Permit Writers. EPA 833-B-93-003, U.S. Environmental Protection Agency, Washington, D.C., 1993.

SECTION 16

NEW SOURCE PERFORMANCE STANDARDS (NSPS)

16.1 Introduction

The basis for new source performance standards under Section 306 of the CWA is the best available demonstrated technology. Industry has the opportunity to design and install the best and most efficient process operations and wastewater treatment systems at new pharmaceutical manufacturing facilities. Accordingly, Congress directed EPA to consider the best demonstrated alternative processes, process changes, in-plant control measures, and end-of-pipe wastewater treatment technologies that reduce pollution to the maximum extent feasible. In response to that directive, and as with the development of options for the BAT effluent limitations guidelines, EPA considered effluent reductions attainable by the most advanced treatment technologies at pharmaceutical manufacturing facilities.

NSPS establish quantitative limits on the direct discharge of conventional, priority, and nonconventional pollutants to waters of the United States. These standards are based upon the performance of specific advanced technologies, but do not specify which technologies must be used to achieve compliance. NSPS are applied to individual facilities through NPDES permits issued by EPA or authorized states under Section 402 of the CWA. Each facility then chooses its own approach to complying with its permit limitations.

NSPS apply to all new sources in the pharmaceutical manufacturing industry. The NPDES permit regulations define the term "new source" at 40 CFR 122.2 and 122.29. According to these regulations, to be "new", a source must:

- Be constructed at a site at which no other source is located;
- Totally replace the process or production equipment that causes the discharge of pollutants at an existing source; or

- Be a process substantially independent of an existing source at the same site, considering the extent of integration with the existing source and the extent to which the new source is engaged in the same general type of activity as the existing source.

The Agency has selected end-of-pipe advanced biological treatment with nitrification of ammonia as the technology basis for the NSPS for Subcategories A and C. The performance level of the advanced biological treatment system component of NSPS for Subcategories A and C is equivalent to the selected BPT, for COD, and BAT, for priority, nonconventional organic pollutants and ammonia. Standards for conventional pollutants (BOD_5, TSS and pH) are being established for new sources consistent with that same performance level.

The Agency has selected end-of-pipe advanced biological treatment as the technology basis for the NSPS for Subcategories B and D. The performance level of the advanced biological treatment system component of NSPS for Subcategories B and D is equivalent to the selected BPT for COD. Standards for conventional pollutants (BOD_5, TSS and pH) are being established for new sources consistent with that same performance level. The rationale behind these selections is discussed in Section 11.

The following information is presented in this section:

- Section 16.2 reviews the subcategories and the pollutants to be regulated by NSPS and presents the NSPS; and
- Section 16.3 discusses NSPS implementation with regard to point of application, permit limitations, and monitoring and compliance issues.

16.2 Summary of the NSPS

16.2.1 Regulated Subcategories

The NSPS, as discussed in Section 7.3 are for Subcategories A, B, C, and D. As discussed in Section 4.3, Subcategories A, B, and C include wastewater discharges resulting from the

manufacture of pharmaceuticals by fermentation, biological or natural extraction processes, and chemical synthesis processes, respectively. Subcategory D includes wastewater discharges resulting from mixing, compounding, and formulating of pharmaceutical products.

16.2.2 Regulated Pollutants

The NSPS establish effluent limitations for the conventional, priority, and nonconventional pollutants listed in Table 16-1 for direct dischargers in Subcategories A and C. In addition, the NSPS establish effluent limitations for the conventional, and nonconventional pollutants listed in Table 16-2 for direct dischargers in Subcategories B and D.

The NSPS in this rulemaking clarifies existing in-plant cyanide limitations for Subcategory A and C facilities. Compliance monitoring for cyanide should occur immediately after cyanide destruction, before commingling cyanide-bearing waste streams with non-cyanide-bearing waste streams, unless a facility can demonstrate that cyanide is detectable at end-of-pipe. The 1983 cyanide limitations for Subcategory B and D direct dischargers are being withdrawn; these subcategories do not use or generate cyanide.

16.2.3 NSPS

The NSPS for each subcategory are based on a combination of long-term mean effluent values and variability factors that account for day-to-day variation in measured treated effluent concentrations. Long-term means, discussed in Section 8, are target values that a facility should achieve on a long-term, average basis. The variability factors, discussed in the Statistical Support Document(1), which is located in the Administrative Record for this rulemaking, represent the ratio of an elevated value, expected to occur only rarely, to the long-term mean. The purpose of the variability factor is to allow for variations in measured effluent concentrations that comprise the long-term mean. A facility that designs and operates its treatment system to achieve a long-term mean on a consistent basis should be able to comply with the daily and monthly limitations in the course of normal operations.

EPA is promulgating NSPS equal to the final BAT effluent limitations for 30 organic pollutants, cyanide and ammonia for Subcategory A and C facilities. NSPS for Subcategory A, B, C, and D facilities are also being revised for BOD_5, COD and TSS, at a level equal to the discharge characteristics of the best performing BPT plants.

Table 16-3 presents the maximum daily and monthly average NSPS for Subcategory A, and C operations. Table 16-4 presents the maximum daily and monthly average NSPS for Subcategory B and D operations.

The NSPS for acetonitrile, benzene, diethylamine, dimethyl sulfoxide, ethanol, n-heptane, methanol, methyl cellosolve, and triethylamine are based on the analytical method minimum level. The minimum level for a pollutant is the level at which an analytical system gives recognizable signals and an acceptable calibration point. For pollutants with a long-term mean below the minimum level, typically in cases where treatment performance was established through data transfer, the final long-term mean was set at a value no lower than the minimum level for the pollutant. The final effluent limitations are determined by applying 1-day and 4-day variability factors to the final long-term means.

The pH effluent limit, established in the 1976 Final Rule (41 FR 50676) to be the range of 6.0 to 9.0 standard units for all subcategories, is not being revised. The NSPS cyanide effluent limit, established in the 1983 Final Rule to be a daily maximum of 33.5 mg/L and a maximum monthly average of 9.4 mg/L for all subcategories, is not being revised for Subcategories A and C. The cyanide effluent limit is being withdrawn for Subcategories B and D, because EPA has determined that cyanide is neither used nor generated by facilities with these subcategory operations.

16.3 Implementation of NSPS

16.3.1 Establishing List of Pollutants for Compliance Monitoring

Permitting authorities should establish permit limitations and compliance monitoring requirements for each pollutant listed in Table 16-1 for Subcategory A and C facilities, or Table 16-2 for Subcategory B and D facilities, generated or used at a pharmaceutical manufacturing facility. Limitations and routine compliance monitoring should not be required for regulated pollutants not generated or used at a facility. A determination that regulated pollutants are not generated or used should be based on a review of all raw materials and chemical processes used, considering resulting products and by-products. The determination that a regulated pollutant is not generated or used should be confirmed by annual chemical analyses of wastewater from each monitoring location. Such confirmation would be provided by an analytical measurement of a non-detect value.

