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Development Document for Effluent Limitations Guidelines and Standards for the

Final

Textile Mills

Point Source Category

DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS

for the

TEXTILE MILLS POINT SOURCE CATEGORY

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ABSTRACT

This document presents the findings of an extensive study of the textile industry for the purpose of developing effluent limitations for existing point sources, standards of performance for new sources, and pretreatment standards for existing and new sources to implement Sections 301, 304, 306, and 307 of the Clean Water Act. The study covers approximately 6,000 textile manufacturing facilities in SIC Major Group 22 of which approximately 2,000 are specifically affected by the findings.

Effluent limitation guidelines are set forth for the degree of effluent reduction attainable through the application of the best practicable control technology currently available (BPT), and the best available technology economically achievable (BAT) and the best conventional pollutant control technology (BCT) which must be achieved by existing point sources by July 1, 1984. Standards of performance for new sources (NSPS) set forth the degree of effluent reduction that is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives. Pretreatment standards for existing and new sources (PSES and PSNS) set forth the degree of effluent reduction that must be achieved in order to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs.

BPT regulations for new subcategories are established based on biological treatment. The regulations for BAT are equal to existing BPT for toxic and nonconventional pollutants. NSPS are based on biological treatment as demonstrated by the best performing mills in the industry. The regulations for PSES and PSNS shall be the General Pretreatment Regulations at 40 CFR Part 403, 43 FR 27736 (June 26, 1978) and at 46 FR 9462 (January 28, 1981).

Supporting data, rationale, and methods for development of the effluent limitation guidelines and standards are contained in this document.

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SECTION I

EXECUTIVE SUMMARY

SUBCATEGORIZATION

For the purpose of establishing effluent limitations guidelines for existing sources, standards of performance for new sources and pretreatment standards for new and existing sources, the textile mills point source category has been subcategorized as follows:

- Wool Scouring
- Wool Finishing
- Low Water Use Processing (formerly Dry Processing)
- Woven Fabric Finishing
- Knit Fabric Finishing
- Carpet Finishing
- Stock and Yarn Finishing
- Nonwoven Manufacturing
- Felted Fabric Processing

The subcategorization scheme from previous rulemaking was reviewed, taking into account all available information. Factors such as age, size of plant, location, raw material, process employed, products and waste treatability were considered in reviewing the adequacy of the original subcategorization scheme. This review resulted in the establishment of a new subdivision of an existing subcategory (water jet weaving in the low water use processing subcategory) and two new subcategories (nonwoven manufacturing and felted fabric processing).

The water jet weaving subdivision of the low water use processing subcategory (formerly the dry processing subcategory) has been established to account for mills using this new process. The nonwoven manufacturing and felted fabric processing subcategories have been added to account for these distinct processing operations.

In the woven fabric finishing subcategory, simple, complex and desizing subdivisions have been developed for NSPS that reflect those processing differences. For BAT, allowances for complexity of processing, fiber type and commission finishing remain the same as for BPT effluent limitations.

Also, the knit fabric finishing subcategory has been subdivided into simple, complex, and hosiery products subdivisions for NSPS to reflect these processing differences. For BAT, as in the woven fabric finishing subcategory, allowances for complexity of processing, fiber type and commission finishing remain the same as for BPT.

EFFLUENT LIMITATIONS

BPT

BPT effluent limitations are established for the nonwoven manufacturing and the felted fabric finishing subcategories and for the water jet weaving subdivision of the low water use processing subcategory. These limitations control three conventional pollutants (BOD_5, TSS and pH), three nonconventional pollutants (COD, sulfide and total phenols) and one toxic pollutant (total chromium). BPT limitations are presented in Table I-1 in terms of kilograms of pollutant per 1000 kilograms of product (lb/1000 lbs). Product is defined as the final material produced or processed at the mill.

BPT for the water jet weaving subdivision of the low water use processing subcategory is based on the average performance of two water jet weaving mills where biological treatment is employed. BPT for the nonwoven manufacturing and felted fabric processing subcategories is based on the transfer of technology from the carpet finishing and wool finishing subcategories, respectively, because those subcategories have similar waste characteristics.

BAT

BAT effluent limitations control toxic and nonconventional pollutants and are equal to BPT effluent limitations. Therefore, BAT effluent limitations have the same technology basis as BPT, biological treatment. The toxic pollutant total chromium and the nonconventional pollutants, COD, total phenols and sulfide (as measured by the procedures listed in 40 CFR Part 136) are regulated in all subcategories except low water use processing. The nonconventional pollutant chemical oxygen demand (COD) is regulated in all subcategories. BAT effluent limitations are presented in Table I-2. Additional discharge allowances for COD in the woven fabric finishing, knit fabric finishing and carpet finishing subcategories based on complexity of processing and fiber type are presented in Table I-3.

In all subcategories except wool scouring and wool finishing, limitations for total chromium, total phenols, sulfide and COD are presented on a mass basis in terms of kilograms of pollutant per 1000 kilograms of product (lbs/1000 lbs). Product is defined as the final material produced or processed at the mill. In the wool scouring subcategory, limitations are presented on a mass basis in terms of kilograms of pollutant per 1000 kilograms (lbs/1000 lbs) of wool. Wool is defined as the dry raw wool as it is received by the wool scouring mill. In the wool finishing subcategory, limitations are presented on a mass basis in terms

TABLE I-1
BPT EFFLUENT LIMITATIONS*

Conventional Pollutants

Subcategory	Maximum for any one day		Average of daily values for 30 consecutive days	
	BOD5	TSS	BOD5	TSS
Low Water Use Processing Water Jet Weaving	8.9	5.5	4.6	2.5
Nonwoven Manufacturing	4.4	6.2	2.2	3.1
Felted Fabric Processing	35.2	55.4	17.6	27.7

pH shall be within the range 6.0 to 9.0 at all times.

Toxic and Nonconventional Pollutants

Subcategory	Maximum for any one day				Average of daily values for 30 consecutive days			
	COD	Sulfide	Phenols	Total Chromium	COD	Sulfide	Phenols	Total Chromium
Low Water Use Processing Water Jet Weaving	21.3	--	--	--	13.7	--	--	--
Nonwoven Manufacturing	40.0	0.046	0.023	0.023	20.0	0.023	0.011	0.011
Felted Fabric Processing	256.8	0.44	0.22	0.22	128.4	0.22	0.11	0.11

* Expressed as kg pollutant/kkg of product (lb/1000 lb)

TABLE I-2
BAT EFFLUENT LIMITATIONS*

Subcategory	Maximum for any one day: COD	Sulfide	Phenols	Total Chromium	Average of daily values for 30 consecutive days: COD	Sulfide	Phenols	Total Chromium
Wool Scouring**	138.0	0.20	0.10	0.10	69.0	0.10	0.05	0.05
Wool Finishing**	163.0	0.28	0.14	0.14	81.5	0.14	0.07	0.07
Low Water Use Processing								
General Processing	2.8	-	-	-	1.4	-	-	-
Water Jet Weaving	21.3	-	-	-	13.7	-	-	-
Woven Fabric Finishing**	60.0	0.20	0.10	0.10	30.0	0.10	0.05	0.05
Knit Fabric Finishing**	60.0	0.20	0.10	0.10	30.0	0.10	0.05	0.05
Carpet Finishing	70.2	0.08	0.04	0.04	35.1	0.04	0.02	0.02
Stock and Yarn Finishing	84.6	0.24	0.12	0.12	42.3	0.12	0.06	0.06
Nonwoven Manufacturing	40.0	0.046	0.023	0.023	20.0	0.023	0.011	0.011
Felted Fabric Processing	256.0	0.44	0.22	0.22	128.4	0.22	0.11	0.11

* Expressed as kg pollutant/kkg of product (lb/1000 lb) except for wool scouring, which is expressed as kg pollutant/kkg of wool processed and wool finishing which is expressed as kg pollutant/kkg of fiber processed.

** For commission finishers, an additional allocation of 100% of the limitations is allowed.

TABLE I-3

BAT ALLOWANCES*

CHEMICAL OXYGEN DEMAND (COD)

	Maximum for any one day	Average of daily values for 30 consecutive days
Simple Manufacturing Operations employing a synthetic fiber or complex manufacturing operations employing a natural fiber.		
Woven Fabric Finishing	20.0	10.0
Simple Manufacturing Operations employing a natural and synthetic fiber blend or complex manufacturing operations employing a synthetic fiber.		
Woven Fabric Finishing	40.0	20.0
Knit Fabric Finishing	20.0	10.0
Complex manufacturing Operations employing a natural and synthetic fiber blend.		
Woven Fabric Finishing	60.0	30.0
Knit Fabric Finishing	40.0	20.0
Complex Manufacturing Operations		
Carpet Finishing	20.0	10.0

* Quantities of pollutant which may be discharged by a point source in addition to the BAT limitations in Table I-1.

of kilograms of pollutant per 1000 kilograms of fiber. Fiber is defined as the dry wool and other fibers as received at the wool mill for processing into wool and blended fibers.

NSPS

NSPS are based on the performance of the best performing biological treatment systems currently in place at textile mills. Three conventional pollutants (BOD_5, TSS and pH) and one nonconventional pollutant (COD) are regulated in all subcategories. One toxic pollutant (total chromium) and the two nonconventional pollutants (total phenols and sulfide) are regulated in all but the low water use processing subcategory. NSPS are presented in Table I-4.

PSES and PSNS

Categorical pretreatment standards have not been promulgated for existing and new indirect dischargers. The textile mills point source category is subject only to General Pretreatment Regulations (40 CFR Part 403).

TABLE I-4
NEW SOURCE PERFORMANCE STANDARDS*
CONVENTIONAL POLLUTANTS**

Subcategory	Maximum for any one day		Average of daily values for 30 consecutive days	
	BOD5	TSS	BOD5	TSS
Wool Scouring	3.6	30.3	1.9	13.5
Wool Finishing	10.7	32.3	5.5	14.4
Low Water Use Processing				
General Processing	1.4	1.4	0.7	0.7
Water Jet Weaving	8.9	5.5	4.6	2.5
Woven Fabric Finishing				
Simple Operations	3.3	8.8	1.7	3.9
Complex Operations	3.7	14.4	1.9	6.4
Desizing	5.5	15.6	2.8	6.9
Knit Fabric Finishing				
Simple Operations	3.6	13.2	1.9	5.9
Complex Operations	4.8	12.2	2.5	5.4
Hosiery Products	2.3	8.4	1.2	3.7
Carpet Finishing	4.6	8.6	2.4	3.8
Stock and Yarn Finishing	3.6	9.8	1.9	4.4
Nonwoven Manufacturing	2.6	4.9	1.4	2.2
Felted Fabric Processing	16.9	50.9	8.7	22.7

* Expressed as kg pollutant/kkg of product (lb/1000 lb) except for wool scouring which is expressed as kg pollutant/kkg of wool processed and wool finishing which is expressed as kg pollutant/kkg of fiber processed.
** For all subcategories, pH within the range 6.0 to 9.0 at all times.

TABLE I-4 (cont'd)
NEW SOURCE PERFORMANCE STANDARDS*

TOXIC AND NONCONVENTIONAL POLLUTANTS

Subcategory	Maximum for any one day				Average of daily values for 30 consecutive days			
	COD	Sulfide	Total Phenols	Total Chromium	COD	Sulfide	Total Phenols	Total Chromium
Wool Scouring	52.4	0.20	0.10	0.10	33.7	0.10	0.05	0.05
Wool Finishing	113.8	0.28	0.14	0.14	73.3	0.14	0.07	0.07
Low Water Use Processing								
General Processing	2.8	-	-	-	1.4	-	-	-
Water Jet Weaving	21.3	-	-	-	13.7	-	-	-
Woven Fabric Finishing								
Simple Operations	41.7	0.20	0.10	0.10	26.9	0.10	0.05	0.05
Complex Operations	68.7	0.20	0.10	0.10	44.2	0.10	0.05	0.05
Desizing	59.5	0.20	0.10	0.10	38.3	0.10	0.05	0.05
Knit Fabric Finishing								
Simple Operations	48.1	0.20	0.10	0.10	31.0	0.10	0.05	0.05
Complex Operations	51.0	0.20	0.10	0.10	32.9	0.10	0.05	0.05
Hosiery Products	30.7	0.20	0.10	0.10	19.8	0.10	0.05	0.05
Carpet Finishing	26.6	0.08	0.04	0.04	17.1	0.04	0.02	0.02
Stock and Yarn Finishing	33.9	0.24	0.12	0.12	21.9	0.12	0.06	0.06
Nonwoven Manufacturing	15.2	0.046	0.023	0.023	9.8	0.023	0.011	0.011
Felted Fabric Manufacturing	179.3	0.44	0.22	0.22	115.5	0.22	0.11	0.11

* Expressed as kg pollutant/kkg of product (lb/1000 lb) except for wool scouring which is expressed as kg pollutant/kkg of wool processed and wool finishing which is expressed as kg pollutant/kkg of fiber processed.

SECTION II

INTRODUCTION

PURPOSE AND AUTHORITY

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 " (Section 101(a)). By July 1, 1977, existing industrial dischargers were required to achieve "effluent limitations requiring the application of the best practicable control technology currently available (BPT)," [Section 301(b)(1)(A)]. By July 1, 1983, these dischargers were required to achieve "effluent limitations requiring the application of the best available technology economically achievable (BAT), which will result in reasonable further progress toward the national goal of eliminating the discharge of pollutants," [Section 301(b)(2)(A)]. New industrial direct dischargers were required to comply with Section 306, new source performance standards (NSPS), based on best available demonstrated technology. New and existing dischargers to publicly owned treatment works (POTWs) were subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers were to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards were made enforceable directly against dischargers to POTWs (indirect dischargers).

Although Section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis in the absence of regulations, Congress intended that, for the most part, control requirements would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b) and 307(c) required promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

The Agency was unable to promulgate many of these toxic pollutant regulations and guidelines within the time periods stated in the Act. In 1976, EPA was sued by several environmental groups and, in settlement of this lawsuit, EPA and the plaintiffs executed a

"Settlement Agreement," which was approved by the Court. This Agreement required EPA to develop a program and adhere to a schedule for promulgating, for 21 major industries, BAT effluent limitations guidelines, pretreatment standards and new source performance standards for 65 "priority" pollutants and classes of pollutants. [See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833 (D.D.C. 1979).] On December 27, 1977, the President signed into law the Clean Water Act of 1977. Although this law makes several important changes in the federal water pollution control program, its most significant aspect is its incorporation into the Act of many of the basic elements of the Settlement Agreement program for toxic pollution control. Sections 301(b)(2)(A) and (b)(2)(C) of the Act now require the achievement by July 1, 1984, of effluent limitations requiring application of BAT for "toxic" pollutants, including the 65 "priority" pollutants and classes of pollutants which Congress declared "toxic" under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant control. Moreover, to strengthen the toxics control program, Congress added a new Section 304(e) to the Act, authorizing the Administrator to prescribe what have been termed "best management practices" (BMPs) to prevent the release of toxic pollutants from plant-site runoff, spillage or leaks, sludge or waste disposal and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revises the control program for nontoxic pollutants. Instead of BAT for "conventional" pollutants identified under Section 304(a)(4) (including biological oxygen demanding pollutants, suspended solids, fecal coliform and pH), the new Section 301(b)(2)(E) requires achievement by July 1, 1984, of "effluent limitations requiring the application of the best conventional pollutant control technology" (BCT). The factors considered in assessing BCT include the reasonableness of the relationship between the costs of attaining a reduction in effluents and the effluent reduction benefits derived, and the comparison of the cost and level of reduction for an industrial discharge with the cost and level of reduction of similar parameters for a typical POTW [Section 304(b)(4)(B)]. For nontoxic nonconventional pollutants, Sections 301(b)(2)(A) and 301 (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment, but not later than July 1, 1987.

The purpose of this document is to describe the development of effluent limitations guidelines for BPT, BAT, NSPS and pretreatment standards for existing and new sources (PSES and PSNS) under authority of Sections 301, 304, 306 and 307 of the Clean Water Act.

PRIOR EPA REGULATIONS

BPT, BAT, NSPS and PSNS were originally promulgated for the textile mills category in 1974. Industry representatives challenged these limitations in the Fourth Circuit Court of Appeals. In response to a joint motion of petitioners and EPA to hold the case in abeyance while EPA reconsidered the BAT limitations, the Court remanded all the regulations except BPT to EPA for reconsideration. In the joint motion, petitioners withdrew their challenge to the BPT limitations and therefore, those limitations are presently in effect. As a result of the court order, the Agency and the American Textile Manufacturers Institute (ATMI) began a joint study to collect information and data necessary to reconsider the BAT, NSPS, PSES and PSNS regulations. PSES were promulgated in 1977 (42 FR 26979; May 26, 1977).

The regulations supported by this document include BPT for two new subcategories and one new subdivision and revised BAT, NSPS, PSNS and PSES for all subcategories and subdivisions.

OVERVIEW OF THE INDUSTRY

The United States textile industries are covered by two of the twenty major groups of manufacturing industries in the Standard Industrial Classification (SIC). They are Textile Mill Products, Major Group 22, and Apparel and Other Textile Mill Products, Major Group 23. According to the SIC, the Textile Mill Products group includes 30 separate industries that manufacture approximately 90 classes of products. The Apparel and Other Textile Products group includes 33 separate industries that manufacture some 70 classes of products.

The original Textile Mills Point Source Category Development Document (1) published in 1974 covers those facilities classified in Major Group 22. These facilities are principally engaged in receiving and preparing fiber; transforming this material into yarn, thread or webbing; converting the yarn and webbing into fabric or related products; and finishing these materials at various stages of the production. Many of the facilities produce a final consumer product such as thread, yarn, bolt fabric, hosiery, towels, sheets and carpet. The balance of the facilities produce a transitional products for use by other establishments in Major Groups 22 and 23.

The facilities in Major Group 23, Apparel and Other Textile Mill Products, are principally engaged in receiving woven or knitted fabric for cutting, sewing and packaging. Some of the products manufactured are dry cleaned and some undergo auxiliary processing to prepare them for the consumer. In general, the processing is dry and no process-related wastewater is generated.

Exact figures for the number of wet-processing mills or the total number of mills in the textile industry are difficult to establish because of the relatively large numbers involved, the dynamic state of the industry and differing classification criteria. Published reports and surveys place the first figure (wet processing) around 2,000 mills and the total mills between 5,000 and 7,500. Nearly 80 percent of the facilities are located in the Mid-Atlantic and Southern regions of the U.S. The remaining 20 percent are distributed nearly equally between the New England region and the North Central and Western regions.

SUMMARY OF METHODOLOGY

The data and technical findings presented in this document were developed by performing the following major tasks:

1. Collecting, reviewing and evaluating existing information including: the administrative record from previous effluent guidelines development studies; historical wastewater data from EPA regional offices, state water pollution control agencies and municipalities; the literature; current research projects; and information available from textile trade associations.

2. Profiling the industry with regard to age, production, geographic location, type of discharge, raw materials, production processes, final products, in-plant controls, end-of-pipe treatment practices and wastewater data.

3. Reviewing the existing industry categorization and developing a revised categorization, where appropriate, to accommodate any previously unidentified segments of the industry.

4. Conducting a screening sampling program to determine qualitatively which of the 129 toxic pollutants appear in textile industry raw wastewaters and treated effluents.

5. Developing, distributing and retrieving 308 data collection portfolios (DCPs) to update the existing data base.

6. Conducting a verification wastewater sampling program to confirm the presence of the toxic pollutants identified in the screening sampling program and to establish the effectiveness of in-place and pilot-scale advanced treatment technologies in removing toxic pollutants.

7. Organizing, analyzing and interpreting the data collected in each task area to establish an updated administrative record.

8. Establishing the alternative in-plant control measures and end-of-pipe treatment technologies that will result in the elimination or reduction of pollutant discharge from the industry.

9. Estimating the capital and the annual costs and effectiveness of the alternative control measures and treatment technologies for representative mills in each subcategory of the industry.

10. Identifying technologies, developing the methodology and establishing the effluent limitations and standards that can be achieved in each subcategory of the industry.

DATA AND INFORMATION GATHERING PROGRAM

Previous Data Collection Activities

The collection, review and evaluation of existing information was the initial major task performed. This task provided the starting point for subsequent activities and established the extent of effort that was to be required in each of the other tasks. The review of literature and evaluation of current research projects continued throughout the project.

308 Data Request

The 308 data request (Data Collection Portfolio (DCP) - Industry Survey) was performed to update the existing data base. The survey involved the following activity: 1) developing a master list of textile mills thought to have wet-manufacturing operations; 2) contacting mills on the master list by letter to outline the purpose and intent of the survey; 3) contacting mills on the master list by telephone to assess the value of available wastewater information and to gather basic facility information; 4) distributing detailed DCPs; and 5) retrieving and analyzing the DCPs.

In developing the master list of wet-manufacturing facilities, consideration was given to several sources of information. These sources included the Standard Industrial Classification (SIC), the Census of Manufactures, data collected during previous textile industry studies, information from trade associations, and information in a commercial directory, "Davison's Textile Blue Book" (8). Examination of the various sources and knowledge gained from previous studies indicated that the directory provided the most useful and most current information. It was reviewed and each facility listed was tentatively classified as either a wet- or dry-manufacturing facility. Of 5,500 mills listed in the directory, approximately 2,900 were initially classified as dry manufacturing and 2,600 were classified as wet manufacturing. Wet-manufacturing facilities were further studied to determine if additional subcategorization based on product, raw materials, production processes and type of processing equipment would be appropriate. Information necessary to identify and contact each wet-manufacturing facility was computerized and used to develop the master list.

A telephone survey of those mills originally classified as having wet-manufacturing reduced the number of mills on the master list to 1,973 because many turned out to be dry-manufacturing facilities or were no longer in the textile manufacturing business. Information on selected low water use mills was obtained by means of a separate general survey. General survey information was replaced by detailed survey information obtained from the DCPs for the wet-manufacturing facilities that noted the availability of historical wastewater data. DCPs were received from 538 wet-manufacturing mills and an additional 573 mills provided general survey information. The information obtained from both types of surveys was computerized. It provides the best general representation of the textile industry developed to date and serves as the basis for this document and the resulting regulation.

Mill Visits

Visits to 25 mills were made during the initial data gathering program to develop an understanding of the current operating practices used in the textile industry. Raw materials, production processes, final products, in-plant controls and end-of-pipe treatment technologies were examined and the information obtained was added to existing information about the industry. Visits to 53 mills (including 15 of the 25 noted above) were made in conjunction with the wastewater sampling program. Information similar to that noted above was obtained during these visits.

Raw Materials Review

The raw materials used to manufacture textile products include various natural and manmade fibers and a wide variety of organic and inorganic chemicals and chemical products. The types and nature of these fibers and chemicals are discussed under "Profile of Manufacturing" in Section III. Current information about the raw materials was obtained from the literature, from industry trade associations, from manufacturers of the materials and from the mills surveyed and visited.

Screening and Verification Sampling

The wastewater sampling program conducted to characterize textile industry wastewater with respect to the 129 toxic pollutants was performed in two phases. The first phase (screening) was conducted between February and October of 1977. During this phase, 12,446 data points were obtained by collecting 98 samples from 40 mills. The second phase (verification) was conducted between September 1977 and March 1980. During this phase, 38,227 data points were obtained by collecting 301 samples from 24 mills. A total of 53 individual mills was sampled during the study, some in both phases of the sampling program.

During both phases, mill visits were made before the actual sampling to obtain process information and make the necessary arrangements for the sampling crews. The samples collected were analyzed by either a private laboratory under contract to EPA or by one of several EPA laboratories. The sampling and analytical procedures employed in all phases followed recommended EPA procedures. A detailed discussion of the sampling and analytical methods is included in the record.

The screening phase of the wastewater sampling program was designed to identify which of the toxic pollutants were present in textile industry untreated wastewaters and treated effluents. During this phase, the source water, untreated wastewater and treated effluent at each mill were sampled to determine qualitatively which pollutants were present.

The verification phase consisted of sampling waste streams and treated effluents to determine the amount of the toxic pollutants identified in the screening phase that are present in textile industry wastewaters. In addition to this objective, sampling was also conducted to determine the effectiveness of in-place treatment technologies and pilot-scale advanced treatment technologies in removing toxic, nonconventional and conventional pollutants. The pilot-scale data were obtained on biologically treated effluents at 19 of the mills sampled during the screening phase by utilizing one of two mobile pilot plants. Each pilot plant contained the following treatment systems: chemical coagulation/clarification, multimedia filtration, activated carbon adsorption and ozonation. Bench-scale dissolved air flotation studies also were performed on the waste at some of these mills.

Processing of Data and Information

The data collected as part of the evaluation of existing information, the DCP requests and the wastewater sampling program were processed and analyzed. Most of the data were processed electronically. Information obtained from the DCPs provides the basis for the industry profile presented in Section III and the industry subcategorization presented in Section IV. Historical and current wastewater monitoring data were used to establish the typical raw waste and treated effluent characteristics for each subcategory (See Section V). Subsequent to the October 1979 proposal, we found that additional data, especially daily monitoring data, were needed in order to determine accurately the performance of wastewater treatment systems. Therefore, EPA requested and received from ten mills daily results of treatment technology performance for the most recent full year of operation. The historical data and the full-scale and pilot-scale field sampling results were used to determine the effectiveness of the control and treatment technologies available to the industry (Section VII) and to provide information related to the design and costing of those technologies (Appendix A). These data and information, along with the findings of separate environmental and economic impact analyses, were evaluated to develop the effluent limitations guidelines, new source performance standards and pretreatment standards presented in Sections VIII through XI.

SECTION III

DESCRIPTION OF THE INDUSTRY

This section presents a detailed profile of the textile industry and a discussion of the unit manufacturing processes used by the industry.

GENERAL DESCRIPTION

The United States textile industries are covered by two of the twenty major groups of manufacturing industries in the Executive Office of the President - Bureau of the Budget's Standard Industrial Classification (SIC). They are Textile Mill Products, Major Group 22, and Apparel and Other Textile Mill Products, Major Group 23. The Textile Mill Products group includes 30 separate industries that manufacture approximately 90 classes of products. The Apparel and Other Textile Products group includes 33 separate industries that manufacture some 70 classes of products.

The textile mills point source category effluent limitations guidelines and standards (40 CFR Part 410) apply to facilities in Major Group 22. The facilities are engaged principally in: receiving and preparing fibers; transforming these materials into yarn, thread or webbing; converting the yarn and webbing into fabric or related products; and finishing these materials. Many facilities produce a final consumer product such as thread, yarn, bolt fabric, hosiery, towels, sheets and carpet, while the rest produce a transitional product for use by other establishments in Major Groups 22 and 23.

The facilities in Major Group 23, Apparel and Other Textile Mill Products, are involved principally in receiving woven or knitted fabric for cutting, sewing and packaging. Some of the products manufactured are dry cleaned and some undergo auxiliary processing to prepare them for the consumer. In general, the processing is dry and no process related wastewater is generated.

Profile of Major Group 22

Exact figures for the number of wet processing mills or the total number of mills in the textile industry are difficult to establish because of their relatively large number, the dynamic state of the industry and differing classification criteria. Published reports (1, 3, 4, 5, 6) and surveys (7, 8) over the past ten years estimate the number of wet processing mills at approximately 2,000, and the total mills at between 5,000 and 7,500. A U.S. Department of Commerce Publication, Census of Manufactures (Census) provided the most structured and inclusive information. Reports from the 1977 Census were used in developing the general profile (7).

A breakdown of the textile mill products group by SIC code (major product class) and region (geographic location) is provided in Table III-1. The information in this table was taken from preliminary statistics developed for the 1977 Census. Approximately 16 percent of the known facilities had not yet been assigned to a specific region. Assignments for these facilities were not specified to avoid disclosing operations of individual companies and to avoid further verification of data for smaller producing states. Nearly 77 percent of the facilities for which the locations are specified are located in the Middle-and South-Atlantic regions. Of the remaining 23 percent of the specified facilities, approximately 10 percent are located in the New England region, approximately six percent are located in the Pacific region, approximately four percent are located in the East South Central region and approximately one and one-half percent each are located in the East North Central and West South Central regions. Only a few facilities are in the West North Central region. Many mills, particularly yarn manufacturing, weaving and carpet manufacturing, are concentrated in a few southeastern states.

The geographic distribution of mills is based in part on historic considerations. The textile industry in this country began in the northeast and spread south because of that region's cotton production. Although synthetics have replaced cotton as the primary raw material in recent years, the southeast continues to be the center of the textile industry.

General statistics regarding number of establishments, number of employees and economics of manufacture are presented in Table III-2 for the textile mill products group. The Standard Industrial Classification system (SIC) identifies nine major product classes. Of these nine classes (three digit SIC Codes), three have been subdivided to present information for the industry segments that are of primary concern here and are most likely to be affected by the development of effluent limitations guidelines, new source performance standards and pretreatment standards.

Knitting Mills (SIC 225) is the largest single major product class in terms of number of establishments with 36 percent of the industry total. These mills employ 25 percent of all textile workers and the value of their shipments is 18 percent of the industry total. Weaving mills (SIC 221), yarn and thread mills (SIC 228), finishing mills (SIC 226) and floor covering mills (SIC 227) follow knitting mills in terms of number of establishments and number of employees. The number of facilities manufacturing felt goods, nonwoven goods and scoured wool is small relative to the rest of the industry. Combined, these three subdivisions accounted for less than three percent of the employees and three percent of the value of shipments, based on data available for the period prior to 1977.

TABLE III-1
GEOGRAPHICAL DISTRIBUTION
TEXTILE MILL PRODUCTS MAJOR INDUSTRIAL GROUP

	SIC Code									
Region	221	222	223	224	225	226	227	228	229	22
New England	5	50	60	91	38	91	5	74	169	583
Middle Atlantic	36	74	36	112	1149	245	32	113	343	2140
East North Central	3	-	2	6	8	9	5	5	56	94
West North Central	-	-	3	-	-	-	2	-	5	10
South Atlantic	163	230	14	87	760	193	381	454	213	2495
East South Central	31	16	1	12	63	19	19	63	38	262
West South Central	10	12	8	-	-	1	12	3	35	81
Mountain Division	-	-	-	-	-	-	-	-	-	0
Pacific	20	26	7	11	73	41	71	19	92	360
Unspecified*	46	41	34	16	498	79	65	67	303	1149
Total	314	449	165	335	2589	678	592	798	1254	7174

* Census incomplete at time distribution was prepared; not all facilities have been assigned to a region to avoid disclosing operations of individual companies and to permit further verification of data for smaller producing states.

Notes:
- New England - ME, NH, VT, MA, RI, CT
- Middle Atlantic - NY, NJ, PA
- East North Central - OH, IN, IL, MI, WI
- West North Central - MN, IA, MO, ND, SD, NB, KS
- South Atlantic - DE, MD, DC, VA, WV, NC, SC, GA, FL
- East South Central - KT, TN, AL, MS
- West South Central - AR, LA, OK, TX
- Mountain Division - MT, ID, CO, NM, AZ, UT, NV
- Pacific - WA, OR, CA, AK, HI

221 - Weaving Mills, Cotton
222 - Weaving Mills, Synthetic
223 - Weaving & Finishing Mills, Wool
224 - Narrow Fabrics Mills
225 - Knitting Mills (Incl. Finishing)
226 - Textile Finishing, Exc. Wool & Knits
227 - Floor Covering Mills
228 - Yarn & Thread Mills
229 - Miscellaneous Textile Goods
22 - Textile Mill Products

Source: 1977 Census of Manufacturers

TABLE III-2
GENERAL STATISTICS
TEXTILE MILL PRODUCTS MAJOR INDUSTRIAL GROUP

Industry Segment	SIC Code	Establishments Total	Establishments 20+ Employees	Employees (1000's)	Value Added by Manufacture (million dollars/year)	Value of Shipments (million dollars/year)
Weaving Mills, Cotton	All Group No. 221	314	192	117.2	1944	4431
Weaving Mills, Synthetics	All Group No. 222	449	351	151.0	2791	6326
Weaving & Finishing Mills, Wool	All Group No. 223	165	84	14.6	313	583
Narrow Fabrics Mills	All Group No. 224	335	182	20.8	351	683
Knitting Mills (+ Finishing)	All Group No. 225	2589	1491	230.7	3720	9222
Hosiery Mills	2251, 2252	613	375	58.7	818	1790
All Other Knitting Mills	2253, 2254, 2257 2258, 2259	1976	1116	172.0	2902	7431
Finishing Mills (Except Wool & Knits)	All Group No. 226	678	395	72.1	1417	3995
Broadwoven Fabric	2261, 2262	495	283	58.0	1143	3164
Stock, Yarn, Narrow Fabric	2269	183	112	14.1	274	831
Floor Covering Mills	All Group No. 227	592	285	55.8	1530	4775
Yarn & Thread Mills	All Group No. 228	798	608	140.4	2261	6114
Miscellaneous Textile Goods	All Group No. 229	1254	523	67.8	1641	4174
Felt Goods	2291	46	27	4.3	103	198
Nonwoven Goods	2297	100	74	13.0	386	864
Wool Scouring & NEC Goods	2299	436	90	6.7	109	231
Other Miscellaneous Products	2292, 2293, 2294 2295, 2296, 2298	672	332	43.8	1043	2881
Total Industry-All Segments	Major Group No. 22	7174	4048	914.2	17011	52405

NEC = Not Elsewhere Classified
Source: 1977 Census of Manufacturers

Water use and wastewater discharge statistics for the nine major product classes and their subdivisions are provided in Table III-3. Because this information has not yet been compiled from the 1977 Census data, the values were developed from the 1972 Census. Because of this, and because the Census reports these statistics only for establishments that discharge 75,700 cubic meters (20 million gallons) per year or more, the numbers of establishments do not correspond between Tables III-2 and III-3. The value of shipments, which are provided in each table, give a good indication of the significance of the establishments covered in Table III-3. The average value of shipments for the facilities covered by Table III-3 constituted approximately 50 percent of the industry total in 1972, while the average number of establishments represented only about 10 percent of the total mills in the industry at that time.

Based on the 1977 Census, the industries in Major Group 22 employ over 900,000 persons and manufacture goods valued at over 52 billion dollars annually. According to the 1972 Census, approximately 600 million cubic meters (160 billion gallons) of process wastewater is discharged annually.

Industry Survey (308 Data Request)

The industry survey discussed in Section II provided specific information about the facilities in Major Group 22. A primary result of the survey was compilation of a master list of the wet processing facilities in the industry. A breakdown of those facilities is presented in Table III-4. The manufacturing segments listed correspond to the recommended subcategorization of the industry for purposes of effluent limitation guidelines, new source performance standards and pretreatment standards. There are 1,165 mills in the nine wet processing classifications and 808 mills classified as low water use processing operations. Detailed survey information was received for 537 of the wet processing mills, with 574 mills providing general survey information. Wet processing activities at the remaining 54 locations could not be confirmed.

Just over two-thirds of the wet processing facilities finish either woven or knit fabrics (including hosiery). Stock and yarn finishing mills comprise nearly one-fifth of the wet processing facilities; wool goods processing, carpet manufacturing and nonwoven manufacturing and felted fabric processing together each comprise approximately five percent. Detailed surveys provide information on more than one-third of the mills in each wet processing segment.

Low water use processing operations were surveyed separately from the wet processing mills; 315 detailed survey responses were obtained from a random sample of approximately half of the mills initially classified as low water use operations.

TABLE III-3
WATER USE AND WASTEWATER DISCHARGE STATISTICS
TEXTILE MILL PRODUCTS MAJOR INDUSTRIAL GROUP

Industry Segment	Establishments*	Value of Shipments (10^6 $/yr)	Water Use# (10^6 cu m/yr)	Wastewater Discharge Indirect (10^6 cu m/yr)	Wastewater Discharge Direct (10^6 cu m/yr)
Weaving Mills, Cotton	96	2058	35.2	22.0	26.9
Weaving Mills, Synthetics	113	2179	51.9	28.4	48.1
Weaving & Finishing Mills, Wool	32	277	22.0	11.4	13.6
Narrow Fabrics Mills	10	87	0.8	1.1	0.4
Knitting Mills (+ Finishing)	162	2357	88.9	84.8	25.7
Hosiery Mills	47	459	5.7	9.1	0.0
All Other Knitting Mills	115	1898	83.3	75.7	25.7
Finishing Mills (Except Wool & Knits)	139	1852	169.6	78.3	105.2
Broadwoven Fabric	93	1463	141.9	53.0	100.7
Stock, Yarn, Narrow Fabric	46	389	27.3	25.4	4.5
Floor Covering Mills	65	1868	58.7	43.5	23.8
Yarn & Thread Mills	101	1907	39.0	30.7	27.6
Miscellaneous Textile Goods	70	1328	15.5	20.8	12.1
Felt Goods	7	64	1.5	0.8	1.5
Nonwoven Goods	10	140	4.9	2.3	3.4
Wool Scouring & Goods NEC	13	74	3.8	3.4	2.3
Other Miscellaneous Products	40	1050	5.3	14.4	4.9
Total Industry - All Segments	788	13913	481.6	321.0	283.4

* Only includes locations with greater than 7.57×10^4 cu m/yr discharge.
# Process water not including recirculated flow.
NEC = Not Elsewhere Classified
Source: 1972 Census of Manufactures

TABLE III-4
SURVEY STATUS SUMMARY - MILLS ON MASTER LIST

Manufacturing Segment	SIC Codes Covered	Total Mills Listed	Survey Status*		
			Detailed	General	No Response
Wool Scouring	2299	17	13	4	0
Wool Finishing	223	37	19	15	3
Low Water Use Processing	221, 222, 224, 2295 2296, 2298	808	315	15	478#
Woven Fabric Finishing	2261, 2262	336	151	158	27
Knit Fabric Finishing	2253, 2254, 2257 2258, 2259, 2292	280	113	155	12
Hosiery Finishing	2251, 2252	162	58	103	1
Carpet Finishing	227	58	37	18	3
Stock & Yarn Finishing	2269	217	121	90	6
Nonwoven Manufacturing	2297	38	14	23	1
Felted Fabric Processing	2291	20	11	8	1
		1973	852	589	532

* A "detailed" survey status signifies that a detailed survey questionnaire (308 portfolio), was obtained. A "general" survey status signifies that a telephone survey questionnaire only was obtained. A "no response" survey status signifies that while contact was attempted, and in some cases made, no response was obtained.

A random sample of approximately 50 percent of the low water use processing segment was surveyed, so this value represents facilities that were not surveyed as well as facilities that did not respond to the surveys.

Source: EPA Industry Surveys, 1977 & 1980.

The geographic distribution of the industry survey responses is shown in Table III-5. The distribution confirms observations made previously regarding Major Group 22. Over half of the wet processing facilities are located in the southeast (EPA Region IV), principally in the Carolinas and Georgia. Another 25 percent are located in the northeast (EPA Regions I and II). Less than 5 percent of the mills are located in the west (EPA Regions VI through X).

Table III-6 illustrates the range of plant sizes (in terms of production exposed to wet processing). Wet production is dependent on the weight of material in the final product. Therefore, mills producing lightweight products such as hosiery and other sheer knit goods occupy the smaller production ranges while mills manufacturing heavyweight woven goods (upholstery, drapery fabric and carpet) occupy the larger production ranges. Variation in production is substantial even within individual manufacturing segments as evidenced by the fact that all but two segments have production ranges of two to three orders of magnitude. The woven fabric finishing segment is the largest, with almost twice as many facilities than any other segment, processing greater than 22,000 kg/day (48,000 lb/day).

Wastewater discharge quantities, discharge type (direct or indirect) and general treatment status are illustrated in Tables III-7 and III-8 and Figure III-1, respectively. Table III-7 illustrates the distribution of discharge volume for the mills in each segment of manufacturing. Each segment shows variation in discharge from two to four orders of magnitude. The largest dischargers are in the woven fabric finishing manufacturing segment, which has almost 50 percent of the mills discharging greater than 3,785 cu m/day (1.0 mgd). The smallest discharges are associated with hosiery finishing, nonwoven manufacturing and felted fabric processing facilities with 87, 76 and 90 percent of the facilities, respectively, discharging less than 1,890 cu m/day (0.5 mgd).

Based on the results of the industry survey, it is estimated that over three-fourths of the wet processing facilities in the industry discharge process wastewater to POTWs. Table III-8 illustrates the numbers of mills on the master list that are known to be direct dischargers, indirect dischargers or zero discharge facilities. At one extreme, 95 percent of the hosiery mills discharge to POTWs (indirect discharge), while on the other extreme, less than 30 percent of the wool scouring mills discharge to POTWs.

Figure III-1 illustrates the type of wastewater treatment provided by direct and indirect dischargers. Over half of the indirect dischargers provide no treatment of process wastewater, while slightly less than 10 percent provide treatment processes equivalent to, or better than biological treatment. Over two-thirds of the direct dischargers provide biological treatment.

TABLE III-5
GEOGRAPHICAL DISTRIBUTION - MILLS ON MASTER LIST

Manufacturing Segment	EPA Region I	II	III	IV	V	VI	VII	VIII	IX	X	All Regions
Wool Scouring	6	1	3	3	0	3	0	0	0	1	17
Wool Finishing	20	2	4	3	1	1	1	1	0	4	37
Low Water Use Processing	86	108	125	463	11	8	1	0	4	2	808
Woven Fabric Finishing	69	54	34	155	11	3	1	2	7	0	336
Knit Fabric Finishing	27	57	45	133	9	1	2	0	6	0	280
Hosiery Finishing	2	2	9	141	5	2	0	0	0	1	162
Carpet Finishing	0	1	4	39	1	4	0	0	9	0	58
Stock & Yarn Finishing	33	19	31	120	6	3	1	0	4	0	217
Nonwoven Manufacturing	10	3	4	11	7	2	0	0	1	0	38
Felted Fabric Processing	7	2	3	3	2	0	0	0	3	0	20
All Segments	260	249	262	1071	53	27	6	3	34	8	1973

Notes:

EPA Region I - ME,NH,VT,MA,RI,CT
EPA Region II - NY,NJ
EPA Region III - PA,WV,VA,MD,DE
EPA Region IV - KY,TN,NC,SC,MS,AL,GA,FL
EPA Region V - MN,WI,MI,IL,IN,OH
EPA Region VI - NM,TX,OK,AR,LA
EPA Region VII - NE,KS,IA,MO
EPA Region VIII - MT,ND,SD,WY,UT,CO
EPA Region IX - CA,NV,AZ,HI
EPA Region X - AK,WA,OR,ID

Source: EPA Industry Surveys, 1977 & 1980.

TABLE III-6
PRODUCTION SIZE - MILLS ON MASTER LIST

Manufacturing Segment	Mills Within Given Production Range, kkg/day										Un-	All
	0-2	2-4	4-9	9-13	13-22	22-34	34-45	45-68	68-91	91+	known*	Mills
Wool Scouring	2	3	0	1	4	2	2	2	0	0	1	17
Wool Finishing	8	9	9	2	1	2	2	0	0	0	4	37
Low Water Use Processing	10	7	11	19	23	21	7	5	3	2	700	808
Woven Fabric Finishing	36	27	33	28	33	21	20	12	9	21	96	336
Knit Fabric Finishing	42	26	34	29	48	21	7	9	5	1	58	280
Hosiery Finishing	94	26	10	5	2	0	0	0	0	0	25	162
Carpet Finishing	2	2	7	3	8	5	6	7	5	5	8	58
Stock & Yarn Finishing	32	47	35	23	25	20	6	7	1	2	19	217
Nonwoven Manufacturing	3	3	2	4	3	5	2	2	0	1	13	38
Felted Fabric Processing	6	5	2	1	0	0	0	1	0	0	5	20
All Segments	235	155	143	115	147	97	52	45	23	32	929	1973

* Reflects the fact that many of the facilities surveyed by telephone were reluctant to provide production information.

Source: EPA Industry Surveys, 1977 & 1980.

TABLE III-7
WASTEWATER DISCHARGE - MILLS ON MASTER LIST

Manufacturing Segment	Mills Within Given Discharge Range, 10^2 cu m/day (mgd) 0-0.36 (0-0.009)	0.36-3.70 (0.010-0.099)	3.70-18.9 (0.10-0.49)	18.9-37.8 (0.50-0.99)	37.8-94.6 (1.0-2.4)	94.6-378 (2.5-10.0)	Un-known*	All Mills
Wool Scouring	0	10	5	1	1	0	0	17
Wool Finishing	5	8	10	4	5	0	5	37
Low Water Use Processing	243	60	23	0	1	0	481	808
Woven Fabric Finishing	48	65	71	33	35	19	65	336
Knit Fabric Finishing	38	60	68	44	26	3	41	280
Hosiery Finishing	57	70	13	0	0	0	22	162
Carpet Finishing	2	7	17	16	9	0	7	58
Stock & Yarn Finishing	27	61	70	25	18	1	15	217
Nonwoven Manufacturing	16	7	6	2	0	0	7	38
Felted Fabric Processing	7	1	10	0	0	0	2	20
All Segments	443	349	293	125	95	23	645	1973

* Reflects the fact that many of the facilities surveyed by telephone could not provide an estimate of their rate of discharge.

Source: EPA Industry Surveys, 1977 & 1980.

TABLE III-8
DISCHARGE TYPE - MILLS ON MASTER LIST

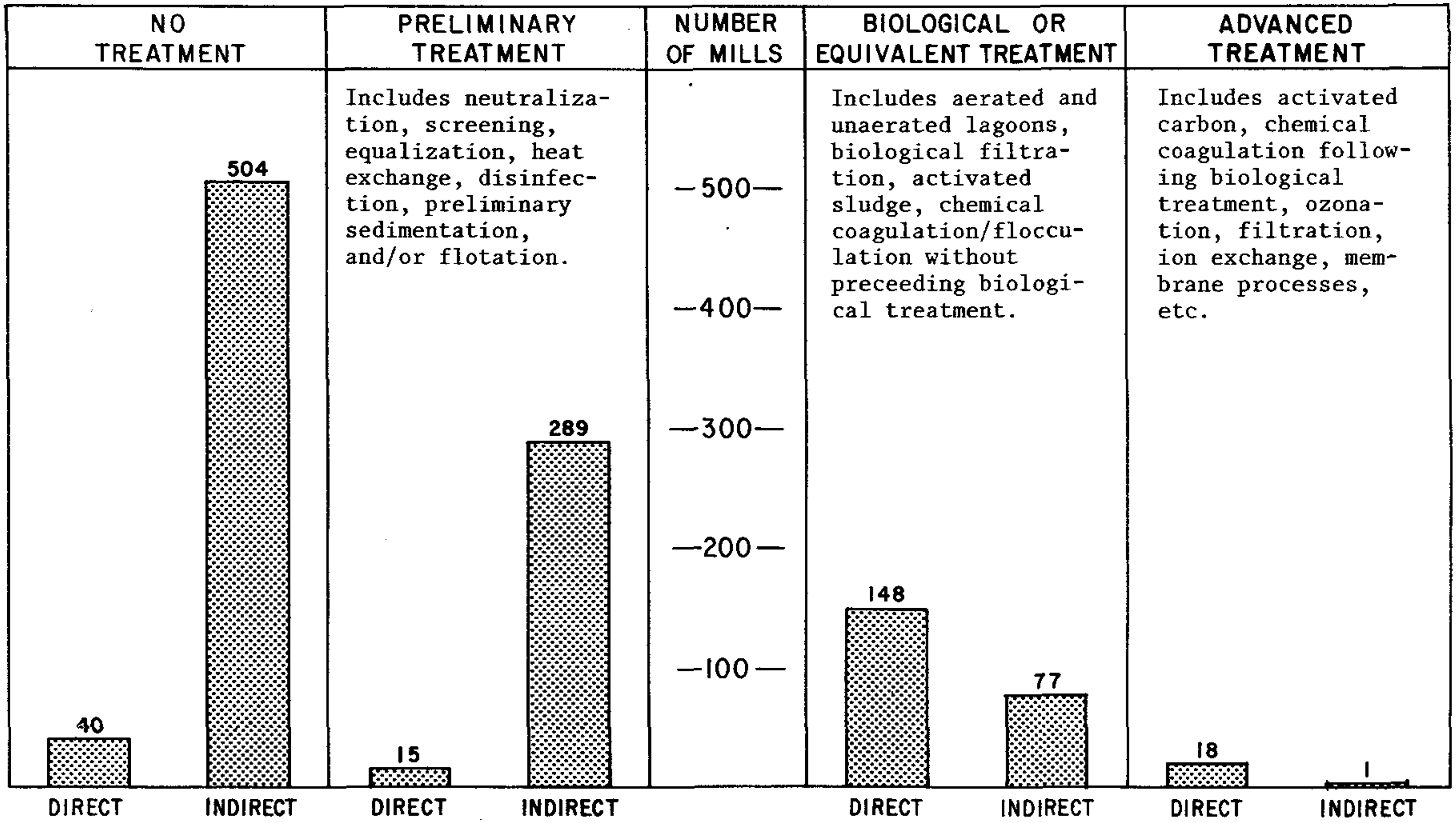
Manufacturing Segment	Total Mills Listed	Mills Reporting Discharge Type	Direct Dischargers	Indirect Dischargers	Zero Discharge*
Wool Scouring	17	17	6	10	1
Wool Finishing	37	36	8	25	3
Low Water Use Processing	808#	309	26	87	196
Woven Fabric Finishing	336	311	77	226	8
Knit Fabric Finishing	280	268	38	221	9
Hosiery Finishing	162	161	7	152	2
Carpet Finishing	58	55	11	42	2
Stock & Yarn Finishing	217	211	36	172	3
Nonwoven Manufacturing	38	37	5	25	7
Felted Fabric Processing	20	19	1	14	4
	1,973	1,424	215	974	235

* Includes mills that recycle wastewater, dispose of wastewater on land (spray irrigation), send waste to a landfill, use septic tanks, place wastewater into nondischarging holding ponds, or have waste hauled from mill site by a private contractor.

Only 408 of these mills were surveyed.

Source: EPA Industry Surveys, 1977 & 1980.

FIGURE III-1
WASTEWATER TREATMENT STATUS - WET PROCESSING MILLS ON MASTER LIST*



*Of the 1,973 mills on the master list, the figure does not include 808 mills classified as "Low Water Use Processing," 57 mills that could not be contacted, and 16 wet processing mills for which the treatment could not be classified.

Source: EPA Industry Survey, 1977.

Direct dischargers without treatment are predominantly mills waiting to connect to POTWs presently in the design or construction phases.

UNIT MANUFACTURING (INDUSTRIAL) PROCESSES

The textile industry (SIC Major Group 22) consists of an estimated 6,000 manufacturing facilities. These facilities are engaged in various processing operations which transform fiber, the industry's basic raw material, into yarn, fabric or other finished textile products. Approximately 70 percent of the facilities perform manufacturing operations that require no process water and an additional 10 percent use only small quantities of process water. In contrast, the remaining 20 percent of the facilities that scour wool fibers, clean and condition other natural and man-made fibers and dye or finish various textile products generally require large quantities of process water. The remainder of this section discusses the principal raw materials utilized by the industry, final products manufactured by the industry and the processing operations required to manufacture those products. Emphasis is placed on operations and products requiring large quantities of process water.

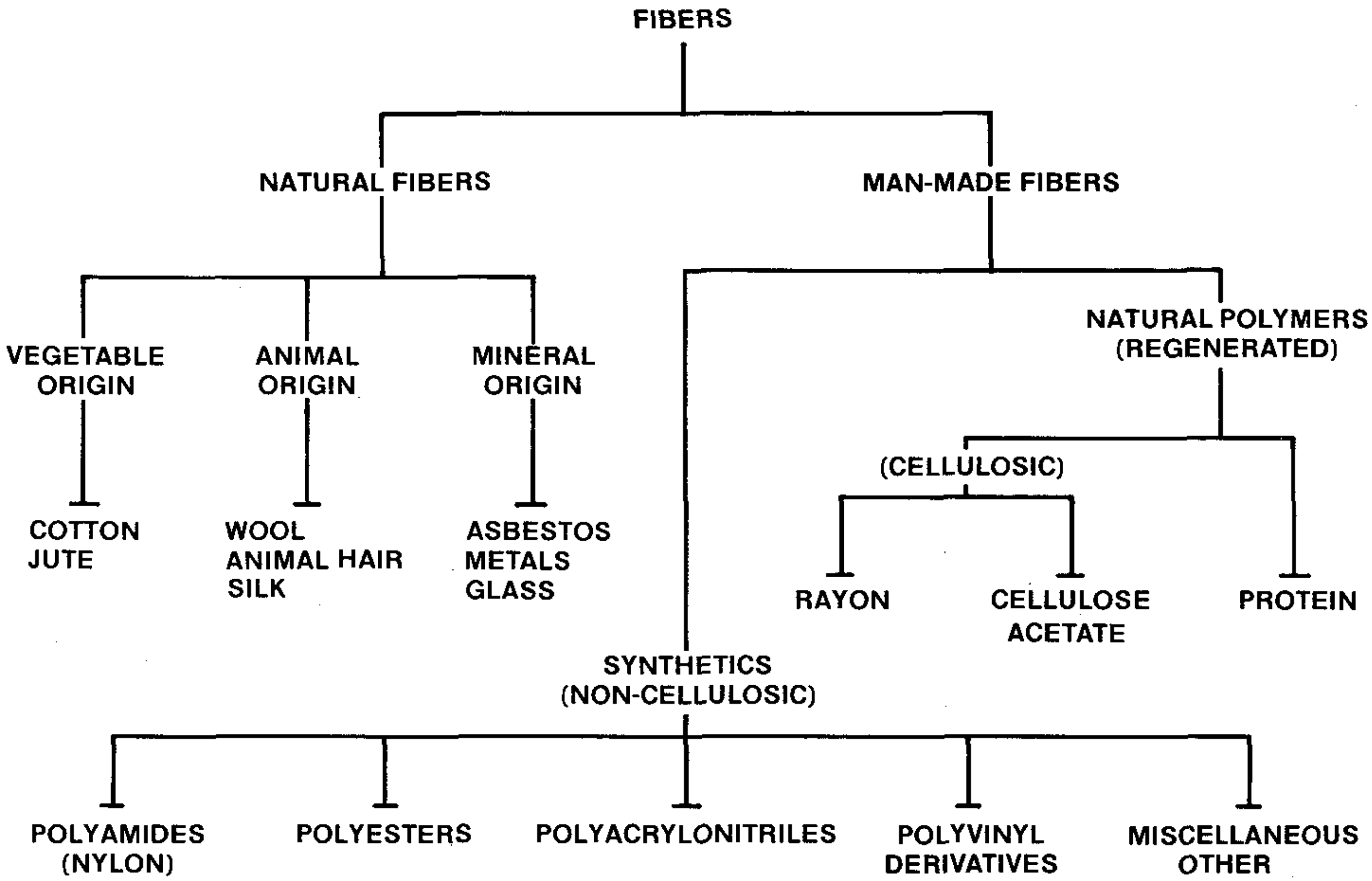
Raw Materials

A variety of natural and man-made fibers are used in the manufacture of textiles. Presently, wool, cotton and various man-made fibers (e.g., nylon, polyesters and rayon) are the basic fibers used.

The term "synthetic" often is used synonymously with the term "man-made" when referring to fiber. There is, however, a technical distinction. As shown in Figure III-2, man-made fibers consist of two major groups: the synthetic fibers (noncellulosic) and the natural polymers (regenerated) group. Synthetic fibers are usually synthesized from simple monomers while natural polymer fibers are manufactured from naturally occurring raw materials. The major portion of the man-made fibers produced are synthetic fibers, with a lesser amount of regenerated fibers produced. Because the term "synthetic" commonly is used to refer to all man-made fibers, this terminology has been adopted for this document.

In 1977, wool consumption by the industry (computed on a scoured basis) was approximately 0.05 billion kilograms (0.11 billion pounds), cotton consumption was approximately 1.6 billion kilograms (3.5 billion pounds) and synthetic fiber consumption was approximately 4.0 billion kilograms (8.8 billion pounds) (9). Other fibers such as animal hair, silk and glass also are used by the industry, but consumption is insignificant in comparison to wool, cotton or synthetic fiber.

FIGURE III-2
FIBERS USED IN THE MANUFACTURE OF TEXTILES (9,10)



Cotton and wool are supplied in staple (short fiber) form while the synthetic fibers are supplied as either staple or continuous filament. The steps required to prepare these fibers for processing are dependent on fiber type.

Wool Raw wool, depending on the breed and habitat of the sheep from which it is obtained, may contain from 30 to 70 percent natural and acquired impurities such as grease, soluble salts (suint) and dirt (10). Thorough scouring of this fiber prior to spinning and other processing is necessary, and there are a number of mills in the industry that perform this function only.

Cotton Consumption of cotton exceeded that of any other single fiber in 1977. Cotton is a much cleaner raw fiber than wool and initial fiber preparation consists only of dry operations such as opening, picking, carding, combing and drawing to mechanically remove vegetable matter and other impurities and to align the fibers for spinning.

Synthetics Total synthetic fiber consumption was two and one-half times greater than cotton consumption in 1977. Noncellulosic fibers, including nylon (polyamides), acrylics, modacrylics and particularly polyester, are used more extensively than cellulosic fibers. Major cellulosic fibers are rayon and cellulose acetate. Synthetic fibers are much cleaner than cotton fibers, eliminating the need for the extensive dry fiber preparation processes used with cotton.

Major Dry or Low Water Use Processes

Depending on the primary fiber type, a variety of production processes are used to manufacture the various products of this industry. In general, the dry or low water use processing operations precede the wet processing operations in the manufacturing sequence.

Spinning Spinning is the process by which fiber is converted into yarn or thread. It is performed after initial fiber preparation and consists of drawing out the fibers, twisting them into yarn and winding the newly made yarn onto a bobbin, cone or other suitable holder. This process is completely dry. Texturizing (modification of physical and surface properties of yarn by mechanical or chemical means) also may be performed during yarn manufacture.

Some yarn is dyed and finished as a final consumer product; however, most manufactured yarn is used within the industry for tufting, knitting, weaving or other fabric manufacturing.

Tufting *Mechanical tufting is the predominant method of* manufacturing carpet. It is performed on large, vertically positioned needle punch machines (tufting machines) that have hundreds of needles in a horizontal bank. Multiple ends of yarn are fed to the bank of needles and the needles pull or loop the yarns through a woven or nonwoven backing material, usually made of polypropylene or jute. The backing moves relative to the needles to anchor each stitch, and the result is loops that form the carpet pile. If the loops are cut during the tufting process, the construction is known as cut pile rather than loop pile. Tufting is a completely dry operation.

Knitting Knitting is a major method for manufacturing fabrics. Nearly all hosiery is knit, as well as large amounts of piece goods, outerwear and underwear. Knitting is accomplished by interlocking series of loops of one or more yarns using any of a number of popular stitches and is performed with sophisticated, high-speed machinery. Although knitting is a completely dry process, oils usually are applied to the yarn to provide lubrication during stitching. These oils are removed in subsequent wet processing and enter the wastewater stream.

Weaving Weaving is the most common method of producing fabrics in the textile industry, and woven fabrics are used in the manufacture of numerous consumer and industrial products. Weaving is performed on any of a number of types of looms which, generally speaking, cause lengthwise yarns (warp yarns) to interlace with yarns running at right angles (filling yarns) by going over and under the filling yarns. A special type of shuttleless loom, known as a water jet loom, uses a jet of water to propel the filling yarn. Similarly, an air jet loom, which is a new weaving technology, uses sequential pulses of air to propel the filling yarn. With the exception of water jet looms, weaving is a dry operation. However, to prevent warp yarn breakage caused by friction during the weaving operation, a processing step known as slashing usually is necessary and a small amount of wastewater may be generated as a result.

Slashing Slashing consists of coating warp yarns with sizing compounds to impart tensile strength and smoothness and thus prevent yarn rupture. It is performed by dipping the yarns through a box or trough containing the sizing agent. This size is dried on the yarn and remains until removed in subsequent operations at a finishing mill. As a result of slashing, the woven fabric may contain add-ons (sizing compounds) equivalent to as much as 15 percent of the weight of the fabric (11). The most common sizing agents are starch, polyvinyl alcohol (PVA), carboxymethyl cellulose (CMC) and polyacrylic acid (PAA). Starch traditionally is associated with the sizing of cotton. Slashing may generate occasional wastewater discharges, usually because of spillage and the cleaning of slasher boxes, rolls and size makeup tanks.

Other Fabric Manufacturing

Two other general fabric manufacturing methods, in addition to the methods previously described, are felted fabric manufacturing and nonwoven fabric manufacturing. These manufacturing methods do not involve the use of yarn. Instead, they involve the direct use of fiber to form a web or continuous sheet of fibers. The differences between felts and nonwovens are in the types of fibers used and in the methods of bonding the fibers together into a fabric.

Traditionally, felt has been made of wool, with manufacture based on the ability of the scaly structured wool fibers to felt, or adhere, together naturally. Although use of wool in felts is still common, the use of synthetics (mostly rayon and polyester) has increased in recent years. Felts are made by physically interlocking the fibers through a combination of mechanical action, chemical action, moisture and heat.

Nonwovens, or webbed textiles as they are sometimes called, are used in numerous applications, with more uses being discovered as the relatively new industry expands. They are made of fibers held together by an applied bonding agent or by the fusing of self-bonding thermoplastic fibers. This results in a fabric structure built up from a web or continuous mat of fibers. Although a number of methods are used to form the web and accomplish bonding of the fibers, certain operations are basic to all methods of nonwoven fabric manufacture. These include, in sequence: (1) preparation of the fiber; (2) web formation; (3) web bonding; (4) drying; and (5) finishing techniques.

Web formation usually is accomplished by overlaying several layers of carded fiber or, in the case of thermal processing, randomly laying down filament. A less common method of web formation, called "wet lay," uses water as a transport medium for the fibers. The fibers, suspended in the water, are deposited onto a screen, and a web that is carried from the screen by a large moving belt is formed. Once a nonwoven web is formed, by any method, bonding usually is achieved by roller padding, dipping or spraying with adhesives such as acrylic or polyvinyl acetate resins. A less common bonding method, applicable only to low melting point fibers, is to fuse the fibers together thermally.

Adhesive Products Processing Adhesive product processes include operations such as bonding, laminating, coating and flocking. These processes are similar in that an adhesive or other continuous coating is applied to a fabric or carpet in order to change the original properties. These processes are completely dry or extremely low in water use, although discharge of the bonding and adhesive chemicals (often latex compounds) or coating materials (often polyvinyl chloride) may result from overspraying, spillage, rinsing and equipment cleanup. Brief descriptions of the most prevalent adhesive product processes follow.

Bonding joins two textile materials together permanently by application of a thin adhesive layer. The process enables different fabric constructions, colors and textures to be combined so that performance, appearance and use are extended. Fabric-to-fabric bonding frequently is performed using either a wet adhesive (often a water based acrylic compound) or urethane foam. In wet adhesive bonding, the underside of the first fabric is coated with adhesive and the second fabric is joined by passing both fabrics through rollers. The adhesive is cured with heat to effect a permanent bond. In foam flame bonding, a layer of urethane foam is passed over a gas flame to make it tacky on one side. The foam and the first fabric then are joined as they pass through rollers. The second fabric can be joined to the other side of the foam layer by repeating the process.

Laminating is similar to bonding except that laminated goods generally consist of foam or nontextile materials bonded to fabrics, or thick layers of foam bonded to two fabrics. Carpet backing, performed to secure the yarns and impart dimensional stability, is a specialized laminating process. It is achieved by bonding a foamed latex or jute backing to the underside of the carpet. Latex adhesives typically are used in both cases. An alternative to latex adhesives is the application of a hot melt (thermoplastic) composition.

Fabric coating is an adhesive process that uses various chemicals and synthetic resins to form a relatively distinct, continuous film on a base fabric. Polyvinyl chloride (PVC) is the most common coating for textile fabrics. The coatings may be applied as a 100 percent "active solids" system either as plastisols (dispersions of polymer particles in liquid plasticizers) or as melts (flexible grade polymer plus plasticizer). The plastisols generally are applied by knife over roll coaters; and the melts are applied by calenders (rollers). Although coatings of PVC plastisols and melts are the most common, other substances and methods also may be used for various reasons. One important process is the application of latex coating to tire cord fabric. The loosely woven tire cord fabric is dipped and coated with latex so that the fabric will bond securely with rubber during the manufacture of tires.

Flocking is an adhesive process in which short chopped fibers are applied to an adhesive pattern that has been "preprinted" on a fabric. In this manner, design areas can be produced on any type of fabric to resemble embroidery or woven clipped figures. The process is achieved by spray or electrostatic techniques.

<u>Functional Finishing</u> Functional finishing refers to the application of a large group of chemical treatments that extend the function of a fabric by providing it with desirable properties. Special finishes can be applied to make a fabric wrinkle resistant, crease retentive, water repellent, flame resistant, mothproof, mildew resistant, bacteriostatic and stain

resistant. Although the range of chemicals used is broad, the wastewater generated during application usually is relatively small. The finishes often are applied to the fabric from a water solution. It is possible to apply several finishes from a single bath. Application is by means of calenders that transport the finish from a trough to a roll to the surface of the fabric. The finish then is dried and cured onto the fabric. The wastewater sources are bath dumps and cleanup of applicator equipment and mix tanks.

Wrinkle resistance and crease retention (permanent press) are achieved by treating the fabric with synthetic resins. The resins are adhesive in nature and are permanently cross-linked with the fiber molecules. Durability is achieved by curing with heat and a catalyst, resulting in a reaction called polymerization. The actual physical structure of the fabric is changed and the fabric is said to have obtained a "permanent memory" of its flat, finished state.

Water repellency is achieved by treating the fabric with silicones and other synthetic materials. Insoluble soaps and wax emulsions have been used in the past, but these materials lack permanency. If properly applied, the silicone treatments can stand repeated washings or dry cleanings. In addition to water, the silicones successfully repel oily fluids.

Flame resistant finishes are applied to cellulosic fabrics to prevent them from supporting combustion. Phosphorus is a component of most flame retardants, as it is theorized that oxides of phosphorus combine with water formed at high temperatures to restrict the production of combustible gases. Tetrakis (hydroxymethyl) phosphonium chloride (THPC) is the essential ingredient of many flame retardant formulations.

Mothproofing finishes typically are applied to wool and other animal hair fibers. Fabric made from these fibers are impregnated with chemicals that make the fabric unfit as food for the moth larva. Chemicals such as silicofluoride and chromium fluoride are used in the formulations.

The growth of mildew, mold, fungus and rot is inhibited by application of biocides that destroy their growth. Commonly used compounds contain chlorinated phenols or metallic salts of zinc, copper or mercury. Hygienic additives also are used to inhibit the growth of bacteria. These additives prevent odors, prolong the life of the fabric and also combat mildew, mold and fungus.

Soil release finishes make it possible to remove stains from fabrics by ordinary washing. Most of the finishes use organosilicone compounds that are applied by the pad-dry-cure process. Other soil release finishes in use contain fluorocompounds or oxazoline derivatives. Soil release finishes produce a hydrophilic state in the fabric and thus make polyester and polyester blend fabrics less conducive to static collection.

In addition to functional finishing processes, there are a number of mechanical finishing operations such as calendering, embossing and napping that change the surface effect of fabric by means of rollers, pressure, heat or similar actions. These processes can be performed before or after the chemical treatment but do not result in wastewater.

<u>Major Wet Processes</u>

Most high water use textile manufacturing processes involve the conventional finishing of fiber and fabric products. The most significant processes are desizing, scouring, mercerizing, bleaching, dyeing and printing. In the case of wool products, the distinct nature of this fiber often makes additional wet processing necessary prior to conventional finishing. Additional specific processes for wool include raw wool scouring, carbonizing and fulling.

Although the various wet processes are described separately, it is not uncommon for two or more operations to occur sequentially in a single batch unit or on a continuous range. For example, it is common for desizing, scouring and mercerizing operations to be placed in tandem with the continuous bleaching range to finish cotton more efficiently. A variety of wet finishing situations of this type may occur, depending upon factors such as processes used, type and quality of materials and product and original mill and equipment design.

<u>Raw Wool Scouring</u> Wool scouring is the first treatment performed on wool and is employed to remove the impurities peculiar to wool fibers. These impurities are present in great quantities and variety in raw wool and include natural wool grease and sweat and acquired impurities such as dirt, feces and vegetable matter. Disinfectants and insecticides applied in sheep dips for therapeutic purposes also may be present. Most of the natural and acquired impurities in wool are removed in the scouring process.

Two methods of wool scouring, solvent and detergent, are practiced in the U. S., although detergent scouring is used almost exclusively. In the detergent process, the wool is raked through a series of 5,700 to 11,400 liter (1,500 to 3,000 gallon) scouring bowls known as a "scouring train." Unless the first bowl is used as a steeping or desuinting bowl, the first two bowls contain varying concentrations of either soap and alkali, or nonionic detergents of the ethylene oxide condensate class. The soap-alkali scouring baths are generally at a temperature of 46° to 54°C (115° to 130°F) and a pH of 9.5 to 10.5; neutral detergent baths normally have a pH of 6.5 to 7.5 and a temperature of 57° to 71°C (135° to 160°F). The last two bowls of the scouring train are for rinsing and a counterflow arrangement usually is employed using the relatively clean waters from these bowls in preceding bowls.

Scouring emulsifies the dirt and grease and produces a brown, gritty, turbid waste that often is covered with a greasy scum. It is estimated that for every pound of fibers obtained, one and one-half pounds of waste impurities are produced. Because the wool grease present in the scour liquor is not readily biodegradable and is of commercial value, grease recovery usually is practiced. In the most typical recovery process, the scour liquor first is piped to a separation tank where settling of grit and dirt occurs. The supernatant from the tank then is centrifuged (one or more stages) into high density, medium density and low density streams. The high density stream consists mainly of dirt and grit, and is discharged as waste. The medium density stream is recycled to the wool scouring train. The low density stream contains concentrated grease that normally is refined further to produce lanolin. Acid cracking, utilizing sulfuric acid and heat, is an alternative method of grease recovery, but it is not practiced widely at this time.

<u>Carbonizing</u> Carbonizing removes burrs and other vegetable matter from loose wool or woven wool goods. These cellulosic impurities may be degraded to hydrocellulose, without damaging the wool, when acted on by acids. It is important to remove these impurities from the wool to prevent unequal absorption of dyes.

The first operation in carbonization is acid impregnation. Typically, this step consists of soaking the wool in a 4 to 7 percent solution of sulfuric acid for a period of 2 to 3 hours. The excess acid is squeezed out and the wool is baked to oxidize the cellulosic contaminants to gases and a solid carbon residue. The charred material, primarily hydrocellulose, is crushed between pressure rollers so that it may be shaken out by mechanical agitation. Some solid waste is generated but, with the exception of an occasional dump of contaminated acid bath, no liquid waste results. However, after the residue has been shaken out, the acid must be removed. This is achieved by preliminary rinsing to remove most of the acid followed by neutralization with sodium carbonate solution. A final rinse is used to remove residual alkali. As a result, the overall water requirements for the carbonization of wool are substantial.

<u>Fulling</u> Fulling gives woven woolen cloth a thick, compact and substantial feel, finish and appearance. To accomplish it, the cloth is mechanically worked in fulling machines in the presence of heat, moisture and sometimes pressure. This allows the fibers to felt together, which causes shrinkage, increases the weight and obscures the woven threads of the cloth.

There are two common methods of fulling, alkali and acid. In alkali fulling, soap or detergent provides the needed lubrication and moisture for proper felting action. The soap or detergent usually is mixed with sodium carbonate and a sequestering agent in a concentrated solution. In acid fulling, which can be used to prevent bleeding of color, an aqueous solution of sulfuric acid, hydrogen peroxide and a small amount of a metallic catalyst (chromium, copper or cobalt) is used.

The first step in both methods is to impregnate the fabric in the fulling machines with heated fulling solution. If acid fulling is performed, it is followed by alkali fulling. No waste is produced during this step because all of the solution is absorbed by the cloth. At this point, 10 to 25 percent of the fabric weight may be process chemicals such as soap, alkali, sequesterant and carding oil. Fulling is followed by extensive washing to remove process chemicals and prevent rancidity and wool spoilage. The usual washing procedure is to subject the fulled cloth to two soapings, two warm rinses and one cold rinse. The first soaping usually is achieved by agitation of the fabric in the soapy solution created by the fulling soap already on the cloth. After a warm rinse, the cloth usually is soaped a second time in a stationary bath with a two percent solution of soap or synthetic detergent. This step is followed by a second warm rinse at 40°C (105°F) and a cold rinse to cool the cloth.

<u>Desizing</u> Desizing removes the sizing compounds applied to yarn in the slashing operation and is usually the first wet finishing operation performed on woven fabric. It consists of solubilizing the size with mineral acid or enzymes (starch size only) and thoroughly washing the fabric. Acid desizing uses a solution of dilute sulfuric acid to hydrolyze the starch and render it water soluble. Enzyme desizing uses vegetable or animal enzymes to decompose starches to a water soluble form. In either case, the desizing agent normally is applied to the fabric by roller pad. After the desizing solution has been applied, the goods are soaked or steeped in storage bins, steamers or J-boxes. After the size has been solubilized, the solution is discarded and the fabric is washed and rinsed. For desizing of PVA and CMC, sizing materials that are directly soluble in water, no decomposition is required and the goods are washed only with water.

<u>Scouring</u> Scouring is employed to remove natural and acquired impurities from fibers and fabric. The nature of the scouring operation depends on the fiber type. Raw wool scouring has been discussed separately because of its uniqueness among textile processes. Synthetic fiber scouring is milder than scouring of cotton fiber because of the smaller amount of impurities present.

Cotton fabric contains natural impurities such as wax, pectins and alcohols, as well as processing impurities such as size, dirt and oil. These substances are removed from the fabric by hot alkaline detergents or soap solutions. Also, cotton scouring makes the fibers whiter and more absorbent for subsequent bleaching and dyeing. Scouring of cotton often is done in conjunction with desizing rather than as a totally separate operation and usually is accomplished by either kier or open width boiling.

In kier boiling, desized cotton fabric in rope form is loaded into a large cylindrical pressure vessel. An aqueous solution of sodium hydroxide, soap and sodium silicate, or a similar mixture, is recirculated through the goods at temperatures up to 104°C (220°F), pH values of 10 to 13, and pressures of 0.70 to 1.41 kg/sq cm (10 to 20 psig) for 6 to 12 hours. The fabric then is cooled and rinsed in the kier. Goods processed in the open width normally are scoured in open width boil-out machines, also known as progressive jigs. The goods are fed continuously through the scouring solution by the use of transfer rolls, and after the required contact period, are unrolled through wash boxes. Methods of scouring and dumping the scour waste vary from mill to mill, but at all mills the cloth is rinsed completely to clean the fibers and remove residual alkali. Either light or heavy scouring of wool goods may be performed during wool finishing to remove acquired impurities.

Special Scouring The manufacture of synthetic fibers is well controlled and the fibers are relatively free of impurities. Consequently, only light scouring and little or no bleaching is required prior to dyeing. Sizes and lubricating oils applied to synthetics usually are removed in a special scouring process rather than in a separate desizing step. Scour baths usually contain weak alkalis, antistatic agents, lubricants, soap or detergents, and special scouring agents such as ethoxylated phenols and other emulsifiers. Optical brighteners, which function in a capacity similar to dyes, often are applied to a fabric during the special scouring process. The optical brighteners function to absorb ultraviolet rays and reflect certain wavelengths of visible light, which in turn add brightness to the color of the fabric.

Although acetate fibers may be scoured and dyed in one bath, most synthetics are scoured independently of the dyeing operation. Rope soapers, jig scours, beck scours, drum or paddle scours or beam dyeing equipment may be used. After scouring, the goods are rinsed to remove excess material in preparation for the dye bath.

Mercerizing Mercerization increases the tensile strength, luster, sheen, dye affinity and abrasion resistance of cotton goods. It may be performed on yarn or greige goods, but usually is conducted after fabric scouring. It is accomplished by impregnating the fabric with cold sodium hydroxide solution (15 to 30 percent by volume). The solution causes swelling of the cotton (cellulose) fibers as the alkali is absorbed. Higher concentrations, longer residence times and lower temperatures favor greater swelling. When increased tensile strength is a primary consideration, the fabric is mercerized on a tenter frame. After the desired period of contact, the caustic is washed off thoroughly, sometimes with the aid of an intermediate acid wash. In many mills, the sodium hydroxide is reclaimed in caustic recovery units and concentrated for reuse in scouring or mercerization. It is estimated that less than half of all cotton fabrics are mercerized and, with the increasing use of cotton-polyester blends, less mercerization is likely in the future.

Bleaching Bleaching is a common finishing process used to whiten cotton, wool and some synthetic fibers. In addition to removing color, bleaching can dissolve sizing, natural pectins, waxes and small particles of foreign matter. It usually is performed immediately after scouring or mercerizing and prior to dyeing or printing. Bins, jigs or continuous equipment may be employed. Bleaching is accomplished primarily with hydrogen peroxide, although hypochlorite, peracetic acid, chlorine dioxide, sodium perborate or even reducing agents may be used.

Most cotton fabrics are bleached on continuous bleaching ranges directly after scouring. The fabric, fed in either rope or open width form, first is washed with hot water to ensure removal of all contaminants. As the goods leave the washer, excess water is removed and sodium hydroxide is added. The saturated fabric remains at about 80° to 82°C (175° to 180°F) for approximately 40 to 60 minutes, resulting in the conversion of fats and waxes to soaps. The material then is rinsed with hot water and passed through a peroxide solution containing hydrogen peroxide and sodium silicate. At this point, the cotton is bleached out at a temperature of 90°C (195°F) for approximately 40 to 60 minutes before the final hot water rinse. A second stage of bleaching, sometimes with sodium hypochlorite, may be used in some mills.

In sodium hypochlorite bleaching, whether batch or continuous, the cloth is rinsed, scoured with a weak solution of sulfuric or hydrochloric acid and rinsed again. The cloth then is passed through a solution of sodium hypochlorite and allowed to bleach out in bins (batch) or J-boxes (continuous) for a designated period of time. A final rinse then is performed.

Bleaching methods for synthetic fabrics depend on fiber type. Because there is less coloring matter to remove, cellulosic fibers (rayon and acetate) are bleached using methods similar to, but less extensive than, those used in bleaching cotton. Noncellulosic fibers (polyesters, acrylics, nylons) usually are not bleached unless blended with natural fibers (principally cotton and wool). When bleaching is performed, various weak acids may be used.

Wool top or fabric may be bleached if white or very light colored fabric is required. Hydrogen or sodium peroxide, or optical brighteners composed of various organic compounds may be used. Control of pH is important in peroxide bleaching of wool and usually is achieved by mixing hydrogen peroxide with sodium silicate or sodium peroxide with acid. Optical brighteners are useful in combination with peroxide bleaching agents to help give wool a good white base for subsequent dyeing. Solvent bleaching systems and pressure steamers for reduction of residence time in continuous bleaching are two developments that may change the character of bleaching operations in the future.

Dyeing Dyeing is the most complex of all the wet processing operations. It is performed essentially for aesthetic reasons in that it does not contribute to the basic structural integrity, wearability or durability of the final product. It does, however, play a major role in the marketability of textile products.

The function of dyeing is to anchor dyestuff molecules to textile fibers. The color observed is a result of the light waves absorbed and reflected by the dyestuffs. The methods of dyeing, the types of dyestuffs and auxiliary chemicals used in dyeing and the types of equipment available and in use for the application of dyes are discussed below.

The mechanisms of dyeing textile fibers can be summarized as follows (10):

1. Migration of the dye from the solution to the interface, accompanied by adsorption on the surface of the fiber.

2. Diffusion of the dye from the surface towards the center of the fiber.

3. Anchoring of the dye molecules by covalent or hydrogen bonds, or other physical forces.

Dye/fiber interfacing is a function of the type of equipment utilized, while the specific dye formulas provide the chemical conditions for bonding to take place. Dyeing can be performed while the goods (fiber) are in the stock, top (wool or wool blends), yarn or fabric state. Both single and multiple fiber goods can be dyed, although multiple fiber dyeing may require multiple steps.

Stock dyeing is performed before the fiber has been converted to the top or yarn state. In simplest terms, the process involves placing stock fiber in a vat or pressure kettle, applying a sufficient quantity of dye liquor, providing optimum conditions, allowing time for the chemical reaction and rinsing. Wool used to produce fancy goods and a small amount of cotton or synthetic fibers used for flocking are dyed in this manner.

Top dyeing is performed on sliver or slubbing that is wound into a cylindrical shape approximately 46 cm (18 in.) in diameter. The top has been carded and combed but not spun into yarn. Dyeing is accomplished by placing the top in cans, placing the cans in a dye vat, circulating the dye liquor and allowing sufficient time for reaction. Fibers used for worsted fabric usually are dyed in this manner.

Yarn dyeing is performed on yarns that are used for woven goods, knit goods and carpets. The traditional methods are skein (hank), package and space dyeing. Skein dyeing is accomplished by placing turns of yarn on a frame, placing the frame in a dye bath in which either the frame or the dye liquor is circulated, providing optimum conditions, allowing time for reaction and rinsing. Package dyeing is the most common yarn dyeing process and is accomplished by placing yarn wound onto perforated tubes on a frame, placing the frame into a pressure vessel, circulating dye liquor in and out of the cones and yarn under optimum conditions and rinsing. Warp yarns wound on large perforated beams also are dyed using the package method. The beams of dyed yarn can be used directly in weaving.

Package dyeing is favored over skein dyeing because skein-reeling is a comparatively expensive process, more working space is required and the skein-dyed yarn must be wound onto a bobbin, cone or spool at a later stage.

Space dyeing is a specialty yarn dyeing process. The technique resembles the roller printing process discussed below, in that the dye liquor is applied to warp yarns at a repeat or random interval by a roller type dye pad. The dyed yarn then enters a hot water steam box for development and fixation of the color and finally is rinsed. Two or more dyes can be padded. The process is especially important to the manufacture of tufted carpet.

Fabric dyeing is the most common dyeing method in use today. It is preferred over yarn dyeing because it is a continuous or semicontinuous process and because a mill does not have to process large lots to be cost effective. The methods employed include beck (winch), jet, jig and continuous range.

Beck dyeing is accomplished with the fabric in the rope form. Both atmospheric and pressure machines are used. In either case, the fabric, connected end to end, is rotated through dye liquor by passing over a large rotating drum. Twelve or more loops of fabric can be dyed side by side, being kept apart by dividing fingers. The length of each loop is such that the fabric lies in a heap at the bottom of the beck for a short time. The proper conditions and residence time must be provided as in the other previously described methods.

Jet dyeing also is accomplished with the fabric in rope form. Jet machines are similar to the pressure becks except that each loop of fabric passes through a venturi tube. A pump circulates the dye liquor through the tubes and the suction at the venturi causes the fabric to rotate. Jet machines have improved on certain deficiencies of beck dyeing by allowing shorter liquor-to-fabric ratios (less dye liquor per unit weight of fabric), reducing the risk of tangling, providing a more uniform temperature, reducing elongation of the fabric caused by tension and lessening the formation of creases in synthetic fabrics. Jet dyeing is especially suitable to synthetic fibers.

Jig dyeing is performed with the fabric in the open width. Both atmospheric and pressure equipment are available. Dyeing is accomplished by slowly winding the fabric over rollers that stand above a shallow trough containing the dye liquors. The rollers, by rotating in clockwise and counterclockwise directions alternately, move the cloth through the dye liquor, complete immersion being insured by guide rollers at the bottom of the trough. Because only a few meters of the fabric are immersed at a time, it is possible to work with an exceedingly short liquor ratio (low dye liquor volume per unit weight of fabric). Jig dyeing is particularly attractive for cellulosic fibers because the dyes used generally do not exhaust well and less dyestuff is wasted.

Continuous dyeing also is performed with the fabric in the open width. It is accomplished under atmospheric conditions on what are termed "continuous dyeing ranges." These ranges generally consist of a number of dip troughs through which the fabric is dyed and oxidized, rinse boxes that remove excess dye liquor and heated rotating drying cans.

Thermosol dyeing is a continuous process used for dyeing polyester, and polyester/cotton blends. Dye is padded onto the fabric in the pigment form from a pad box and dried, causing a film containing the dye to adhere to the surface of the fibers. The fabric then is heated to 180° to 220°C (355° to 430°F) for a period of 30 to 60 seconds to set the dye. The transfer of dye from the surface deposit to the polyester is through the vapor phase.

Dyes are classified according to their chemical constitution or on the basis of their dyeing properties, with little correlation between the two systems. Classification according to application is most relevant and is discussed below. Classification according to chemical constitution is not discussed, but the reader is referred to the Colour Index, Volume III, published by the Society of Dyers and Colourists and the American Association of Textile Chemists and Colorists for a thorough coverage of this subject.

The following tabulation provides the classification name and the principal fiber types for which the dye classes are used, based on the application classification.

Dye Class	Applicable Fiber Types
Acid	Protein, polyamide (nylon)
Azoic (Naphthal)	Cellulosic
Basic (Cationic)	Acrylic, silk, protein, cellulosic if mordanted
Direct	Cellulosic
Disperse	Cellulosic, acetate, synthetics (man-made)
Mordant (Chrome)	Protein, cellulosic
Premetallized	Protein
Reactive	Cellulosic, protein, silk
Sulfur	Cellulosic
Vat	Cellulosic, protein, silk

Acid Dyes - These dyes are sodium salts, usually of sulfonic acids, but in a few cases carboxylic acids. They invariably are manufactured as sodium salts because free acid dyes are more difficult to isolate and they are hygroscopic, which makes them difficult to pack and store. Acid dyes have a direct affinity for protein fibers and are the main class of dyes used in wool dyeing. Most will not exhaust on cellulosic fiber but, because acid dyes resemble the direct dyes in chemical constitution, there are a number that dye cellulose quite well. The dyes also have an affinity for polyamide fibers.

There are many ways in which the acid dyes are applied. Primarily, the variations create conditions suitable to the type of dye used. In addition to the dyes, the following auxiliary chemicals may be required for satisfactory dyeing:

sodium sulfate (Glauber's salt)
sulfuric acid
formic acid
acetic acid
ammonium acetate
ammonium sulfate
ammonium phosphate
leveling agents

Azoic Dyes - These dyes are insoluble pigments anchored within the fiber by padding with a soluble coupling compound and then treating with a diazotized base or stabilized color salt. Because naphthol is used as the coupling component, azoic dyes are also referred to as naphthol dyes. They are used for dyeing cellulosic fibers when comparatively good water fastness and brightness of shade are required at a reasonable cost. They are especially satisfactory in the yellow, orange and red spectrum. They have been applied to protein fibers, but equally good results can be obtained with acid dyes by simpler methods.

Dyeing with azoic dyes is a two-stage process involving impregnating the fiber with an azoic coupling component and coupling with a diazonium salt. There are over 50 coupling components listed in the Color Index (C.I.), and over 50 bases that can be diazotized and coupled with the former (10). In addition to the coupling component and base, common salt and surface-active compounds (sulfated fatty alcohol or ethylene oxide condensate) are usually used to speed the reaction.

Basic Dyes - These dyes are usually hydrochlorides of salts or organic bases. The chromophores are found in the cation; therefore, these dyes often are referred to as cationic dyes. Because of poor fastness to light, these dyes virtually had been discontinued until it was discovered that they would dye acrylic fibers and give bright, clear shades of color which possess good light fastness. Cellulosic fibers have, for all practical purposes, no affinity for basic dyes. The dyes can be applied to cellulose if the fibers are mordanted before dyeing; however, these dyes are rarely applied to cotton in current practice. In the case of protein fiber, there is substantial evidence that the affinity is of a chemical nature.

There are several methods of applying basic dyes to acrylic fibers and many dyes that are suitable. In addition to the dye, the following auxiliary chemicals may be necessary for satisfactory dyeing:

acetic acid
formic acid
oxalic acid
tannic acid
sodium sulfate
sodium acetate
ethylene carbonate

Direct Dyes - These dyes resemble acid dyes in that they are sodium salts of sulfonic acids and are almost invariably azo compounds. They have a direct affinity for cellulosic fibers. These dyes frequently are referred to as substantiative dyes and, in special circumstances, they are used to dye protein fibers. The distinction between acid and direct dyes is often not well defined. For example, C.I. Direct Dye 37 may be applied as a direct dye to cellulose or as an acid dye to protein fibers. The dyes offer a rather wide range of color; however, their water fastness and light fastness vary depending on shade.

The direct dyes are divided into three classes; self-leveling (Class A), salt controllable (Class B), and temperature controllable (Class C). Depending on the class of the dye used, one or more of the following auxiliary chemicals may be necessary for satisfactory dyeing:

sodium chloride
sequestering agents
sodium sulfate
sodium nitrite
hydrochloric acid
aromatic amines

Disperse Dyes - this class of dyes arose out of the need to find an easy and satisfactory way to dye cellulose acetate. These dyes are suspensions of finely divided organic compounds with very slight aqueous solubility. Hydrophobic fibers, such as secondary or tertiary cellulose acetate, and the synthetic fibers often will dye better with insoluble dyes than those that are dissolved in water.

There are numerous disperse dyes but no sharp dividing lines to group them into separate classifications according to their dyeing behavior. In addition to the dyes, one or more of the following auxiliary chemicals may be necessary for satisfactory dyeing:

acetic acid
dispersing agents
orthophenylphenol
butyl benzoate carriers
chlorobenzene
diethyl phthalate
other carriers

Mordant Dyes - This class of dyes includes many natural and synthetic dyes, the latter usually being obtained from anthracene. These dyes have no natural affinity for textile fibers, but are applied to cellulosic or protein fibers that have been mordanted with a metallic oxide. Because chromium is the most commonly used mordant, these dyes often are referred to as chrome dyes. At one time, there were a number of naturally occurring mordant dyes in use, but acid mordant dyes have replaced these. The acid mordant dyes are applied to wool or polyamide fibers as if they were acid dyes and, by subsequent mordanting, are given good water fastness.

The mordant dyes usually are applied in a boiling acid dye bath and, when exhaustion is complete, an appropriate amount of dichromate is added and the bath boiled for an additional 30 minutes. The following auxiliary chemicals are generally necessary to achieve satisfactory results:

acetic acid
sodium sulfate (Glauber's salt)
penetrating agents
sulfuric or formic acid
potassium or sodium dichromate
ammonium sulfate

Premetallized Dyes - These dyes were developed so wool could be dyed directly without the need for mordanting in an after-treatment step. They are classified as 1:1 and 2:1 metal complex dyes depending on the number of dye molecules present for each metallic atom. Premetallized dyes are quicker to apply, easier to match, and for some colors, brighter than mordant dyes.

The premetallized dyes are applied like acid mordant dyes in a boiling acid dye bath. In addition to the dyes, the following auxiliary chemicals are necessary to achieve satisfactory results:

sulfuric acid
sodium sulfate
leveling agent

<u>Reactive Dyes</u> - These are the latest dyestuff discovery and, because they react chemically with cotton, viscose, linen, wool and silk, they possess very good water fastness. They can be dyed by many methods and adapt well to the requirements of continuous dyeing. The whole spectrum of color can be applied with these dyes.

There are several classes of reactive dyes that are specific to the fibers being processed. In addition to the dyes, one or more of the following auxiliary chemicals may be necessary for satisfactory dyeing:

sodium chloride
urea
sodium carbonate
sodium hydroxide
trisodium phosphate
tetrasodium pyrophosphate

<u>Sulfur Dyes</u> - These dyes are complex organic compounds that contain sulfur linkages within the molecules. Sulfur dyes usually are insoluble in water, but dissolve in a solution of sodium sulfide to which sodium carbonate may be added. The sodium sulfide acts as a reducing agent, severing the sulfide linkage and breaking down the molecules into simpler components that are soluble in water and have an affinity toward cellulose. The soluble components then are oxidized in the fiber to the original insoluble sulfur dyes. These dyes have excellent resistance to washing, but poor resistance to sunlight. Sulfur dyes will dye cotton, linen and rayon, but the colors are not very bright.

In the reduced state, the dyeing properties of the sulfur dyes resemble those of the direct dyes. These dyes exhaust better in the presence of electrolytes and vary considerably with regard to the temperatures at which maximum exhaustion takes place. Sulfur dyes are decomposed by acids, usually with the liberation of hydrogen sulfide, and when exposed to air or acted upon by mild oxidizing agents, some of the sulfur is oxidized to sulfuric acid. In addition to the dyes, one or more of the following auxiliary chemicals may be necessary for satisfactory dyeing:

sodium sulfide
sodium carbonate

sodium dichromate
acetic or alternative acids
hydrogen peroxide
sodium chloride
sodium sulfate
copper sulfate

Vat Dyes - These are the best known dyes in use today because of all-around fastness to both washing and sunlight. Vat dyes are among the oldest natural coloring matters used for textiles. These dyes are insoluble in water and cannot be used without modification. When treated with reducing agents, vat dyes are converted into leuco (combining) compounds, all of which are soluble in water in the presence of alkali. The leuco compounds have an affinity for cellulose and reoxidize to the insoluble colored pigment within the fiber when exposed to air. Vat dyes are made from indigo, anthraquinone and carbazol and are successfully used on cotton, linen, rayon, wool, silk and sometimes nylon. These dyes also are used in the continuous piece goods dyeing process, sometimes called the pigment application process. In this method, the dyes are reduced after they have been introduced into the fabric.

Each vat dye has its own optimum temperature and specific proportions of alkali and reducing agents for vatting. In practice, however, it is practical to classify them into four groups, based on method of application:

Method 1 - Dyes requiring relatively high alkali concentration and high vatting and dyeing temperatures.

Method 2 - Dyes requiring moderate alkali concentrations, lower temperatures for reducing and dyeing, and some electrolyte to complete exhaustion.

Method 3 - Dyes requiring low alkali concentration, low vatting and dyeing temperatures and large quantities of electrolyte.

Method 4 - A special case for dyeing blacks requiring exceptionally high alkali concentration and temperature but no electrolyte.

In addition to the dyes, one or more of the following auxiliary chemicals may be necessary for satisfactory dyeing:

sodium hydroxide
sodium hydrosulfite
dispersing agents
hydrogen peroxide
acetic acid
sodium perborate
sodium chloride

Printing Printing, like dyeing, is a process for applying color to fabric. However, the color application techniques are quite different. Instead of coloring the whole cloth as in dyeing, print color is applied only to specific areas of the cloth to achieve a planned design. Consequently, printing often is referred to as localized dyeing.

Most of the textiles wet-printed in the U.S. are printed by the roller machine method and a smaller proportion by the screen method. Highly advanced electronically-controlled spray printing techniques are beginning to emerge, especially in the printing of carpet.

Roller printing is accomplished by transferring the desired design onto copper rollers; applying print paste from reservoirs to rotating rollers that contact a main cylinder roller that transports the fabric; transferring the design to the fabric by contacting the rollers and fabric; and steaming, aging or performing other after-printing operations.

The design can be transferred to the rollers by hand engraving, photo engraving or chemical etching. The latter two methods are used most today. The copper rollers, as many as 16 per print machine, may have a circumference of from 35 to 91 cm (14 to 36 in.), and a length of from 117 to 152 cm (46 to 60 in.). They are hollow, and steel mandrils are pressed into the hollows to hold the rollers in position and to turn them at the desired speed. The rollers generally are coated with a thin layer of chromium to prevent damage to the engraving during handling. Each roller imprints one repeat of the design with color supplied from the color trough. As the roller spins, a doctor knife continuously scrapes the extraneous color back to the color trough. A different design and color can be transferred for each roller. Generally, only one side of the fabric is printed.

Final washing of the fabric removes excess print paste and leaves a uniformly smooth effect. This process, along with the cleanup of print paste mixing tanks, applicator equipment (troughs and rollers) and belts, contributes the pollutant loading associated with the printing process.

Screen printing differs from roller printing in that the print paste is transferred forceably to the fabric through the openings in specially designed screens. The process can be manual, semiautomatic or completely automatic. Automatic screen printing can be either flat bed or rotary, while manual and semiautomatic screen printing are flat bed processes only.

Screens are made by manually (sketching or tracing) or photographically transferring the desired design. If the transfer is performed manually, the area outside the design is opaqued so that print paste will be retained. In the photographic transfer technique, which is the method most widely used in current practice, the negative is used for the opaquing process, using a specially sensitized coating. The screens, which are largely made of synthetic materials today, are securely stretched over a wooden frame so they can be correctly positioned. A separate screen is made for each color in the design.

In manual screen printing, the fabric is stretched out on long tables, the screens representing the pattern laid on it according to the repeat pattern, and the selected print paste forced through the screen mesh onto the fabric by squeegee. The fabric is dried by placing it on a rack above the table, steamed to set the color, followed by other finishing treatments for fineness and texture.

The semiautomatic process is similar to the manual process except that the fabric travels and the screens representing the pattern are stationary. The handling of the screens and the application of the color still are performed manually.

Automatic flat bed screen printing is accomplished on a machine that electronically performs and controls each step of the operation. It is a continuous process in which the fabric moves along a table, the screens representing the design are automatically positioned and the color automatically is deposited and squeegeed through the screen onto the fabric. The fabric moves forward one frame between each application of color and as it leaves the last frame, it passes into a drying box, from which it emerges dry and ready for aging (curing).

Rotary screen printing combines some of the advantages of both roller printing and screen printing. Instead of flat screens, the color is transferred to the fabric through lightweight metal foil screens that resemble the cylinder rollers of the roller printing process. The desired design is transferred to the foil screens in much the same way as for the flat screens. The fabric moves continuously under the cylinder screens and print paste is forced, under pressure, from the inside of the screens through and onto the fabric. A separate screen is required for each color in the design.

Rotary screen printing is faster than flat bed printing and approaches the production speed of roller printing. The down time (out of production time) during pattern changeover is somewhat less than for roller printing. As with roller printing, wastewater is generated primarily from the final cleaning of the fabric, cleanup of applicator equipment and cleaning of belts.

Another type of printing that is in use today is sublistatic (heat transfer) printing. This method employs a prepared pattern paper from which a design can be transferred to nearly any fabric by a simple hot transfer or calendering operation. The main advantages of the sublistatic process are ease of application, clarity of reproduction, flexibility in design choice and a wide range of design sizes. After printing, no subsequent treatment such as washing or steaming is required and there is no print paste to clean from equipment. Consequently, the process does not generate wastewater.

The auxiliary chemicals used in printing each of the dye types are included in the lists provided in the discussion of dyeing. In addition, a thickener is used to give the print paste the desired viscosity for the method employed and the pattern desired. The thickeners commonly used are locust bean, guar, alginate, starch and combinations of these gums. Urea, thiourea and glycols also are used in many print formulations.

In printing with pigments, which do not react chemically with the fiber as do some dyes, the same general formula is used for all fiber types. The formula includes the pigment, resin, binder, latex, emulsifier, varsol (solvent), thickener and water.

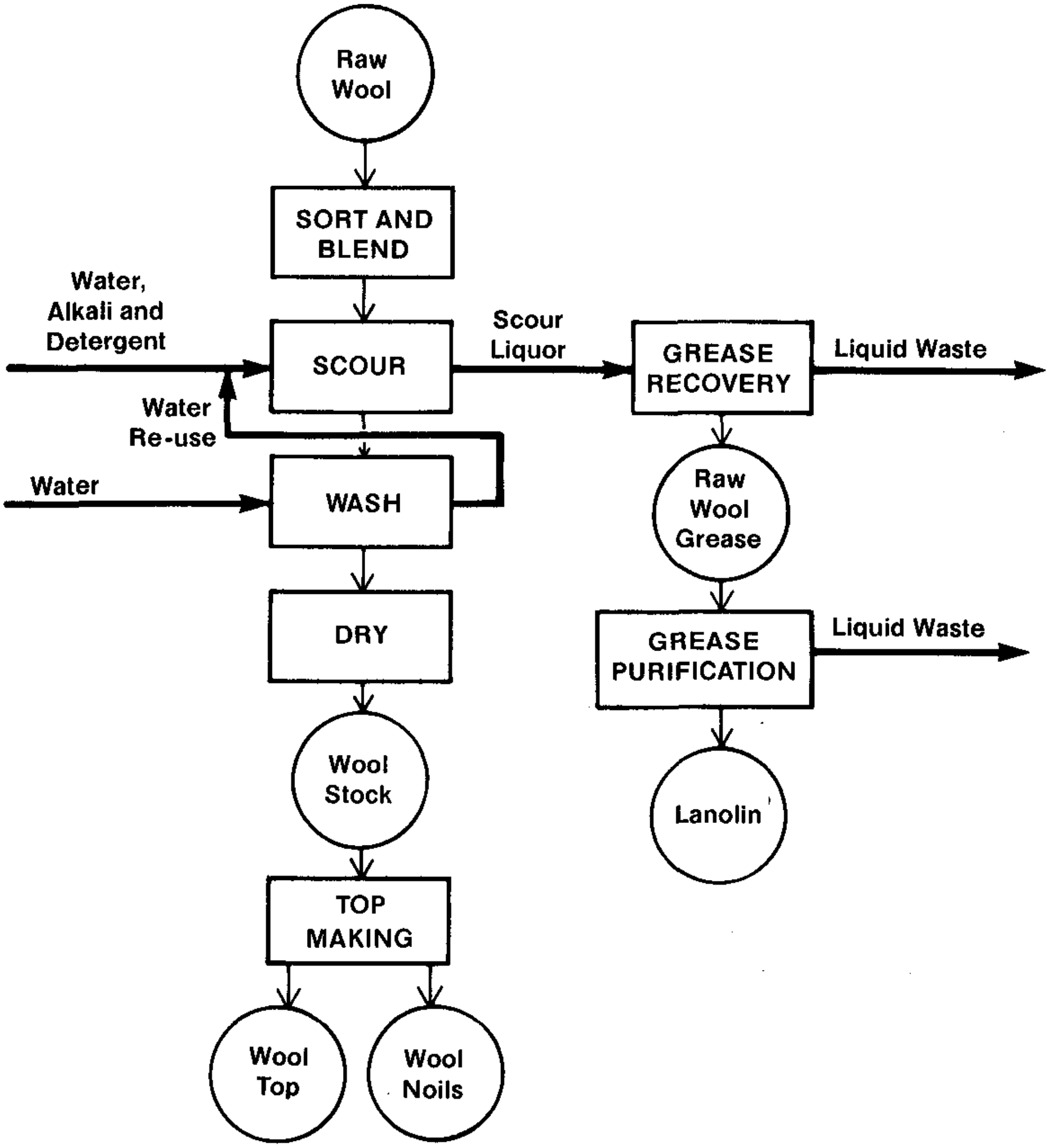
FINAL PRODUCTS

It has been noted earlier in this section that the textile mill products group (SIC Major Group 22) includes 30 separate industries that manufacture approximately 90 classes of products. Throughout the 90 product classes, there are hundreds of individual products and the number is changing constantly as a result of ongoing research, development and marketing. Many of the industries and product classes do not include wet operations in their manufacturing processes and, consequently, are not of specific interest here. Nine major subcategories have been established to represent the wet processing segment of the industry in the development of effluent limitations guidelines and standards for this industry. Two of the nine major classes (woven fabric and knit fabric) have been further subdivided resulting in thirteen separate subcategories or subdivisions. (See Section IV for explanation of the subcategorization developed for the textile industry). The subcategories/subdivisions represent 13 processing classes in which the products are composed of characteristic raw materials and in which the production is the result of similar manufacturing operations. A description of each major class (subcategory) follows.

Wool Stock and Top (Wool Scouring subcategory)

Raw wool is very dirty and must be cleaned and prepared before it can be processed. A number of mills scour wool and make wool top as a final product and ship it to other facilities for further processing. A schematic of a typical wool scouring operation is presented in Figure III-3. Raw wool is scoured after it has been sorted and blended. The scouring process has been described previously. Most mills in this segment practice countercurrent flow of wash water and recover grease from the scour waste. The

FIGURE III-3
SUBCATEGORY 1: TYPICAL WOOL SCOURING PROCESS FLOW DIAGRAM



scoured wool must be dried thoroughly to prevent rancidity. Dried wool may be shipped as a final product, combed to create wool top or finished in another portion of the mill.

Finished Wool Goods (Wool Finishing subcategory)

Wool not only requires more preparation than other fibers, but also requires unique finishing operations. As a result, there are a number of mills in the industry devoted exclusively to finishing wool goods. A schematic of the typical wool finishing process is presented in Figure III-4. Finished wool products include top, yarn, blankets and fabrics for apparel, upholstery, outerwear and numerous other uses. A single mill may manufacture any number of these products. Light scouring, dyeing and washing are employed regardless of whether top, yarn or fabric is being finished. In addition, carbonizing, bleaching, oiling, carding and spinning may be performed when finishing wool top. Carbonizing and bleaching also are performed at mills finishing wool fabric, as is fulling (felting) and final finishing. Knitting or slashing and weaving must be performed to produce wool fabric from yarn. These steps can occur at a greige mill, at a top finishing mill after spinning, at a yarn finishing mill after dyeing and washing, or at a fabric finishing mill prior to carbonizing or fulling.

Greige Goods and Adhesive Products (Low Water Use Processing subcategory)

Greige goods are materials that are woven or knit, but not finished. A large number of mills perform the mechanical operations to produce greige goods and ship them to other mills for dyeing and finishing. The manufacture of woven greige goods is the only fabric construction process that results in the generation of process wastewater. A typical woven greige mill operation (Figure III-5) consists of opening and picking the fiber, carding and spinning the fiber into yarn, applying size to the yarn and weaving the yarn into fabric on a loom. Usually, only a small quantity of wastewater is generated during slasher cleanup, although at the few mills where water jet weaving is employed, the wastewater discharge may be substantial.

Adhesive products are goods that have been created or modified because of operations such as bonding, laminating, coating or flocking. Backed carpet, tire cord fabric other coated fabrics, laminated fabric, and flocked fabrics are the principal products. A schematic of a typical adhesive operation is presented in Figure III-5. Application of adhesive and setting or drying are the main adhesive processes.

Finished Woven Goods (Woven Fabric Finishing subcategory)

Finished woven fabric is a primary textile product that is used in countless applications. Sheeting, industrial fabrics,

FIGURE III-4
SUBCATEGORY 2: TYPICAL WOOL FINISHING PROCESS FLOW DIAGRAM

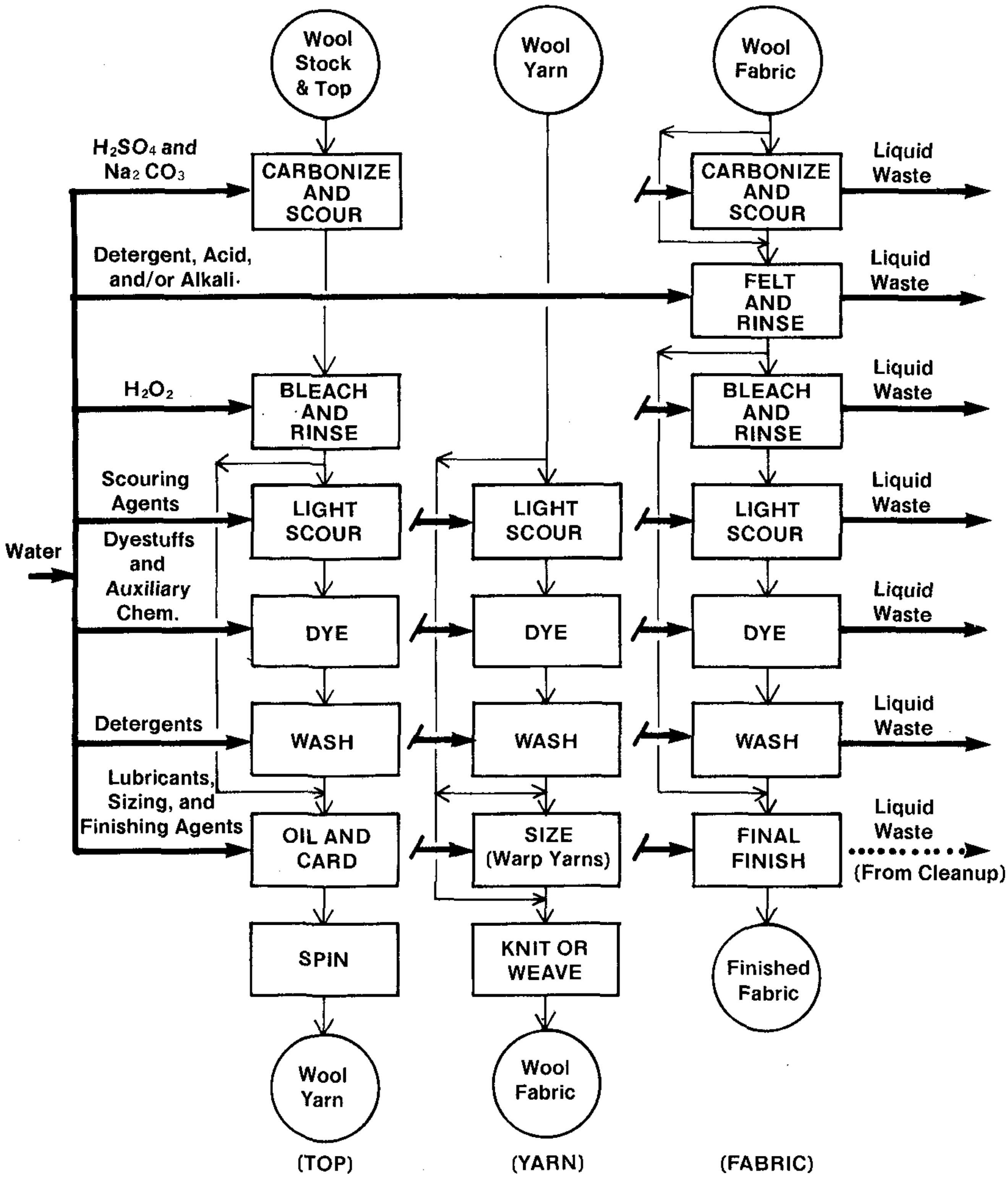
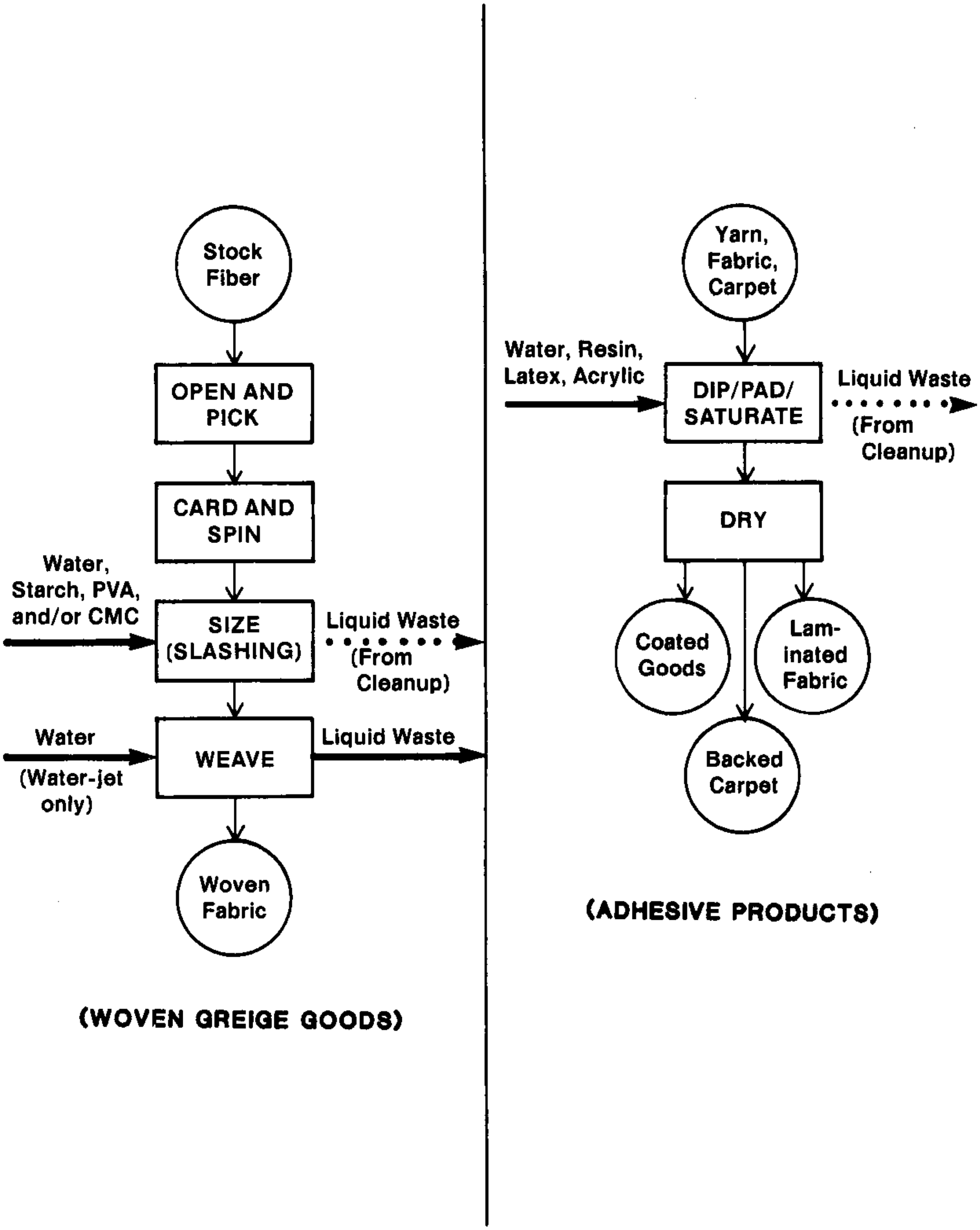


FIGURE III-5

SUBCATEGORY 3: TYPICAL LOW WATER USE PROCESSING PROCESS FLOW DIAGRAMS



upholstery, towels and materials for numerous types of apparel are finished at the mills in this subcategory. A typical process flow diagram is presented in Figure III-6. For cotton fabrics, typical processing consists of desizing to remove size applied to the yarn prior to weaving, scouring to remove natural and acquired impurities from the fabric, mercerizing to increase the luster, strength and dye affinity of cotton fabric, bleaching to whiten cloth and remove stains, dyeing and/or printing to impart desired colors and patterns to the fabric and final finishing to add other desired qualities and properties to the fabric. For synthetic fabrics, extensive desizing, mercerizing and bleaching are less common.

Finished Knit Goods (Knit Fabric Finishing subcategory)

Finished knit goods include fabrics and hosiery. Principal fabric products are underwear, numerous types of outerwear, various types of household and industrial items, circular knits and warp knits. Hosiery products include both conventional footwear, ladies nylon hose and pantyhose. Typical process flow diagrams for knit fabric processing and hosiery processing are presented in Figure III-7. Knit fabric finishing is similar to the finishing required for woven goods, except that desizing and mercerizing are not necessary. Hosiery finishing usually is simpler because the cleaning and dyeing processes often are combined and can be less extensive.

Finished Carpet (Carpet Finishing subcategory)

Carpet manufacturing is an important and distinct segment of the textile industry. Most carpet mills are integrated operations that tuft, finish and back carpet at the same location. Finishing operations may include scouring, bleaching, dyeing, printing and application of functional finishing agents. A typical process flow diagram is presented in Figure III-8.

Finished Stock and Yarn (Stock and Yarn Finishing subcategory)

Many of the products previously noted often are manufactured from finished yarn. Stock also is used in the manufacture of products already noted. Both yarn and thread are used outside the industry and as such are sold as final products. A schematic of typical yarn and stock finishing operations is provided in Figure III-9. Yarn finishing and stock finishing basically involve the same processes except that mercerizing is not performed on stock.

Nonwovens (Nonwoven Manufacturing subcategory)

Nonwoven manufacturing is a relatively new and rapidly growing segment of the textile industry. Typical products include filter media, diapers, interliners, padding, surgical gowns, absorbent wipes and other disposable products, as well as fabrics for other uses. A schematic of a typical nonwoven manufacturing operation

FIGURE III-6

SUBCATEGORY 4: TYPICAL WOVEN FABRIC FINISHING PROCESS FLOW DIAGRAM

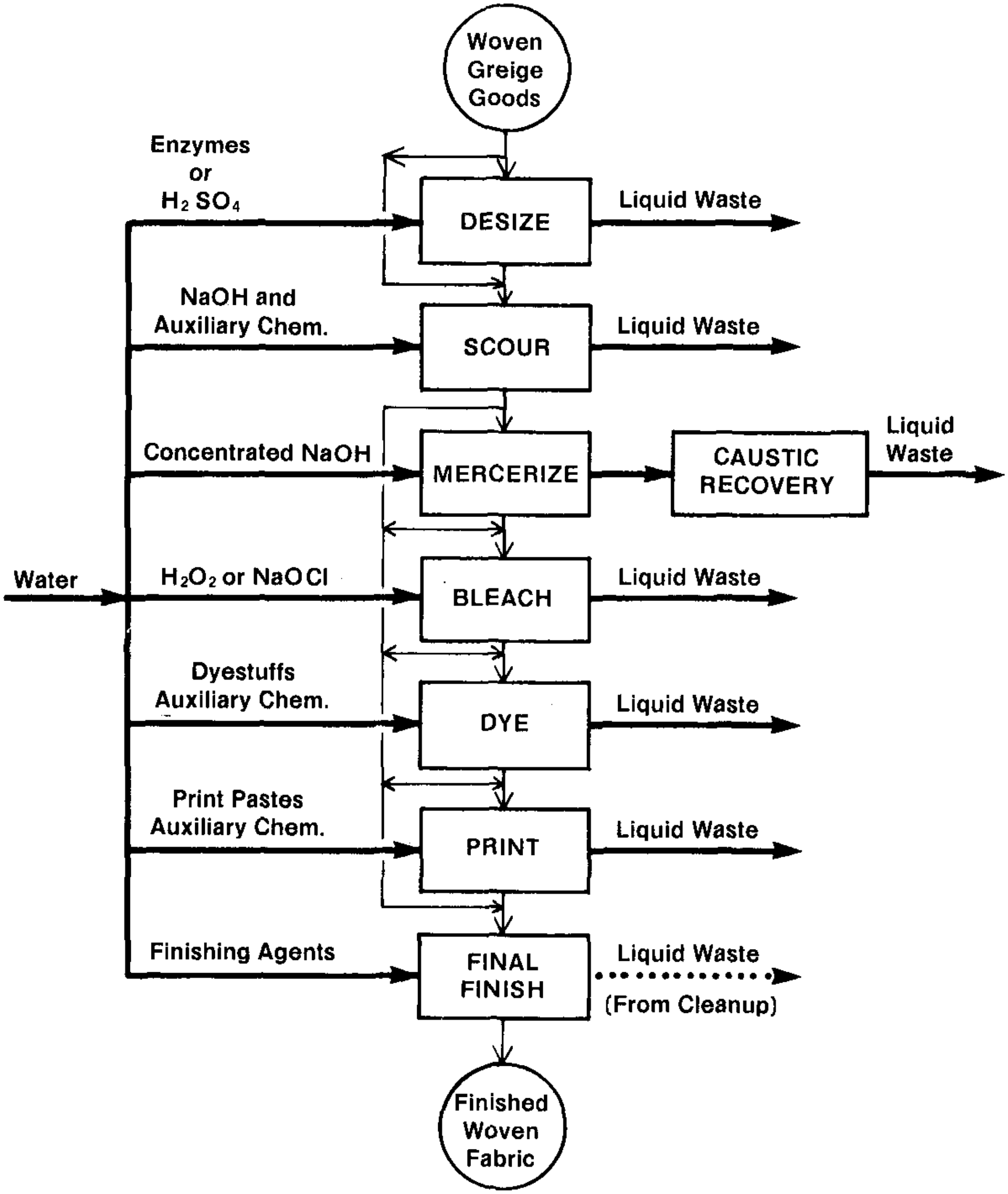


FIGURE III-7

SUBCATEGORY 5: TYPICAL KNIT FABRIC FINISHING PROCESS FLOW DIAGRAM

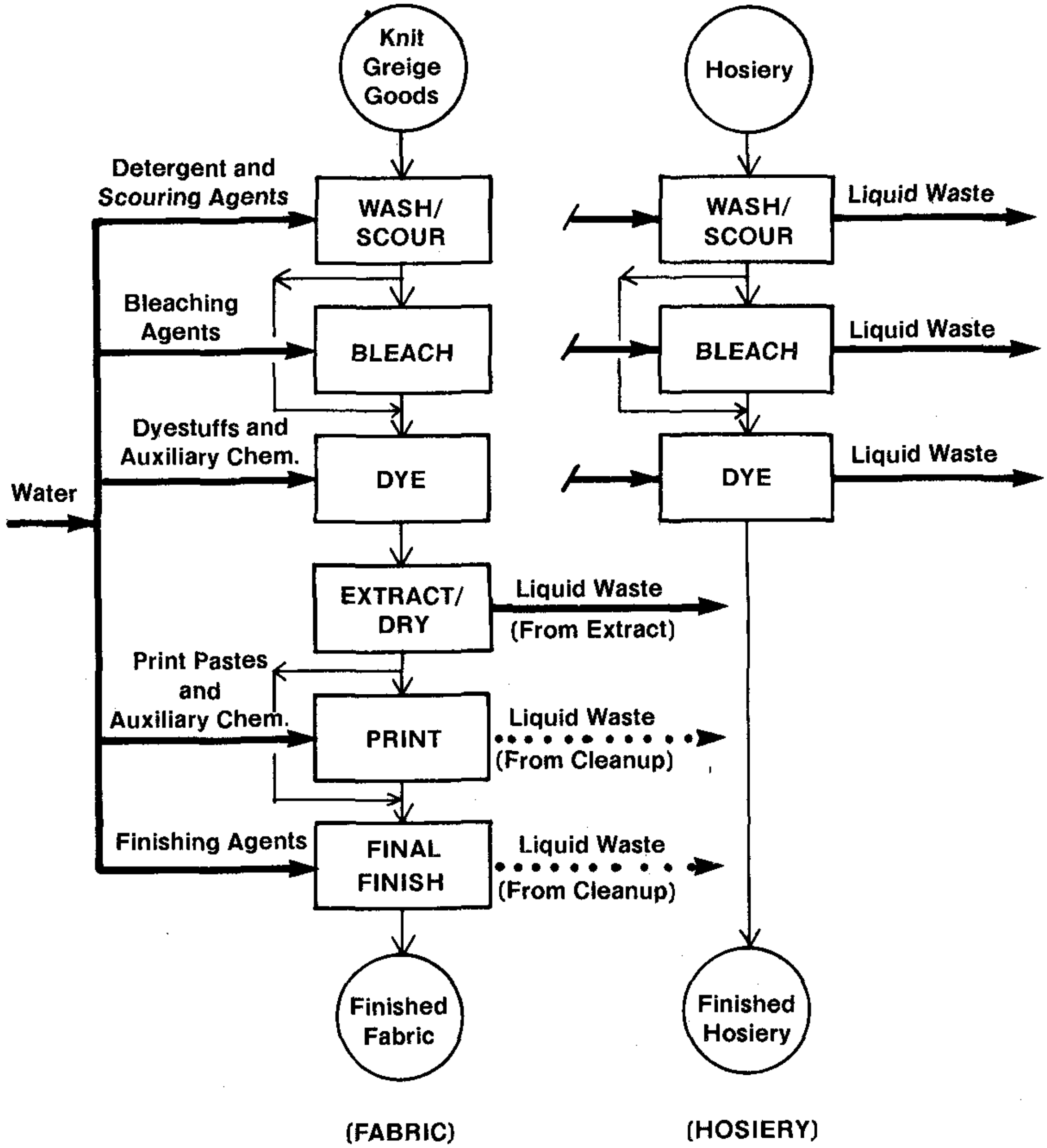


FIGURE III-8

SUBCATEGORY 6: TYPICAL CARPET FINISHING PROCESS FLOW DIAGRAM

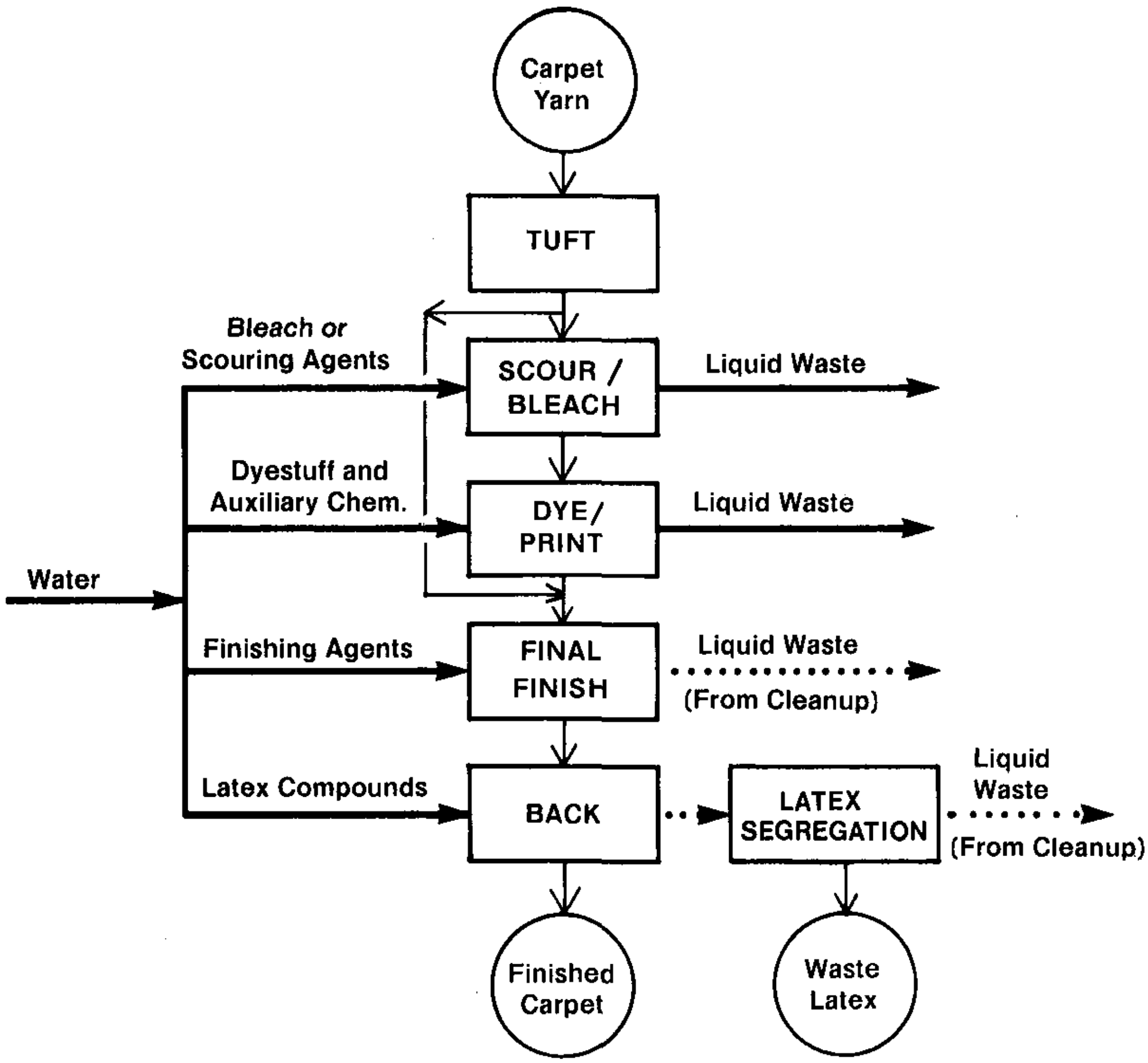
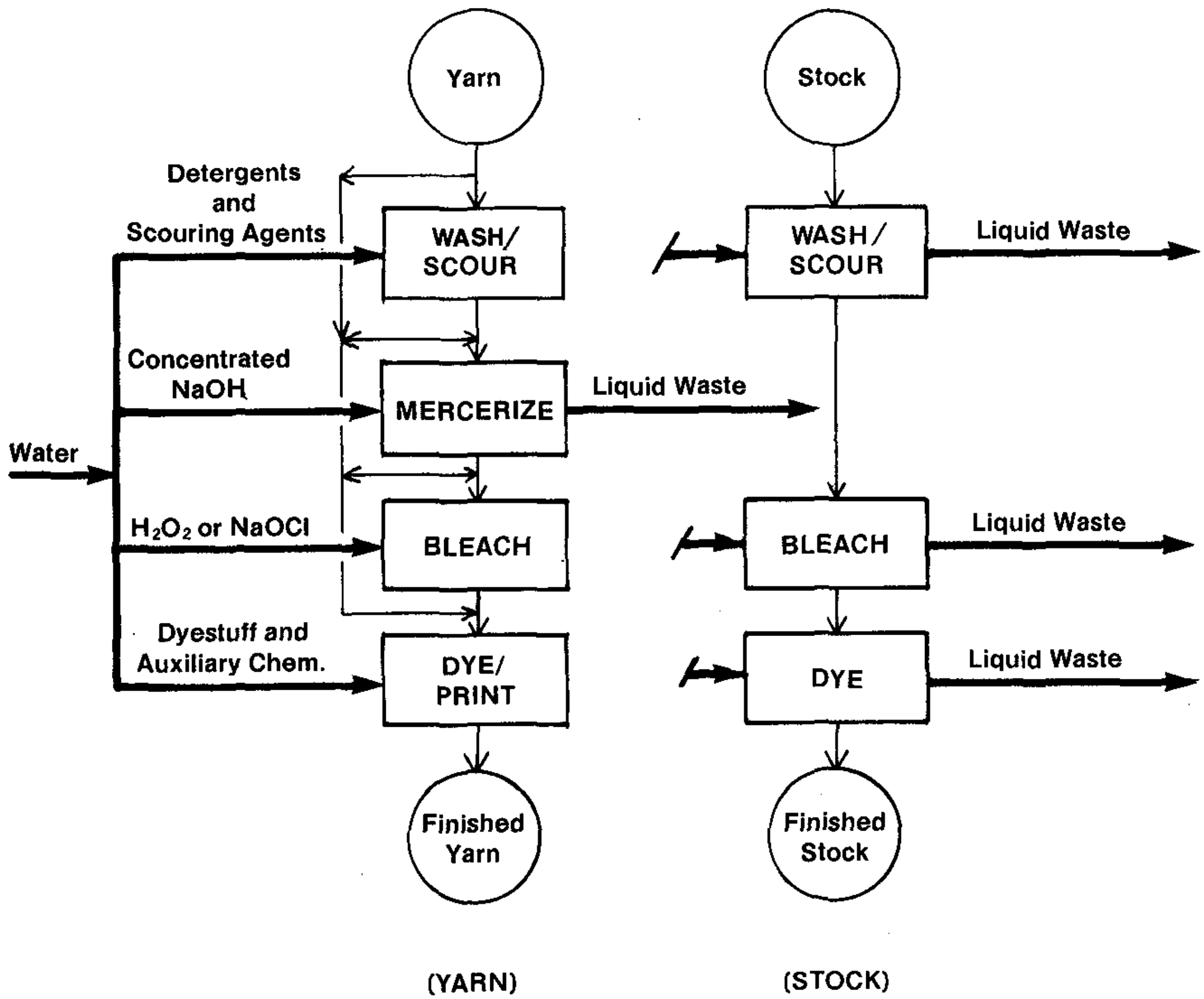


FIGURE III-9

SUBCATEGORY 7: TYPICAL STOCK AND YARN FINISHING PROCESS FLOW DIAGRAM



is presented in Figure III-10. Web formation is a dry operation unless the wet-lay process is employed. In the latter case, a portion of the water used to transport the fibers and form the web often is discharged.

Felted Fabric (Felted Fabric Processing subcategory)

Although felted fabrics comprise a relatively small segment of the textile industry, they are used in a variety of applications. In addition to woven papermakers' felt, there are pressed felts and punched or needleloom felts. Typical products include polishing cloth, insulating fabric, lining, trimming, acoustical fabric, automotive padding, felt mats and felt apparel fabric. A typical felted fabric processing flow diagram is presented in Figure III-11. Rinsing following fulling and dyeing (if employed) is responsible for the rather high water use of this segment.

FIGURE III-10

SUBCATEGORY 8: TYPICAL NONWOVEN MANUFACTURING PROCESS FLOW DIAGRAM

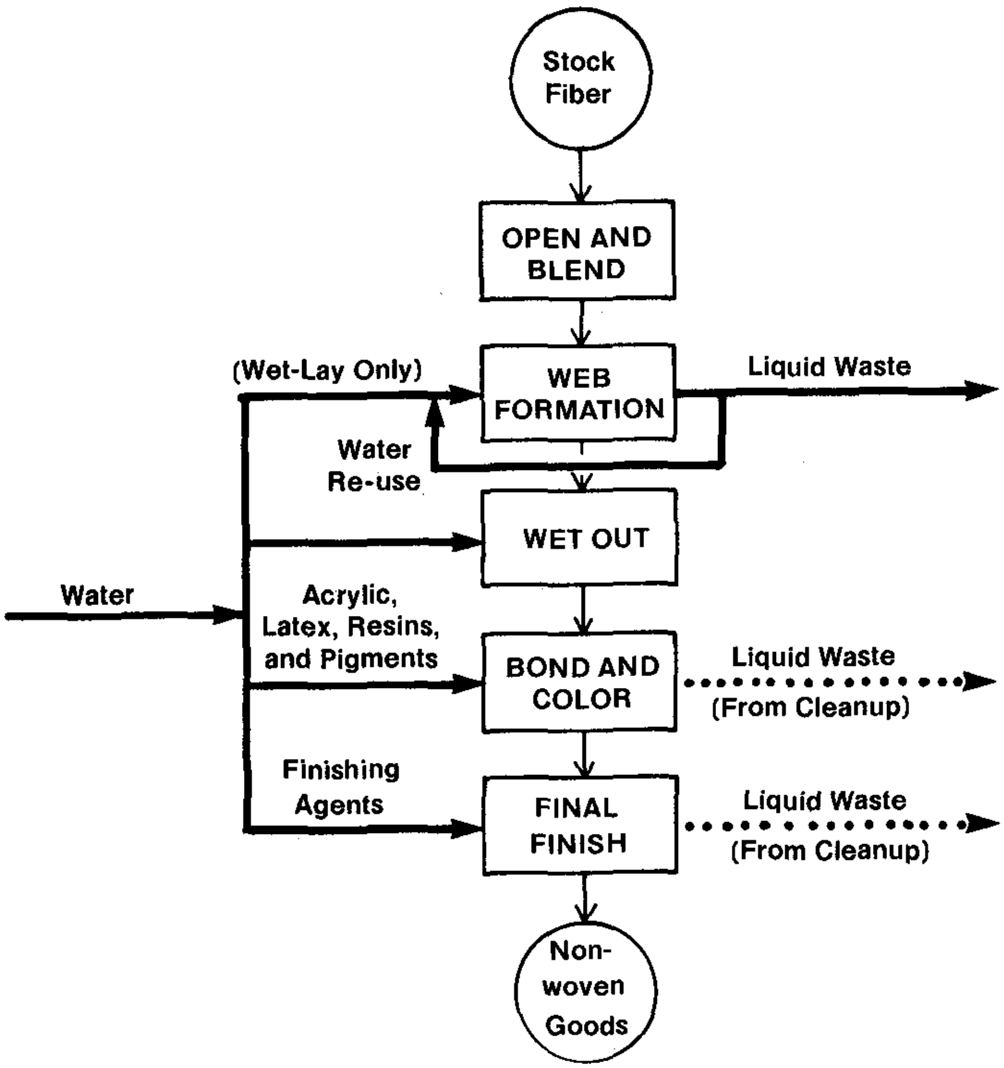
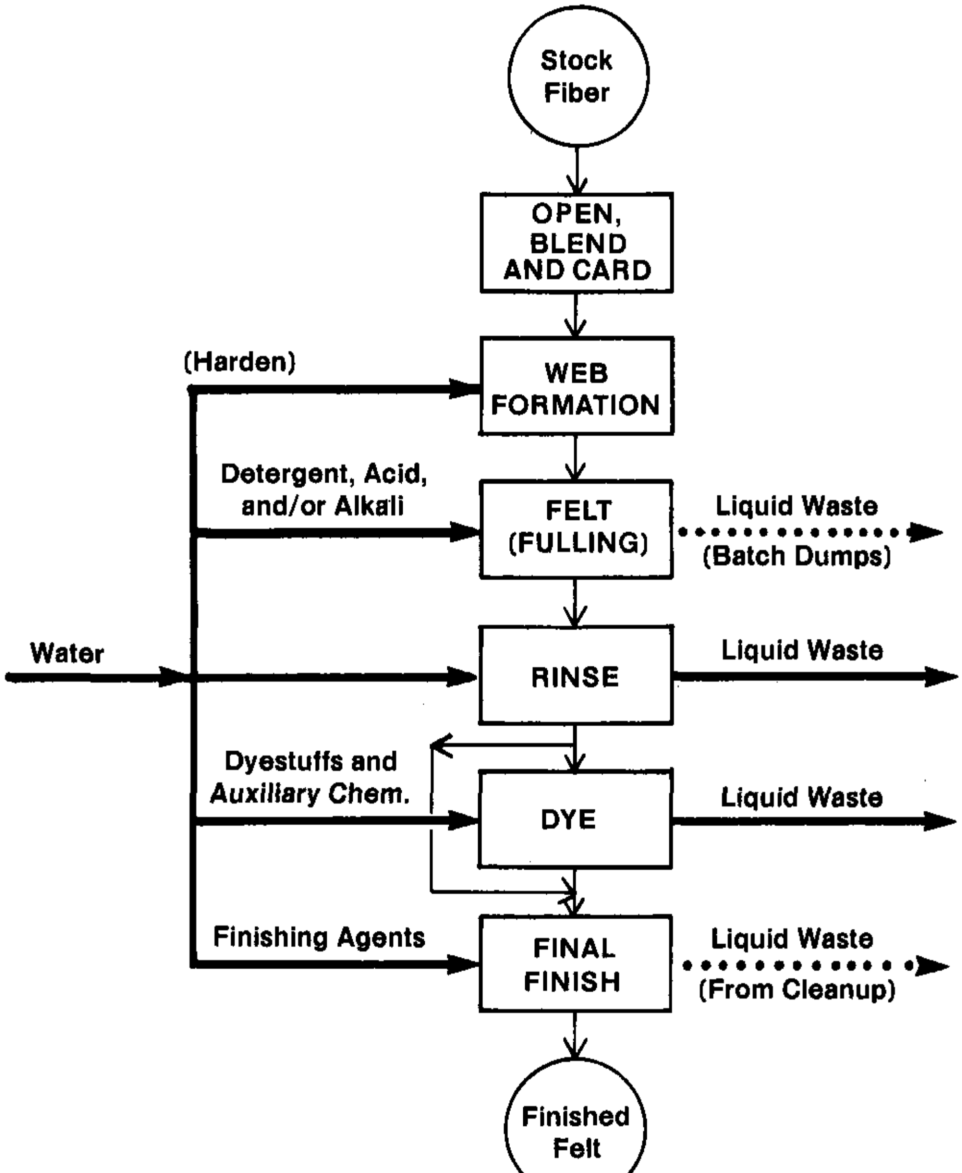


FIGURE III-11
SUBCATEGORY 9 - TYPICAL FELTED FABRIC PROCESSING PROCESS FLOW DIAGRAM



SECTION IV

INDUSTRY SUBCATEGORIZATION

INTRODUCTION

The purpose of subcategorization is to group together mills of similar characteristics to allow for development of effluent limitations and standards representative of each group (subcategory) of mills. This enables permits to be written on a uniform basis. The following seven subcategories were established when BPT, BAT, NSPS and PSNS were promulgated on July 5, 1974 (39 FR 24736; 40 CFR Part 410):

- Wool Scouring
- Wool Finishing
- Dry Processing
- Woven Fabric Finishing
- Knit Fabric Finishing
- Carpet Mills
- Stock and Yarn Dyeing and Finishing

The factors considered in identifying these subcategories included raw materials used, products manufactured, production processes employed, mill size and age, waste treatability, location, climate and treatment costs. Additional pollutant allowances were provided in the wool scouring, wool finishing, woven fabric finishing and knit fabric finishing subcategories for "commission finishers" (those facilities where textile materials, 50 percent or more of which are owned by others, are finished). In the woven fabric finishing and knit fabric finishing subcategories, additional allowances were provided for COD to account for different combinations of specified simple and complex processing operations and natural, synthetic or natural/synthetic blend fiber types. In the carpet mills subcategory, additional COD allowances were provided for specified complex processing operations.

As part of the BAT review program, detailed information has been collected on 538 mills in the textile industry. EPA reviewed available data in light of the original subcategorization scheme to determine the adequacy of the original subcategories in representing current industry characteristics. Conventional pollutant data have been reviewed to determine the relationship of raw wastewater characteristics to the processes employed and the products manufactured at mills in the textile industry. In addition, toxic pollutant data have been gathered and the subcategorization scheme has been reviewed for validity in accounting for toxic pollutant generation. As discussed below, this review led to the identification of two new subcategories and one subdivision of an existing subcategory representative of portions of the textile industry not recognized in the original subcategorization scheme.

RESULTS

With the following exceptions, the revised subcategorization scheme that forms the basis of final regulations is identical to the subcategorization scheme used in establishing BPT regulations promulgated in 1974. Two new subcategories, the nonwoven manufacturing subcategory and the felted fabric processing subcategory, have been established. In addition, a new subdivision of the low water use processing subcategory (formerly dry processing) has been established to account for a new textile manufacturing process, water jet weaving. Water jet weaving is not technically a low water use process; it is included as a subdivision of the low water use processing subcategory because it is related to greige goods production.

In addition, the Agency has decided to change the names of three existing subcategories: (a) the dry processing subcategory is now called the low water use processing subcategory; (b) the carpet mills subcategory is now called the carpet finishing subcategory; and (c) the stock and yarn dyeing and finishing subcategory is now called the stock and yarn finishing subcategory.

The following revised subcategorization scheme forms the basis of final regulations for the textile mills point source category:

- Wool Scouring
- Wool Finishing
- Low Water Use Processing
  - -General Processing
  - -Water Jet Weaving
- Woven Fabric Finishing
- Knit Fabric Finishing
- Carpet Finishing
- Stock and Yarn Finishing
- Nonwoven Manufacturing
- Felted Fabric Processing

In addition, separate NSPS are being established for subdivisions of the woven fabric finishing subcategory (simple manufacturing operations, complex manufacturing operations and desizing) and the knit fabric finishing subcategory (simple manufacturing operations, complex manufacturing operations and hosiery products.

BASIS OF FINAL SUBCATEGORIZATION SCHEME

Rationale for Selection of Final Subcategorization Scheme

The original subcategorization scheme of the textile mills point source category included seven subcategories. After reviewing all available data on the textile industry, the Agency determined that certain processing operations were not covered by the existing subcategorization scheme: nonwoven manufacturing, felted fabric processing and water jet weaving. The Agency determined that raw waste loadings at mills where these operations are employed are significantly different than those at mills that conform to the seven original subcategory definitions (see Table IV-1). Therefore, EPA has revised the original subcategorization scheme to account for these process differences.

Water jet weaving is a relatively new weaving technology. Because it is used in the production of greige goods, the Agency has included it as a new subdivision of the low water use processing subcategory which includes mills where greige goods are produced. EPA has established separate nonwoven manufacturing and felted fabric processing subcategories to account for these processing operations.

Also, as shown in Table IV-1, raw wastewater loadings of various mills within the woven fabric finishing and the knit fabric finishing subcategories differ significantly. In the woven fabric finishing subcategory, at mills where complex processing operations (printing, water-proofing and application of functional finishes in addition to dyeing and fiber preparation) are performed, wastewaters are discharged that are higher in volume and have higher BOD_5, COD and TSS raw waste loads than at mills where simple operations (dyeing and fiber preparation) are performed. In addition, at mills where the desizing process is employed, wastewaters are generated that are higher in volume and raw waste loadings than at complex mills.

In the knit fabric finishing subcategory, wastewaters that are higher in volume and raw waste loadings are generated at complex mills (mills where printing, water-proofing and application of functional finishes are performed in addition to dyeing and fiber preparation) than at simple mills (mills where dyeing and fiber preparation are performed). In addition, at mills where hosiery products are manufactured, wastewater loadings are distinguishable from those associated with both simple and complex processing.

Accordingly, final NSPS include separate limitations for these subdivisions of the woven fabric finishing and knit fabric finishing subcategories; however, the promulgated BAT limitations do not. As discussed in Sections I and IX, the Agency is establishing BAT effluent limitations controlling toxic and nonconventional pollutants equal to the previously promulgated BPT limitations. BPT limitations were based on biological treatment and apply to all of the different operations employed in the woven fabric finishing and the knit fabric finishing subcategories. BPT does include COD allowances to account for the higher COD raw waste loads typical of more complex operations in both subcategories. It is likely that costs would be incurred at some mills if BAT limitations required attainment of specific new limitations for the new subdivisions (simple, complex and desizing or hosiery operations) different from those specified in

TABLE IV-1

MEDIAN UNTREATED WASTEWATER CHARACTERISTICS

Subcategory	Wastewater Discharge Rate (l/kg)	(gal/lb)	Pollutant Mass Discharge Rate BOD5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)
1. Wool Scouring	11.7	1.4	41.8	225.7	51.9
2. Wool Finishing	304.4	36.5	63.6	204.8	16.3
3. Low Water Use Processing					
a. General Processing	6.7	0.8	1.3	7.7	1.6
b. Water Jet Weaving	86.7	10.4	16.0	18.2	2.7
4. Woven Fabric Finishing					
a. Simple Processing	76.7	9.2	22.3	88.4	7.7
b. Complex Processing	97.6	11.7	33.2	104.9	9.1
c. Desizing	105.9	12.7	45.1	122.0	14.8
5. Knit Fabric Finishing					
a. Simple Processing	117.6	14.1	23.1	84.4	6.3
b. Complex Processing	122.6	14.7	28.1	121.5	8.4
c. Hosiery Products	75.1	9.0	25.8	88.4	6.1
6. Carpet Finishing	46.7	5.6	25.6	82.3	4.7
7. Stock & Yarn Finishing	96.7	11.6	19.5	62.1	4.5
8. Nonwoven Manufacturing	40.0	4.8	6.7	38.4	2.2
9. Felted Fabric Processing	212.7	25.5	70.2	186.0	64.1

Source: Industry 308 Survey.

existing permits based on the BPT regulation. The Agency does not have sufficient information to determine the magnitude of these costs and, therefore, cannot assess the economic impact of establishing different limitations. Accordingly, other than those allowances included in the existing BPT regulation, separate BAT limitations are not established for simple, complex and desizing operations in the woven fabric finishing subcategory or for simple, complex and hosiery operations in the knit fabric finishing subcategory.

Additional Analyses

Prior to proposal of regulations in October of 1979, EPA conducted additional analyses to investigate the possibility that certain of the subcategories could be combined to simplify the subcategorization scheme. The subcategories tested were those established in earlier effluent guidelines studies of the textile industry (wool scouring, wool finishing, woven fabric finishing, knit fabric finishing, carpet finishing and stock and yarn finishing), plus segments not previously recognized (hosiery products, nonwoven manufacturing and felted fabric processing). Specific statistical tests were used to determine if any of the subcategories or industry segments could be combined or to verify that they are truly different. Wastewater discharge rates and BOD_5, COD and TSS raw waste loadings were used in this analysis. Long-term averages (means) were calculated for these parameters based on historical sampling data and available production information. The medians of the long-term averages were determined for each subcategory and new industry segment and compared. Because extensive historical sampling data were not available for all mills, it was necessary to use only those data that are representative of the segments of the industry being compared. Questionable data, such as single grab samples and estimated production values, and old data suspected of being nonrepresentative of current processing, were not used in the comparisons.

While statistical methods are a powerful tool for comparing and drawing conclusions about different populations (subcategories), other factors also can influence these comparisons. For example, wastewater characterization data can vary from mill to mill because of reasons not related to subcategorization. These reasons include such factors as operation of ancillary equipment and differences in sampling or analytical techniques. In addition, a degree of uncertainty is inherently involved in the use of statistics because conclusions are drawn about entire populations (subcategories) based on limited samples from those populations. This study has attempted to minimize these influences by using the 95 percent confidence level (level of significance) in deciding whether the statistical tests indicate a true difference between subcategories.

To select the most appropriate statistical tests to use in determining statistical validity, it is necessary to establish the type of distribution (e.g., normal, lognormal or geometric) that the data most closely represent. To accomplish this for the textile industry, wastewater discharge rates (l/kg of product) and raw waste loadings (kg/kkg of product) for BOD_5, COD and TSS were plotted for selected trial subcategories on linear and log probability paper. However, the plots, along with graphs of frequency distribution, were inconclusive in establishing a typical distribution for the data. As a result, EPA decided that distribution-free tests would be most appropriate for testing the subcategorization. The tests chosen were the Wilcoxon Two-Sample Test and Mann-Whitney U Test (12, 13, 14). The tests are similar, with the Wilcoxon Two-Sample Test more applicable to smaller samples (usually less than 20 values).

The Wilcoxon Two-Sample and Mann-Whitney U Tests examine the null hypothesis that two samples come from identical continuous populations (subcategories) against the alternative that the populations have unequal means, i.e., that the subcategories are statistically different. Under certain assumptions, they are an alternative to the standard two-sample "t" test used for normally distributed data. The tests employ ranking of observations as the basis for statistical decision-making and take into account the relative position of each data point within the groups of data being tested. The results of the statistical tests are the determination of levels of significance that represent the probability that an error has been made in stating that compared samples come from statistically different subcategories. A low level of significance indicates a high probability that the two samples (subcategories) are statistically different.

The results of this analysis indicated that each of the original subcategories and new industry segments are unique and that combining any of the subcategories was not justified. Some comparisons of the knit fabric finishing, woven fabric finishing, carpet finishing and stock and yarn finishing subcategories and the hosiery and felted fabric segments are shown in Table IV-2. Based on the results of this analysis, EPA used the revised subcategorization scheme as the basis of proposed rules published in October 1979.

Comments received on the October 1979 proposed regulation were very supportive of the revised subcategorization scheme. However, some comments were received suggesting the following revisions to the proposed subcategorization scheme:

a. one commenter suggested that, in the wool finishing subcategory, significant differences in wastewater characteristics result from the processing of virgin and reprocessed wool.

TABLE IV-2

COMPARISON OF RAW WASTEWATER CHARACTERISTICS
OF SELECTED SUBCATEGORIES AND INDUSTRY SEGMENTS

Products Compared (Subcategories)	Wastewater Discharge Rate		Pollutant Mass Discharge Rate: BOD5		Pollutant Mass Discharge Rate: COD		Pollutant Mass Discharge Rate: TSS	
	Sample*	Level #	Sample*	Level #	Sample*	Level #	Sample*	Level #
Woven Fabric vs Knit Fabric	138/108	0.5	94/54	5	70/41	[20]	76/51	3
Knit Fabric vs Carpet	108/37	(0.1)	54/10	[20]	41/14	5	51/12	2
Knit Fabric vs Stock & Yarn	108/117	11	54/61	19	41/45	1	51/58	0.2
Carpet vs Stock & Yarn	37/117	(0.1)	10/61	[20]	14/45	[20]	12/58	[20]
Nonwoven vs Felted Fabric	11/11	0.1	4/4	3	3/4	6	4/4	1
Hosiery vs Carpet	58/37	0.5	42/10	[20]	30/14	17	31/12	17
Hosiery vs Stock & Yarn	58/117	2	42/61	[20]	30/45	11	31/58	15
Knit Fabric vs Hosiery	108/58	(0.1)	54/42	[20]	41/30	[20]	51/31	[20]

* Number of data points (mills) in comparison; slash separates subcategories compared.

The level of significance represents the probability that an error has been made in stating that the samples (subcategories) compared are different (come from different populations). A 0.1 percent level of significance indicates that the probability is 0.1 percent that an error has been made. A 10 percent level of significance indicates that the probability is 10 percent that an error has been made. Levels of significance of 5 percent or less indicate that the samples compared are statistically different.

Notes:
1. ( ) Indicates Level of Significance is less than reported value.
2. [ ] Indicates Level of Significance is greater than reported value.
3. The Mann-Whitney U Test was used when one or both samples exceeded 20.
4. The Wilcoxon Two-Sample Test was used when both samples were less than 20.

b. one commenter suggested that significant differences in wastewater characteristics result from the production of ladies' hosiery compared to anklets and socks.

c. one commenter suggested that COD limits should be revised because of significant differences in process water requirements for yarn dyeing mills processing only polyester/cotton blends.

d. some commenters suggested that the commission finishing allowances contained in the BPT regulations should be retained in final BAT regulations and new source performance standards.

In response to comments on the proposed subcategorization scheme, the Agency performed statistical tests identical to those described above (see Table IV-3). EPA found that, while raw materials, processes and process machinery differ in the production of ladies' hosiery and anklets/socks, differences in wastewater discharge rate and pollutant mass discharge rates are not statistically different. Therefore, further segmentation of the hosiery products subdivision of the knit fabric finishing subcategory cannot be justified. Further, based on the limited data available on wastewater characteristics resulting from the processing of virgin compared to reprocessed wool, further segmentation of the wool finishing subcategory is not warranted.

The Agency does not have sufficient data available to determine if there are differences in process water requirements or COD raw waste loads because of the type of fiber processed at yarn dyeing mills (i.e., natural fibers, synthetic fibers or natural/synthetic fiber blends). The commenter did not submit additional data on water usage, production or COD discharges to support his contention that an additional COD allowance should be provided when only polyester/cotton blends are processed. He simply stated that his yarn dyeing mill requires three times the median wastewater discharge rate reported by the Agency to be typical of the stock and yarn finishing subcategory. In the absence of data, the Agency cannot justify further subdivision of the stock and yarn finishing subcategory.

The Agency also evaluated "commission finishing" to determine if the special nature of the processing performed by commission finishers (small lot sizes, short runs, variability in fabric processed and variability in chemical use) warrants additional discharge allowances. A limited amount of historical data were available on commission finishers from the initial industry survey; therefore, the Agency conducted a special industry survey in which current data on commission finishing were solicited from industry. The Agency expended considerable effort to collect these data, but response by the industry was poor; only a limited amount of new data was made available. The Agency analyzed the available data and determined that the wastewater characteristics

TABLE IV-3

COMPARISON OF RAW WASTEWATER CHARACTERISTICS OF SELECTED SUBCATEGORY SEGMENTS

		Wastewater Discharge Rate		Pollutant Mass Discharge Rate					
				BOD5		COD		TSS	
Subcategory	Subdivisions Compared	Sample*	Level #	Sample*	Level #	Sample*	Level #	Sample*	Level #
Wool Finishing	Virgin vs Reprocessed	138/108	0.5	94/54	5	70/41	[20]	76/51	3
Hosiery Finishing	Ladies vs Socks & Anklets	108/37	(0.1)	54/10	[20]	41/14	5	51/12	2
Woven Fabric, Desizing	Commission vs Noncommission	108/117	11	54/61	19	41/45	1	51/58	0.2
Knit Fabric, Complex	Commission vs Noncommission	37/117	(0.1)	10/61	[20]	14/45	[20]	12/58	[20]

* Number of data points (mills) in comparison; slash separates subcategories compared.

\# The level of significance represents the probability that an error has been made in stating that the samples (subdivisions) compared are different (come from different populations). A 0.1 percent level of significance indicates that the probability is 0.1 percent that an error has been made. A 10 percent level of significance indicates that the probability is 10 percent that an error has been made. Levels of significance of 5 percent or less indicate that the samples compared are statistically different.

Notes:
1. [ ] Indicates Level of Significance is greater than reported value; ( ) indicates less than.
2. NC Indicates that no comparison was made due to an insufficient sample size to perform the statistical test.
3. The Mann-Whitney U Test was used when one or both samples exceeded 20.
4. The Wilcoxon Two-Sample Test was used when both samples were less than 20.

of commission finishers are not significantly different than for other mills (see Table IV-3). In fact, in some subcategories, raw waste loadings for commission finishers are lower than for other mills where commission finishing is not employed. Accordingly, final NSPS do not provide an allowance for commission finishing. Current BPT limitations allow an additional discharge allowance for commission finishing. The Agency has not investigated the economic impact on existing mills of the elimination of the commission finishing allowance. Because, as discussed in Sections I and IX, the Agency is establishing BAT limitations equal to BPT limitations for the textile industry, the Agency has decided that existing dischargers shall still be entitled to this allowance.

IMPACT OF TOXIC POLLUTANT DATA

As part of technical study undertaken to review and revise, if necessary, the effluent guidelines and standards previously published, the Agency conducted a comprehensive sampling and analytical program. The program was designed to determine the frequency and amounts of toxic pollutants discharged from mills in the textile industry. EPA reviewed the analytical data generated through this sampling program. The Agency concluded that, although certain toxic pollutants (e.g., napthalene, acrylonitrile, arsenic, cadmium and silver) occurred more frequently than did other toxic pollutants, no relationship exists between the frequency of occurrence or quantity of toxic pollutants discharged from mills characteristic of a specific subcategory or subcategories. Therefore, toxic pollutant generation is not a factor affecting subcategorization of the textile mills point source category.

SUBCATEGORY DESCRIPTIONS

Wool Scouring Subcategory

This subcategory includes facilities where natural impurities are scoured from raw wool and other animal hair fibers. Before they can be converted into textile products, raw wool and other animal hair fibers must be thoroughly cleaned. This results in the generation of wastewaters that contain considerably higher pollutant concentrations than those of other subcategories (see Section V). A complete description of the wool scouring process is presented in Section III.

At integrated mills where both wool scouring and other finishing operations are employed, discharge allowances should be determined by applying wool scouring effluent limitations to the wool scouring production and by applying limitations associated with other finishing operations to the production associated with each finishing operation.

Wool Finishing Subcategory

This subcategory includes facilities where fabric is finished, the majority of which is wool, other animal hair fiber, or blends containing primarily wool or other animal hair fibers. The following processing operations are employed: carbonizing, fulling, bleaching, scouring (not including raw wool scouring), dyeing and application of functional finish chemicals. A description of typical wool finishing operations is presented in Section III.

Mills where stock or yarn consisting primarily of wool, other animal hair fibers, or blends containing primarily wool or other animal hair fibers are finished and where carbonizing is performed are included in this subcategory; however, those mills where carbonizing is not performed are included in the stock and yarn finishing subcategory.

At integrated mills where both wool finishing and other textile operations are performed, discharge allowances should be determined by applying wool finishing effluent limitations to the wool finishing production and by applying limitations associated with other operations to the production associated with each operation.

Low Water Use Processing Subcategory

Low water use processing operations include the manufacture of greige goods (yarn, woven fabric and knit fabric), laminating or coating fabrics, texturizing yarn, tufting and backing carpet, producing tire cord fabric, and similar manufacturing processes in which either cleanup is the primary source of wastewater or process water requirements per unit of production are small, or both.

As discussed previously, water jet weaving is not technically a low water use process. It is included as a subdivision of this subcategory because it is related to greige goods production. The wastewater discharge rate is significantly higher for water jet weaving than for other low water use processes; however, the low strength of the wastewater results in low pollutant mass discharge rates.

The low water use processing subcategory consists of two subdivisions:

General Processing This low water use processing subdivision includes all low water use processes except water jet weaving.

Water Jet Weaving This low water use processing subdivision covers the manufacture of woven greige goods using the water jet weaving process.

Woven Fabric Finishing Subcategory

This subcategory includes facilities where primarily woven fabric is finished using the following processing operations: desizing, scouring, bleaching, mercerizing, dyeing, printing and application of functional finish chemicals. These processes are described in Section III.

Integrated mills where primarily woven fabric is finished along with greige manufacturing or other finishing operations such as yarn dyeing and denim finishing are included in this subcategory. At many finishing facilities, weaving is also done but the added hydraulic and pollutant loadings from slasher equipment cleanup are insignificant compared to the finishing wastes. Woven fabric composed primarily of wool, other animal hair fiber, or blends containing primarily wool or other animal hair fibers are included in the wool finishing subcategory.

At integrated mills where both woven fabric finishing and other textile operations are performed, discharge allowances should be determined by applying woven fabric finishing effluent limitations to the woven fabric finishing production and by applying limitations associated with other operations to the production associated with each operation.