Facilities discharging more than one regulated organic pollutant may monitor for a single surrogate pollutant to demonstrate an appropriate degree of control for a specified group of pollutants. For the purpose of identifying surrogates, pollutants are grouped according to treatability classes; Table 16-5 presents the treatability classes identified for advanced biological treatment, which is the BAT technology basis for organic pollutant limitations. For treatability classes with more than one possible surrogate pollutant, the analyte with the highest concentration should be chosen as the surrogate pollutant. Plants may monitor for a surrogate pollutant(s) only if they demonstrate that all other pollutants receive the same degree of treatment.

An individual plant may choose to demonstrate by selecting a monitoring pollutant for a given treatability class and maintaining documentation, including flow information and sampling results, that all pollutants in that treatability class receive equivalent treatment. The documentation is then submitted to the permit authority for approval.

16.3.2 Point of Application

The NSPS for pollutants listed in Tables 16-3 and Table 16-4 are end-of-pipe standards and are applicable to the final effluent at the point of discharge to waters of the United States, prior to non-process dilution waters. Compliance monitoring for cyanide should occur in-plant, unless a facility can show a measurable amount of cyanide at end-of-pipe, instead of a non-detect in accordance with 40 CFR 403.6 (e)(2) and 403.6 (e)(4).

16.3.3 Permit Limitations

End-of-pipe permit limitations based on the NSPS limitations for ammonia, conventional, and non-conventional organic pollutants would be mass-based.

Permit writers should use a reasonable estimate of process wastewater discharge flow, allowing for no more than 25% nonprocess wastewater flow, and the concentration-based standards listed in Tables 16-3 and 16-4 to develop mass-based permit limitations for the NPDES permit. Section 15.3.3 presents guidance regarding how a reasonable estimate of process wastewater discharge flow should be established. Additional detailed guidance on establishing permit limitations is available in the Guidance for Implementing the Pharmaceutical Manufacturing Industry Regulations.

EPA expects permit limitations for cyanide at in-plant locations based on the 1983 NSPS limitations should be concentration-based, and would not be converted to a mass basis. A concentration basis offers a direct benchmark to assess whether the in-plant control technology is achieving the intended NSPS level. In-plant wastestreams that require control may be generated or treated on a variable, batch basis. In such a setting, mass-based permit limitations are difficult to establish accurately, hindering compliance because a direct measurement of the control technology performance cannot be made. Concentration-based permit limitations eliminate these problems and offer a direct measure of cyanide to both the permitting authority and the permitted facility that NSPS performance levels are being achieved.

16.3.4 Monitoring and Compliance

Compliance monitoring for the NSPS pollutants should be performed on a frequency basis established by the permit authority. EPA's monitoring costs for this regulation assume compliance monitoring for ammonia and all regulated organic constituents on a weekly basis for Subcategory A and C facilities and monitoring for BOD_5, COD, and TSS on a daily basis for Subcategory A, B, C, and D facilities. The list of pollutants which require monitoring includes all regulated constituents listed in Table 16-1 for A/C Subcategory facilities, or Table 16-2 for B/D Subcategory facilities, generated or used in pharmaceutical manufacturing processes at the facility. Under the NSPS, monitoring for BOD_5, COD, TSS, pH, ammonia, and organic constituents generated or used in pharmaceutical manufacturing processes would occur at the point of discharge to waters of the United States and before dilution with significant amounts of nonprocess waters.

Compliance with mass-based permit limitations is determined by multiplying the measured concentration of a regulated pollutant in the effluent sample by a conversion factor and by the total wastewater flow at the monitoring location during the effluent sampling period. Thus, the mass compliance value should be based on the total flow discharged on the day of sampling, not on the long-term average process water flow rate that provided the basis for establishing the permit limitations and standards.

Monitoring for cyanide for Subcategories A and C would be performed in-plant, prior to commingling or dilution with non-cyanide-bearing wastewater, unless a facility can show end-of-pipe monitoring for cyanide is feasible. To show that end-of-pipe monitoring is feasible, the facility would need to demonstrate compliance with cyanide limitations, adjusted as necessary to account for dilution with non-cyanide-bearing wastewater, at a level above the detection limit.

The list of pollutants for which EPA proposes to require monitoring should be updated based on consideration of raw material and process changes throughout the facility and an annual scan for all pollutants in Table 16-1 for Subcategory A/C facilities. The annual scan should be performed at the compliance monitoring point(s) to identify any regulated pollutants in the wastewater.

Permit monitoring and compliance should be required at all monitoring locations for all pollutants detected at any locations.

Dischargers must use the test methods promulgated at 40 CFR Part 136.3 or incorporated by reference in the tables of that part, when available, to monitor pollutant discharges from the pharmaceutical manufacturing industry, unless specified otherwise in part 439 (see 40 CFR 401.13) or by the permitting authority.

As a part of the final rule, EPA promulgated additional test methods for the pollutants to be regulated under Part 439 for which there are no test methods listed at 40 CFR Part 136.3. To support the Part 439 regulations at the time of proposal, EPA published test methods developed specifically for the pharmaceutical industry in a compendium entitled, "Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewater," EPA-821-B-94-001. These test methods were discussed in the proposed rule and have been revised in response to public comment. The revised test methods are available for monitoring some pollutants covered by today's final rule. The revised test methods have been published in a revised compendium (the "Pharmaceutical Methods Compendium, Revision A;" EPA-821-B-98-016, 1998), with the same title as the proposed compendium.

In addition, EPA is allowing use of applicable drinking water methods that have been promulgated at 40 CFR Part 141 and use of ASTM Methods D3371, D3695, and D4763, for monitoring of the pollutants included in this rulemaking. The final rule allows for use of these additional test methods for several reasons: (1) it allows greater flexibility in monitoring; (2) it conforms use of methods in EPA's drinking water and wastewater programs; (3) it moves toward a performance-based measurement system; and (4) it allows use of technical standards as contemplated by the National Technology Transfer and Advancement Act of 1995 (NTTAA).

Table 16-1

Pollutants Regulated Under NSPS for Subcategory A and C Facilities

Conventional Pollutants	
BOD_5	TSS
Priority Pollutants	
Benzene	1,2-Dichloroethane
Chlorobenzene	Methylene chloride
Chloroform	Phenol
o-Dichlorobenzene (1,2-Dichlorobenzene)	Toluene
Cyanide [(a)]	
Nonconventional Pollutants	
Ammonia	n-Hexane
COD (Chemical Oxygen Demand)	Isobutyraldehyde
Acetone	Isopropanol
Acetonitrile	Isopropyl acetate
n-Amyl acetate	Isopropyl ether
Amyl alcohol	Methanol
n-Butyl acetate	Methyl cellosolve
Diethylamine	Methyl formate
Dimethyl Sulfoxide	Methyl isobutyl ketone (MIBK)
Ethanol	Tetrahydrofuran
Ethyl acetate	Triethylamine
n-Heptane	Xylenes

(a) Retaining cyanide effluent limits established in the 1983 final rule.

Table 16-2

Pollutants Regulated Under NSPS for Subcategory B and D Facilities

Conventional Pollutants	
BOD_5	TSS
Nonconventional Pollutants	
COD (Chemical Oxygen Demand)	

Table 16-3

NSPS for Subcategory A and C Operations

Pollutant or Pollutant Property	NSPS for In-Plant Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Cyanide[(a)]	33.5	9.4

(a) Cyanide effluent limit established in the 1983 Final Rule.