The desizing process is a major contributor to the oxygen demand in woven fabric finishing wastewater. When synthetic compounds such as PVA, CMC and PAA are the primary sizing agents removed, the COD load is noticeably increased. In addition, the number of processes performed at a particular mill may vary from only scouring or only bleaching to all of those listed above. As explained previously, BPT effluent limitations provided additional allowances for COD to account for the higher COD raw waste loads typical of more complex operations in this subcategory. In addition, in developing new source performance standards, the following subdivisions were identified to account for higher raw waste loads associated with more complex operations and desizing:

Simple Manufacturing Operations This woven fabric finishing subdivision includes facilities where desizing, dyeing or other fiber preparation processes are performed.

Complex Manufacturing Operations This woven fabric finishing subdivision includes facilities where the simple unit processes (desizing, dyeing and fiber preparation) are employed in addition to other manufacturing operations such as printing, water-proofing or application of stain resistance or other functional fabric finishes.

Desizing This woven fabric finishing subdivision includes facilities where more than 50 percent of total production is desized. At these facilities, other processes are employed such as fiber preparation, scouring, mercerizing, functional finishing, bleaching, dyeing and printing.

Knit Fabric Finishing Subcategory

This subcategory includes facilities where primarily knit fabrics of cotton and/or synthetic fibers are finished. The following processing operations are employed: scouring, bleaching, dyeing, printing and application of lubricants, antistatic agents and functional finish chemicals. Basic knit fabric finishing operations are similar to those in the woven fabric finishing subcategory. Knitting is performed in conjunction with finishing at most of these facilities. Desizing is not required in knit fabric finishing and mercerizing is uncommon. The generally lower wastewater loads of this subcategory compared to the woven fabric finishing subcategory can be attributed to the absence of these processes.

Integrated mills where primarily knit fabrics or hosiery are finished and greige manufacturing or other finishing operations such as yarn dyeing are employed are included in this subcategory. At integrated mills where both knit fabric finishing and other textile operations are performed, discharge allowances should be determined by applying knit fabric finishing effluent limitations to the knit fabric finishing production and by applying limitations associated with other operations to the production associated with each operation.

As with woven fabric finishing, the number of processes performed at a mill may vary considerably. In addition, hosiery manufacture is distinct in terms of manufacturing and raw wastewater characteristics (see Tables V-29 and V-30). As explained previously, BPT effluent limitations provided additional allowances for COD to account for the higher COD raw waste loads typical of more complex operations in this subcategory. In addition, in developing NSPS, the following subdivisions were identified to account for higher raw waste loads associated with more complex operations and to account for hosiery production.

Simple Manufacturing Operations This knit fabric finishing subdivision includes facilities where fiber preparation and dyeing are performed.

Complex Manufacturing Operations This knit fabric finishing subdivision includes facilities where simple unit processes (dyeing and fiber preparation) are employed in addition to manufacturing operations such as printing, water-proofing or application of stain resistance or other functional fabric finishes.

Hosiery Products This knit fabric finishing subdivision includes facilities where hosiery of any type is dyed or finished. Compared to other knit fabric finishing facilities, hosiery finishing mills are generally much smaller in terms of wet production (an average of 2,950 kg/day for hosiery mills compared to 18,400 kg/day for other knit fabric finishing mills), more frequently employ batch processing and more often perform only one major wet-processing operation (dyeing). All of these factors contribute to the lower raw waste loadings associated with hosiery production (see Tables V-1 and V-2).

Carpet Finishing Subcategory

This subcategory includes facilities where textile-based floor covering products, of which carpet is the primary element, are finished by employing any of the following processing operations: scouring, carbonizing, fulling, bleaching, dyeing, printing and application of functional finish chemicals. These processes are described in Section III.

Integrated mills where primarily carpet is finished along with tufting or backing operations or other finishing operations (such as yarn dyeing) are included in this subcategory. Mills where only carpet tufting and/or backing are performed are included in the low water use processing (general processing subdivision) subcategory.

At integrated mills where both carpet finishing and other textile operations are performed, discharge allowances should be determined by applying carpet finishing effluent limitations to the carpet finishing production and by applying limitations associated with other operations to the production associated with each operation. Carpet manufactured by woven or nonwoven processes are included in this subcategory if the wet-finishing operations are consistent with those presented above.

Stock and Yarn Finishing Subcategory

This subcategory includes facilities where stock, yarn or cotton and/or synthetic fiber thread is finished by employing any of the following processing operations: scouring, bleaching, mercerizing, dyeing or application of functional finish chemicals. Thread processing (including bonding, heat setting, lubrication and dressing) is basically dry and does not generate much wastewater. Stock and yarn finishing processes are described in Section III. The concentrations and mass discharge rates of the commonly measured conventional and nonconventional wastewater pollutants (BOD, COD and TSS) are typically lower than in the other major wet-processing subcategories (see Tables V-29 and V-30).

Facilities where stock or yarn consisting principally of wool, other animal hair fiber (or blends containing primarily wool or other animal hair fibers) is finished are also included in this subcategory if carbonizing is not performed. At integrated mills where both stock and yarn finishing and other textile operations are performed, discharge allowances should be determined by applying stock and yarn finishing effluent limitations to the stock and yarn finishing production and by applying limitations associated with other operations to production associated with each operation.

Nonwoven Manufacturing Subcategory

This subcategory includes facilities where nonwoven textile products of wool, cotton or synthetics, singly or as blends, are manufactured by mechanical, thermal and/or adhesive bonding procedures. Nonwoven products manufactured by fulling and felting processes are covered in the felted fabric processing subcategory.

The nonwoven manufacturing subcategory includes a variety of products and processing methods. The processing is dry (mechanical and thermal bonding) or low water use (adhesive bonding) with the major influence on process-related waste characteristics resulting from the cleanup of bonding mix tanks and application equipment. Typical processing operations are described in Section III and include carding, web formation, wetting, bonding (padding or dipping with latex acrylic or polyvinyl acetate resins) and application of functional finish chemicals. Pigments for coloring the goods are sometimes added to the bonding materials. As discussed in Section IX, wastewaters generated in this subcategory are similar to those discharged from mills in the carpet finishing subcategory.

At integrated mills where both nonwoven manufacturing and other textile operations are performed, discharge allowances should be determined by applying nonwoven manufacturing effluent limitations to the nonwoven manufacturing production and by applying limitations associated with other operations to the production associated with each operation.

Felted Fabric Processing Subcategory

This subcategory includes facilities where primarily nonwoven products are manufactured by employing fulling and felting operations as a means of achieving fiber bonding. Wool, rayon and blends of wool, rayon and polyester are typically used to produce felts. Felting is accomplished by subjecting the web or mat to moisture, chemicals (detergents) and mechanical action. Wastewater is generated during rinsing steps that are required to prevent rancidity and spoilage of the fibers. Typical felted fabric processing operations are discussed in Section III. As discussed in Section IX, wastewaters generated in this subcategory are similar to those discharged from mills in the wool finishing subcategory.

At integrated mills where both felted fabric processing and other textile operations are performed, discharge allowances should be determined by applying felted fabric processing effluent limitations to the felted fabric processing production and by applying limitations associated with other operations to the production associated with each operation.

SECTION V

WASTE CHARACTERISTICS

INTRODUCTION

Section IV provides the rationale for the subcategorization scheme developed by EPA in establishing effluent limitations guidelines, new source performance standards and pretreatment standards for existing and new sources in the textile industry. The information presented in this section includes: a detailed discusssion of the untreated wastewater characteristics relative to the typical processing in each subcategory; total wastewater discharge (cu m/day) and rate of wastewater discharge per unit of production (liter of wastewater/kg of production) for each subcategory; pollutant concentrations (ug/l or mg/l) and mass discharge rates (kg of pollutant/kkg of production) for each subcategory. Pollutant characteristics are presented separately for toxic pollutants and for the traditionally monitored nonconventional and conventional pollutants in the textile industry.

The discussion of untreated wastewater characteristics was developed from textbooks, technical periodicals, mill visits, survey information and general discussion with knowledgeable industry personnel.

Wastewater volume and traditionally monitored nonconventional and conventional pollutant data were, for the most part, acquired from the records of textile industry wastewater treatment plants, Federal and state discharge monitoring reports, records of publicly owned treatment works (POTWs) and field sampling. Toxic pollutant data were not readily available and acquisition required a detailed field sampling program. (See Section II for a discussion of the sampling and analysis program.)

Besides characterizing untreated wastewater, the field sampling program included the acquisition of toxic, nonconventional and conventional pollutant data for the water supply at various mills. These data were collected to determine the relationship between water supply and untreated process wastewater. In addition, data were acquired for biological and physical/chemical treatment systems. These data are presented in detail in Section VII to document the effectiveness of treatment technologies. The data showing the presence and concentrations of toxic pollutants after biological treatment are presented in this section to identify the toxic pollutants of significance in the industry. The methods used to aggregate individual mill data, the data for the mills represented by each subcategory and the data for the industry as a whole are presented and discussed below.

DISCUSSION OF UNTREATED WASTEWATER CHARACTERISTICS

The untreated wastewater characteristics for the textile industry generally reflect the products produced and the methods employed to produce them. Because there is such a diversity in products, processing raw materials and process control, there is a wide range in wastewater characteristics. This variation exists within subcategories as well as between the subcategories. Nonprocess variables such as intake water quality and discharge of nonprocess wastes (e.g., sanitary wastewater, boiler blowdown, cooling water) contribute to this lack of uniformity.

In Section III, the typical wet processing operations contributing to wastewater discharge are presented and discussed. In Section IV, the selected subcategories are presented and the basis for their selection explained. The discussions that follow relate the processing and untreated wastewater characteristics for each subcategory and explain the source(s) of the pollutants specific to each.

Wool Scouring Subcategory

Wool scouring wastewater contains significant quantities of natural oils, fats, suint and adventitious dirt that, even after in-process grease recovery steps, result in wastewater characteristics that are distinctly different from other subcategories. These materials are collectively responsible for high concentrations and quantities of BOD_5, COD, TSS and oil and grease. Because the natural fat is technically a wax, it is not readily biodegradable and must be removed by physical or chemical treatment.

According to Trotman (10), a typical dirty wool might consist of 33 percent keratin (wool protein), 26 percent dirt, 28 percent suint, 12 percent fat and 1 percent mineral matter. The constituents are different for the wool from different breeds of sheep, and it is stated that raw wool may contain between 30 and 70 percent impurities.

Sulfur, phenolics and other organic compounds are brought in with the wool. Phenolics are derived from sheep urine, feces, blood, tars, branding fluids and insecticides used in sheep dips. Sulfur makes up approximately 3 to 4 percent of clean keratin and enters the waste stream as fiber (10).

Wool scouring is generally performed in a series of scouring bowls using a counterflow process. The total concentration of soap or detergents and alkali (generally sodium carbonate) is about 1 percent. The contribution of pollutants from these scouring materials is insignificant compared to the residual materials scoured from the stock fiber. Complete purification of the wool is not practical, and it is usually accepted that the scouring has been satisfactory if the wool contains less than 0.5 percent oil and grease (10).

Wastewater from the wool scouring process is usually brown, thickly turbid and noticeably greasy. It is strongly alkaline and very putrescibe.

Wool Finishing Subcategory

Wool finishing wastewaters are typically low in concentration of BOD_5, COD, TSS and oil and grease, but because of the large volumes generated, contribute large quantities of these pollutants per unit of production relative to the other subcategories. The other traditionally monitored pollutants (total phenols, chromium, sulfide and color) are high in both concentration and mass discharge rate, relative to the other subcategories. These conditions can be attributed to the numerous steps required in processing and finishing wool yarn and wool fabric and to the wide variety of chemicals used. The contributions of pollutants from each of the major wool finishing steps are detailed below.

Heavy Scour Even after effective raw grease wool scouring, wool fiber contains a small amount of grease and foreign material. Also, oil (2 to 5 percent by weight) is often added prior to spinning to provide lubrication. All of these materials must be removed before finishing can be performed and to prevent future degradation of the wool fiber by bacteriological action.

The heavy scour process consists of washing the fabric with detergents, wetting agents, emulsifiers, alkali, ammonia or various other agents to remove the foreign and applied materials. Fibers used to manufacture fancy goods are dyed in the stock state and undergo heavy scour prior to the stock dyeing step. Piece-dyed goods are scoured in the fabric state before the dyeing step; the weight, foreign material content and degree of felting of the fabric all have a direct bearing on the degree of scouring required.

Heavyweight, closely-woven fabrics with a high percentage of recycled wool require very heavy detergents, long wash times and extensive rinsing periods. Relative to lighter weight fabric with no or a low percentage of recycled wool, high organic and hydraulic discharge rates are associated with the scouring of these types of fabric. Light, open goods with a low percentage of recycled wool generally scour more easily with lighter detergents, shorter wash times and less rinsing, resulting in lower organic and hydraulic discharges than the heavy scour process.

Because some woolen mills produce only heavyweight fabric, some produce only lightweight fabric, and some produce both, it is apparent that considerable hydraulic and organic fluctuations can exist from the heavy scour process. Typically, these fluctuations alone do not significantly influence the variability of the total discharge among wool finishing mills because of the large amount of flow associated with the other major wool finishing processes.

Carbonizing Carbonizing does not contribute greatly to the pollutant concentration of wool finishing wastewater but, because of the rinsing steps used to neutralize the acid taken up by the fabric, does add significantly to the hydraulic load. As discussed in Section III, carbonized vegetable matter is removed as a solid waste and only the residual sulfuric acid and neutralizing agents (generally sodium carbonate) enter the wastewater. The acid bath must be dumped when it becomes too contaminated for efficient carbonization and the acid taken up by the fabric must be neutralized to prevent damage to the wool fibers. The wastewaters from the carbonizing process are typically acidic, low in organic content and high in total solids.

Fulling Fulling, like carbonizing, does not contribute greatly to the pollutant concentration of wool finishing wastewater but does add to the hydraulic load. Wastewater is generated during the washing and rinsing steps, which are required to prevent rancidity and wool spoilage, when the water bath (wet fulling only) is dumped. If alkali fulling is used, the rinse streams will contain soap or detergent, sodium carbonate and sequestering agents (phosphate compounds). If acid fulling is used, sulfuric acid, hydrogen peroxide and small amounts of metallic catalysts (chromium, copper or cobalt) also are present.

Bleaching Bleaching is performed on woolens, but to a lesser degree than on cotton goods. Only 40 percent of the woolen mills that returned detailed surveys practice bleaching. Those mills that perform bleaching do so on 20 percent or less of their production. Hydrogen peroxide is generally used because sodium hydrochloride and calcium hydrochloride discolor and damage wool fibers. The discharge rate of wastewater from hydrogen peroxide bleaching of wool is generally in the range of 8.3 to 25.0 l/kg (1 to 3 gal/lb) of product and the BOD contribution is usually less than 1 percent of the total for the typical wool finishing process. The mass discharge rates for other conventional parameters are generally very small relative to the discharge rates from other processes.

Dyeing The typical dyeing processes for the industry are discussed in Section III. As noted in that discussion, some of the dyes and dye chemicals used for wool goods are specific to the wool fiber. The acid and metalized dyes are commonly used while mordant and fiber reactive dyes are used to a lesser extent. Because of the recognized hazards of chromium entering the waste streams, the use of mordant dyes has greatly diminished and they presently are used only if exceptional wash fastness is required.

In sensitive dyeing, a prescour step is often used. Detergents and wetting agents are added, the scouring performed and the fabric thoroughly rinsed. The wastewater generated contributes to the hydraulic load but adds little to the pollutant concentration.

For acid dyes, control of pH to a value suitable to the type of dye in use is necessary. The ingredients, in addition to the dyes, include Glauber's salt (sodium sulfate), sulfuric acid and formic acid.

The metalized dyes have very good wash fastness and a very high affinity for wool even under mildly acidic conditions and at low temperatures (below 110°C). These dyes often are used on 100 percent wool fabric. Metalized dyes are almost completely exhausted so only a small quantity of metallic ions (chromium) enter the wastewater.

Blends of wool and synthetic fibers are dyed in a single bath or in two separate baths. When two baths are used, dyes specific to each fabric type are used and the hydraulic load can increase by 50 percent. In each type of dyeing, the fabric is cooled with fresh water and thoroughly rinsed; both steps add greatly to the hydraulic load.

<u>Low Water Use Processing Subcategory</u>

Low water use processing refers, almost exclusively, to weaving or adhesive products processing. Weaving facilities include the conventional weavers and water jet weavers. The conventional weavers and adhesive products processors (general processing subdivision of the subcategory) have very low wastewater discharge rates relative to the other subcategories, while the water jet weavers have wastewater discharge rates comparable to many of the other subcategories (see Table V-1). The only mills with relatively large discharges are those engaged in water jet weaving and those discharging large volumes of cooling or other nonprocess wastwater. Process wastewater characteristics are determined primarily by the slashing process (conventional weaving), the weaving process (water jet weaving mills) or the dipping, padding or saturating process (adhesive products processing mills). The contributions of pollutants from these processes are discussed below.

<u>Slashing</u> The slashing operation (see Section III) consists of coating yarn with sizing compounds prior to weaving. At conventional weaving mills, slashing is generally the only source of process wastewater. Wastewater results from spillage in the size mixing area, dumps of excess sizing and cleanup of the slasher and mixing equipment. Among the components that are used

in sizing formulations and that may enter the wastewater are the sizing compounds (e.g., starch, PVA, CMC or PAA), wax or tallow, wetting agents, softeners, penetrants, plasticizers, fungicides, bacteriostats and other preservatives. Sizing formulations typically exert a high COD and, when starch is the primary sizing agent, high BOD_5 also is exerted. In general, the wastes from the slashing operation are diluted by nonprocess wastewater, such as sanitary wastewater, boiler blowdown and noncontact cooling water generated at these mills.

Water Jet Weaving Water jet looms are a special type of shuttleless loom that use a jet of water to propel the filling yarns during the weaving operation. Although not widely practiced during 1976 to 1979, water jet weaving is becoming more popular. Each type of water jet loom has different water requirements and discharges from the different machines were reported to range less than 3,785 l/day (100 gpd) up to 37,850 l/day (1000 gpd). The water drains from beneath the machines and may contain sizing chemicals and contaminants collected from the fiber. Chemical sizing requirements are less with water jet looms than with conventional looms because the water serves as the lubricant. Most of the wastewater from greige mills that use water jet weaving comes from this process.

Adhesive Products Processing Adhesive products processing (see Section III) includes operations such as bonding, laminating, coating and flocking. In all of these operations, a continuous adhesive or coating is applied to the material by padding, dipping, saturating or similar means. Wastewater occurs as a result of equipment cleanup, rinsing, overspraying or spillage. PVC from coating or latex compounds from bonding, laminating or flocking are likely to be the chief constituents of these wastewaters. Latex wastes may be high in COD and suspended solids. Depending on the plant operations, other contaminants such as oil and grease and solids also may find their way into adhesive products processing wastewaters.

Woven Fabric Finishing Subcategory

The wastewater generated from the finishing of woven fabric is represented by a broad range of concentration and mass discharge rates for BOD_5, COD, TSS and oil and grease. Three internal subdivisions of this subcategory (simple manufacturing, complex manufacturing and desizing) have been identified. The bases for these subdivisions are discussed in Section IV. A schematic displaying the typical processes employed is presented in Section III. The differences between the three subdivisions are a function of the complexity of the wet processing. Mills classified in the complex manufacturing subdivision perform simple manufacturing plus one or more additional major wet processing steps. Mills classified in the desizing subdivision perform desizing on the majority of their production. The typical wastewater discharge and pollutant mass discharge rates are progressively greater for each subsequent subdivision and generally reflect an increase in the same basic pollutant parameters.

The wet processing used by a woven fabric finishing mill could include desizing, scouring, bleaching, mercerizing, dyeing, printing and functional finishing. The contributions of pollutants from these processing operations are discussed below.

Desizing Desizing contributes to the organic load, adds some oil and grease, and is responsible for most of the suspended material found in woven fabric finishing wastewater. Natural starch size is high in BOD5 while the synthetic sizing agents, which tend to be less biodegradable unless exposed to an acclimated biological environment, result in constant BOD5 but result in increased COD. Over an extended period (such as the 20 days required for the BOD20 test), however, the synthetic sizing agents can exert a substantial biochemical oxygen demand. Depending on the fabric type, desizing can contribute 50 percent or more of the total solids resulting from the finishing of woven fabrics (1). For an average woven fabric finishing mill processing 100 percent cotton goods and using starch as the sizing agents, the desizing waste generally will constitute about 16 percent of the total wastewater volume, 45 percent of the BOD5, 36 percent of the total solids and 6 percent of the alkalinity (11).

Synthetic sizing agents such as PVA, CMC and PAA are soluble in water and are removed from woven fabric without difficulty. Starch is not readily soluble and must be hydrolyzed into a soluble from by the action of special enzymes or acid solutions before removal. Enzymatic removal generates starch solids, fat, wax, enzymes, sodium chloride and wetting agents. The waste contains organic and inorganic dissolved solids, suspended solids and some oil and grease. It has a pH of 6 to 8 and is light in color. Sulfuric acid removal generates starch solids, fat, wax and sulfuric acid. The waste also contains organic and inorganic dissolved solids, suspended solids and some oil and grease. It has a pH of 1 to 2 and is relatively light in color. The desizing subdivision of the woven fabric finishing subcategory was established principally because of the additional contribution of pollutants from the desizing operation.

Scouring Scouring of cotton and cotton-synthetic fiber blends generates wastewater that is strongly alkaline (pH greater than 12), dark in color from cotton impurities and high in dissolved solids relative to other processes. The wastewater contains oil and grease and suspended solids that are removed as impurities in the cotton fiber. Besides sodium hydroxide, of which a 2 percent solution typically is used; phosphate, chelating agents and wetting agents may be used as auxiliary scouring chemicals. For the typical finishing mill processing 100 percent cotton goods, the scouring waste generally constitutes about 19 percent of the total wastewater volume, 16 percent of the BOD_5, 43 percent of the total solids and 60 percent of the alkalinity (11).

Synthetic fibers are relatively free of natural impurities so they require less vigorous scouring. These fibers absorb very little moisture, so static electricity can be a problem during processing. To minimize this problem, antistatic materials are applied to the yarns; these materials also serve as lubricants in sizing compounds. Commonly used compounds are styrene-based resins, polyalkylene glycols, gelatin, PAA and polyvinyl acetate. These compounds become a source of water pollution when they are removed from the fabrics during scouring. In general, a milder sodium carbonate solution and a surfactant will suffice in scouring synthetics.

Bleaching Cotton bleaching is accomplished with hypochlorite, hydrogen peroxide, chlorine dioxide, sodium perborate, peracidic acid or other oxidizing agents. Reducing agents also may be used, although the oxidizing agents usually give a more permanent white color. Today, most cotton bleaching uses hydrogen peroxide or hypochlorite, either in kiers or on a continuous range; hydrogen peroxide is the preferred oxidizing agent and the continuous range the most efficient bleaching method.

Bleaching of cellulosic regenerated fibers is accomplished using the same methods as for cotton; however, there is less coloring matter to remove so the strength of the oxidizer can be decreased. Polyester and polyacrylonitrile fibers are not often bleached unless part of a cotton-synthetic fiber blend.

Hydrogen peroxide bleaching contributes very small waste loads relative to other processes, most of which are inorganic dissolved solids (sodium silicate, sodium hydroxide and sodium phosphate) and organic dissolved solids (surfactants and chelating agents). A relatively low level of suspended solids (fibers and natural impurities) will be present when goods containing cotton are bleached.

Mercerization Mercerization is practiced to increase the tensile strength of the cotton fiber and to increase its affinity for dyes (see Section III). Essentially, the process amounts to saturating the fabric with sodium hydroxide (usually a 25 to 30 percent solution), allowing sufficient residence time for interaction and washing the fabric to remove the excess caustic.

Mercerization wastewater is predominantly the sodium hydroxide solution used in the process, diluted as a result of the washing step. The wastewater contains high levels of dissolved solids and may have a pH of 12 to 13. Depending on whether mercerization is practiced before or after bleaching, small amounts of foreign material and wax may be removed from the fiber and will appear as suspended solids and oil and grease. In total, mercerization has been found to contribute about 1 percent of the BOD_5 load generated during the processing of 100 percent cotton woven fabric (15). Today, with synthetics and cotton-synthetic blends replacing 100 percent cotton fabric, mercerization is practiced less often. Most of the mills that do utilize the process have found it economically attractive to recover sodium hydroxide for reuse. Consequently, the wastewater contribution from the process has decreased at many mills.

Dyeing Dyeing is without question the most complex of all the wet finishing operations in the textile industry. There are 9 basic classifications of dyes according to application and approximately 17 types according to use by the textile industry (10). There are thousands of individual dyes. In addition to the dyestuff itself, various other chemicals are added to help deposit the dye or to develop the color. Chemicals that are used include acids, bases, salts, wetting agents, retardants, accelerators, detergents, oxidizing agents, reducing agents, developers and stripping agents. A detailed discussion of the various dyes and dyeing methods is provided in Section III.

Woven fabric usually is dyed as piece goods with batch or continuous dye equipment. The batch equipment is either atmospheric type or pressure type; continuous dye equipment is operated under atmospheric pressure conditions. Atmospheric dyeing generally requires greater amounts of auxiliary chemicals to achieve the desired results. Because most of these chemicals are not retained in the final product but are discarded after they have served their purpose, atmospheric dyeing customarily results in increased pollutant mass discharge rates.

Depending on the type of fabric, dye, equipment used and the efficiency of the processes, the wastewater from the dyeing of woven fabric may contain many combinations of the dyes and auxiliary chemicals. The process contributes substantially to the total pollutant mass discharge rate and is responsible for most of the wastewater flow. The wastewater from the process may contain organic and metallic toxic pollutants and is high in dissolved solids relative to other processes. It is, however, low in suspended solids relative to other processes. The wastewater typically is colored and, if the color is not reduced, can be aesthetically undersireable for discharge into receiving waters.

For woven fabric finishing mills that process 100 percent cotton, the BOD_5 contribution resulting from the dyeing process was found to vary from 1.5 to 30 percent of the total (15). Carriers, which are essential for dyeing polyester, can result in an even greater BOD_5 contribution when cotton/polyester blends and pure polyesters are being processed.

Printing Printing generally occurs at the same stage in woven fabric finishing as dyeing. The fabric goes through the preliminary cleaning and conditioning steps and is printed using one of several methods. When woven fabric is both dyed and printed, printing is performed last. A complete discussion of the types of printing and equipment used is provided in Section III. Printing often is referred to as "localized dyeing," and the same basic dyestuffs are used. Dyes are applied as liquid, while a paste is used in printing. In addition to the dyestuff and auxiliary chemicals discussed under "Dyeing," a thickener is used to give the print paste the desired viscosity. Gums serve as thickeners and those commonly used include locust bean, guar, alginate, starch and combinations of these. Urea, thiourea and glycols also are used in many print formulations.

Printing wastes are comparable in constituents to dye wastes, although the volumes are much lower and the concentrations greater. The thickeners contribute to the biochemical oxygen demand and solvents used to prepare pigments and clean pigment application equipment often are present. Printing pigments will contribute suspended solids when the fabric is rinsed, although much of the wastewater from printing comes from the cleaning of make-up tanks and process equipment.

Functional Finishing The functional finishes represent a large group of chemical treatments that improve the function of a fabric by making it resist creasing, water, stains, rot, mildew, moths, bacteria and other undesirable items. They are more often applied to the natural fibers (cotton and wool) and are quite prevalent in the finishing of woven fabrics. As would be expected from processes that provide such diverse effects, the range of chemicals used is very broad. For resin treatment, a urea-formaldehyde-glyoxal compound (DMDHEU), a fatty softener and a catalyst (zinc nitrate, magnesium chloride) are used together. Water repellents include silicones, fluorochemicals and fatty materials, each generally applied with a catalyst. Soil release treatments include special acrylic polymers and fluorochemicals.

These finishes generally are applied by impregnation of the fabric followed by squeezing to retain the desired amount of chemical in the fabric. The moist material is dried and then heat cured. The cured fabric is frequently packed for shipment without rinsing. Most resin treated goods are precured (fixed by the application of heat) during the finishing process. Some fabrics are postcured (fixed after a garment has been cut, sewn and pressed). Wastewater from resin treatment, water proofing, flame proofing and soil release are small in volume relative to other finishing processes because the chemicals are applied by padding, followed by drying and curing. Only small quantities of these chemicals enter the mill's wastewater. Some finishes do require rinsing after application, which increases the volume of wastewater and quantity of chemicals discharged.

Knit Fabric Finishing Subcategory

The wastewater generated from the finishing of knit fabric is, like that from the finishing of woven fabric, represented by a broad range in concentration and mass discharge rates for BOD_5, COD, TSS and oil and grease. The concentrations of these pollutants are lower than those of the woven fabric finishing subcategory (see Table V-15) and the variability from mill to mill also is somewhat less. Three internal subdivisions of this subcategory (simple manufacturing, complex manufacturing and hosiery products) have been identified. As with woven fabric finishing, the subdivisions are based on complexity of the operations. Hosiery production requires less water and a less variable quantity and variety of process chemicals than simple and complex manufacturing. The justification for the subdivisions is discussed fully in Section IV, and a schematic representing the typical processing sequence for each subdivision, as well as a description of processes, is presented in Section III.

The wet processing used by a knit fabric finishing mill (simple manufacturing and complex manufacturing subdivisions) includes various combinations of the following operations: scouring, bleaching, dyeing and printing. Hosiery production typically uses scouring, bleaching and dyeing. Mills in each subdivision might apply chemical coatings during the final finishing step, but only a small amount, if any, of these chemicals enters the wastewater. The impact of these processes on wastewater discharged by knit fabric finishing mills is discussed below.

Sizing, as such, is not applied to knitted goods because the knitting process does not stress the yarn to the same degree as does weaving. Lubricants (generally mineral oils, vegetable oils, synthetic esters or waxes) are added during the knitting process and are effectively removed during scouring.

Scouring Washing or scouring is frequently the first process at knit fabric finishing mills. Knit goods are washed or scoured with detergents, soaps or solvents to remove natural or artificial waxes, oil and other impurities. The discharge from the process is high in dissolved solids and color (because of cotton impurities) and may contain a significant amount of the lubricants noted above. The scouring or washing of 100 percent synthetic fabrics results in a waste contaminated with greater concentrations of lubricating oil and and special scouring agents such as ethoxylated phenols and other emulsifiers.

Bleaching Bleaching of knit fabrics is similar to bleaching of woven fabrics. The bleaching agents used are generally sodium hypochlorite or hydrogen peroxide. The previous discussion in this section on wastewater characteristics associated with bleaching woven fabrics is applicable to this subcategory. Bleaching is generally associated with cotton fabric and blends and is not applied to 100 percent synthetic fabrics.

Dyeing The dyeing operation is a major source of wastewater in knit fabric finishing. Beck, beam and jet dyeing are all commonly employed using either atmospheric or pressure operating modes. Paddle, rotary or tub dyeing also may be used, especially for hosiery. Jig dyeing and continuous dyeing are less common. The types of dyestuff, auxiliary chemicals and conditions employed for dyeing knit goods are essentially the same as for woven goods of comparable fiber composition. The discussion previously presented in this section concerning wastewater characteristics associated with dyeing woven fabrics also is applicable to knit fabric dyeing and is not repeated here. In knit fabric finishing, rinse solutions are often mechanically extracted. In this step, a centrifugal extractor is used to draw water out of the fabric.

Printing Printing methods used in finishing knit fabrics are similar to the methods used on woven fabrics. Sources and characteristics of the wastes are similar to those previously discussed for the woven fabric finishing subcategory.

Functional Finishing The functional finishes applied to knit fabrics are essentially the same as those previously noted for woven fabrics. The methods of application are also similar and the same variety of constituents is likely to appear in the waste.

Carpet Finishing Subcategory

The total volume of wastewater discharged from a carpet mill is typically quite large but, when the discharge is normalized for production, the discharge rate (l/kg of production) is low relative to other subcategories (see Table V-1). This is because of the specialized nature of carpet manufacturing. Factors that contribute to low discharge rates per unit of production are: limited preliminary wet processing such as scouring and bleaching is required; dyeing that is performed is usually directed at less then the total weight of the material placed in the dye machine (the primary backing is not dyed and often part of the yarn has been predyed); there is less redyeing to try to match shade; printing of carpet results in small wastewater flows; and carpet is heavier per square yard than any of the other textile products.

The wet processing at a carpet mill includes various combinations of the following operations: scouring, bleaching, dyeing, printing, functional finishing and backing. Wastewater from dyeing and printing are the major contributors to the flows at these mills, but these processes result in only moderate levels of the traditionally monitored conventional and nonconventional pollutants, relative to other subcategories. Functional finishing and carpet backing make relatively small contributions to the total flow; the latter often results in a latex waste that can be segregated from the rest of the wastewater discharge for separate treatment. The contributions of pollutants from these processes are discussed below.

Scouring/Bleaching Carpets may be scoured with soaps or detergents to remove processing oils, waxes and other impurities and prepare them for dyeing or printing. If bleaching is requiring, the bleaching agents are added after scouring (5). Less than 15 percent of the mills that returned detailed surveys perform scouring, and at all of these the percentage of total production scoured is small (1 to 40 percent with an average of 16 percent). Only three mills that returned detailed surveys perform bleaching; the amount of production on reported bleached was 1, 2 and 10 percent, respectively. Thus, scouring and bleaching have only a minor effect on the characteristics of carpet mill wastewaters.

Dyeing Nearly all carpet finishing mills perform piece dyeing, and the wastewaters are greatly influenced by the dyes and dye machines employed. Nylon is the major fiber type used in the manufacture of carpet, although the use of polyester fiber is substantial. Other fibers are used by only five mills that returned detailed surveys. Dyeing is typically accomplished using atmospheric dye becks or, to a lesser extent, continuous dye ranges. Only four dye classifications were identified as being used by carpet finishing mills. Acid dyes, dispersed dyes and cationic dyes are most frequently used; relatively small quantities of direct dyes are used.

In addition to the dyestuffs themselves, numerous auxiliary chemicals such as leveling agents, inorganic compounds, acids, sequestering agents, organic compounds, dispersing agents and various carriers may be employed (see Section III). Because most of these auxiliary chemicals are used to improve the quality of the dyeing operation, they do not remain with the carpet. As a result, they are found in the wastewater along with excess dyes and contribute to BOD_5, COD, dissolved solids, organics and color.

Printing Carpet is generally printed by rotary, flat bed, warp yarn or tuft dyeing equipment. Flat bed printing is the most common method, although even this mode of printing occurs at less than 10 percent of the carpet mills returning detailed surveys. Spray printing techniques, using highly advanced electronically-controlled machinery, may play an important role in carpet printing in the future but, at the present time, wastewater from carpet printing should not differ substantially from woven fabric printing wastewater.

Functional Finishing Chemical agents may be applied to carpets after dyeing or printing to impart certain desirable qualities. Chemicals that increase the water repellency, flame or mildew resistance and soil retardance sometimes are used, as are antistatic agents and softeners. Because these agents are not applied as frequently and are not as numerous as those which might be used in finishing woven fabric, their effect on the raw waste load should be less.

Carpet Backing The carpet backing process laminates a secondary backing (normally jute or propylene) to the dyed or printed carpet. The adhesive is normally a latex compound, although a form backing of urethane or latex sometimes is used. The latex used in both foamed and unfoamed backing is not soluble in water but is used in a highly dispersed form. Wastewater from this process will contain suspended solids and COD.

Stock and Yarn Finishing Subcategory

The volume of wastewater discharged by stock and yarn finishing facilities is comparable to that from mills in other finishing subcategories. The wastes generated generally are not as concentrated as those found in the other subcategories and the components of the wastes depend substantially on whether natural fibers, blends or synthetic fibers alone are processed.

The wet processing employed by a stock and yarn finishing mill includes various combinations of the following operations: scouring, bleaching, mercerizing, dyeing and printing. Bleaching and dyeing are the processes that generate most of the wastewater in this subcategory. Scouring, mercerizing and "printing" (space or knit-deknit dyeing) are performed less frequently. A description of stock and yarn processing, as well as schematics of typical finishing operations, is presented in Section III. The contributions of pollutants from the wet processing operations are discussed below.

Mercerization Concentrated caustic solution is used to mercerize cotton yarns at some of the mills in this subcategory. The resulting wastewater will contain dissolved solids and have a pH of 12 to 13.

Bleaching/Scouring Bleaching is performed on either raw stock or yarn to whiten the fibers and remove any natural colors. Sodium hypochlorite or hydrogen peroxide are typically used for this purpose. The contribution of bleaching to wastewater characteristics has been discussed previously for woven fabric finishing. Scouring is employed less frequently at stock and yarn finishing mills and also has been discussed previously.

Dyeing/Printing Stock dyeing usually is performed in a vat or pressure kettle. Yarn dyeing usually is performed by skein or package dyeing methods. A specialty yarn dyeing process, similar to and sometimes referred to as printing, is known as space dyeing. All these methods have been discussed previously in Section III; a discussion of dyes and auxiliary chemicals associated with coloring various fibers also is presented there. The effect of dyeing on wastewater characteristics is presented earlier in this section under woven fabric finishing. Virtually all dye classes are used in stock and yarn dyeing, and the waste generated will be similar to those generated in dyeing fabric or carpet of the same fiber type.

Nonwoven Manufacturing Subcategory

The nature of nonwoven manufacturing is such that a typical facility has a small hydraulic loading and small pollutant mass discharge rates relative to other subcategories. The wastewater may contain latex and numerous other contaminants such as acrylic, pigments and dirt. At a few facilities, manufacturing operations common to the other subcategories (bleaching, dyeing or printing of fabric) are performed with resultant higher wastewater discharges. However, performing these operations are the exception rather than the rule. The wastewater generated during the typical nonwoven manufacturing processes are discussed below.

Web Formation Web formation is a dry operation unless the "wet lay" process is used (see Section III). Because water is used as a transport medium for the fibers in this method, some wastewater results from this process. This waste is generally low in BOD_5, COD and TSS, has a pH of 6 to 7 and is slightly milky in color.

Bonding and Coloring Bonding is used to impart structural integrity to the nonwoven fabric. Adhesives such as acrylics, polyvinyl acetate resins or other latex compounds are usually used. Cleanup of applicator equipment and mixing tanks results in wastewater contaminated with adhesives. The function of nonwoven fabrics (e.g., commercial applications and disposable items such as diapers) may not require adding color. When color is required, it is generally applied in the form of pigments added to the bonding agents.

Functional Finishing Chemical treatments to impact flame resistance, water repellency or mildew resistance also are applied to nonwovens. The methods of application and effects on wastewater characteristics are similar to those previously described for other subcategories.

Felted Fabric Processing Subcategory

Felted fabric processing typically results in a high wastewater volume, relative to other subcategories, and low pollutant concentrations. The wet processing operations include felting, dyeing and functional finishing. The rinses that follow felting (fulling) and dyeing, if used, result in high wastewater discharge volumes and contribute most of the pollutants. Functional finishing also may make a contribution to the wastewater. The contribution of pollutants from the typical wet processing steps is discussed below.

Felting (Fulling) Fulling of felted fabric is similar to the fulling used in wool finishing. Detergents, alkalis or acids may be used. These constituents, along with auxiliary chemicals, are discharged when the baths are dumped. In some cases, neutralization of the acid absorbed by the fabric is necessary. The major hydraulic loading comes from the washes or rinses that follow fulling. Hardening is a mechanical pressure process used by some mills prior to fulling to cause the wool to felt. The only waste resulting from this step is from steam or mist condensate that collects on the heavy vibrating metal plates.

Dyeing Dyeing of felts is like dyeing other fabrics. Dyes appropriate to the fiber content of the felt are used, along with appropriate amounts of auxiliary chemicals. Together, these materials contribute to BOD_5, COD and dissolved solids loadings in the wastewater.

Functional Finishing A wide variety of functional finishes and chemical treatments are applied to felts. These chemicals and the methods of application have been previously described. Although functional finishing has only a minor impact on hydraulic loading, a wide variety of chemicals may be introduced into the wastewater.

WATER USE

Although there is some loss of water by evaporation during textile processing and textile wastewater treatment, wastewater discharge is generally taken to represent water usage in the industry. A summary of the wastewater discharge rates in l/kg (gal/lb) for each subcategory is presented in Table V-1. The values presented include minimum, median and maximum annual average values for the plants in each subcategory. As noted these data are from the industry surveys.

With the exception of low water use processing (general processing), wool scouring requires the least water per unit of production. In comparing the values shown, however, it should be noted that raw wool contains between 30 to 70 percent by weight of nonwool materials such as dirt and grease.

In contrast, wool finishing requires the greatest amount of water, principally because of the numerous low temperature rinsing steps that are required to remove natural contaminants of the wool and residual process chemicals from the carbonizing, scouring and bleaching operations and soaps from the fulling process. Detailed descriptions of the process water requirement are provided in Section III.

Minimum, median and maximum wastewater discharge flows for each subcategory are presented in Table V-2. The minimum flows are reported by mills in the low water use processing (general processing) subcategory and the hosiery products subdivision of

TABLE V-1
WASTEWATER DISCHARGE RATE - SUMMARY OF HISTORICAL DATA

Subcategory	Wastewater Discharge Rate, l/kg (gal/lb) of Product* Minimum	Median	Maximum	No. of Mills
1. Wool Scouring	4.2 (0.5)	11.7 (1.4)	38.4 (4.6)	11
2. Wool Finishing	124.3 (14.9)	304.4 (36.5)	879.0 (105.4)	15
3. Low Water Use Processing				
a. General Processing	0.08 (0.01)	6.3 (0.75)	76.7 (9.2)	86
b. Water Jet Weaving	19.2 (2.3)	86.7 (10.4)	194.3 (23.3)	6
4. Woven Fabric Finishing				
a. Simple Processing	12.5 (1.5)	76.7 (9.2)	275.2 (33.0)	40
b. Complex Processing	10.8 (1.3)	97.6 (11.7)	276.9 (33.2)	39
c. Desizing	5.0 (0.6)	105.9 (12.7)	507.9 (60.9)	59
5. Knit Fabric Finishing				
a. Simple Processing	8.3 (1.0)	117.6 (14.1)	387.8 (46.5)	57
b. Complex Processing	12.5 (1.5)	122.6 (14.7)	392.8 (47.1)	51
c. Hosiery Products	5.8 (0.7)	75.1 (9.0)	289.4 (34.7)	58
6. Carpet Finishing	8.3 (1.0)	46.7 (5.6)	162.6 (19.5)	37
7. Stock & Yarn Finishing	3.3 (0.4)	96.7 (11.6)	538.7 (64.6)	117
8. Nonwoven Manufacturing	2.5 (0.3)	40.0 (4.8)	82.6 (9.9)	11
9. Felted Fabric Processing	33.4 (4.0)	212.7 (25.5)	930.7 (111.6)	11

* Wool scouring flows are per unit of raw wool.
Wool finishing flows are per unit of product, although effluent limitations are per unit of fiber.

Source: EPA Industry Surveys, 1977 & 1980.

TABLE V-2
WASTEWATER DISCHARGE - SUMMARY OF HISTORICAL DATA

Subcategory	Wastewater Discharge, cu m/day (MGD) Minimum	Median	Maximum	No. of Mills
1. Wool Scouring	38 (0.010)	193 (0.051)	1,919 (0.507)	11
2. Wool Finishing	189 (0.050)	1,207 (0.319)	4,621 (1.221)	15
3. Low Water Use Processing				
a. General Processing	4 (0.001)	95 (0.025)	1,575 (0.416)	86
b. Water Jet Weaving	299 (0.079)	640 (0.169)	1,158 (0.306)	6
4. Woven Fabric Finishing				
a. Simple Processing	42 (0.011)	678 (0.179)	8,327 (2.200)	40
b. Complex Processing	170 (0.045)	1,703 (0.450)	28,955 (7.650)	39
c. Desizing	38 (0.010)	3,217 (0.850)	29,845 (7.885)	59
5. Knit Fabric Finishing				
a. Simple Processing	15 (0.004)	1,438 (0.380)	10,560 (2.790)	57
b. Complex Processing	11 (0.003)	2,029 (0.536)	13,248 (3.500)	51
c. Hosiery Products	4 (0.001)	182 (0.048)	1,537 (0.406)	58
6. Carpet Finishing	76 (0.020)	1,590 (0.420)	6,923 (1.829)	37
7. Stock & Yarn Finishing	45 (0.012)	946 (0.250)	9,637 (2.546)	117
8. Nonwoven Manufacturing	53 (0.014)	379 (0.100)	1,893 (0.500)	11
9. Felted Fabric Processing	11 (0.003)	564 (0.149)	1,514 (0.400)	11

Source: EPA Industry Surveys, 1977 & 1980.

the knit fabric finishing subcategory. This is expected because process water requirements are lower in the low water use processing subcategory, and the mill production is lower in the hosiery products subdivision than in any of the other subcategories. Maximum discharges are reported at mills in the woven fabric finishing subcategory where complex processing and desizing operations are employed. This also is predictable because of the high water usage and large production capacity of these mills. The median discharges tend to increase with increase in complexity of the processing.

Estimates of the total flow of wastewater discharged by the industry are presented in Table V-3. Values are presented for direct dischargers, indirect dischargers and the total mills in each subcategory. These estimates were developed by adding the known average discharges from the historical data base and estimated average discharges for mills not reporting flow. The greatest amount of flow discharged by direct dischargers is in the woven fabric finishing (desizing) subcategory. For indirect dischargers, the greatest flow is discharged by the knit fabric finishing (simple processing) subcategory. Considering all dischargers, the greatest flow is discharged by the woven fabric finishing (desizing) subcategory, which accounts for over 20 percent of the total wastewater flow discharged by the industry. Four industry segments (wool scouring, low water use processing (water jet weaving), nonwoven manufacturing and felted fabric processing) each account for less than one percent of the total wastewater flow discharged by the industry. The total industry discharges an estimated wastewater flow of 1.85 million cu m/day (490 MGD).

TOXIC POLLUTANTS

Industry Survey Information

Most of the organic toxic pollutants are specific compounds and more sophisticated laboratory analytical techniques are required to quantify them than are required for nonspecific parameters such as solids, COD and alkalinity. Because the concentrations of the organic toxics are considerably lower than for most of the conventional and nonconventional pollutants, more elaborate sample collection and handling methods are necessary to insure that meaningful and reproducible results are obtained. Because of this, and the fact that control of the toxic pollutants, with the exception of total chromium, generally was not included in previous permits requirements, there is relatively little historical information about the presence or concentrations of most of the toxic pollutants (especially the nonmetals) in textile mill wastewaters.

One source of information utilized in developing information about the toxic pollutants in textile wastes was the industry survey. The questionnaire used in the survey has been described

TABLE V-3
WASTEWATER DISCHARGE - ESTIMATED SUBCATEGORY TOTALS

Subcategory	Estimated Wastewater Discharge, cu m/day (MGD) Direct Dischargers*		Indirect Dischargers		Total Subcategory	
1. Wool Scouring	3,849	(1.017)	8,679	(2.293)	12,528	(3.310)
2. Wool Finishing	41,120	(10.864)	30,836	(8.147)	71,956	(19.011)
3. Low Water Use Processing						
a. General Processing	16,775	(4.432)	62,044	(16.392)	78,819	(20.824)
b. Water Jet Weaving	4,527	(1.196)	4,527	(1.196)	9,054	(2.392)
4. Woven Fabric Finishing						
a. Simple Processing	65,870	(17.403)	131,752	(34.809)	197,622	(52.212)
b. Complex Processing	96,650	(25.535)	145,950	(38.560)	242,600	(64.095)
c. Desizing	225,034	(59.454)	151,491	(40.024)	376,525	(99.478)
5. Knit Fabric Finishing						
a. Simple Processing	66,722	(17.628)	238,251	(62.946)	304,973	(80.574)
b. Complex Processing	45,216	(11.946)	105,651	(27.913)	150,867	(39.859)
c. Hosiery Products	753	(0.199)	22,824	(6.030)	23,577	(6.229)
6. Carpet Finishing	20,378	(5.384)	87,559	(23.133)	107,937	(28.517)
7. Stock & Yarn Finishing	82,350	(21.757)	169,477	(44.768)	251,827	(66.525)
8. Nonwoven Manufacturing	2,490	(0.658)	14,500	(3.831)	16,990	(4.489)
9. Felted Fabric Processing	791	(0.209)	7,831	(2.069)	8,622	(2.278)
Total Industry	672,525	(177.682)	1,181,372	(312.111)	1,853,897	(489.793)

* Includes wastewater generated and disposed of by zero discharge mills (see Table III-8).

Note: The estimates were developed by adding the known average discharge values for the mills in each subcategory reporting flow data plus estimates of the average discharge for the mills not reporting flow. The estimates for mills not reporting values were based on the mill's assignment to a specific model. Model assignments were made on the basis of survey information and information about products and production equipment published in the 1978 edition of the Davison's Textile Blue Book.

Source: EPA Industry Surveys, 1977 & 1980 and Contractor estimates.

previously. In the questionnaire, respondents were asked to identify whether each of 123 toxic pollutants* was "known present," "suspected absent" or "known absent" in the untreated wastewater or treated effluent. The agency rated the responses to Section VI as "good," "poor" and "no response." A "good" rating was assigned if an effort was made by the survey responder to consider each of the toxic pollutants listed. A "poor" rating was assigned if the only response was a single statement such as "known absent," "none used," "none present," or an "X" through the entire list. A "no response" rating was assigned when the question was not addressed. In summary, 418 responses were rated as "good," 65 as "poor" and 131 as "no response." The responses for each pollutant were tallied for the mills that provided "good" responses. A summary of the "good" responses is presented in Table V-4 and shows that 53 pollutants are know to be present and an additional 47 are suspected to be present by at least one mill. A total of 69 pollutants are reported known or suspected present by more than two mills; 29 of these are known to be present by more than two mills.

Field Sampling Program

Because of the absence of historical data for the toxic pollutants noted above, it was necessary to perform a field sampling program. The program was conducted in five phases and involved a total to 51 textiles mills. The first phase was conducted in connection with the joint ATMI/EPA mobile pilot plant project. Untreated wastewater, biologically treated effluent and, in some cases, physical/chemical treated effluent samples were collected at 23 mills during March, April and May of 1977. In the second phase, during May, June and July of 1977, untreated wastewater and biologically-treated effluent samples were collected at eight additional mills and from the various physical/chemical treatment modes of the mobile pilot plant at one previously sampled mill. In the third phase, during September, October and November of 1977, water supply, untreated wastewater, biologically-treated effluent and/or physical/chemical-treated effluent samples were collected at 13 additional mills and from the various treatment modes of the mobile pilot at one previously sampled mill. An additional five mills and six previously sampled mills were sampled in the fourth phase from April to September 1978. This phase investigated the day-to-day fluctuations in untreated wastewater and treated effluents and the efficiencies of various full-scale

*At the time of the survey (March, 1977), the toxic pollutant list contained only 123 compounds; shortly thereafter, the list was increased to 129 with the addition of di-n-octyl phthalate, PCB-1221, PCB-1232, PCB-1248, PCB-1260 and PCB-1016.

TABLE V-4
INDUSTRY RESPONSES TO TOXIC POLLUTANTS LIST
SUMMARY OF ALL MILLS

Toxic Pollutant	Known Present	Suspected Present	Known Absent	Suspected Absent
1. acenaphthene		7	262	43
2. acrolein		3	264	46
3. acrylonitrile	6	26	243	38
4. benzene	5	27	254	40
5. benzidine	6	42	236	43
6. carbon tetrachloride (tetrachloromethane)	1	9	244	61
7. chlorobenzene	4	28	235	44
8. 1,2,4-trichlorobenzene	33	53	182	38
9. hexachlorobenzene	1	5	256	48
10. 1,2-dichloroethane	1	6	245	50
11. 1,1,1-trichloroethane	5	34	233	46
12. hexachloroethane		1	260	51
13. 1,1-dichloroethane	1	1	258	53
14. 1,1,2-trichloroethane		9	254	52
15. 1,1,2,2-tetrachloroethane		2	258	52
16. chloroethane	1	8	256	48
17. bis(chloromethyl) ether		5	246	60
18. bis(2-chloroethyl) ether		3	255	53
19. 2-chloroethyl vinyl ether (mixed)		1	256	54
20. 2-chloronaphthalene	3	2	263	42
21. 2,4,6-trichlorophenol		7	260	44
22. parachlorometa cresol		3	259	47
23. chloroform (trichloromethane)	2	5	249	55
24. 2-chlorophenol	1	8	257	43
25. 1,2-dichlorobenzene	2	16	252	40
26. 1,3-dichlorobenzene	2	9	259	40
27. 1,4-dichlorobenzene	2	8	259	40
28. 3,3-dichlorobenzidine	1	10	260	41
29. 1,1-dichloroethylene			267	41
30. 1,2-trans-dichloroethylene		2	265	41
31. 2,4-dichlorophenol		2	263	43
32. 1,2-dichloropropane			263	45
33. 1,3-dichloropropylene			263	45
34. 2,4-dimethylphenol		2	260	45
35. 2,4-dinitrotoluene		3	261	45
36. 2,6-dinitrotoluene		3	262	44
37. 1,2-diphenylhydrazine		5	263	39
38. ethylbenzene	2	7	256	41
39. fluoranthene		1	263	42
40. 4-chlorophenyl phenyl ether		4	264	41

TABLE V-4 (Cont.)

Toxic Pollutant	Known Present	Suspected Present	Known Absent	Suspected Absent
41. 4-bromophenyl phenyl ether		1	266	43
42. bis(2-chloroisopropyl) ether		1	263	46
43. bis(2-chloroethoxy) methane			265	45
44. methylene chloride (dichloromethane)	3	17	242	41
45. methyl chloride (chloromethane)	1	2	264	43
46. methyl bromide (bromomethane)		4	265	43
47. bromoform (tribromomethane)		1	266	44
48. dichlorobromomethane			265	46
49. trichlorofluoromethane			264	45
50. dichlorodifluoromethane			263	45
51. chlorodibromomethane			261	49
52. hexachlorobutadiene		5	260	44
53. hexachlorocyclopentadiene		2	265	43
54. isophorone		1	262	45
55. naphthalene	7	48	232	33
56. nitrobenzene		7	260	42
57. 2-nitrophenol		2	262	43
58. 4-nitrophenol		2	260	43
59. 2,4-dinitrophenol		4	257	43
60. 4,6-dinitro-o-cresol		2	259	45
61. N-nitrosodimethylamine		5	260	42
62. N-nitrosodiphenylamine		4	261	42
63. N-nitrosodi-n-propylamine			265	42
64. pentachlorophenol	2	15	248	45
65. phenol	81	48	161	38
66. bis(2-ethylhexyl) phthalate		4	263	41
67. butyl benzyl phthalate	3	2	261	43
68. di-n-butyl phthalate	1	6	261	42
69. di-n-octyl phthalate*				
70. diethyl phthalate		7	261	41
71. dimethyl phthalate	8	17	243	40
72. 1,2 benzanthracene		5	260	41
73. 3,4-benzopyrene		2	261	43
74. 3,4-benzofluoranthene		1	263	44
75. 11,12-benzofluoranthene		1	262	45
76. chrysene		1	262	44
77. acenaphthylene	3	2	262	41
78. anthracene	2	8	256	41
79. 1,12-benzoperylene		2	259	45
80. fluorene	1	4	256	45

TABLE V-4 (Cont.)

Toxic Pollutant	Known Present	Suspected Present	Known Absent	Suspected Absent
81. phenanthrene		3	260	43
82. 1,2,5,6-dibenzanthracene		6	258	42
83. indeno(1,2,3-cd) pyrene			261	46
84. pyrene		2	261	45
85. tetrachloroethylene	10	19	242	43
86. toluene	8	40	223	43
87. trichloroethylene	4	17	251	40
88. vinyl chloride (chloroethylene)		5	253	47
89. aldrin	2	1	242	78
90. dieldrin	1		241	78
91. chlordane (technical mixture and metabolites)	1		242	78
92. 4,4'-DDT		1	239	82
93. 4,4'-DDE (p,p'-DDX)			240	82
94. 4,4'-DDD (p,p'-TDE)			240	82
95. alpha-endosulfan			243	77
96. beta-endosulfan			243	77
97. endosulfan sulfate			244	77
98. endrin			246	77
99. endrin aldehyde			246	77
100. heptachlor	1	1	246	77
101. heptachlor epoxide			246	77
102. alpha-BHC			244	77
103. beta-BHC			245	77
104. gamma-BHC (lindane)	1		245	77
105. delta-BHC			245	77
106. PCB-1242 (Arochlor 1242)			244	79
107. PCB-1254 (Arochlor 1254)			244	79
108. PCB-1221 (Arochlor 1221)*				
109. PCB-1232 (Arochlor 1232)*				
110. PCB-1248 (Arochlor 1248)*				
111. PCB-1260 (Arochlor 1260)*				
112. PCB-1016 (Arochlor 1016)*				
113. Toxaphene		1	243	77
114. Antimony (Total)	16	36	208	56
115. Arsenic (Total)	10	6	246	70
116. Asbestos (Fibrous)	3	3	257	65
117. Beryllium (Total)	2	5	257	65
118. Cadmium (Total)	24	17	219	57
119. Chromium (Total)	117	55	117	38
120. Copper (Total)	87	79	146	27

TABLE V-4 (Cont.)

Toxic Pollutant	Known Present	Suspected Present	Known Absent	Suspected Absent
121. Cyanide (Total)	10	6	240	72
122. Lead (Total)	34	27	204	59
123. Mercury (Total)	19	15	212	68
124. Nickel (Total)	28	28	208	53
125. Selenium (Total)	7	3	242	59
126. Silver (Total)	12	4	244	56
127. Thallium (Total)	2	1	251	59
128. Zinc (Total)	100	64	140	30
129. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)		1	260	44

* Pollutant not included on original list of 123.

Known Present - The compound has been detected by reasonable analytical procedures in the discharge or by reference is known to be present in the raw waste load.

Suspected Present- The compound is a raw material in the processes employed, a product, a by-product, catalyst, etc. Its presence in the raw waste load and discharge is a reasonable technical judgment.

Suspected Absent - No known reason to predict that the compound is present in the discharge.

Known Absent - The application of reasonable analytical procedures designed to detect the material have yielded negative results.

Source: EPA Industry Survey, 1976-1977.

physical/chemical treatment technologies. In the last phase, two additional mills and six previously sampled mills were sampled from December 1977 to October 1979, and one previously sampled mill was sampled in March 1980.

A special sampling program was conducted during October and November 1979 to measure asbestos levels, which had not been investigated during previous sampling. Water supply, untreated wastewater and treated effluent samples were collected at 13 previously sampled mills. The asbestos analyses were subsequently conducted on these samples.

The scope of the field sampling program is presented in Table V-5. The 51 mills sampled represent all subcategories, with greater emphasis placed on the major subcategories. Most of the direct discharging mills provided biological treatment, with a few providing physical/chemical treatment. The sample collection and handling procedures and the analytical procedures conformed to protocols developed by EPA.

The field sampling program was designed to insure that the number of mills sampled in each subcategory would closely fit the distribution of mills in the industry. Because of the wide diversity within the manufacturing processes used by the textile industry, it was recognized that the screening phase should include more than one mill in each subcategory.

Field Sampling Results - Water Supply

A summary of the analytical results showing the minimum, maximum, average and median concentrations of all water supply samples for each pollutant detected, the number of times each pollutant was analyzed for and the number of times detected, is presented in Table V-6. Samples were collected for 34 mills, with two pairs of mills using the same water supply source. Thus, 32 separate water supply samples were collected and analyzed. Seven toxic organic pollutants, 9 toxic metals, asbestos and cyanide were detected at concentrations greater than 10 ug/l. Chloroform and copper, detected at concentrations of 1,360 and 781 ug/l respectively, were the maximum toxic organic and maximum toxic metal detected in the water supplies. Zinc, toluene and copper were the most frequently detected pollutants. Bis(2-ethylhexyl) phthalate, a compound present in a high percentage of the samples analyzed across the industries being studied, may be an anomaly, its presence explained by the fact that it is used as a plasticizer in the plastic tubing used for sample collection.

Field Sampling Results - Untreated Wastewater

The overall qualitative results of the field sampling program of textile mill untreated wastewaters are presented by subcategory in Table V-7. Two toxic pollutants: copper and zinc were detected in all nine subcategories. An additional eight

TABLE V-5
SUMMARY OF MILL CHARACTERISTICS AND SAMPLE COLLECTION
FIELD SAMPLING PROGRAM

Report Number	Mill Type	Typical Processing	Products	Samples Collected: Water Supply	Raw Waste	Biological	Physico-chemical
10006	Wool Scouring	Raw wool scouring, spinning	Wool top & carpet yarn	X	X	X	
10013	Wool Scouring	Raw wool scouring, heavy scour, carbonizing, bleaching	Wool top & wool/ polyester fabric	X	X	X	X
10015	Wool Scouring	Raw wool scouring	Wool top	X	X	X	X*
20011	Wool Finishing	Heavy scouring, bleaching, stock & yarn dyeing	Apparel & upholstery fabric	X	X	X	X*
20021	Wool Finishing	Heavy scouring, stock & yarn dyeing	Woven fabric	X	X	X	X*
		Low Water Use Processing					
(04935)	General Processing	Spinning, slashing, weaving	Woven greige goods		X	X	
(01304)	Water Jet Weaving	Water jet weaving	Woven greige goods	X	X		
(90200)	Other	Fiberglass extrusion#	Fiberglass yarns	X	X	X	X**

* Collected from mobile pilot plant.
( ) Represents mill sequence number instead of report number.
\# Nontextile processing so data, with the exception of water supply, not included in results of field sampling program.
** Collected from in-place treatment technology.

TABLE V-5 (Cont.)

Report Number	Mill Type	Typical Processing	Products	Samples Collected Water Supply	Raw Waste	Biolog-ical	Physico-chemical
		<u>Woven Fabric Finishing</u>					
40023	Simple Processing	Piece dyeing	Upholstery fabric	X	X	X	X*
40144	Simple Processing	Printing	Sheets, blankets, towels		X	X	X**
40077	Complex Processing	Scouring, bleaching, printing, piece dyeing	Finished fabric	X	X	X	X*
40135	Complex Processing	Slashing, weaving, desizing, bleaching, printing, yarn & piece dyeing	Sheets & towels		X	X	
40160	Complex Processing	Desizing, scouring, bleaching, mercerizing, printing, piece dyeing	Finished fabric		X	X	
(04742)	Desizing	Desizing, scouring, bleaching, mercerizing, piece dyeing	Finished fabric & yarn		X	X	X*
40034	Desizing	Desizing, scouring, bleaching, mercerizing, printing, piece dyeing	Sheeting		X	X	

* Collected from mobile pilot plant.
** Collected from in-place treatment technology.
( ) Represents mill sequence number instead of report number.

TABLE V-5 (Cont.)

Report Number	Mill Type	Typical Processing	Products	Samples Collected Water Supply	Raw Waste	Biological	Physico-chemical
40059	Desizing	Desizing, scouring, bleaching, mercerizing, piece dyeing	Finished fabric	X	X	X	X*
40072	Desizing	Desizing, scouring, bleaching, mercerizing, piece dyeing	Sheeting & shirting		X	X	
40081	Desizing	Desizing, scouring, bleaching, mercerizing, printing, piece dyeing	Finished fabric	X	X	X	X**
40097	Desizing	Desizing, scouring, bleaching, piece dyeing	Finished fabric	X	X	X	
40099	Desizing	Desizing, scouring, bleaching, mercerizing, piece dyeing	Finished fabric		X	X	
40103	Desizing	Desizing, scouring, bleaching, mercerizing, printing, piece dyeing	Finished fabric		X	X	
40120	Desizing	Desizing, scouring, bleaching, mercerizing, printing, piece dyeing	Sheeting & apparel	X	X	X	

* Collected from mobile pilot plant.
** Collected from in-place treatment technology.

TABLE V-5 (Cont.)

Report Number	Mill Type	Typical Processing	Products	Samples Collected Water Supply	Raw Waste	Biological	Physico-chemical
40145	Desizing	Desizing, scouring, bleaching, mercerizing, yarn & piece dyeing	Finished fabric		X	X	
40146	Desizing	Slashing, weaving, desizing, scouring, bleaching, yarn dyeing	Denim fabric	X	X	X	
40150	Desizing	Weaving, desizing, scouring, bleaching, printing, piece dyeing	Sheets		X	X	
40156	Desizing	Slashing, desizing, scouring, bleaching, yarn & piece dyeing	Finished fabric	X	X	X	X*
		Knit Fabric Finishing					
50030	Simple Processing	Scouring, piece dyeing	Flat goods	X	X	X	X*
50104	Simple Processing	Scouring, printing piece dyeing	Finished fabric	X	X#	X	X*
50108	Simple Processing	Piece dyeing	Outerwear fabric		X	X	
50112	Simple Processing	Piece dyeing	Apparel & auto upholstery fabric	X	X	X	X**
50116	Simple Processing	Scouring, bleaching, piece dyeing	Finished fabric		X	X	

* Collected from in-place technology.
\# Pretreatment effluent.
** Collected from in-place technology and mobile pilot plant.

TABLE V-5 (Cont.)

Report Number	Mill Type	Typical Processing	Products	Samples Collected: Water Supply	Raw Waste	Biological	Physicochemical
50013	Complex Processing	Scouring, piece dyeing	Finished fabric	X	X	X	X*
50035	Complex Processing	Scouring, bleaching, printing, piece dyeing	Apparel fabric	X	X	X	X**
50099	Complex Processing	Scouring, piece dyeing	Apparel fabric	X	X	X	X**
5H012	Hosiery Products	Piece dyeing	Ladies' hosiery	X	X		
5H027	Hosiery Products	Scouring, bleaching, piece dyeing	Men's hosiery	X	X		
5H034	Hosiery Products	Piece dyeing	Men's hosiery	X	X	X	
60008	Carpet Finishing	Tufting, printing, piece dyeing, latex backing	Finished carpet	X	X	X	
60031	Carpet Finishing	Tufting, piece dyeing latex backing	Finished carpet	X	X		X*
60034	Carpet Finishing	Tufting, piece dyeing, latex backing	Finished carpet		X	X	
60037	Carpet Finishing	Tufting, piece dyeing latex backing	Finished carpet		X	X	
(06443)	Stock & Yarn Finishing	Yarn dyeing	Finished yarn	X	X		X*

* Collected from in-place technology.
** Collected from mobile pilot plant.
( ) Represents mill sequence number instead of report number.

TABLE V-5 (Cont.)

Report Number	Mill Type	Typical Processing	Products	Samples Collected Water Supply	Raw Waste	Biological	Physico-chemical
70009	Stock & Yarn Finishing	Bleaching, mercerizing, yarn dyeing	Sewing thread & yarn		X	X	
70072	Stock & Yarn Finishing	Yarn dyeing	Finished yarn		X	X	
70081	Stock & Yarn Finishing	Yarn dyeing	Finished yarn	X	X	X	X*
70087	Stock & Yarn Finishing	Yarn dyeing	Greige & finished yarn		X	X	
70096	Stock & Yarn Finishing	Desizing, scouring, bleaching	Surgical gauze & cotton		X	X	
70120	Stock & Yarn Finishing	Wool scouring, stock dyeing, yarn dyeing	Carpet yarn	X	X	X	X**
80008	Nonwoven Manufacturing	Carding, adhesive bonding, viscose regeneration	Finished fabric	X	X		
80011	Nonwoven Manufacturing	Fiber preparation, wet lay, adhesive bonding	Finished fabric		X		
80019	Nonwoven Manufacturing	Carding, adhesive bonding	Disposable wiping towels		X		X#
80025	Felted Fabric Processing	Weaving, scouring, felting	Papermaker's felt	X	X	X	X**

* Collected from in-place treatment technology.
** Collected from polishing pond.
\# Asbestos analysis only.

TABLE V-6
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - WATER SUPPLY

	Toxic Pollutant	Concentration Observed, ug/l Water Supply Minimum	Maximum	Average	Median	Analyzed*	Detected#
4.	benzene	1	8	4	4	34	10
7.	chlorobenzene	1	2	2	2	34	2
8.	1,2,4-trichlorobenzene	2	5	4	4	32	2
9.	hexachlorobenzene	1	1	1		32	1
11.	1,1,1-trichloroethane	1	2	1	1	34	3
13.	1,1-dichloroethane	1	1	1		33	1
23.	chloroform	3	1,360	179	30	34	11
24.	2-chlorophenol	1	1	1		31	1
29.	1,1-dichloroethylene	4	4	4		33	1
38.	ethylbenzene	1	6	2	1	34	8
39.	fluoranthene	1	1	1	1	29	3
44.	methylene chloride	4	47	16	14	34	14
45.	methyl chloride	2	9	6	6	33	2
48.	dichlorobromomethane	3	7	5	5	33	2
49.	trichlorofluoromethane	6	6	6		34	1
51.	chlorodibromomethane	2	2	2		31	1
55.	naphthalene	1	1	1		32	1
65.	phenol (GC/MS)	1	36	10	6	32	8
66.	bis(2-ethylhexyl) phthalate	1	140	19	7	32	25
67.	butyl benzyl phthalate	1	5	2	1	32	6
68.	di-n-butyl phthalate	1	15	3	2	32	13
69.	di-n-octyl phthalate	2	2	2		29	1
70.	diethyl phthalate	1	8	3	2	32	8
72.	1,2-benzoanthracene	1	1	1		29	1
73.	3,4-benzopyrene	1	1	1		29	1

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-6 (Cont.)

Toxic Pollutant	Minimum	Maximum	Concentration Observed, ug/l Water Supply Average	Median	Analyzed*	Detected#
74. 3,4-benzofluoranthene	1	1	1		31	1
78. anthracene	1	1	1	1	32	8
80. fluorene	1	1	1	1	31	3
84. pyrene	1	1	1	1	32	3
85. tetrachloroethylene	1	7	3	2	34	5
86. toluene	1	13	3	2	34	20
87. trichloroethylene	1	6	2	2	34	8
102. alpha-BHC	5	5	5		23	1
114. antimony (total)	1	36	23	25	33	10
115. arsenic (total)	1	72	12	4	33	9
116. asbestos (MFL)	1	68	13	2	7	6
117. beryllium (total)	1	1	1		31	1
118. cadmium (total)	2	29	11	7	33	5
119. chromium (total)	6	30	15	13	33	7
120. copper (total)	6	781	86	47	33	17
121. cyanide	22	22	22		32	1
122. lead (total)	8	75	44	46	33	8
123. mercury (total)	1	1	1	1	31	3
124. nickel (total)	18	150	74	61	33	10
125. selenium (total)	1	6	2	1	31	5
126. silver (total)	1	129	32	19	33	11
128. zinc (total)	14	418	109	64	33	24

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: EPA Field Sampling Program.

TABLE V-7
TOXIC POLLUTANTS DETECTED IN TEXTILE MILL UNTREATED WASTEWATERS

Toxic Pollutant	Subcategory 1	2	3a	3b	4a	4b	4c	5a	5b	5c	6	7	8	9
1. acenaphthene					X		X	X			X	X		
2. acrolein								X						
3. acrylonitrile								X		X				
4. benzene	X	X			X	X	X	X	X	X		X	X	
7. chlorobenzene	X	X				X	X		X		X	X		
8. 1,2,4-trichlorobenzene		X			X		X	X	X			X		
9. hexachlorobenzene	X				X									
10. 1,2-dichloroethane					X		X							
11. 1,1,1-trichloroethane	X	X			X		X	X	X		X			
13. 1,1-dichloroethane	X						X	X						
15. 1,1,2,2-tetrachloroethane									X			X		
17. bis(chloromethyl) ether												X		
21. 2,4,6-trichlorophenol						X	X			X		X		
22. parachlorometa cresol							X					X		
23. chloroform	X	X	X		X	X	X	X	X	X	X	X	X	
24. 2-chlorophenol						X						X		
25. 1,2-dichlorobenzene		X					X	X				X		
26. 1,3-dichlorobenzene		X												
27. 1,4-dichlorobenzene		X					X	X				X		
29. 1,1-dichloroethylene		X					X	X						
30. 1,2-trans-dichloroethylene		X					X		X					
31. 2,4-dichlorophenol							X					X		
32. 1,2-dichloropropane							X	X				X		
33. 1,3-dichloropropylene								X						
34. 2,4-dimethylphenol									X			X		

TABLE V-7 (Cont.)

	Toxic Pollutant	Subcategory													
		1	2	3a	3b	4a	4b	4c	5a	5b	5c	6	7	8	9
36.	2,6-dinitrotoluene												X		
37.	1,2-diphenylhydrazine											X			
38.	ethylbenzene	X	X			X	X	X	X	X		X	X	X	
44.	methylene chloride	X	X			X		X	X	X			X		
48.	dichlorobromomethane											X			
49.	trichlorofluoromethane							X	X						
54.	isophorone	X													
55.	naphthalene		X			X		X	X	X	X	X	X	X	
57.	2-nitrophenol							X							
58.	4-nitrophenol							X					X		
62.	N-nitrosodiphenylamine		X				X	X			X				
64.	pentachlorophenol	X	X			X	X	X	X					X	
65.	phenol (GC/MS)	X	X	X	X	X		X	X	X	X	X	X		X
66.	bis (2-ethylhexyl) phthalate	X	X	X	X	X	X	X	X	X	X	X	X	X	X
67.	butyl benzyl phthalate							X		X				X	
68.	di-n-butyl phthalate	X	X	X		X	X	X		X			X		
69.	di-n-butyl phthalate	X						X							
70.	diethyl phthalate	X	X				X	X	X	X			X		
71.	dimethyl phthalate		X			X	X			X			X		
77.	acenaphthylene										X				
78.	anthracene		X					X					X		
80.	fluorene								X			X	X		
81.	phenanthrene		X										X		
83.	indeno(1,2,3-cd)pyrene												X		
84.	pyrene						X								

TABLE V-7 (Cont.)

Toxic Pollutant	Subcategory 1	2	3a	3b	4a	4b	4c	5a	5b	5c	6	7	8	9
85. tetrachloroethylene	X	X				X	X	X	X	X		X		X
86. toluene	X	X			X	X	X	X	X	X		X	X	X
87. trichloroethylene	X	X	X			X	X	X	X			X		X
88. vinyl chloride														X
90. dieldrin	X													
94. 4,4'-DDD(p,p'-TDE)	X													
95. alpha-endosulfan	X													
96. beta-endosulfan	X													
100. heptachlor		X												
101. heptachlor epoxide	X													
102. alpha-BHC	X	X												
103. beta-BHC	X								X					
104. gamma-BHC (lindane)	X	X												
105. delta-BHC	X													
106. PCB-1242 (Arochlor 1242)	X													
114. antimony (total)	X	X		X			X	X	X	X	X	X		
115. arsenic (total)	X	X				X	X	X	X	X		X		
116. asbestos		X	X			X				X			X	X
117. beryllium (total)	X													
118. cadmium (total)	X	X	X		X	X	X	X			X	X	X	
119. chromium (total)	X	X	X	X	X	X	X	X	X	X	X	X	X	
120. copper (total)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
121. cyanide	X	X		X	X		X	X	X	X	X	X	X	
122. lead (total)	X	X	X	X	X	X	X	X	X		X	X	X	
123. mercury (total)	X	X			X	X	X				X	X		

TABLE V-7 (Cont.)

Toxic Pollutant	Subcategory 1	2	3a	3b	4a	4b	4c	5a	5b	5c	6	7	8	9
124. nickel (total)	X	X	X		X	X	X	X	X		X	X	X	
125. selenium (total)	X	X		X			X	X		X		X		X
126. silver (total)	X	X	X	X	X	X	X	X	X	X	X	X	X	
127. thallium (total)	X				X		X							
128. zinc (total)	X	X	X	X	X	X	X	X	X	X	X	X	X	X

<u>Source</u>: EPA Field Sampling Program.

pollutants were detected in eight of the nine subcategories. However, 24 toxic pollutants were detected in only a single subcategory. This reflects the wide variety of manufacturing methods and process machinery in the textile industry, and perhaps, the fluctuating character of textile wastewaters caused by batch operations and frequent changes in product line. The quantitative results of the field sampling program are summarized in Table V-8. Results are shown for both the untreated wastewater and the biologically-treated effluent to illustrate the pollutants of most significance in the industry. The results from biological and physical/chemical treatment units are included in Section VII to describe the performance of the different technologies.

Table V-7 shows that 80 of the 129 toxic pollutants were detected in textile industry untreated wastewaters. Sixty-five were organic pollutants, 13 were metals, one was asbestos and one was cyanide. Seventeen of the pollutants were detected only once.

The results of the field sampling program are summarized by subcategory in Table V-9a through V-9n. The table is similar in format to Table V-8 and serves to identify the toxic pollutants of most significance in each subcategory.

The greatest variety of toxic pollutants detected in the untreated wastewater at concentrations greater than 10 ug/l was found at mills in the woven fabric finishing subcategory where desizing operations are employed. (Table V-9g); 27 organics, 9 metals and cyanide were detected. The next greatest number was in the stock and yarn finishing subcategory (Table v-91) with 20 organics, 9 metals and cyanide detected. Ten toxic metals were detected in the wool finishing subcategory (Table V-9b). These three subcategories perform the most complex and variable processing steps with a large variety of associated chemicals, as noted in the general discussion earlier in this section.

The smallest variety of toxic pollutants detected in the untreated wastewater at concentrations greater than 10 ug/l occurred in the water wet weaving subdivision of the low water use processing subcategory (Table V-9d), with no organic and five metals detected; felted fabric processing subcategory (Table V-9n), with four organics and three metals detected; at mills in the knit fabric finishing subcategory where hosiery products are manufactured (Table V-9j), with seven organics and three metals detected. These results reflect the fact the these subcategories perform the fewest complex processing steps and generally do not use a great number of processing chemicals.

Field Sampling Results - Biologically-Treated Effluents

The quantitative results of the field sampling program for biologically-treated effluents have been previously introduced as part of Table V-8 for the industry as a whole, and Table V-9a

TABLE V-8
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - UNTREATED WASTEWATER AND BIOLOGICALLY TREATED EFFLUENT

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#	Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#
1. acenaphthene	2	273	52	20	69	8	1	2	2	2	64	3
2. acrolein	199	199	199		66	1	87	87	87		62	1
3. acrylonitrile	90	1600	845	845	78	2	400	400	400		80	1
4. benzene	1	200	30	10	78	22	1	64	11	5	96	15
7. chlorobenzene	1	296	30	10	73	16	2	26	8	4	69	5
8. 1,2,4-trichlorobenzene	28	14000	2212	315	76	15	1	1900	407	29	92	15
9. hexachlorobenzene	1	2	2	2	71	2	1	1	1	1	66	3
10. 1,2-dichloroethane	4	6	5	5	70	2						
11. 1,1,1-trichloroethane	2	1200	89	16	73	21	1	130	37	10	67	6
13. 1,1-dichloroethane	1	14	7	6	70	5	2	2	2		64	1
15. 1,1,2,2-tetrachloroethane	1	21	11	11	68	2	5	5	5		62	1
17. bis(chloromethyl) ether	6	6	6		58	1						
21. 2,4,6-trichlorophenol	1	94	29	20	76	7	2	21	12	12	94	2
22. parachlorometa cresol	5	29	14	9	76	3	1	32	8	4	94	7
23. chloroform	1	642	77	15	78	34	2	1020	78	7	95	19
24. 2-chlorophenol	10	131	71	71	68	2	10	10	10		65	1
25. 1,2-dichlorobenzene	1	460	85	10	76	15	1	20	4	1	94	18
26. 1,3-dichlorobenzene	10	1700	705	555	68	4	13	33	23	23	63	2
27. 1,4-dichlorobenzene	1	760	188	11	71	8	1	16	6	5	66	6
29. 1,1-dichloroethylene	10	84	41	34	72	4	1	44	15	7	64	4

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-8 (Cont.)

Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#
					Concentration Observed, ug/l							
30. 1,2-trans-dichloroethylene	2	360	66	10	68	6	7	7	7		62	1
31. 2,4-dichlorophenol	20	41	31	31	71	2						
32. 1,2-dichloropropane	2	100	49	46	70	4						
33. 1,3-dichloropropylene	2	2	2		68	1	1	10	6	6	62	2
34. 2,4-dimethylphenol	2	190	65	2	68	3	1	9	6	8	62	3
36. 2,6-dinitrotoluene	54	54	54		68	1						
37. 1,2-diphenylhydrazine	22	22	22		68	1						
38. ethylbenzene	1	19000	917	43	78	47	1	3018	157	3	95	23
39. fluoranthene							1	1	1	1	61	2
44. methylene chloride	3	2600	145	10	75	22	1	58	17	10	67	16
45. methyl chloride							20	20	20		64	1
48. dichlorobromomethane	7	7	7		70	1	2	10	6	6	64	2
49. trichlorofluoromethane	27	45	36	36	76	2	2	2138	328	10	67	7
51. chlorodibromomethane							1	1	1		62	1
54. isophorone	111	111	111		66	1						
55. naphthalene	1	2079	222	27	76	44	1	255	25	3	94	15
57. 2-nitrophenol	60	60	60		68	1	4	4	4		63	1
58. 4-nitrophenol	65	240	138	110	68	3						
62. N-nitrosodiphenylamine	11	130	69	72	71	5						
63. N-nitrosodi-n-propylamine							2	19	8	3	94	3

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-8 (Cont.)

Concentration Observed, ug/l

	Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
64.	pentachlorophenol	1	310	56	31	76	20	1	66	21	14	94	10
65.	phenol (GC/MS)	1	4930	165	20	77	57	1	103	16	10	95	24
66.	bis(2-ethylhexyl) phthalate	1	1449	149	32	76	57	1	760	56	19	94	75
67.	butyl benzyl phthalate	1	160	52	38	71	6	1	5	2	2	66	5
68.	di-n-butyl phthalate	1	67	17	12	71	20	1	58	7	4	66	18
69.	di-n-octyl phthalate	1	10	6	6	66	2	1	1	1		61	1
70.	diethyl phthalate	1	150	22	7	71	20	1	12	4	2	66	14
71.	dimethyl phthalate	3	111	26	13	71	7	1	1	1	1	66	4
72.	benzo(a)anthracene							2	2	2		61	1
73.	benzo(a)pyrene							1	1	1		61	1
74.	3,4-benzofluoranthene							1	1	1		63	1
77.	acenaphthylene	4400	4400	4400		68	1						
78.	anthracene	1	12	4	1	71	4	1	4	1	1	66	9
80.	fluorene	1	15	7	5	68	3						
81.	phenanthrene	1	12	7	7	68	2	1	1	1		63	1
83.	indeno (1,2,3-cd) pyrene	2	2	2		66	1						
84.	pyrene	1	1	1		71	1	1	1	1	1	65	7
85.	tetrachloroethylene	1	1126	178	11	78	24	1	370	59	10	96	19
86.	toluene	1	3200	199	12	78	54	1	140	13	4	96	51
87.	trichloroethylene	1	5600	303	16	78	24	1	130	33	15	94	16

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

<u>Note</u>: Concentrations shown represent detected values only.

TABLE V-8 (Cont.)

Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#
	Concentration Observed, ug/l											
88. vinyl chloride	11	11	11		70	1						
90. dieldrin	2	5	4	5	50	3	1	5	3	3	50	2
94. 4,4'-DDD	5	5	5		50	1						
95. alpha-endosulfan	1	1	1		50	1						
96. beta-endosulfan	5	5	5		50	1						
100. heptachlor	5	6	5	5	50	3	2	2	2		50	1
101. heptachlor epoxide	1	1	1		50	1						
102. alpha-BHC	2	5	4	5	50	5	1	1	1		50	1
103. beta-BHC	1	1	1	1	50	2	1	1	1		50	1
104. gamma-BHC	5	5	5	5	50	3	1	5	3	3	50	2
105. delta-BHC	3	5	4	4	50	2						
106. PCB-1242	1	1	1		50	1						
114. antimony (total)	1	515	41	10	65	47	1	867	172	32	83	65
115. arsenic (total)	1	225	41	11	70	35	1	160	24	6	64	33
116. asbestos (MFL)	1	197	31	5	15	7	1	391	139	24	11	3
117. beryllium (total)	2	3	3	3	58	3	1	1	1		78	1
118. cadmium (total)	1	46	7	5	76	25	1	130	8	4	96	31
119. chromium (total)	1	4930	334	27	76	61	1	1800	97	35	96	65
120. copper (total)	3	3120	292	49	76	69	2	323	54	30	96	82
121. cyanide	4	242	37	10	65	24	3	980	83	18	91	34

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-8 (Cont.)

Toxic Pollutant	Concentration Observed, ug/l — Untreated Wastewater: Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent: Min.	Max.	Avg.	Med.	Analyzed*	Detected#
122. lead (total)	6	752	105	55	76	38	1	3500	133	44	96	42
123. mercury (total)	1	4	1	1	64	12	1	2	1	1	57	7
124. nickel (total)	6	304	84	73	75	44	4	2000	119	80	94	54
125. selenium (total)	1	736	58	8	60	19	1	97	24	10	57	10
126. silver (total)	1	130	31	19	75	33	1	500	42	22	94	44
127. thallium (total)	1	9	4	2	64	3	8	18	13	13	57	2
128. zinc (total)	14	7900	664	224	75	73	25	38400	996	185	94	90

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Notes: Concentrations shown represent detected values only. Toxic pollutants not listed were not detected in the untreated wastewater or biologically treated effluent.

Source: EPA Field Sampling Program.

through V-9n for individual subcategories. On an industry-wide basis, 68 of 129 toxic pollutants were detected. Fifty-three were organic pollutants, 13 were metals, 1 was asbestos and 1 was cyanide. Eighteen of the pollutants were detected only once. The maximum concentrations of any organic or metal pollutant were ethylbenzene at 3,018 ug/l and zinc at 38,400 ug/l.

On an individual subcategory basis, the greatest variety of organic pollutants detected in the effluent at greater than 10 ug/l was in the woven fabric finishing subcategory where desizing operations are employed, with 15 pollutants detected (Table V-9g). The greatest variety of metals detected at greater than 10 ug/l was in the wool scouring (Table V-9a) and wool finishing (Table V-9b) subcategories and in the knit fabric finishing subcategory where simple operations are employed, each with nine pollutants detected (Table V-9h).

The smallest variety of organics detected was one pollutant in the general processing subdivision of the low water use processing subcategory (Table V-9c) and two pollutants in the felted fabric processing subcategory (Table V-9n). The smallest variety of metals detected was three pollutants in the felted fabric processing subcategory (Table V-9n), and four pollutants at mills where hosiery products are manufactured, (Table V-9j). The data indicates that many of the toxic organic pollutants are reduced or removed through biological treatment, while many of the metals are not affected.

<u>Field Sampling Results - Individual Subcategories</u>

<u>Wool Scouring</u> Three mills in this subcategory were sampled for toxic pollutants and the results are shown in Table V-9a. Thirteen organics, eight metals and cyanide were detected in the untreated wastewater at greater than 10 ug/l, with 4,930 ug/l phenol (GC/MS) the maximum organic concentration and 1, 969 ug/l zinc the maximum metal concentration. These results seem to reflect the presence of phenol in the raw grease wool resulting from the treatment of the wool with branding compounds and insecticides. The metals may be present in mineral impurities in the wool.

Five organics, nine metals and cyanide were detected in the treated effluent at greater than 10 ug/l, with 87 ug/l trichloroethylene the maximum organic concentration and 3,500 ug/l lead the maximum metal concentration.

<u>Wool Finishing</u> Two mills in this subcategory plus the wool finishing waste stream from an integrated wool scouring and wool finishing mill were sampled for toxic pollutants and the results of the sampling are shown in Table V-9b. Seventeen organics and ten metals were detected in the untreated wastewater at greater than 10 ug/l, with 14,000 ug/l 1,2,4-trichlorobenzene the maximum organic concentration and 7,500 ug/l zinc the maximum metal

TABLE V-9a
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - WOOL SCOURING SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
4. benzene	10	19	13	10	6	3	10	10	10		8	1
7. chlorobenzene	10	20	16	18	6	3						
8. 1,2,4-trichlorobenzene							32	32	32		7	1
9. hexachlorobenzene	1	1	1		5	1						
11. 1,1,1-trichloroethane	7	52	19	10	6	5	10	10	10	10	8	2
13. 1,1-dichloroethane	12	14	13	13	6	2						
23. chloroform	10	10	10	10	6	3	10	18	14	14	8	2
29. 1,1-dichloroethylene							10	10	10		8	1
38. ethylbenzene	1	23	12	12	6	2						
39. fluoranthene							1	1	1		7	1
44. methylene chloride	10	10	10	10	6	3	10	10	10	10	8	3
48. dichlorobromomethane							10	10	10		8	1
54. isophorone	111	111	111		5	1						
64. pentachlorophenol	24	24	24		5	1						
65. phenol (GC/MS)	10	4930	1222	211	6	6	8	16	11	10	8	4
66. bis(2-ethylhexyl) phthalate	18	330	123	20	5	3	10	42	20	15	7	4
68. di-n-butyl phthalate	10	67	39	39	5	2	10	10	10	10	7	2
69. di-n-octyl phthalate	10	10	10		5	1						
70. diethyl phthalate	86	86	86		5	1						
72. benzo(a)anthracene							2	2	2		7	1

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9a (Cont.)

Toxic Pollutant	Concentration Observed, ug/l: Untreated Wastewater: Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#	Biologically Treated Effluent: Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#
73. benzo(a)pyrene							1	1	1		7	1
74. 3,4-benzofluoranthene							1	1	1		7	1
78. anthracene							2	2	2		7	1
84. pyrene							1	1	1		7	1
85. tetrachloroethylene	10	10	10		6	1	10	10	10	10	8	3
86. toluene	10	62	31	27	6	4	1	10	7	10	8	5
87. trichloroethylene	13	13	13		6	1	87	87	87		8	1
90. dieldrin	2	5	4	5	5	3	1	5	3	3	6	2
94. 4,4'-DDD (p,p'-TDE)	5	5	5		5	1						
95. alpha-endosulfan	1	1	1		5	1						
96. beta-endosulfan	5	5	5		5	1						
101. heptachlor epoxide	1	1	1		5	1						
102. alpha-BHC	5	5	5	5	5	2	1	1	1		6	1
103. beta-BHC	1	1	1		5	1						
104. gamma-BHC	5	5	5		5	1	5	5	5		6	1
105. delta-BHC	3	5	4	4	5	2						
106. PCB-1242 (Arochlor 1242)	1	1	1		5	1						
114. antimony	2	4	3	4	5	3	21	540	153	26	6	4
115. arsenic	162	225	193	192	4	3	4	160	37	6	6	6
117. beryllium	2	3	3	3	5	3						

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9a (Cont.)

Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#
	Concentration Observed, ug/l											
118. cadmium	9	13	11	11	5	4	3	130	26	5	7	6
119. chromium	12	269	199	240	5	5	3	80	42	48	7	6
120. copper	23	430	131	66	5	5	2	320	75	16	7	5
121. cyanide	10	39	21	15	3	3	20	980	313	200	5	5
122. lead	18	752	435	477	5	5	57	3500	929	79	7	4
123. mercury	1	1	1		5	1	1	1	1		5	1
124. nickel	54	304	134	99	5	5	28	2000	452	60	7	5
125. selenium	6	8	7	7	4	2	2	4	3	3	4	2
126. silver	1	65	17	2	5	4	1	500	130	49	7	5
127. thallium	1	1	1		5	1						
128. zinc	190	1969	832	665	5	5	25	1500	299	72	7	7

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

<u>Note</u>: Concentrations shown represent detected values only.

<u>Source</u>: Compilation of field sampling data for plants 10006, 10013, and 10015.

TABLE V-9b
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - WOOL FINISHING SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
4. benzene	5	10	8	8	8	4	4	5	5	5	8	2
7. chlorobenzene	8	10	9	10	8	4	2	2	2		6	1
8. 1,2,4-trichlorobenzene	90	14000	4195	960	8	7	46	1900	1257	1541	8	4
11. 1,1,1-trichloroethane	9	80	26	10	8	5	1	1	1		6	1
22. parachlorometa cresol							4	5	5	5	8	2
23. chloroform	10	11	10	10	8	5	2	3	3	3	8	2
25. 1,2-dichlorobenzene	10	460	160	11	8	7	1	20	7	6	8	7
26. 1,3-dichlorobenzene	10	1700	705	555	8	4	13	33	23	23	6	2
27. 1,4-dichlorobenzene	10	760	299	215	8	5	1	16	7	5	6	4
29. 1,1-dichloroethylene	10	10	10		8	1						
30. 1,2-trans-dichloroethylene	10	10	10	10	6	3						
34. 2,4-dimethylphenol							8	8	8		5	1
38. ethylbenzene	6	1770	267	10	8	7	1	75	21	4	7	4
39. fluoranthene							1	1	1		4	1
44. methylene chloride	4	10	8	10	8	5	6	46	21	12	6	3
49. trichlorofluoromethane							3	3	3		6	1
55. naphthalene	1	35	17	17	8	7	1	1	1	1	8	2
62. N-nitrosodiphenylamine	110	130	120	120	8	2						
64. pentachlorophenol	29	71	50	50	8	2	1	2	2	2	8	2
65. phenol (GC/MS)	1	47	18	11	8	7						
66. bis(2-ethylhexyl)phthalate	1	160	51	10	8	5	6	760	204	56	8	8
68. di-n-butyl phthalate	10	10	10		8	1	1	1	1		6	1
70. diethyl phthalate	1	10	7	10	8	5	1	9	5	5	6	2
71. dimethyl phthalate	3	3	3		8	1	1	1	1		6	1
78. anthracene	12	12	12		8	1	1	1	1	1	6	2

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9b (Cont.)

Toxic Pollutant	Untreated Wastewater Min.	Untreated Wastewater Max.	Untreated Wastewater Avg.	Untreated Wastewater Med.	Untreated Wastewater Analyzed*	Untreated Wastewater Detected#	Biologically Treated Effluent Min.	Biologically Treated Effluent Max.	Biologically Treated Effluent Avg.	Biologically Treated Effluent Med.	Biologically Treated Effluent Analyzed*	Biologically Treated Effluent Detected#
	Concentration Observed, ug/l											
81. phenanthrene	12	12	12		8	1	1	1	1		6	1
84. pyrene							1	1	1		6	1
85. tetrachloroethylene	2	1126	193	10	8	6	1	5	3	3	8	2
86. toluene	6	44	15	10	8	6	1	31	11	7	8	6
87. trichloroethylene	2	187	39	10	8	6	2	4	3	3	8	2
100. heptachlor	5	6	5	5	5	3	2	2	2		4	1
102. alpha-BHC	2	5	4	5	5	3						
104. gamma-BHC (lindane)	5	5	5	5	5	2						
114. antimony	1	43	28	34	7	6	2	32	22	23	8	7
115. arsenic	2	200	37	5	8	6	2	60	17	3	6	4
116. asbestos (MFL)	3	3	3		1	1	24	24	24		1	1
118. cadmium	4	46	13	5	8	5	6	6	6		8	1
119. chromium	63	880	310	175	8	8	116	1800	363	164	8	8
120. copper	3	70	28	21	8	8	8	30	20	23	8	7
121. cyanide	5	5	5		5	1	15	15	15		8	1
122. lead	84	133	109	109	8	2	30	200	115	115	8	2
123. mercury	1	4	2	1	7	4						
124. nickel	9	100	50	41	8	3	30	140	72	58	8	4
125. selenium	4	18	9	5	7	3	2	15	9	9	8	2
126. silver	1	47	24	24	8	2	6	140	73	73	8	2
128. zinc	51	7500	1307	385	8	8	320	38400	6833	1073	8	8

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 20011, 20021, and 10013 (Finishing Waste).

TABLE V-9c
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - LOW WATER USE PROCESSING (GENERAL PROCESSING) SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
23. chloroform	48	48	48		1	1	10	10	10		1	1
65. phenol (GC/MS)	23	23	23		1	1						
66. bis (2-ethylhexyl) phthalate	26	26	26		1	1	3	3	3		1	1
68. di-n-butyl phthalate	61	61	61		1	1						
86. toluene							3	3	3		1	1
87. trichloroethylene	42	42	42		1	1						
116. asbestos (MFL)	1	1	1	1	2	2						
118. cadmium	4	4	4		1	1	5	5	5		1	1
119. chromium	11	11	11		1	1	12	12	12		1	1
120. copper	39	39	39		1	1	37	37	37		1	1
122. lead	43	43	43		1	1	84	84	84		1	1
124. nickel	110	110	110		1	1	120	120	120		1	1
126. silver	46	46	46		1	1	50	50	50		1	1
128. zinc	120	120	120		1	1	2300	2300	2300		1	1

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 04935 (sequence number) and 40023 (Weave Mill Waste).

TABLE V-9d
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - LOW WATER USE PROCESSING (WATER-JET WEAVING) SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
65. phenol (GC/MS)	1	1	1		1	1						
66. bis(2-ethylhexyl) phthalate	10	10	10		1	1						
114. antimony	38	38	38		1	1			Not Sampled			
119. chromium	4	4	4		1	1						
120. copper	10	10	10		1	1						
121. cyanide	10	10	10		1	1						
122. lead	22	22	22		1	1						
125. selenium	50	50	50		1	1						
126. silver	14	14	14		1	1						
128. zinc	63	63	63		1	1						

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plant 01304 (sequence number).

TABLE V-9e
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - WOVEN FABRIC FINISHING (SIMPLE PROCESSING) SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
1. acenaphthene	9	9	9		3	1						
4. benzene	32	32	32		3	1						
8. 1,2,4-trichlorobenzene	28	28	28		3	1						
9. hexachlorobenzene	2	2	2		3	1						
10. 1,2-dichloroethane	6	6	6		3	1						
11. 1,1,1-trichloroethane	17	17	17		3	1						
23. chloroform	11	11	11		3	1						
25. 1,2-dichlorobenzene							1	1	1		6	1
38. ethylbenzene	5	460	233	233	3	2						
44. methylene chloride	47	47	47		3	1	24	24	24		4	1
55. naphthalene	87	410	249	249	3	2						
64. pentachlorophenol	32	42	37	37	3	2	15	66	41	41	6	2
65. phenol (GC/MS)	40	147	94	94	3	2	12	24	18	18	6	2
66. bis(2-ethylhexyl) phthalate	5	860	382	280	3	3	10	10	10	10	6	2
68. di-n-butyl phthalate	13	13	13	13	3	2	6	6	6		4	1
71. dimethyl phthalate	13	13	13		3	1						
78. anthracene							1	1	1		4	1
86. toluene	8	620	216	20	3	3	1	140	48	2	6	3
87. trichloroethylene							1	76	39	39	6	2
114. antimony							4	28	18	21	4	3

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9e (Cont.)

Toxic Pollutant	Concentration Observed, ug/l: Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
115. arsenic							4	4	4		2	1
118. cadmium	5	5	5		3	1						
119. chromium	4	12	8	8	3	2	3	6	4	4	6	4
120. copper	230	329	292	317	3	3	48	170	87	82	6	6
121. cyanide	6	6	6		2	1	3	23	14	18	6	5
122. lead	13	15	14	14	3	2	25	38	32	32	6	2
123. mercury	1	1	1		2	1	1	1	1		4	1
124. nickel	54	54	54		2	1	11	54	37	46	6	3
126. silver	6	6	6		2	1	7	12	10	10	6	2
127. thallium	9	9	9		2	1	8	18	13	13	4	2
128. zinc	48	460	254	254	2	2	195	340	248	229	6	4

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent statistics of detected values only.

Source: Compilation of field sampling data for plants 40023 and 40144.

TABLE V-9f
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - WOVEN FABRIC FINISHING (COMPLEX PROCESSING) SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
4. benzene	31	31	31		3	1	6	64	28	13	6	3
7. chlorobenzene	42	296	169	169	3	2	2	26	11	4	6	3
21. 2,4,6-trichlorophenol	20	20	20		3	1	21	21	21		6	1
22. p-chloro-m-cresol							32	32	32		6	1
23. chloroform	33	33	33		3	1	18	18	18		6	1
24. 2-chlorophenol	131	131	131		3	1	10	10	10		4	1
25. 1,2-dichlorobenzene							1	1	1		6	1
29. 1,1-dichloroethylene							4	4	4		4	1
38. ethylbenzene	18	2835	960	26	3	3	1	29	11	7	6	4
45. methyl chloride							20	20	20		4	1
55. naphthalene							1	5	3	3	6	2
62. N-nitrosodiphenylamine	11	11	11		3	1						
64. pentachlorophenol	20	20	20		3	1	56	56	56		6	1
65. phenol (GC/MS)							1	103	38	10	6	6
66. bis(2-ethylhexyl) phthalate	9	138	90	123	3	3	1	24	15	18	6	6
67. butyl benzyl phthalate							5	5	5		4	1
68. di-n-butyl phthalate	7	7	7		3	1	4	4	4		4	1
70. diethyl phthalate	3	3	3		3	1	2	2	2		4	1
71. dimethyl phthalate	12	12	12		3	1						
84. pyrene	1	1	1		3	1	1	1	1		4	1

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9f (Cont.)

Toxic Pollutant	Concentration Observed, ug/l — Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
85. tetrachloroethylene	6	15	11	11	3	2	3	3	3		6	1
86. toluene	28	303	204	281	3	3	1	33	15	13	6	4
87. trichloroethylene	52	52	52		3	1	1	1	1		6	1
103. beta-BHC							1	1	1		3	1
114. antimony							50	54	52	53	5	3
115. arsenic	120	120	120		3	1	3	3	3		4	1
116. asbestos (MFL)	197	197	197		1	1	391	391	391		1	1
118. cadmium	2	2	2		3	1	2	4	3	3	6	2
119. chromium	16	67	42	42	3	2	13	140	92	102	6	5
120. copper	86	510	239	120	3	3	37	290	120	111	6	6
121. cyanide							6	11	9	10	6	3
122. lead	25	49	37	37	3	2	22	44	33	33	6	2
123. mercury	1	1	1		2	1						
124. nickel	50	77	64	64	3	2	4	110	75	86	6	5
125. selenium							2	2	2		3	1
126. silver	22	22	22		3	1	23	44	29	25	6	4
128. zinc	240	1080	537	290	3	3	80	390	188	167	6	6

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 40077, 40135, and 40160.

TABLE V-9g
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - WOVEN FABRIC FINISHING (DESIZING) SUBCATEGORY

Toxic Pollutant	Concentration Observed, ug/l — Untreated Wastewater Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#
1. acenaphthene	2	27	15	15	21	2	1	1	1		21	1
4. benzene	1	170	49	30	28	6	1	33	17	17	23	2
7. chlorobenzene	1	1	1	1	23	2	4	4	4		21	1
8. 1,2,4-trichlorobenzene	45	156	101	101	26	2	2	10	6	6	23	2
10. 1,2-dichloroethane	4	4	4		20	1						
11. 1,1,1-trichloroethane	16	306	79	24	23	5	4	4	4		21	1
13. 1,1-dichloroethane	4	4	4		20	1						
21. 2,4,6-trichlorophenol	1	94	44	37	26	3						
22. parachlorometa cresol	5	9	7	7	26	2	1	1	1		23	1
23. chloroform	3	32	18	20	28	9	2	58	21	12	23	4
25. 1,2-dichlorobenzene	1	62	17	2	26	4	1	1	1	1	23	2
27. 1,4-dichlorobenzene	2	2	2		21	1	1	9	5	5	21	2
29. 1,1-dichloroethylene	39	84	62	62	22	2	44	44	44		18	1
30. 1,2-trans-dichloroethylene	2	360	181	181	20	2						
31. 2,4-dichlorophenol	41	41	41		21	1						
32. 1,2-dichloropropane	36	100	68	68	20	2						
33. 1,3-dichloropropylene							1	1	1		18	1
38. ethylbenzene	1	19000	1692	112	28	19	1	3018	440	2	23	7
44. methylene chloride	3	120	53	42	25	8	5	58	22	7	21	5
48. dichlorobromomethane							2	2	2		18	1

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9g (Cont.)

Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
	Concentration Observed, ug/l											
49. trichlorofluoromethane	27	27	27		26	1	89	2138	1114	1114	21	2
51. chlorodibromomethane							1	1	1		18	1
55. naphthalene	1	2079	468	80	26	17	1	22	12	12	23	2
57. 2-nitrophenol	60	60	60		18	1						
58. 4-nitrophenol	65	110	88	88	18	2						
62. N-nitrosodiphenylamine	72	72	72		21	1						
64. pentachlorophenol	2	310	75	46	26	12	7	16	10	7	23	3
65. phenol (GC/MS)	1	295	58	26	26	21	1	31	15	12	23	6
66. bis(2-ethylhexyl) phthalate	5	1449	210	63	26	22	2	231	44	14	23	16
67. butyl benzyl phthalate	1	66	24	4	21	3	1	2	2	2	21	3
68. di-n-butyl phthalate	1	28	13	14	21	9	1	58	10	4	21	8
69. di-n-octyl phthalate	1	1	1		18	1	1	1	1		18	1
70. diethyl phthalate	1	69	15	6	21	7	1	3	2	2	21	6
71. dimethyl phthalate							1	1	1	1	21	2
78. anthracene	1	1	1	1	21	2	1	4	2	1	21	3
84. pyrene							1	1	1	1	21	2
85. tetrachloroethylene	1	26	15	16	28	4	1	51	14	3	23	4
86. toluene	2	3200	490	34	28	18	1	111	16	7	23	14
87. trichloroethylene	1	5600	812	18	28	7	1	130	42	5	23	5
104. gamma-BHC (lindane)							1	1	1		16	1

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9g (Cont.)

Toxic Pollutant	Concentration Observed, ug/l — Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
114. antimony	1	180	17	7	25	23	1	96	21	12	19	17
115. arsenic	1	77	22	15	24	16	1	71	31	23	21	13
118. cadmium	3	6	5	5	26	4	1	6	2	2	23	6
119. chromium	4	4930	787	35	26	19						
120. copper	8	3120	656	98	26	24	5	100	32	29	23	21
121. cyanide	4	242	71	8	22	7	5	212	75	27	20	10
122. lead	8	120	57	55	26	12	11	120	50	43	23	8
123. mercury	1	1	1	1	22	2	1	1	1		18	1
124. nickel	6	280	70	40	26	17	40	140	79	81	23	10
125. selenium	1	80	17	1	20	5	1	1	1		16	1
126. silver	6	130	33	17	26	10	11	80	28	16	23	7
127. thallium	2	2	2		22	1						
128. zinc	56	7900	999	274	26	24	27	5100	502	210	23	23

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 04742 (sequence number), 40034, 40059, 40072, 40081, 40097, 40099, 40103, 40120, 40145, 40146, 40150, and 40156.

TABLE V-9h
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - KNIT FABRIC FINISHING (SIMPLE PROCESSING) SUBCATEGORY

Concentration Observed, ug/l

	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
1. acenaphthene	12	53	33	33	6	2						
2. acrolein	199	199	199		6	1	87	87	87		7	1
3. acrylonitrile	90	90	90		6	1						
4. benzene	20	20	20		6	1						
8. 1,2,4-trichlorobenzene	120	2700	1045	315	6	3	6	6	6		8	1
11. 1,1,1-trichloroethane	8	1200	406	11	6	3	69	130	100	100	6	2
13. 1,1-dichloroethane	1	6	4	4	6	2	2	2	2		6	1
23. chloroform	22	498	260	260	6	2	2	2	2	2	8	2
25. 1,2-dichlorobenzene	1	35	18	18	6	2						
27. 1,4-dichlorobenzene	7	7	7		6	1						
29. 1,1-dichloroethylene	29	29	29		6	1	1	1	1		6	1
32. 1,2-dichloropropane	2	2	2		6	1						
33. 1,3-dichloropropylene	2	2	2		6	1	10	10	10		6	1
34. 2,4-dimethylphenol							9	9	9		6	1
38. ethylbenzene	2	2600	711	369	6	5	3	4	4	4	8	2
44. methylene chloride	30	2600	1315	1315	6	2	28	28	28		6	1
49. trichlorofluoromethane	45	45	45		6	1	2	2	2		6	1
55. naphthalene	1	51	32	45	6	3						
57. 2-nitrophenol							4	4	4		6	1
64. pentachlorophenol	2	2	2		6	1						

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represents detected values only.

TABLE V-9h (Cont.)

Toxic Pollutant	Concentration Observed, ug/l — Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
65. phenol (GC/MS)	1	55	17	8	6	5						
66. bis(2-ethylhexyl) phthalate	1	430	157	41	6	3	5	50	20	17	8	6
70. diethyl phthalate	34	34	34		6	1						
71. dimethyl phthalate							1	1	1		6	1
80. fluorene	15	15	15		6	1						
85. tetrachloroethylene	9	1108	438	317	6	4	8	27	17	17	8	3
86. toluene	4	140	45	12	6	5	1	1	1	1	8	2
87. trichloroethylene	5	840	322	121	6	3	37	41	39	39	8	2
114. antimony	1	186	59	13	5	5	1	684	230	83	7	7
115. arsenic	1	100	35	4	6	3	3	70	27	7	6	3
118. cadmium	4	10	6	5	6	4	2	10	5	4	9	3
119. chromium	6	210	53	14	6	5	4	150	63	32	9	6
120. copper	17	590	156	64	6	6	7	130	65	70	9	9
121. cyanide	8	10	9	8	6	3	6	17	11	9	9	3
122. lead	32	99	61	60	6	5	1	48	36	42	9	6
123. mercury							1	1	1		6	1
124. nickel	36	130	89	100	6	5	54	150	79	64	9	5
125. selenium	3	15	9	9	5	2	20	62	41	41	5	2
126. silver	12	100	41	19	6	5	13	80	33	17	9	6
128. zinc	34	343	163	144	6	6	47	570	154	68	9	9

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

<u>Note</u>: Concentrations shown represents detected values only.

<u>Source</u>: Compilation of field sampling data for plants 50030, 50104, 50108, 50112, and 50116.

TABLE V-9i

SUMMARY OF ANALYTICAL RESULTS

TOXIC POLLUTANT SAMPLING PROGRAM - KNIT FABRIC FINISHING (COMPLEX PROCESSING) SUBCATEGORY

Concentration Observed, ug/l

Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
1. acenaphthene							2	2	2		5	1
4. benzene	1	1	1		3	1	1	15	6	5	22	5
7. chlorobenzene	14	25	20	20	3	2						
8. 1,2,4-trichlorobenzene	190	190	190		3	1	1	916	237	15	21	4
11. 1,1,1-trichloroethane	3	3	3		3	1						
15. 1,1,2,2-tetrachloroethane	21	21	21		3	1	5	5	5		5	1
23. chloroform	17	71	44	44	3	2	3	1020	221	44	21	6
25. 1,2-dichlorobenzene							1	1	1	1	21	4
30. 1,2-trans-dichloro-ethylene	5	5	5		3	1	7	7	7		5	1
34. 2,4-dimethylphenol	2	2	2		3	1	1	1	1		5	1
38. ethylbenzene	852	1209	1031	1031	3	2	1	278	78	2	22	5
44. methylene chloride	8	8	8		3	1	1	6	4	4	5	2
55. naphthalene	2	210	118	143	3	3	2	255	87	3	21	3
63. N-nitrosodi-n-propylamine							3	19	11	11	21	2
65. phenol (GC/MS)	2	7	5	5	3	2	1	1	1	1	21	3
66. bis(2-ethylhexyl) phthalate	30	135	83	83	3	2	6	109	34	27	21	18
67. butyl benzyl phthalate	160	160	160		3	1						
68. di-n-butyl phthalate	3	10	7	7	3	2	2	4	3	3	5	3
70. diethyl phthalate	2	150	76	76	3	2	1	1	1		5	1
71. dimethyl phthalate	12	12	12		3	1						

* Values represent the number of samples analyzed.

Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9i (Cont.)

Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
	Concentration Observed, ug/l											
77. acenaphthylene	4400	4400	4400		3	1						
78. anthracene							1	1	1		5	1
85. tetrachloroethylene	39	890	465	465	3	2	1	370	194	270	22	5
86. toluene	3	61	33	36	3	3	1	22	6	3	22	11
87. trichloroethylene	3	3	3		3	1	3	47	25	24	22	3
103. beta-BHC	1	1	1		1	1						
114. antimony	57	515	286	286	3	2	31	867	452	478	22	17
115. arsenic	4	5	5	5	3	2	2	2	2		5	1
118. cadmium							2	6	4	4	22	9
119. chromium	1	4	3	3	3	3	4	98	28	9	22	9
120. copper	40	44	42	42	3	2	7	323	42	22	22	17
121. cyanide	7	190	70	12	3	3	3	140	72	72	22	2
122. lead	13	62	38	38	3	2	11	82	42	45	22	13
123. mercury							1	2	2	2	5	2
124. nickel	100	126	113	113	3	2	40	187	107	104	22	17
126. silver	11	30	21	21	3	2	8	73	26	21	22	14
128. zinc	75	200	132	120	3	3	42	5160	614	115	22	20

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 50013, 50035, and 50099.

TABLE V-9j
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - KNIT FABRIC FINISHING (HOSIERY PRODUCTS) SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
3. acrylonitrile	1600	1600	1600		4	1	400	400	400		1	1
4. benzene	1	3	2	2	4	2						
21. 2,4,6-trichlorophenol	27	27	27		4	1						
23. chloroform	140	642	391	391	4	2						
55. naphthalene	7	9	8	8	4	2	1	1	1		1	1
62. N-nitrosodiphenylamine	20	20	20		4	1						
65. phenol (GC/MS)	3	59	39	54	4	3	14	14	14		1	1
66. bis(2-ethylhexyl) phthalate	22	22	22		4	1	172	172	172		1	1
85. tetrachloroethylene	2	16	9	9	4	2						
86. toluene	1	3	2	2	4	3	2	2	2		1	1
114. antimony	6	10	8	8	4	2						
115. arsenic	2	2	2		4	1						
116. asbestos (MFL)	6	6	6		2	1						
119. chromium	8	656	226	14	4	3	199	199	199		1	1
120. copper	5	5	5		4	1	14	14	14		1	1
121. cyanide	10	10	10		4	1						
125. selenium	38	736	275	50	4	3	97	97	97		1	1
126. silver	10	10	10		4	1						
128. zinc	40	1420	611	491	4	4	112	112	112		1	1

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 5H012, 5H027, and 5H034.

TABLE V-9k
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - CARPET FINISHING SUBCATEGORY

Toxic Pollutant	Concentration Observed, ug/l — Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
1. acenaphthene	273	273	273		5	1	2	2	2		4	1
7. chlorobenzene	7	7	7		4	1						
9. hexachlorobenzene							1	1	1		4	1
11. 1,1,1-trichloroethane	2	2	2		4	1						
23. chloroform	5	280	143	143	4	2						
37. 1,2-diphenylhydrazine	22	22	22		5	1						
38. ethylbenzene	43	43	43		4	1						
48. dichlorobromomethane	7	7	7		4	1						
55. naphthalene	95	260	198	240	5	3						
65. phenol (GC/MS)	1	68	40	54	5	5	2	50	30	39	4	3
66. bis(2-ethylhexyl) phthalate	19	400	121	33	5	4	10	27	18	18	4	4
70. diethyl phthalate							11	11	11		4	1
80. fluorene	5	5	5		5	1						
86. toluene							1	1	1		4	1
114. antimony	52	52	52		2	1	11	105	58	58	2	2
118. cadmium	2	2	2		5	1	4	4	4		4	1
119. chromium	4	75	35	30	5	4	3	411	221	235	4	4
120. copper	3	63	28	16	5	5	28	46	37	37	4	2
121. cyanide	6	40	23	23	4	2	3	12	7	6	4	3
122. lead	6	33	20	20	5	2	25	25	25		4	1

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-9k (Cont.)

Toxic Pollutant	Untreated Wastewater Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Analyzed*	Detected#
	Concentration Observed, ug/l											
123. mercury	1	1	1	1	4	2						
124. nickel	28	98	63	63	5	2	13	79	46	46	2	2
126. silver	9	42	26	26	5	2	33	33	33		2	1
128. zinc	17	450	121	36	5	5	130	260	195	195	2	2

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 60008, 60031, 60034, and 60037.

TABLE V-91
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - STOCK & YARN FINISHING SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
1. acenaphthene	13	30	22	22	7	2						
4. benzene	1	1	1		7	1	1	1	1	1	8	2
7. chlorobenzene	1	2	2	2	7	2						
8. 1,2,4-trichlorobenzene	270	270	270		7	1	19	43	27	19	8	3
9. hexachlorobenzene							1	1	1	1	6	2
15. 1,1,2,2-tetrachloroethane	1	1	1		7	1						
17. bis(chloromethyl)ether	6	6	6		7	1						
21. 2,4,6-trichlorophenol	9	16	13	13	7	2	2	2	2		8	1
22. p-chloro-m-cresol	29	29	29		7	1	2	7	4	4	8	3
23. chloroform	1	410	86	3	7	5	5	5	5		8	1
24. 2-chlorophenol	10	10	10		7	1						
25. 1,2-dichlorobenzene	1	56	29	29	7	2	1	5	3	2	8	3
27. 1,4-dichlorobenzene	1	1	1		7	1						
31. 2,4-dichlorophenol	20	20	20		7	1						
32. 1,2-dichloropropane	56	56	56		7	1						
34. 2,4-dimethylphenol	2	190	96	96	7	2						
36. 2,6-dinitrotoluene	54	54	54		7	1						
38. ethylbenzene	1	6	3	2	7	5	3	3	3		8	1
44. methylene chloride	4	9	7	7	7	2	9	9	9		6	1
49. trichlorofluoromethane							3	48	20	10	6	3

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-91 (Cont.)

Toxic Pollutant	Concentration Observed, ug/l Untreated Wastewater Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#	Biologically Treated Effluent Min.	Max.	Avg.	Med.	Ana-lyzed*	De-tected#
55. naphthalene	1	41	14	6	7	5	1	13	6	6	8	4
58. 4-nitrophenol	240	240	240		7	1						
63. N-nitrosodi-n-propylamine							2	2	2		8	1
64. pentachlorophenol							13	23	18	18	8	2
65. phenol (GC/MS)	2	19	10	10	7	3	3	3	3		8	1
66. bis(2-ethylhexyl) phthalate	3	490	90	22	7	7	2	340	89	58	8	8
67. butyl benzyl phthalate							1	1	1		6	1
68. di-n-butyl phthalate	3	24	14	14	7	2	5	7	7	7	6	2
70. diethyl phthalate	3	15	8	5	7	3	3	12	7	7	6	3
71. dimethyl phthalate	14	111	48	18	7	3						
78. anthracene	1	1	1		7	1	1	1	1		6	1
80. fluorene	1	1	1		7	1						
81. phenanthrene	1	1	1		7	1						
83. indeno (1,2,3-c,d) pyrene	2	2	2		7	1						
84. pyrene							1	1	1	1	6	2
85. tetrachloroethylene	1	310	156	156	7	2	3	3	3		8	1
86. toluene	2	12	5	4	7	6	1	38	18	15	8	3
87. trichloroethylene	1	229	80	10	7	3						
114. antimony	5	200	94	86	7	4	3	177	95	141	8	5
115. arsenic	3	19	9	6	7	3	2	9	6	6	8	4

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

TABLE V-91 (Cont.)

Toxic Pollutant	Untreated Wastewater (Concentration Observed, ug/l) Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Biologically Treated Effluent (Concentration Observed, ug/l) Min.	Max.	Avg.	Med.	Analyzed*	Detected#
117. beryllium							1	1	1		6	1
118. cadmium	1	6	4	4	7	3	3	7	5	5	8	2
119. chromium	3	650	125	25	7	6	1	290	70	49	8	8
120. copper	36	300	91	49	7	7	10	132	86	110	8	7
121. cyanide	17	17	17		7	1	29	172	101	101	8	2
122. lead	36	160	86	63	7	3	35	160	77	36	8	3
123. mercury	1	1	1		6	1	1	1	1		5	1
124. nickel	12	200	103	100	7	4	35	160	98	98	8	2
125. selenium	3	32	18	18	6	2						
126. silver	51	68	60	60	7	2	6	57	32	32	8	2
128. zinc	130	1000	418	300	7	7	91	865	337	233	8	8

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plants 06443 (sequence number), 70009, 70072, 70081, 70087, 70096, and 70120.

TABLE V-9m
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - NONWOVEN MANUFACTURING SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
4. benzene	5	200	103	103	3	2						
23. chloroform	160	160	160		3	1						
38. ethylbenzene	42	42	42		3	1						
55. naphthalene	29	44	37	37	3	2						
64. pentachlorophenol	1	1	1		3	1						
65a. phenol (4-AAP)	8	44	28	33	3	3						
66. bis(2-ethylhexyl) phthalate	14	14	14		3	1						
67. butyl benzyl phthalate	10	73	42	42	3	2		Not Sampled				
86. toluene	3	83	43	43	3	2						
116. asbestos (MFL)	8	8	8		2	1						
118. cadmium	5	5	5		3	1						
119. chromium	4	10	7	7	3	2						
120. copper	11	41	26	26	3	2						
121. cyanide	4	4	4		3	1						
122. lead	78	78	78		3	1						
124. nickel	37	120	79	79	3	2						
126. silver	48	48	48		3	1						
128. zinc	14	116	68	73	3	3						

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

<u>Note</u>: Concentrations shown represent detected values only.

<u>Source</u>: Compilation of field sampling data for plants 80008, 80011, and 80019.

TABLE V-9n
SUMMARY OF ANALYTICAL RESULTS
TOXIC POLLUTANT SAMPLING PROGRAM - FELTED FABRIC PROCESSING SUBCATEGORY

	Concentration Observed, ug/l											
	Untreated Wastewater						Biologically Treated Effluent					
Toxic Pollutant	Min.	Max.	Avg.	Med.	Analyzed*	Detected#	Min.	Max.	Avg.	Med.	Analyzed*	Detected#
55. naphthalene							56	56	56		1	1
65. phenol (GC/MS)	85	85	85		1	1	2	2	2		1	1
66. bis(2-ethylhexyl) phthalate	26	26	26		1	1	18	18	18		1	1
85. tetrachloroethylene	5	5	5		1	1						
86. toluene	2	2	2		1	1						
87. trichloroethylene	32	32	32		1	1						
88. vinyl chloride	11	11	11		1	1						
116. asbestos (MFL)	5	5	5		1	1	1	1	1		1	1
119. chromium							35	35	35		1	1
120. copper	12	12	12		1	1						
125. selenium	57	57	57		1	1	32	32	32		1	1
128. zinc	31	31	31		1	1	45	45	45		1	1

* Values represent the number of samples analyzed.
# Values represent the number of times pollutant was detected.

Note: Concentrations shown represent detected values only.

Source: Compilation of field sampling data for plant 80025.

concentration. The results seem to reflect the use of metallic catalysts in fulling and the presence of a variety of organics in the wool stock and processing agents.

Eight organics, nine metals, asbestos and cyanide were detected in the treated effluent at greater than 10 ug/l, with 1,900 ug/l 1,2,4-trichlorobenzene the maximum organic concentration and 38,400 ug/l zinc the maximum metal concentration. The high zinc concentration does not appear to be representative of normal treatment in the wool finishing subcategory because no other treated effluent sample exceeded 6,402 ug/l. In fact, the maximum zinc concentration in the untreated wastewaters of this subcategory was only 7,500 ug/l, as noted above.

Low Water Use Processing Two mills in this subcategory were sampled, one each in the general processing and water jet weaving subdivisions. Five organics and eight metals were detected above 10 ug/l in untreated wastewater.

Low Water Use Processing (General Processing) - One mill in this subdivision was sampled for toxic pollutants and the results are shown in Table V-9c. Five organic and six metals were detected in the untreated wastewater, with 61 ug/l di-n-butylphthalate the maximum organic concentration and 120 ug/l zinc the maximum metal concentration.

No organics and six metals were detected in the treated effluent, with 2,300 ug/l zinc the maximum metal concentration. The low concentrations of toxic pollutants detected in this subcategory reflect the fact that few chemicals are used.

Low Water Use Processing (Water Jet Weaving) - One mill in this subdivision was sampled for toxic pollutants and the results are shown in Table V-9d. Five metals detected in the untreated wastewater, with 63 ug/l zinc the maximum concentration. The mill is an indirect discharger, so no treated effluent samples were collected. As with the general processing subdivision the low concentrations of toxic pollutants detected reflect the fact that usually, few chemicals are used.

Woven Fabric Finishing Eighteen mills in this subcategory were sampled. Thirty organics, nine metals, asbestos and cyanide were detected above 10 ug/l in untreated wastewater. A summary of the analytical results, by subdivision (simple, complex and desizing), is presented below.

Woven Fabric Finishing (Simple Manufacturing Operations) - Two mills in this subdivision were sampled for toxic pollutants and the results are shown in Table V-9e. Thirteen organics and five metals were detected in the untreated wastewater, with 620 ug/l toluene the maximum organic concentration and 460 ug/l zinc the maximum metal concentration.

Five organics, seven metals and cyanide were detected in the treated effluent, with 140 ug/l toluene the maximum organic concentration and 340 ug/l zinc the maximum metal concentration.

Woven Fabric Finishing (Complex Manufacturing Operations) - Three mills in this subdivision were sampled for toxic pollutants and the results are shown in Table V-9f. Thirteen organics, seven metals and asbestos were detected in the untreated wastewater, with 2,835 ug/l ethylbenzene the maximum organic concentration and 1,080 ug/l zinc the maximum metal concentration.

Eleven organics, seven metals, asbestos and cyanide were detected in the treated effluent, with 103 ug/l phenol the maximum organic concentration and 390 ug/l zinc the maximum metal concentration. Asbestos was detected in the untreated wastewater at 197 MFL (million fibers per liter) and in the treated effluent at 391 MFL; however, the results are based on data from a single plant only.

Woven Fabric Finishing (Desizing) - Thirteen mills in this subdivision were sampled for toxic pollutants and the results are shown in Table V-9g. As stated earlier, 27 organics, 9 metals and cyanide were detected in the untreated wastewater. It should be noted that more woven fabric finishing mills where desizing is employed were sampled than any other, which may partly account for why more pollutants were detected. Ethylbenzene detected at 19,000 ug/l was the maximum organic concentration and zinc detected at 7,900 ug/l the maximum metal concentration.

Fourteen organics, eight metals and cyanide were detected in the treated effluent, with 3,018 ug/l ethylbenzene the maximum organic concentration and 5,100 ug/l zinc the maximum metal concentration.

The results for the woven fabric finishing subcategory reflect the overall trends for toxics in the industry and demonstrate the effect of increasing the complexity of processing on both the variety and the concentrations of the pollutants found.

Knit Fabric Finishing Eleven mills in this subcategory were sampled. 29 organics, 9 metals and cyanide were detected above 10 ug/l in untreated wastewaters. A summary of the analytical results, by subdivision (simple, complex and hosiery), is presented below.

Knit Fabric Finishing (Simple Manufacturing Operations) - Five mills in this subdivision were sampled for toxic pollutants and the results are shown in Table V-9h. Twenty organics and nine metals were detected in the untreated wastewater, with 2,700 ug/l 1,2,4-trichlorobenzene the maximum organic concentration and 590 ug/l copper the maximum metal concentration.

Six organics, nine metals, and cyanide were detected in the treated effluent, with 130 ug/l 1,1',1-trichloroethane the maximum organic concentration and 684 ug/l antimony the maximum metal concentration.

Knit Fabric Finishing (Complex Manufacturing Operations) - Three mills in this subdivision were sampled for toxic pollutants and the results are shown in Table V-9i. Thirteen organics, six metals and cyanide were detected in the untreated wastewater, with 4,400 ug/l acenaphthylene the maximum organic concentration and 515 ug/l antimony the maximum metal concentration.

Ten organics, seven metals and cyanide were detected in the treated effluent, with 1,020 ug/l chloroform the maximum organic concentration and 5,160 ug/l zinc the maximum metal concentration.

Knit Fabric Finishing (Hosiery Products) - Three mills in this subdivision were sampled for toxic pollutants and the results are shown in Table V-9j. Seven organics and three metals were detected in the untreated wastewater, with 1,600 ug/l acrylonitrile the maximum organic concentration and 1,420 ug/l zinc the maximum toxic metal concentration.

Three organics and four metals were detected in the treated effluent, with 400 ug/l acrylonitrile the maximum organic concentration and 199 ug/l chromium the maximum metal concentration.

The results for the knit fabric finishing subcategory are less clear then the results for the woven fabric finishing subcategory with regard to a relationship between complexity of processing and variety and concentration of pollutants found. The number of pollutants is greater where simple processing is employed but the concentrations are higher where complex processing is employed.

Carpet Finishing Four mills in this subcategory were sampled for toxic pollutants and the results are shown in Table V-9k. Seven organics, seven metals and cyanide were detected in the untreated wastewater, with 280 ug/l chloroform the maximum organic concentration and 450 ug/l zinc the maximum metal concentration.

Three organics, seven metals and cyanide were detected in the treated effluent, with the maximum organic concentration and 411 ug/l chromium the maximum metal concentration.

The variety and concentrations of toxic pollutants detected in this subcategory are reflective of the less complex processing involved, particularly the relative absence of scouring, bleaching and functional finishing.

Stock and Yarn Finishing Seven mills in this subcategory were sampled for toxic pollutants and the results are shown in Table

V-9l. Twenty organics, nine metals and cyanide were detected in the untreated wastewater, with 410 ug/l chloroform the maximum organic concentration and 1,000 ug/l zinc the maximum metal concentration.

Seven organics, seven metals and cyanide were detected in the treated effluent, with 50 ug/l phenol the maximum organic concentration and 865 ug/l zinc the maximum metal concentration.

The variety of toxic pollutants detected in this subcategory is extensive, although the concentrations are somewhat lower than those found in the woven and the knit fabric finishing subcategories.

Nonwoven Manufacturing Three mills in this subcategory were sampled for toxic pollutants and the results are shown in Table V-9m. Seven organics and five metals were detected in the untreated wastewater, with 200 ug/l benzene the maximum organic concentration and 120 ug/l nickel the maximum metal concentration. Because these mills were all indirect dischargers, treated effluent samples could not be obtained. These results reflect the less complex processing involved in this subcategory, most particularly the absence of dyeing and printing.

Felted Fabric Processing One mill in this subcategory was sampled for toxic pollutants, and the results are shown in Table V-9n. Four organics and three metals were detected in the untreated wastewater, with 85 ug/l phenol the maximum organic concentration and 57 ug/l selenium the maximum metal concentration.

Two organics and three metals were detected in the treated effluent, with 56 ug/l naphthalene the maximum organic concentration and 45 ug/l zinc the maximum metal concentration.

Other Sources of Information

Various chemical and textile industry publications were reviewed to obtain general information about the use of the 129 toxic pollutants in the textile industry. These sources are included in the bibliography. The most useful sources included the Condensed Chemical Dictionary, the Merck Index and the Color Index. Background information on the use of the toxic pollutants also was compiled for all industrial segments from groups such as the National Institute of Occupational Safety and Health and the EPA Environmental Research Laboratory. In addition, specialists within the textile industry were asked to provide information about certain toxic pollutants. In some cases, the results were opinions from chemists, engineers and others and were based on the individual's experience. In other cases, special study committees were established by trade associations to gather information about certain toxic pollutants. Except for some of the metals, the findings of these committees were qualitative because of the absence of quantitative historical information. Two committees, one from the American Textile Manufacturers Institute (ATMI) and one from the Dyes Environmental and Toxicology Organization (DETO), were particularly helpful in providing useful information.

ATMI organized a special Task Group on Priority (Toxic) Pollutants that reviewed in detail a list of 52 toxic pollutants that were neither clearly present nor clearly absent in textile mill wastewaters. This list was based on the literature and some early results of the field sampling program. Information was requested about the likelihood of each pollutant being present and, if so, information about potential sources. The Task Group classified each pollutant as "probable," "possible," or "not likely."

A pollutant was classified as "probable" if it was established as present in a product or process. A pollutant was classified as "possible" if it was known or suspected to be an intermediate or contaminant of products and processes being used. Many of the pollutants in this category could be entering the waste in an auxiliary manner such as a component of maintenance products and as agricultural contaminants in process water. A pollutant was classified as "not likely" if the task group was unable to find data to support its probable presence.

For each "probable" or "potential" pollutant, possible sources were suggested. This information is incorporated in the discussions of the sources of the individual toxic pollutants in Section VI.

The other industry-related group was the Ecology Committe of the Dyes Environmental and Toxicology Organization, Inc. (DETO). DETO comprises 18 member companies that, in aggregate, produce over 90 percent of the dyes manufactured in the United States. The committee carried out a survey of the DETO membership to determine which of the toxic pollutants in textile wastewater might originate in dyes. The list of pollutants was narrowed to 40 that the committee believed could possibly be present in commercial dye products. The committe focused on dye products for which domestic sales (1976) exceeded 90,000 kg (approximately 200,000 pounds) per year and for which there are more than two producers. The list of dyes numbered 70. Questionnaires were sent to all 18 member companies and, in addition to the 70 listed dyes, responses were received for an additional 81 dyes, for a total of 151 dye products representing 55.3 percent of the 113,380 metric tons (approximately 250 million pounds) sold in 1976. Six toxic pollutants (chromium, copper, pentachlorophenol, parachlorometacresol, phenol and zinc) were classified as "believed present in (some) commercial dyes at greater than 0.1%" and 19 additional pollutants were classified as "believed present in (some) commerical dyes at less than 0.1%." The results of the

DETO survey are presented in more detail in the discussion of the sources of the individual pollutant parameters in Section VI.

TRADITIONALLY-MONITORED POLLUTANTS

As a result of past regulatory efforts and studies certain toxic, nonconventional and conventional pollutants have traditionally been monitored in the textile industry. These pollutants include:

Conventional

Biochemical Oxygen Demand (BOD_5)
Total Suspended Solids (TSS)
Oil & Grease
pH

Nonconventional

Chemical Oxygen Demand (COD)
Total Phenols
Sulfide
Color

Toxic

Total Chromium

Even though the above parameters are recognized as significant in textile mill wastewater, monitoring practices across the industry differ significantly. National Pollutant Discharge Elimination System (NPDES) permits specify the parameters to be monitored by these facilities. Im many cases, permit requirements were developed prior to promulgation of BPT and the monitoring requirements at the time of the survey did not include all of the regulated pollutants. For mills discharging wastewater to POTWs, monitoring requirements range from none, which is the typical case, to very extensive requirements. The majority of the indirect dischargers pay for wastewater disposal based on a local surcharge factor per unit of water consumption; monitoring of wastewater constituents is not regularly conducted.

In order to obtain the best possible characterization of the wastewater from each subcategory of the industry, mills believed to be potential dischargers of wastewater were contacted regarding the availability of historical data. Based on the contacts, 637 mills were sent a detailed questionnaire in 1977 that requested that the mills provide representative monitoring results or information about where such data could be obtained. The Agency specifically requested data for 1976 in order to obtain a consistent and up-to-date data base.

Data considered useful in developing untreated wastewater characteristics were received for 506 wet processing mills and 92 low water use processing mills. In addition, field sampling data were collected on the traditionally-monitored nonconventional and conventional pollutants in textile mill water supplies and untreated wastewater and are presented to confirm, and in some cases, supplement the historical data.

Characterization of Mill Water Supply

The field sampling results for water supply for the traditionally monitored conventional and nonconventional pollutants are summarized in Table V-10.

The concentrations of these pollutants in the water supply are shown to be generally at insignificant levels across the industry. Thus, the levels that are present in textile untreated wastewaters primarily are caused by the raw materials used and the manufacturing processes.

Characterization of Untreated Wastewaters

The raw wastewater concentrations and mass discharge rates reported in the mill surveys for the traditionally-monitored nonconventional pollutant parameters are presented by mill and subcategory in Table V-11. The summaries provide the minimum, maximum, average, median and standard deviation of the values as well as the number of mills represented for each parameter in each subcategory. The values represent averages for mills for which historical data were obtained. The range in these data demonstrates the degree of variability that is inherent in the industry. Untreated wastewater concentrations for the traditionally-monitored nonconventional and conventional pollutant parameters are summarized for each subcategory in Table V-12. Values are included for each parameter for which three or more mills are available. The values are the medians of the reported values.

Wastewater concentrations are of primary importance in predicting the treatability of a particular waste stream and are used to design, monitor and control the operation of treatment systems. But concentration alone does not provide a complete picture of the relative pollutant contributions of each subcategory. Mass discharge rates, which relate pollutant concentrations and wastewater discharge to production levels, provide a more suitable means of regulating wastewater discharges by preventing dilution of wastewater to meet concentration limits. Median mass discharge rates for the appropriate pollutant parameters are presented in Table V-13. Again, values are reported for each parameter for which three or more mills are available.

The nonconventional and conventional pollutant data collected in conjunction with the field sampling program helped develop a more

TABLE V-10
SUMMARY OF ANALYTICAL RESULTS
TRADITIONALLY MONITORED CONVENTIONAL AND
NONCONVENTIONAL POLLUTANTS
FIELD SAMPLING PROGRAM - WATER SUPPLY

Pollutant Parameter	Minimum	Maximum	Average	Median	Analyzed*	Detected#
BOD (mg/l)	1	1	1	1	10	10
COD (mg/l)	2	95	25	20	28	22
TSS (mg/l)	1	38	7	5	28	18
Oil & Grease (mg/l)	1	38	16	15	15	11
Total Phenols (ug/l)	1	1020	51	10	26	26
Sulfide (ug/l)	3	100	64	100	23	9
Color (APHA Units)	15	15	15		2	1
Color (ADMI pH 7.6)	5	276	40	16	22	17

* Values represent the number of samples analyzed.
\# Values represent the number of times pollutant was detected.

Note: Statistical values based on detected values only.

Source: EPA Field Sampling Program.

TABLE V-11

RAW WASTE CHARACTERISTICS
WOOL SCOURING SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
10014	I	1.4	2270	28.41	--	--	2742	34.32	2825	35.35	--	--	--	--	--	--	--
10012	D	1.3	4000	44.32	--	--	4800	51.89	--	--	--	--	--	--	--	--	--
10004	D	1.3	--	--	--	--	--	--	308	3.59	--	--	--	--	--	--	--
10005	D	1.2	364	3.80	--	--	480	5.01	158	1.64	--	--	--	--	--	--	--
10011	I	.7	6678	41.79	--	--	13190	82.55	5000	31.29	--	--	--	--	--	--	--
10008	I	2.2	313	6.01	1136	20.10	217	4.18	580	10.26	--	--	--	--	--	--	--
10015	D	4.6	1825	67.22	7692	334.44	2655	114.48	942	29.70	--	--	--	--	--	--	--
10006	D	1.5	4578	57.93	17831	225.66	82.17	103.99	--	--	--	--	--	--	--	--	--
10002	I	1.9	413	6.58	2020	32.21	120	1.91	80	1.27	--	--	--	--	--	--	--
10001	D	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10013	D	4.6	1606	61.71	6895	263.92	2958	113.69	--	--	--	--	--	--	--	--	--
Minimum		.5	313	3.80	1136	20.10	120	1.91	80	1.27	--	--	--	--	--	--	--
Maximum		4.6	6676	67.22	17831	334.44	13190	114.48	5000	35.35	--	--	--	--	--	--	--
Average		1.9	2449	35.30	7114	175.26	3931	56.89	1413	16.15	--	--	--	--	--	--	--
Median		1.4	1825	41.79	6895	225.66	2742	51.89	580	10.26	--	--	--	--	--	--	--
Standard Deviation		1.4	2208	25.18	6650	141.66	4316	48.01	1841	15.30	--	--	--	--	--	--	--
Number		11	9	9	5	5	9	9	7	7	--	0	--	0	--	0	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger.
D - indicates direct discharger.

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
FELTED FABRIC PROCESSING SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
80027	D	28.1	136	31.89	521	122.19	68	15.94	--	--	70	16.41	50	11.72	500	117.27	300
80013	I	15.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80024	I	24.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80021	D	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80006	I	25.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80023	I	16.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80017	I	33.3	55	15.43	230	63.97	149	41.44	8	2.36	--	--	500	139.07	--	--	--
80010	I	49.7	271	108.57	586	249.77	285	119.72	28	11.15	575	247.35	--	--	--	--	--
80020	I	9.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80025	D	111.6	376	309.97	2091	2379.96	86	86.79	156	126.40	1097	1497.56	--	--	--	--	--
80018	I	31.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum		4.0	55	15.43	230	63.97	68	15.94	8	2.36	70	16.41	50	11.72	500	117.27	300
Maximum		111.6	376	309.97	2091	2379.96	285	119.72	156	126.40	1097	1497.56	500	139.07	500	117.27	300
Average		31.8	209	116.46	857	703.97	147	65.97	64	46.63	580	587.11	275	75.39	500	117.27	300
Median		25.5	203	70.23	553	185.98	117	64.11	28	11.15	575	247.35	275	75.39	500	117.27	300
Standard Deviation		29.2	142	135.23	837	1120.02	98	46.28	80	69.21	513	796.89	318	90.04	--	--	--
Number		11	4	4	4	4	4	4	3	3	3	3	2	2	1	1	1

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
WOOL FINISHING SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
20015	I	78.8	66	43.41	--	--	17	11.18	--	--	--	--	100	65.77	--	--	--
20005	D	61.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20020	D	32.1	89	22.36	592	148.84	66	14.97	--	--	--	--	--	--	--	--	--
20021	I	42.6	466	160.47	1336	448.27	128	43.57	70	9.16	8	2.90	107	38.89	73	26.05	--
20012	I	33.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20017	D	105.4	94	83.47	341	300.60	32	28.68	--	--	--	--	--	--	--	--	--
20008	I	34.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20009	D	27.2	150	34.13	900	204.81	175	39.82	--	--	50	11.37	--	--	--	--	1550
20011	D	36.5	247	85.76	653	212.35	51	16.26	--	--	187	82.74	456	194.14	--	--	--
20007	I	40.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20010	I	41.6	183	63.62	280	97.35	51	17.73	--	--	--	--	--	--	--	--	--
20006	I	27.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20004	I	18.6	150	24.80	--	--	59	9.53	--	--	--	--	--	--	--	--	--
20018	I	50.0	232	96.79	--	--	24	10.01	--	--	--	--	--	--	--	--	--
20022	I	14.9	--	--	1328	166.22	--	--	--	--	--	--	--	--	--	--	--
Minimum		14.9	66	22.36	280	97.35	17	9.53	70	9.16	8	2.90	100	38.89	73	26.05	1500
Maximum		105.4	466	160.47	1336	448.27	175	43.57	70	9.16	187	82.74	456	194.14	73	26.05	1500
Average		42.9	186	68.31	775	225.49	67	21.30	70	9.16	81	32.33	221	99.60	73	26.05	1500
Median		36.5	150	63.62	653	204.81	51	16.26	70	9.16	50	11.37	107	65.77	73	26.05	1500
Standard Deviation		23.5	122	44.23	431	116.67	51	12.94	--	--	93	43.85	203	82.96	--	--	--
Number		15	9	9	7	7	9	9	1	1	3	3	3	3	1	1	1

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
LOW WATER USE PROCESSING (GENERAL) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
G3034	I	2.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3055	D	4.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3035	I	.07	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3111	I	.05	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3075	D	2.8	37	.87	--	--	70	1.60	--	--	91	2.34	97	3.42	180	3.78	--
G3076	I	.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3077	I	5.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3027	I	1.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3033	I	9.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3061	I	.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3031	I	.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3048	I	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3060	I	.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3067	D	.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
63001	I	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3003	I	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3017	I	.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3107	D	.01	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3054	I	.3	450	1.37	--	--	372	1.13	--	--	--	--	--	--	--	--	--
G3065	D	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3078	D	1.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3116	D	.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3118	D	.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3106	D	.07	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3040	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
38001	I	.06	450	.21	--	--	--	--	--	--	--	--	--	--	--	--	--
G3025	I	2.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3079	I	1.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3016	I	1.0	795	6.98	2955	25.95	216	1.90	--	--	--	--	--	--	--	--	--
G3080	I	.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3058	D	4.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3092	D	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3004	I	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3011	I	5.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3036	D	.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3086	I	2.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3084	D	4.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3081	I	1.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3062	I	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3082	I	.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
LOW WATER USE PROCESSING (GENERAL) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
G3066	D	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3013	I	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3010	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3009	I	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
34007	D	.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3005	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3085	I	3.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3030	I	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
38004	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3059	I	1.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3039	D	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3090	I	1.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3028	I	.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3026	I	.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3049	I	.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3023	I	.09	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3072	I	.1	650	.77	--	--	235	.33	--	--	--	--	--	--	--	--	--
G3045	I	3.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3029	I	2.0	497	8.65	788	13.70	92	1.59	--	--	--	--	--	--	--	--	--
G3022	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3050	I	.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3064	D	2.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3083	I	.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3073	D	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3057	D	.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3108	I	.5	275	1.32	--	--	220	1.05	--	--	--	--	--	--	--	--	--
G3021	I	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3019	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3070	D	2.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3056	I	.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3071	I	1.3	209	2.41	595	6.87	187	2.16	--	--	--	--	--	--	--	--	--
G3041	I	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3042	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3046	I	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3020	I	.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3024	I	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3053	I	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3113	D	.2	293	.70	1063	2.74	183	.44	--	--	--	--	--	--	--	--	--
G3015	I	1.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3119	D	.8	317	2.31	1069	7.72	532	4.02	--	--	--	--	--	--	--	--	--
G3063	D	.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3052	I	.04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3032	I	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3069	D	1.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3007	I	2.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

*I - indicates indirect discharger
D - indicates direct discharger

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
LOW WATER USE PROCESSING (GENERAL) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
G3018	D	.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3068	D	1.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum		.01	37	.21	595	2.74	70	.33	--	--	91	2.34	97	3.42	180	3.78	--
Maximum		9.2	795	8.65	2955	25.95	532	4.02	--	--	91	2.34	97	3.42	180	3.78	--
Average		1.22	397	2.55	1294	11.39	234	1.58	--	--	91	2.34	97	3.42	180	3.78	--
Median		.75	383	1.34	1063	7.72	216	1.59	--	--	91	2.34	97	3.42	180	3.78	--
Standard Deviation		1.54	219	2.88	949	9.02	141	1.10	--	--	--	--	--	--	--	--	--
Number		86	10	10	5	5	9	9	--	0	1	1	1	1	1	1	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
LOW WATER USE PROCESSING (WATER JET WEAVING) SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
G3117	D	15.3	119	15.95	137	18.19	26	3.40	--	--	--	--	5	.50	--	--	--
G3012	I	6.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3014	I	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
G3115	I	9.0	55	4.33	247	19.20	26	2.05	--	--	--	--	15	1.46	--	--	--
G3114	D	11.8	204	20.41	183	17.57	28	2.69	--	--	--	--	8	.63	--	--	--
G3038	D	23.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum		2.3	55	4.33	137	17.57	26	2.05	--	--	--	--	5	.50	--	--	--
Maximum		23.3	204	20.41	247	19.20	28	3.40	--	--	--	--	15	1.46	--	--	--
Average		11.3	126	13.56	189	18.32	26	2.71	--	--	--	--	9	.86	--	--	--
Median		10.4	119	15.95	183	18.19	26	2.69	--	--	--	--	8	.63	--	--	--
Standard Deviation		7.3	74	8.30	55	.82	1	.67	--	--	--	--	5	.52	--	--	--
Number		6	3	3	3	3	3	3	--	0	--	0	3	3	--	0	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
WOVEN FABRIC FINISHING (SIMPLE) SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
40147	I	6.1	213	10.89	1801	92.11	16	.81	--	--	--	--	100	5.11	--	--	10000
40001	I	3.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40063	I	10.0	747	62.88	--	--	590	49.66	--	--	--	--	--	--	--	--	--
40045	D	1.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40086	I	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40108	I	24.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40138	I	9.5	383	29.06	--	--	--	--	--	--	--	--	--	--	--	--	--
40019	I	5.2	2048	90.42	5020	221.64	258	11.39	153	6.75	40	1.76	--	--	--	--	--
40152	I	22.1	212	38.70	1266	239.82	53	9.55	67	12.54	--	--	--	--	--	--	--
40013	I	4.0	611	20.85	1396	47.65	345	11.77	--	--	--	--	530	18.09	--	--	--
40116	I	26.3	30	6.69	218	47.92	29	6.41	--	--	50	11.01	30	6.55	580	128.21	--
40123	D	33.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40021	I	8.5	305	22.13	862	60.51	31	2.16	286	21.69	600	45.51	--	--	--	--	--
40101	I	9.4	877	69.52	2277	180.54	289	22.93	782	61.99	--	--	--	--	--	--	3795
40124	I	8.5	322	23.00	1985	141.81	460	32.86	154	11.00	--	--	1	.07	--	--	800
40055	I	12.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40029	I	5.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40127	I	2.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40143	D	14.4	188	22.29	659	52.06	28	3.28	--	--	--	--	--	--	--	--	--
40035	D	28.0	133	30.49	472	114.04	34	7.73	--	--	--	--	--	--	--	--	--
40113	I	.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40057	I	7.5	66	4.16	203	12.70	--	--	--	--	29	1.84	40	2.50	55	3.44	--
40110	I	28.2	915	215.35	1856	436.82	24	5.64	--	--	--	--	--	--	--	--	800
40088	I	18.4	69	10.80	644	99.46	54	8.19	6	.86	--	--	--	--	--	--	--
40144	D	2.3	298	5.73	--	--	--	--	--	--	350	6.73	40	.77	--	--	--
40009	I	15.7	300	39.33	1230	161.39	64	8.49	--	--	--	--	24	3.14	--	--	--
40005	I	2.7	660	15.42	1400	32.71	262	6.12	32	.74	410	9.57	150	3.50	25	.58	5000
40080	I	30.5	89	23.76	317	84.64	75	20.02	36	9.08	205	51.21	10	2.31	90	22.07	1283
40027	I	24.9	143	29.93	472	98.51	60	12.67	9	1.87	47	9.85	50	10.43	50	10.43	503
40098	D	28.8	136	28.84	384	78.90	28	6.73	--	--	--	--	37	9.93	--	--	--
40071	I	4.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40036	I	3.8	616	19.96	940	30.43	192	6.22	--	--	--	--	--	--	--	--	--
40023	D	23.8	19	3.77	218	43.31	890	176.82	--	--	10	1.98	37	7.35	--	--	424
40100	D	9.0	232	18.02	567	43.02	36	2.75	--	--	48	3.50	22	1.66	--	--	--
40076	D	3.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40050	D	14.5	142	17.21	767	92.70	35	4.28	--	--	--	--	--	--	--	--	--
40070	I	21.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40128	D	4.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40066	D	3.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40109	D	17.1	486	69.56	999	143.00	--	--	--	--	--	--	--	--	--	--	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
WOVEN FABRIC FINISHING (SIMPLE) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
40032	D	2.4	313	6.05	1411	28.31	135	2.50	--	--	--	--	--	--	--	--	--
Minimum		1.5	19	3.77	203	12.70	16	.81	6	.74	10	1.76	1	.07	25	.58	424
Maximum		33.0	2048	215.35	5020	436.82	890	176.82	782	61.99	600	51.21	530	18.09	580	128.21	10000
Average		12.5	390	34.62	1140	107.66	173	18.21	169	14.05	178	14.29	82	5.49	160	32.94	2825
Median		9.2	298	22.29	901	88.37	60	7.73	67	9.08	49	8.15	37	3.50	55	10.43	1041
Standard Deviation		9.7	418	42.29	1022	93.04	221	36.34	247	19.18	206	18.34	140	5.02	235	53.89	3357
Number		40	27	27	24	24	23	23	9	9	10	10	13	13	5	5	8

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
WOVEN FABRIC FINISHING (COMPLEX) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
40046	I	20.4	106	18.79	--	--	55	9.14	--	--	--	--	--	--	--	--	--
40008	I	1.3	--	--	1850	21.30	425	4.89	5	.05	1500	17.32	100	1.15	100	1.15	500
40106	I	9.8	853	70.31	--	--	--	--	--	--	--	--	--	--	--	--	--
40078	I	14.9	450	56.32	3100	388.01	136	17.02	48	6.00	62	7.76	19	2.37	100	12.51	700
40020	I	11.9	780	78.10	--	--	616	61.68	--	--	--	--	--	--	--	--	--
40102	I	4.9	--	--	244	10.18	--	--	--	--	600	25.03	1180	49.23	--	--	--
40122	I	8.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40011	I	12.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40119	I	2.9	630	15.77	--	--	78	1.95	--	--	--	--	100	2.50	--	--	--
40132	I	7.1	201	12.03	864	51.72	74	4.43	--	--	--	--	--	--	--	--	--
40094	I	29.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40036	I	6.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40134	I	4.4	97	3.59	--	--	--	--	--	--	--	--	--	--	--	--	317
40082	I	16.6	144	20.15	--	--	136	19.01	--	--	--	--	--	--	--	--	--
40139	I	6.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40091	D	9.3	356	27.92	--	--	56	4.35	--	--	--	--	--	--	100	7.84	--
40067	D	8.6	106	9.19	--	--	40	3.18	--	--	--	--	--	--	--	--	--
40135	D	9.7	399	33.15	--	--	--	--	--	--	--	--	--	--	--	--	--
40115	I	3.9	350	11.67	--	--	61	2.05	--	--	--	--	--	--	--	--	--
40154	D	23.5	337	62.24	--	--	47	9.29	--	--	--	--	--	--	--	--	--
40131	I	10.4	471	41.28	1076	94.23	55	4.84	34	2.97	10	.91	30	2.62	--	--	--
40133	I	8.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40163	I	22.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40041	I	25.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40148	D	11.9	328	32.74	1168	116.37	220	21.97	44	4.45	--	--	--	--	--	--	--
40022	D	33.2	83	23.11	308	85.68	43	12.05	--	--	--	--	157	44.68	--	--	--
40040	I	2.4	2164	44.08	5138	104.88	866	17.75	158	3.24	--	--	125	2.54	--	--	--
40090	I	3.5	281	8.44	1886	56.66	185	5.55	--	--	--	--	110	3.30	--	--	--
40077	D	12.7	389	41.27	--	--	41	4.39	--	--	298	31.63	133	14.13	5840	619.21	--
40125	I	24.9	119	24.99	--	--	48	10.13	--	--	--	--	--	--	--	--	--
40160	D	11.7	461	53.34	1442	142.64	165	16.73	--	--	--	--	--	--	--	--	--
40024	I	27.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40033	I	19.8	219	36.28	726	119.29	182	30.15	86	14.24	46	7.62	--	--	120	19.88	--
40111	D	17.7	288	42.71	934	138.51	--	--	--	--	--	--	--	--	--	--	--
40026	I	15.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40025	I	29.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40117	I	5.9	1125	57.09	--	--	155	7.87	44	2.24	--	--	--	--	--	--	--
40114	D	18.4	565	87.03	1174	180.84	--	--	--	--	--	--	--	--	--	--	--
40126	D	3.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum		1.3	83	3.59	244	10.18	40	1.95	5	.05	10	.91	19	1.15	100	1.15	317
Maximum		33.2	2164	87.03	5136	388.01	866	61.68	158	14.24	1500	31.63	1180	49.23	5840	619.21	700
Average		13.2	452	36.46	1531	116.17	175	12.78	59	4.74	419	15.04	217	13.61	1252	132.11	505
Median		11.7	350	33.15	1168	104.88	78	9.14	44	3.24	180	12.54	110	2.62	100	12.51	500
Standard Deviation		8.6	439	22.89	1316	95.20	212	13.49	49	4.57	574	11.72	363	19.32	2564	272.37	191
Number		39	25	25	13	13	21	21	7	7	6	6	9	9	5	5	3

* I - indicates indirect discharger
D - indicates direct discharger

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
WOVEN FABRIC FINISHING (DESIZING) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
40075	I	32.4	222	60.20	--	--	--	--	--	--	--	--	--	--	--	--	--
40120	D	9.5	908	72.67	2355	181.59	309	24.01	--	--	--	--	--	--	--	--	--
40146	D	11.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40031	D	10.7	523	46.97	1708	153.13	--	--	--	--	--	--	--	--	--	--	--
40121	I	17.8	295	44.04	997	148.94	86	12.90	100	14.93	1000	149.32	100	14.93	--	--	--
40089	I	.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40083	I	15.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40010	D	25.0	164	34.21	372	77.60	1	.20	--	--	--	--	100	20.86	--	--	--
40018	I	13.2	422	46.76	883	97.88	56	6.25	--	--	1215	134.71	--	--	--	--	--
40093	I	60.9	281	142.97	1569	798.32	147	74.79	--	--	--	--	--	--	--	--	--
40141	I	23.0	506	97.24	--	--	246	47.27	--	--	--	--	--	--	--	--	--
40047	D	16.5	311	42.93	834	114.85	--	--	--	--	--	--	317	43.76	--	--	--
40104	I	4.3	195	7.16	836	30.62	33	1.20	18	.65	--	--	4	.14	130	4.76	20
40060	I	16.8	204	28.75	716	100.68	64	9.07	--	--	--	--	260	36.57	--	--	--
40130	D	15.7	200	26.33	845	111.25	82	10.79	31	4.08	151	19.88	30	3.95	--	--	--
40064	D	8.6	640	45.50	--	--	--	--	--	--	--	--	--	--	--	--	--
40012	D	6.8	494	28.27	--	--	--	--	--	--	--	--	--	--	--	--	--
40118	D	25.2	125	26.30	574	120.80	213	44.82	--	--	--	--	--	--	--	--	--
40072	D	10.3	366	31.64	--	--	78	6.80	--	--	--	--	--	--	--	--	--
40028	I	10.8	231	20.98	746	67.42	131	11.82	--	--	--	--	--	--	--	--	--
40053	I	3.3	2604	63.68	--	--	1260	34.76	84	2.22	--	--	--	--	--	--	--
40015	I	2.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40043	I	30.5	435	109.02	--	--	121	31.31	--	--	--	--	1851	480.56	--	--	--
40049	D	20.0	193	33.16	800	130.55	162	23.31	--	--	--	--	--	--	--	--	--
40052	I	7.9	712	47.52	1837	122.63	239	15.95	68	4.53	14	.93	7070	471.96	4400	293.72	--
40073	D	3.1	242	5.90	--	--	97	2.43	--	--	--	--	--	--	--	--	--
40054	D	6.6	1011	56.71	2778	153.04	434	24.38	--	--	--	--	--	--	--	--	--
40056	I	4.3	395	14.42	1316	48.04	--	--	--	--	--	--	--	--	--	--	--
40081	I	21.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40065	D	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40097	D	7.0	195	11.56	1845	107.24	--	--	--	--	--	--	--	--	--	--	--
40058	D	17.1	311	44.48	--	--	135	19.31	--	--	35	5.00	555	79.39	110	15.73	--
40037	D	14.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40042	I	32.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40007	D	13.9	690	80.63	--	--	904	105.69	--	--	--	--	--	--	--	--	--
40004	I	9.8	1110	98.30	2120	194.95	2442	222.11	1444	151.25	--	--	--	--	--	--	--
40068	I	12.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40155	I	7.5	240	15.15	1580	99.80	155	9.79	--	--	--	--	250	15.79	--	--	--
40016	I	14.5	668	81.28	2488	302.74	311	37.84	--	--	--	--	12500	1521.01	--	--	--
40074	D	23.4	972	188.51	--	--	186	40.06	--	--	--	--	--	--	--	--	--

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
WOVEN FABRIC FINISHING (DESIZING) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
40092	I	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40140	D	5.2	640	28.33	1240	54.15	173	7.63	--	--	--	--	--	--	--	--	--
40079	D	1.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40002	I	5.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40014	D	51.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40069	D	4.9	441	17.86	1562	61.30	310	12.26	--	--	142	6.33	14	.57	--	--	--
40017	D	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40151	D	8.7	713	51.89	2408	175.14	--	--	5	.36	--	--	40	2.90	--	--	--
40145	D	21.8	--	--	846	154.11	--	--	--	--	--	--	--	--	--	--	--
40099	D	15.8	355	46.96	918	121.99	60	7.88	--	--	--	--	20	2.63	--	--	--
40153	D	17.5	533	77.97	1026	151.47	78	11.44	--	--	--	--	--	--	--	--	--
40150	D	9.6	--	--	1400	113.10	168	13.57	--	--	--	--	--	--	--	--	--
40103	D	10.5	897	79.12	1899	167.51	127	11.20	--	--	--	--	--	--	--	--	--
40034	I	14.2	411	49.13	1527	181.57	196	23.27	--	--	--	--	--	--	--	--	--
40059	D	14.5	273	33.14	853	103.56	--	--	--	--	--	--	--	--	--	--	--
40061	D	12.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40087	D	7.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
40003	D	18.3	788	119.96	1763	266.85	548	83.50	--	--	--	--	--	--	--	--	--
40142	D	14.7	366	44.74	835	103.22	--	--	--	--	--	--	--	--	--	--	--
40030	D	20.9	178	30.52	1092	185.01	--	--	--	--	--	--	--	--	--	--	--
Minimum		.6	125	5.90	372	30.62	1	.20	5	.36	14	.93	4	.14	110	4.76	20
Maximum		60.9	2604	188.51	2778	798.32	2442	222.11	1444	151.25	1215	149.32	12500	1521.01	4400	293.72	20
Average		14.4	510	53.16	1350	151.54	298	30.86	250	25.43	426	52.69	1650	192.50	1546	104.73	20
Median		12.7	403	45.12	1240	121.97	158	14.76	68	4.08	146	13.10	175	18.32	130	15.73	20
Standard Deviation		10.9	421	37.80	617	129.65	467	42.63	527	55.69	534	69.63	3638	416.84	2471	163.75	--
Number		59	42	42	33	33	32	32	7	7	6	5	14	14	3	3	1