Pollutant or Pollutant Property	NSPS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
BOD_5	267	111
COD	1,675	856
TSS	472	166

Pollutant or Pollutant Property	NSPS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Ammonia as N	84.1	29.4
Acetone	0.5	0.2
Acetonitrile	25.0	10.2
n-Amyl Acetate	1.3	0.5
Amyl Alcohol	10.0	4.1
Benzene	0.05	0.02
n-Butyl Acetate	1.3	0.5
Chlorobenzene	0.15	0.06
Chloroform	0.02	0.01
o-Dichlorobenzene	0.15	0.06
1,2-Dichloroethane	0.4	0.1
Diethylamine	250.0	102.0
Dimethyl Sulfoxide	91.5	37.5
Ethanol	10.0	4.1
Ethyl Acetate	1.3	0.5
n-Heptane	0.05	0.02
n-Hexane	0.03	0.02
Isobutyraldehyde	1.2	0.5

Table 16-3 (Continued)

Pollutant or Pollutant Property	NSPS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Isopropanol	3.9	1.6
Isopropyl Acetate	1.3	0.5
Isopropyl Ether	8.4	2.6
Methanol	10.0	4.1
Methyl Cellosolve	100.0	40.6
Methylene Chloride	0.9	0.3
Methyl Formate	1.3	0.5
MIBK	0.5	0.2
Phenol	0.05	0.02
Tetrahydrofuran	8.4	2.6
Toluene	0.06	0.02
Triethylamine	250.0	102.0
Xylenes	0.03	0.01

Table 16-4

NSPS for Subcategory B and D Operations

Pollutant or Pollutant Property	NSPS for End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
BOD_5	35	18
COD	228	86
TSS	58	31

Table 16-5

Surrogates for Subcategory A/C Direct Dischargers (Biotreatment)

Group	Compound	Surrogate (yes/no)
Alcohols	Ethanol	Yes
	Isopropanol	Yes
	Methanol	Yes
	Phenol	No
	Amyl alcohol	No
Aldehdes	Isobutyraldehyde	No
Alkanes	n-Heptane	Yes
	n-Hexane	Yes
Amides & Amines	Triethylamine	No
	Diethylamine	No
Aromatics	Toluene	Yes
	Xylenes	Yes
	Chlorobenzene	No
	o-Dichlorobenzene	No
	Benzene	No
Chlorinated Alkanes	Methylene chloride	Yes
	Chloroform	Yes
	1,2-Dichloroethane	Yes
Esters & Ethers	Ethyl acetate	Yes
	Tetrahydrofuran	Yes
	Isopropyl acetate	No
	n-Amyl acetate	No
	Isopropyl ether	No
	n-Butyl acetate	No
	Methyl formate	No
Ketones	Acetone	Yes
	MIBK	No
Miscellaneous	Ammonia (aqueous)	No
	Acetonitrile	No
	Dimethyl sulfoxide	No
	Methyl cellosolve	No

Yes-Surrogate pollutant for that group
No-Not a surrogate pollutant for that group

REFERENCES

1. U.S. EPA, Office of Water. Statistical Support Document for the Effluent Limitations Guidelines for the Pharmaceutical Manufacturing Industry EPA-821-B-98-002. U.S. Environmental Protection Agency, Washington, D.C., 1998.

SECTION 17

PRETREATMENT STANDARDS FOR EXISTING SOURCES (PSES) AND PRETREATMENT STANDARDS FOR NEW SOURCES (PSNS)

17.1 Introduction

Pretreatment standards for existing sources are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. The CWA requires pretreatment for pollutants that pass through POTWs in amounts that would exceed direct discharge effluent limitations or limit POTW sludge management alternatives, including the beneficial use of sludges on agricultural lands. EPA also determines that there is pass through of a pollutant if the pollutant exhibits significant volatilization prior to treatment by POTWs. Pretreatment standards are to be technology-based and analogous to the BAT for removal of priority and nonconventional pollutants.

Section 307(c) of the CWA requires EPA to promulgate pretreatment standards for new sources at the same time that it promulgates NSPS. New indirect discharging facilities, like new direct discharging facilities, have the opportunity to incorporate the best available demonstrated technologies, including process changes and in-plant treatment technologies that reduce pollution to the maximum extent feasible. Pretreatment standards for new sources (see Section 16 for a discussion of the definition of new source) are to be technology-based and analogous to the NSPS for the removal of priority and nonconventional pollutants.

The owners or operators of facilities subject to PSES or PSNS are not required to use the specific process technologies and wastewater treatment technologies selected by EPA to establish the PSES or PSNS, but may choose to use any combination of process technologies and wastewater treatments to comply with permit limitations derived from the PSES or PSNS.

The Agency has selected in-plant steam stripping for organics and ammonia as the technology basis for the PSES for Subcategory A and C operations. The Agency has selected in-plant steam stripping for organics as the technology basis for the PSES for Subcategory B and D operations.

The Agency has selected in-plant steam stripping for organics and ammonia as the technology basis for PSNS for Subcategory A and C operations. The Agency also selected in-plant steam stripping for organics as the PSNS for Subcategory B and D operations. The rationale behind these selections is discussed in Section 11.

The Agency is making changes to the current PSES/PSNS effluent limitations set for cyanide in the October 27, 1983 regulation for the pharmaceutical manufacturing industry. Specifically, EPA is withdrawing the PSES/PSNS regulation for cyanide at Subcategory B and D facilities. EPA is retaining the existing PSES/PSNS regulations for cyanide at Subcategory A and C facilities. In addition, the Agency is clarifying that the existing in-plant cyanide limitations apply to Subcategory A and C facilities unless a facility can demonstrate compliance with the existing end-of-pipe cyanide limitations and standards with a measurable amount of cyanide in the facility's effluent. A facility effluent cyanide concentration of "not detect" is more likely to represent dilution instead of treatment and therefore, in these cases, the limitations and standards should be applied in-plant at the point of cyanide destruction.

The following information is presented in this section:

- Section 17.2 reviews the subcategories regulated by PSES and PSNS, the results of the Agency's POTW pass-through analysis to determine pollutants regulated by PSES and PSNS, and presents the selected PSES and PSNS; and
- Section 17.3 discusses PSES and PSNS implementation with regard to point of application, permit limitations, and monitoring and compliance issues.

17.2 Summary of PSES and PSNS

17.2.1 Regulated Subcategories

PSES and PSNS have been revised for Subcategories A, B, C, and D. As discussed in Section 4.3, Subcategories A, B, and C include wastewater discharges resulting from the manufacture of

pharmaceuticals by fermentation, biological or natural extraction processes, and chemical synthesis processes, respectively. Subcategory D includes discharges resulting from mixing, compounding, and formulating of pharmaceutical products.