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
KNIT FABRIC FINISHING (SIMPLE) SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
50008	D	20.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50001	I	17.4	303	44.27	--	--	--	--	--	--	--	--	--	--	--	--	--
50025	I	28.4	--	--	727	172.54	83	19.91	195	46.43	1675	397.35	15	3.55	55	13.04	380
50038	I	2.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50088	I	2.1	550	9.86	4000	71.76	355	6.36	30	.53	--	--	--	--	--	--	--
50120	I	20.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50081	D	6.0	181	8.97	369	17.90	95	5.46	--	--	--	--	13	.64	--	--	--
50117	D	5.8	91	4.44	--	--	--	--	--	--	--	--	--	--	--	--	--
50020	I	12.4	130	13.46	452	46.81	77	7.97	--	--	1	.10	--	--	--	--	170
50005	I	20.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50043	D	27.9	318	77.47	1522	372.39	42	9.96	14	3.52	22	5.35	26	6.21	--	--	366
50017	I	11.0	--	--	522	48.06	122	11.23	204	18.78	10	.92	--	--	--	--	--
50073	I	1.0	1860	16.33	194000	170.40	2160	18.97	455	3.99	--	--	--	--	--	--	--
50110	I	31.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50022	D	16.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50067	I	19.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50044	I	46.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50042	I	31.1	164	42.57	529	137.41	57	14.90	--	--	--	--	--	--	--	--	718
50010	I	3.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50077	I	16.3	--	--	728	99.22	--	--	--	--	--	--	--	--	--	--	--
50118	I	4.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50028	I	24.3	338	69.51	1762	306.98	--	--	--	--	--	--	--	--	--	--	--
50002	I	14.8	304	36.61	1300	159.40	58	7.17	--	--	--	--	600	85.25	--	--	--
50087	I	14.7	161	19.78	535	65.73	30	3.68	--	--	--	--	80	9.82	--	--	--
50080	I	13.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50121	I	12.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50103	I	9.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50102	I	13.8	157	17.83	--	--	38	4.69	--	--	--	--	171	25.90	--	--	--
50104	D	4.8	327	13.18	1261	50.80	119	4.88	--	--	126	4.18	58	2.35	--	--	--
50070	I	20.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50014	I	14.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50122	D	10.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50057	D	12.4	380	40.48	--	--	31	3.22	--	--	--	--	--	--	--	--	--
50108	D	16.1	115	15.47	429	57.53	21	2.91	--	--	--	--	--	--	--	--	--
50116	D	8.8	181	13.34	--	--	18	1.32	--	--	--	--	--	--	--	--	--
50093	I	19.9	209	34.87	947	158.04	25	4.17	--	--	--	--	--	--	--	--	--
50040	I	20.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50119	I	6.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50112	D	18.2	279	42.75	934	143.96	41	6.33	--	--	--	--	--	--	--	--	454
54060	I	39.2	158	51.79	--	--	61	20.16	93	30.48	106	34.74	78	25.56	--	--	--

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
KNIT FABRIC FINISHING (SIMPLE) SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
50030	D	8.2	334	23.13	1265	87.60	--	--	--	--	--	--	--	--	--	--	1462
50059	I	4.0	505	17.19	982	33.44	168	5.72	--	--	--	--	--	--	--	--	--
50011	D	6.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50046	I	29.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50037	D	17.2	196	28.76	--	--	70	10.43	--	--	--	--	--	--	--	--	198
50101	I	8.8	158	11.74	--	--	93	6.95	--	--	--	--	--	--	--	--	--
50007	I	1.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50047	D	16.6	139	20.34	664	81.11	60	5.89	--	--	--	--	--	--	--	--	--
50054	I	18.7	60	9.38	344	53.82	32	5.00	17	2.65	110	17.21	50	7.82	20	3.12	400
50082	D	13.5	205	23.39	536	60.49	31	3.42	--	--	--	--	103	11.33	--	--	--
50015	D	27.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50094	I	19.7	209	34.68	873	144.33	37	6.14	--	--	--	--	--	--	--	--	--
50048	I	12.9	256	27.74	1087	117.79	383	41.50	--	--	1000	108.36	30	3.25	7100	769.42	--
50098	D	8.2	412	29.76	790	55.66	163	11.40	--	--	--	--	--	--	--	--	--
50106	I	35.4	119	35.30	342	101.29	42	12.59	--	--	--	--	--	--	--	--	--
50113	D	12.2	198	20.35	745	76.75	49	5.08	--	--	--	--	--	--	--	--	--
50026	D	14.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum		1.0	60	4.44	342	17.90	18	1.32	14	.53	1	.10	13	.64	20	3.12	170
Maximum		46.5	1860	77.47	19400	372.39	2160	41.50	455	46.43	1675	397.35	600	85.25	7100	769.42	1462
Average		15.6	290	27.57	1655	111.20	157	9.22	144	15.19	381	71.02	111	16.51	2391	261.86	518
Median		14.1	205	23.13	767	84.35	58	6.33	93	3.99	108	11.28	58	7.82	55	13.04	390
Standard Deviation		9.7	313	17.36	3691	81.51	395	8.02	158	17.58	619	136.70	168	24.38	4077	439.58	416
Number		57	31	31	26	26	29	29	7	7	8	8	11	11	3	3	8

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
KNIT FABRIC FINISHING (COMPLEX) SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	PHENOL (ug/l)	PHENOL (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
50085	I	21.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50107	I	10.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50090	D	19.9	--	--	760	126.83	127	21.19	107	17.85	72	12.01	10	1.66	50	8.34	--
50062	I	27.7	167	38.70	--	--	--	--	--	--	--	--	--	--	--	--	--
50086	I	30.0	550	137.69	--	--	430	107.65	--	--	--	--	100	25.03	--	--	--
50024	D	26.6	123	27.36	--	--	38	8.45	--	--	--	--	--	--	--	--	750
50032	I	45.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50035	D	17.7	150	22.10	614	88.56	742	110.04	--	--	--	--	--	--	--	--	--
50021	I	18.5	151	23.31	514	79.34	35	5.40	--	--	--	--	230	35.50	--	--	--
50072	I	8.9	266	20.59	791	60.34	31	2.38	38	2.94	--	--	--	--	--	--	--
50034	D	4.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50074	I	8.1	275	18.69	--	--	32	2.17	--	--	--	--	20	1.35	--	--	829
50066	I	5.1	187	8.04	--	--	53	2.28	23	.98	80	3.42	80	3.42	210	8.98	937
50111	D	8.9	261	19.60	1905	143.06	164	12.31	6	.45	160	12.01	80	6.00	1470	110.39	37
50006	I	1.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50029	I	5.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50065	D	14.1	264	31.25	1057	124.76	46	5.52	--	--	--	--	65	7.66	--	--	--
50009	I	19.1	500	79.86	3149	503.01	46	7.34	--	--	230	36.73	10	1.59	--	--	777
50061	I	11.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50031	I	11.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50039	I	11.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50079	I	27.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50100	I	19.6	519	85.06	2311	378.79	35	5.73	--	--	--	--	--	--	--	--	781
50069	I	34.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50099	D	14.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50071	I	20.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50105	I	10.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50056	D	24.2	272	53.56	694	135.93	28	5.72	--	--	100	19.10	100	19.10	100	19.10	--
50109	I	16.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50123	D	2.8	869	20.67	--	--	656	15.69	--	--	--	--	--	--	--	--	--
50068	I	6.3	166	8.33	--	--	133	6.65	--	--	--	--	--	--	--	--	--
50097	I	21.7	229	38.61	1114	199.07	48	9.16	20	3.63	--	--	--	--	--	--	--
50027	I	16.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50016	I	25.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50012	D	9.1	250	19.12	976	74.65	108	8.26	83	6.34	114	8.71	100	7.64	--	--	--
50063	I	26.7	200	44.57	545	121.46	50	11.14	--	--	--	--	--	--	--	--	640
50018	I	6.8	503	26.82	--	--	--	--	--	--	--	--	--	--	--	--	--
50115	D	47.1	173	67.91	--	--	45	18.07	--	--	--	--	--	--	--	--	--
50076	I	11.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50092	I	4.3	277	10.15	1348	49.43	88	3.22	113	4.14	--	--	--	--	--	--	417

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - *indicates indirect discharger*
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
KNIT FABRIC FINISHING (COMPLEX) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
50019	D	12.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50051	I	8.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50114	I	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50083	I	16.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50023	I	7.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50052	D	20.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50078	I	15.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50084	I	11.8	280	28.11	834	79.86	108	10.69	66	6.73	--	--	--	--	--	--	--
50045	I	32.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50013	D	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50091	I	23.3	223	43.51	593	115.45	60	11.68	--	--	--	--	180	35.04	--	--	--
Minimum		1.5	123	8.04	514	49.43	28	2.17	6	.45	72	3.42	10	1.35	50	8.34	37
Maximum		47.1	869	137.69	3149	503.01	742	110.04	113	17.85	230	36.73	230	35.50	1470	110.39	937
Average		16.4	298	38.07	1147	152.03	141	17.76	57	5.38	126	15.33	88	13.09	457	36.70	646
Median		14.7	261	28.11	834	121.46	51	8.35	52	3.88	107	12.01	80	7.64	155	14.04	763
Standard Deviation		10.1	176	30.26	753	125.42	200	29.90	41	5.50	59	11.66	68	13.29	678	49.37	289
Number		51	23	23	15	15	22	22	8	8	6	6	11	11	4	4	8

** - Color units are APHA color units
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
KNIT FABRIC FINISHING (HOSIERY) SUBCATEGORY

Report No.	Dis-Charge*	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
5H044	I	2.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H012	I	3.4	176	5.01	1371	38.91	--	--	--	--	--	--	--	--	--	--	--
5H059	I	10.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H043	I	7.6	202	12.92	1015	64.93	24	1.53	79	5.05	--	--	--	--	--	--	--
5H038	I	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H001	I	4.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H023	D	15.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H005	D	31.1	235	60.83	--	--	66	16.84			583	151.59	983	265.63	675	180.10	--
5H056	I	14.8	792	98.39	1568	194.80	61	7.57	49	6.08	--	--	80	9.93	--	--	--
5H052	I	12.5	533	55.92	1397	146.59	57	5.98	--	--	--	--	250	26.23	--	--	--
5H009	I	22.6	351	65.31	3302	625.76	94	18.43	144	27.74	--	--	--	--	--	--	--
5H018	I	6.9	323	18.91	--	--	--	--	--	--	--	--	--	--	--	--	1062
5H032	I	1.1	280	2.73	--	--	--	--	--	--	--	--	--	--	--	--	407
5H045	I	11.1	190	17.66	--	--	--	--	--	--	--	--	--	--	--	--	533
5H051	I	26.4	166	36.65	--	--	--	--	--	--	--	--	--	--	--	--	241
5H034	I	8.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H054	I	4.0	540	18.04	--	--	--	--	--	--	--	--	--	--	--	--	--
5H002	I	1.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H020	D	5.9	503	25.20	705	35.33	134	6.73	--	--	55	2.75	45	2.25	--	--	40
5H008	I	.8	740	5.48	4980	36.93	182	1.34	195	1.44	--	--	50	.37	--	--	--
5H014	I	15.0	221	27.81	694	87.33	--	--	--	--	--	--	--	--	--	--	--
5H050	I	24.5	675	138.33	1699	348.02	115	23.59	--	--	--	--	145	29.69	--	--	--
5H031	I	5.9	557	27.48	1770	87.27	82	4.08	--	--	--	--	205	10.10	--	--	--
5H026	I	11.2	487	45.78	2254	211.64	113	10.65	--	--	--	--	--	--	--	--	--
5H040	I	5.4	390	17.70	1225	55.92	63	2.92	--	--	--	--	144	6.61	--	--	--
5H021	I	10.7	803	74.50	1671	155.10	45	3.95	--	--	--	--	191	16.67	--	--	--
5H039	I	3.7	506	14.35	1846	50.21	118	3.41	--	--	--	--	--	--	--	--	--
5H024	I	6.6	477	26.56	1083	60.27	125	6.98	--	--	--	--	210	11.68	--	--	--
5H025	I	9.7	283	23.55	802	63.13	22	1.86	--	--	--	--	38	2.75	--	--	--
5H029	D	7.5	195	12.20	503	31.50	--	--	--	--	--	--	--	--	--	--	--
5H028	D	4.7	57	2.27	--	--	119	4.78	--	--	--	--	--	--	--	--	--
5H027	I	5.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H049	I	8.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H030	I	12.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H058	I	7.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H057	I	11.1	174	16.50	--	--	110	9.74	--	--	--	--	--	--	--	--	--
5H055	I	13.7	176	21.00	--	--	78	9.03	--	--	--	--	--	--	--	--	--
5H048	I	.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H007	I	13.4	320	36.04	950	107.01	34	3.83	--	--	69	7.77	30	3.37	--	--	--
5H011	I	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
* I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
KNIT FABRIC FINISHING (HOSIERY) SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
5H046	I	8.3	385	26.77	1702	118.38	87	6.04	142	9.90	26	1.84	170	11.82	--	--	--
5H003	I	9.9	527	44.01	2125	177.31	124	10.34	79	6.63	41	3.46	1200	100.13	--	--	--
5H042	I	10.2	253	21.54	1049	89.38	72	6.13	197	16.81	--	--	--	--	--	--	--
5H010	I	6.3	312	16.52	1107	58.52	58	3.08	43	2.27	47	2.51	21	1.10	450	23.78	312
5H035	I	9.9	486	40.61	2167	180.84	--	--	--	--	--	--	--	--	--	--	--
5H015	I	24.1	324	65.25	659	132.84	--	--	--	--	--	--	--	--	--	--	--
5H016	I	6.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H036	I	34.7	444	125.78	--	--	55	16.06	--	--	--	--	--	--	--	--	--
5H041	I	17.7	233	34.27	1114	161.99	93	12.85	136	19.60	--	--	--	--	--	--	--
5H037	I	14.3	225	27.06	--	--	89	10.78	--	--	--	--	--	--	--	--	--
5H053	I	33.3	95	26.42	450	125.16	14	3.89	27	7.51	90	25.03	21	5.84	--	--	--
5H047	I	4.2	220	7.85	730	26.05	9	32	99	3.53	82	2.92	10	.35	--	--	--
5H006	I	11.2	400	37.55	990	92.93	54	5.06	--	--	--	--	--	--	--	--	500
5H013	I	3.1	523	13.96	1507	40.25	--	--	--	--	--	--	--	--	--	--	--
5H022	I	12.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H019	I	5.0	490	20.65	1542	59.25	179	7.09	275	9.54	160	5.00	142	6.38	--	--	940
5H017	I	10.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5H004	I	23.7	117	23.20	--	--	44	8.72	15	2.97	30	5.95	30	5.95	10	1.98	--
Minimum		.7	57	2.27	450	26.05	9	.32	15	1.44	26	1.84	10	.35	10	1.98	40
Maximum		34.7	803	138.33	4980	625.76	182	23.59	275	27.74	583	151.59	1200	265.63	675	180.10	1062
Average		10.7	366	34.25	1465	122.11	81	7.53	113	9.15	118	20.88	208	27.20	378	68.62	504
Median		9.0	323	25.81	1298	88.35	78	6.13	99	6.63	62	4.23	142	6.61	450	23.78	453
Standard Deviation		8.0	188	30.16	905	118.38	43	5.44	76	7.77	167	46.43	322	61.92	338	97.16	344
Number		58	42	42	30	30	31	31	13	13	10	10	19	19	3	3	8

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
CARPET FINISHING SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
60008	I	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60021	D	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60018	D	4.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60010	I	4.7	--	--	2117	84.15	208	8.26	27	1.08	--	--	300	11.92	--	--	1900
60024	I	11.7	--	--	905	87.27	96	9.27	93	9.37	115	11.34	30	3.44	50	5.27	590
60028	I	5.4	--	--	745	33.74	75	3.39	18	.81	400	18.11	250	11.32	300	13.58	--
60027	I	9.3	--	--	281	21.88	44	3.49	3	.23	10	.77	30	2.33	10	.77	65
60023	I	4.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60035	I	11.5	421	40.78	1390	134.62	55	5.35	--	--	--	--	--	--	--	--	--
60011	I	11.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60005	D	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60006	I	5.9	342	17.03	869	42.48	95	4.76	--	--	1	.04	44	.22	450	22.00	--
60036	I	6.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60025	I	5.0	561	23.52	1997	83.73	37	1.55	--	--	--	--	--	--	--	--	--
60026	I	5.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60032	I	6.1	569	29.23	1564	80.92	42	2.17	--	--	1138	58.91	20	1.07	--	--	--
60013	D	3.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60016	I	3.3	506	14.20	986	27.67	59	1.65	--	--	--	--	--	--	--	--	--
60029	D	6.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60022	I	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60007	I	6.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60037	D	5.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60012	I	8.5	458	32.75	1886	134.89	--	--	--	--	--	--	--	--	--	--	--
60014	I	8.2	411	28.11	1402	95.94	--	--	--	--	--	--	--	--	--	--	--
60015	I	6.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60030	I	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60004	D	2.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60001	D	5.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60017	I	17.4	188	27.63	621	91.00	58	8.37	10	1.58	314	45.86	40	6.35	--	--	383
60020	I	2.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60031	D	4.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60034	D	7.5	217	13.73	474	41.39	101	6.40	--	--	130	8.05	--	--	--	--	--
60009	I	5.3	483	21.66	1646	73.84	102	4.57	--	--	--	--	--	--	--	--	--
60002	I	4.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60038	I	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60003	I	19.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60039	D	14.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
CARPET FINISHING SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
Minimum		1.0	188	13.73	281	21.88	37	1.55	3	.23	1	.04	4	.22	10	.77	65
Maximum		19.5	565	40.78	2117	134.89	208	9.27	93	9.37	1138	58.91	300	11.92	450	22.00	1900
Average		6.6	415	24.86	1205	73.82	81	4.93	30	2.61	301	20.44	96	5.23	202	10.40	734
Median		5.6	439	25.57	1188	82.32	67	4.66	18	1.08	130	11.34	30	3.44	175	9.42	486
Standard Deviation		4.0	131	8.58	589	36.28	46	2.67	36	3.80	397	22.98	123	4.78	209	9.37	806
Number		37	10	10	14	14	12	12	5	5	7	7	7	7	4	4	4

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
STOCK AND YARN FINISHING SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
70045	I	19.9	450	76.18	--	--	104	15.00	--	--	--	--	--	--	--	--	--
70026	I	5.5	--	--	554	25.69	80	3.70	35	1.62	--	--	223	10.35	--	--	57
70042	D	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70010	I	19.0	210	33.37	485	77.08	27	4.37	--	--	200	31.86	100	15.97	--	--	--
70043	I	5.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70005	I	1.3	286	3.18	1147	12.77	192	2.13	--	--	--	--	--	--	--	--	--
70108	I	10.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70037	I	24.6	116	23.95	282	58.08	44	9.06	9	1.99	180	37.07	860	177.12	293	60.41	--
70092	I	12.0	150	15.08	880	88.47	58	5.83	--	--	--	--	60	6.03	--	--	2300
70039	I	6.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70057	D	6.2	252	13.14	556	29.00	--	--	--	--	--	--	--	--	--	--	--
70041	D	4.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70072	D	6.6	327	18.13	1572	86.98	26	1.44	1	.05	--	--	--	--	--	--	--
70118	D	6.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70087	D	6.7	296	16.85	386	21.59	33	1.89	--	--	--	--	16	.86	--	--	--
70121	I	5.7	306	14.79	945	45.60	163	7.88	52	2.53	519	25.05	36	1.76	--	--	566
70067	I	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70120	D	7.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70077	I	13.4	--	--	190	21.40	35	3.94	--	--	5	.56	100	11.26	--	--	--
70035	D	53.7	180	80.91	845	380.40	56	25.88	--	--	--	--	--	--	--	--	--
70106	D	3.9	924	31.00	2431	109.97	309	10.09	--	--	--	--	--	--	--	--	--
70113	I	33.8	102	28.97	250	70.68	10	2.82	--	--	--	--	--	--	--	--	--
70102	D	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70095	I	7.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70107	I	7.1	633	37.60	1217	72.30	64	3.80	144	8.55	40	2.37	1400	83.17	--	--	--
70109	I	39.9	48	16.11	224	74.86	24	8.05	8	2.81	175	58.45	1087	362.86			
70119	I	13.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70038	D	51.9	108	47.30	--	--	21	9.12	--	--	--	--	--	--	--	--	--
70029	I	16.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70069	I	5.9	77	3.90	887	43.27	138	6.85	--	--	--	--	60	2.97	--	--	--
70125	I	16.6	180	25.03	390	54.23	30	4.17	--	--	600	83.44	600	83.44	200	27.81	--
70096	D	6.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70016	D	6.2	167	8.74	--	--	47	2.46	--	--	--	--	--	--	--	--	--
70079	I	3.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70061	I	10.3	46	3.19	--	--	18	1.28	--	--	--	--	--	--	--	--	228
70027	I	8.3	235	16.37	805	56.03	27	1.93	--	--	--	--	34	2.36	--	--	--
70011	D	37.1	154	46.75	--	--	38	11.72	--	--	--	--	--	--	--	--	--
70012	I	5.4	484	22.02	--	--	2	.09	--	--	--	--	--	--	--	--	--
70052	I	10.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70054	I	1.8	1631	24.95	4756	72.76	136	2.09	--	--	--	--	--	--	--	--	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger
 D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
STOCK AND YARN FINISHING SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
70066	I	10.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70071	D	18.5	171	26.53	--	--	223	34.53	--	--	--	--	129	19.97	--	--	--
70065	D	11.3	156	15.08	--	--	24	2.17	--	--	120	12.14	250	19.75	700	66.68	--
70028	D	2.3	375	7.23	--	--	985	18.87	--	--	--	--	--	--	4437	85.37	1835
70006	I	1.0	1120	9.75	3809	33.16	140	1.21	30	.26	--	--	--	--	--	--	--
70101	I	7.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70082	I	13.6	990	112.77	1400	159.48	4200	478.45	--	--	--	--	--	--	--	--	--
70098	I	9.9	199	16.65	3669	306.22	58	4.87	--	--	--	--	--	--	--	--	66
70073	I	3.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70046	D	17.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70058	I	13.3	102	10.89	420	45.21	11	1.11	57	6.11	--	--	--	--	--	--	--
70070	I	8.0	190	12.77	923	62.12	11	.75	24	1.64	--	--	--	--	--	--	--
70112	I	32.8	105	29.00	--	--	--	--	--	--	--	--	--	--	--	--	583
70062	I	9.9	464	38.75	--	--	77	6.48	8	.74	--	--	--	--	--	--	--
70030	I	10.1	180	15.27	--	--	--	--	8	.67	--	--	--	--	--	--	--
70021	I	12.5	302	31.75	792	83.30	17	1.78	15	1.65	--	--	--	--	--	--	--
70086	I	11.4	285	27.22	619	59.03	118	11.33	--	--	--	--	--	--	--	--	--
70114	I	15.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70115	I	42.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70117	I	11.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70104	D	25.8	90	19.32	333	71.75	32	6.91	--	--	--	--	--	--	--	--	--
70008	I	64.6	67	36.15	406	219.07	42	22.66	--	--	--	--	--	--	--	--	3000
70056	I	36.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70124	I	5.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70048	I	10.1	200	16.93	--	--	25	2.11	--	--	--	--	--	--	2000	169.30	--
70116	I	14.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70032	I	13.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70015	I	15.3	890	113.00	1994	254.65	52	6.48	--	--	--	--	--	--	--	--	--
70033	I	24.9	283	59.19	686	143.26	8	1.66	--	--	--	--	57	11.99	--	--	--
70004	I	7.3	258	15.93	980	60.51	--	--	24	1.48	50	3.08	30	1.85	80	4.93	--
70023	I	15.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70111	I	23.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70064	I	12.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70009	D	19.3	83	13.51	366	59.34	38	6.20	--	--	--	--	--	--	--	--	--
70080	I	20.5	229	39.29	852	146.08	49	8.50	38	6.54	--	--	--	--	--	--	228
70089	I	41.7	141	49.30	--	--	47	16.40	--	--	--	--	--	--	--	--	--
70014	I	7.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70123	I	8.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70047	I	12.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70094	I	51.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70127	I	.4	180	.75	591	2.46	31	.13	--	--	621	2.59	200	.83	--	--	--
70003	I	22.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70018	I	21.3	368	65.70	--	--	12	2.22	--	--	--	--	--	--	--	--	--
70002	I	17.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70074	I	6.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
STOCK AND YARN FINISHING SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
70075	D	8.2	151	10.22	546	31.25	68	5.04	--	--	--	--	--	--	--	--	--
70022	I	22.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70025	I	12.0	196	19.46	--	--	--	--	--	--	--	--	--	--	--	--	--
70031	D	10.6	160	14.45	505	45.24	36	3.20	--	--	--	--	--	--	--	--	--
70034	D	10.7	148	12.32	--	--	16	1.47	--	--	--	--	--	--	--	--	--
70019	I	2.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70100	I	13.4	160	18.04	683	76.74	24	2.76	--	--	--	--	68	7.63	--	--	--
70020	I	2.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70110	I	13.3	101	11.36	201	22.54	41	4.65	--	--	--	--	650	72.68	--	--	--
70007	I	60.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70053	I	18.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70090	I	21.4	160	28.62	1460	261.24	25	4.47	18	3.22	3	.53	1600	286.29	10	1.78	760
70063	I	5.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70036	D	25.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70078	D	48.9	127	57.44	--	--	31	12.90	--	--	--	--	32	14.15	--	--	--
70076	I	30.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70088	D	22.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70024	I	14.9	105	13.24	313	39.29	32	4.00	--	--	--	--	--	--	--	--	--
70085	I	14.3	346	41.44	1349	161.42	70	8.39	180	21.52	--	--	--	--	--	--	--
70122	I	11.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70097	I	4.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70084	D	10.3	285	24.72	716	61.55	55	5.22	--	--	--	--	679	56.91	--	--	--
70081	D	22.9	218	41.72	800	151.75	12	2.43	--	--	--	--	26	4.89	100	19.11	--
70059	I	12.6	300	31.65	600	63.31	45	4.74	3	.31	170	17.93	310	32.71	--	--	500
70093	I	2.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70017	I	45.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70105	D	17.6	60	8.86	331	48.88	31	4.57	--	--	--	--	--	--	--	--	--
70103	D	28.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70044	D	33.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70099	I	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70126	D	11.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70013	I	5.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Minimum		.4	46	.75	190	2.46	2	.09	1	.05	3	.53	16	.83	10	1.78	57
Maximum		64.6	1631	113.00	4756	380.40	4200	478.45	180	21.52	621	83.44	1600	362.86	4437	169.30	3000
Average		15.6	283	28.25	981	90.44	144	14.55	38	3.62	223	22.92	358	53.65	977	54.42	989
Median		11.6	190	19.46	686	62.12	38	4.52	24	1.65	172	15.03	114	13.07	246	44.11	574
Standard Deviation		13.4	285	23.43	968	81.08	558	62.32	49	5.19	226	26.25	461	93.51	1543	55.44	1022
Number		117	61	61	45	45	58	58	17	17	12	12	24	24	8	8	10

Source: EPA Industry 308 Survey.
** - Color units are APHA color units.
*I - indicates indirect discharger
D - indicates direct discharger

TABLE V-11 (continued)

RAW WASTE CHARACTERISTICS
NONWOVEN MANUFACTURING SUBCATEGORY

Report No.	Dis-* Charge	WASTEWATER DISCHARGE RATE (gal/lb)	BOD-5 (mg/l)	BOD-5 (kg/kkg)	COD (mg/l)	COD (kg/kkg)	TSS (mg/l)	TSS (kg/kkg)	O & G (mg/l)	O & G (kg/kkg)	TOTAL PHENOLS (ug/l)	TOTAL PHENOLS (g/kkg)	TOT-CR (ug/l)	TOT-CR (g/kkg)	SULFIDE (ug/l)	SULFIDE (g/kkg)	COLOR** UNITS
80008	I	5.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80012	I	.3	--	--	--	--	83	.24	--	--	--	--	--	--	--	--	--
80016	D	4.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80014	I	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80026	I	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80011	I	6.0	64	3.27	205	10.38	74	3.75	--	--	--	--	10	.50	10	.50	--
80015	D	9.9	195	16.14	--	--	179	14.81	--	--	--	--	--	--	--	--	--
80005	I	1.3	633	6.73	3945	38.39	59	.63	--	--	21	.19	50	.43	--	--	--
80019	I	1.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80009	I	6.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80002	I	5.0	158	6.65	2360	99.44	--	--	81	3.41	--	--	370	15.59	--	--	28
Minimum		.3	64	3.27	205	10.38	59	.24	81	3.41	21	.19	10	.43	10	.50	28
Maximum		9.9	633	16.14	3945	99.44	179	14.81	81	3.41	21	.19	370	15.59	10	.50	28
Average		3.8	262	8.19	2170	49.40	98	4.85	81	3.41	21	.19	143	5.50	10	.50	28
Median		4.8	176	6.69	2360	38.39	78	2.19	81	3.41	21	.19	50	.50	10	.50	28
Standard Deviation		3.1	253	5.53	1877	45.53	54	6.81	--	--	--	--	197	8.73	--	--	--
Number		11	4	4	3	3	4	4	1	1	1	1	3	3	1	1	1

** - Color units are APHA color units
*I - indicates indirect discharger
D - indicates direct discharger

TABLE V-12
UNTREATED WASTEWATER CONCENTRATIONS
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
HISTORICAL DATA - MEDIAN VALUES

	Subcategory	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O & G (mg/l)	Sulfide (ug/l)	Total Phenols (ug/l)	Color (APHA Units)
1.	Wool Scouring	1830	6900	2740	580	#	#	#
2.	Wool Finishing	150	650	50	#	#	50	#
3.	Low Water Use Processing							
	a. General Processing	380	1060	220	#	#	#	#
	b. Water Jet Weaving	120	180	25	#	#	#	#
4.	Woven Fabric Finishing							
	a. Simple Processing	300	900	60	65	55	49	1000
	b. Complex Processing	350	1170	80	45	100	180	500
	c. Desizing	405	1240	160	70	130	146	#
5.	Knit Fabric Finishing							
	a. Simple Processing	205	765	60	95	55	108	390
	b. Complex Processing	260	835	50	50	155	107	760
	c. Hosiery Products	325	1300	80	100	560	62	450
6.	Carpet Finishing	440	1190	65	20	175	130	490
7.	Stock & Yarn Finishing	190	685	40	25	245	172	570
8.	Nonwoven Manufacturing	175	2360	80	#	#	#	#
9.	Felted Fabric Processing	205	555	115	30	#	575	#

Insufficient data to report value.

Source: 308 Survey Data, Table V-11.

TABLE V-13
MASS DISCHARGE RATES FOR UNTREATED WASTEWATER
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
HISTORICAL DATA - MEDIAN VALUES

	Subcategory	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	O & G (kg/kkg)	Sulfide (g/kkg)	Total Phenols (g/kkg)
1.	Wool Scouring	41.8	225.7	51.9	10.3	#	#
2.	Wool Finishing	63.6	204.8	16.3	#	#	11.4
3.	Low Water Use Processing						
	a. General Processing	1.3	7.7	1.6	#	#	#
	b. Water Jet Weaving	16.0	18.2	2.7	#	#	#
4.	Woven Fabric Finishing						
	a. Simple Processing	22.3	88.4	7.7	9.1	10.4	8.2
	b. Complex Processing	33.2	104.9	9.1	3.2	12.5	12.5
	c. Desizing	45.1	122.0	14.8	4.1	15.7	13.1
5.	Knit Fabric Finishing						
	a. Simple Processing	23.1	84.4	6.3	4.0	13.0	11.3
	b. Complex Processing	28.1	121.5	8.4	3.9	14.0	7.6
	c. Hosiery Products	25.8	88.4	6.1	6.6	23.8	6.6
6.	Carpet Finishing	25.6	82.3	4.7	1.1	9.4	11.3
7.	Stock & Yarn Finishing	19.5	62.1	4.5	1.7	44.1	15.0
8.	Nonwoven Manufacturing	6.7	38.4	2.2	#	#	#
9.	Felted Fabric Processing	70.2	186.0	64.1	11.2	#	247.4

Insufficient data to report value.

Source: 308 Survey Data, Table V-11.

complete characterization of the typical wastewater from each subcategory. Average data for each mill sampled is presented by mill in Table V-14. These results are summarized by subcategory in Table V-15, which presents the median values of the individual mill averages. With the exception of oil and grease, the data are for composite samples. The samples were collected with automatic sampling equipment over either 8 or 24 hour periods or by combining individual grab samples collected at representative intervals over 8 or 24 hour periods. Although somewhat limited in scope compared to the historical data base, the field sampling data are useful to confirm or supplement the historical data base.

Mass discharge rates for the traditionally-monitored pollutant data from the field sampling program are presented by mill in Table V-16. The wastewater discharge rates shown are calculated on the basis of average discharges and productions, and the mass discharge rates are calculated on the basis of the average of the daily concentrations, as presented in Table V-15. The results are summarized by subcategory in Table V-17, which presents the median values from the individual mill averages. Again, the values are useful to confirm or supplement the historical data base.

Typical untreated wastewater concentrations for the traditionally-monitored pollutant parameters, based on both the historical data and the field sampling results, are presented in Table V-18. The values are representative of the typical mill in each subcategory and are those used in developing the treatment options and costs in subsequent sections. For several subcategory and parameter combinations, typical values could not be established with sufficient confidence and are not presented.

Typical mass discharge rates for the traditionally-monitored pollutants, based on both the historical data and field sampling results, are presented in Table V-19. The values are representative of the typical mill in each subcategory.

TABLE V-14
SUMMARY OF ANALYTICAL RESULTS - RAW WASTE CONCENTRATIONS
TRADITIONALLY MONITORED POLLUTANTS - FIELD SAMPLING PROGRAM

Report Number	Mill Type	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O & G (mg/l)	Sulfide (ug/l)	Total Phenols (ug/l)	Color APHA (Units)	Color ADMI (Units, pH 7.6)
10006	Wool Scouring	5000	24000	87000	1100	-	-	-	-
10013	Wool Scouring	6300	14000	4900	1300	-	2800	110	-
10015	Wool Scouring	1900	6100	2300	-	500	670	2200	-
20011	Wool Finishing	330	1100	68	-	1100	160	1000	-
20021	Wool Finishing	480	2400	370	500	1600	82	2000	390
10013*	Wool Finishing	360	860	24	68	ND	120	110	320
	Low Water Use Processing								
(04935)	General Processing	-	1900	-	-	ND	82	-	-
(01304)	Water Jet Weaving	-	720	14	83	ND	23	-	12
	Woven Fabric Finishing								
40023	Simple Processing	53	-	54	-	ND	18	500	-
40144	Simple Processing	400	1100	200	-	ND	92	-	-
40077	Complex Processing	500	500	28	-	7600	73	1300	-
40135	Complex Processing	-	2000	-	-	ND	150	-	-
40160	Complex Processing	450	1700	87	-	ND	280	1500	-
(04742)	Desizing	71	220	16	-	ND	24	1900	-
40034	Desizing	210	810	1	-	1800	63	1900	-
40059	Desizing	450	800	49	-	5200	74	2600	-
40072	Desizing	560	1700	69	-	ND	67	40000	-
40081	Desizing	-	2100	400	-	ND	190	-	210
40097	Desizing	470	2100	100	52	2800	50	3200	250
40099	Desizing	290	320	39	-	ND	47	1300	-

Note: A dash indicates that analyses were not performed.
ND Indicates "Not Detected."
* Represents finishing stream from Report 10013.
( ) Indicates sequence number instead of report number.

TABLE V-14 (Cont.)

Report Number	Mill Type	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O & G (mg/l)	Sulfide (ug/l)	Total Phenols (ug/l)	Color APHA (Units)	Color ADMI (Units, pH 7.6)
40103	Desizing	830	2300	210	-	ND	37	1000	-
40120	Desizing	1500	-	500	21	-	-	-	-
40145	Desizing	350	810	20	-	2500	560	500	-
40146	Desizing	420	990	90	-	-	-	-	-
40150	Desizing	18	2700	52	-	ND	69	250	-
40156	Desizing	-	770	1	-	1000	42	-	380
	Knit Fabric Finishing								
50030	Simple Processing	360	700	150	72	270	180	750	-
50108	Simple Processing	190	580	23	-	2100	740	150	-
50112	Simple Processing	240	780	20	320	380	520	1200	280
50116	Simple Processing	-	730	-	-	ND	1	-	-
50104*	Simple Processing	-	1700	200	-	50	-	-	160
50013	Complex Processing	-	2400	100	-	ND	48	-	120
50035	Complex Processing	220	560	25	-	9200	110	250	-
50099	Complex Processing	680	170	6	-	6200	230	300	-
5H012	Hosiery Products	-	2900	95	630	ND	110	-	270
5H027	Hosiery Products	-	820	24	340	ND	170	-	220
5H034	Hosiery Products	-	880	17	190	1800	190	-	820
60008	Carpet Finishing	180	740	21	-	-	-	-	-
60031	Carpet Finishing	-	-	-	-	-	5	-	-
60034	Carpet Finishing	-	940	-	-	ND	10	-	-
60037	Carpet Finishing	200	1300	37	-	ND	28	300	-

Note: A dash indicates that analyses were not performed.
ND Indicates "Not Detected".
* Represents pretreatment effluent.
( ) Indicates sequence number instead of report number.

TABLE V-14 (Cont.)

Report Number	Mill Type	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O & G (mg/l)	Sulfide (ug/l)	Total Phenols (ug/l)	Color APHA (Units)	Color ADMI (Units, pH 7.6)
(06443)	Stock & Yarn Finishing	-	740	58	-	420	-	-	110
70009	Stock & Yarn Finishing	120	460	33	-	ND	64	10000	-
70072	Stock & Yarn Finishing	-	-	-	-	-	-	-	-
70081	Stock & Yarn Finishing	-	230	25	-	44	810	-	130
70087	Stock & Yarn Finishing	380	1100	19	-	4500	38	1300	-
70096	Stock & Yarn Finishing	1100	1300	32	-	1400	42	1400	-
70120	Stock & Yarn Finishing	-	640	130	210	ND	-	-	310
80008	Nonwoven Manufacturing	-	220	36	26	ND	33	-	140
80011	Nonwoven Manufacturing	-	480	16	97	ND	8	-	34
80019	Nonwoven Manufacturing	-	340	-	-	ND	44	-	-
80025	Felted Fabric Processing	-	1100	40	260	1200	160	-	190

<u>Note</u>: *A dash indicates that analyses were not performed.*
ND Indicates "Not Detected".
( ) Indicates sequence number instead of report number.

TABLE V-15
UNTREATED WASTEWATER CONCENTRATIONS
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
FIELD SAMPLING DATA - MEDIAN VALUES

Subcategory	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O & G (mg/l)	Sulfide (ug/l)	Total Phenols (ug/l)	Color APHA (units)	Color ADMI (units pH 7.6)
1. Wool Scouring	5000	14000	4900	1200	500	1740	1200	#
2. Wool Finishing	360	1100	68	280	1100	120	1000	360
3. Low Water Use Processing								
a. General Processing	#	1900	#	#	ND	82	#	#
b. Water Jet Weaving	#	720	14	83	ND	23	#	12
4. Woven Fabric Finishing								
a. Simple Processing	230	1100	130	#	ND	55	500	#
b. Complex Processing	480	1700	58	#	3800	150	1400	#
c. Desizing	420	900	52	37	ND	67	1900	250
5. Knit Fabric Finishing								
a. Simple Processing	240	730	87	200	270	350	750	220
b. Complex Processing	450	560	25	#	6200	110	280	120
c. Hosiery Products	#	880	24	340	900	170	#	270
6. Carpet Finishing	190	940	29	#	ND	10	300	#
7. Stock & Yarn Finishing	380	690	33	210	230	40	1400	130
8. Nonwoven Manufacturing	#	340	26	62	ND	33	#	87
9. Felted Fabric Processing	#	1100	40	260	1200	160	#	190

No data.
ND Indicates "Not Detected."

Source: Field Sampling Program, Table V-14.

TABLE V-16
RAW WASTE MASS DISCHARGE
TRADITIONALLY MONITORED POLLUTANTS
FIELD SAMPLING PROGRAM

Report Number	Mill Type	Wastewater Discharge Rate (gal/lb)	BOD5	COD	TSS	O & G	Sulfide (g/kkg)	Total Phenols g/kkg
			(kg/kkg)					
10006	Wool Scouring	1.5	62.6	300.2	1088.4	13.8	-	-
10013	Wool Scouring	4.6	241.7	537.1	188.0	49.9	-	108.0
10015	Wool Scouring	4.6	72.9	234.0	88.3	-	19.2	25.7
20011	Wool Finishing	36.5	100.5	334.8	20.7	-	334.8	48.8
20021	Wool Finishing	42.6	170.4	852.5	131.4	177.8	568.5	29.2
10013*	Wool Finishing	-	-	-	-	-	-	
	Low Water Use Processing							
(04935)	General Processing	0.03	-	0.48	-	-	ND	0.02
(01304)	Water-Jet Weaving	-	-	-	-	-	-	-
	Woven Fabric Finishing							
40023	Simple Processing	23.8	10.5	-	10.7	-	ND	3.6
40144	Simple Processing	2.3	7.7	21.1	3.8	-	ND	0.44
40077	Complex Processing	12.7	53.0	53.0	3.0	-	805.0	7.7
40135	Complex Processing	9.7	-	161.8	-	-	ND	12.2
40160	Complex Processing	11.7	43.9	165.9	8.5	-	ND	27.3
(04742)	Desizing	50.5	29.9	92.7	6.7	-	ND	10.1
40034	Desizing	14.2	24.9	95.9	0.1	-	213.2	7.5
40059	Desizing	14.5	54.4	96.7	5.9	-	628.8	9.0
40072	Desizing	10.3	48.1	146.0	5.9	-	ND	5.8
40081	Desizing	21.5	-	376.6	71.7	-	ND	34.4
40097	Desizing	7.0	27.4	122.6	5.8	3.0	163.5	2.9
40099	Desizing	15.8	38.2	42.2	5.1	-	ND	6.2

Note: A dash indicates that analyses were not performed, or that loads were not calculable (no water use data).
( ) Indicates sequence number instead of report number.
ND Indicates "Not Detected."
* Represents finishing stream from Report 10013.

TABLE V-16 (Cont.)

Report Number	Mill Type	Wastewater Discharge Rate (gal/lb)	BOD5	COD (kg/kkg)	TSS	O & G	Sulfide (g/kkg)	Total Phenols g/kkg
40103	Desizing	10.5	72.7	201.4	18.4	-	ND	3.2
40120	Desizing	9.5	118.8	-	39.6	1.66	-	-
40145	Desizing	21.8	63.6	147.3	3.6	-	454.5	102.0
40146	Desizing	11.7	41.0	96.6	8.8	-	-	-
40150	Desizing	9.6	1.4	216.2	4.2	-	ND	5.5
40156	Desizing	-	-	-	-	-	-	-
	Knit Fabric Finishing							
50030	Simple Processing	8.2	24.6	47.9	10.3	4.9	18.5	12.3
50108	Simple Processing	16.1	25.5	77.9	3.1	-	282.0	99.6
50112	Simple Processing	18.2	36.4	118.4	3.0	48.6	57.7	78.8
50116	Simple Processing	8.8	-	53.6	-	-	ND	0.007
50104*	Simple Processing	4.8	-	68.1	8.0	-	2.0	-
50013	Complex Processing	8.0	-	160.1	6.7	-	ND	3.2
50035	Complex Processing	17.7	32.5	82.7	3.7	-	1358.0	16.2
50099	Complex Processing	14.7	83.4	20.8	0.7	-	760.1	28.2
5H012	Hosiery Products	3.4	-	82.2	2.7	17.9	ND	3.1
5H027	Hosiery Products	5.6	-	38.3	1.1	15.9	ND	8.0
5H034	Hosiery Products	8.3	-	60.9	1.2	13.2	124.6	13.2
60008	Carpet Finishing	2.3	3.4	14.2	0.4	-	-	-
60031	Carpet Finishing	4.4	-	-	-	-	-	0.18
60034	Carpet Finishing	7.5	-	58.8	-	-	ND	0.62
60037	Carpet Finishing	5.6	9.3	60.7	1.7	-	ND	1.3

Note: A dash indicates that analyses were not performed, or that loads were not calculable (no water use data).
( ) Indicates sequence number instead of report number.
ND Indicates "Not Detected."
* Represents pretreatment effluent.

TABLE V-16 (Cont.)

Report Number	Mill Type	Wastewater Discharge Rate (gal/lb)	BOD5	COD (kg/kkg)	TSS	O & G	Sulfide (g/kkg)	Total Phenols g/kkg
(06443)	Stock & Yarn Finishing	0.8	-	4.9	0.4	-	2.8	-
70009	Stock & Yarn Finishing	19.3	19.3	74.0	5.3	-	ND	10.3
70072	Stock & Yarn Finishing	6.6	-	-	-	-	-	-
70081	Stock & Yarn Finishing	22.9	-	43.9	4.8	-	8.4	155.0
70087	Stock & Yarn Finishing	6.7	21.2	61.5	1.1	-	251.5	2.1
70096	Stock & Yarn Finishing	6.7	61.5	72.6	1.8	-	78.2	2.4
70120	Stock & Yarn Finishing	7.5	-	40.0	8.1	13.1	ND	-
80008	Nonwoven Manufacturing	5.6	-	10.3	1.7	1.2	ND	1.5
80011	Nonwoven Manufacturing	6.0	-	24.0	0.8	4.8	ND	0.40
80019	Nonwoven Manufacturing	1.6	-	4.5	-	-	ND	0.59
80025	Felted Fabric Processing	111.6	-	1023.8	37.2	242.0	1116.9	149.0

Note: A dash indicates that analyses were not performed.
( ) Indicates sequence number instead of report number.
ND Indicates "Not Detected."

TABLE V-17
MASS DISCHARGE RATES FOR UNTREATED WASTEWATER
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
FIELD SAMPLING DATA - MEDIAN VALUES

Subcategory	BOD5	COD	TSS	O & G	Sulfide (g/kkg)	Total Phenols g/kkg
	(kg/kkg)					
1. Wool Scouring	72.9	300.2	188.0	31.9	19.2	66.9
2. Wool Finishing	135.5	593.7	76.1	177.8	451.7	39.0
3. Low Water Use Processing						
a. General Processing	#	0.5	#	#	ND	0.02
b. Water Jet Weaving	#	#	#	#	#	#
4. Woven Fabric Finishing						
a. Simple Processing	9.1	21.1	7.3	#	ND	2.0
b. Complex Processing	48.5	161.8	5.7	#	402.5	12.2
c. Desizing	41.0	122.6	5.9	2.4	ND	6.8
5. Knit Fabric Finishing						
a. Simple Processing	25.5	68.1	5.6	26.8	18.5	45.6
b. Complex Processing	58.0	82.7	3.7	#	760.1	16.2
c. Hosiery Products	#	60.9	1.2	15.9	62.3	8.0
6. Carpet Finishing	6.4	58.8	1.1	#	ND	0.62
7. Stock & Yarn Finishing	21.2	52.7	3.3	13.1	5.6	6.3
8. Nonwoven Manufacturing	#	10.3	1.2	3.0	ND	0.59
9. Felted Fabric Processing	#	1023.8	37.2	242.0	1116.9	149.0

No data.
ND Indicates "Not Detected."

Source: Field Sampling Program, Table V-16.

TABLE V-18
TYPICAL UNTREATED WASTEWATER CONCENTRATIONS
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
SUMMARY OF HISTORICAL AND FIELD SAMPLING DATA

	Subcategory	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O&G (mg/l)	Sulfide (ug/l)	Total Phenols ug/l	Color APHA (units)	Color ADMI (units pH 7.6)
1.	Wool Scouring	1800	6900	2700	580	(500)	(1700)	(1200)	#
2.	Wool Finishing	150	650	50	(280)	(1100)	(120)	(1000)	(360)
3.	Low Water Use Processing								
	a. General Processing	380	1100	220	#	(ND)	(80)	#	#
	b. Water Jet Weaving	120	180	30	(80)	(ND)	(20)	#	(10)
4.	Woven Fabric Finishing								
	a. Simple Processing	300	900	60	70	60	50	1000	#
	b. Complex Processing	350	1200	80	50	100	180	500	#
	c. Desizing	400	1200	160	70	130	150	(1900)	(250)
5.	Knit Fabric Finishing								
	a. Simple Processing	210	770	60	90	60	110	390	(220)
	b. Complex Processing	260	830	50	50	160	110	760	(120)
	c. Hosiery Products	320	1300	80	100	560	60	450	(270)
6.	Carpet Finishing	440	1200	70	20	180	130	490	#
7.	Stock & Yarn Finishing	190	690	40	20	250	170	570	(130)
8.	Nonwoven Manufacturing	180	2400	80	(60)	(ND)	(30)	#	(90)
9.	Felted Fabric Processing	200	550	120	30	(1200)	580	#	(190)

Insufficient data to report value.
( ) Median of field sampling results.
ND Indicates "Not Detected."

Source: Tables V-12 and V-15.

TABLE V-19
TYPICAL MASS DISCHARGE RATES FOR UNTREATED WASTEWATER
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENIONAL POLLUTANTS
SUMMARY OF HISTORICAL AND FIELD SAMPLING DATA - MEDIAN VALUES

	Subcategory	BOD5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	O & G (kg/kkg)	Sulfide (g/kkg)	Total Phenols g/kkg
1.	Wool Scouring	41.8	225.7	51.9	10.3	(19.2)	(66.9)
2.	Wool Finishing	63.6	204.8	16.3	(177.8)	(451.7)	11.4
3.	Low Water Use Processing						
	a. General Processing	1.3	7.7	1.6	#	(ND)	(0.02)
	b. Water Jet Weaving	16.0	18.2	2.7	#	#	#
4.	Woven Fabric Finishing						
	a. Simple Processing	22.3	88.4	7.7	9.1	10.4	8.2
	b. Complex Processing	33.2	104.9	9.1	3.2	12.5	12.5
	c. Desizing	45.1	122.0	14.8	4.1	15.7	13.1
5.	Knit Fabric Finishing						
	a. Simple Processing	23.1	84.4	6.3	4.0	13.0	11.3
	b. Complex Processing	28.1	121.5	8.4	3.9	14.0	7.6
	c. Hosiery Products	25.8	88.4	6.1	6.6	23.8	6.6
6.	Carpet Finishing	25.6	82.3	4.7	1.1	9.4	11.3
7.	Stock & Yarn Finishing	19.5	62.1	4.5	1.7	44.1	15.0
8.	Nonwoven Manufacturing	6.7	38.4	2.2	(3.0)	(ND)	(0.59)
9.	Felted Fabric Processing	70.2	186.0	64.1	11.2	(1116.9)	247.4

( ) Median of field sampling results.
Insufficient data to report value.
ND Indicates "Not Detected."

Source: Tables V-13 and V-17.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

WASTEWATER PARAMETERS OF SIGNIFICANCE

The Agency has conducted a thorough study of the textile industry, the purpose of which is to establish effluent limitations reflecting the best practicable control technology currently available (BPT), the best available technology economically achievable (BAT), new source performance standards (NSPS) and pretreatment standards for new and for existing sources (PSNS and PSES). After completion of a review of existing regulations, a review of available literature and an evaluation of data obtained during sampling at 51 mills, the following pollutants or pollutant parameters have been identified as present in textile wastewaters and should be subject to limitation under BPT, BAT and NSPS as appropriate.

Conventional Pollutants:	BOD_5, TSS and pH.
Toxic Pollutants:	Total Chromium.
Nonconventional Pollutants:	COD, Phenols and Sulfide.

In plant specific situations the amounts and concentrations of individual pollutants, either the pollutants discussed in this section or other pollutants, may not be insignificant and should be regulated. Permit-issuing authorities may find it necessary to collect information, analyze for, or conduct bioassay testing prior to issuing a NPDES permit. Specific pollutants may be limited on a case-by-case basis when limitations are necessary to carry out the purposes of the Act.

Presented below are the reasons that pollutants present in textile wastewater have been excluded from national regulations.

Conventional Pollutants

1. The pollutant is indirectly measured by measurement for another parameter.

2. The pollutant is indirectly controlled when a selected parameter is controlled.

Toxic Pollutants

Paragraph 8 of the Settlement Agreement in _Natural Resources Defense Council, Inc._ v. _Train_, 8 ERC 2120 (D.D.C. 1976), _modified_, 12 ERC 1833 (D.D.C. 1979), provides guidance to the Agency on exclusions of specific toxic pollutants, subcategories or categories from regulation under the effluent limitations guidelines, standards of performance and pretreatment standards:

"8(a) The Administrator may exclude from regulation under the effluent limitations and guidelines, standards of performance, and/or pretreatment standards contemplated by this Agreement a specific pollutant or category or subcategory of point sources for any of the following reasons, based upon information available to him:

(i) For a specific pollutant or a subcategory or category, equally or more stringent protection is already provided by an effluent, new source performance, or pretreatment standard or by an effluent limitation and guideline promulgated pursuant to Section(s) 301, 304, 306, 307(a), 307(b) or 307(c) of the Act;

(ii) For a specific pollutant, except for pretreatment standards, the specific pollutant is present in the effluent discharge solely as a result of its presence in intake waters taken from the same body of water into which it is discharged and, for pretreatment standards, the specific pollutant is present in the effluent which is introduced into treatment works (as defined in Section 212 of the Act) which are publicly owned solely as a result of its presence in the point source's intake waters, <u>provided</u> however, that such point source may be subject to an appropriate effluent limitation for such pollutant pursuant to the requirements of Section 307;

(iii) For a specific pollutant, the pollutant is not detectable (with the use of analytical methods approved pursuant to 304(h) of the Act, or in instances where approved methods do not exist, with the use of analytical methods which represent state-of-the-art capability) in the direct discharges or in the effluents which are introduced into publicly-owned treatment works from sources within the subcategory or category; or is detectable in the effluent from only a small number of sources within the subcategory and the pollutant is uniquely related to only those sources; or the pollutant is present only in trace amounts and is neither causing nor likely to cause toxic effects; or is present in amounts too small to be effectively reduced by technologies known to the Administrator; or the pollutant will be effectively controlled by the technologies upon which are based other effluent limitations and guidelines, standards of performance, or pretreatment standards; or

(iv) For a category or subcategory, the amount and the toxicity of each pollutant in the discharge does not justify developing national regulations in accordance with the schedule contained in Paragraph 7(b).

(b) The Administrator may exclude from regulation under the pretreatment standards contemplated by this Agreement all point sources within a point source category or point source subcategory:

(i) if 95 percent or more of all point sources in the point source category or subcategory introduce into treatment works (as defined in Section 212 of the Act) which are publicly owned, only pollutants which are susceptible to treatment by such treatment works and which do not interfere with, do not pass through, or are not otherwise incompatible with such treatment works; or

(ii) if the toxicity and amount of the incompatible pollutants (taken together) introduced by such point sources into treatment works (as defined in Section 212 of the Act) that are publicly owned is so insiginficant as not to justify developing a pretreatment regulation..."

Nonconventional Pollutants

1. The pollutant is indirectly measured by measurement for another parameter.

2. The pollutant is indirectly controlled when a selected parameter is controlled.

3. The pollutant is not of uniform national concern (i.e., the pollutant is present at only a small number of sources and is uniquely related to those sources) and should be regulated on a case-by-case basis, as appropriate.

4. The pollutant is present but cannot be effectively reduced by technologies known to the Administrator.

Summary of Previous Regulations

Toxic nonconventional and conventional pollutants have been limited under promulgated effluent limitations guidelines and standards applicable to wastewater discharges from the textile mills point source category. Table VI-1 presents a summary of the pollutants that have been regulated in previous Agency rulemaking for each of the subcategories of the industry.

SELECTION OF POLLUTANTS OF CONCERN

Toxic Pollutants

In addition to the pollutants controlled by existing regulations, the Agency has investigated the potential for discharge of other toxic pollutants as a part of EPA's ongoing studies. A total of 129 specific toxic pollutants have been the subject of extensive study (see Section II). A sampling program has been conducted

TABLE VI-1

SUMMARY OF POLLUTANTS CONTROLLED BY
PREVIOUS EFFLUENT LIMITATIONS GUIDELINES

	Conventional Pollutants				*Toxic Pollutant*	*Nonconventional Pollutants*			
Subcategory	BOD_5	TSS	pH	Oil and Grease	Total Chromium	COD	Sulfide	Phenols	Color*
Wool Scouring	x	x	x	x	x	x	x	x	x
Wool Finishing	x	x	x		x	x	x	x	x
Low Water Use Processing	x	x	x			x			
Woven Fabric Finishing	x	x	x		x	x	x	x	x
Knit Fabric Finishing	x	x	x		x	x	x	x	x
Carpet Finishing	x	x	x		x	x	x	x	x
Stock and Yarn Finishing	x	x	x		x	x	x	x	x
Nonwoven Manufacturing	(New subcategory, no previous regulation.)								
Felted Fabric Finishing	(New subcategory, no previous regulation.)								

* *Color was regulated only under previously promulgated BAT.*

that has led to the exclusion of many specific toxic pollutants from regulation based on the guidance provided in Paragraph 8 of the Settlement Agreement.

A summary of toxic pollutants detected in textile mill untreated wastewaters is presented in Table V-7. A summary of analytical results for the individual pollutants detected in untreated wastewater and biologically treated effluents is presented in Table V-8. Table V-9 (a through n) presents a summary of toxic pollutant analyses by subcategory.

On December 18, 1980, EPA submitted an affidavit to the court explaining that the Agency decided not to regulate 102 of the 129 toxic pollutants under the authority of Paragraph 8(a)(iii) of the modified Settlement Agreement. The Agency excluded 65 of the toxic pollutants from regulation because "they are not detectable by Section 304(h) analytical methods or other state-of-the-art methods;" 22 pollutants because "they are detected at only a small number of sources within a subcategory and are uniquely related to those sources;" and 15 because "they are present only in trace amounts and neither cause nor are likely to cause toxic effects." These 102 pollutants are listed in Table VI-2.

The remaining 27 toxic pollutants have been assessed to identify those pollutants of potential concern and to determine if any should be subject to limitation through the implementation of uniform national standards. Table VI-3 presents projected treatability levels for the 27 compounds not previously excluded from regulation. Analytical results for each compound were compared to the treatability levels to determine the frequency and extent that these compounds were found in excess of anticipated treatability.

A summary of pollutants that were found in excess of treatability in either raw or biologically treated effluent in each subcategory is presented in Table VI-4. A summary of the data assessment including number of samples analyzed, number of samples in excess of treatability, concentration range, and average concentrations is presented in Table VI-5.

Based on the results of the analysis of toxic pollutant data presented in Table VI-5, EPA decided to exclude 17 toxic pollutants from regulation because "they are present in trace amounts too small to be effectively reduced by technologies known to the Administrator." The data in Table VI-5 show that these pollutants have been found in excess of treatability in raw and treated effluents in only a few subcategories and in only a small percentage of samples. Two pollutants have been found at "only a small number of sources within a subcategory and are uniquely related to those sources." Six pollutants are "effectively controlled by the technologies on which other effluent limitations and standards are based." (see Table VI-6) Although these pollutants were found above treatability in raw wastewaters

TABLE VI-2
POLLUTANTS INITIALLY EXCLUDED FROM REGULATION*

Pursuant to Paragraph 8(a)(iii) of the Settlement Agreement, the following 65 toxic pollutants are excluded from regulation in all subcategories because they were not detected in treated effluents by Section 304(h) analytical methods or other state-of-the-art methods:

benzidine
3,3-dichlorobenzidine
methyl bromide
2,4-dinitrophenol
N-nitrosodimethylamine
phenanthrene
carbon tetrachloride
1,1,2-trichloroethane
chloroethane
4-chlorophenyl phenyl ether
dichlorodifluoromethane
isophorone
nitrobenzene
4,6-dinitro-o-cresol
acenaphthylene
aldrin
chlordane
4,4' -DDE
4,4' -DDD
alpha-endosulfan
beta-endosulfan
endosulfan sulfate
endrin
endrin aldehyde
heptachlor
heptachlor epoxide
alpha-BHC
beta-BHC
gamma-BHC (lindane)
delta-BHC
toxaphene
acrolein
hexachloroethane
1,1,2,2-tetrachloroethane
bis (chloromethyl) ether
bis (2-chloroethyl) ether
2-chloroethyl vinyl ether
1,3-dichlorobenzene
1,2-trans-dichloroethylene
1,3-dichloropropylene
2,4-dinitrotoluene
fluoranthene
4-bromophenyl phenyl ether
bis (2-chloroisopropyl) ether
bis (2-chloroethoxy) methane
bromoform
chlorodibromomethane
hexachlorobutadiene
hexachlorocyclopentadiene
di-n-octyl phthalate
1,2-benzanthracene
benzo(a)pyrene
chrysene
1,12-benzoperylene
1,2,5,6-dibenzanthracene
indeno (1,2,3-cd)pyrene
PCB 1242
PCB 1254
PCB 1221
PCB 1232
PCB 1248
PCB 1260
PCB 1016
asbestos
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

* By affadavit dated December 18, 1980 to parties to the Settlement Agreement.

TABLE VI-2 (cont.)

Pursuant to Paragraph 8(a)(iii) of the Settlement Agreement, the following 22 toxic pollutants are excluded from regulation in all subcategories because they were detected in treated effluents by Section 304(h) analytical methods or other state-of-the-art methods at only a small number of sources and were uniquely related to those sources. The following 20 pollutants were found at only one plant at concentrations less than the nominal detection limit in the treated effluent:

1,2-dichloroethane
1,1-dichloroethane
2-chloronaphthalene
2-chlorophenol
1,1-dichloroethylene
1,2-dichloropropane
2,4-dimethylphenol
2,6-dinitrotoluene
1,2-diphenylhydrazine
methyl chloride
dichlorobromomethane
2-nitrophenol
4-nitrophenol
3,4-benzofluoranthene
11,12-benzofluoranthene
fluorene
vinyl chloride
dieldrin
4,4' -DDT
beryllium

The following two pollutants were detected only in the treated effluents and not in the raw effluents.

trichlorofluoromethane
N-nitrosodi-n-propylamine

Pursuant to Paragraph 8(a)(iii) of the Settlement Agreement, the following 15 toxic pollutants are excluded from regulation in all subcategories because they were detected in treated effluents by Section 304(h) analytical methods or other state-of-the-art methods at only trace amounts not likely to cause toxic effects:

acenaphthene
chlorobenzene
hexachlorobenzene
1,1,1-trichloroethane
1,4-dichlorobenzene
2,4-dichlorophenol
methylene chloride
N-nitrosodiphenylamine
butyl benzyl phthalate
di-n-butyl phthalate
diethyl phthalate
dimethyl phthalate
anthracene
pyrene
thallium

TABLE VI-3
PROJECTED TREATABILITY FOR TOXIC POLLUTANTS

	Toxic Pollutants	Compound Concentration Used for Comparison	Source for Concentration Used
3.	acrylonitrile	100	*
4.	benzene	50	*
8.	1,2,4-trichlorobenzene	10	*
21.	2,4,6-trichlorophenol	25	*
22.	parachlorometacresol	50	*
23.	chloroform	100	*
25.	1,2-dichlorobenzene	50	*
38.	ethylbenzene	50	*
55.	naphthalene	50	*
64.	pentachlorophenol	10	*
65.	phenol	50	*
66.	bis(2-ethylhexyl)phthalate	10	*
85.	tetrachloroethylene	50	*
86.	toluene	50	*
87.	trichloroethylene	100	*
114.	antimony	80	*
115.	arsenic	830	***
118.	cadmium	270	***
119	chromium	2500	**
120.	copper	1800	**
121.	cyanide	280	**
122.	lead	230	**
123.	mercury	100	***
124.	nickel	1260	**
125.	selenium	20	****
126.	silver	130	***
128.	zinc	1800	**

* Murray P. Strier, "Treatability of Organic Priority Pollutants - Part C - Their Estimated (30 Day Average) Treated Effluent Concentration - A Molecular Engineering Approach, "Table I, 1978.

** Treatability levels as specified in the Pretreatment Regulations for the Electroplating Industry point source category.

*** Development Document for Proposed Effluent Limitations Guidelines and Standards for the Metal Finishing Point Source Category, EPA 440/1-82/091b, August 1982.

**** Memorandum from Ben Honaker, Project Officer, Metals and Machinery Branch, Effluent Guidelines Division, August 1982.

TABLE VI-4
SUMMARY OF TOXIC POLLUTANTS OF POTENTIAL CONCERN

Subcategory	3	4	8	21	22	23	25	38	55	64	65	66	85	86	87	114	115	118	119	120	121	122	123	124	125	126	128
									Toxic Pollutants																		
Wool Scouring			x							x	x			x	x	x						x	x	x		x	x
Wool Finishing			x				x	x		x		x	x													x	
Low Water Use (General)											x	x															x
Woven Fabric Finishing																											
Simple			x					x		x	x	x		x													
Complex		x						x		x	x	x		x													
Desizing		x	x	x			x	x	x	x	x	x	x	x	x	x			x	x							x
Knit Fabric Finishing																											
Simple			x			x		x	x		x	x	x	x	x	x											
Complex			x			x		x	x			x	x	x		x											x
Hosiery	x			x		x					x	x															
Carpet Finishing						x			x		x	x				x											
Stock and Yarn Finishing			x			x	x			x		x	x		x	x											
Nonwoven Manufacturing		x				x						x		x													
Felted Fabric Processing									x		x	x													x		

x indicates detected above anticipated treatability levels in raw or treated effluent.

Toxic Pollutants are as Follows:

3. acrylonitrile
4. benzene
8. 1,2,4-trichlorobenzene
21. 2,4,6-trichlorophenol
22. parachlorometa cresol
23. chloroform
25. 1,2-dichlorobenzene
38. ethylbenzene
55. napthalene
64. pentachlorophenol
65. phenol
66. bis(2-ethylhexyl)pthalate
85. tetrachloroethylene
86. toluene
87. trichlorethylene
114. antimony
115. arsenic
118. cadimum
119. chromium
120. copper
121. cyanide
122. lead
123. mercury
124. nickel
125. silenium
126. silver
128. zinc

TABLE VI-5
SUMMARY OF DATA ASSESSMENT - POLLUTANTS OF POTENTIAL CONCERN

	Number of Samples Analyzed		Concentration Range µg/l		Average Concentrations µg/l		Number of Samples in Excess of Treatability Levels	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
3. Acrylonitrile								
Knit Fabric Finishing (Hosiery Products)	4	1	0-1600	400	1600	400	1	1
4. Benzene								
Woven Fabric Finishing (Complex)	3	6	31	6-64	31	28	0	1
Woven Fabric Finishing (Desizing)	28	23	1-170	1-33	49	17	4	0
Nonwoven Manufacturing	3	0	5-200	--	103	--	1	-
8. 1,2,4 Trichlorobezene								
Wool Scouring	0	1	--	0-32	--	7	0	32
Wool Finishing	8	4	90-14,000	46-1900	4195	8	2	1257
Woven Fabric Finishing (Simple)	3	--	28	--	28	0	1	--
Woven Fabric Finishing (Desizing)	26	0	45-156	2-10	101	23	2	6
Knit Fabric Finishing (Simple)	6	0	120-2700	6	1045	8	3	6
Knit Fabric Finishing (Complex)	3	2	190	1-916	190	21	1	237
Stock and Yarn Finishing	7	3	270	19-43	270	6	1	27
21. 2,4,6-Trichlorophenol								
Woven Fabric Finishing (Desizing)	26	--	1-94	--	44	0	2	--
Knit Fabric Finishing (Hosiery)	4	--	27	--	27	0	1	--
23. Chloroform								
Knit Fabric Finishing (Simple)	6	0	22-498	2-2	260	8	1	2
Knit Fabric Finishing (Complex)	3	2	17-71	3-1020	44	21	0	221
Knit Fabric Finishing (Hosiery)	4	--	140-642	--	391	0	2	--
Carpet Finishing	4	--	5-280	--	143	0	1	--
Stock and Yarn Finishing	7	0	1-410	5	86	8	1	5
Nonwoven Manufacturing	3	--	160	--	160	0	1	--

TABLE VI-5 (Continued)

	Number of Samples Analyzed		Concentration Range µg/l		Average Concentrations µg/l		Number of Samples in Excess of Treatability Levels	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
25. 1,2-Dichlorobenzene								
Wool Finishing	8	8	10-460	1-20	160	7	3	0
Woven Fabric Finishing (Desizing)	26	23	1-62	1-1	17	1	1	0
Stock and Yarn Finishing	7	8	1-56	1-5	29	3	1	0
38. Ethylbenzene								
Wool Finishing	8	7	6-1770	1-75	267	21	1	1
Woven Fabric Finishing (Simple)	3	0	5-460	--	233	--	1	--
Woven Fabric Finishing (Complex)	3	6	18-2835	1-29	960	11	1	0
Woven Fabric Finishing (Desizing)	28	23	1-19,000	1-3018	1692	440	15	2
Knit Fabric Finishing (Simple)	6	8	2-2600	3-4	711	4	4	0
Knit Fabric Finishing (Complex)	3	22	852-1209	1-278	1031	78	2	2
55. Napthalene								
Woven Fabric Finishing (Desizing)	26	23	1-2079	1-22	468	12	9	0
Knit Fabric Finishing (Simple)	6	0	1-51	--	32	--	1	--
Knit Fabric Finishing (Complex)	3	21	2-210	2-255	118	87	2	1
Carpet Finishing	5	0	95-260	--	198	--	3	--
Felted Fabric Processing	0	1	--	56	--	56	--	1
64. Pentachlorophenol								
Wool Scouring	5	--	0-24	--	24	--	1	--
Wool Finishing	8	8	29-71	1-2	50	2	2	0
Woven Fabric Finishing (Simple)	3	6	32-42	15-66	37	41	2	2
Woven Fabric Finishing (Complex)	3	6	20	56	20	56	1	1
Woven Fabric Finishing (Desizing)	26	23	2-310	7-16	75	10	9	1
Stock and Yarn Finishing	0	8	--	13-23	--	18	--	2

TABLE VI-5 (Continued)

	Number of Samples Analyzed		Concentration Range µg/l		Average Concentrations µg/l		Number of Samples in Excess of Treatability Levels	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
65. Phenol								
Wool Scouring	6	8	10-4930	8-16	1222	11	5	0
Woven Fabric Finishing (Simple)	3	6	40-147	12-24	94	18	1	0
Woven Fabric Finishing (Complex)	0	6	--	10-103	--	38	--	1
Woven Fabric Finishing (Desizing)	26	23	1-295	1-31	58	15	6	0
Knit Fabric Finishing (Simple)	6	0	1-55	--	17	--	1	--
Knit Fabric Finishing (Hosiery)	4	1	3-59	14	39	14	2	0
Carpet Finishing	5	4	1-68	2-50	40	30	3	0
Felted Fabric Processing	1	1	85	2	85	2	1	0
Low Water Use Processing (General)	1	1	82	10	82	10	1	0
66. Bis(2-ethylhexyl)pthalate								
Wool Finishing	8	8	1-160	6-760	51	204	2	7
Woven Fabric Finishing (Simple)	3	6	5-860	10-10	382	10	2	0
Woven Fabric Finishing (Complex)	3	6	9-138	1-24	90	15	2	4
Woven Fabric Finishing (Desizing)	26	23	5-1449	2-231	210	44	20	9
Knit Fabric Finishing (Simple)	6	8	1-430	5-50	157	20	2	2
Knit Fabric Finishing (Complex)	3	21	30-135	6-109	83	34	3	14
Knit Fabric Finishing (Hosiery)	4	1	22	172	22	172	1	1
Carpet Finishing	5	4	19-400	10-27	121	18	4	3
Stock and Yarn Finishing	7	8	3-490	2-230	90	89	3	7
Nonwoven Manufacturing	3	0	14	--	14	--	1	--
Felted Fabric Processing	1	1	26	18	26	18	1	1
Low Water Use (General Processing)	1	1	26	3	26	3	1	0
85. Tetrachloroethylene								
Wool Finishing	8	8	2-1126	1-5	193	3	1	0
Woven Fabric Finishing (Desizing)	28	23	1-26	1-51	15	14	0	1
Knit Fabric Finishing (Simple)	6	8	9-1108	8-27	438	17	3	0
Knit Fabric Finishing (Complex)	3	22	39-890	1-370	465	194	2	3
Stock and Yarn Finishing	7	8	1-310	3	156	3	1	0

TABLE VI-5 (Continued)

	Number of Samples Analyzed		Concentration Range µg/l		Average Concentrations µg/l		Number of Samples in Excess of Treatability Levels	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
86. Toluene								
Wood Scouring	6	8	10-62	1-10	31	7	1	0
Woven Fabric Finishing (Simple)	3	6	8-620	1-140	216	48	1	1
Woven Fabric Finishing (Complex)	3	6	28-303	1-33	204	15	2	0
Woven Fabric Finishing (Desizing)	28	23	2-3200	1-111	490	16	7	1
Knit Fabric Finishing (Simple)	6	8	4-140	1-1	45	1	2	0
Knit Fabric Finishing (Complex)	3	22	3-61	1-22	33	6	1	0
Noncover Manufacturing	3	0	3-83	--	43	--	1	--
87. Trichloroethylene								
Wool Finishing	8	8	2-187	2-4	39	3	1	0
Woven Fabric Finishing (Desizing)	28	23	1-5600	1-130	812	42	1	1
Knit Fabric Finishing (Simple)	6	8	5-840	37-41	322	39	2	0
Stock Yarn Finishing	7	0	1-229	--	80	--	1	--
114. Antimony								
Wool Scouring	5	6	2-4	21-540	3	153	0	1
Woven Fabric Finishing (Desizing)	25	19	1-180	1-96	17	21	1	1
Knit Fabric Finishing (Simple)	5	7	1-186	1-684	59	230	1	5
Knit Fabric Finishing (Complex)	3	22	57-515	31-867	286	452	1	11
Carpet Finishing	2	2	52	11-105	52	58	0	1
Stock and Yarn Finishing	7	8	5-200	3-177	94	95	1	4
115. Arsenic								
Wool Scouring	4	6	162-225	4-160	193	37	3	0
Wool Finishing	8	6	2-200	2-60	37	17	1	0
Woven Fabric Finishing (Complex)	3	4	120	3	120	3	1	0
118. Cadmium								
Wool Scouring	5	7	9-13	3-130	11	26	0	0

TABLE VI-5 (Continued)

	Number of Samples Analyzed		Concentration Range µg/l		Average Concentrations µg/l		Number of Samples in Excess of Treatability Levels	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
119. Chromium								
Woven Fabric Finishing (Desizing)	26	0	4-4930	--	787	--	7	--
120. Copper								
Woven Fabric Finishing (Desizing)	26	23	8-3120	5-100	656	32	5	0
122. Lead								
Wool Scouring	5	7	18-752	57-3500	435	929	4	1
124. Nickel								
Wool Scouring	5	7	54-304	28-2000	134	452	0	1
125. Selenium								
Knit Fabric Finishing (Hosiery)	4	1	38-736	97	275	97	1	0
Felted Fabric Processing	2	2	57	32	57	32	1	1
126. Silver								
Wool Scouring	5	7	1-65	1-500	17	130	0	1
Wool Finishing	8	8	1-47	6-140	24	73	0	1
128. Zinc								
Wool Scouring	5	7	190-1969	25-1500	832	299	1	0
Wool Finishing	8	8	51-7500	320-38400	1307	6833	1	3
Woven Fabric Finishing (Desizing)	26	23	56-7900	27-5100	999	502	4	1
Knit Fabric Finishing (Complex)	3	22	75-200	42-5160	132	614	0	2
Low Water Use Processing (General)	1	1	120	2300	120	2300	0	1

TABLE VI-6
TOXIC POLLUTANTS EXCLUDED

(1) Toxic pollutants present in trace amounts too small to be effectively reduced by the technologies known to the Administrator:

2,4,6-trichlorophenol
chloroform
1,2,4-trichlorobenzene
1,2-dichlorobenzene
pentachlorophenol
parachlorometacresol
tetrachloroethylene
arsenic
cadmium
copper
cyanide
lead
mercury
nickel
selenium
silver
zinc

(2) Toxic pollutants detected at only a small number of sources within a subcategory and uniquely related to those sources:

acrylonitrile
antimony

(3) Toxic pollutants effectively controlled by the technologies on which other effluent limitations and standards are based:

benzene
trichloroethylene
ethylbenzene
naphthalene
phenol
toluene

(4) Toxic pollutant not detectable with the use of analytical methods approved pursuant to section 304(h) of the Act:

bis(2-ethylhexyl)phthalate

they were consistently removed in biological treatment and anticipated treatability levels were exceeded in only a few instances.

Pollutants Found in Trace Amounts For each of the pollutant found in trace amounts too small to be effectively reduced by technologies known to the administrator, possible sources and analytical results are discussed below.

2,4,6-Trichlorophenol - The compound 2,4,6-trichlorophenol belongs to the chemical class known as chlorinated phenols. This class represents a group of commercially produced, substituted phenols and cresols referred to as chlorophenols and chlorocresols. Chlorinated phenols are used as intermediates in the synthesis of dyes, pigments, phenolic resins, pesticides and herbicides. Certain chlorophenols also are used directly as flea repellents, fungicides, wood preservatives, mold inhibitors, antiseptics, disinfectants, and antigumming agents for gasoline. Sources of trichlorophenol in the textile industry include possible usage as a preservative and as a constituent or impurity in carrier systems for dyeing polyester. Out of 418 questionnaire returns, 7 indicated "suspected presence" in mill wastewaters. Trichlorophenol was detected in the wastes at only five textile mills during the field sampling program. It was not detected above treatability levels in any biologically treated effluent samples.

Chloroform - The major uses of chloroform are as a solvent and as an intermediate in the production of refrigerants, plastics and pharmaceuticals. Chloroform seems to be ubiquitous in the environment in trace amounts; discharges into the environment result largely from chlorination treatment of water and wastewater.

Sources of chloroform reported by the textile industry include its use in dyeing operations and in the laboratory. Only 7 out of 418 questionnaire returns indicated "known or suspected presence" of chloroform. Although chloroform was occasionally found above treatability levels in raw wastes it was found above treatability levels only twice in biologically treated effluents.

1,2,4-Trichlorobenzene - The compound 1,2,4-trichlorobenzene is a chlorinated benzene and is one of the class of aromatic organic compounds characterized by the substitution of from one to six chlorine atoms on the benzene nucleus. Other trichlorobenzene isomers are 1,2,3-trichlorobenzene, and 1,3,5-trichlorobenzene but these are not used in significant quantities. The compound has seen use as a dye carrier in the textile industry, a herbicide intermediate, a heat transfer medium, a dielectric fluid in transformers, a degreaser, a lubricant, and as a potential insecticide against termites. During the period 1973-1974, production and use of trichlorobenzenes resulted in approximately 8,182 metric tons (7,421 tons) entering the aquatic environment.

Sources of trichlorobenzene reported by the textile industry include usage as a dye carrier in dyeing polyester fiber, laboratory operations, scouring in the dyeing process, and as a raw material. Out of 418 questionnaire returns, 86 indicated "known or suspected presence" in mill wastewaters. 1,2,4-Trichlorobenzene was found above treatability in only one effluent sample in the wool scouring subcategory. It was found at high levels in one plant in the wool scouring subcategory and not detected at the other wool scouring plant. Only two of 21 effluent samples at one plant were above treatability in the knit fabric finishing subcategory, while only one raw waste sample was found above treatability level. Although three final effluent samples were found above treatability levels in the stock and yarn finishing subcategory, they were at one plant. Only one raw waste sample was detected above treatability.