17.2.2 POTW Pass-Through Analysis

The Agency has evaluated POTW pass through for those pollutants selected for regulation as listed in Section 6.6 and 6.7. In determining whether a pollutant is expected to pass through a POTW, the Agency assessed the following:

- Whether the pollutant would be volatilized from conveyance systems, equalization or other treatment units or POTW head works which are open to the atmosphere;
- Whether the nation-wide average percentage of a pollutant removed by well-operated POTWs achieving secondary treatment is less than the percentage removed by the BAT model treatment system; or
- Whether there are any specific instances of POTW interference, upset, or pass through known to the Agency as being caused by the pollutants selected for regulation.

For promulgation, EPA used an inclusive approach to determine pass through instead of a divided multi-pronged approach when considering pass through criteria. At proposal and for the NOA, EPA considered whether a pollutant would readily volatilize to the air prior to treatment or whether a pollutant would pass through based on the BAT/POTW pollutant percent removal comparison. If a pollutant met the pass-through criteria for either of these criteria, the pollutant was considered to pass through. For promulgation, EPA adopted a more unified approach where a pollutant needed to meet the pass through criteria based on pollutant volatility, solubility, and the BAT/POTW pollutant percent removal comparison in order to be considered to pass through. The approach was developed in consideration of the unique characteristics of pharmaceutical industry wastewater, and the attributes of the selected BAT and PSES technology bases. Lastly, pollutants known to cause treatment problems at POTWs accepting pharmaceutical manufacturing wastewaters were considered for regulation.

Presented below are brief descriptions of PSES pass-through analysis methodologies utilized for proposal and the NOA as well as a more detailed discussion of the methodology and results of the adopted PSES pass-through analysis used for the final regulation.

17.2.2.1 May 2, 1995 Approach

In the May 2, 1995 proposal, the Agency used a two-pronged approach for identifying pollutants that potentially pass through POTWs. This approach consisted of the volatility override and POTW percent removal in comparison with the BAT percent removal. Both criteria were carried through for the final POTW pass-through analysis, with some modifications to the data editing.

Pollutant Volatility Analysis

POTW pass-through was assumed to occur for those compounds with significant volatilization in the collection systems and head works of POTWs, thereby reducing the amount of organics that can be biodegraded in the POTW secondary treatment works. In evaluating a pollutant's volatility, EPA looked at the pollutant's Henry's Law Constant, the emissions predicted for that pollutant by WATER7 modeling for direct dischargers (1), and whether the pollutant was identified as a wastewater pollutant requiring control in the Hazardous Organic NESHAP (HON) (59 FR 19402, 4/22/94) (2).

Based on the analysis of Henry's Law Constants, the estimate of pollutant air emissions from the WATER7 fate analysis at direct dischargers and the inclusion of pollutants in the HON wastewater provisions, those pollutants with a Henry's Law Constant equal to or greater than that of methanol (1.0 x 10-6 atm/gmole/m3) were identified as being volatile. These pollutants were determined to potentially be volatilized to the air before reaching treatment at POTWs and were therefore considered to pass through.

BAT and POTW Percent Removal Analysis

The traditional pass-through analysis evaluates the percentage removal of a pollutant in POTWs nationwide with the proposed BAT percent removal for the same pollutant. In evaluating the POTW percent removal nationwide, EPA primarily used the Domestic Sewage Study Report (3) as well as other sources of bench- and pilot-scale biological treatment performance data. The Agency used pollutant loading information provided by the industry in their 1990 detailed questionnaire responses and the long-term mean treatment performance concentrations developed for each pollutant after application of the BAT treatment technology(ies) in developing BAT percent removal values.

POTW pollutant percent removals were determined either from specific sources or by transfer of a POTW percent removal from a similar constituent when data were not available. POTW percent removal data were collected from the following sources: The Domestic Sewage Study (DSS), sampling episode report for the Syracuse POTW, and the US EPA Risk Reduction Engineering Laboratory (RREL) Treatability Database (4). BAT pollutant percent removals were determined using the raw loadings data (represented as the sum of the pollutant load from air emissions from wastewater prior to discharge, discharges to surface water, or degraded/destroyed on-site) and the effluent loadings data (calculated from the proposed BAT long-term mean treatment performance concentrations, facility wastewater flow, and appropriate conversion factors) that would be achieved if BAT were in place at these facilities. A percent removal was then determined between the raw and effluent loads for each candidate pollutant. A load weighted average percent removal was calculated to represent nationwide BAT percent removal where multiple direct discharging facilities were discharging the same pollutant of concern.

Evidence of Pass-Through

In February 1993, EPA sent a survey to nine POTWs known to receive pharmaceutical manufacturing industry discharges. These responses were reviewed to identify pharmaceutical candidate pollutants from pharmaceutical plants that may be causing upsets or pass-through at POTWs. In addition, data collected by EPA from the Syracuse POTW and data submitted

previously to EPA by the Syracuse POTW were also reviewed for evidence of pollutants that may cause POTW upset or pass through. Based on these reviews, POTW personnel have reported POTW interference or upset by discharges from pharmaceutical facilities of ammonia, tetrahydrofuran, and dimethyl sulfoxide (5).

17.2.2.2 August 8, 1997 NOA Approach

EPA used the same basic approach for determining pollutant POTW pass-through for the NOA as at proposal. EPA considered pollutant volatility, BAT pollutant percent removal compared to POTW pollutant percent removal, and potential POTW upsets. The following paragraphs note the revisions made to the original POTW pass-through analysis upon receiving public comments to the proposal and additional data.

Pollutant Volatility

EPA considered three options for the volatile override approach for the NOA. The first option was to have the override cutoff at a Henry's Law Constant of 1.0×10-5 atm/gmole/m3 based on the precedent in the OCPSF rulemaking (52 FR 42522). The second option was to have an override cutoff based on a Henry's Law Constant of 1.0×10-4 atm/gmole/m3. The last option was to eliminate the volatility override approach. The three options were considered in response to commenters who opposed the proposed cutoff claiming it was too low.

Percent Removal Analysis

EPA made modifications to its BAT pollutant percent removal and POTW pollutant percent removal analyses based on comments from the industry and acquired new data.

BAT Percent Removal

The following modifications were made to the proposal BAT pollutant percent removal calculations:

1. Facility data sets that had an influent load less than ten times the proposed option load were removed from consideration;

2. BAT percent removal was calculated for each facility pollutant combination, and the median percent removal for each pollutant was used to compare with the POTW percent removal; and

3. Three different options, each considered as the basis for BAT were used to determine POTW pass-through. The first option included steam stripping followed by advanced biological treatment; the second, biological treatment; and the third, based on EPA's OAQPS percent removal of partially soluble/ soluble pollutants assuming 99% and 90% removal, respectively.

POTW Percent Removal

The following modifications were made to the POTW pollutant percent removal calculations:

1. Unacclimated DSS data were discarded from further evaluation and acclimated DSS data were used;

2. Data sets were edited so that influent concentrations less than ten times the detection limit were discarded from further evaluation (this did not apply to the acclimated DSS data because raw data from the DSS are not available);

3. DSS data were compared with other POTW sources and EPA determined that the data showed no significant differences between the percent removals achieved by the DSS POTWs and the POTWs submitting their own data. Therefore, the DSS percent removals were considered reliable;

4. The nationwide POTW pollutant percent removal was calculated as the median of all acclimated POTW data submitted; and

5. The data transfers made from secondary alcohols to primary alcohols were evaluated. Transfers to primary alcohols were revised such that the transfers were made from a primary alcohol.