<u>1,2-Dichlorobenzene</u> - The compound 1,2-dichlorobenzene belongs to the chemical class known as dichlorobenzenes. This class of compounds is represented by three isomers: 1,2-dichloro-, 1,3-dichloro- and 1,4-dichlorobenzene. Both 1,2-dichloro- and 1,4-dichlorobenzene are produced almost entirely as byproducts from the production of monochlorobenzene. The major uses of 1,2-dichlorobenzene are as a process solvent in the manufacture of toluene di-isocyanate,and as an intermediate in the synthesis of dyestuffs, herbicides and degreasers.

In the survey carried out by DETO, 1,2-dichlorobenzene was judged to be present in some commerical dyes, but at levels less than 0.1 percent. This is the only reported source of this compound in textile mill wastewaters. Out of 418 questionnaire returns, 18 indicated "known or suspected presence" in the wastewaters. 1,2-dichlorobenzene was not found above treatability levels in textile mills biological effluent samples.

<u>Pentachlorophenol</u> - Pentachlorophenol (PCP) is a commercially produced bactericide, fungicide and slimicide used primarily for the preservation of wood, wood products and other materials. As a chlorinated hydrocarbon, its biological properties have also resulted in its use as a herbicide, insecticide and molluscicide.

Pentachlorophenol is used in the textile industry as a preservative in dyes. In the DETO survey results, this was one of six toxic pollutants that could be expected in some commerical dyes at levels greater than 0.1 percent, resulting in possible raw textile wastewater concentrations in the 100 to 1,000 ug/l range. Out of 418 questionnaire returns, 17 indicated "known or suspected presence" in mill wastewaters. Pentachlorophenol was detected above treatability in only 4 of 35 effluent samples in the woven fabric finishing and in 2 of 8 effluent samples in the stock and yarn finishing subcategory. It was not found above treatability in either raw waste or treated effluent samples in any of the other textiles subcategories.

Parachlorometacresol - Parachlorometacresol belongs to the chemical class known as chlorinated phenols. This class represents a group of commercially produced substituted phenols and cresols referred to as chlorophenols and chlorocresols. Chlorinated phenols are used as intermediates in the synthesis of dyes, pigments, phenolic resins, pesticides, and herbicides. Certain chlorophenols also are used directly as flea repellents, fungicides, wood preservatives, mold inhibitors, antiseptics, disinfectants, and antigumming agents for gasoline.

Sources of parachlorometacresol reported by the industry include its possible use as a biocide or disinfectant in dyestuffs, dye carrier systems, and in industrial cleaning compounds. The survey of the dye manufacturing industry conducted by DETO indicated that this compound was one of six toxic pollutants that could be present at levels greater than 0.1 percent in some commerical dyes, resulting in possible raw waste loadings from 100 to 1,000 ug/l. Of 418 questionnaire returns, only 3 indicated "suspected presence" in the mill wastewater. Parachlorometacresol was not found above treatability levels in either raw waste or treated effluent.

Tetrachloroethylene - (Tetrachloroethylene, (1,1,2,2-tetrachloroethylene, perchloroethylene, PCE) is a colorless, nonflammable liquid used primarily as a solvent in dry cleaning industries. It is used to a lesser extent as a degreasing solvent in metal industries. Tetrachloroethylene is widespread in the environment, and is found in water, aquatic organisms, air, foodstuffs and human tissues, in micrograms per liter quantities. The highest environmental levels of PCE are found in commercial dry cleaning and metal degreasing industries.

Although PCE is released into water via aqueous effluents from production plants, consumer industries, and househould sewage, its level in ambient water is reported to be minimal because of its high volatility.

Tetrachloroethylene is used in the textile industry as a dry cleaning solvent and in some dyeing operations as part of the carrier systems or scouring formulations. Out of 418 questionnaire returns, 29 indicated "known or suspected presence" in mill wastes. Tetrachloroethylene was detected slightly above treatability only once in the wool finishing subcategory effluent. It was detected above treatability in only 3 of 22 effluent samples in the knit fabric finishing (complex) subcategory. All three were at the same facility.

Arsenic - Arsenic is a naturally occurring element often referred to as a metal, although chemically classified as a metalloid. Environmental concentrations of arsenic have been reported at 0.0005 percent in the earth's crust and 3 u/gl in sea water. Analysis of 1577 surface waters samples in the U.S. showed arsenic present in 87 samples, with concentrations ranging forom 5 to 336 ug/l, and a mean level of 64 ug/l (16). Arsenic and its compounds are used in the manufacturing of glass, cloth, and electrical semiconductors, as fungicides and wood preservatives, as growth stimulants for plants and animals, and in veterinary applications.

Individual textile mills reported likely sources of arsenic in their wastewaters as dyes and "raw materials." Out of 418 questionnaire responses, 16 indicated "known or suspected presence" in mill wastes. The survey carried out by DETO confirmed that some commerical dyes contain arsenic; likely levels are less than 0.1 percent. Other possible uses include its presence in fungicides and specialty chemicals. Arsenic was not detected at appreciable levels in any mill water supplies sampled. Arsenic was not detected above treatability in any biologically treated effluent samples.

Cadmium - Cadmium is a soft, white metal that dissolves readily in mineral acids. Biologically, it is a non-essential element of high toxic potential. It occurs in nature chiefly as a sulfide salt, frequently in association with zinc and lead ores. Accumulations of cadmium in soils in the vicinity of mines and smelters may result in high local conentrations in nearby waters. The salts of the metal also may occur in wastes from electroplating plants, pigment works, and textile and chemical industries. Seepage of cadmium from electroplating plants has resulted in groundwater cadmium concentrations of 0.01 to 3.2 mg/l.

Dissolved cadmium was found in less than 3 percent of 1,577 U.S. surface water samples with a mean concentration of slightly under 10 ug/l. Most fresh waters contain less than 1 ug/l cadmium and most analyses of seawater indicate an average concentration of about 0.15 ug/l (16).

Sources of cadmium reported by individual textile mills include pigments, dyes, nylon carpet processing, and "raw materials", including dirt in raw wool. Cadmium was one of the toxic pollutants in the DETO survey that could be present in dyes at levels less than 0.1 percent. Of 418 questionnaire returns, 24 indicated "known presence" and 17 indicated "suspected presence" in mill wastes. In the field sampling program cadmium was measured above detectability in only 1 of the 12 water supplies sampled. It was not found above treatability levels in any final effluent samples.

Copper - Copper is a soft heavy metal that is ubiquitous in its distribution in rocks and minerals of the earth's crust. In nature, copper occurs usually as sulfide and oxide salts and occasionally as metallic copper. Weathering and solution of these natural copper minerals result in background levels of copper in natural surface waters at concentrations generally well below 20 ug/l. Higher concentrations of copper are usually from anthropogenic sources. These sources include corrosion of brass and copper pipe by acidic waters, industrial effluents and fallout, sewage treatment plant effluents and the use of copper compounds as aquatic algicides.

A five year study of natural surface waters in the U.S. revealed copper concentrations ranging from less than 10 ug/l (the limit of detection) to 280 ug/l, with a mean value for U.S. waters of 15 ug/l. Values from 0.6 ug/l to 4.3 ug/l have been reported in seawater (16).

Sources of copper reported by individual textile mills include pigments, dyestuffs, and the mill plumbing system. The DETO survey results indicated that copper may be present in some commerical dyes at levels of 3 to 4 percent. Because the copper is an integral part of the dye molecule, most of it should be exhausted from the dye bath onto the fiber being dyed. Of 418 questionnaire returns, 87 indicated "known presence" and 79 indicated "suspected presence" in the mill wastewaters. In the field sampling program, copper was not detected in nine of the twelve water supply samples. Only one sample had more than 11 ug/l. Copper was found above treatability levels in only 5 of 26 raw waste samples, all in the woven fabric finishing subcategory and was not found above treatability levels in samples of treated effluent from any mill.

<u>Cyanide</u> - Cyanide compounds are almost universally present where life and industry are found. Besides being very important in a number of manufacturing processes, they are found in many plants and animals as metabolic intermediates that generally are not stored for long periods of time.

Possible sources of cyanide reported by individual textile mills include dyestuffs and "raw materials." The ATMI Task Group suggested that cyanide is probable in some waste streams, originating in laboratory and specialty chemicals. Cyanide was not among the 25 toxic pollutants identified in the DETO survey as possibly present in commerical dyes. Of 418 questionnaire returns, 16 indicated either "known or suspected presence" in mill wastewaters. In the field sampling program, cyanide was at less than 2 ug/l in 9 of the 12 water supply samples with the maximum level at 22 ug/l. Cyanide was not detected above treatability levels in any raw waste or final effluent samples.

<u>Lead</u> - Lead is a naturally occurring metal that makes up 0.002 percent of the earth's crust. The reported concentration of lead in seawater of 35 parts per thousand salinity is 0.03 ug/l, while available data indicate that the mean natural lead content of the world's lakes and rivers ranges from 1 to 10 ug/l.

Analyses of over 1500 stream samples from 1962 to 1967 found lead in 19.3 percent of the samples, with concentrations ranging from 2 to 140 ug/l, and a mean value of 23 ug/l (16).

Lead is used in the metallurgy of steel and other metals; in ceramics, plastics and electronic devices; in construction materials and in x-ray and atomic radiation protection devices.

Sources of lead reported by individual textile mills include pigments, process chemicals, "raw materials," and tramp impurities in dyes. The DETO survey results indicated that lead may be present in some commerical dyes at levels less than 0.1 percent. Of 418 questionnaire returns, 34 indicated "known presence" and 27 indicated "suspected presence" in mill wastewaters. In the field sampling program, lead was either not detected or detected at less than 5 ug/l in 10 of the 12 water supply samples measured. Two samples had lead levels of 37 and 45 ug/l, respectively. Lead was only detected above treatability in the wool scouring subcategory in four raw waste samples and one treated effluent sample.

<u>Mercury</u> - Mercury, a silver-white metal that is a liquid at room temperature, can exist in three oxidation states: elemental, mercurous and mercuric; it can be part of both inorganic and organic compounds.

Sources of mercury reported by individual textile mills include pigments, dyes and "raw materials", including impurities in caustic soda. The ATMI Task Group suggested that mercury is probably present in some textile mill wastewaters, originating in dyes and specialty chemicals.

The DETO survey results included mercury among the toxic pollutants possibly present in some commerical dyes at levels less than 0.1 percent. Of 418 questionnaire returns, 19 indicated "known presence" and 15 indicated "suspected presence" in mill wastewaters. In the field sampling program, mercury was detected above minimum detectable levels in only 1 of the 12 water supply samples tested, at 0.79 ug/l. Mercury was not detected above treatability levels in either raw wastes or treated effluent.

<u>*Nickel*</u> *- Nickel is a silver-white ductile metal commonly* occurring in natural waters in the +2 valence state in concentrations ranging from a few micrograms per liter, to more than 100 ug/l. Nickel seldom is found in groundwater, and if present, probably exists in colloidol form.

Sources of nickel reported by individual textile mills include pigments, dyes, processing chemicals, and "raw materials." The DETO survey confirmed that nickel may be present in some commercial dyes at levels less than 0.1 percent. Nickel may also originate from plating operations in resurfacing of printing rolls. Of 418 questionnaire survey returns, 28 indicated "known presence" and 23 indicated "suspected presence" in the mill wastewaters. In the field sampling program, nickel was measured at greater than 5 ug/l in 2 of the 12 water supplies sampled; one at 41 ug/l and the other at 47 ug/l. Nickel was not found above treatability levels in any raw waste samples and was found only once in a wool scouring subcategory final effluent samples.

Selenium - Selenium is a naturally occurring element and is an essential nutrient. In ground waters, selenium levels are low (less than 1 ug/l) but in areas with seleniferous soils, water levels up to 300 ug/l have been reported (16).

No widely recognized sources of selenium in textile mill wastewaters were reported in this study. The ATMI Task Group suggested that selenium might be present in some dyes and specialty chemicals. This was not confirmed by the DETO survey of dye manufacturers. Of 418 questionnaire responses, seven indicated "known presence" and three indicated "suspected presence" in the mill wastewaters, although no specific sources were mentioned. In the field sampling program, it was detected above treatability in only one raw waste sample in the knit fabric finishing subcategory and it was not found in any treated effluent samples. In the felted fabric processing subcategory it was found above treatability in one raw waste sample and one final effluent sample.

Silver - Silver is a white ductile metal occurring naturally in the pure form and in ores. Principal uses of silver are in photographic materials, as a conductor, in dental alloys, solder and braying alloys, paints, jewelry, silverware, and mirror production.

Of 418 questionnaire returns, 12 indicated "known presence" and 4 indicated "suspected presence" in textile mill wastewaters, although no specific sources were given. The ATMI Task Group suggested that silver was a probable constituent of some textile mill wastewaters, originating in dyes and/or specialty chemicals. The DETO survey did not confirm commerical dyes as a likely source of silver. In the field sampling program, silver was measured at greater than 5 ug/l in 2 of the 12 water supplies sampled, both at 17 ug/l. Silver was not detected above treatability levels in raw wastes and only twice in final effluent samples.

Zinc - Zinc is a naturally occurring element that makes up approximately 0.02 percent of the earth's crust. It is used in various alloys, as a protective coating for other metals, in galvanizing sheet iron, and as a reducing agent. Zinc was detected in 1,207 of 1,577 surface water samples collected at 130 sampling locations throughout the U.S. between 1962 and 1967. The maximum observed concentration was 1,183 ug/l and the mean value was 64 ug/l. Levels of zinc in natural seawater approximate 5 ug/l (16).

Zinc originates from many sources in textile mill wastewaters, including pigements, dyes, dye stripping, coating materials, catalysts, latex curing, and in many specialty chemicals both as an added component and as an impurity. The DETO survey pointed out that some dyes are prepared as double salts of zinc and may contain up to 3 percent of this metal. Unlike chromium and copper, the zinc is not exhausted onto the fiber in dyeing. Zinc can also be contributed by water conditioning chemicals, alloys used in pumps and valves, galvanized metals, painted surfaces, and several other sources in industrial facilities. Of 418 questionnaire returns, 100 indicated "known presence" and 64 indicated "suspected presence" in the mill wastewaters. In the field sampling program, zinc concentrations in the 12 water supply samples ranged from 10 to 4500 ug/l. Four samples had levels above 100 and two were above 1000. Zinc was found above treatability in seven final effluent samples from four subcategories. It was only found above treatability levels in six raw waste samples from three subcategories.

Pollutants Unique to Source. For pollutants detected at only a small number of sources within a subcategory and uniquely related to those sources, the traditional uses, possible sources and analytical results are discussed below.

Acrylonitrile - Acrylonitrile is an unsaturated synthetic organic compound primarily used in the production of acrylic and modacrylic fibers, nitrile rubber, and plastics. Annual production totals approximately 0.7 billion kilograms (1.5 billion pounds).

Sources of acrylonitrile reported by textile industry include fibers and other raw materials, laboratory operations, dyes, and latex compounds. Out of 418 questionnaire returns, 32 indicated "known or suspected presence" in mill wastewaters. Despite this indication of rather common usage, acrylonitrile was detected at only 1 mill of 44 in the field sampling program.

Antimony - Environmental concentrations of antimony are reported at 0.33 ug/l in seawater of 35 parts per thousand salinity and at 1.1 ug/l in freshwater streams. Antimony and its compounds are used in the manufacturing of alloys, as flame retardants, pigments and catalysts, as well as for medicinal and veterinary uses.

Individual mills reported possible sources of antimony in textile wastewaters as finishing agents, dyestuffs and raw materials. The DETO survey results did not list antimony as one of the 25 toxic pollutants likely to be present in the bulk of commerical dyes produced. Various antimony compounds have been used as mordants in dyeing, in printing pastes and as pigments in dye manufacture. Antimony trioxide is used as a flame retarding agent. Out of 418 questionnaire returns, 52 indicated "known or suspected presence" in mill wastes. Antimony was detected above treatability in only one raw waste sample in each of four subcategories although it was found above treatability levels in 16 final effluent samples in the knit fabric finishing subcategory.

Three of the 16 samples were at one facility and 7 at a second facility. It is believed that these high levels are related to the use of antimony trioxide fire retardants which are not in common use in the industry. As antimony was either not detected or detected at low levels throughout the industry EPA concluded that antimony discharge is uniquely related to these two facilities.

Pollutants Controlled by Other Standards For pollutants effectively controlled by the technologies on which other effluent limitations and standards are based, the traditional uses, possible sources and analytical results are discussed below:

Benzene - Benzene is produced principally from coal for tar distillation and from petroleum by catalytic reforming of light naphthas from which it is isolated by distillation or solvent extraction. The broad utility spectrum of benzene (commercially sometimes called "Benzol") includes: extraction and rectification; as an intermediate for synthesis in the chemical and pharmaceutical industries; the preparation and use of inks in the graphic arts industries; as a thinner for lacquers; as a degreasing and cleaning agent; as a solvent in the rubber industry; as an antiknock fuel additive and as a general solvent in laboratories. Industrial processes involving the production of benzene and chemical synthesis usually are performed in sealed and protected systems. Currently, benzene is used by the chemical industry at the rate of 5.3 billion liters (1.4 billion gallons) annually. Sources of benzene reported by the textile industry include raw materials, use as a solvent and dyes, although it was not one of 25 priority pollutants suggested by DETO as likely to be present in the 151 dye products that represent the bulk of the dye industry's commercial volume by weight. Out of 418 questionnaire returns, 32 indicated "known or suspected presence" in mill wastewaters. Benzene was detected above treatability levels in only one final effluent sample. Benzene is effectively removed in biological treatment systems; removal is reflected by the lower final effluent concentrations reported for benzene.

Trichloroethylene - Trichloroethylene (1,1,2-trichloroethylene, TCE), a volatile nonflammable liquid, is used mostly in the metal industries as a degreasing solvent. It had minor applications as a dry cleaning solvent and as an extractive solvent for decaffeinating coffee, but was replaced in both these capacities by perchloroethylene and methylene chloride, respectively.

Its volatilization during production and use is the major source of environmental levels of this compound. TCE has been detected in ambient air, in food and in human tissue in ug/l (ppb) quantities. Its detection in rivers, municipal water supplies, the sea and aquatic organisms indicates that TCE is widely distributed in the aquatic environment at the microgram/kg level or lower. Trichloroethylene is not expected to persist in the environment. This is in part because of its short half-life in air and its evaporation from water.

Sources of trichloroethylene in textile mill wastewaters reported by the industry include its use as a solvent in dyeing and cleaning, and also in some raw materials. Out of 418 questionnaire returns, 21 indicated "known or suspected presence" in mill wastes. Trichloroethylene is effectively reduced in biological treatment systems as is reflected by the fact that it was found above treatability in only one biologically treated final effluent sample.

Ethylbenzene - Ethylbenzene is an alkyl substituted aromatic compound employed as an antiknock compound for airplane engine fuel, as a lacquer diluent, in the synthesis of styrols for resins, as a solvent for paraffin waxes, and in the production of cellulose acetate silks. It is only slightly soluble in water, but will dissolve in organic solvents.

Ethylbenzene was one of 25 toxic pollutants that may be present in some commerical dyes, at less than 0.1 percent, according to the survey carried out by DETO. Its presence in dyestuffs and as a solvent in print pastes was also reported by individual mills. While only 9 out of 418 questionnaire returns indicated "known or suspected presence" in mill wastewaters. Ethylbenzene was only detected above treatability in a few final effluent samples at levels well below raw wastewater concentrations. It is effectively removed in biological treatment which forms the basis for BPT regulations.

Naphthalene - Naphthalene, a bicyclic aromatic compound, is the most abundant single constituent of coal tar. It is also found in cigarette smoke. This compound is used as an intermediate in the production of dye compounds and in the formation of solvents, lubricants, and motor fuels. The largest use of napthalene in 1975 (58 percent of total use) was for the synthesis of phthalic anhydride. It has also been used as a moth repellent and insecticide.

Sources of naphthalene in textile mill wastewaters reported by the industry are dyes and possibly laboratory operations. The direct dyes were cited as specific sources of this compound. The DETO survey results indicated that this toxic pollutant was likely to be present in some dyes at levels less than 0.1 percent. Out of 418 questionnaire returns, 55 indicated "known or suspected presence" in mill wastewaters. Although napthalene was detected above treatability levels in 15 raw waste samples it was only detected above treatability 2 times in final effluent samples. It was effectively reduced by biological treatment which is the basis for BPT effluent limitations.

Phenol - Phenol is an aromatic compound that has a hydroxyl group attached directly to the benzene ring. It is a liquid and is somewhat soluble in water. Phenol is used in large quantities as an industrial chemical. It is produced almost entirely as an intermediate for the preparation of other chemicals. These include synthetic polymers such as phenolic resins, bis-phenol and caprolactam plastics intermediates, and chlorinated and alkylated phenols.

Phenol is used in the textile industry as a preservative in dyes and could be present in textile mill raw wastes in the 100 to 1,000 ug/l range according to the results of the DETO survey. Out of 418 questionnaire returns, 81 reported "known presence" and an additional 47 reported "suspected presence" in mill wastewaters. Reported sources cover a wide spectrum including the water supply; raw materials, including various fibers; dyes and dye carriers; finishing resins; nylon carpet processing; laboratory operations; and general cleaners and distinfectants used in the mill. Phenol was detected above treatability levels in 20 raw waste samples but only 1 final effluent sample. It is effectively controlled by biological treatment.

Toluene - Toluene is a clear, colorless, noncorrosive liquid with a sweet, pungent odor. The production of toluene in the U.S. has increased steadily since 1940 when approximately 117 million liters (31 million gallons) were produced; in 1970, production was 2.62 billion liters (694 million gallons). Approximately 70 percent of the toluene produced is converted to benzene, another 15 percent is used to produce chemicals, and the remainder is used as a solvent for paints and as a gasoline additive.

Toluene is a volatile compound and is readily transferred from water surfaces to the atmosphere. In the atmosphere, it is subject to photochemical degradation. It degrades to benzaldehyde and traces of peroxybenzoyl nitrate. Toluene can also re-enter the hydrosphere in rain.

Sources of toluene reported by the textile industry include dyes and dye carriers, raw materials, and use as a cleaning solvent. Toluene is one of 25 toxic pollutants that may be present in commerical dyes at levels less than 0.1 percent according to the survey carried out by DETO. Out of 418 questionnaire responses, 48 indicated "known or suspected presence" in mill wastewaters. Toluene was detected above treatability in 15 raw waste samples and in only 2 final effluent samples. It is effectively removed by biological treatment.

Toxic Pollutant Not Detectable - For the following pollutant, which is not detectable with the use of analytical methods approved pursuant to Section 304(h) of the Act, the traditional uses, possible sources and analytical results are discussed below.

Bis (2-ethylhexyl) Phthalate - Bis(2-ethylhexyl) phthalate belongs to the group of compounds known as phthalate esters. The phthalic acid esters (PAE) are a large group of substances widely used in the U.S. and the rest of the world as plasticizers. In the plastics industry, they are used to impart flexibility to plastic polymers, to improve workability during fabrication, and to extend or modify properties not present in the original plastic resins.

PAE are extensively used in polyvinylchloride plastics, which have a wide variety or applications. They are contained in building and construction materials (flooring, weatherstripping, wire, and cable), home furnishings (garden hoses, wall covering and upholstery), transportation materials (seat covers, auto mats), apparel (footwear, outerwear and baby pants), and food surfaces and medical products (food wrap film, medical tubing and intravenous bags). Dioctylphthalate (DOP) and its isomer di-2-ethylhexyl phthalate (DEPH) are probably the most widely used plasticizers today. PAE also have minor non-plastic uses as pesticide carriers, in cosmetics, fragrances, industrial oils, and insect repellents.

The PAE plasticizers, which can be present in concentrations up to 60 percent of the total weight of the plastic, are only loosely linked to the plastic polymers and are easily extracted. PAE are known to be widely distributed in the environment. They have been found in soil, water, air, fish tissue, and human tissue. As shown in Table VI-5, bis(2-ethylhexyl) phthalate was apparently detected in excess of treatability in raw waste and treated effluents in nearly every subcategory. It was also detected frequently in raw water samples and even tubing blanks EPA concluded that its presence in nearly every subcategory indicates sample contamination. This compound also was reported to be a laboratory contaminant in other analytical programs. The results for this pollutant, therefore, cannot be considered valid.

Pollutant Controlled by Existing Regulation The remaining toxic pollutant, total chromium, is controlled by existing BPT effluent limitations; during the Agency sampling programs, total chromium was found above anticipated treatability levels infrequently. BPT limitations established in 1974 have resulted in a significant reduction in the total mass discharge, as well as the concentration of chromium in treated textile industry wastewater effluents. Because the effectiveness of the control of chromium is well demonstrated by BPT; that level of control should be continued.

Nonconventional Pollutants

The nonconventional pollutants of potential concern that are present in textile mills wastewaters are:

Chemical Oxygen Demand (COD)
Phenols
Sulfide
Color

Chemical Oxygen Demand (COD) Chemical oxygen demand (COD) is an alternative to the BOD test for estimating the oxygen demanding potential of a wastewater. This test procedure relies on the principle that many organic compounds can be oxidized by strong chemical agents under acidic conditions with the assistance of inorganic catalysts. When an industrial wastewater contains substances which tend to inhibit biological degradation of the carbonaceous substrate, COD is a more reliable indicator of the organic pollutant content of a water sample than is BOD. The COD test measures the oxygen demand of both compounds that are biologically degradable and of compounds that are not. Pollutants that are measured by the BOD_5 test as well as pollutants which are more resistant to biological oxidation are measured as COD. Because of this fact, COD yields higher oxygen demand values than the BOD_5 test.

Compounds that are more resistant to biological oxidation are of interest not only because they can exert a long-term oxygen demand on surface waters but also because a potential exists that these compounds can affect human health and aquatic life. Some of the compounds that exert a COD have carcinogenic, mutagenic or similar adverse effects, either alone or in combination with other chemicals. An additional source of concern is that the relatively long life of high COD, low BOD chemicals in surface waters may result in contamination of downstream water intakes. The standard water purification technologies are not always effective in removing these chemicals. If disinfection with chlorine during water treatment is practiced, the presence of organic compounds in the water may result in the creation of hazardous chlorinated organic chemicals.

COD is present in the wastewater from all types of textile operations. In most cases the concentrations of COD are two to three times the BOD concentration. COD concentrations in raw textile wastewater are contributed by organic materials, such as fats and dirt present in raw wool, sizing materials (slashing) and desizing, the application of functional finishes and in some cases dyeing operations.

The continuation of controls on the discharge of COD will prevent the discharge, on a national scale, of materials that can have an adverse effect on receiving water quality. Likewise, it is appropriate that limitations and standards controlling the discharge of COD be continued.

<u>Sulfide</u> Sulfides discharged to neutral receiving waters can be reduced to hydrogen sulfide. Hydrogen sulfide is an extremely toxic and corrosive gas. It is very soluble and exists as a dissolved gas in surface waters. Minute concentrations (less than 2 μg/l) of hydrogen sulfide impart an objectionable odor and taste to water, making it unfit for municipal consumption. The proven toxicity of sulfides to aquatic life makes them objectionable components of the discharge stream.

Sulfide corrosion of metal and cement structures is an additional problem. In addition to corrosion, discoloration of structures as a result of sulfide oxidation is a cause for concern.

Organic sulfur and sulfides can be present in the wastewater discharges from textile industry dyeing operations. They can also be discharged as a result of the use of organic sulfur compounds in other textile processes. The BPT control established in 1974 has adequately controlled the discharge of sulfide and should be continued.

<u>Phenols</u> Phenols and phenolic wastes (as measured by the 4-AAP method) are derived from textile processing chemicals; petroleum, coke and chemical industries; wood distillation; and domestic and animal wastes. Many phenolic compounds are more toxic than pure phenol; their toxicity varying with the combinations and general nature of total wastes. The effect of combinations of different phenolic compounds is cumulative. Phenols and phenolic compounds are both acutely and chronically toxic to fish and other aquatic animals. Also, chorinated phenols produce an unpleasant taste in fish flesh that can destroy their commercial value.

It is necessary to limit phenolic compounds in raw water used for drinking water supplies, because conventional treatment methods used at water supply facilities do not remove phenols. The ingestion of concentrated solutions of phenols will result in severe pain, renal irritation, shock and possibly death. Phenols also reduce the utility of water for certain industrial uses, particularly food and beverage processing, where they create unpleasant tastes and odors in the product.

Phenolic compounds are used in the textile industry as preservatives in dyes. In addition, sources include raw materials, dye carriers, finishing resins, laboratory operations and cleaners and disinfectants. Phenols should continue to be regulated in those subcategories for which total phenols limitations now exist.

Color Color is defined as either "true" or "apparent." In Standard Methods for the Examination of Water and Wastewater (2), the true color of water is defined as "the color of water from which the turbidity has been removed." Apparent color includes "not only the color due to substances in solution, but also due to suspended matter."

Foreign color bodies interfere with the transmission of light within the visible spectrum which is used in the photosynthetic process of microflora. Color can affect the aquarian ecosystem by changing the amount of light transmitted and may cause species turnover. Color discharges can alter natural stream color and become an aesthetic pollutant affecting both the visual appeal and the recreational value of the waterways.

Color discharged to surface waters may have a detrimental effect on downstream municipal and industrial water users. Color is not treated in conventional water treatment systems and, when passed to users, may result in consumer discontent or interfere with industrial processes requiring clear water.

Color, which is present in textile wastewater, results from equipment washup, textile washwater and dyes not exhausted in the dyeing process. Some colors are water soluble and some are not (dispersed and vat dyes). Biodegradability of many of the dyes responsible for the color is highly variable, and the toxicity and effects of many of these dyes on aquatic life has not been studied to any great extent. Because many different hues are used in the dyeing process, they may appear in the wastewater. However, the combination of hues in many waste streams frequently results in a dominant gray or black color.

The Agency has decided not to establish either BAT limitations or NSPS for color. The decision is based on an evaluation of color discharged by the textile industry in terms of its national significance. Color, in many instances, is simply an aesthetic pollutant. In the textile industry, color is a mill-specific problem related to the combination of dyes and finishing chemicals used. For this reason, EPA feels that color should be controlled on a case-by-case basis by local authorities as dictated by water quality considerations.

Conventional Pollutants

The conventional pollutants of concern in textile mill discharges are:

Biochemical Oxygen Demand (BOD)
Total Suspended Solids (TSS)
pH

Biochemical Oxygen Demand Biochemical oxygen demand (BOD) is the quantity of oxygen required for the biological and chemical oxidation of waterborne substances under controlled test conditions. Materials that may contribute to the BOD include: carbonaceous organic materials usable as a food source by aerobic organisms; oxidizable nitrogen derived from nitrates, ammonia and organic nitrogen compounds which serve as food for specific bacteria; and certain chemically oxidizable materials such as ferrous iron, sulfides and sulfite, which will react with dissolved oxygen or are metabolized by bacteria. In most industrial and municipal wastewaters, the sources of BOD are principally organic materials and ammonia (which is itself derived from animal or vegetable matter).

The BOD of a waste can exert an adverse effect on the dissolved oxygen resources of a body of water by reducing the oxygen available to fish, plant life and other aquatic species. Conditions can be reached where all of the dissolved oxygen in the water is utilized, resulting in anaerobic conditions and the production of undesirable gases such as hydrogen sulfide and methane. The reduction of dissolved oxygen levels can be detrimental to fish populations, fish growth rate and organisms used as fish food. A total lack of oxygen can result in the death of all aerobic aquatic inhabitants in the affected area.

Water with a high BOD indicates the presence of decomposing organic matter and associated increased bacterial concentrations that degrade the water's quality and its potential uses. A by-product of high BOD concentrations can be increased algal concentrations and blooms that result from decomposition of the organic matter.

The BOD_5 (five-day BOD) test is used widely to estimate the oxygen demand of domestic and industrial wastewaters. The test also is used to determine the amount of aeration required in biological treatment and to measure the oxygen demand created by organic pollutants in surface waters. Complete biochemical oxidation of a given wastewater may require a period of incubation too long for practical analytical test purposes. For this reason, the five-day period is used, and the test results are expressed as BOD_5. The biochemical reactions involved in the oxidation of carbon compounds are related to the period of incubation. The five-day BOD usually measures only 60 to 80 percent of the carbonaceous biochemical oxygen demand of the sample; for many purposes, this represents a reasonable measure of the oxygen demanding potential of wastewater.

Because the BOD_5 test is a measure of biological activity in surface waters, standard conditions of time, temperature, microbial seed and dilution water for the test are included in the analytical procedure. The environmental conditions of the BOD test must be suitable for uninhibited microorganism activity. Therefore, toxic substances must be absent and nutrients, such as nitrogen, phosphorus and trace elements, must be present. Through the use of this procedure, the oxygen demand of diverse wastes can be evaluated and compared, and the treatability in biological treatment systems estimated.

BOD5 is present in wastewaters from textile processing operations in varying concentrations and amounts. The processes with the highest concentrations are wool scouring, carpet finishing and felted fabric processing.

BOD5 should continue to be regulated in all subcategories of the textile industry.

Total Suspended Solids (TSS) Suspended solids include both organic and inorganic materials. The inorganic compounds include sand, silt and clay. The organic fraction includes materials such as grease, oil, tar and animal and vegetable waste products. These solids may settle out rapidly and often leaving bottom deposits composed of a mixture of both organic and inorganic solids. Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These solids may be inert, slowly biodegradable materials or rapidly biodegradable substances. While in suspension, solids increase the turbidity of the water, reduce light penetration and retard the photosynthetic activity of aquatic plants.

Suspended solids in water can interfere with many industrial processes, and cause foaming in boilers and incrustations on equipment exposed to such water, especially at elevated temperatures. Suspended solids are undesirable in process water used in most industries.

Solids in suspension are aesthetically displeasing. In addition, suspended solids which settle to form sludge deposits on a stream or lake bed often damage aquatic life. Solids that are transformed to sludge deposits also may cause other damage such as blanketing a stream or lake bed, destroying the living spaces for the benthic organisms normally present in that habitat. Organic solids use a portion of all of the dissolved oxygen available in the area. Organic materials also serve as a food source for sludgeworms and associated organisms.

Disregarding any toxic effects of these solids in water, suspended solids may kill fish and shellfish by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Suspended solids indirectly may harm aquatic life by screening out light and by depleting the available oxygen. This results in the killing of fish and fish food organisms. Suspended solids can also reduce the recreational value of the water.

Sources of solids in textile industry wastewater include the following operations: wool scouring, low water use processing, desizing, scouring, bleaching, printing and backing of carpet and solids generated by biological activity in wastewater treatment systems. TSS should continue to be regulated in all subcategories of the textile industry.

pH pH is related to the acidity or alkalinity of water, or wastewater. It is not a linear or direct measure of either; however, it may properly be used as a surrogate to control both excess acidity and excess alkalinity in water. The term pH is used to describe the hydrogen ion - hydroxyl ion balance in water. Technically, pH is the negative logarithm of the hydrogen ion concentrations. A pH of 7 indicates neutrality or a balance between free hydrogen and free hydroxyl ions. Solutions with a pH above 7 indicate that the solution is alkaline, while a pH below 7 indicates that the solution is acidic.

The pH value of water or wastewater is useful in determining necessary measures for corrosion control, pollution control and disinfection. Waters with a pH below 6.0 are corrosive to water system distribution lines and household plumbing fixtures. Such corrosion can add constituents to drinking water such as iron, copper, zinc, cadmium and lead. Low pH waters not only dissolve metals from structures and fixtures, but also redissolve or leach metals from sludges and bottom sediments. The hydrogen ion concentrations can affect the taste of the water; at a low pH, water tastes sour.

Extremes of pH or rapid pH changes can cause stress conditions or kill aquatic life outright. Even moderate changes from acceptable criteria limits of pH are deleterious to some species. The harmful effect on aquatic life of many materials is increased by changes in pH. For example, metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. Similarly, the toxicity of ammonia is a function of pH. The bacteriocidal effect of chlorine in most cases is less as the pH increases, and it is economically advantageous to keep the pH close to 7. Extremes of pH can occur in the textile industry as a result of run changes, process adjustments and other variabilities in process operations, therefore, pH should continue to be regulated in all subcategories of the textile industry.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

This section describes the control and treatment technologies that are in use and available to reduce the discharge of pollutants from textile mills. There are two major technology approaches available: 1) in-plant controls and process changes and 2) effluent treatment technology. Programs combining elements of both approaches are applicable to many mills in the industry. Both approaches should be considered to determine which specific combination is best suited to a particular facility.

In-plant controls and process changes reduce hydraulic and pollutant loadings originating from mill operations. Although their use for pollutant reduction has been limited, greater attention is now being given to them because of economic and energy considerations.

Considerable research has taken place on the various effluent treatment technologies applicable to textile mills. Over 80 percent of the direct discharging mills in the industry provide wastewater treatment. Similarly, over 40 percent of the indirect discharging mills provide wastewater treatment before discharging to POTWs. Preliminary treatment, biological treatment, chemical treatment, physical separation and sorption systems applicable to textile industry wastewater are described following the discussion of in-plant controls. In addition to the description of each treatment method, detailed information on application of the method in the textile industry and its effectiveness is presented.

IN-PLANT CONTROLS AND PROCESS CHANGES

It is often more efficient to control pollution at its source, i.e., to prevent the generation of waste, rather than to depend on treatment to reduce or remove it. For this reason, an investigation of in-plant controls and process changes that might be instituted to reduce the strength or volume of wastewaters is a logical first step in any pollution control program. Conscientious implementation of in-plant controls and process changes can be effective in reducing water use and pollutant discharges.

For discussion purposes, in-plant measures have been divided into five types: 1) water reuse, 2) water use reduction, 3) chemical substitution, 4) material reclamation and 5) process changes and new process technology. Water reuse and water use reduction modifications result in a lower hydraulic loading on existing treatment facilities that in turn yield an improved effluent quality because of increased detention time. For new facilities, smaller treatment units may be used, involving less capital and lower operating costs. Chemical substitution and material reclamation can be used to reduce toxic, nonconventional and conventional pollutant loadings on treatment facilities. Process changes and new process technology can result in water and pollutant reductions through improved process control and operating efficiency.

Summary of In-Plant Controls Data

The Agency received surveys from 541 textile mills during the initial phase of this study. Of these, 152 provided relevant information about the use of in-plant process control. In some instances, this information was supplemented by telephone discussions with knowledgeable mill personnel. A summary of the responses, reported by subcategory, is provided in Table VII-1. The number of controls cited by the 152 mills totaled 195, or 1.3 controls per mill. Approximately 47 percent are water reuse measures, 23 percent are process water reduction measures, 19 percent involve substitution of process chemicals and 11 percent involve reclamation of process chemicals.

Water Reuse

Water reuse measures reduce hydraulic loadings to treatment systems by using the same water in more than one process. Water reuse resulting from advanced wastewater treatment (recycle) is not considered an in-plant control, because it does not reduce hydraulic or pollutant loadings on the treatment plant. The two major water reuse measures available to textile mills are: 1) reuse of uncontaminated cooling water in operations requiring hot water, and 2) reuse of process water from one operation in a second, unrelated operation.

Cooling water that does not come in contact with fabric or process chemicals can be collected and reused directly. Examples include condenser cooling water, water from water-cooled bearings, heat-exchanger water, and water recovered from cooling rolls, yarn dryers, pressure dyeing machines, and air compressors. This water can be pumped to hot water storage tanks for reuse in operations such as dyeing, bleaching, rinsing and cleaning where heated water is required. Energy and water savings can be substantial.

Reuse of certain process water elsewhere in mill operations also results in significant wastewater discharge reductions. Examples of process water reuse include: reuse of wash water from bleaching operations in caustic washing and scouring; reuse of scouring rinses for desizing or for cleaning printing equipment; and reuse of mercerizing wash water to prepare baths for scouring, bleaching, and wetting fabric.

TABLE VII-1
MILLS REPORTING IN-PLANT CONTROL MEASURES - RESULTS OF INDUSTRY SURVEY

Subcategory	Water Reuse	Water Use Reduction	Chemical Substitution	Material Reclamation	Total
	Number of Mills Reporting Measure				
1. Wool Scouring	2	1	0	1	4
2. Wool Finishing	2	4	1	0	7
4. Woven Fabric Finishing	28	20	17	16	81
5. Knit Fabric Finishing Fabric Processing	24	8	9	1	42
Hosiery Processing	1	0	1	0	2
6. Carpet Finishing	10	2	3	3	18
7. Stock & Yarn Finishing	21	9	3	1	34
8. Nonwoven Manufacturing	2	1	1	0	4
9. Felted Fabric Processing	2	0	1	0	3
All Subcategories	92	45	36	22	195

Source: EPA Industry Survey, 1977.

Ninety-two mills of the 541 mills in the survey reported some form of water reuse. The most common item is the reuse of cooling water to heat process water. Temperature increases as great as 33°C (91°F) were reported. Most mills in the survey that reported the reuse of cooling water began the practice in the mid-seventies to conserve energy. At some mills, both energy and water savings were major considerations in instituting reuse. Energy savings were reported ranging from 252 million to 25.2 billion kilogram-calories (1 billion to 100 billion Btu/yr), while water savings varied from 9.5 to 380 cu m/d (2,500 to 100,000 gpd) or more. Costs to institute water reuse measures ranged from less than $5,000 to more than $50,000 at some facilities. The principal cost items were pumps, piping modifications and hot water storage tanks.

As the costs of energy and wastewater treatment increase, reuse of cooling water is expected to become more widespread in the industry. This is supported by the fact that many mills have reported current engineering studies in this area. The reuse of water from various textile processing operations also is practiced at a few mills and is being investigated at a number of others. Savings similar to those noted for cooling water reuse were reported and it is expected that more reuse of this nature also will become common.

Water Use Reduction

While water reuse is the use of the same water more than once, water use reduction is the elimination of unnecessary water consumption. Three in-plant control measures that are considered forms of water use reduction are: 1) countercurrent flow washing or rinsing, 2) conservation, and 3) process modification.

The countercurrent flow system is based on the principle that wash water is not used effectively if it is cleaner than the fabric when the water leaves the washbox. In countercurrent flow applied to operations such as wash boxes on a continuous range, the water flows through the process in the direction opposite to that of the material. As the water passes into each box, it contacts material containing increasing amounts of impurities and other undesirable matter. This system is considered standard procedure in wool scouring and is not an uncommon practice at finishing mills that scour, mercerize, bleach, or dye on continuous ranges. At some of these mills, countercurrent flow wash boxes have been used for a long time. However, many mills still do not use countercurrent flow, especially where water is inexpensive. This practice is expected to change as water and wastewater treatment become more costly (17).

Conservation measures include a variety of steps that can be taken to reduce water use in textile mills. They consist primarily of maintaining close control over mill operations to avoid accidental loss of process chemical baths and avoiding the preparation of larger batches than required. Supervision to insure efficient operation of in-plant controls, such as the countercurrent flow systems discussed above, is an important conservation technique. Reduction of dirt, grease and rust in production areas to avoid unnecessary washing and processing of soiled material also contributes to conservation. Other measures that are used are the construction of retaining walls, splashboards and sills, and proper maintenance of machinery and plumbing to minimize process fluid losses through spillage and leaks. Use of liquid level controls, flow indicators and meters and automatic shut-off devices also reduce water requirements at textile mills.

Simply implemented process modifications that reduce water use include longer process runs between dumps and modulation of water supply to match the speed of the textile products being handled. Carefully supervised trials should be run to determine minimum water requirements possible without reducing product quality. Instrumentation and automation can be incorporated into processes to assist in uniformity of application, reduction of rework, control of operating parameters, e.g., pH and temperature, or similar functions may be used to achieve reductions in water and chemical use.

Based on questionnaire and telephone surveys, 45 mills have instituted water use reduction control measures. The most common water use reduction measure identified was countercurrent flow of water during wet processing operations. Countercurrent flow in scouring and desizing, and the use of rinse water in bleaching, dyeing and mercerizing have been instituted at various mills. Energy and water savings can be substantial, but installation costs can vary considerably.

A few mills have reported that they can use chemicals in operations such as scouring and dyeing (continuous type) for longer periods without dumping. For example, one mill has recently extended the time between scour dumps from once every 2 hours to once every 24 hours without affecting quality. More extensive modifications that result in lower water use generally require process changes and are discussed later in this section.

Chemical Substitution

The objective of chemical substitution is to replace process chemicals having high pollutant strength or toxic properties with others that have less impact on water quality or that are more amenable to wastewater treatment. A number of process chemical substitutions have been suggested or developed for the textile industry, and it is expected that this area will play a more important role in the future. The cost to substitute other chemicals and products for those containing toxic pollutants is usually much less than the cost to remove the pollutants from a mill's discharge via end-of-pipe treatment. For any substitution, however, a careful evaluation should be made to assure that one pollution problem is not being substituted for another.

Foaming problems in treatment facilities and receiving streams have been solved by substituting biodegradable, low-foaming detergents for the so-called "hard" detergents. Potentially toxic pollutants have been reduced or eliminated by substitution. For example, switching from chromate oxidizers to hydrogen peroxide or iodates eliminates chromium in dyeing processes. The replacement of soap with sulfuric acid in wool fulling operations is a substitution that results in lower BOD loadings. Mineral acids are substituted for high BOD acetic acid in dyeing processes, offering an advantage in terms of wastewater treatability. The substitution of mineral oils with nonionic emulsifiers for the more traditional olive oil in carding wool also results in lower pollutant levels.

Starch wastes from desizing are the single greatest source of BOD at many mills. Consequently, substitutes with low BOD, such as CMC, PVA and PAA, have become useful to reduce BOD loadings on wastewater treatment systems. However, another consideration is the net effect on the environment. These low BOD, high COD sizes contribute substantially to the ultimate oxygen demand of the wastewater. In view of this, the following from a report prepared for the American Textile Manufacturers Institute (18) is pertinent.

> "Substitution should assume the direction of easily treatable materials in terms of waste control technology and recoverability. Chemists and environmental engineers must work together in considering which process chemical is best handled by the means or unit process most efficiently suited to its recovery or removal. Certainly, in terms of conventional biological systems, low BOD chemicals will not lose their significance. However, as physical-chemical treatment methods are adopted, other characteristics (COD, ultimate BOD, solids, toxic pollutants, etc.) will likely become increasingly important. Additional research is necessary to determine the viability of COD versus BOD substitutions and the economic and treatability impact of such cursory changes."

Thirty-six mills reported that they had instituted chemical substitution as an in-plant control measure. Substitution for dyes requiring chromium mordants and chromate oxidizers are the most commonly cited. One wool finishing mill reported that savings in labor and other processing costs more than offset the higher cost of the dyes substituted for the traditional chrome dyes. BOD reductions were achieved at some mills by substituting synthetic warp sizes for starch, using low BOD detergents for those with high BOD, and eliminating the use of acetic acid as a pH adjuster.

Material Reclamation

Material reclamation measures often are implemented to reduce processing costs, the reduction of pollutant loadings being a secondary benefit. As noted previously, caustic recovery after mercerizing is quite common, especially in large finishing operations. Recovery of various warp sizes has been investigated at length and shows promise. Size recovery was identified at three facilities; two mills reclaim PVA and one reclaims WP-50. While many carpet finishing mills segregate latex waste streams for treatment, only two segregate for recycle. Some mills reclaim scouring detergent or dye liquor for future batches. Reclamation of print solvent is practiced at one mill. In all, some form of material reclamation was noted at 22 mills. It is anticipated that chemical and wastewater treatment costs will make material conservation and recovery a more viable alternative in the future.

Process Changes and New Process Technology

Process changes and the implementation of new process technology are modifications to the basic manufacturing operations of a mill. Some reduce water use and eliminate or minimize the discharge of high strength or toxic chemicals. Others provide for material and energy reclamation. One new technology, water jet weaving, requires additional water, although the wastewater generated is relatively low in pollutant concentration.

Adoption of process changes and new process technology offers the greatest opportunity for reducing hydraulic and pollutant loads from textile mills. Technological advances in fibers, process chemicals, other raw materials and processing equipment are constantly occurring and, in general, these changes are resulting in lower hydraulic and conventional pollutant loadings (3).

Solvent processing is an example of a new process technology. It involves the use of a nonaqueous solvent such as perchloroethylene to scour and dye fabric. Because the solvent has a high vapor pressure (compared to water), it is possible to vaporize it more easily and recover it for reuse. It has not, however, achieved the original expectations of performance, except for specialized processing and small batch operations. Effective applications include solvent scouring of wool fabric and some synthetic knit fabrics and solvent finishing of upholstery, drapery, synthetic knits, and fabrics that are sensitive to water.

There are a number of reasons for the limited application of solvent processing to date. The most troublesome problem is that the value of the recovered solvent is often less than is necessary to make the process economically feasible. In addition, only a limited number of the thousands of different dyestuffs and chemicals now used in commercial textile processing can be transferred directly to solvent use. Another problem is the emission of unrecovered solvent to the work place or the atmosphere.

A more common method of reducing hydraulic and pollutant loadings in the industry is changing process and material flow procedures. It has been noted (19) that continuous operations generally require less space, water and process chemicals than do batch operations. Circulating baths and rinses also require less water. Rope washers are reportedly more effective than open-width washers in reducing water use. Significant water use reductions also are achieved by combining separate operations, such as scouring and dyeing in the finishing of synthetic fibers and the desizing and scouring of cotton fibers.

Some of the newer textile processing equipment results in lower water and chemical usage. For example, pressure dye machines use dyestuff more efficiently, reduce water requirements and reduce the level of toxic dye carriers required in atmospheric dyeing. It is reasonable to expect that the textile processing equipment of the future will be even more efficient in the use of water, chemicals and energy.

EFFLUENT TREATMENT TECHNOLOGIES

Treatment of the total waste stream is the primary method used by the textile industry to remove or reduce the pollutants present in the wastewater from wet processing operations. This approach is used because of the difficulty and expense of segregating waste streams at existing facilities. New facilities, however, have the opportunity to segregate more concentrated or more troublesome wastes and treat them independently.

A summary of current wastewater treatment practices by the wet processing mills surveyed is presented in Table VII-2. Not all of the mills surveyed provided information on their treatment systems so the table only includes 1,085 of the 1,169 mills in the major wet processing subcategories. Eighteen percent of the direct dischargers provide no wastewater treatment (discharge directly to surface waters or have wastewater transported from the site), 19 percent provide only preliminary treatment (i.e., screening, equalization, heat exchange, primary sedimentation, flotation, filtration, neutralization, chemical coagulation and oxidation), 56 percent provide biological treatment (i.e., aerated or unaerated lagoons, biological filtration and activated sludge), and 7 percent provide an advanced level of treatment (i.e., chemical coagulation/precipitation, filtration, activated carbon adsorption, ozonation, ion exchange and membrane processes).

TABLE VII-2
WASTEWATER TREATMENT STATUS - WET PROCESSING MILLS SURVEYED

	Mills Reporting Treatment Status			Level of Treatment														
							Preliminary											
				None			Physical			Chemical			Biological			Advanced		
Subcategory	D	I	Z	D	I	Z	D	I	Z	D	I	Z	D	I	Z	D	I	Z
1. Wool Scouring	6	10	1	1	5	0	2	3	1	0	0	0	3	2	0	0	0	0
2. Wool Finishing	6	24	3	0	9	2	0	8	1	0	3	0	6	4	0	0	0	0
4. Woven Fabric Finishing	78	210	8	14	125	4	3	54	1	2	17	0	54	13	3	5	1	0
5. Knit Fabric Finishing																		
Fabric Processing	37	218	9	6	135	5	25	48	0	0	11	0	2	24	1	4	0	3
Hosiery Processing	7	149	2	4	99	2	0	38	0	0	7	0	3	4	0	0	1	0
6. Carpet Finishing	11	42	2	0	6	1	0	33	0	0	1	0	10	2	1	1	0	0
7. Stock & Yarn Finishing	36	168	3	6	104	0	2	36	0	1	17	0	25	11	1	2	0	2
8. Nonwoven Manufacturing	5	25	7	3	11	7	0	9	0	0	2	0	1	3	0	1	0	0
9. Felted Fabric Processing	1	13	4	0	1	1	0	8	1	0	4	0	1	0	2	0	0	0
All Subcategories	187	859	39	34	495	22	32	237	4	3	62	0	105	63	8	13	2	5

Notes: D refers to direct dischargers, I to indirect dischargers, and Z to zero discharge mills.
None - direct discharge to POTWs, surface waters, land, or wastewater hauled from site.
Preliminary, Physical - screening, equalization, heat exchange, sedimentation, flotation, filtration.
Preliminary, Chemical - neutralization, chemical coagulation, oxidation.
Biological - unaerated and aerated lagoons, biological filtration, activated sludge.
Advanced - chemical coagulation/precipitation, filtration, activated carbon adsorption, ozonation, ion exchange, membrane processes.

Source: EPA Industry Survey, 1977.

Effluent treatment technologies applicable to textile wastewaters can be categorized as follows: 1) preliminary treatment (screening, neutralization and equalization), 2) biological treatment (aerated lagoons, activated sludge, biological beds and stabilization lagoons), 3) chemical treatment (coagulation, precipitation and oxidation), 4) physical separation (filtration, hyperfiltration/ultrafiltration, dissolved air flotation, stripping and electrodialysis), and 5) sorption systems (activated carbon and powdered activated carbon). Each of these categories is discussed in detail below.

Fifty-eight percent of the indirect dischargers provide no treatment, 35 percent provide preliminary treatment, 7 percent provide biological treatment and 0.2 percent (2 mills) provide an advanced level of treatment.

Fifty-six percent of the zero discharge mills provide no treatment, 10 percent provide preliminary treatment, 21 percent provide biological treatment and 13 percent provide an advanced level of treatment.

Approximately 18 percent of the mills that furnished data (63 percent of the direct dischargers, 8 percent of the indirect dischargers and 33 percent of the zero discharge mills) provide a minimum of biological treatment.

The specific treatment technologies employed by the mills surveyed are presented in Table VII-3 for mills that discharge directly to surface waters and zero discharge mills, and in Table VII-4 for mills that discharge to a POTW.

Of the direct and zero discharge mills that treat their wastewater, 65 percent provide screening, 36 percent provide equalization and 23 percent provide neutralization. Similarly, 57, 46 and 19 percent of the indirect discharge mills that treat their wastewater provide screening, equalization and neutralization. Approximately 68 percent of the direct and zero discharge mills have activated sludge treatment systems.

Preliminary Treatment

Screening Screening is a physical unit operation and is usually the first operation used in wastewater treatment. Based on size of openings, less than or greater than 0.63 cm (0.25 in.), screens may be classified as coarse or fine. Coarse screens consist of parallel bars, rods or wires, grating, wire mesh or perforated plate. The openings can be any shape, with circular or rectangular slots the most common. Screens are hand cleaned by plant personnel or mechanically cleaned and have the primary function of removing rags, sticks and similar coarse solids that may clog or damage the pipes, pumps, valves or other mechanical equipment of the treatment system. Fine screens include inclined disks or drums, static plates and mesh units and vibratory mesh

TABLE VII-3
EXISTING TREATMENT TECHNOLOGIES - DIRECT AND ZERO DISCHARGE MILLS

		Treatment																
		Physical							Biological					Chemical			Sorption	
Subcategory	No. of Mills	Sc	Eq	1°	2°	Sk	Fl	Fi	AS	A1	A2	An	TF	Ne	CC	Ox	AC	PC
1. Wool Scouring	6	3	1	2	3		1		3		1					2		
2. Wool Finishing	5	4	2		3				3	2	2			3	1			
4. Woven Fabric Finishing	56	39	21	4	41		1	2	40	13	16		2	13	8	19	1	
5. Knit Fabric Finishing																		
Fabric Processing	29	20	10		23	1		5	23	6	9			6	3	20		
Hosiery Processing	2	1			2		2		2									
6. Carpet Finishing	11	8	4	2	6			1	6	4	5			3		5		3
7. Stock & Yarn Finishing	29	17	13	4	18			3	18	8	9			7	2	12		
8. Nonwoven Manufacturing	1			1						1					1			
9. Felted Fabric Processing	3	1	1		1				1		2					2		
Total	142	93	52	13	97	1	4	11	96	34	44	0	2	32	15	60	1	3

Note:
Sc = Screening
Eq = Equalization
1° = Primary Sedimentation
2° = Secondary Sedimentation
Sk = Skimming
Fl = Flotation
Fi = Filtration
AS = Activated Sludge
A1 = Aerated Lagoon
A2 = Facultative or Tertiary Lagoon
An = Anaerobic Lagoon
TF = Trickling Filter
Ne = Neutralization
CC = Chemical Coagulation
Ox = Oxidation, incl. Disinfection
AC = Activated Carbon
PC = Powdered Activated Carbon

Source: EPA Industry Survey, 1977.

TABLE VII-4
EXISTING PRETREATMENT TECHNOLOGIES - INDIRECT DISCHARGERS

		Treatment																
		Physical							Biological					Chemical			Sorption	
Subcategory	No. of Mills	Sc	Eq	1°	2°	Sk	Fl	Fi	AS	A1	A2	An	TF	Ne	CC	Ox	AC	PC
1. Wool Scouring	2	1		1							2							
2. Wool Finishing	10	8	4		2				2	2				3	1	1		
4. Woven Fabric Finishing	46	25	23	2	3		3	1	1	6	3			8	4	1		
5. Knit Fabric Finishing																		
Fabric Processing	42	17	18	1	2				2	11	5			3	1	3		
Hosiery Processing	20	12	7		1			1	1	2	2			2				
6. Carpet Finishing	24	23	9	2	1	1			1			1		2	2	2		
7. Stock & Yarn Finishing	43	21	26	7	4			1	4	2	3			13	2	4		
8. Nonwoven Manufacturing	6	2	4								1			2				
9. Felted Fabric Processing	7	5	2	1										5				
Total	200	114	93	14	13	1	3	3	11	23	16	1	0	38	10	11	0	0

Note: Sc = Screening
Eq = Equalization
1° = Primary Sedimentation
2° = Secondary Sedimentation
Sk = Skimming
Fl = Flotation
Fi = Filtration
AS = Activated Sludge
A1 = Aerated Lagoon
A2 = Facultative or Tertiary Lagoon
An = Anaerobic Lagoon
TF = Trickling Filter
Ne = Neutralization
CC = Chemical Coagulation
Ox = Oxidation, incl. Disinfection
AC = Activated Carbon
PC = Powdered Activated Carbon

Source: EPA Industry Survey, 1977.

units. These are cleaned by continuous water spray, by mechanically driven brushes, or, in the case of vibratory screens, automatically by the vibration. Fine screens remove floc, strings, short fibers, vegetable matter or other small solids that clog or damage equipment or form a mat or scum layer over aeration basins.

Industry Application - Both coarse and fine screening are practiced in the textile industry. The number of direct (including zero discharge mills) and indirect dischargers in each subcategory using screening is provided in Table VII-5. The data is from the mills that returned detailed questionnaires and is the same data base previously noted. Only the most extensive type of screening at each plant is noted in the tabulation.

Approximately 40 percent of the direct and zero discharge mills and nearly 25 percent of the indirect discharge mills reported static coarse screening as the only screening in their treatment systems. Fine screening (static, mechanical, hydrosieve or vibrating) is practiced by 34 percent of the direct and zero discharge mills, and 31 percent of the indirect discharge mills that provided detailed survey information.

Nearly all of the mills in the wool finishing and carpet finishing subcategories provide some type of screening. This is because of the high fiber content of the untreated wastewater in both subcategories.

Neutralization Neutralization is the process of adjusting the pH to within acceptable limits for discharge to surface waters or subsequent treatment operations. Generally, a pH range of 6.0 to 9.0 is acceptable for discharge to surface waters while additional treatment operations usually require more specific pH tolerances. Neutralization of acidic waste is accomplished by: 1) mixing with an on-site alkaline waste stream; 2) passing through beds of limestone; 3) mixing with lime slurries; or 4) adding a solution of caustic soda (NaOH) or soda ash (Na_2CO_3). Alkaline waste may be neutralized by: 1) mixing with an on-site acidic waste stream; 2) blowing waste boiler flue gas through the waste; 3) adding compressed CO_2; or 4) adding sulfuric acid (H_2SO_4). Mixing of various wastewater streams is usually insufficient to meet the pH requirements of biological treatment. Therefore, chemical addition frequently is required for proper pH control. Limestone is the least expensive reagent for neutralizing acidic wastewater but is not satisfactory for sulfate-bearing wastewater because it becomes coated and inactive. If the wastewater is deficient in either nitrogen or phosphorus, ammonia or trisodium phosphate addition serves the dual purpose of providing both alkalinity and the deficient nutrient.

Industry Application - Current wastewater neutralization practices reported by the textile mills surveyed are summarized

TABLE VII-5
WASTEWATER SCREENING BY TEXTILE INDUSTRY - RESULTS OF INDUSTRY SURVEY

	Mills Employing Screens															
	Coarse				Fine										Mills In Survey	
	Static		Mechanical		Static		Mechanical		Hydrosieve		Vibrating					
Subcategory	D	I	D	I	D	I	D	I	D	I	D	I	D	I		
1. Wool Scouring	2	1	1	0	0	0	0	0	0	0	0	0	6	2		
2. Wool Finishing	3	2	0	3	0	0	0	0	1	0	1	3	5	10		
4. Woven Fabric Finishing	24	14	2	1	7	5	1	0	2	2	3	3	56	46		
5. Knit Fabric Finishing Fabric Processing	13	9	0	0	4	5	2	1	0	0	0	2	29	42		
Hosiery Processing	1	6	0	0	0	4	0	1	0	0	0	0	2	20		
6. Carpet Finishing	2	3	0	1	3	12	2	5	1	2	0	0	11	24		
7. Stock & Yarn Finishing	10	8	1	0	3	10	0	1	2	1	1	1	29	43		
8. Nonwoven Manufacturing	0	1	0	0	0	0	0	1	0	0	0	0	1	6		
9. Felted Fabric Processing	0	1	0	0	1	0	0	1	0	0	0	3	3	7		
All Subcategories	55	45	4	5	18	36	5	10	6	5	5	12	142	200		

Note: D represents direct and zero discharge mills.
I represents indirect discharge mills.

Source: EPA Industry Survey, 1977.

in Table VII-6. Approximately 21 percent of the direct and zero discharge mills and 19 percent of the indirect discharge mills surveyed practice neutralization. Neutralization of acidic waste by indirect dischargers represents the greatest total. Only a small percentage of both direct and indirect dischargers find it necessary to provide both acidic and alkaline neutralizing capability.

Equalization Industrial discharges that result from a variety of processes in the mill often are treated more effectively when equalization is practiced as an initial treatment step. Subsequent physical, chemical and biological treatment steps are more efficient if operated at uniform hydraulic, organic and solids loading rates.

Equalization of discharges with fluctuating pollutant loads is accomplished by holding the untreated wastewater for the period of time that corresponds to the repetitive manufacturing operations. For example, facilities that discharge a variable waste over an eight hour work shift need to provide up to eight hours of storage. Similar facilities that operate on two or three shifts may need to provide storage for 16 to 24 hours of wastewater flow. Equalization basins may be earthen or fabricated and may be mixed or unmixed. Mixing is typically accomplished by aeration to provide for a uniform influent to the treatment processes.

Industry Application - Current equalization practices reported by the textile mills surveyed are summarized in Table VII-7. A higher percentage of indirect dischargers (46 percent) than direct dischargers (37 percent) provide equalization. This is a result of two factors. First, many of the direct discharge mills have extended aeration activated sludge treatment systems with several days detention time and do not require equalization. Secondly, many of the indirect dischargers are required by the municipalities to equalize their flow.

Biological Treatment

Biological treatment of industrial wastewater has been practiced for decades, but most activated sludge processes have been constructed in the last 10 to 15 years. Biological treatment is based on the ability of microorganisms to consume organic carbon as a food source. Biological treatment is classified aerobic or anaerobic depending on the presence of free dissolved oxygen in the wastewater. Aerobic biological treatment is accomplished by aerobic bacteria that utilize free dissolved oxygen in breaking down (oxidizing) organic compounds. Anaerobic biological treatment is accomplished by anaerobic bacteria that utilize chemically bound oxygen in oxidizing organic compounds. A third class of bacteria, facultative, also is active. These bacteria

TABLE VII-6

WASTEWATER NEUTRALIZATION BY TEXTILE INDUSTRY - RESULTS OF INDUSTRY SURVEY

	Mills Practicing Neutralization							
	Addition of Acid		Addition of Base		Addition of Both		Mills in Survey	
Subcategory	Direct*	Indirect	Direct*	Indirect	Direct*	Indirect	Direct*	Indirect
1. Wool Scouring	0	0	0	0	0	0	6	2
2. Wool Finishing	0	0	2	3	1	0	5	10
4. Woven Fabric Finishing	10	4	2	4	1	0	56	46
5. Knit Fabric Finishing								
Fabric Processing	0	1	5	1	0	1	29	42
Hosiery Processing	0	1	0	1	0	0	2	20
6. Carpet Finishing	0	0	3	2	0	0	11	24
7. Stock & Yarn Finishing	3	5	2	7	1	1	29	43
8. Nonwoven Manufacturing	0	1	0	0	0	1	1	6
9. Felted Fabric Processing	0	1	0	2	0	2	3	7
All Subcategories	13	13	14	20	3	5	142	200

* Includes zero discharge mills.

Source: EPA Industry Survey, 1977.

TABLE VII-7
WASTEWATER EQUALIZATION BY TEXTILE INDUSTRY - RESULTS OF INDUSTRY SURVEY

Subcategory	Unmixed				Mixed				Mills in Survey	
	Direct & Zero		Indirect		Direct & Zero		Indirect			
	LT 24*	ETGT 24*	LT 24	ETGT 24	LT 24	ETGT 24	LT 24	ETGT 24	Direct#	Indirect
1. Wool Scouring	0	0	0	0	0	1	0	0	6	2
2. Wool Finishing	1	0	1	3	1	0	0	0	5	10
4. Woven Fabric Finishing	4	8	19	3	4	5	1	0	56	46
5. Knit Fabric Finishing										
Fabric Processing	4	3	10	4	2	1	2	1	29	42
Hosiery Processing	0	0	3	4	0	0	0	0	2	20
6. Carpet Finishing	2	1	7	2	0	1	0	0	11	24
7. Stock & Yarn Finishing	3	4	21	5	3	3	1	0	29	43
8. Nonwoven Manufacturing	0	1	2	2	0	0	2	0	1	6
9. Felted Fabric Processing	0	0	0	0	0	0	0	0	3	7
All Subcategories	14	17	63	23	10	11	6	1	142	200

* LT 24 = Less than 24 hours; ETGT 24 = Equal to or greater than 24 hours.
# Includes zero discharge mills.

Note: For four direct discharge mills (two Subcategory 4 and two Subcategory 7) and seven indirect discharge mills (two Subcategory 2, two Subcategory 5 - Fabric Processing, one Subcategory 5 - Hosiery Processing, one Subcategory 6, and one Subcategory 7) the equalization detention times could not be calculated so 24 hours was assumed.

Source: EPA Industry Survey, 1977.

can act as aerobes or anaerobes depending on the availability of free oxygen in the wastewater.

Unlike municipal wastewater, industrial wastes frequently lack nutrients to sustain microbial growth. This deficiency often is eliminated by mixing sanitary wastewater from the plant site with the process wastewater, or by addition of chemicals (usually nitrogen or phosphorus). A description and discussion of each biological process relevant to the treatment of textile mill wastewaters follows (20).

Aerated lagoons An aerated lagoon is a basin to which air is added through mechanical agitation or diffusion. The air provides the oxygen required for aerobic biodegradation of organic waste. If properly designed, the aeration provides sufficient mixing to maintain the biological solids in suspension so that they can be removed efficiently in a secondary sedimentation tank. After settling, sludge may be recycled to the head of the lagoon to insure the presence of a properly acclimated seed. When operated in this manner, the aerated lagoon is analogous to the activated sludge process, which is discussed later in this section. The viable biological solids concentration in an aerated lagoon is low when compared to that of an activated sludge unit. The aerated lagoon relies primarily on detention time for the breakdown and removal of organic matter and aeration periods of 3 to 8 days are common.

Industry Application - Thirty-four direct dischargers and 23 indirect dischargers report using aerated lagoons as part of their treatment systems. Of the direct dischargers, 12 employ aerated lagoons as their primary means of treatment; 14 employ aerated lagoons followed by unaerated aerobic lagoons as their primary means of treatment; 2 employ aerated lagoons as polishing ponds following activated sludge biological treatment; and 6 employ aerated lagoons in combination with advanced treatment (2 chemical coagulation, 2 filtration, 1 chemical coagulation plus filtration and 1 activated carbon). Of the indirect dischargers, 21 employ aerated lagoons as their primary pretreatment step, 1 employs an aerated lagoon followed by an unaerated aerobic lagoon and 1 provides multimedia filtration following an aerated lagoon.

Historical Data - The performance of aerated lagoons in the treatment of textile wastewater is demonstrated in Table VII-8 for those mills that provided wastewater monitoring data. The values reported are averages for each mill and generally represent data for the year 1976.

Field Sampling - Sampling was conducted at two woven fabric finishing mills and one knit fabric finishing mill to determine the effectiveness of aerated lagoons in the treatment of toxic pollutants. Summaries of the data obtained from this program are presented in Tables VII-9 through VII-11.

TABLE VII-8

PERFORMANCE OF AERATED LAGOONS IN THE TREATMENT
OF TRADITIONALLY MONITORED POLLUTANTS

	DESIGN DATA				EFFLUENT CONCENTRATIONS (% REMOVAL)							
Subcategory/Mill	Direct/ Indirect	Detention (hrs)	Aer./Mixing (Hp/mil.gal)	Settling Pond	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O&G (mg/l)	Total Phenols (µg/l)	Total Chromium (µg/l)	Total Sulfide (µg/l)	Color (APHA Units)
Wool Scouring												
10002	I	---	---	Yes	*80(-)*	*1096(-)*	*64(-)*	*67(-)*	---	---	---	---
Wool Finishing												
20017	D	240	16	Yes	53(44)	190(44)	17(47)	---	---	---	---	---
20020	D	120	34	Yes	11(88)	183(69)	23(65)	---	76(-)	31(-)	280(-)	---
Woven Fabric Finishing (Simple)												
40066	D	999	4.8	Yes	95(-)	2804(-)	208(-)	---	---	---	---	---
40128	D	624	4.7	Yes	28(-)	177(-)	40(-)	---	---	---	---	---
Woven Fabric Finishing (Complex)												
40067	D	48	64	No	36(66)	20(-)	27(33)	---	---	---	---	---
40077	D	288	15	Yes	52(87)	---	55(0)	25(-)	70(77)	131(2)	169(97)	---
Woven Fabric Finishing (Desizing)												
40047	D	168	26	No	147(53)	676(19)	99(-)	---	---	27(91)	---	---
40142	D	60	45	No	94(74)	814(3)	89(-)	---	---	---	---	---
Knit Fabric Finishing (Simple)												
50037	D	336	12	No	45(77)	---	28(60)	---	21(-)	---	---	---
50117	D	267	0.7	Yes	56(-)	84(-)	54(-)	---	---	---	---	---
Knit Fabric Finishing (Complex)												
50019	D	72	43	Yes	87(-)	---	107(-)	46(-)	32(-)	---	---	306(-)
50034	D	576	38	No	13(-)	---	31(-)	---	---	---	---	---
50065	D	288	46	No	63(76)	491(54)	52(0)	---	15(-)	113(0)	16(-)	---
Carpet Finishing												
60001	D	252	11	Yes	20(-)	133(-)	25(-)	---	84(-)	---	---	---
60021	D	210	6.8	Yes	78(-)	376(-)	85(-)	---	285(-)	15(-)	266(-)	---
60029	D	24	100	No	23(-)	330(-)	44(-)	---	60(-)	25(-)	---	287(-)

TABLE VII-8 (continued)

PERFORMANCE OF AERATED LAGOONS IN THE TREATMENT
OF TRADITIONALLY MONITORED POLLUTANTS

	DESIGN DATA				EFFLUENT CONCENTRATIONS (% REMOVAL)							
Subcategory/Mill	Direct/ Indirect	Detention (hrs)	Aer./Mixing (Hp/mil.gal)	Settling Pond	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O&G (mg/l)	Total Phenols (μg/l)	Total Chromium (μg/l)	Total Sulfide (μg/l)	Color (APHA Units)
Stock and Yarn Finishing												
70035	D	240	23	Yes	9(95)	218(74)	16(71)	---	12(-)	25(-)	55(-)	---
70038	D	75	25	No	14(87)	---	12(43)	---	---	---	---	---
70044	D	264	10	Yes	11(-)	130(-)	18(-)	5(-)	52(-)	21(-)	236(-)	67(-)
70088	D	240	26	Yes	15(-)	189(-)	24(-)	---	40(-)	70(-)	79(-)	---
70103	D	240	3.0	No	48(-)	239(-)	19(-)	---	---	---	---	---

Source: EPA/Industry 308 Study

TABLE VII-9
PERFORMANCE OF AERATED LAGOONS
IN THE TREATMENT OF TOXIC POLLUTANTS
WOVEN FABRIC FINISHING MILLS (SIMPLE)

Parameter	Mill 40144	Subcategory Average ug/l	%
Discharge type	D		
Detention, hrs	168		
Mixing, hp/mil gal	18		
Average Effluent Concentration, ug/l (Removal, %)			
Benzene	ND (100)	ND	100
1,2-Dichloroethane	ND (100)	ND	100
1,1,1-Trichloroethane	ND (100)	ND	100
Chloroform	ND (100)	ND	100
Ethylbenzene	ND (100)	ND	100
Methylene Chloride	ND (100)	ND	100
Naphthalene	ND (100)	ND	100
Pentachlorophenol	TA (77)	TA	77
Phenol	18 (66)	18	66
Bis(2-ethylhexyl) Phthalate	ND (100)	ND	100
Di-n-butyl Phthalate	ND (100)	ND	100
Toluene	ND (100)	ND	100
Chromium (Total)	ND (100)	ND	100
Copper (Total)	52 (84)	52	84
Cyanide	TA (NC)	TA	NC
Lead (Total)	32 (NR)	32	NR
Mercury (Total)	TA (NC)	TA	NC
Nickel (Total)	33 (80)	33	80
Silver (Total)	TA (100)	TA	100
Thallium (Total)	13 (NR)	13	NR
Zinc (Total)	ND (100)	ND	100

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-10
PERFORMANCE OF AERATED LAGOONS
IN THE TREATMENT OF TOXIC POLLUTANTS
WOVEN FABRIC FINISHING MILLS (COMPLEX)

Parameter	Mill 40077		
Discharge type	D		
Detention, hrs	288		
Mixing, hp/mil gal	15		
		Subcategory Average	
	Average Effluent Concentration, ug/l (Removal, %)	ug/l	%
Benzene	TA (NC)	TA	NC
Chlorobenzene	TA (NC)	TA	NC
Chloroform	TA (NC)	TA	NC
1,2-Dichlorobenzene	TA (NC)	TA	NC
1,1-Dichloroethylene	TA (NC)	TA	NC
Ethylbenzene	TA (100)	TA	100
Methyl Chloride	10 (NC)	10	NC
Naphthalene	TA (NC)	TA	NC
N-nitrosodiphenylamine	ND (100)	ND	100
Phenol	29 (NC)	29	NC
Bis(2-ethylhexyl) Phthalate	18 (83)	18	83
Butyl Benzyl Phthalate	TA (NC)	TA	NC
Di-n-butyl Phthalate	TA (NC)	TA	NC
Tetrachloroethylene	TA (NC)	TA	NC
Toluene	11 (89)	11	89
Trichloroethylene	TA (NC)	TA	NC
Antimony (Total)	39 (NC)	39	NC
Arsenic (Total)	TA (NC)	TA	NC
Asbestos (MFL)	391 (NR)	391	NR
Cadmium (Total)	TA (NC)	TA	NC
Chromium (Total)	77 (NC)	77	NC
Copper (Total)	98 (50)	98	50
Cyanide	TA (NC)	TA	NC
Lead (Total)	TA (100)	TA	100
Mercury (Total)	ND (100)	ND	100
Nickel (Total)	66 (80)	66	80
Selenium (Total)	TA (NC)	TA	NC
Silver (Total)	18 (NC)	18	NC
Zinc (Total)	132 (72)	132	72

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-11
PERFORMANCE OF AERATED LAGOONS
IN THE TREATMENT OF TOXIC POLLUTANTS
KNIT FABRIC FINISHING MILLS (SIMPLE)

Parameter	Mill 50030		
Discharge type	D		
Detention, hrs	6		
Mixing, hp/mil gal	750		
Average Effluent Concentration, ug/l (Removal,%)		Subcategory Average ug/l	Subcategory Average %
Benzene	ND (100)	ND	100
1,1,1-Trichloroethane	100 (94)	100	94
1,1-Dichloroethane	TA (NC)	TA	NC
Chloroform	TA (55)	TA	55
1,1-Dichloroethylene	TA (66)	TA	66
Ethylbenzene	TA (100)	TA	100
Methylene Chloride	ND (100)	ND	100
Tetrachloroethylene	18 (95)	18	95
Toluene	ND (100)	ND	100
Antimony (Total)	10 (23)	10	23
Arsenic (Total)	TA (NC)	TA	NC
Cadmium (Total)	TA (NR)	TA	NR
Chromium (Total)	145 (29)	145	29
Copper (Total)	68 (56)	68	56
Cyanide	13 (NC)	13	NC
Zinc (Total)	240 (NR)	240	NR

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

Activated Sludge The activated sludge process is an aerobic biological process. The basic components consist of an aerated biological reactor, a clarifier for separation of biomass and a piping arrangement to return separated biomass to the biological reactor. Aeration provides the oxygen for aerobic biodegradation and the mixing to maintain the biological solids in suspension. The aeration requirements for activated sludge are similar to those of the aerated lagoon.

The activated sludge process is flexible and adaptable to many wastewater treatment situations. Factors that are considered in design include: 1) loading criteria, 2) reactor type, 3) sludge production, 4) oxygen requirements and transfer efficiency, 5) nutrient requirements, 6) temperature, 7) solid-liquid separation, and 8) desired effluent characteristics. Depending on these factors, the conventional activated sludge process or a commonly used modification of the conventional process is selected. The processes that can be used to treat textile wastewaters include: 1) conventional, 2) complete-mix, 3) tapered-aeration, 4) step-aeration, 5) modified-aeration, 6) contact-stabilization, 7) extended-aeration, 8) oxidation ditch, and 9) pure oxygen.

In the conventional activated sludge process, influent wastewater and recycled sludge enter the head of the reactor and are aerated for a period of about 4 to 8 hours. Aeration is by either diffusion or mechanical agitation and is constant as the mixed liquor moves through the tank in a plug-flow fashion. Oxygen demand decreases as the mixed liquor travels the tank length. The mixed liquor is settled in a conventional clarifier, and the activated sludge is returned at a rate of approximately 25 to 50 percent of the influent flow rate.

In the complete-mix activated sludge process, influent wastewater and recycled sludge enter the reactor from several points along a central channel running the length of the reactor. The mixed liquor is aerated at a constant rate as it passes from the central channel to effluent channels at both sides of the reactor. The contents of the reactor are completely mixed and the oxygen demand remains uniform throughout. The aeration period is from 3 to 5 hours, and the activated sludge is returned at a rate of 25 to 100 percent of influent flow rate.

The tapered aeration process is a modification of the conventional process, with the arrangement of the aerators and the amount of air supplied the primary differences. At the head of the reactor, where wastewater and returned activated sludge are mixed, more oxygen is required so the aerators are spaced close together. As the mixed liquor traverses the aeration tank, the oxygen demand decreases so aeration is decreased by spacing the aerators further apart. Because the decreased oxygen supply is matched to the decreased oxygen demand, less total aeration is required in the tapered-aeration process.

The step aeration process also is a modification of the conventional activated sludge process. The wastewater is introduced to each segment of a compartmentalized reactor while the return activated sludge is introduced at the head of the reactor. The compartments of the reactor are linked together in series. Aeration is either diffused or mechanical and is constant as the mixed liquor moves through the tank in a plug-flow fashion. Because wastewater is added in each compartment, the oxygen demand is more uniformly spread over the length of the reactor than in the conventional activated sludge process. This results in better utilization of the oxygen supply and reduces the aeration time. The aeration period is typically between 3 and 5 hours, and the activated sludge is returned at a rate of 25 to 75 percent of influent flow rate.

The modified-aeration activated sludge process is similar to the conventional or tapered-aeration processes, except that the aeration period is shorter (usually 1.5 to 3 hours) and the food-to-microorganism ratio is higher. Activated sludge is returned at a rate of only 5 to 15 percent of the influent flow rate. BOD_5 removal is approximately 70 percent (for typical sanitary wastewater).

The contact stabilization process takes advantage of the absorptive properties of activated sludge by operating the process in two stages. In the first stage, most of the colloidal, finely suspended and dissolved organics are absorbed in the activated sludge in a contact tank. The wastewater and return stabilized sludge enter at the head of the contact tank, are aerated for a period of 20 to 40 minutes, and settled in a conventional clarifier. In the second stage, the absorbed organics are metabolically consumed providing energy and producing new cells. In this stage the settled sludge from the absorptive stage is aerated for a period of from 3 to 6 hours in a stabilization tank. A portion of the sludge is wasted to maintain a constant mixed liquor volatile suspended solids (MLVSS) concentration in the stabilization tank. Total aeration requirements are approximately 50 percent of those of the conventional or tapered-aeration plants. However, the process usually is not effective in treating industrial waste in which the organic matter is predominantly soluble.

The extended-aeration process is a complete-mix activated sludge process in which the aeration period is relatively long (24 to 48 hours) and the organic loading relatively low (16 to 40 kg BOD_5/100 m^3 or 10 to 25 lb BOD_5/1000 cu ft). Because of these conditions, the process is very stable and can accept intermittent loads without upset. In smaller applications, the reactor and clarifier are generally a single-fabricated unit and all sludge is returned to the reactor. The mixed liquor solids concentration is allowed to increase over a period of several months and then is removed directly from the aeration basin. The reactor and clarifier are separate in larger applications, and some means of wasting and treating sludge is usually necessary. Reactors can be concrete with diffused aeration or a lined earthen basin with mechanical aerators. The extended-aeration activated sludge process is used by the majority of direct dischargers in the textile industry.

The oxidation ditch activated sludge process is an extended-aeration process in which aeration and circulation are provided by brush rotors placed across a basin shaped like a race track. The waste enters the ditch at one end, is aerated by the rotors, and circulates at about 1 to 0.6 m/sec (2 fps). When the operation is intermittent, the ditch is similar to a lagoon. During continuous operation, a separate clarifier and piping for recycling settled sludge are provided and treatment is similar to activated sludge.

The pure oxygen activated sludge process is a modification of the complete-mix process in which high purity oxygen, instead of air, is introduced into the wastewater. Wastewater, returned activated sludge and oxygen gas under a slight pressure are introduced at the head of an aeration tank that is divided into stages by baffles and covered with a gas-tight enclosure. Oxygen is reintroduced to the mixed liquor by circulation through a hollow shaft with a rotating sparger device or by surface mechanical aerators. The mixed liquor passes from compartment to compartment and is discharged from the last compartment to a clarifier. Waste gas, which is a mixture of carbon dioxide, nitrogen and 10 to 20 percent of the oxygen applied, is exhausted in the last compartment. Reported advantages of the pure oxygen process are improved oxygen transfer efficiency, decreased sludge volume, reduced aeration tank volume, and improved sludge settleability.

Industry Application - Ninety-four direct dischargers and 11 indirect dischargers report using activated sludge as part of their wastewater treatment systems. Fifty-five direct dischargers rely on activated sludge treatment alone; 24 use activated sludge followed by unaerated lagoons; 3 use activated sludge followed by chemical coagulation; 4 use activated sludge with chemical addition to the activated sludge effluent to aid in settling; 4 use activated sludge followed by filtration; 2 use activated sludge followed by aerated lagoons; 1 uses activated sludge followed by filtration and aeration lagoons; and 1 uses activated sludge followed by a trickling filter. Nine indirect dischargers rely on activated sludge alone for pretreatment, while 2 other mills use activated sludge followed by chemical coagulation.

Historical Data - The performance of the activated sludge process in treating textile wastewater is demonstrated in Table VII-12 for those mills that reported applicable historical monitoring data. The values reported are averages for each mill and generally represent data for the year 1976.

Seventy-nine of the 82 mills listed are operating their activated sludge systems with aeration detention times of 24 hours or more, and all but one use surface aerators for mixing and oxygenation. The detention periods noted are calculated based on reported average flow conditions and full basin volumes.

The Agency conducted a detailed study of the effectiveness of biological treatment in the textile industry using responses to the EPA industry survey and monitoring data reports. The extended-aeration mode of operating activated sludge systems is commonly used by direct discharging mills. An analysis of the available data indicated that the two principal design variables affecting the quality of an aeration basin effluent are detention time (hours) and aeration horsepower per unit volume of the basin (hp/1000 cu ft). EPA conducted an analysis of treatment plants with activated sludge biological treatment to determine the minimum horsepower and detention time which would result in an effluent meeting the BPT limitations. A total of 69 treatment plants in subcategories 4, 5, 6 and 7 used activated sludge biological treatment. The Agency found that 40 of 42 (95 percent) of the plants maintaining a minimum detention time of 40 hours, a minimum of 5.3 kw/1000 cu m (0.2 hp 1,000 cu ft) of basin hours, and a minimum of 680 kg cal/cu m (0.2 hp per 1,000 cu ft) of basin volume, met the BPT limitations. Figure VII-1 presents this analysis.

Figure VII-1 shows that increasing detention time will compensate for inadequate aeration horsepower but that the reverse is not true. This emphasizes the importance of designing aeration basins with sufficient detention time. Selecting and spacing aerators for proper mixing and adequate recycle of activated sludge also are important factors in achieving optimum performance.

<u>Field Sampling</u> - Sampling was conducted at 32 mills (2 wool scouring, 1 low water use processing, 15 woven fabric finishing, 4 knit fabric finishing, 3 carpet finishing, 6 stock and yarn finishing and 1 nonwoven manufacturing) to determine the effectiveness of activated sludge in the treatment of toxic pollutants. Details of the overall sampling program are discussed in Section V. Summaries of the data obtained for these mills can be found in Tables VII-13 through VII-24.

In addition to the analysis of toxic pollutants, color (ADMI method) was measured at 11 mills using the activated sludge process. All measurements were performed at pH 7.6 to allow comparisons between mills. Table VII-25 shows the effectiveness of the activated sludge process in removing color.

<u>Biological Beds</u> Biological beds are fixed-growth biological systems that contact wastewater with organisms attached to the surfaces of supporting media. Systems that are in common use include trickling filters, packed towers, and rotating biological

TABLE VII-12

PERFORMANCE OF ACTIVATED SLUDGE IN THE TREATMENT
OF TRADITIONALLY MONITORED POLLUTANTS

	DESIGN DATA				EFFLUENT CONCENTRATIONS (% REMOVAL)							
Subcategory/Mill	Direct/ Indirect	Detention (hrs)	Aer./Mixing (Hp/mil.gal)	Settling Pond	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O&G (mg/l)	Total Phenols (μg/l)	Total Chromium (μg/l)	Total Sulfide (μg/l)	Color (APHA Units)
Wool Scouring												
10006	D	48	343	No	60(99)	1443(92)	166(98)	---	---	---	---	---
10015	D	77	160	No	42(98)	810(89)	297(89)	48(95)	37(-)	42(-)	219(-)	1887(-)
Wool Finishing												
20005	D	120	80	No	24(-)	---	49(-)	---	---	24(-)	---	---
20009	D	48	100	No	25(83)	---	64(63)	---	111(0)	---	---	---
20011	D	36	67	No	25(90)	212(68)	61(0)	---	45(76)	120(74)	---	---
20021	I	24	145	No	153(67)	800(40)	80(38)	20(71)	---	---	---	---
Woven Fabric Finishing (Simple)												
40023	D	120	38	No	5(74)	139(36)	19(98)	---	114(0)	20(46)	---	337(21)
40035	D	24	59	No	22(83)	307(35)	38(0)	24(-)	56(-)	182(-)	---	---
40050	D	40	129	Yes	15(89)	384(50)	36(0)	---	13(-)	20(-)	200(-)	---
40098	D	42	71	No	12(91)	177(54)	56(0)	---	17(-)	31(16)	---	---
40100	D	320	30	No	45(81)	409(28)	49(0)	---	35(27)	16(27)	---	---
40109	D	24	70	Yes	124(74)	---	55(-)	---	87(-)	14(-)	57(-)	---
40143	D	53	60	No	9(95)	159(76)	18(36)	---	20(-)	17(-)	---	---
Woven Fabric Finishing (Complex)												
40022	D	24	59	No	14(83)	152(51)	35(19)	---	250(-)	118(25)	47(-)	---
40091	D	96	111	No	69(81)	301(-)	95(0)	---	---	---	100(0)	---
40111	D	120	50	Yes	24(-)	426(-)	24(-)	---	25(-)	27(-)	28(-)	---
40114	D	36	52	Yes	101(82)	714(39)	51(-)	---	112(-)	9(-)	60(-)	---
40148	D	24	90	No	5(98)	---	48(78)	---	---	---	---	---
40154	D	24	80	No	3(99)	86(-)	18(62)	---	---	8(-)	133(-)	---
40160	D	240	20	Yes	43(91)	452(69)	105(36)	---	30(-)	169(-)	1000(-)	---
Woven Fabric Finishing (Desizing)												
40003	D	7	789	Yes	53(-)	244(-)	67(-)	---	---	---	---	---
40007	D	24	500	Yes	73(-)	---	231(-)	---	---	---	---	---
40012	D	96	122	No	19(96)	---	91(-)	---	---	---	---	---
40017	D	236	29	No	27(-)	155(-)	21(-)	---	15(-)	22(-)	1000(-)	---
40031	D	222	10	No	151(-)	912(-)	123(-)	---	103(-)	*11637(-)	1606(-)	---
40034	I	86	45	No	14(97)	254(83)	54(72)	---	---	---	---	---
40037	D	36	60	Yes	27(-)	214(-)	15(-)	---	---	---	---	---
40059	D	72	41	No	24(-)	336(-)	27(-)	---	2(-)	5(-)	1250(-)	---
40064	D	---	---	No	42(93)	---	148(-)	---	---	94(-)	---	---
40072	D	120	57	No	8(98)	252(-)	8(90)	---	---	31(-)	---	---

TABLE VII-12 (continued)

PERFORMANCE OF ACTIVATED SLUDGE IN THE TREATMENT
OF TRADITIONALLY MONITORED POLLUTANTS

	DESIGN DATA				EFFLUENT CONCENTRATIONS (% REMOVAL)							
Subcategory/Mill	Direct/ Indirect	Detention (hrs)	Aer./Mixing (Hp/mil.gal)	Settling Pond	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O&G (mg/l)	Total Phenols (µg/l)	Total Chromium (µg/l)	Total Sulfide (µg/l)	Color (APHA Units)
(continued) Woven Fabric Finishing (Desizing)												
40074	D	72	80	No	10(99)	272(-)	69(63)	14(-)	347(-)	46(-)	---	118(-)
40087	D	120	43	Yes	30(-)	---	41(-)	6(-)	22(-)	22(-)	---	---
40097	D	39	248	No	23(88)	594(68)	44(-)	---	---	---	---	---
40099	D	48	63	No	16(95)	252(73)	49(18)	9(-)	17(-)	16(20)	---	---
40103	D	45	120	Yes	19(98)	---	21(83)	11(-)	47(-)	1(-)	---	---
40118	D	8	2000	No	14(89)	227(60)	124(42)	---	100(-)	10(-)	300(-)	---
40120	D	168	63	Yes	7(99)	181(92)	57(82)	---	---	---	---	---
40140	D	60	79	No	105(84)	664(46)	176(0)	---	---	28(-)	---	---
40145	D	120	57	No	7(-)	164(81)	54(-)	---	18(-)	18(-)	100(-)	---
40151	D	120	84	No	43(94)	199(92)	67(-)	5(0)	---	40(0)	---	---
40153	D	60	6.7	No	62(88)	464(55)	132(0)	---	132(-)	59(-)	224(-)	---
Knit Fabric Finishing (Simple)												
50008	D	31	77	Yes	14(-)	---	20(-)	---	---	---	---	---
50015	D	120	40	No	11(-)	277(-)	22(-)	---	41(-)	58(-)	90(-)	---
50026	D	432	5.4	No	19(-)	---	15(-)	---	---	1(-)	---	---
50057	D	24	133	Yes	21(94)	744(-)	35(0)	8(-)	---	---	---	52(-)
50081	D	48	74	No	19(90)	164(56)	63(34)	---	---	11(15)	126(-)	---
50082	D	264	29	No	13(94)	250(53)	71(0)	90(-)	32(-)	62(40)	---	---
50098	D	144	8.3	No	139(66)	533(33)	180(0)	---	---	---	---	---
50108	D	22	64	Yes	6(95)	154(64)	11(48)	---	---	---	---	---
50113	D	141	38	No	13(93)	226(70)	62(0)	8(-)	72(-)	63(-)	222(-)	---
50116	D	60	75	No	5(97)	124(-)	18(0)	---	---	25(-)	---	---
Knit Fabric Finishing (Complex)												
50013	D	24	133	Yes	143(-)	1752(-)	187(-)	110(-)	323(-)	---	1113(-)	---
50035	D	72	37	No	21(86)	277(55)	116(84)	---	---	---	---	---
50052	D	200	40	No	24(-)	272(-)	65(-)	---	2(-)	12(-)	75(-)	---
50056	D	48	60	No	45(83)	354(49)	55(0)	32(-)	100(0)	100(0)	100(0)	---
50063	I	96	60	No	37(82)	232(57)	53(0)	---	---	---	---	---
50099	D	48	65	No	11(-)	174(-)	26(-)	---	83(-)	15(-)	73(-)	---
50115	D	60	113	Yes	4(-)	291(-)	27(-)	---	---	---	---	321(-)
50123	D	72	163	No	6(99)	145(-)	27(96)	---	---	---	---	---
Knit Fabric Finishing (Hosiery)												
5H028	D	130	67	No	63(0)	596(-)	99(1)	---	28(-)	66(-)	46(-)	---
5H029	D	48	667	No	98(42)	---	---	---	---	---	---	---

TABLE VII-12 (continued)

PERFORMANCE OF ACTIVATED SLUDGE IN THE TREATMENT
OF TRADITIONALLY MONITORED POLLUTANTS

	DESIGN DATA				EFFLUENT CONCENTRATIONS (% REMOVAL)							
Subcategory/Mill	Direct/ Indirect	Detention (hrs)	Aer./Mixing (Hp/mil.gal)	Settling Pond	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	O&G (mg/l)	Total Phenols (μg/l)	Total Chromium (μg/l)	Total Sulfide (μg/l)	Color (APHA Units)
Carpet Finishing												
60005	D	96	60	No	27(-)	546(-)	113(-)	---	100(-)	---	---	---
60013	D	60	83	No	54(-)	311(-)	57(-)	---	80(-)	29(-)	60(-)	---
60018	D	30	19	No	33(-)	286(-)	70(-)	---	---	---	---	---
60034	D	96	44	No	29(87)	227(52)	50(50)	---	128(2)	22(-)	---	---
60037	D	192	40	Yes	36(-)	---	33(-)	---	100(-)	17(-)	---	---
60039	D	128	125	Yes	38(-)	274(-)	91(-)	6(-)	370(-)	45(-)	67(-)	309(-)
Stock and Yarn Finishing												
70009	D	62	46	Yes	5(94)	106(71)	9(76)	---	41(-)	---	---	225(-)
70031	D	36	80	No	6(96)	124(75)	27(25)	---	186(-)	42(-)	92(-)	---
70034	D	48	92	No	6(-)	179(-)	6(-)	---	---	---	---	---
70036	D	384	30	No	15(-)	203(-)	35(-)	---	91(-)	18(-)	141(-)	---
70054	I	48	500	No	233(86)	1844(61)	195(0)	---	---	---	---	---
70075	D	40	91	No	7(95)	146(73)	36(47)	---	---	---	---	---
70084	D	58	33	No	21(93)	268(62)	71(89)	---	40(-)	265(61)	185(-)	---
70087	D	126	14	No	21(93)	148(62)	24(27)	---	56(-)	14(13)	27(-)	---
70089	I	24	80	No	5(96)	158(-)	21(55)	---	---	---	---	---
70096	D	65	107	No	29(-)	204(-)	24(-)	---	---	---	---	---
70102	D	5664	3.4	No	16(-)	134(-)	46(-)	---	240(-)	---	---	---
70104	D	24	56	Yes	3(97)	96(71)	20(38)	---	---	146(-)	---	---
70106	D	96	114	Yes	7(99)	119(93)	10(97)	---	---	---	---	719(-)
70126	D	40	200	No	73(-)	176(-)	60(-)	---	12(-)	138(-)	1193(-)	---
Felted Fabric Finishing												
80025	D	160	60	Yes	40(89)	383(82)	66(23)	192(0)	29(97)	---	---	---

Source: EPA Industry 308 Study

FIGURE VII-1
DETENTION TIME VS AERATION HORSEPOWER PER UNIT VOLUME OF BASIN
PLANTS WITH ACTIVATED SLUDGE TECHNOLOGY

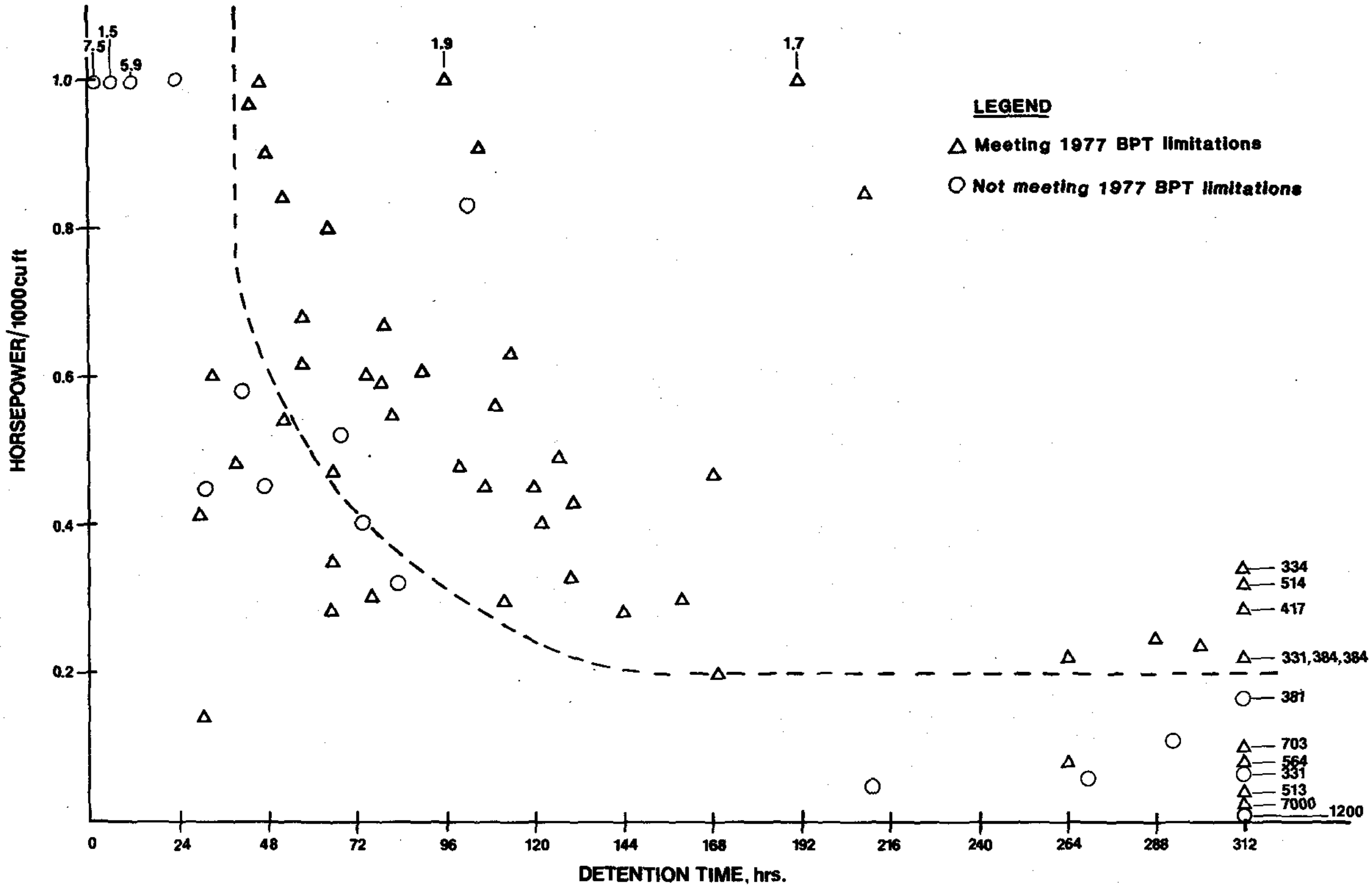


TABLE VII-13
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
WOOL SCOURING MILLS

Parameter	Mill 10006		Mill 10015		Subcategory Average ug/l	Subcategory Average %
Discharge type	D		D			
Detention, hrs	48		77			
Mixing, hp/mil gal	343		160			
	Average Effluent Concentration, ug/l (Removal, %)					
Benzene	ND		ND	(100)	ND	100
Hexachlorobenzene	ND		ND	(100)	ND	100
1,1,1-Trichloroethane	ND	(100)	ND		ND	100
1,1-Dichloroethane	ND	(100)	ND		ND	100
Ethylbenzene	ND		ND	(100)	ND	100
Fluoranthene	ND		TA	(NC)	TA	NC
Phenol	TA	(100)	TA	(100)	TA	100
Bis(2-ethylhexyl) Phthalate	ND	(100)	31	(NR)	16	50
Di-n-butyl Phthalate	ND	(100)	ND		ND	100
Diethyl Phthalate	ND	(100)	ND		ND	100
Benzo(a)anthracene	ND		TA	(NC)	TA	NC
Benzo(a)pyrene	ND		TA	(NC)	TA	NC
3,4-Benzofluoranthene	ND		TA	(NC)	TA	NC
Anthracene	ND		TA	(NC)	TA	NC
Pyrene	ND		TA	(NC)	TA	NC
Toluene	ND		TA	(84)	TA	84
Trichloroethylene	ND		ND	(100)	ND	100
Antimony (Total)	ND		270	(NC)	135	NC
Arsenic (Total)	NA	(NC)	21	(NR)	21	NR
Cadmium (Total)	ND		72	(NR)	36	NR
Chromium (Total)	17	(92)	TA	(17)	14	55
Copper (Total)	16	(96)	161	(57)	89	77
Cyanide	658	(NR)	110	(NR)	384	NR
Lead (Total)	92	(88)	1779	(NR)	936	44
Mercury (Total)	ND	(100)	TA	(NR)	TA	50
Nickel (Total)	52	(83)	1030	(NR)	541	42
Silver (Total)	TA	(NR)	298	(NR)	154	NR
Zinc (Total)	25	(99)	795	(53)	410	76

Note: ND indicates "not detected."
NA indicates "not analyzed."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-14
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
WOOL FINISHING MILLS

Parameter	Mill 20011		Mill 20021		Subcategory Average ug/l	Subcategory Average %
Discharge type	D		I			
Detention, hrs	36		24			
Mixing, hp/mil gal	67		145			
Average Effluent Concentration, ug/l (Removal, %)						
Benzene	ND		TA	(NC)	TA	NC
Chlorobenzene	ND		TA	(100)	TA	100
1,2,4-Trichlorobenzene	ND		1,257	(74)	629	74
1,1,1-Trichloroethane	ND		TA	(100)	TA	100
Parachlorometa Cresol	TA	(NC)	ND		TA	NC
Chloroform	ND		TA	(9)	TA	9
1,2-Dichlorobenzene	TA	(97)	TA	(65)	TA	81
1,3-Dichlorobenzene	ND		12	(98)	TA	98
1,4-Dichlorobenzene	TA	(95)	TA	(68)	TA	82
2,4-Dimethylphenol	TA	(NR)	ND		TA	NR
Ethylbenzene	19	(96)	TA	(NC)	15	96
Fluoranthene	TA	(NC)	ND		TA	NC
Methylene Chloride	23	(NC)	TA	(NR)	17	NR
Trichlorofluoromethane	ND		TA	(NR)	TA	NR
Naphthalene	ND	(100)	TA	(77)	TA	89
N-nitrosodiphenylamine	ND		ND	(100)	ND	100
Pentachlorophenol	TA	(NC)	ND	(100)	TA	100
Phenol	ND	(100)	ND	(100)	ND	100
Bis(2-ethylhexyl) Phthalate	374	(NR)	34	(63)	204	32
Di-n-butyl Phthalate	TA	(NC)	ND		TA	NC
Diethyl Phthalate	TA	(NC)	ND	(100)	TA	100
Dimethyl Phthalate	ND		ND	(100)	ND	100
Anthracene	TA	(NC)	TA	(17)	TA	17
Phenanthrene	ND		TA	(17)	TA	17
Pyrene	TA	(NC)	ND		TA	NC
Tetrachloroethylene	TA	(NC)	TA	(100)	TA	100
Toluene	TA	(61)	12	(NR)	11	31
Trichloroethylene	ND	(100)	TA	(NC)	TA	100
Heptachlor	ND		TA	(NC)	TA	NC
Antimony (Total)	TA	(NC)	29	(17)	20	17

TABLE VII-14 (Cont.)

Parameter	Mill 20011		20021			
Arsenic (Total)	TA	(NC)	16	(NC)	13	NC
Asbestos (MFL)*	24	(NR)	NA	(NC)	24	NR
Cadmium (Total)	ND	(100)	TA	(NC)	TA	100
Chromium (Total)	584	(NR)	142	(49)	363	25
Copper (Total)	TA	(50)	28	(38)	19	44
Cyanide	ND		TA	(NR)	TA	NR
Lead (Total)	ND		58	(NR)	29	NR
Mercury (Total)	ND	(100)	ND	(100)	ND	100
Nickel (Total)	TA	(NR)	64	(NR)	37	NR
Selenium (Total)	ND		TA	(8)	TA	8
Silver (Total)	TA	(NC)	35	(NC)	23	NC
Zinc (Total)	10,296	(NR)	3,371	(24)	6,834	12

* Values reported as million fibers per liter.

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-15
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
LOW WATER USE PROCESSING MILLS (GENERAL)

Parameter	Mill 30*		
Discharge type	I		
Detention, hrs	-		
Mixing, hp/mil gal	-		
		Subcategory Average	
Average Effluent Concentration, ug/l (Removal, %)		ug/l	%
Chloroform	10 (79)	10	79
Phenol	ND (100)	ND	100
Bis(2-ethylhexyl) Phthalate	TA (62)	TA	62
Di-n-butyl Phthalate	ND (100)	ND	100
Toluene	TA (NR)	TA	NR
Trichloroethylene	ND (100)	ND	100
Asbestos (MFL)**	ND (100)	ND	100
Cadmium (Total)	TA (NC)	TA	NC
Chromium (Total)	12 (NR)	12	NR
Copper (Total)	37 (5)	37	5
Lead (Total)	84 (NR)	84	NR
Nickel (Total)	120 (NR)	120	NR
Silver (Total)	50 (NR)	50	NR
Zinc (Total)	2300 (NR)	2300	NR

* Data is for POTWs to which mill discharges.
** Value reported as million fibers per liter.

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-16
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
WOVEN FABRIC FINISHING MILLS (SIMPLE)

Parameter	Mill 40023		
Discharge type	D		
Detention, hrs	120		
Mixing, hp/mil gal	38		
		Subcategory Average	
Average Effluent Concentration, ug/l (Removal, %)		ug/l	%
Acenaphthene	ND (100)	ND	100
1,2,4-Trichlorobenzene	ND (100)	ND	100
Hexachlorobenzene	ND (100)	ND	100
1,2-Dichlorobenzene	TA (NC)	TA	NC
Ethylbenzene	ND (100)	ND	100
Methylene Chloride	12 (NC)	12	NC
Pentachlorophenol	17 (NC)	17	NC
Bis(2-ethylhexyl) Phthalate	TA (NR)	TA	NR
Di-n-butyl Phthalate	TA (NC)	TA	NC
Dimethyl Phthalate	ND (100)	ND	100
Anthracene	TA (NC)	TA	NC
Toluene	36 (NR)	36	NR
Trichloroethylene	19 (NC)	19	NC
Antimony (Total)	13 (NR)	13	NR
Arsenic (Total)	TA (NC)	TA	NC
Cadmium (Total)	ND (100)	ND	100
Chromium (Total)	TA (NC)	TA	NC
Copper (Total)	105 (26)	105	26
Cyanide	17 (NR)	17	NR
Nickel (Total)	12 (NC)	12	NC
Silver (Total)	TA (NC)	TA	NC
Zinc (Total)	248 (26)	248	26

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-17
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
WOVEN FABRIC FINISHING MILLS (COMPLEX)

Parameter	Mill 40160	Subcategory Average ug/l	Subcategory Average %
Discharge type	D		
Detention, hrs	240		
Mixing, hp/mil gal	20		
Average Effluent Concentration, ug/l (Removal, %)			
Benzene	ND (100)	ND	100
Chlorobenzene	ND (100)	ND	100
Parachlorometa Cresol	32 (NR)	32	NR
Chloroform	ND (100)	ND	100
Ethylbenzene	29 (99)	29	99
Pentachlorophenol	56 (NR)	56	NR
Bis(2-ethylhexyl) Phthalate	12 (90)	12	90
Di-n-butyl Phthalate	ND (100)	ND	100
Diethyl Phthalate	TA (NR)	TA	NR
Tetrachloroethylene	ND (100)	ND	100
Toluene	17 (94)	17	94
Beta-BHC	TA (NR)	TA	NR
Chromium (Total)	140 (NR)	140	NR
Copper (Total)	290 (43)	290	43
Zinc (Total)	210 (13)	210	13

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-18
PERFORMANCE OF ACTIVATED SLUDGE IN THE TREATMENT OF TOXIC POLLUTANTS
WOVEN FABRIC FINISHING MILLS (DESIZING)

Parameter	Mill 40	40034*	40059	40072	40081*	40097	40099
Discharge type	D	I	D	D	I	D	D
Detention, hrs	48	86	72	120	-	39	48
Mixing, hp/mil gal	88	45	41	57	-	248	63
	Average Effluent Concentration, ug/l (Removal, %)						
Acenaphthene	ND	ND	TA (NR)	ND	ND	ND (100)	ND (100)
Benzene	ND	ND	ND	ND	33 (42)	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	TA (NR)	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	TA (92)	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND (100)	ND
2,4,6-Trichlorophenol	ND	ND	ND	ND (100)	ND	ND	ND
Parachlorometa Cresol	ND	ND	ND	ND	TA (NC)	ND	ND (100)
Chloroform	ND (100)	ND	ND	58 (NR)	ND	TA (25)	ND
1,2-Dichlorobenzene	ND	ND	TA (NC)	ND	ND	ND (100)	ND (100)
1,4-Dichlorobenzene	ND	ND	TA (NC)	ND	ND	ND	ND
1,1-Dichloroethylene	ND	ND	ND	ND	44 (NR)	ND	ND
1,2-Trans-Dichloroethylene	ND	ND	ND	ND	ND (100)	ND	ND
2,4-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropylene	ND	ND	ND	ND	ND	TA (NR)	ND
Ethylbenzene	ND (100)	51 (NR)	TA (91)	TA (84)	TA (86)	ND (100)	ND (100)
Methylene Chloride	ND	ND	ND	ND	58 (NR)	12 (64)	ND
Dichlorobromomethane	ND	ND	ND	ND	ND	TA (NR)	ND
Trichlorofluoromehtane	ND	ND	ND	ND	ND	ND	2138 (NR)
Chlorodibromomethane	ND	ND	TA (NC)	ND	ND	ND	ND
Naphthalene	ND (100)	ND (100)	ND	TA (NR)	ND (100)	TA (50)	ND (100)
2-Nitrophenol	ND	ND	ND	ND	ND	ND	ND (100)
4-Nitrophenol	ND	ND	ND	ND	ND	ND	ND (100)

* Data is for POTWs to which the mill discharges.

TABLE VII-18 (Cont.)

Parameter	40	40034*	40059	Mill 40072	40081*	40097	40099
	Average Effluent Concentration ug/l (Removal, %)						
N-nitrosodiphenylamine	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND (100)	ND	TA (NC)	ND (100)	ND	TA (92)	ND
Phenol	ND	ND	12 (100)	ND	TA (NC)	ND (100)	ND (100)
Bis(2-ethylhexyl) Phthalate	10 (NC)	35 (78)	TA (93)	TA (NR)	15 (76)	87 (21)	231 (NR)
Butyl Benzyl Phthalate	ND	ND	ND	ND	TA (85)	TA (NR)	ND
Di-n-butyl Phthalate	ND (100)	TA (57)	TA (NC)	ND	TA (41)	TA (34)	ND (100)
Di-n-octyl Phthalate	ND	ND	ND	ND	ND	ND	ND
Diethyl Phthalate	TA (NR)	ND (100)	ND (100)	ND (100)	ND	TA (46)	ND
Dimethyl Phthalate	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	TA (NR)	ND	ND (100)	ND	ND
Pyrene	ND	TA (NR)	ND	ND	ND	ND	ND
Tetrachloroethylene	ND	ND	ND (100)	ND	51 (NR)	TA (47)	ND
Toluene	TA (NC)	TA (72)	23 (87)	24 (17)	TA (69)	TA (50)	12 (54)
Trichloroethylene	ND	ND	ND (100)	TA (NR)	TA (100)	ND	ND
Gamma-BHC	ND	ND	ND	TA (NR)	ND	ND	ND
Antimony (Total)	TA (NC)	ND (100)	50 (NC)	TA (NC)	ND	15 (2)	TA (NC)
Arsenic (Total)	31 (41)	ND	TA (NC)	ND (100)	TA (NC)	21 (40)	ND
Cadmium (Total)	TA (NC)	ND	TA (NC)	ND (100)	ND	ND	ND
Chromium (Total)	56 (NC)	25 (48)	19 (11)	TA (47)	53 (79)	TA (83)	ND (100)
Copper (Total)	18 (100)	100 (96)	39 (NR)	15 (42)	55 (59)	27 (49)	ND (100)
Cyanide	105 (NR)	ND	TA (NR)	ND	210 (13)	212 (NR)	ND
Lead (Total)	TA (NC)	ND (100)	74 (NR)	ND (100)	ND	ND	ND
Mercury (Total)	ND	ND	TA (NR)	ND	ND	ND	ND
Nickel (Total)	22 (100)	90 (7)	70 (7)	ND (100)	49 (NR)	ND (100)	ND (100)
Selenium (Total)	ND	ND	ND	ND	ND (100)	TA (100)	ND
Silver (Total)	TA (100)	ND (100)	40 (NC)	ND (100)	15 (NR)	ND	ND (100)
Thallium (Total)	ND	ND	ND	ND	ND	ND (100)	ND
Zinc (Total)	225 (NR)	800 (62)	142 (NR)	110 (27)	90 (59)	137 (71)	960 (75)

* Data is for POTWs to which mill discharges.

Source: Field Sampling Program

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

TABLE VII-18 (Cont.)

Parameter	Mill 40103	40120	40145	40146	40150	40156	Subcategory Average ug/l	%
Discharge type	D	D	D	D	D	D		
Detention, hrs	45	168	120	120	40	24		
Mixing, hp/mil gal	120	63	57	16	150	115		
	Average Effluent Concentration, ug/l (Removal, %)							
Acenaphthene	ND	ND	ND	ND	ND	ND	TA	67
Benzene	ND	ND	ND	ND	ND (100)	TA (50)	TA	64
Chlorobenzene	ND	ND	TA (NR)	ND	ND (100)	ND	TA	50
1,2,4-Trichlorobenzene	TA (94)	ND	ND (100)	ND	ND	ND	TA	65
1,1,1-Trichloroethane	ND	ND	ND	ND	ND (100)	ND	TA	96
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	100
2,4,6-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND	100
Parachlorometa Cresol	ND	ND	ND	ND	ND	ND	TA	100
Chloroform	ND	ND (100)	ND	ND	ND (100)	TA (89)	TA	69
1,2-Dichlorobenzene	ND	ND	ND	ND	TA (NR)	ND	TA	67
1,4-Dichlorobenzene	ND	ND	ND	ND	TA (NC)	ND	TA	NC
1,1-Dichloroethylene	ND	ND	ND	ND	ND	ND	TA	NR
1,2-Trans-Dichloroethylene	ND	ND	ND	ND	ND (100)	ND	ND	100
2,4-Dichlorophenol	ND	ND (100)	ND	ND	ND	ND	ND	100
1,2-Dichloropropane	ND	ND (100)	ND	ND	ND	ND	ND	100
1,3-Dichloropropylene	ND	ND	ND	ND	ND	ND	TA	NR
Ethylbenzene	ND	ND (100)	3018 (NR)	ND	ND (100)	TA (89)	239	77
Methylene Chloride	ND	ND (100)	ND	ND	ND	TA (NR)	TA	41
Dichlorobromomethane	ND	ND	ND	ND	ND	ND	TA	NR
Trichlorofluoromehtane	ND	ND	89 (NR)	ND	ND	ND	171	NR
Chlorodibromomethane	ND	ND	ND	ND	ND	ND	TA	NC
Naphthalene	ND (100)	ND	ND (100)	ND	ND (100)	ND (100)	TA	85
2-Nitrophenol	ND	ND	ND	ND	ND	ND	ND	100
4-Nitrophenol	ND	ND	ND	ND	ND	ND (100)	ND	100
N-nitrosodiphenylamine	ND	ND (100)	ND	ND	ND	ND	ND	100
Pentachlorophenol	ND (100)	ND (100)	ND	ND	ND (100)	ND	TA	99
Phenol	ND (100)	12 (77)	ND (100)	21 (89)	ND (100)	ND (100)	TA	96

TABLE VII-18 (Cont.)

Parameter	Mill 40103	Mill 40120	Mill 40145	Mill 40146	Mill 40150	Mill 40156	Subcategory Average ug/l	Subcategory Average %
	Average Effluent Concentration, ug/l (Removal, %)							
Bis(2-ethylhexyl) Phthalate	ND (100)	ND (100)	TA (95)	ND	18 (NR)	TA (100)	34	60
Butyl Benzyl Phthalate	ND	ND	ND	ND	ND	ND	TA	43
Di-n-butyl Phthalate	58 (NR)	ND	ND	ND	ND	TA (NC)	TA	55
Di-n-octyl Phthalate	ND	ND	ND	ND	ND	TA (NC)	TA	NC
Diethyl Phthalate	ND	ND	ND	ND	TA (NR)	ND	TA	58
Dimethyl Phthalate	ND	ND	ND	ND	TA (NR)	ND	TA	NR
Anthracene	ND	ND	ND	ND	ND	TA (NC)	TA	50
Pyrene	ND	ND	ND	ND	TA (NR)	ND	TA	NR
Tetrachloroethylene	ND	ND	ND (100)	ND	ND	TA (NR)	TA	49
Toluene	TA (NR)	ND	111 (NR)	ND	TA (84)	TA (NR)	18	43
Trichloroethylene	ND	ND	ND	ND	ND (100)	67 (NR)	TA	60
Gamma-BHC	ND	ND	ND	ND	ND	ND	TA	NR
Antimony (Total)	TA (NC)	50 (NR)	12 (NR)	NA (NC)	TA (NC)	22 (NR)	17	20
Arsenic (Total)	ND	23 (NR)	ND	NA (NC)	ND	67 (8)	14	38
Cadmium (Total)	ND	ND	ND	ND	TA (NC)	TA (NR)	TA	50
Chromium (Total)	ND	ND (100)	ND	ND (100)	TA (9)	TA (NR)	15	58
Copper (Total)	TA (NC)	32 (62)	50 (48)	26 (49)	30 (96)	TA (NR)	32	58
Cyanide	ND	TA (NR)	ND	TA (5)	ND	27 (NR)	45	3
Lead (Total)	ND	ND (100)	ND	61 (11)	ND (100)	27 (NR)	13	59
Mercury (Total)	ND	ND	ND	ND (100)	ND	ND	TA	50
Nickel (Total)	ND	93 (60)	ND (100)	ND (100)	40 (NR)	55 (33)	32	59
Selenium (Total)	ND	ND (100)	ND	NA (NC)	ND	ND	TA	100
Silver (Total)	ND	ND (100)	ND	ND (100)	ND (100)	21 (NR)	TA	78
Thallium (Total)	ND	ND	ND	ND	ND	ND	ND	100
Zinc (Total)	410 (66)	429 (39)	370 (NR)	45 (30)	5100 (35)	426 (NR)	711	36

Note: NA indicates "not analyzed."
ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program.

TABLE VII-19
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
KNIT FABRIC FINISHING MILLS (SIMPLE)

Parameter	Mill 50108	Mill 50112	Mill 50116	Subcategory Average ug/l	Subcategory Average %
Discharge type	D	D	D		
Detention, hrs	22	32	60		
Mixing, hp/mil gal	64	148	75		
	Average Effluent Concentration, ug/l (Removal, %)				
Acenaphthene	ND (100)	ND	ND	ND	100
1,2,4-Trichlorobenzene	TA (92)	ND (100)	ND (100)	TA	97
1,1,1-Trichloroethane	ND (100)	ND	ND	ND	100
1,1-Dichloroethane	ND (100)	ND	ND	ND	100
Chloroform	ND	ND	ND (100)	ND	100
1,2-Dichlorobenzene	ND (100)	ND	ND (100)	ND	100
1,4-Dichlorobenzene	ND (100)	ND	ND	ND	100
1,2-Dichloropropane	ND (100)	ND	ND	ND	100
1,3-Dichloropropylene	10 (NR)	ND	ND	TA	NR
2,4-Dimethylphenol	TA (NR)	ND	ND	TA	NR
Ethylbenzene	TA (NR)	ND (100)	ND (100)	TA	67
Trichlorofluoromethane	TA (78)	ND	ND	TA	78
Naphthalene	ND	ND (100)	ND (100)	ND	100
2-Nitrophenol	ND	TA (NR)	ND	TA	NR
Pentachlorophenol	ND (100)	ND	ND	ND	100
Phenol	ND (100)	ND (100)	ND (100)	ND	100
Bis(2-ethylhexyl) Phthalate	23 (NR)	15 (63)	TA (NR)	16	21
Diethyl Phthalate	ND (100)	ND	ND	ND	100
Dimethyl Phthalate	ND	ND	TA (NR)	TA	NR
Fluorene	ND (100)	ND	ND	ND	100
Tetrachloroethylene	ND	17 (NR)	ND (100)	TA	50
Toluene	TA (17)	ND (100)	ND	TA	59
Trichloroethylene	ND	ND (100)	ND (100)	ND	100
Antimony (Total)	TA (NC)	673 (NR)	NA (NC)	342	NR
Arsenic (Total)	ND	ND	70 (30)	23	30
Cadmium (Total)	10 (NR)	ND	TA (NC)	TA	NR
Chromium (Total)	TA (NC)	32 (NR)	20 (NR)	21	NR
Copper (Total)	130 (78)	104 (NR)	92 (NR)	109	26
Cyanide	ND	ND (100)	TA (NC)	TA	100
Lead (Total)	TA (88)	24 (NR)	48 (20)	27	36
Mercury (Total)	TA (NR)	ND	NA (NC)	TA	NR
Nickel (Total)	60 (40)	ND (100)	150 (NR)	70	47
Selenium (Total)	ND	41 (NR)	NA (NC)	21	NR
Silver (Total)	80 (20)	TA (NR)	56 (3)	49	8
Zinc (Total)	570 (NR)	49 (16)	68 (NR)	229	5

Note: NA indicates "not analyzed."
ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-20
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
KNIT FABRIC FINISHING MILLS (COMPLEX)

Parameter	Mill 50013	Mill 50035	Mill 50099	Subcategory Average ug/l	Subcategory Average %
Discharge type	D	D	D		
Detention, hrs	24	72	48		
Mixing, hp/mil gal	133	37	65		
	Average Effluent Concentration, ug/l (Removal, %)			ug/l	%
Acenaphthene	ND	TA (NC)	ND	TA	NC
Benzene	TA (100)	TA	TA (NC)	TA	100
Chlorobenzene	ND	ND (100)	ND (100)	TA	100
1,2,4-Trichlorobenzene	ND	135 (NR)	TA (NC)	48	NR
1,1,1-Trichloroethane	ND (100)	ND	ND	ND	100
1,1,2,2-Tetrachloroethane	TA (52)	ND	ND	TA	52
Chloroform	41 (NR)	128 (100)	20 (41)	63	47
1,2-Dichlorobenzene	ND	ND	TA (NC)	TA	NC
1,2-Trans-dichloroethylene	TA (NC)	ND	ND	TA	NC
2,4-Dimethylphenol	TA (NC)	ND	ND	TA	NC
Ethylbenzene	ND	14 (87)	26 (77)	13	82
Methylene Chloride	TA (NC)	ND	TA (NC)	TA	NC
Naphthalene	ND (100)	36 (NR)	TA (100)	15	67
N-nitrosodi-n-propylamine	ND	ND	TA (NR)	TA	NR
Phenol	TA (100)	TA (NC)	TA (100)	TA	100
Bis(2-ethylhexyl) Phthalate	TA (NR)	21 (70)	40 (NR)	24	23
Butyl benzyl Phthalate	ND (100)	ND	ND	ND	100
Di-n-butyl Phthalate	TA (NC)	TA (NC)	TA (100)	TA	100
Diethyl Phthalate	ND (100)	ND	TA (100)	TA	100
Dimethyl Phatalate	ND	ND	ND (100)	ND	100
Acenaphthylene	ND (100)	ND	ND	ND	100
Anthracene	ND	ND	TA (NC)	TA	NC
Tetrachloroethylene	317 (64)	TA (74)	ND	109	69
Toluene	TA (NC)	TA (66)	TA (39)	TA	53
Trichloroethylene	24 (33)	TA (NC)	ND	11	33
Antimony (Total)	454 (12)	676 (NR)	83 (NC)	404	6
Arsenic (Total)	TA (NC)	ND (100)	ND	TA	100
Cadmium (Total)	TA (NR)	TA (NC)	TA (NC)	TA	NR
Chromium (Total)	TA (NC)	ND (100)	21 (100)	10	100
Copper (Total)	14 (69)	66 (NR)	12 (NC)	31	35
Cyanide	TA (72)	ND (100)	13 (26)	TA	66
Lead (Total)	47 (25)	40 (NC)	TA (100)	32	63
Mercury (Total)	ND	TA (NC)	TA (NC)	TA	NC
Nickel (Total)	151 (NR)	52 (NC)	87 (60)	97	30
Silver (Total)	16 (NR)	11 (NC)	21 (67)	16	34
Zinc (Total)	54 (28)	77 (30)	1046 (30)	392	29

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-21
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
KNIT FABRIC FINISHING MILLS (HOSIERY)

Parameter	Mill 5H034		
Discharge type	I		
Detention, hrs	12		
Mixing, hp/mil gal	250		
		Subcategory Average	
Average Effluent Concentration, ug/l (Removal, %)		ug/l	%
Acrylonitrile	400 (75)	400	75
Naphthalene	TA (NR)	TA	NR
N-nitrosodiphenylamine	ND (100)	ND	100
Phenol	14 (NR)	14	NR
Bis(2-ethylhexyl) Phthalate	172 (NR)	172	NR
Tetrachloroethylene	ND (100)	ND	100
Toluene	TA (NR)	TA	NR
Antimony (Total)	ND (100)	ND	100
Chromium (Total)	199 (70)	199	70
Copper (Total)	14 (NR)	14	NR
Selenium (Total)	97 (87)	97	87
Zinc (Total)	112 (NR)	112	NR

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-22
PERFORMANCE OF ACTIVATED SLUDGE IN THE TREATMENT OF TOXIC POLLUTANTS
CARPET FINISHING MILLS

Parameter	Mill 60008		Mill 60034		Mill 60037		Subcategory Average ug/l	%
Discharge type	I		D		D			
Detention, hrs	48		96		192			
Mixing, hp/mil gal	73		44		40			
Average Effluent Concentration, ug/l (Removal, %)								
Acenaphthene	ND		ND		TA	(96)	TA	96
Chlorobenzene	ND	(100)	ND		ND		ND	100
Hexachlorobenzene	ND		ND		TA	(NR)	TA	NR
Chloroform	ND	(100)	ND		ND	(100)	ND	100
1,2-Diphenylhydrazine	ND	(100)	ND		ND		ND	100
Ethylbenzene	ND	(100)	ND		ND		ND	100
Dichlorobromomethane	ND	(100)	ND		ND		ND	100
Naphthalene	ND	(100)	ND		ND	(100)	ND	100
Phenol	45	(25)	ND	(100)	TA	(NC)	18	63
Bis(2-ethylhexyl) Phthalate	18	(36)	27	(NR)	10	(47)	18	28
Diethyl Phthalate	ND		ND		11	(NR)	TA	NR
Fluorene	ND		ND		ND	(100)	ND	100
Toluene	ND		ND		TA	(NR)	TA	NR
Antimony (Total)	105	(NC)	NA	(NC)	11	(79)	58	79
Cadmium (Total)	ND		TA	(NC)	ND		TA	NC
Chromium (Total)	356	(NR)	170	(NR)	TA	(NC)	179	NR
Copper (Total)	ND	(100)	46	(2)	28	(56)	25	53
Cyanide	TA	(NC)	ND	(100)	TA	(NR)	TA	50
Lead (Total)	ND		25	(24)	ND	(100)	TA	62
Nickel (Total)	NA	(NC)	79	(19)	13	(54)	46	37
Silver (Total)	NA	(NC)	33	(21)	ND	(100)	17	61
Zinc (Total)	NA	(NC)	130	(NR)	260	(42)	195	21

Note: NA indicates "not analyzed."
ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-23

PERFORMANCE OF ACTIVATED SLUDGE IN THE TREATMENT OF TOXIC POLLUTANTS

STOCK & YARN FINISHING MILLS

Parameter	Mill 70009	Mill 70072	Mill 70081	Mill 70087	Mill 70096	Mill 70120	Subcategory Average ug/l	Subcategory Average %
Discharge type	D	D	D	D	D	D		
Detention, hrs	62	55	120	126	65	24		
Mixing, hp/mil gal	46	140	114	14	107	150		
	Average Effluent Concentration, ug/l (Removal, %)							
Acenaphthene	ND	ND (100)	ND	ND (100)	ND	ND	ND	100
Benzene	ND	ND	TA (NR)	TA (NR)	ND	ND	TA	NR
Chlorobenzene	ND	ND (100)	ND	ND	ND	ND	ND	100
1,2,4-Trichlorobenzene	ND	ND	27 (90)	ND	ND	ND	TA	90
Hexachlorobenzene	TA (NR)	ND	TA (NR)	ND	ND	ND	TA	NR
Bis(chloromethyl) Ether	ND	ND	ND (100)	ND	ND	ND	ND	100
2,4,6-Trichlorophenol	ND	ND	TA (79)	ND	ND	ND	TA	79
Parachlorometa Cresol	ND	TA (NR)	TA (77)	ND	ND	ND	TA	39
Chloroform	TA (NR)	ND (100)	ND	ND (100)	ND (100)	ND (100)	TA	80
1,2-Dichlorobenzene	TA (NC)	ND	TA (88)	ND	ND	ND	TA	88
1,4-Dichlorobenzene	ND	ND	ND	ND (100)	ND	ND	ND	100
2,4-Dichlorophenol	ND	ND	ND (100)	ND	ND	ND	ND	100
1,2-Dichloropropane	ND	ND	ND (100)	ND	ND	ND	ND	100
2,4-Dimethyphenol	ND	ND	ND (100)	ND	ND	ND	ND	100
2,6-Dinitrotoluene	ND (100)	ND	ND	ND	ND	ND	ND	100
Ethylbenzene	ND	ND (100)	TA (100)	ND (100)	ND	ND (100)	TA	100
Methylene Chloride	ND	ND	TA (NC)	ND	ND	ND	TA	NC
Trichlorofluoromethane	10 (NR)	ND	ND	ND	TA (NR)	48 (NR)	11	NR
Naphthalene	TA (NC)	TA (NC)	TA (87)	ND	ND (100)	ND	TA	94
N-nitrosodi-n-propylamine	ND	ND	ND	ND	TA (NR)	ND	TA	NR
Pentachlorophenol	ND	ND	12 (NR)	ND	ND	ND	TA	NR
Phenol	ND (100)	TA (47)	ND (100)	ND	ND	ND	TA	82
Bis(2-ethylhexyl) Phthalate	25 (71)	134 (NR)	169 (65)	TA (NC)	TA (NC)	40 (NR)	65	34
Butyl Benzyl Phthalate	ND	ND	TA (NR)	ND	ND	ND	TA	NR

TABLE VII-23 (Cont.)

Parameter	Mill 70009	Mill 70072	Mill 70081	Mill 70087	Mill 70096	Mill 70120	Subcategory Average ug/l	Subcategory Average %
	Average Effluent Concentration, ug/l (Removal, %)							
Di-n-butyl Phthalate	TA (NR)	ND	TA (58)	ND	ND	ND	TA	29
Diethyl Phthalate	TA (NR)	12 (20)	TA (NR)	ND	ND (100)	ND	TA	30
Dimethyl Phthalate	ND	ND	ND (100)	ND (100)	ND	ND (100)	ND	100
Anthracene	ND	ND	TA (NR)	ND	ND (100)	ND	TA	50
Fluorene	ND	ND	ND (100)	ND	ND	ND	ND	100
Indeno(1,2,3-cd) Pyrene	ND	ND (100)	ND	ND	ND	ND	ND	100
Pyrene	ND	ND	TA (NR)	ND	TA (NR)	ND	TA	NR
Tetrachloroethylene	ND	ND	TA (99)	ND	ND	ND	TA	99
Toluene	ND	15 (NR)	13 (50)	ND (100)	ND (100)	ND (100)	TA	70
Trichloroethylene	ND	ND	ND (100)	ND	ND	ND (100)	ND	100
Antimony (Total)	TA (38)	ND	157 (4)	TA (NC)	ND	ND	30	21
Arsenic (Total)	ND	ND	TA (47)	ND	ND	TA (NC)	TA	47
Beryllium (Total)	ND	NA (NC)	TA (NR)	ND	NA (NC)	ND	TA	NR
Cadmium (Total)	ND	TA (NC)	TA (NR)	ND	ND (100)	ND	TA	50
Chromium (Total)	TA (62)	290 (55)	76 (NR)	30 (NR)	TA (17)	TA (NR)	71	22
Copper (Total)	110 (NR)	ND (100)	119 (NR)	96 (68)	30 (59)	10 (72)	61	50
Cyanide	ND	29 (NR)	ND	172 (NR)	ND (100)	ND	34	33
Lead (Total)	ND	160 (NR)	12 (NR)	ND (100)	ND	36 (NR)	35	25
Mercury (Total)	ND	NA (NC)	ND	ND	TA (NC)	ND	TA	NC
Nickel (Total)	ND (100)	160 (20)	ND	35 (35)	ND	ND	33	52
Selenium (Total)	ND	NA (NC)	ND	ND	ND	ND (100)	ND	100
Silver (Total)	ND	57 (16)	ND	ND	ND	TA (NR)	11	8
Zinc (Total)	91 (62)	100 (23)	250 (50)	720 (28)	170 (43)	865 (NR)	366	34

Note: NA indicates "not analyzed."
ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-24
PERFORMANCE OF ACTIVATED SLUDGE
IN THE TREATMENT OF TOXIC POLLUTANTS
FELTED FABRIC FINISHING MILLS

Parameter	Mill 80025			
Discharge type	D			
Detention, hrs	160			
Mixing, hp/mil gal	60			
			Subcategory Average	
Average Effluent Concentration, ug/l (Removal, %)			ug/l	%
Naphthalene	56	(NR)	56	NR
Phenol	TA	(88)	TA	88
Bis(2-ethylhexyl) Phthalate	18	(31)	18	31
Tetrachloroethylene	ND	(100)	ND	100
Toluene	ND	(100)	ND	100
Trichloroethylene	ND	(100)	ND	100
Vinyl Chloride	ND	(100)	ND	100
Asbestos (MFL)*	TA	(NC)	TA	NC
Chromium (Total)	35	(NR)	35	NR
Copper (Total)	ND	(100)	ND	100
Selenium (Total)	32	(44)	32	44
Zinc (Total)	45	(NR)	45	NR

* Value reported as million fibers per liter.

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NC indicates "not able to calculate removal."
NR indicates "no removal."

Source: Field Sampling Program

TABLE VII-25
PERFORMANCE OF ACTIVATED SLUDGE
IN THE REMOVAL OF COLOR

Mill	Average Color, ADMI (pH = 7.6) Influent	Effluent	Average Removal, %
10013	343*	113	68
20021	390	210	43
40081	148	62	58
40097	253	880	NR
40156	380	114	70
50112	278	187	33
50013	121	82	32
5H034	816	898	NR
70081	134	114	15
70120	312	208	33
80025	194	283	NR

* Value for untreated wastewater from finishing plant.

Note: NR indicates "no removal."

Source: Field Sampling Program

disks. While the physical structures differ, the biological process is the same in all of these systems.

As wastewater contacts the supporting media, a thin film of biological mass develops and coats the surfaces. The film consists primarily of bacteria, protozoa and fungi that feed on material in the wastewater. Organic matter and dissolved oxygen are extracted from the wastewater and the metabolic end products are released. Because the biological mass layer is anaerobic near the supporting media, hydrogen sulfide, methane and organic acids are generated. Periodically the mass separates (sloughs off) from the supporting media and is carried through the system with the hydraulic flow. The sloughed biomass is typically removed in a clarifier.

Trickling filters are classified by hydraulic or organic loading as low or high rate. Low rate filters have a hydraulic loading rate of 9350 to 37400 cu m/hectare/day (1 to 4 mil gal/acre/day), an organic loading rate of 136 to 454 kg/hectare/meter/day (300 to 1000 lb BOD5/acre ft/day), a depth of 1.8 to 3.0 m (6 to 10 ft), and no recirculation. High rate filters have a hydraulic loading rate of 93500 to 374000 cu m/hectare/day (10 to 40 mil gal/acre/day), an organic loading rate of 453 to 2265 kg/hectare/meter/day (1000 to 5000 lb BOD5/acre ft/day), a depth of 0.9 to 3.0 m (3 to 10 ft), and a recirculation rate of 0.5 to 4. High rate filters have one or two stages. The most suitable trickling filter media are crushed stone or gravel graded to a uniform size within the range of 2.5 to 7.6 cm (1 to 3 in. in diameter. The media must be strong and durable so that it does not deteriorate.

Biological towers are similar to conventional trickling filters but with manufactured media instead of crushed rock or gravel media. The manufactured media are corrugated plastic packing or rough-sawn redwood slats, both of which are effective in retaining biological films. The advantages of this type of media are a high specific surface [(sq m/cu m) (sq ft/cu ft)], a high percentage of void volume, uniformity for better liquid distribution, light weight allowing construction of deeper beds, resistance to chemical reactivity, and the ability to treat high strength and unsettled wastewaters. Biological towers are used in flow patterns similar to normal high rate natural media filter systems. For strong wastewater, two towers are set in series and settled solids from the final clarifier are returned to the first tower influent. Because of the increased void space, activated sludge will build up in the flow and the system will perform as both a filter, with fixed biological growth, and as a mechanical aeration system. Biological beds have a hydraulic loading rate of up to 0.8 l/sec/sq cm (2 gpm/sq ft), an organic loading rate of from 0.4 to 2.4 kg/cu m/day) (25 to 150 lb BOD5/1000 cu ft/day), and a depth of 6.1 m (20 ft).

The rotating biological disk makes use of the advantages of the manufactured plastic media used in the packed tower to increase the contact time between the wastewater and fixed biological growth. A series of disks constructed of corrugated plastic plate and mounted on a horizontal shaft are placed in a tank and immersed to approximately 40 percent of the diameter. The disks rotate as wastewater passes through the tank and a fixed film biological growth, similar to that on trickling filter media, adheres to the surface. Alternating exposure to the wastewater and the oxygen in the air results in biological oxidation of the organics in the wastes. Biomass sloughs off, as in the trickling filter and packed tower systems, and is carried out in the effluent for gravity separation. Direct recirculation usually is not practiced with the rotating biological disk.

Industry Application - Based on the industry survey there are only three textile mills that utilize biological beds in their wastewater treatment systems. Two direct discharging woven fabric finishers use trickling filters. One of these mills uses a modified approach to the standard filtration process. The beds are square, 4.3 to 4.9 m (14 to 16 ft) deep, wastewater is applied continuously, and forced ventilation insures aerobic conditions throughout. The system obtains 96 percent BOD_5 reduction. The other mill uses a standard high rate trickling filter as a polishing process after activated sludge treatment. The overall system performance is 98 percent BOD_5 removal and 93 percent COD removal. The third mill uses a rotating biological disk as an intermediate step between filtration and biological aeration. This mill is a direct discharger and practices recovery of dyestuff.

Stabilization Lagoons Stabilization lagoons are a popular biological treatment process. They are often called lagoons or oxidation ponds and are classified aerobic, facultative, anaerobic, and polishing. They are used extensively in the treatment of municipal wastewater in small communities and in the treatment of industrial or combined industrial and muncipal wastewaters that are amenable to biological treatment.

Aerobic lagoons contain bacteria and algae in suspension, and aerobic conditions prevail throughout the depth. Wastewater is stabilized as a result of the symbiotic relationship between aerobic bacteria and algae. Bacteria break down waste and generate carbon dioxide and nutrients (primarily nitrogen and phosphorus). Algae, in the presence of sunlight, utilize the nutrients and inorganic carbon; they in turn supply oxygen that is utilized by aerobic bacteria. Aerobic lagoons are usually less than 45 cm (18 in) deep (the typical depth of light penetration) and are periodically mixed to maintain aerobic conditions throughout. In order to achieve effective organic and suspended solids removal with aerobic lagoons, some means of removing algae (coagulation, filtration, multiple cell design) is necessary. Algae have a high degree of mobility and do not settle well using conventional clarification.

In facultative lagoons, the bacterial reactions include both aerobic and anaerobic decomposition. The symbiotic relationship between aerobic bacteria and algae exists, as in aerobic lagoons, and anaerobic decomposition takes place by bacteria that feed on settled solids. Facultative lagoons are up to 1.5 m (5 ft) in depth and require the same types of provisions for removing algae if effective pollutant removals are to be realized. Most of the textile mills reporting use of stabilization lagoons are operating facultative lagoons.

Anaerobic lagoons are anaerobic throughout their depth and have the advantage of a low production of waste biological sludge and low operating costs. Stabilization is accomplished by a combination of precipitation and anaerobic decomposition of organics to carbon dioxide, methane, other gaseous end products, organic acids, and cell tissue. Lagoons are constructed with depths up to 6 m (20 ft) and steep side walls to minimize the surface area relative to total volume. This allows grease to form a natural cover, which retains heat, suppresses odors, and maintains anaerobic conditions. Wastes enter near the bottom and the discharge is located on the opposite end below the grease cover. Sludge recirculation is not necessary because gasification and the inlet-outlet flow pattern provides adequate mixing. The anaerobic lagoon is not particularly suitable for treating textile wastewaters, with the possible exception of wool scouring waste.

Polishing ponds serve as a polishing step following other biological treatment processes. They are often called maturation ponds and primarily serve the purpose of reducing suspended solids. Water depth is generally limited to 0.6 or 1.0 m (2 or 3) ft and mixing is usually provided by surface aeration at a low power-to-volume ratio. Polishing ponds are popular as a final treatment step for textile wastewater treated with the extended-aeration activated sludge process.

Industry Application - Current use of stabilization lagoons by the textile mills surveyed is summarized in Table VII-26. Forty-four direct dischargers and 17 indirect dischargers report using stabilization lagoons as part of their treatment system. Three direct dischargers rely on facultative lagoons alone for treatment; 15 use facultative lagoons following aerated lagoons; 25 use polishing lagoons following activated sludge; and one uses a polishing lagoon after activated sludge and prior to chemical coagulation. Fifteen indirect dischargers rely on facultative lagoons alone for treatment, one uses a facultative lagoon following an aerated lagoon, and one uses two parallel anaerobic lagoons prior to activated sludge.

TABLE VII-26
USE OF STABILIZATION LAGOONS BY TEXTILE INDUSTRY - RESULTS OF INDUSTRY SURVEY

Subcategory	Facultative Lagoon		Aerated Lagoon + Facultative Lagoon		Activated Sludge + Polishing Lagoon	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
1. Wool Scouring	0	2	0	0	1	0
2. Wool Finishing	0	0	2	0	0	0
4. Woven Fabric Finishing	2	3	3	0	11	0
5. Knit Fabric Finishing Fabric Processing	0	7	3	0	5*	1
Hosiery Processing	0	2	0	0	0	0
6. Carpet Finishing	0	0	3	0	2	0
7. Stock & Yarn Finishing	0	2	4	1	5	0
8. Nonwoven Manufacturing	1	1	0	0	1	0
9. Felted Fabric Processing	0	0	0	0	0	0
All Subcategories	3	17	15	1	25	1

* One mill follows polishing lagoon with chemical coagulation.

Source: EPA Industry Survey, 1977.

Historical Data - Only one mill reported both influent and effluent monitoring data for the lagoon portion of their treatment system. However, several of the mills employing facultative lagoons alone for treatment or pretreatment provided effluent data. These data are presented in Table VII-27. The general effectiveness of the lagoons can be established by comparing the effluent concentration with those presented earlier in this section for aerated lagoons and activated sludge.

Field Sampling - Although a number of textile mills use polishing lagoons as a final treatment step (see Industry Application), there are limited historical data available to demonstrate the effectiveness of the lagoons in treating conventional, nonconventional and toxic pollutants. Sampling was conducted around the polishing lagoons at a stock and yarn finishing and at a felted fabric processing mill where polishing ponds are used after activated sludge treatment. Analytical results do not demonstrate any significant improvement in effluent quality. Because only single 24 hour composite samples were obtained, these results are not conclusive. The detailed results of this sampling episode can be found in the field sampling results in the administrative record for mills 70120 and 80025.

Chemical Processes

Coagulation/Sedimentation Suspended solids (TSS) are a significant constituent of most textile mill wastewaters. The larger solids are removed in preliminary treatment steps but a variety of colloidal particulates remain even after biological treatment. Besides fiber, these solids include color bodies, soaps, fine mineral particulates, oil and grease and microscopic organisms. The wastewater from carpet mills, other adhesive related processing mills, and nonwoven manufacturing facilities may, in addition, contain considerable amounts of latex. Coagulation/sedimentation can be used to remove these pollutants.

Coagulation is the process by which chemicals are used to destabilize suspended material so that the particles agglomerate. Two forces, hydration, which results in a protective shell of water molecules, and electrostatic charge keep small particles apart and lead to a stable, colloidal suspension. Most colloidal particles carry a characteristic negative charge and are unable to coalesce because of to this electrostatic repulsion. Neutralization of these repulsive forces by the addition of multivalent cations attracts the particles together. The weight of the coagulated particles results in sedimentation (20).

The most effective inorganic coagulants for wastewater treatment are alum (aluminum sulfate), copperas (ferrous sulfate), lime (calcium hydroxide), ferric chloride, and ferric sulfate. The multivalent cation (Al^{+3}, Fe^{+3}) enters into a series of hydrolytic reactions to form multivalent positively charged

TABLE VII-27
PERFORMANCE OF STABILIZATION LAGOONS
IN THE TREATMENT OF TRADITIONALLY MONITORED POLLUTANTS

Subcategory	Mill	Discharge	Average Effluent Concentration, mg/l BOD5	COD	TSS
4c	40014	Direct	53	175	14
4c	40065	Direct	35	115	35
4b	40038	Indirect	482	2186	18
5b	50023	Indirect	325	810	40
5b	50045	Indirect	145	-	-
5a	50069	Indirect	141	862	-
5c	5H049	Indirect	211	548	-
7	70023	Indirect	233	634	59
7	70122	Indirect	111	789	945
8	80027	Direct	17	-	29
8	80014	Indirect	79	-	179

Source: EPA Industry Survey, 1977.

hydrous oxide species that are adsorbed onto the negatively charged colloid. This neutralizes the colloidal system and allows the particles to agglomerate.

Because these chemical reactions are instantaneous, a rapid mix process is used to mix the coagulant with the wastewater. This brief mixing provides a complete dispersion of the coagulant throughout the wastewater but is not long enough for agglomeration to take place. The second stage of the process, flocculation, promotes interparticle contact of the stabilized colloids to form a floc that is removed in the final stage of the process, sedimentation.

In addition to the coagulants noted, polyelectrolytes (polymers) are used as coagulants or as coagulant aids. These compounds contain repeating units of small molecular weight, combined to form a molecule of colloidal size. Each of the repeating units carries one or more electrical charges or ionizable groups. Because of their large size, the major benefit of polyelectrolytes is an increase in floc size. It is generally agreed that a "bridging" mechanism is responsible for flocculation enhancement. One end of the polymer molecule attaches itself to the surface of a suspended particle at one or more sites and the free end is able to adsorb onto yet another suspended particle forming a "bridge" between the two. This union increases the mass of the colloidal-polymer system and increases the settling velocity. As the particle settles, it entraps other colloids and polymers and thus clarifies the wastewater with a "sweep floc" effect.

Industry Application - Thirty-four of the wet processing mills surveyed report that chemical coagulation is employed in their wastewater treatment system. Sixteen of these mills are direct dischargers, 15 are indirect dischargers, 2 practice complete recycle and one discharges to an evaporation lagoon after coagulation. At 13 of these mills, coagulation is used for the treatment of latex or printing wastewater, 10 of these mills are indirect dischargers, which is two-thirds of all the indirect discharge mills that identify coagulation as part of their treatment system. Of the direct dischargers using coagulation for treatment of wastewater other than latex or print wastes, two employ it as a last step after biological treatment, six add polymer and/or alum to the effluent from an aeration basin prior to secondary sedimentation, two coagulate as an intermediate step between activated sludge and filtration, and two coagulate in place of biological treatment. The use of coagulation at two mills was unclear from the survey results.

Historical Data - Based on the above breakdown, there are only two mills of the thirty-four presently using coagulation as their principal treatment process and 6 mills (4 direct dischargers and 2 recycle) that employ coagulation as an advanced treatment measure. However, because of the nature of the historical data available from these mills, i.e., influent and effluent data for the entire treatment systems, the effectiveness of the chemical coagulation process alone cannot be determined. The performance of the treatment systems that include coagulation are presented in Table VII-20. The concentrations generally represent average values for the year 1976 for those mills that provided historical monitoring data.

Literature/Research Coagulation of textile wastewater has received considerable attention from the engineering and research communities. Much of the work is general and does not address adaptability to high volume textile discharges. Some of the studies are specific to individual wastewater streams and are not applicable to total mill effluent performance. The following cases offer relevant information on studies that are applicable. In addition to the laboratory and full-scale studies presented, two mills with full scale systems were sampled during the field sampling program. The results of this sampling are included with the other cases.

In case 1 a laboratory study performed in 1974(68) evaluated coagulation using alum in removing color from a dyehouse effluent. The effluent was from a woven fabric finishing mill that processes cotton-polyester broadwoven fabrics. The types of processing performed and the types of dye utilized were not provided by the author.

The mill's dyehouse wastewater, boiler blowdown, and air conditioning condensate were being treated in a two-stage aerated lagoon. Approximately 50 percent removal of BOD was achieved prior to discharge to a small creek.

The study used a jar test apparatus to conduct a series of coagulation investigations using various dosages of alum. The results, which are presented in Table VII-29, establish the feasibility of removing COD and color from the dyehouse wastewater prior to biological treatment.

In case 2 a laboratory study was performed to evaluate coagulation of textile mill printing waste. The waste studied was collected from the discharge line of the printing department of a large woven fabric finishing-desizing facility. The facility dyes and/or prints sheets, and the wastewater streams resulting from the dyeing and printing operations are segregated. The waste from the printing department contained printing pigment, adhesives, an acrylic latex emulsion, and varsol (print paste carrier). These constituents are typically suspended in the wastewater in particulate or colloidal form and are not readily solubilized by microorganisms when subjected to biological treatment.

A series of jar test experiments were performed using ferric chloride, ferric sulfate and aluminum sulfate. The experiments

TABLE VII-28
PERFORMANCE OF CHEMICAL COAGULATION IN THE TREATMENT
OF TRADITIONALLY MONITORED POLLUTANTS

Subcategory	Mill	Coagulant(s)	Treatment Step	BOD5, mg/l		COD, mg/l		TSS, mg/l	
				Inf#	Eff	Inf#	Eff	Inf#	Eff
			(Direct Dischargers)						
2	20009	Alum, Polymer	Secondary Clarifier	150	25	900	-	175	64
4b	40022	Alum	Secondary Clarifier	83	14	308	152	43	35
4b*	40126	-	Flotation Unit	-	51	-	482	-	188
4c	40130	-	Secondary Clarifier	200	51	845	663	82	142
4c	40145	Polymer	Secondary Clarifier	-	7	846	164	-	54
4c*	40150	Ferric Chloride, Lime	Coag/Floc - Raw Waste	-	4	1,400	99	168	30
4c*	40156	-	-	760	12	1,600	248	420	99
5a	50030	-	Coag/Floc - Secondary	334	24	1,265	206	-	40
5a	50052	Polymer	Secondary Clarifier	-	24	-	272	-	65
5a	50112	Polymer	Injection Prefiltration	279	5	934	196	41	7
7	70072	Alum, Polymer	Secondary Clarifier	327	20	1,572	480	26	23
7	70105	Copperas, Lime	Secondary Clarifier	60	15	331	129	31	11
8	80016	-	Flotation-Post Biological	-	6	-	-	-	14
			(Indirect Dischargers)						
2	20022	Lime	Coag/Floc - Raw Waste	-	-	1,328	556	-	560
4a*	40001	Lime, Alum	Flotation	-	250	-	400	-	30
4c*	40081	Ferric Chloride	Coag/Clarify-Print Waste	-	420	-	695	-	118
4a**	40112	Aluminum Chloride	Flotation-Print Waste	-	341	-	885	-	206
4a*	40124	Alum	Coag/Clarify-Print Waste	322	126	1,985	263	460	72
			(Recycle Mill)						
4a*	40144	Alum	Flotation	298	10	-	1,550	-	5

* Fabric printing is a significant portion of production.
** Latex and PVC coating operation.
# Influent indicates raw waste concentration not influent to coagulation/sedimentation.

Source: EPA Industry Survey, 1977.

TABLE VII-29
CASE 1 - LABORATORY STUDY OF
CHEMICAL COAGULATION ON DYEHOUSE EFFLUENT

Alum Dosage, mg/l as $Al_2(SO_4)_3$ 18H_2O	Total COD, mg/l Inf*	Total COD, mg/l Eff**	Soluble COD, mg/l Inf	Soluble COD, mg/l Eff	TSS, mg/l Inf	TSS, mg/l Eff	Color, APHA Inf	Color, APHA Eff
660	935	490	582	429	132	49	12,800	580
660	903	471	-	-	-	-	10,200	288
550	1,590	598	667	559	590	12	8,800	428
440	1,030	525	730	335	-	-	7,700	450
440	973	590	-	-	-	-	11,000	442
440	954	573	740	519	-	-	12,200	340
330	805	398	-	-	-	-	11,800	690

* "Inf" represents dyehouse effluent
** "Eff" represents supernatant from jar test after 1 hr settling

Source: Reference 68.

TABLE VII-30
CASE 2 - LABORATORY STUDY OF CHEMICAL COAGULATION
ON A PRINTING WASTE STREAM

Coagulant	Dosage, mg/l of Metal+3	pH	Turbidity, JTU Inf	Turbidity, JTU Eff	COD, mg/l Inf	COD, mg/l Eff
Ferric Chloride	25	6.6	270	19	2,100	665
Ferric Sulfate	25	7.1	270	26	2,100	155
Aluminum Sulfate	25	6.6	270	14	2,100	235

Source: Reference 69.

reported here consisted of: placing a one-liter sample into a standard flocculation vessel and stirring at 100 rpm; adding the desired quantity of coagulant and adjusting the pH with HCl or NaOH; mixing for one minute after pH adjustment at 100 rpm and flocculating for two minutes at 10 rpm; and quiescent settling for 30 minutes followed by analysis. Results are presented in Table VII-30 for removal of suspended and colloidal materials.

In case 3 the results of a full-scale investigation of activated sludge and alum coagulation treatment of the wastewater from a knit fabric finishing - simple processing mill are summarized. The investigations were supported by an EPA Demonstration Grant(24), and were conducted over a 1 year period.

At the time of the study, the mill was producing velour fabric for the apparel trade (approximately 56 percent), nylon fabric for the automotive industry (approximately 13 percent), fabric of polyester/nylon blends for the uniform trade (approximately 13 percent), and various other fabrics each at less significant production levels.

During the study period, the mill's daily production ranged from a low monthly average of approximately 14,790 kg (34,000) lbs to a high monthly average of approximately 24,800 kg (57,000) lbs. Average daily production was approximately 20,900 kg (48,000 lbs). The production was pressure beam-dyed (approximately 54 percent), atmospheric beck-dyed (approximately 27 percent), or pad-dyed (approximately 17 percent). Approximately 30 percent of the dyestuff utilized was of the disperse class and 20 percent was of the acid class. Besides dyeing, the production was scoured and various functional finishes (water repellents, softeners, and flame retardants) were applied.

The wastewater treatment system included heat reclamation, equalization, activated sludge (aerated lagoon plus clarifier), alum coagulation, chlorination, and mechanical sludge processing (horizontal scroll centrifuge). Each component of the treatment system was evaluated. The performance of the alum coagulation component throughout the study period is presented in Table VII-31 for the parameters of primary concern here.

As part of the field sampling program sampling was performed at a woven fabric finishing-desizing mill that performs desizing, scouring, bleaching and dyeing to produce finished woven goods. Piece dyeing accounts for approximately 90 percent of the production. No production figures were reported for the sampling period. The processing operations result in a wastewater discharge of 4,730 cu m/day (1.25 mgd).

Wastewater treatment at this mill consists of static screening, mixed equalization, aeration (1 basin), secondary sedimentation, chemical addition, clarification, a polishing pond and disinfection (chlorine). Aeration detention time is

TABLE VII-31
CASE 3 - FULL SCALE CHEMICAL COAGULATION AT A
KNIT FABRIC FINISHING MILL

Parameter/Pollutant	Influent (yearly median)*	Effluent (yearly median)*
BOD_5, mg/l	122	33
COD, mg/l	1,056	416
TOC, mg/l	200	105
TSS, mg/l	368	122
Dissolved Solids, mg/l	619	600
Phenolics, ug/l	30	40
Color, APHA Units	804	320
Chromium, ug/l	360	280
Copper, ug/l	30	ND
Lead, ug/l	28**	23**
Nickel, ug/l	10**	10**
Zinc, ug/l	220	110
Mercury, ug/l	1.8**	1.7**

* Samples were collected daily and daily analyses were performed for all parameters listed except phenolics and metals; the samples for these parameters were combined into a composite sample and analyzed once per month.

** average value

Note: ND indicates "not detected."

Source: Reference 70.

approximately 24 hours, and air is provided by surface aerators with a total power-to-volume ratio of approximately 325 kwh/1000 cu m (115 hp/million gal).

Three 24 hour composite samples were collected over a typical 72-hour period of operation of the raw waste stream, the effluent from the biological clarifiers, the effluent from the chemical clarifiers, and the effluent from the chlorine contact tank. The results presented in Table VII-32 demonstrate the effectiveness of chemical coagulation in treating toxic, nonconventional and conventional pollutants.

Sampling was also performed at a stock and yarn finishing mill that used chemical coagulation after aerated equalization. The processing operations result in a wastewater discharge of 1,770 cu m/day (467,000 gpd).

Wastewater treatment at this mill consists of aerated equalization, chemical addition (ferric chloride), flocculation, clarification, and filtration. The discharge from the treatment plant is recycled for reuse in the mill operations.

Three 24 hour composite samples were collected over a typical 72-hour period of operation at the discharge from the equalization basin, at the discharge from the chemical clarifiers, and at the discharge from the clear well following the filters. The results are presented in Table VII-33.