Comparison of BAT and POTW Percent Removals

EPA considered differential ranges between BAT pollutant percent removal and POTW pollutant percent removal, assuming that once the percent removals were within a certain range of each other, they were essentially equivalent. Differential ranges of 2% and 5% were considered equivalent to a no pass-through determination. That is, if the POTW removal percentage was within 2 or 5 percent of the BAT removal percentage for a pollutant, the pollutant would be determined not to pass through.

17.2.2.3 Adopted Approach

After reviewing the public comments received on the August 8, 1997 NOA pass-through methodology evaluation, the Agency again examined its methodology and instituted a final set of changes. The Agency modified its two-pronged approach to a more inclusive approach and several criteria were met before a pollutant was determined to pass through a POTW. These criteria included: a volatility analysis, an evaluation of solubility in water, and a BAT and POTW pollutant percent removal comparison. Again, this approach was developed in consideration of the unique characteristics of pharmaceutical industry wastewater.

Volatility Analysis

Consistent with the OCPSF, Pesticides, and Central Waste Treaters (CWT) rule, EPA considered pollutants with a Henry's Law Constant greater than 1.0x10-5 atm/gmole/m3 to significantly volatilize to the air before reaching treatment at a POTW. This cutoff level is greater than the cutoff level presented at proposal and addresses commenters concerns that the proposal cutoff level was too low. The list of organic pollutants that EPA has determined pass through POTWs based on this criterion are shown in Table 17-1.

BAT and POTW Percent Removal Comparison

The Agency evaluated the percentage removed by the BAT model treatment systems using the detailed questionnaire data submitted by direct dischargers and the long-term mean treatment performance concentrations developed for the BAT treatment technology as discussed in Section 8. At the time of the NOA, data pairs with raw influent loads less than ten times the proposed option load were removed from the analysis. For promulgation, EPA modified this approach so that all pollutant data sets were edited to remove data pairs with raw influent concentrations less than ten times the pollutant detection limit. The adopted approach better indicates whether pollutants are present in raw wastewater at treatable levels. The approach used at the NOA for determining median BAT pollutant percent removal was also adopted for the final rule.

The sources of the average percentage of a pollutant removed by well-operated POTWs achieving secondary treatment included the acclimated percent removals reported in the Domestic Sewage Study, data from the 40 Plant Study, the USEPA Risk Reduction Engineering Laboratory Treatability Database (RREL), and various reports of POTW performance submitted to EPA prior to and after the May 2, 1995 proposal. The data editing criteria used at the NOA for editing POTW percent removals were not modified for the final rule. The list of organic pollutants that EPA has determined pass-through POTWs based on this criterion are also shown in Table 17-1.

The Agency decided not to use a 2 or 5 percent differential and concluded that the most reasonable approach is to accept the available data as the best information on the relative percent removals of BAT and POTWs and to perform a BAT/POTW comparison directly based on that data. EPA decided that such an approach was unbiased in that it does not favor either the over-statement or under-statement of pass-through for the pollutants.

Water Soluble Compounds

The Agency used several sources to evaluate the fate of alcohols and related compounds in pharmaceutical manufacturing wastewater treatment systems. For the purpose of this analysis,

water soluble compounds are alcohols or related compounds that are biodegradable and are no more strippable than amyl alcohol (based on a Henry's Law Constant cutoff of 2.23×10^{-5} atm/gmole/m^3). EPA adopted this approach in order to be consistent with the MACT standards which state that water soluble compounds are less likely to volatilize than compounds that are partially soluble. The following data sources were used in this analysis:

- EPA and Pharmaceutical Research and Manufacturers Association (PhRMA) wastewater samples collected from the primary treatment works at the Barceloneta POTW in Barceloneta, Puerto Rico;
- WATER8 air emissions modeling of the Barceloneta POTW;
- An industry submitted literature study evaluating volatilization potential in sewers; and
- An industry submitted study evaluating volatilization potential in an enclosed equalization tank.

EPA and PhRMA conducted sampling at the Barceloneta POTW to obtain data on the removal of alcohols (methanol, ethanol, and isopropanol) and other oxygenates in the primary treatment works of a POTW. The Barceloneta POTW was selected for sampling because the influent wastewater to this POTW was known to contain measurable quantities of alcohols and other pollutants for which pretreatment standards were proposed in May 1995. Three separate sampling episodes were conducted at this POTW. They consisted of:

- In August 1996, EPA and PhRMA collected wastewater samples from the influent to the treatment system, the effluent from the aerated grit chamber, and the effluent from the primary clarifier. EPA's lab analyzed the results using analytical Method 1671, whereas PhRMA's lab analyzed the results using Method 8015. EPA performed a biodegradation study to determine the extent to which pollutants were aerobically biodegraded in the aerated grit chambers.
- In April 1997, PhRMA conducted an anaerobic (anoxic) biodegradation study on the primary clarifier influent using Methods 1671 and 8015. EPA used the data obtained from Method 1671 to determine the overall biodegradation and volatilization rates associated with the August 1996 data.

- In August 1997, PhRMA conducted additional sampling around the primary clarifier to determine if more frequent sampling would explain all or part of the alcohol losses measured in the August 1996 study.

Samples were collected in the influent and effluent from treatment units. Percent loss across the treatment units was calculated from the influent and effluent mass from the unit. Percent losses were assumed to be due to two major fate pathways: biodegradation and volatilization. Knowing the overall percentage loss and the loss estimated to be attributed to biodegradation (both aerobic and anoxic), EPA estimated the percent of loss attributed to volatilization. The sampling results shown in Table 17-2 indicate the range of percent loss of alcohols in the primary treatment units due to volatilization.

In addition, EPA performed WATER8 air emissions modeling of the Barceloneta POTW using the sampled pollutant influent concentrations in order to obtain an estimate of how much volatilization of volatile organic pollutants occurs throughout the entire POTW system (6). The results of the modeling study shown in Table 17-3 show less volatilization in the primary treatment portion than the measured data from the Barceloneta POTWs sampling episode suggests.

EPA also evaluated an industry submitted study evaluating sewer losses for water soluble compounds. The results of this study indicate that volatilization of methanol and ethanol in closed sewers is expected to be minimal with maximum emission rates of 0.03 and 0.19% being projected under most sewer conditions, respectively. However, under open sewer conditions, volatilization percentages of methanol and ethanol could be as high as 6.5 and 20%, respectively (7).

Since the August 8, 1997 NOA, EPA also has received information on a study conducted by Pfizer at its Groton, CT production facility to analyze the volatilization of methanol from their enclosed equalization tank (primary treatment at their biological treatment system). The equalization tank is covered and vented to a combustion device and is mixed with a jet aeration system. The headspace of the tank is under negative pressure due to an induced airflow by an auxiliary combustion blower downstream of the tank vent. The study included air samples to

determine the concentration of the selected organics in the head space of the equalization tank and influent and effluent wastewater samples.

The results of the above study show an average methanol concentration of 500 mg/L in the equalization tank and an average vent gas methanol concentration of 70 ppmv. This results in a volatilization loss of methanol of 0.31% (assuming that the only loss of methanol in the tank is volatilization).

POTW Pass-Through Determination

Based on EPA's review of the total body of measurement and modeling data, data from other POTWs, a facility submitted equalization study, literature articles submitted by commenters, and facility submitted data for on-site wastewater treatment systems related to the volatilization of water soluble organics in pharmaceutical manufacturing industry wastewater, EPA has concluded that these pollutants will not volatilize to a significant extent to the air prior to treatment and are biodegraded in POTWs. Although these data sources yield conflicting information as to the extent of volatilization and biodegradation in primary and secondary treatment, most results show at least 90% treatment (biodegradation) of alcohols (not including volatilization). This percentage is in accordance with the 90% treatment required by the MACT for soluble HAPs and is equivalent to the losses likely occurring at direct discharger biological treatment systems. Therefore, EPA concludes that alcohols and related compounds will not pass through. The list of organic pollutants that EPA has determined pass-through POTWs based on this criterion are also shown in Table 17-1.

Organic pollutants that meet the pass-through criteria based on volatility, the BAT/POTW percent removal comparison, and solubility in water were selected for regulation for indirect dischargers.

Of the three pollutants (dimethyl sulfoxide, tetrahydrofuran, and ammonia) identified as problem pollutants from the 1993 POTW survey, dimethyl sulfoxide is a pollutant that is not treated by steam stripping, the technology basis for PSES and PSNS, and EPA has not promulgated pretreatment standards for this pollutant. Tetrahydrofuran is found to pass through POTWs since

it meets the before mentioned pass-through criteria. Ammonia is considered to pass through because many POTWs do not have nitrification capability that is part of the BAT model treatment system and therefore they will not achieve as much ammonia removal as the BAT model treatment system. However, EPA concluded that ammonia does not pass through for indirect discharging facilities that discharge to POTWs with nitrification capabilities based on an evaluation of EPA and POTW nitrification data. Thus, PSES ammonia limitations will not apply to Subcategory A and C facilities discharging to POTWs with well-operated nitrification systems. POTWs with nitrification capability are defined as being able to oxidize ammonium salts to nitrites (via nitrosamas bacteria) and then further oxidize nitrites to nitrates (via nitribacter bacteria) and achieve greater removals of ammonia than POTWs without nitrification. Nitrification can be accomplished in either a singe or two-stage activated sludge system. Indicators of nitrification capability are 1) biological monitoring for ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) to determine if nitrification is occurring, and 2) analysis of the nitrogen balance to determine if nitrifying bacteria reduce the amount of ammonia and increase the amount of nitrite and nitrate.

EPA did receive and review data to determine whether COD should be considered to pass through POTWs. EPA has determined based on its data that COD does not pass through POTWs and is not regulating COD under PSES or PSNS. With regard to the priority pollutant cyanide, EPA found that this pollutant passes through POTWs because the removal of cyanide by the BAT cyanide destruction systems is significantly greater than the documented removals by well-operated POTWs achieving secondary treatment. For a detailed discussion of the Agency's POTW pass-through analysis see the memorandum entitled, "Final POTW Pass-Through Analysis for the Pharmaceutical Manufacturing Industry" (8) which is located in the Record for this rulemaking.

17.2.3 Regulated Pollutants

Section 6.0 of this document discusses potential pollutants to regulate for the pharmaceutical manufacturing industry. The set of potential pollutants to regulate for Subcategory A and C

dischargers is different from the set of potential pollutants to regulate for Subcategory B and D dischargers. EPA separately applied the pass-through criteria to both sets to determine the final list of regulated pollutants for each respective subcategory. EPA is regulating 24 priority and nonconventional pollutants (including ammonia, where applicable, and cyanide) for indirect dischargers in Subcategories A and C. EPA is regulating 5 priority and nonconventional pollutants for indirect dischargers in Subcategories B and D.

The final PSES and PSNS establish effluent standards for the priority and nonconventional pollutants listed in Table 17-4 for indirect discharges in Subcategories A, B, C, and D.

17.2.4 PSES and PSNS

The effluent limitations for PSES and PSNS for each subcategory are based on a combination of long-term mean treatment performance concentrations and variability factors that account for day-to-day variation in measured treated effluent concentrations. Long-term mean treatment performance concentrations, discussed in Section 8, are target values that a facility should achieve on a long-term, average basis. The variability factors, discussed in the Statistical Support Document (9), which is located in the Record for this rulemaking, represent the ratio of an elevated value that would be expected to occur only rarely to the long-term mean. The purpose of the variability factor is to allow for variations in effluent concentrations that comprise the long-term mean. A facility that designs and operates its treatment system to achieve a long term mean on a consistent basis should be able to comply with the daily and monthly limitations in the course of normal operations.

The PSES are the same for Subcategories A and C, and then the same for Subcategories B and D. The same is true for PSNS. The PSES and PSNS for Subcategories A and C are presented in Table 17-5. The PSES and PSNS for Subcategories B and D are presented in Table 17-6. These standards were determined by multiplying the long-term mean treatment performance concentrations for the selected treatment technology bases by the respective 1-day and 4-day variability factors (VFs).

The PSES/PSNS for diethylamine, methyl cellosolve, and triethylamine are based on the analytical method minimum level. The minimum level for a pollutant is the level at which an analytical system gives recognizable signals and an acceptable calibration point. For pollutants with a long-term mean below the minimum level, typically in cases where treatment performance was established through data transfer, the final long-term mean was set at a value no lower than the minimum level for the pollutant. The final pretreatment standards are determined by applying 1-day and 4-day variability factors to the final long-term means.

The PSES/PSNS cyanide effluent standard, established in the 1983 Final Rule to be a daily maximum of 33.5 mg/L and a maximum monthly average of 9.4 mg/L for all subcategories, is not being revised for Subcategories A and C. The cyanide limit is being withdrawn for Subcategories B and D because EPA has determined that cyanide is neither used nor generated by facilities with these subcategory operations.

The PSES/PSNS ammonia standard for Subcategory A and C operations that discharge to non-nitrifying POTWs is being set equal to the corresponding BAT ammonia effluent limit. EPA has decided to set the PSES/PSNS ammonia standard at a level higher than the standards based on steam stripping treatment performance data in response to commenters who want to be able to comply with the ammonia standards at indirect dischargers using biological treatment with nitrification technology.

17.3 Implementation of the PSES and PSNS

The PSES and PSNS standards for Subcategory A and C and Subcategory B and D operations are presented in Tables 17-5 and 17-6, respectively.

17.3.1 Establishing List of Pollutants for Compliance Monitoring

Permitting authorities should establish permit limitations and compliance monitoring requirements for each regulated pollutant listed in Table 17-4, generated or used at a pharmaceutical manufacturing facility. Limitations and routine compliance monitoring should not be required for

regulated pollutants not generated or used at a facility. A determination that regulated pollutants are not generated or used should be based on a review of all raw materials used and an assessment of all chemical processes used, considering resulting products and by-products. The determination that a regulated pollutant is not generated or used would need to be confirmed by annual chemical analyses of wastewater from each monitoring location. Such confirmation would be provided by an analytical measurement of a non-detect value.

Facilities discharging more than one regulated organic pollutant may monitor for a single surrogate pollutant to demonstrate an appropriate degree of control for a specified group of pollutants. For the purpose of identifying surrogates, pollutants are grouped according to treatability classes; Table 17-7 presents the treatability classes identified for steam stripping, which is the PSES/PSNS technology basis for organic pollutant limitations. For treatability classes with more than one possible surrogate pollutant, the analyte with the highest concentration or loadings should be chosen as the surrogate pollutant. Plants may monitor for a surrogate pollutant(s) only if they demonstrate that all other pollutants receive the same degree of treatment.

An individual plant may choose to demonstrate by selecting a monitoring pollutant for a given treatability class and maintaining documentation, including flow information and sampling results, that all pollutants in that treatability class receive equivalent treatment. The documentation is then submitted to the permit authority for approval.

17.3.2 Point of Application

The PSES and PSNS standards for wastewaters from Subcategory A, B, C, and D operations are applicable at an end-of-pipe discharge point for all pollutants (except cyanide), as denoted in Tables 17-5 and 17-6. The end-of-pipe monitoring point should be placed prior to discharge to the POTW sewer system. Cyanide should be monitored in-plant for Subcategory A and C wastewaters unless a facility can show a measurable amount of cyanide at end-of-pipe, instead of a non-detect in accordance with 40 CFR 403.6 (e)(2) and 403.6 (e)(4).

17.3.3 Permit Limitations

End-of-pipe permit limitations based on the PSES and PSNS limitations for ammonia (for Subcategories A and C) and organic constituents will be mass-based. To determine PSES and PSNS limits, permit writers should use a reasonable estimate of process wastewater discharge flow and the concentration-based standards listed in Tables 17-5 and 17-6 to develop mass-based permit limitations. Section 15.3.3 presents guidance regarding how a reasonable estimate of process wastewater discharge flow would be established after final PSES and PSNS are adopted.

EPA expects that permit limitations for cyanide, based on the 1983 PSES limitations, at in-plant locations will be concentration-based, and not converted to a mass basis. A concentration basis should be used for cyanide because it offers a direct benchmark to assess whether the in-plant control technology is achieving the intended PSES and PSNS levels. In-plant wastestreams that require control may be generated or treated on a variable, batch basis. In such a setting, mass-based permit limitations are difficult to establish accurately, and compliance is hindered because the permitted facility cannot make a direct measurement to determine if its control technology is performing at the required level. Concentration-based permit limitations eliminate these problems and offer a direct measure of cyanide to both the permitting authority and the permitted facility that PSES and PSNS performance levels are being achieved.

17.3.4 Monitoring and Compliance

The compliance monitoring frequency for ammonia and all other regulated organic constituents should be performed on a frequency basis established by a permit writer or pretreatment authority. EPA's monitoring costs for this regulation assumed compliance monitoring for ammonia (for Subcategory A and C facilities) and all regulated organic constituents on a weekly basis for Subcategory A, B, C, and D facilities. The list of pollutants for which monitoring will need to be performed includes all constituents from Subcategory A, B, C, and D operations listed in Table 17-4 generated or used in pharmaceutical manufacturing processes at the facility unless the facility discharges ammonia to a POTW with nitrification capabilities in which case an ammonia no pass-through determination may apply. Monitoring of regulated constituents generated or used in any

pharmaceutical manufacturing processes at the facility would occur at every process wastewater end-of-pipe discharge point for compliance with PSES and PSNS effluent standards.

Compliance with mass-based permit limitations is determined by multiplying the measured concentrations of a regulated pollutant in the effluent sample by a conversion factor and the total wastewater flow at the monitoring point during the effluent sampling period. Thus, the mass compliance value should be based on the total flow discharged on the day of sampling, not on the long-term average flow rate that provided the basis for establishing the permit limitations.

Compliance monitoring for cyanide should occur in-plant, prior to commingling or dilution with non-cyanide-bearing wastewater, unless a facility can show end-of-pipe monitoring for cyanide is feasible. To show that end-of-pipe monitoring is feasible, the facility would need to demonstrate compliance with cyanide limitations, adjusted as necessary to account for dilution with non-cyanide-bearing wastewater, at a level above the detection limit for cyanide.

The list of pollutants for which monitoring would be required should be updated based on consideration of raw material and process changes throughout the facility and an annual scan for all regulated pollutants listed in Table 17-4. The annual scan should be performed at the compliance monitoring point(s) to identify any regulated pollutants in the wastewater. Permit monitoring and compliance should be required at all monitoring locations for all pollutants detected at any locations.

Dischargers must use the test methods promulgated at 40 CFR Part 136.3 or incorporated by reference in the tables of that Part, when available, to monitor pollutant discharges from the pharmaceutical manufacturing industry, unless specified otherwise in Part 439 (See 40 CFR 401.13) or by the permitting authority.

As a part of the final rule, EPA promulgated additional test methods for the pollutants to be regulated under Part 439 for which there are no test methods listed at 40 CFR Part 136.3. To support the Part 439 regulations at the time of proposal, EPA published test methods developed

specifically for the pharmaceutical industry in a compendium entitled, “Analytical Methods for the Determination of Pollutants in Pharmaceutical Manufacturing Industry Wastewater,” EPA-821-B-94-001. These test methods were discussed in the proposed rule and have been revised in response to public comment. The revised test methods are available for monitoring some pollutants covered by the final rule. The revised test methods are available for monitoring some pollutants covered by the final rule. The revised test methods have been published in a revised compendium (the “Pharmaceutical Methods Compendium, Revision A”; EPA-821-B-98-016, 1998) with the same title as the proposed compendium.

In addition EPA is allowing use of applicable drinking water methods that have been promulgated at 40 CFR Part 141 and use of ASTM Methods D3371, D3695, and D4763, for monitoring of the pollutants included in this rulemaking. The final rule allows for use of these additional test methods for several reasons: (1) it allows greater flexibility in monitoring, (2) it conforms use of methods in EPA’s drinking water and wastewater programs, (3) it moves toward a performance-based measurement system, and (4) it allows use of technical standards as contemplated by the National Technology Transfer and Advancement Act of 1995 (NTTAA).

Table 17-1

Organic Pollutants Considered for Regulation That Pass Through POTWs

Pollutant	Passes Through Based on Volatilization Potential (a)	Passes Through Based on Water Soluble Compound Analysis	Passes Through Based on Evaluation of % POTW Removal
Acetone	X	X	X
Acetonitrile (b)			X
n-Amyl acetate	X	X	X
Amyl alcohol	X		X
Benzene	X	X	X
n-Butyl acetate	X	X	X
tert-Butyl alcohol	X		X
Chlorobenzene	X	X	X
Chloroform	X	X	X
o-Dichlorobenzene (1,2-Dichlorobenzene)	X	X	X
1,2-Dichloroethane	X	X	X
Diethylamine	X	X	X
N,N-Dimethylaniline	X		
Dimethyl sulfoxide (b)			X
Ethanol			X
Ethyl acetate	X	X	X
Formamide	X		X
n-Heptane	X	X	X
n-Hexane	X	X	X
Isobutyraldehyde	X	X	X
Isopropanol			X
Isopropyl acetate	X	X	X
Isopropyl ether	X	X	X
Methanol			X
Methyl cellosolve	X	X	NA
Methylene chloride	X	X	X
Methyl formate	X	X	X
Methyl isobutyl ketone (MIBK)	X	X	X

Table 17-1 (Continued)

Pollutant	Passes Through Based on Volatilization Potential (a)	Passes Through Based on Water Soluble Compound Analysis	Passes Through Based on Evaluation of % POTW Removal
Phenol (b)			
n-Propanol			X
Pyridine			X
Tetrahydrofuran	X	X	X
Toluene	X	X	X
Triethylamine	X	X	X
Xylenes	X	X	X

(a) Assumes a volatile override cutoff of Henry's Law Constant $\geq$ 1 x 10^{-5} atm/gmole/m^3.
(b) These pollutants are not treatable by the PSES/PSNS technology and are not regulated under PSES/PSNS in the final rule.
NA - No POTW % removal available.

Table 17-2

EPA and PhRMA Sampling Results for Primary Treatment at Barceloneta POTW Data from Method 1671

Pollutant	1996 Primary Treatment Data (Aerated Grit Chamber + Primary Clarifier)		1996 Primary Clarifier Only Data		1997 Primary Clarifier Only Data	
	Percent Loss	Percent Volatilization	Percent Loss	Percent Volatilization	Percent Loss(a)	Percent Volatilization (a)
Methanol	19.1	14.2-16.1	8.1	7.9-8.0	4.5-6.8	4.4-6.7
Ethanol	25.3	4.1-8.8	15.2	4.7-10.0	51.2-59.8	37.3-52.7
Isopropanol	11.4	0.0-5.1	5.9	0.0-5.5	10.8-18.2	8.3-13.4

(a) The ranges shown represent the average loss or volatilization amounts on Day 1 and 2, respectively.

Table 17-3

Water8 Modeling Results for Primary and Secondary Treatment at BRWTP

Pollutant	Percent Volatilization in Primary %	Percent Biodegradation in Primary %	Percent Volatilization in Secondary %	Percent Biodegradation in Secondary %	Percent Overall Volatilization %	Percent Overall Biodegradation %
Methanol	2.1	0.0	2.0	90.8	4.0	90.5
Ethanol	2.2	0.0	0.5	97.7	2.7	92.9
Isopropanol	4.2	0.0	10.8	74.0	14.3	77.0
Acetone	8.0	0.0	3.2	94.9	10.7	84.8
Chloroform	40.9	0.0	58.7	40.5	71.2	23.9
Methylene Chloride	38.9	0.0	70.4	28.6	78.2	17.8
Toluene	46.1	0.0	36.9	62.7	60.4	32.4

Note: Volatilization and biodegradation percentages may not add up to 100% since some of the compound remains in the effluent and some goes out with the sludge.

Table 17-4

Pollutants to be Regulated Under PSES and PSNS

Pollutant	Subcategories A and C	Subcategories B and D
Priority Pollutants		
Cyanide (a)	X	
Benzene	X	
Chlorobenzene	X	
Chloroform	X	
o-Dichlorobenzene (1,2-Dichlorobenzene)	X	
1,2-Dichloroethane	X	
Methylene Chloride	X	X
Toluene	X	
Non-Conventional Pollutants		
Acetone	X	X
Ammonia as N (b)	X	
n-Amyl Acetane	X	X
n-Butyl Acetate	X	
Diethylamine	X	
Ethyl Acetate	X	X
n-Heptane	X	
n-Hexane	X	
Isobutraldehyde	X	
Isopropyl Acetate	X	X
Isopropyl Ether	X	
Methyl Cellosolve Methyl Formate	X	
Methyl isobutyl ketone (MIBK)	X	
Tetrahydrofuran	X	
Thethylamine	X	
Xylenes	X	

(a) EPA is only clarifying the monitoring point on the existing regulation.
(b) Ammonia is only regulated for indirect dischargers that discharge to non-nitrifying POTWs.

Table 17-5

PSES and PSNS Effluent Limitations for Subcategory A and C Operations

Pollutant or Pollutant Property	PSES/PSNS for In-Plant Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Cyanide (1)	33.5	9.4

(1) Cyanide effluent limit established in the 1983 final rule, applies to Subcategory A and C operations only.

Pollutant or Pollutant Property	PSES Effluent Limitations End-of-Pipe Monitoring Points	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	20.7	8.2
Ammonia as N (2)	84.1	29.4
n-Amyl Acetate	20.7	8.2
Benzene	3.0	0.6
n-Butyl Acetate	20.7	8.2
Chlorobenzene	3.0	0.7
Chloroform	0.1	0.03
o-Dichlorobenzene	20.7	8.2
1,2-Dichloroethane	20.7	8.2
Diethylamine	255.0	100.0
Ethyl Acetate	20.7	8.2
n-Heptane	3.0	0.7
n-Hexane	3.0	0.7
Isobutyraldehyde	20.7	8.2
Isopropyl Acetate	20.7	8.2
Isopropyl Ether	20.7	8.2
Methyl Cellosolve	275.0	59.7
Methylene Chloride	3.0	0.7
Methyl Formate	20.7	8.2
MIBK	20.7	8.2
Tetrahydrofuran	9.2	3.4
Toluene	0.3	0.1
Triethylamine	255.0	100.0
Xylenes	3.0	0.7

(2) Ammonia is only regulated for indirect dischargers that discharge to non-nitrifying POTWs.

Table 17-6

PSES and PSNS Effluent Limitations for Subcategory B and D Operations

Pollutant or Pollutant Property	PSES Effluent Limitations End-of-Pipe Monitoring Point	
	Maximum for any 1 day mg/L	Monthly Average mg/L
Acetone	20.7	8.2
n-Amyl Acetate	20.7	8.2
Ethyl Acetate	20.7	8.2
Isopropyl Acetate	20.7	8.2
Methylene Chloride	3.0	0.7

Table 17-7

Steam Stripping Surrogates for Indirect Dischargers

Strippability Group	Compound	Surrogate (Yes/No)
High	Methylene Chloride	Yes
	Toluene	Yes
	Chloroform	Yes
	Methyl Cellosolve	No
	Xylenes	No
	n-Heptane	No
	n-Hexane	No
	Chlorobenzene	No
	Benzene	No
Medium	Acetone	Yes
	Ammonia as N	Yes
	Ethyl acetate	Yes
	Tetrahydrofuran	Yes
	Triethyamine	No
	MIBK	No
	Isopropyl acetate	No
	Diethylamine	No
	1,2-Dichloroethane	No
	n-Amyl acetate	No
	Isopropyl ether	No
	n-Butyl acetate	No
	Methyl formate	No
	Isobutraldehyde	No
	o-Dichlorobenzene	No

Yes-Surrogate pollutant for that strippability group.
No-Not a surrogate pollutant.

REFERENCES

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