<u>EPA/Industry Field Studies</u> - In a joint research effort between EPA and the textile industry (ATMI, NTA, and CRI), pilot plant studies were conducted during 1977 and 1978 at 19 textile mills to evaluate the effectiveness of alternative advanced wastewater treatment technologies. The studies were performed on the effluent from treatment systems using extended aeration activated sludge. One of the technologies was chemical coagulation using a 6,245 liter (1,650 gallon) reactor/clarifier. Prior to initiating the pilot plant studies, jar testing was performed to determine the coagulant(s) and dosage(s) most effective for removal of suspended solids and organic material. Among the coagulants evaluated were alum, ferric chloride, polymers and lime, individually and in various combinations. The jar tests established operating conditions for the reactor/clarifier during screening (comparison) experiments against other treatment modes. Based on the comparisons, promising modes were selected for more extensive study in candidate process evaluations. The effectiveness of precoagulation on filtration effectiveness also was studied. These experiments are discussed later (see Filtration).

Chemical coagulation was included as the first treatment step in the selected candidate process modes at 10 of the 19 mills studied. Processing information, waste treatment information, and statistical summaries of the results of the pilot plant

TABLE VII-32
FULL SCALE CHEMICAL COAGULATION AT A
WOVEN FABRIC FINISHING (DESIZING) MILL

Parameter/Pollutant	Biological Effluent			Chemical Clarifier Effluent		
	Min	Max	n	Min	Max	n
Conventional & Nonconventional Pollutants						
COD, mg/l	184	343	3	23	50	3
TSS, mg/l	7	13	3	ND	3	3
Sulfide, ug/l	4	4	1	3	3	1
Color, ADMI Units	107	135	3	40	70	3
Color, ADMI Units (pH 7.6)	100	134	3	47	79	3
Toxic Pollutants ug/l						
Total Phenols	14	17	3	16	40	3
Bis(2-ethylhexyl) Phthalate	ND	13	3	ND	22	3
Trichloroethylene	TA	130	3	ND	140	3
Antimony (Total)	12	28	3	ND	16	3
Arsenic (Total)	61	71	3	58	70	3
Chromium (Total)	TA	10	3	ND	TA	3
Copper (Total)	TA	13	3	ND	10	3
Cyanide	26	27	3	27	30	3
Lead (Total)	ND	49	3	ND	34	3
Nickel (Total)	ND	95	3	36	47	3
Silver (Total)	11	36	3	13	18	3
Zinc (Total)	416	434	3	406	442	3

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the influent and/or effluent: Benzene; Chlorobenzene; 1,2,4-Trichlorobenzene; Chloroform; Ethylbenzene; Methylene Chloride; Dichlorobromomethane; Di-n-butyl Phthalate; Di-n-octyl Phthalate; Diethyl Phthalate; Anthracene; Tetrachloroethylene; Toluene; Cadmium.

Source: EPA Field Sampling Results for Mill 40156, August 1978.

TABLE VII-33
FULL SCALE CHEMICAL COAGULATION AT A STOCK
AND YARN FINISHING MILL

Parameter/Pollutant	Raw Waste	Chemical Clarifier Effluent Min	Chemical Clarifier Effluent Max	n
Conventional & Nonconventional Pollutants				
COD, mg/l	736	426	722	3
TSS, mg/l	58	30	65	3
Sulfide, ug/l	420	25	170	3
Color, ADMI Unit	140	71	108	3
Color, ADMI Unit (pH 7.6)	114	75	108	3
Toxic Pollutants, ug/l				
1,2,4-Trichlorobenzene	ND	ND	18	3
Parachlorometa Cresol	ND	ND	80	3
2-Chlorophenol	10	60	60	1
1,2-Dichlorobenzene	ND	ND	45	3
Naphthalene	TA	TA	100	3
2-Nitrophenol	ND	92	92	1
4-Nitrophenol	240	ND	ND	3
N-nitrosodi-n-propylamine	ND	ND	32	3
Total Phenols	69	66	110	3
Phenol	ND	TA	140	3
Bis(2-ethylhexyl) Phthalate	22	10	190	3
Trichloroethylene	TA	TA	26	3
Antimony (Total)	200	51	78	3
Chromium (Total)	23	16	24	3
Copper (Total)	40	TA	12	3
Lead (Total)	63	48	98	3
Nickel (Total)	146	128	148	3
Silver (Total)	51	42	51	3
Zinc (Total)	141	42	1,790	3

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the influent and/or effluent: Benzene; Chlorobenzene; 1,1,2,2-Tetrachloroethane; 2,4,6-Trichlorophenol; Chloroform; 2,4-Dimethylphenol; Ethylbenzene; Methylene Chloride; Trichlorofluoromethane; Di-n-butyl Phthalate; Diethyl Phthalate; Anthracene; Phenanthrene; Tetrachloroethylene; Toluene; Arsenic; Cadmium; Selenium.

Source: EPA Field Sampling Results for Mill 70, August 1978.

studies during the candidate process evaluations at each of these mills is included in the administrative record. In addition to the regular pilot plant testing, sampling was conducted at selected mills to evaluate the performance of chemical coagulation in the treatment of toxic pollutants. The detailed results of the sampling at each mill also are included in EPA's administrative record.

The data from these studies are summarized in Tables VII-34 and VII-35 for wool finishing mills and for all other mills in Tables VII-36 and VII-37.

Precipitation Precipitation is a chemical unit process in which undesirable soluble metallic ions are removed from water or wastewater by conversion to an insoluble form. It is a commonly used treatment technique for removal of hardness (calcium, magnesium, strontium, ferrous iron, and manganous ions and other metals) and phosphorus. The procedure involves alteration of the ionic equilibrium to produce insoluble metallic hydroxides that can be easily settled in a clarifier. The hydroxide is usually supplied in the form of lime ($Ca(OH)_2$).

For example, a precipitation reaction involving the removal of magnesium ions (Mg^{+2}) with lime is:

$$Mg^{+2} + SO_4^{-2} + Ca(OH)_2 = Ca^{+2} + SO_4^{-2} + \underline{Mg(OH)_2}$$

Metallic hydroxides have an optimal pH where they are most insoluble. For $Mg(OH)_2$, noted in the equation above, 10.8 is considered optimal. When precipitation of several metals is required, a pH of about 9 is often useful in practice.

In order to precipitate hexavalent chromium (Cr^{+6}), a pollutant found in textile wastewaters, it first must be reduced to the trivalent state (Cr^{+3}). The reducing agents used are ferrous sulfate, sodium metabisulfate, and sulfur dioxide. If ferrous sulfate is used, acid must be added for pH adjustment.

Industry Application - Precipitation was not reported as a treatment method by any of the direct or indirect dischargers surveyed. One possible reason why this technology is not favored is that some of the auxiliary chemicals used in dyeing can act as complexing agents with metals. These chemicals act as chelates and make the metals less susceptible to precipitation.

Literature/Research - Literature describing the treatment of textile wastewaters by precipitation is limited. The only applicable research study (21) compared chemical precipitation with lime and sulfide.

TABLE VII-34
SUMMARY OF RESULTS - EPA/INDUSTRY FIELD STUDIES
CHEMICAL COAGULATION AT WOOL FINISHING MILLS
TRADITIONALLY MONITORED POLLUTANTS

Parameter	Mill B	Mill B	Mill O	
Loading rate, gpd/sq ft	400	520	400	
Alum as Al+3, mg/l	35	35	7	
	Average Effluent Concentration			Subcategory Average
BOD, mg/l	33	17*	2.5	18
COD, mg/l	212	216	111	180
TSS, mg/l	20	82	31	44
TOC, mg/l	71	77	30	59
Total Phenols, ug/l	20*	-	41	41
Color, ADMI Units (pH 7.6)	106	-	67	87
	Average Removal, Percent			Subcategory Average
BOD	80	93*	56	68
COD	75	73	33	60
TSS	81	69	41	64
TOC	75	71	10	52
Total Phenols	0*	-	27	27
Color	76*	-	30	30

*Value represents a single data point and was not included in calculating subcategory average.

Source: EPA/Industry Field Studies

TABLE VII-35
SUMMARY OF RESULTS - EPA/INDUSTRY FIELD STUDIES
CHEMICAL COAGULATION AT WOOL FINISHING MILLS
TOXIC POLLUTANTS

Parameter/Pollutant	Mill B	Subcategory Average ug/l	Subcategory Average %
Loading rate, gpd/sq ft	400 - 520		
Alum as Al+3, mg/l	27 - 35		
	Average Effluent Concentration, ug/l (Removal,%)		
1,2,4-Trichlorobenzene	154 (90)	154	90
1,2-Dichlorobenzene	ND (100)	ND	100
Bis(2-ethylhexyl)Phthlate	44 (NR)	44	NR
Toluene	14 (55)	14	55
Antimony (Total)	32 (NR)	32	NR
Arsenic (Total)	62 (NR)	62	NR
Chromium (Total)	41 (65)	41	65
Copper (Total)	16 (30)	16	30
Lead (Total)	30 (NR)	30	NR
Nickel (Total)	57 (25)	57	25
Silver (Total)	172 (NR)	172	NR
Zinc (Total)	5730 (11)	5730	11

Note: ND indicates "not detected."
NR indicates "no removal."

Source: EPA/Industry Field Studies

TABLE VII-36
SUMMARY OF RESULTS - EPA/INDUSTRY FIELD STUDIES
CHEMICAL COAGULATION
TRADITIONALLY MONITORED POLLUTANTS

Parameter	Mill BB	Mill V	Mill E	Mill Q	Mill Q	Mill F	Mill EE	Mill S	
Subcategory	4b	4c	5b	5a	5a	6	7	7	
Loading rate, gpd/sq ft	100	400	400	400	320	400	400	400	
Alum as Al+3, mg/l	120	40	-	20	30	-	30	-	
Anionic Polymer, mg/l	-	-	-	0.75	0.75	1	-	-	
Cationic Polymer, mg/l	-	-	20	-	-	35	-	20	
	Average Effluent Concentration								Average
BOD, mg/l	12	3.6	10	5.4	3.8	7.4	(2)	6.1	6.3
COD, mg/l	162	352	124	195	178	142	93	83	166
TSS, mg/l	60	51	13	73	61	28	26	19	41
TOC, mg/l	43	72	24	-	22	26	36	6.8	33
Total Phenols, ug/l	65	-	52	-	-	60	(20)	-	49
Color, ADMI Units (pH 7.6)	189	263	47	196	133	164	44	90	141
	Average Removal, Percent								Average
BOD	50	50	48	29	59	85	24	80	53
COD	56	8.9	50	26	38	68	29	22	37
TSS	38	9.8	69	0.4	10	61	14	41	30
TOC	55	4.9	12	-	29	69	18	37	32
Total Phenols	27	-	14	-	-	49	-	-	30
Color	50	1.2	69	19	50	54	73	64	48

Note: ( ) indicates "less than" value.

Source: EPA/Industry Field Studies

TABLE VII-37
SUMMARY OF RESULTS - EPA/INDUSTRY FIELD STUDIES
CHEMICAL COAGULATION
TOXIC POLLUTANTS

Parameter/Pollutant	Mill V	Mill E		
Subcategory	4c	5b		
Loading rate, gpd/sq ft	400	400		
Alum as Al+3, mg/l	40	-		
Polymer, mg/l	-	20		
	Average Effluent Concentration, ug/l (Removal,%)		Average ug/l	Average %
Benzene	ND	TA (NR)	TA	NR
Chloroform	ND	28 (33)	14	33
1,2-Dichlorobenzene	13 (NR)	TA (NC)	12	NR
Phenol	16 (30)	226 (NR)	121	15
Bis(2-ethylhexyl)Phthalate	34 (NR)	13 (29)	24	15
Toluene	TA (33)	ND	TA	33
Antimony (Total)	123 (NR)	14 (44)	69	22
Chromium (Total)	17 (NR)	TA (90)	14	45
Copper (Total)	11 (81)	ND (100)	TA	91
Lead (Total)	66 (NR)	ND (100)	33	50
Nickel (Total)	ND	14 (35)	TA	35
Silver (Total)	72 (10)	ND	36	10
Zinc (Total)	195 (NR)	48 (97)	122	49

Note: NC indicates "not able to calculate removal."
ND indicates "not detected."
NR indicates "no removal."
TA indicates "trace amount," less than 10 ug/l.

Source: EPA/Industry Field Studies

The sulfide removes heavy metals from solution as it precipitates because metal sulfides are several orders of magnitude less soluble than the corresponding metal hydroxides. This process is useful in the removal of hexavalent chromium because prior reduction to trivalent chromium is unnecessary.

A wastewater sample from the aeration basin of a knit fabric finishing-complex processing mill was used in the research. The mill dyes 95 percent of the production. The dyes are: acid (64 percent), direct (32 percent), sulfur (2 percent), dispersed (1 percent), and reactive (1 percent) dyes. Analytical results are summarized in Table VII-38.

Oxidation Oxidation is a chemical unit process that is used in wastewater treatment for removal of color and ammonia, reduction of organics and reduction of bacteria and viruses. The disinfection of wastewater with chlorine is the most common form of oxidation used. Other available and tested oxidants include: hydrogen peroxide, potassium permanganate, chlorine dioxide, and ozone. Ozone oxidation is favored in the treatment of industrial wastes.

Ozone (O_3) is a faintly blue, pungent-smelling, unstable gas that exists as an allotropic form of oxygen. Because of its instability, ozone is generated on-site. Ozone generators use a corona discharge that occurs when a high-voltage alternating current is imposed across a discharge gap. Approximately 10 percent of the applied energy directly results in the conversion of oxygen into ozone. Improvement in the conversion efficiency is achieved if pure oxygen is used in the generator instead of air.

Ozone reacts rapidly with most organic compounds and microorganisms present in industrial wastewaters. Ozone oxidation is practical for color removal in small segregated textile wastewater streams but it is not suitable for reducing the organic concentration of high volume streams because of the high dosages required.

Industry Application - Sixty direct dischargers and 11 indirect dischargers report using oxidation. Fifty-nine of the direct dischargers chlorinate for disinfection only. The other mill adds chlorine in a rapid-mix contact tank for disinfection and color removal. Four indirect dischargers chlorinate for disinfection only, while five add chlorine, usually in the form of hypochlorite, to control color. The other two indirect dischargers recycle part of their effluents and add chlorine for disinfection. No survey data are available to demonstrate the performance of chlorine oxidation for removing color.

Literature/Research - Ozone oxidation of textile wastewaters to remove color is the subject of several engineering and research studies. Two of these case studies are discussed below.

TABLE VII-38
EFFECTIVENESS OF LIME AND SULFIDE
IN THE PRECIPITATION OF TOXIC METALS FROM THE
UNTREATED WASTEWATER OF A
KNIT FABRIC FINISHING MILL

Metal	Concentration, mg/l		
	Raw Sample	Lime Effluent	Sulfide Effluent
Zinc	3.2	0.11	0.09
Nickel	0.05	-	-
Iron	2.3	0.17	0.19
Cadmium	0.01	-	-
Copper	0.50	0.03	0.01
Lead	0.10	-	-
Silver	0.05	-	-
Total Chromium	0.93	0.08	0.05

Source: Reference 21.

In case 1 Snyder and Porter (22) studied the effect of pH on ozone reduction of organics and color in dye wastes from three textile mills. Ozone was produced from compressed air by a commercial electric-discharge ozone generator and fed at a rate of 0.5 g/hr through an experimental apparatus containing 500-ml samples of the dyehouse wastewater. The studies were conducted at room temperature (approximately 20°C) and a contact time of approximately one hour was used. To check the effect of pH on ozone reactivity, each dye waste was studied at neutral, acidic, and basic pH values. Adjustments in pH were made with sulfuric acid and sodium hydroxide.

The researchers found no correlation between pH, and the efficiency of ozonation in reducing the organics in textile dyehouse wastewater. The greatest COD removals occurred in the acid pH samples, but this is in contrast to the results obtained by other researchers. The COD removals for the three samples were 8, 41 and 55 percent. This indicates that a low concentration ozone stream (1 g/l) is not feasible as the central organic treatment operation for textile dyehouse wastewaters. Excellent color removal was observed in each sample tested, which the researchers attributed to the susceptibility of the amine function in the dye molecules to ozone attack.

In case 2 the Georgia Department of Natural Resources (23) investigated ozone treatment and disinfection of tufted carpet dye wastewater. The studies used effluent samples from the City of Dalton, Georgia, POTW. Approximately 90 percent of the plant's flow originates from textile mills that dye and finish carpet. The wastewater from these mills contain significant amounts of unexhausted color bodies and auxiliary organic dye chemicals. The Dalton POTW was treating approximately 15,140 cu m/day (40 mgd) by extended-aeration activated sludge.

The effectiveness of various dosages of ozone were studied by monitoring color, COD, organic carbon, suspended solids (TSS), BOD_5, total and fecal coliform, anionic detergents, dissolved oxygen and ozone residual.

Grab samples were collected from the POTW effluent on five occasions between April 4 and June 21, 1973. Portions of the samples were placed in a 37.8 l (10-gal) plexiglas contact column and ozone was injected at a fixed feed rate. Samples were withdrawn from the column for analysis at specific time intervals. Results of the investigations are summarized for the parameters of most interest here in Table VII-39.

The researchers concluded that:

1. True color was reduced to less than 30 APHA Units at an ozone dosage of 40 mg/l; suspended solids removal decreased that ozone dosage to 26.5 mg/l.

TABLE VII-39
CASE 2 - OZONATION OF TUFTED CARPET DYE WASTEWATER
SUMMARY OF RESULTS

Parameter	Ozone Dosage, mg/l	Parameter Concentration, mg/l Dalton Effluent	Ozonated Effluent
Color (Filtered)	5	300*	125*
Color (Filtered)	10	300*	95*
Color (Filtered)	14	300*	60*
Color (Filtered)	26	300*	32*
Color (Filtered)	45	300*	18*
COD	3	130	125
COD	6	130	110
COD	20	130	100
COD	42	130	75
COD	60	130	75
SS	7	20	12
SS	19	20	8
SS	24	20	6
SS	52	20	2
BOD_5	8	21	27
BOD_5	14	21	53
BOD_5	19	21	25
BOD_5	25	21	20
BOD_5	33	21	19
Biphenyl	5	2.0	1.98
Biphenyl	12	2.0	1.35
Biphenyl	20	2.0	1.62
Biphenyl	26	2.0	1.19
Biphenyl	42	2.0	1.21
Biphenyl	89	2.0	0.10

* APHA Units

Source: Reference 23.

2. A 40 percent COD reduction was achieved with a 45 mg/l ozone dosage; suspended solids removal did not significantly enhance COD reduction.

3. Suspended solids were reduced by approximately 90 percent with a 52 mg/l ozone dosage.

4. The BOD_5 was unchanged at all ozone dosages.

5. Biphenyls were reduced from approximately 2 mg/l to less than 0.1 mg/l with an ozone dosage of 89 mg/l.

EPA/Industry Field Studies - EPA and the textile industry (ATMI, NTA, and CRI) conducted pilot plant studies during 1977 and 1978 at 19 textile mills to evaluate the performance of advanced wastewater treatment technologies following extended-aeration activated sludge biological treatment. Ozonation was tested using a 110 liter (29 gal) contactor [Schedule 80 PVC column, 196 cm high and 29.5 cm inside diameter (77 in. high and 11.6 in. inside diameter)]. Ozone was generated with a commercial ozone generator with a capacity of 6 g/hr (pure oxygen feed) and fed through diffusers of 70 mesh stainless steel screen. The contactors could be operated in either a batch or a continuous mode. The offgases were sampled to determine concentration of ozone for calculation of ozone utilization.

Ozonation was included in the selected process modes at 7 of the 19 mills studied. Multimedia filtration or chemical coagulation plus multimedia filtration preceded the ozone contactor in the process mode. Processing information, waste treatment information, and statistical summaries of the results of the pilot plant studies during the process evaluations at each of these mills are presented in detail in the Agency's administrative record. In addition to the regular pilot plant testing, sampling was conducted at selected mills to evaluate the performance of ozonation in the treatment of toxic pollutants. Statistical summaries of the results of the toxic pollutant sampling at each mill are also presented in the record. The data is summarized in Tables VII-40 through VII-43. Data is presented separately for wool scouring mills and other textile mills.

Filtration Wastewater filtration is a physical unit operation that removes suspended materials. It is used to polish an existing biological effluent, prepare wastewater for subsequent advanced treatment processes, or reclaim wastewater for reuse. Applications of filtration discussed in this section include: 1) filtration of biological treatment effluent alone or as pretreatment for carbon adsorption or ozonation, 2) filtration of chemically clarified effluent, and 3) filtration of biological treatment effluent following in-line chemical injection (precoagulation).

TABLE VII-40
SUMMARY OF RESULTS
OZONATION OF TEXTILE EFFLUENTS
TRADITIONALLY MONITORED POLLUTANTS
WOOL SCOURING MILLS

Parameter	Mill A	
Ozone utilized, mg/l	250	
Batch (B) or Continuous (C)	B	
	Average Effluent Concentration	Subcategory Average
BOD5, mg/l	46	46
COD, mg/l	825	825
TSS, mg/l	104	104
TOC, mg/l	303	303
Total Phenols, ug/l	-	-
Color, ADMI Units (pH 7.6)	265	265
	Average Removal, Percent	Subcategory Average
BOD5	6.0	6.0
COD	4.3	4.3
TSS	16	16
TOC	1.3	1.3
Total Phenols	-	-
Color	57	57

Source: EPA/Industry Field Studies

TABLE VII-41
SUMMARY OF RESULTS
OZONATION OF TEXTILE EFFLUENTS
TOXIC POLLUTANTS
WOOL SCOURING MILLS

Parameter/Pollutant	Mill A		
Ozone utilized, mg/l	250		
Batch (B) or Continuous (C)	B		
		Subcategory Average	
	Average Effluent Concentration, ug/l (Removal,%)	ug/l	%
Phenol	13 (24)	13	24
Bis(2-ethylhexyl)Phthalate	106 (NR)	106	NR
Antimony (Total)	1200 (NR)	1200	NR
Arsenic (Total)	43 (48)	43	48
Cadmium (Total)	250 (NR)	250	NR
Copper (Total)	590 (NR)	590	NR
Cyanide	ND (100)	ND	100
Nickel (Total)	5000 (NR)	5000	NR
Silver (Total)	1300 (NR)	1300	NR
Zinc (Total)	460 (NR)	460	NR

Note: ND indicates "not detected."
NR indicates "no removal."

Source: EPA/Industry Field Studies

TABLE VII-42
SUMMARY OF RESULTS
OZONATION OF TEXTILE EFFLUENTS
TRADITIONALLY MONITORED POLLUTANTS
OTHER MILLS

	Mill								
Parameter	K	AA	D	Z	Q	S	S	S	
Subcategory	4a	4c	4c	4c	5a	7	7	7	
Ozone utilized, mg/l	49	163	427	60	1130-1500	5	35	60	
Batch (B) or Continuous (C)	C	C	C	C	B	B	B	B	
	Average Effluent Concentration								Average
BOD5, mg/l	14	13	47	18	4.9	5.5	12	10	16
COD, mg/l	52	222	349	414	18	81	126	102	171
TSS, mg/l	2.9	12	16	-	3.0	29	16	22	14
TOC, mg/l	-	-	*106*	-	15	*12*	*12**	7.7	35
Total Phenols, ug/l	-	20	15*	-	-	22	(20)	(20)	21
Color, ADMI Units (pH 7.6)	155	125	264	91	13	168	115*	77	128
	Average Removal, Percent								Average
BOD5	5.3	4.0	0	5.9	16	17	15	0	8.0
COD	19	23	25	11	92	14	0	16	25
TSS	43	21	28	-	66	5.5	0	18	26
TOC	-	-	5.4	-	33	7.4	0*	0	11
Total Phenols	-	-	-	-	-	-	-	-	-
Color	58	65	66	59	88	17	59*	68*	59

*Value represents a single data point and was not included in calculating average.

Note: ( ) indicates "less than" value.

Source: EPA/Industry Field Studies

TABLE VII-43
SUMMARY OF RESULTS
OZONATION OF TEXTILE EFFLUENTS
TOXIC POLLUTANTS
OTHER MILLS

Parameter/Pollutant	Mill K		
Subcategory	4a		
Ozone utilized, mg/l	49		
Batch (B) or Continuous (C)	C		
	Average Effluent Concentration, ug/l (Removal,%)	Average ug/l	Average %
Methylene chloride	15 (NR)	15	NR
Pentachlorophenol	ND (100)	ND	100
Bis(2-ethylhexyl)Phthalate	89 (NR)	89	NR
Di-n-butyl Phthalate	TA (17)	TA	17
Trichloroethylene	TA (50)	TA	50
Antimony (Total)	44 (NR)	44	NR
Copper (Total)	91 (NR)	91	NR
Lead (Total)	32 (33)	32	33
Nickel (Total)	65 (7)	65	7
Silver (Total)	17 (13)	17	13
Zinc (Total)	218 (8)	218	8

Note: NR indicates "no removal."
TA indicates "trace amount," less than 10 ug/l.

Source: EPA/Industry Field Studies

The filtration process separates suspended material from wastewater by passing the wastewater through porous material. The mechanisms responsible for removal include: straining, sedimentation, inertial impaction, interception, adhesion, chemical adsorption (bonding and chemical interaction), physical adsorption (electrostatic, electrokinetic, and Van der Waals forces), and two accessory actions within the filter bed, biological growth and flocculation. The mechanisms that will predominate depend on the wastewater characteristics and the characteristics of the filter (media composition; grain size, shape, density, and porosity; bed depth; and filtration rate). (20,24)

Filtration systems are broadly classified as either surface or in-depth. Surface filters include microscreens, diatomaceous earth filters and moving bed filters. These filters achieve solids removal primarily by surface straining and, as a result, yield shorter runs between backwashings. In-depth filters include deep-bed single, dual, or multimedia units. Graded sand was commonly used in the past for in-depth filtration but today, garnet, gravel, resin beads, activated carbon and anthracite coal are also commonly used. The use of multiple layers of different media having specific gravities increasing in the direction of flow permits gradation of the filter bed and allows more efficient utilization of the total bed depth.

Industry Application - Sixteen mills use filtration as part of their treatment systems. Ten are direct dischargers, three are indirect dischargers, and three practice complete recycle. Nine of the ten direct dischargers use activated sludge or a similar biological process prior to filtration. Three of these dischargers also use chemical coagulation or add coagulants in-line prior to filtration (precoagulation). Most of the direct dischargers use multimedia filters with sand, gravel, and anthracite media. They are operated as tertiary filters and are pressurized.

The filter systems used by the indirect dischargers include an in-depth sand filter, a vacumite filter which separates the floc from a chemically treated (coagulation and flocculation) wastewater, and a system that included a multimedia (sand and charcoal) filter following biological aeration. Two mills practicing recycle are operated by the same company and both employ multimedia in-depth filters using gravel, sand, and anthracite media. In both cases the filtration systems follow extended-aeration activated sludge and chemical coagulation. The third recycle mill precedes filtration with air flotation, biological aeration, and chemical coagulation/flocculation.

Historical Data - Many of the filtration systems in use by the textile industry are operated to polish biologically or chemically treated effluents or to allow recycle. The available data from these mills, i.e., influent and effluent for the entire treatment system, do not demonstrate the effectiveness of the filtration systems alone. However, the data presented in Table VII-44 demonstrate the performance of the entire treatment systems that include filtration. The data, which in general represent the results of monitoring during 1976, are average values for those mills that provided historical monitoring reports.

Field Sampling - Little historical or research data exist that demonstrate the performance of filtration systems. Sampling was conducted at five mills during this study to provide such information. The results are summarized in the following cases.

In case 1 two knit fabric finishing-simple processing mills that discharge to a common treatment plant were sampled as part of the EPA/Industry pilot plant field studies (Mill Q). Descriptions of the manufacturing operations, wastewater treatment system, and pilot plant studies are provided in the administrative record.

One 48 hour composite sample was collected at the influent to the treatment plant, and two 24 hour composite samples following secondary clarification, and filtration. The performance of the biological system and multimedia pressure filter for the treatment of conventional, nonconventional and toxic pollutants is presented in Tables VII-45.

Case 2 is a woven fabric finishing-simple processing mill that performs flat bed and rotary screen printing to produce sheets, towels, and bedspreads. Rotary screen printing accounts for approximately 90 percent of the production, which was reported as 30,000 kg/day (approximately 65,000 lb/day). The processing operations result in a wastewater discharge rate of 19.2 l/kg of product (2.3 gal/lb of product) and a wastewater discharge of 570 cu m/day (150,000 gpd).

Wastewater treatment at this mill consists of equalization (small holding tank), grit removal, coarse screening, chemical addition (alum and caustic), fine screening (vibrating), chemical addition (cationic polymer) and flocculation, dissolved air flotation (300 gpm), biological aeration (2 lagoons in series), disinfection (chlorine), secondary clarification (reactor/clarifier in which alum, caustic, and anionic polymer are added), and dual media gravity filtration (sand and carbon). Aeration detention time is approximately 170 hours, and air is provided by surface aerators at a power-to-volume ratio of approximately 3.56 kw/1000 cu m (18 hp/million gal). The discharge from the treatment plant is reused in the printing operations.

Samples were collected over a typical 48-hour period of operation at the bar screen prior to the air flotation unit, at the Parshall flume prior to the aeration basins, at the chlorine contact chamber following aeration, and at the effluent from the dual media filter. The performance of the biological treatment

TABLE VII-44
EFFLUENT CONCENTRATIONS FROM
TEXTILE MILLS USING FILTRATION AS
A FINAL TREATMENT STEP

Subcategory	Mill	Filter Type	Treatment Step	BOD5, mg/l Inf*	BOD5, mg/l Eff	COD, mg/l Inf*	COD, mg/l Eff	TSS, mg/l Inf*	TSS, mg/l Eff
			Direct Discharge						
5a	50011	Multimedia In-depth	Polishing	-	159	-	-	-	65
5a	50022	Dual media In-depth	Polishing	-	33	-	188	-	55
5a	50030	-	Polishing	334	24	1265	206	-	40
5a	50104	Sand In-depth	Polishing	327	43	1261	427	119	88
5a	50112	Multimedia Pressure	Polishing	279	5	934	196	41	7
7	70042	Sand In-depth	Post Flotation	-	17	-	-	-	21
7	70072	Multimedia Pressure	Polishing	327	20	1572	480	26	23
7	70081	Dual media In-depth	Polishing	218	23	800	312	12	93
			Recycle						
4a	40144	Dual media Pressure	Polishing	298	10	-	1550	-	5

* Inf indicates raw waste concentration not influent to filtration.

Source: EPA Industry Survey, 1977.

TABLE VII-45
CASE 1 - BIOSYSTEM AND MULTIMEDIA FILTER
SUMMARY OF ANALYTICAL RESULTS
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Untreated Wastewater*	Secondary Effluent**	Filtration Effluent**
Conventional & Nonconventional Pollutants			
BOD5, mg/l	-	-	-
COD, mg/l	782	312	233
TSS, mg/l	17	28	6
Oil & Grease, mg/l	324	303	476
Total Phenols, ug/l	-	59	48
Color, ADMI Units (pH 7.6)	288	187	192
Toxic Pollutants, ug/l			
1,2,4-Trichlorobenzene	2700	ND	ND
Ethylbenzene	101	ND	ND
Naphthalene	45	ND	ND
Phenol	55	ND	ND
Bis(2-ethylhexyl) Phthalate	41	15	12
Tetrachloroethylene	ND	17	17
Trichloroethylene	840	ND	ND
Antimony (Total)	95	670#	700#
Chromium (Total)	14	32#	32#
Copper (Total)	44	104#	79#
Cyanide	10	ND	10#
Lead (Total)	36	48#	33#
Nickel (Total)	36	ND	ND
Selenium (Total)	15	41#	102#
Silver (Total)	12	13#	TA#
Zinc (Total)	56	48#	84#

* 48-hour composite sample
** average of two 24-hour composite samples
\# average of two 24-hour grab samples

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the raw waste, secondary effluent, and/or final effluent: 2,4,6-Trichlorophenol; 2-Nitrophenol.

Source: EPA Field Sampling Results for Mill 50112, October 1977.

system and reactor/clarifier-dual media filter is presented in Table VII-46.

Case 3 is stock and yarn dyeing facility that performs package dyeing of polyester, cotton and wool yarn. Dispersed dye is the primary dye class employed, although some acid and cationic dyes also are used. The processing results in an average wastewater discharge rate of 154 l/kg of product (18.5 gal/lb of product).

Wastewater treatment at this mill consists of coarse screening, neutralization, aeration [(1 basin with a total volume of 1990 cu m (5,250,000 gal)], secondary clarification, dual media gravity filtration (sand and carbon) and disinfection (chlorine). Aeration detention time is approximately 120 hours, and air is provided by eight surface aerators with a total power-to-volume ratio of approximately 2205 kw/1000 cu m (114 hp/mil gal). It was reported that the carbon in the filter had not been changed within the past two years; therefore, the filter may not be functioning in an adsorptive capacity.

Samples were collected over a 72-hour period of operation of the raw wastewater, the secondary clarifier effluent, and the dual media filter effluent. The performance of the activated sludge system and dual media filter is presented in Table VII-47.

Case 4 is a stock and yarn finishing mill. The processing operations result in a wastewater discharge rate of 13.1 l/kg of product (1.6 gal/lb of product).

Wastewater treatment at this mill consists of aerated equalization, chemical addition (ferric chloride), flocculation, clarification and filtration. The discharge from the treatment plant is recycled for reuse in the mill operations.

Samples were collected over a typical 72-hour period of operation at the discharge from the equalization basin, at the discharge from the chemical clarifiers and at the discharge from the clear well following the filters. The performance of the filter is presented in Table VII-48.

Case 5 is a knit fabric finishing-simple processing mill that performs scouring and piece dyeing on polyester and arnel/nylon fabric. Premetallized (13 percent) and dispersed (81 percent) dyes are the primary dyes employed at this mill. The processing operations result in a wastewater discharge rate of 83.4 l/kg of product (approximately 10.0 gal/lb of product).

Wastewater treatment at this mill consists of neutralization (alkali), equalization, aeration [total volume of 1135 cu m (0.30 million gal)], secondary sedimentation, coagulation, clarification and filtration. Aeration detention time is approximately 6 hours, and air is provided by surface aerators at

TABLE VII-46
CASE 2 - BIOSYSTEM AND REACTOR/CLARIFIER - DUAL MEDIA FILTER
SUMMARY OF ANALYTICAL RESULTS
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Biological Influent*	Biological Effluent*	Filter Effluent*
	Conventional & Nonconventional Pollutants		
BOD5, mg/l	(200)	(67)	(20)
COD, mg/l	725	577	543
TSS, mg/l	32	17	4
Total Phenols, ug/l	26	18	14
Sulfide, ug/l	(200)	(200)	(200)
	Toxic Pollutants, ug/l		
Benzene	19	TA	TA
Ethylbenzene	160	ND	ND
Methyl Chloride	56	TA	TA
4-Nitrophenol	13	(10)	(10)
Pentachlorophenol	34	ND	ND
Phenol	32	24	16
Bis(2-ethylhexyl) Phthalate	45	ND	ND
Toluene	200	ND	ND
Copper (Total)	81**	52**	27**
Lead (Total)	NS	32**	NS
Nickel (Total)	32**	32**	NS
Thallium (Total)	14**	13**	NS

* average of two 24-hour samples
** reported as "less than" value

Notes: ND indicates "not detected."
NS indicates "no sample."
TA indicates "trace amount," less than 10 ug/l.
( ) indicated "less than" value.

The following pollutants also were detected but at less than 10 ug/l in the biological influent, biological effluent, and/or final effluent: 1,2-Dichloroethane; 1,1,1-Trichloroethane; Tetrachloroethylene; Trichloroethylene; Beryllium; Cadmium; Chromium; Cyanide; Mercury; Silver; Zinc.

Source: *EPA Field Sampling Results for Mill 40144, November 1977.*

TABLE VII-47
CASE 3 - BIOSYSTEM AND DUAL MEDIA FILTER
SUMMARY OF ANALYTICAL RESULTS
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Biological Influent	Clarifier Effuent Min	Clarifier Effuent Max	n	Filter Effluent Min	Filter Effluent Max	n
Conventional & Nonconventional Pollutants							
COD, mg/l	226	116	150	3	122	148	3
TSS, mg/l	25	100	170	3	38	115	3
Total Phenols, ug/l	810	12	21	3	17	19	3
Sulfide, ug/l	44	6	8	3	9	9	3
Color, ADMI Units (pH 7.6)	131	112	124	3	105	113	3
Toxic Pollutants, ug/l							
Acrylonitrile	ND	ND	(100)	3	ND	(100)	3
1,2,4-Trichlorobenzene	270	19	43	3	TA	21	3
Bis(chloromethyl) Ether	59	ND	ND	3	ND	ND	3
2,4,6-Trichlorophenol	16	TA	TA	3	ND	TA	3
Parachlorometa Cresol	29	ND	TA	3	ND	TA	3
1,2-Dichlorobenzene	56*	ND	TA	3	TA	TA	3
2,4-Dichlorophenol	20	ND	ND	3	ND	ND	3
1,2-Dichloropropane	56	ND	ND	3	ND	ND	3
2,4-Dimethylphenol	190	ND	ND	3	ND	ND	3
Naphthalene	18	ND	13	3	TA	TA	3
Pentachlorophenol	ND	ND	23	3	ND	13	3
Bis(2-ethylhexyl) Phthalate	490	76	340	3	80	170	3
Di-n-butyl Phthalate	24	ND	TA	3	ND	TA	3
Dimethyl Phthalate	18	ND	ND	3	ND	ND	3
Tetrachloroethylene	310	TA	TA	3	TA	TA	3
Toluene	TA	TA	38	3	TA	TA	3
Trichloroethylene	10	ND	ND	3	ND	ND	3

* Represents sum of concentrations of 1,2-Dichlorobenzene; 1,3-Dichlorobenzene; and 1,4-Dichlorobenzene

TABLE VII-47 (cont.)

Parameter	Biological Influent	Clarifier Effuent Min	Clarifier Effuent Max	n	Filter Effluent Min	Filter Effluent Max	n
Antimony (Total)	156	141	177	3	150	162	3
Arsenic (Total)	19	TA	TA	3	TA	TA	3
Chromium (Total)	34	68	91	3	12	57	3
Copper (Total)	49	110	132	3	20	84	3
Lead (Total)	(22)	(22)	35	3	(22)	(22)	3
Nickel (Total)	(36)	(36)	(36)	3	42	50	3
Silver (Total)	TA	TA	TA	3	11	15	3
Thallium (Total)	(50)	ND	(50)	3	ND	(50)	3
Zinc (Total)	493	228	283	3	139	436	3

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
( ) indicates "less than" value.

The following pollutants also were detected but at less than 10 ug/l in the biological influent, clarifier effluent, and/or filter effluent: Benzene; Hexachlorobenzene; Chloroform; Ethylbenzene; Fluoranthane; Methylene Chloride; N-nitrosodi-n-propylamine; Phenol; Butyl Benzyl Phthalate; Diethyl Phthalate; Anthracene; Fluorene; Pyrene; Beryllium; Cadmium; Cyanide; Mercury; Selenium.

Source: EPA Field Sampling Results for Mill 70081, July 1978.

TABLE VII-48
CASE 4 - MULTIMEDIA FILTER
SUMMARY OF ANALYTICAL RESULTS
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Clarifier Effluent Min	Max	n	Filter Effluent Min	Max	n
Conventional & Nonconventional Pollutants						
COD, mg/l	426	722	3	347	523	3
TSS, mg/l	30	65	3	8	27	3
Sulfide, ug/l	25	170	3	3	3	3
Total Phenols, ug/l	66	110	3	80	109	3
Color, ADMI Units	71	108	3	39	92	3
Color, ADMI Units (pH 7.6)	75	108	3	42	88	3
Toxic Pollutants, ug/l						
1,2,4-Trichlorobenzene	ND	18	3	ND	28	3
2,4,6-Trichlorophenol	TA	TA	3	TA	14	3
Parachlorometa Cresol	ND	80	3	ND	ND	3
Chloroform	ND	TA	3	25	70	3
2-Chlorophenol	60	60	1	TA	TA	1
1,2-Dichlorobenzene	ND	45	3	ND	13	3
Naphthalene	TA	100	3	TA	100	3
2-Nitrophenol	92	92	1	ND	ND	1
N-nitrosodi-n-propylamine	ND	32	3	ND	130	3
Phenol	TA	140	3	TA	100	3
Bis(2-ethylhexyl) Phthalate	10	190	3	47	150	3
Trichloroethylene	TA	26	3	TA	36	3
Antimony (Total)	51	78	3	48	78	3
Chromium (Total)	16	24	3	TA	24	3
Copper (Total)	TA	12	3	ND	12	3
Lead (Total)	48	98	3	58	70	3
Nickel (Total)	128	148	3	119	187	3
Silver (Total)	42	51	3	41	58	3
Zinc (Total)	42	1790	3	29	58	3

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the influent and/or effluent: Benzene; Chlorobenzene; 2,4-Dimethylphenol; Ethylbenzene; Methylene Chloride; Trichlorofluoromethane; Di-n-butyl Phthalate; Diethyl Phthalate; Anthracene; Tetrachloroethylene; Toluene; Arsenic; Cadmium; Selenium.

Source: EPA Field Sampling Results for Mill 70, August 1978.

TABLE VII-49
CASE 5 - REACTOR/CLARIFIER AND MULTIMEDIA FILTER
SUMMARY OF ANALYTICAL RESULTS
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Biological Effluent* Min	Biological Effluent* Max	Final Effluent* Min	Final Effluent* Max
Conventional & Nonconventional Pollutants				
BOD5, mg/l	116	120	11	14
COD, mg/l	285	4477	238	1822
TSS, mg/l	13	272	12	13
Oil & Grease, mg/l	14	44	4	5
Sulfide, ug/l	460	10,000	130	190
Total Phenols, ug/l	177	214	133	140
Color, APHA Units	750	875	120	175
Toxic Pollutants, ug/l				
1,2-Dichloroethane	ND	ND	33	110
1,1,1-Trichloroethane	69	130	31	70
Methylene Chloride	ND	ND	ND	31
Tetrachloroethylene	TA	27	TA	12
Antimony (Total)	10	10	23	32
Chromium (Total)	140	150	TA	12
Copper (Total)	66	70	19	19
Cyanide	TA	17	ND	17
Zinc (Total)	240	240	260	320

* Two 24-hour composite samples except for toxic metals which were 24-hour grab samples.

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the influent and/or effluent: Benzene; 1,1-Dichloroethane; Chloroform; 1,1-Dichloroethylene; Ethylbenzene; Arsenic; Cadmium.

Source: EPA Field Sampling Results for Mill 50030, May 1978.

TABLE VII-50
CASE 6 - SAND FILTER
SUMMARY OF ANALYTICAL RESULTS
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Biological Effluent			Filter Effluent		
	Min	Max	n*	Min	Max	n*
Conventional & Nonconventional Pollutants						
COD, mg/l	154	254	3	107	151	3
TSS, mg/l	44	60	3	28	40	3
Sulfide, ug/l	8	20	3	ND	ND	3
Total Phenols, ug/l	TA	15	3	TA	14	3
Color, ADMI Units	75	89	3	70	77	3
Color, ADMI Units (pH 7.6)	75	85	3	70	77	3
Toxic Pollutants, ug/l						
Acrolein	ND	87	2	ND	190	3
Methylene Chloride	28	28	1	33	33	1
Bis(2-ethylhexyl) Phthalate	TA	50	3	TA	34	3
Trichloroethylene	ND	41	3	ND	89	3
Antimony (Total)	81	87	3	77	84	3
Lead (Total)	36	44	3	54	84	3
Nickel (Total)	54	65	3	46	64	3
Silver (Total)	14	17	3	TA	15	3
Zinc (Total)	48	69	3	43	94	3

* Three 24-hour composite samples except for toxic metals which were 24-hour grab samples.

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the influent and/or effluent: Parachlorometa Cresol; Chloroform; Pentachlorophenol; Anthracene; Toluene; Arsenic; Cadmium; Selenium.

Source: EPA Field Sampling Results for Mill 50104, August 1978.

a total power-to-volume ratio of approximately 14.7 kw/1000 cu m (750 hp/million gal).

Samples were collected over a 48-hour period of operation at the influent to the neutralization tank, at the discharge from the biological clarifier and at the discharge from the filters. The performance of the reactor/clarifier - filtration system is presented in Table VII-49.

Case 6 is a knit fabric finishing-simple processing mill that knits, scours and dyes synthetic bolt cloth of polyester and acetate fiber. Pressure piece dyeing with dispersed dyes is performed on the total production and 20 percent of the production is scoured. During the field sampling, wastewater flow averaged 984 cu m/day (260,000 gpd).

Wastewater treatment at this mill consists of fine screening (vibratory), equalization (mixed with nitrogen addition), aeration (two basins operated in series with powdered activated carbon added to the first basin), secondary sedimentation, sand filtration, disinfection (chlorine) and post aeration. Total detention time in the aeration basins is approximately 48 hours, and air is provided by surface aerators at a power-to-volume ratio of approximately (15.7 kw/1000 cu m (80 hp/mil gal). The performance of the sand filter is presented in Table VII-50.

EPA/Industry Field Studies - In a joint research effort between EPA and the textile industry (ATMI, NTA, and CRI), pilot plant studies were conducted during 1977 and 1978 at 19 textile mills to evaluate the effectiveness of alternative advanced wastewater treatment technologies. The studies were performed on the effluent from treatment systems using extended-aeration activated sludge treatment. One of the technologies was downflow multimedia filtration using one of two filters 1.60 m in height and 0.355 m in diameter (63 in. in height and 14 in. in diameter). The filter provided one foot (0.9-1.5 mm effective size), 30.5 cm (12 in. of sand, 0.4-0.8 mm effective size), and 40.6 cm (16 in. of gravel 6-16 mm effective size).

Multimedia filtration was included in the selected treatment technology at 18 of the 19 mills. It was used as the first treatment step following biological treatment, both alone and with the aid of a precoagulant. Multimedia filtration also was used following chemical coagulation. of surface area and contained 30.5 cm (12 in. of anthracite coal The detailed study reports and analytical results are included in the administrative record.

The data is summarized in Tables VII-51 through VII-62 of this section by subcategory (wool scouring mills, wool finishing mills and other mills) and placement of the filter in the candidate modes (first treatment step, first treatment step with precoagulant, and following chemical coagulation). The tables

TABLE VII-51
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (AFTER CLARIFICATION*)
TRADITIONALLY MONITORED POLLUTANTS
WOOL SCOURING MILLS

Parameter	Mill A	
Loading rate, gpm/sq ft	2.0	
	Average Effluent Concentration	Subcategory Average
BOD5, mg/l	29	29
COD, mg/l	807	807
TSS, mg/l	102	102
TOC, mg/l	289	289
Total Phenols, ug/l	-	-
Color, ADMI Units (pH 7.6)	619	619
	Average Removal, Percent	Subcategory Average
BOD5	37	37
COD	11	11
TSS	45	45
TOC	7.9	7.9
Total Phenols	-	-
Color	2.8	2.8

* The multimedia filter was not preceded by chemical coagulation at this plant and no coagulant was used in the reactor/clarifier.

Source: EPA/Industry Field Studies

TABLE VII-52
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (AFTER CLARIFICATION*)
TOXIC POLLUTANTS
WOOL SCOURING MILLS

Parameter/Pollutant	Mill A	Subcategory Average ug/l	Subcategory Average %
Loading rate, gpm/sq ft	2.0		
Average Effluent Concentration, ug/l (Removal,%)			
Phenol	17 (65)	17	65
Bis(2-ethylhexyl)Phthalate	14 (39)	14	39
Arsenic (Total)	83 (NR)	83	NR
Copper (Total)	120 (NR)	120	NR
Cyanide	260 (NR)	260	NR
Zinc (Total)	400 (NR)	400	NR

* The multimedia filter was not preceded by chemical coagulation at this mill and no coagulant was used in the reactor/clarifier.

Note: NR indicates "no removal."

Source: EPA/Industry Field Studies

TABLE VII-53
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (FIRST TREATMENT STEP)
TRADITIONALLY MONITORED POLLUTANTS
WOOL FINISHING MILLS

Parameter	Mill 0	
Loading rate, gpm/sq ft	3.0	
	Average Effluent Concentration	**Subcategory Average**
BOD5, mg/l	2.7	2.7
COD, mg/l	114	114
TSS, mg/l	6.9	6.9
TOC, mg/l	33	33
Total Phenols, ug/l	40	40
Color, ADMI Units (pH 7.6)	97	97
	Average Removal, Percent	**Subcategory Average**
BOD5	54	54
COD	32	32
TSS	82	82
TOC	3.5	3.5
Total Phenols	30	30
Color	13	13

Source: EPA/Industry Field Studies

TABLE VII-54
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (FIRST TREATMENT STEP)
TOXIC POLLUTANTS
WOOL FINISHING MILLS

Parameter/Pollutant	Mill 0	Subcategory Average ug/l	Subcategory Average %
Loading rate, gpm/sq ft	3.0		
	Average Effluent Concentration, ug/l (Removal,%)		
Parachlorometa Cresol	TA (78)	TA	78
Methylene Chloride	47 (NR)	47	NR
Bis(2-ethylhexyl)Phthalate	42 (92)	42	92
Antimony (Total)	ND (100)	ND	100
Chromium (Total)	91 (49)	91	49
Copper (Total)	118 (NR)	118	NR
Zinc (Total)	489 (46)	489	46

Note: TA indicates "trace amount," less than 10 ug/l.
NR indicates "no removal."
ND indicates "not detected."

Source: EPA/Industry Field Studies

TABLE VII-55
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (AFTER CHEMICAL COAGULATION)
TRADITIONALLY MONITORED POLLUTANTS
WOOL FINISHING MILLS

Parameter	Mill B	Mill B	Mill B	Mill O	
Loading rate, gpm/sq ft	5.4	6.6	7.0	3.0	
	Average Effluent Concentration				Subcategory Average
BOD5, mg/l	20	23*	31	2.0	18
COD, mg/l	203	157	174	84	155
TSS, mg/l	15	31	1.8	7.2	14
TOC, mg/l	41	69	65	27	51
Total Phenols, ug/l	-	-	-	33	33
Color, ADMI Units (pH 7.6)	-	-	5.5*	65	65
	Average Removal, Percent				Subcategory Average
BOD5	25	0*	21	13	20
COD	12	34	12	22	20
TSS	48	59	43	78	57
TOC	36	8.3	5.3	11	15
Total Phenols	-	-	-	19	19
Color	-	-	95*	4.0	4.0

* Value represents a single data point and was not included in calculating subcategory average.

Source: EPA/Industry Field Studies

TABLE VII-56
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (AFTER CHEMICAL COAGULATION)
TOXIC POLLUTANTS
WOOL FINISHING MILLS

Parameter/Pollutant	Mill B	Subcategory Average ug/l	Subcategory Average %
Loading rate, gpm/sq ft	5.4-7.0		
Average Effluent Concentration, ug/l (Removal,%)			
1,2,4-Trichlorobenzene	94 (39)	94	39
Bis(2-ethylhexyl)Phthalate	14 (68)	14	68
Toluene	12 (14)	12	14
Antimony (Total)	12 (63)	12	63
Arsenic (Total)	103 (NR)	103	NR
Cadmium (Total)	105 (NR)	105	NR
Chromium (Total)	41 (NR)	41	NR
Copper (Total)	118 (NR)	118	NR
Lead (Total)	116 (NR)	116	NR
Nickel (Total)	73 (NR)	73	NR
Silver (Total)	158 (8)	158	8
Zinc (Total)	5895 (NR)	5895	NR

Note: NR indicates "no removal."

Source: EPA/Industry Field Studies

TABLE VII-57
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (FIRST TREATMENT STEP)
TRADITIONALLY MONITORED POLLUTANTS
OTHER MILLS

Parameter	Mill K	BB	D	T	Y	Z	E	Q	W	EE	S	
Subcategory	4a	4b	4c	4c	4c	4c	5b	5a	5b	7	7	
Loading rate, gpm/sq ft	5.0	3.0	4.4	5.0	5.0	3.0	3.0	2.0	7.0	7.0	5.0	
	Average Effluent Concentration											Average
BOD5, mg/l	14	23	19	8.5	7.5	17	11	4.3	3.4	2.5	7.0	11
COD, mg/l	65	353	630	478	90	461	157	206	55	123	106	248
TSS, mg/l	4.6	40	85	17	10	20	4.3	4.1	9.5	8.4	12	20
TOC, mg/l	-	93	157	144	14	-	29	22	11	43	8.3	58
Total Phenols, ug/l	(50)	80	-	530	-	-	63	(20)	-	(20)	-	127
Color, ADMI Units (pH 7.6)	368	341	1035	177	175	199	140	226	100	166	229	287
	Average Removal, Percent											Average
BOD5	11	12	18	47	23	22	29	45	26	18	78	30
COD	15	5.9	17	3.7	27	10	36	24	25	13	9.1	17
TSS	55	21	36	20	67	42	90	91	64	46	65	54
TOC	-	5.7	10	5.2	6.4	-	4.1	18	18	2.7	19	9.9
Total Phenols	-	23	-	6.9	-	-	8.3	-	-	-	-	13
Color	2.2	11	0.2	2.8	1.9	9.3	12	4.3	5.4	4.9	9.3	5.8

Note: ( ) Indicates "less than" value.

Source: EPA/Industry Field Studies

TABLE VII-58
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (FIRST TREATMENT STEP)
TOXIC POLLUTANTS
OTHER MILLS

Parameter/Pollutant	Mill K		Mill BB		Mill E		Mill W		Average ug/l	Average %
Subcategory	4a		4b		5b		5b			
Loading rate, gpm/sq ft	5.0		3.0		3.0		7.0			
	Average Effluent Concentration, ug/l (Removal,%)									
Benzene	ND		TA	(100)	TA	(20)	TA	(20)	TA	47
1,2,4-Trichlorobenzene	ND		ND		TA	(NC)	TA	(33)	TA	33
Chloroform	ND		ND	(100)	TA	(33)	TA	(50)	TA	61
Ethylbenzene	ND		TA	(23)	ND		ND		TA	23
Methylene Chloride	13	(46)	19	(NR)	TA	(NC)	ND		TA	23
Methyl Chloride	ND		ND	(100)	ND		ND		ND	100
N-nitrosodi-n-propylamine	ND		ND		TA	(33)	ND		TA	33
Pentachlorophenol	TA	(43)	ND		ND		ND		TA	43
Phenol	ND		TA	(100)	212	(NR)	TA	(NC)	58	50
Bis(2-ethylhexyl) Phthalate	12	(NR)	TA	(40)	11	(45)	21	(11)	14	24
Di-n-butyl Phthalate	12	(NR)	ND		TA	(NC)	TA	(NC)	TA	NR
Tetrachloroethylene	ND		ND		ND		ND	(100)	ND	100
Trichloroethylene	TA	(33)	ND		ND		TA	(NC)	TA	33
Antimony (Total)	22	(NR)	55	(5)	TA	(85)	763	(2)	213	23
Chromium (Total)	TA	(NC)	101	(4)	TA	(31)	ND		30	18
Copper (Total)	77	(8)	103	(7)	TA	(34)	22	(29)	53	20
Cyanide	TA	(69)	18	(NR)	ND		ND		TA	35
Lead (Total)	24	(NR)	43	(NR)	TA	(75)	54	(3)	33	20
Nickel (Total)	23	(NR)	96	(9)	96	(18)	86	(9)	75	9
Selenium (Total)	ND		ND		TA	(NR)	ND		TA	NR
Silver (Total)	TA	(NR)	30	(8)	27	(10)	19	(8)	22	7
Zinc (Total)	209	(8)	117	(25)	137	(27)	61	(19)	131	20

Note: NC indicates "not able to calculate removal."
ND indicates "not detected."
NR indicates "no removal."
TA indicates "trace amount," less than 10 ug/l.

Source: EPA/Industry Field Studies

TABLE VII-59
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (WITH PRECOAGULANT)
TRADITIONALLY MONITORED POLLUTANTS
OTHER MILLS

Parameter	Mill K	Mill AA	Mill P	Mill P	Mill P	Mill P	Mill Z	Mill Q	Mill W	Mill S	Mill S	
Subcategory	4a	4c	4c	4c	4c	4c	4c	5a	5b	7	7	
Loading rate, gpm/sq ft	2.0	3.0	3.0	5.0	5.0	7.0	3.0	2.5	5.0	3.0	4.5	
Alum as AL+3, mg/l	-	0.5	1.5	1.5	2.7	1.5	10	1	-	-	-	
Cationic Polymer, mg/l	-	-	-	-	-	-	-	-	3	13	13	
Ferric Chloride, mg/l	8	-	-	-	-	-	-	-	-	-	-	
				Average Effluent Concentration								Average
BOD5, mg/l	6.3	11	15	11	8*	10	17	7.1	2.6	6.5	8.0	9.5
COD, mg/l	41	292	104	118	83*	113	438	258	48	59	123	159
TSS, mg/l	8.9	14	20	17	12*	20	35	28	13	21	46	22
TOC, mg/l	-	-	23	27	27*	25	-	18	10	20	5.3	18
Total Phenols, ug/l	(50)	21	-	20*	-	0*	-	-	-	-	-	36
Color, ADMI Units (pH 7.6)	106	356	127	-	-	-	240	-	68	56*	63*	179
				Average Removal, Percent								Average
BOD5	57	73	26	0	69*	10	27	31	41	77	86	43
COD	44	22	12	1.5	24*	5.0	13	25	34	48	0	20
TSS	40	81	23	46	0*	45	24	70	48	33	27	44
TOC	-	-	4.3	20	7*	25	-	0	27	24	25	18
Total Phenols	NC	NC	-	60*	-	100*	-	-	-	-	-	-
Color	72	3.8	1.0	-	-	-	4.3	-	30	74*	69*	22

*Value represents a single data point and was not included in calculating subcategory average.

Note: ( ) indicates "less than" value.
NC indicates "not able to calculate removal."

Source: EPA/Industry Field Studies

TABLE VII-60
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (WITH PRECOAGULANT)
TOXIC POLLUTANTS
OTHER MILLS

Parameter/Pollutant	Mill K	Mill DD	Mill W		
Subcategory	4a	4c	5b		
Loading rate, gpm/sq ft	2.0	1.0	5.0		
Polymer, mg/l	-	-	3		
Ferric Chloride, mg/l	8	-	-		
Alum as Al+3, mg/l	-	12	-		
	Average Effluent Concentration, ug/l (Removal,%)			Average ug/l	Average %
Benzene	ND	ND	TA (67)	TA	67
1,2,4-Trichlorobenzene	ND	ND	TA (66)	TA	66
Chloroform	TA (NC)	ND	114 (12)	41	12
Methylene Chloride	ND (100)	ND	ND	ND	100
Pentachlorophenol	ND (100)	ND	ND	ND	100
Bis(2-ethylhexyl) Phthalate	23 (NR)	TA (NC)	21 (17)	18	9
Tetrachloroethylene	ND	ND	ND (100)	ND	100
Trichloroethylene	16 (26)	ND	TA (NC)	TA	26
Antimony (Total)	31 (NR)	ND	753 (1)	261	1
Arsenic (Total)	ND	TA (NC)	11 (NR)	TA	NR
Chromium (Total)	TA (NC)	110 (NR)	ND	40	NR
Copper (Total)	85 (4)	28 (53)	21 (37)	45	31
Cyanide	18 (3)	ND	ND	TA	3
Lead (Total)	23 (NR)	31 (16)	45 (20)	33	12
Nickel (Total)	55 (NR)	67 (7)	72 (7)	65	5
Silver (Total)	13 (NR)	28 (NR)	15 (8)	19	3
Zinc (Total)	275 (NR)	280 (NR)	62 (14)	206	5

Note: NC indicates "not able to calculate removal."
ND indicates "not detected."
NR indicates "no removal."
TA indicates "trace amount," less than 10 ug/l.

Source: EPA/Industry Field Studies

TABLE VII-61
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (AFTER CHEMICAL COAGULATION)
TRADITIONALLY MONITORED POLLUTANTS
OTHER MILLS

Parameter	Mill BB	V	E	Q	Q	Q	F	EE	S	
Subcategory	4b	4c	5b	5a	5a	5a	6	7	7	
Loading rate, gpm/sq ft	1.5	3.0	5.0	3.0	3.0	5.0	5.0	3.0	5.0	
	Average Effluent Concentration									Average
BOD5, mg/l	9.3	2.5	9.3	3.4	2.9	3.1	6.6	(2)	5.5	5.0
COD, mg/l	147	331	104	179	138	134	120	67	67	143
TSS, mg/l	38	20	4.2	24	18	9.2	8.3	7.6	12	16
TOC, mg/l	41	62	22	(20)*	-	20	25	33	6.4	30
Total Phenols, ug/l	54	-	57	-	-	-	42	(20)	(20)	39
Color, ADMI Units (pH 7.6)	167	284	53	195	127	-	168	43	95	142
	Average Removal, Percent									Average
BOD5	10	26	14	43	17	20	18	-	18	21
COD	6.2	5.9	17	20	21	24	16	34	21	18
TSS	28	60	48	68	65	83	65	71	37	58
TOC	6.7	14	8.2	-	-	6.3	11	9.4	8.7	9.2
Total Phenols	18	-	-	-	-	-	31	-	-	25
Color	11	0.6	5.8	2.2	13	-	4.2	8.3	2.0	5.9

* Value represents a single data point and was not included in calculating subcategory average.

Note: ( ) Indicates "less than" value.

Source: EPA/Industry Field Studies

TABLE VII-62
SUMMARY OF ANALYTICAL RESULTS
MULTIMEDIA FILTRATION (AFTER CHEMICAL COAGULATION)
TOXIC POLLUTANTS
OTHER MILLS

Parameter/Pollutant	Mill V	Mill E	Average ug/l	Average %
Subcategory	4c	5b		
Loading rate, gpm/sq ft	3.0	5.0		
	Average Effluent Concentration, ug/l (Removal,%)			
Benzene	ND	18 (NR)	TA	NR
Chloroform	ND	ND (100)	ND	100
1,2-Dichlorobenzene	TA (23)	TA (NC)	TA	23
Pentachlorophenol	12 (NR)	ND	TA	NR
Phenol	19 (NR)	TA (50)	15	25
Bis(2-ethylhexyl)Phthalate	TA (71)	40 (NR)	25	36
Antimony (Total)	136 (NR)	TA (NR)	73	NR
Chromium (Total)	14 (18)	TA (NR)	12	9
Copper (Total)	25 (NR)	TA (NR)	18	NR
Lead (Total)	64 (NR)	TA (NR)	37	NR
Nickel (Total)	ND	76 (NR)	38	NR
Silver (Total)	77 (NR)	29 (NR)	53	NR
Zinc (Total)	234 (NR)	121 (NR)	178	NR

Note: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
NR indicates "no removal."
NC indicates "not able to calculate removal".

Source: EPA/Industry Field Studies

summarize the performance of multimedia filtration in the treatment of traditionally monitored toxic, nonconventional and conventional pollutants.

Hyperfiltration/Ultrafiltration Hyperfiltration (reverse osmosis) is a physical separation process that relies on applied pressure (greater than osmotic pressure) to force flow through a semipermeable membrane (permeable to water but not dissolved materials of a specific molecular size). The process is capable of removing suspended particles and substantial fractions of dissolved impurities, including organic and inorganic materials. The membranes are designed so that water and species smaller in size than the rejection level of the particular membrane pass through while larger species are rejected. The process results in two effluents, one relatively pure, and the other containing the concentrated pollutants.

The membrane is the most important aspect of the reverse osmosis system. Those most widely used are manufactured from a mixture of cellulose acetate, acetone, formamide and magnesium perchlorate. Noncellulose synthetic polymer membranes also have been developed and are commercially available; however, these are more often applicable in ultrafiltration systems. The most common commercially available hyperfiltration systems include tubular, spiral wound and hollow fine fiber. The tubular system has a typical membrane area per unit volume of 65.65 sq m/cu m (20 sq ft/cu ft) and the membrane is situated along the inner wall of a 1.27 cm (0.5 in.) diameter tube. The spiral wound system utilizes a number of flat membranes separated by porous spacers and rolled into a spiral; these systems typically provide 820 sq m of membrane surface per cu m (250 sq ft per cu ft) of volume. The hollow fiber system utilizes microscopic fibers that are in essence very small tubes with thick walls. Pressure is applied from the outside of the tubes and the filtrate (filtered effluent) flows into the tubes. The hollow fiber system can provide from 6565 to 16,410 sq m of membrane surface per cu m of volume (2000 to 5000 sq ft per cu ft). The tubular system is easiest to clean or replace and is usually employed in wastewater applications.

Hyperfiltration systems usually operate at a pressure of 20.4 to 102.1 atm (300 to 1,500 psi) and have a flux rate on the order of 407 l/day/sq m (10 gal/day/sq ft). They generally require extensive pretreatment (pH adjustment, filtration, chemical precipitation, activated carbon adsorption) of the waste stream to prevent rapid fouling or deterioration of the membrane surface.

Ultrafiltration is similar to hyperfiltration and relies on a semipermeable membrane and an applied driving force to separate suspended and dissolved materials from wastewater. The membranes used in ultrafiltration have pores large enough to eliminate osmotic pressure as a factor which allows operation at pressures as low as 0.352 to 0.703 kg/sq cm (5 to 10 psi). Sieving is the predominant removal mechanism, and the process is usually applicable for removal of materials having a molecular weight greater than 500 and a very small osmotic pressure at moderate concentrations. Because of the larger pore sizes, flux rates for ultrafiltration are normally 814 to 2035 l/day/sq m (20 to 50 gal/day/sq ft). The systems have been used for removal or concentration of macromolecules such as proteins, enzymes, starches, and other organic polymers.

Industry Application - None of the textile mills surveyed during this study report the use of hyperfiltration or ultrafiltration in their end-of-pipe wastewater treatment systems.

Literature/Research - Both hyperfiltration and ultrafiltration of textile wastewater has been studied by EPA and others for several years. A research project (25) funded by the EPA Office of Research and Development investigated the feasibility of hyperfiltration membranes for the renovation of composite textile dyeing and finishing wastewater from a woven fabric finishing-simple processing mill. The processing at the mill is piece dyeing of upholstery fabrics made of cotton, rayon, and nylon. The general conclusion of the study is that the product water quality is satisfactory for direct reuse in all dyeing and finishing operations at the facility.

A second research project (26), also funded by the EPA Office of Research and Development, investigated hyperfiltration for renovation of composite wastewater at eight textile finishing mills. The objective of the study was to determine the applicability of the hyperfiltration unit used in the previously mentioned study (25) as a general treatment technology for the textile industry. The study involved the measurement of membrane performance with minimum pretreatment, the evaluation of reuse of both the purified product water and the concentrated residue, and the determination of the treatability of the concentrate by conventional treatment technologies. The conclusions of the study are that the product water (filtrate) is satisfactory for reuse in scouring, bleaching, dyeing and finishing and that the residual concentrate is treatable by the technology currently installed at each facility. Evaluations of equipment performance and projected treatment cost also are provided.

Based on the finding of these hyperfiltration studies, a full-scale demonstration project has been funded by EPA and is currently in the design and construction phase.

Research has been conducted on the recovery of synthetic sizes from scouring wastes, and a full-scale ultrafiltration system is in place.

Dissolved Air Flotation Dissolved air flotation is a physical separation operation that is used to separate solid or liquid particles from a liquid phase. A portion of the flow is pressurized to 2.7 to 3.4 atm (40 to 50 psi) in the presence of sufficient air to approach saturation. The pressurized air-liquid mixture is released in a flotation unit through which the remaining waste stream flows. The entrained air is released as fine bubbles that attach to the particulate matter. The buoyant force of the gas bubbles causes the particles to rise to the surface where the solids are removed by skimming.

The performance of a flotation unit is related to the air-solids ratio, which is defined as pounds of air released per pound of solids in the influent waste. A typical range of the air to solids ratio is 0.01 to 0.1.

The design variables for flotation units are the quantity of air used, the influent solids or oil concentration and the overflow rate. When the flotation process is used primarily for clarification, a detention period of 20 to 30 minutes is adequate for separation and concentration. Rise rates of 61 to 204 l/sq m (1.5 to 5.0 gpm/sq ft) are commonly employed. (27)

The principal components of a dissolved air flotation system are a pressurizing pump, air injection facilities, a retention tank, a back pressure regulating device and a flotation unit. The pressurizing pump creates an elevated pressure to increase the solubility of air. Air is usually added through an injector on the suction side of the pump. Of the total air induced, 30 to 45 percent is usually dissolved.

Chemicals such as aluminum and iron salts and activated silica commonly are used in dissolved air flotation to increase the flocculent properties of the floated particles and aid the capture of gas bubbles. A variety of organic chemicals (polymers) also are used to change the nature of either the air-liquid interface or the solid-liquid interface, or both.

Industry Application - Seven mills use air flotation in their waste treatment systems. Four are direct dischargers, two are indirect dischargers, and one practices complete recycle. One of the direct dischargers uses flotation to separate print pastes from a segregated print department discharge, one reclaims indigo dyestuff for reuse from a yarn dyeing operation, one separates wool grease from a wool scouring discharge, and one separates biological floc from the effluent of a secondary clarifier. One indirect discharger separates print pastes from the discharge of a sheet printing operation while the other removes latex from a coating operation. The recycle plant separates print paste from the discharge of large woven fabric printing operation. Historical monitoring data are not available to describe the performance of the air flotation units alone.

Field Sampling - During this study, sampling was conducted at three of the mills noted above to provide performance data for air flotation. The results are discussed in the following cases.

Case 1 is a wool scouring mill that scours raw grease wool and converts it, usually blended with other fibers, into fabric by combing, spinning and weaving. The wool scouring operations result in a wastewater discharge rate of 33.4 l/kg of product (4.0 gal/lb of product) and a wastewater discharge of 2,300 cu m/day (0.6 mgd). The mill operates in conjunction with a wool finishing mill that converts the product of the wool scouring mill into finished fabric.

After preliminary dissolved air flotation of the wool scouring wastewater and screening of the wool finishing wastewater, the mills share an extended-aeration activated sludge treatment facility. The preliminary treatment of the wool scouring wastewater consists of equalization (mixed), chemical addition (ferric chloride, caustic and polymer) and dissolved air flotation 18.9 lps (300 gpm). The remainder of the treatment facility consists of aeration (1 basin with a total volume of 49,211 cu m (13 million gal), secondary clarification and disinfection (chlorine). Aeration detention time is approximately 60 hours, and air is provided by surface aerators at a power-to-volume ratio of 10.2 kw/1000 cu m (52 hp/million gal).

Samples were collected over a typical 72-hour period of operation at the screens before the finishing plant effluent enters the aeration basin, at the equalization basin prior to the dissolved air flotation unit, at the effluent pipe from the dissolved air flotation unit, and at the effluent from the secondary clarifiers. The performance of the dissolved air flotation unit in treating toxic, nonconventional and conventional pollutants is presented in Table VII-63.

Case 2 is a woven fabric finishing-simple processing mill that performs flat bed and rotary screen printing to produce sheets, towels, and bedspreads. Rotary screen printing accounts for approximately 90 percent of the production. Wastewater is discharge data rate of 19.2 l/kg of product (2.3 gal/lb of product).

Wastewater treatment at this mill consists of equalization (small holding tank), grit removal, coarse screening, chemical addition (alum and caustic), fine screening (vibrating), chemical addition (cationic polymer) and flocculation, dissolved air flotation (300 gpm), aeration (2 lagoons in series), disinfection (chlorine), secondary clarification (reactor/clarifier in which alum, caustic, and anionic polymer are added) and dual media gravity filtration (sand and carbon). Aeration detention time is approximately 170 hours, and air is provided by surface aerators at a power-to-volume ratio of approximately 3.53 kw/1000 cu m (18

TABLE VII-63
SUMMARY OF ANALYTICAL RESULTS
CASE 1 - DISSOLVED AIR FLOTATION UNIT
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Influent Min	Influent Max	n	Effluent Min	Effluent Max	n
Conventional & Nonconventional Pollutants						
BOD_5, mg/l	4,700	9,200	3	1,000	1,900	3
COD, mg/l	10,000	21,000	3	1,700	2,600	3
TSS, mg/l	3,700	6,400	3	32	76	3
Oil & Grease, mg/l	63	2,000	3	220	560	3
Total Phenols, ug/l	1,900	3,200	3	580	1,400	3
Color, APHA Units	65	197	3	9	83	3
Color, ADMI Units (pH 7.6)	*	*	*	446	581	3
Toxic Pollutants, ug/l						
Acenaphthene	ND	ND	3	ND	16	3
Chlorobenzene	ND	20	3	TA	TA	3
Ethylbenzene	ND	23	3	ND	ND	3
Methylene Chloride	TA	10	3	TA	10	3
Isophorone	ND	111	3	ND	ND	3
Pentachlorophenol	ND	24	3	ND	ND	3
Phenol	TA	221	3	ND	517	3
Bis(2-ethylhexyl) Phthalate	ND	20	3	ND	50	3
Di-n-octyl Phthalate	ND	10	3	ND	ND	3
Toluene	TA	43	3	TA	TA	3
Arsenic (Total)	162	225	3	30	39	3
Cadmium (Total)	11	13	3	TA	10	3
Chromium (Total)	240	269	3	163	391	3
Copper (Total)	59	77	3	ND	ND	3
Lead (Total)	437	491	3	154	250	3
Nickel (Total)	81	133	3	88	123	3
Zinc (Total)	613	724	3	241	382	3

* No analytical result, clear filtrate could not be obtained.

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the influent or effluent: Benzene; 1,2,4-Trichloroethane; Chloroform; 1,2-Diphenylhydrazine; N-nitrosodiphenylamine; Butyl Benzyl Phthalate; Di-n-butyl Phthalate; Tetrachloroethylene; Dieldrin; 4,4'-DDD; Alpha Endosulfan; Beta Endosulfan; Heptachlor Epoxide; Alpha-BHC; Beta-BHC; Gamma-BHC; Delta-BHC; PCB-1242; Antimony; Beryllium; Selenium; Silver; Thallium.

Source: EPA Field Sampling Results for Mill 10013, March 1980.

hp/million gal). The discharge from the treatment plant is recycled for reuse in the printing operations.

Samples were collected over a typical 48-hour period of operation at the bar screen prior to the air flotation unit, at the Parshall flume prior to the aeration basins, at the chlorine contact chamber following aeration, and at the effluent from the dual media filters. The performance of the dissolved air flotation unit in treating toxic, nonconventional and conventional pollutants is presented in Table VII-64.

Case 3 is a knit fabric finishing-complex processing mill that knits, scours and piece dyes cloth of wool, cotton, polyester or nylon. Wastewater is discharged at a rate of 129 l/kg of product (15.5 gal/lb of product).

Wastewater treatment at this mill consists of coarse screening, aeration (1 basin), secondary sedimentation, chemical addition (alum, caustic, and polymer), dissolved air flotation, disinfection (chlorine), and a polishing pond. The aeration detention time is approximately 24 hours, and air is provided by surface aerators at a total power-to-volume ratio of 26.1 kw/1000 cu m (133 hp/million gal).

Samples were collected over a typical 72-hour period of operation at the bar screen, at the discharge from the secondary clarifiers, and at the discharge from the dissolved air flotation unit. The performance of dissolved air flotation in treating toxic, nonconventional and conventional pollutants is presented in Table VII-65.

Stripping Stripping refers to the removal of relatively volatile components from a wastewater by the passage of air, steam or other gas through the liquid. For example, ammonia nitrogen has been removed from high pH municipal wastewater by air stripping in a limited number of applications. The exhaust gas usually is vented to the atmosphere without treatment. Steam stripping of ammonia-rich water followed by recovery of the ammonia as ammonium salt in an acidic absorbing liquid is a newer process under development. (28,29) Stripping odorous substances from kraft pulp mill waste streams by steam is another example (30).

Stripping of volatile toxic pollutants under controlled conditions that prevent release to the atmosphere could theoretically be used as a treatment process for textile wastewater. However, this is an expensive process because of the relatively low volatile pollutant concentrations typically present. There is no information available providing design criteria, performance, or detailed costs for treatment systems using stripping of volatile pollutants from industrial wastewater similar to that produced by the textile industry.

TABLE VII-64
SUMMARY OF ANALYTICAL RESULTS
CASE 2 - DISSOLVED AIR FLOTATION UNIT
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Influent*	Effluent*
Conventional & Nonconventional Pollutants		
BOD5, mg/l	400	(200)
COD, mg/l	1050	725
TSS, mg/l	195	32
Total Phenols, ug/l	92	26
Sulfide, ug/l	(200)	(200)
Toxic Pollutants, ug/l		
Benzene	18	12
1,1,1-Trichloroethane	11	TA
Ethylbenzene	460	160
Methylene Chloride	26	30
Naphthalene	250	ND
Pentachlorophenol	37	30
Phenol	94	26
Bis(2-ethylhexyl) Phthalate	570	45
Di-n-butyl Phthalate	13	ND
Toluene	320	132
Copper (Total)	323	81
Lead (Total)	14	ND
Nickel (Total)	28	32
Thallium (Total)	TA	14
Zinc (Total)	25	TA

* average of two 24-hour samples

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
( ) indicates "less than" value.

The following pollutants also were detected at less than 10 ug/l in the influent or effluent: 1,2-Dichloroethane; Chloroform; Tetrachloroethylene; Beryllium; Cadmium; Chromium; Cyanide; Mercury; Selenium; Silver; Thallium.

Source: EPA Field Sampling Results for Mill 40144, November 1977.

TABLE VII-65
SUMMARY OF ANALYTICAL RESULTS
CASE 3 - DISSOLVED AIR FLOTATION
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Biological Effluent			Final Effluent		
	Min	Max	n	Min	Max	n
Conventional & Nonconventional Pollutants						
COD, mg/l	314	706	3	146	159	3
TSS, mg/l	16	36	3	ND	9	3
Total Phenols, ug/l	13	33	3	21	146	3
Color, ADMI Units	77	87	3	46	48	3
Color, ADMI Units (pH 7.6)	74	95	3	46	52	3
Toxic Pollutants, ug/l						
Chloroform	ND	81	2	ND	25	3
1,2-Trans-dichloroethylene	TA	TA	1	14	14	1
Bis(2-ethylhexyl) Phthalate	ND	15	3	11	540	3
Tetrachloroethylene	270	370	3	200	250	3
Trichloroethylene	ND	47	3	ND	TA	3
Antimony (Total)	436	478	3	364	393	3
Copper (Total)	12	16	3	ND	TA	3
Lead (Total)	46	48	3	18	39	3
Nickel (Total)	136	164	3	76	146	3
Silver (Total)	12	20	3	ND	28	3
Zinc (Total)	47	64	3	44	45	3

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.

The following pollutants also were detected but at less than 10 ug/l in the influent or effluent: Benzene; 1,1,2,2-Tetrachloroethane; 2,4-Dimethylphenol; Methylene Chloride; Phenol; Di-N-butyl Phthalate; Anthracene; Toluene; Arsenic; Cadmium; Chromium; Cyanide.

Source: EPA Field Sampling Results for Mill 50013, August 1978.

Electrodialysis Electrodialysis is a membrane separation process that is used to separate ionic components from a liquid phase. The process makes use of an induced electric current that causes migration of cations toward a negative electrode and migration of anions toward a positive electrode. Separation is accomplished by alternately placing membranes which preferentially allow passage of anions or cations across the current path. Because of the alternate spacing, cells of concentrated and dilute solutions are formed. Electrodialysis shares the same operating difficulties as hyperfiltration and ultrafiltration systems in that pretreatment is usually necessary to prevent rapid fouling of the membranes.

Industry Application - There are currently no known textile mills that use electrodialysis as part of their wastewater treatment systems. Because the process primarily is applicable to the separation of soluble inorganic ions, it has not been given much consideration except in the case of wastewater renovation for reuse.

Sorption Systems

Activated Carbon Adsorption Activated carbon adsorption is a physical separation process in which substances in water are removed on the surface of highly porous carbon particles. Various raw materials are used in the production of activated carbon. The carbonized material is activated, usually by steam, to remove tars and other impurities and open up and enlarge the pores. Pore size depends, in part, on the source material and is increased through regeneration (31). Therefore, different activated carbons are used for different applications, such as gaseous versus liquid systems for example.

The primary removal mechanism of activated carbon is adsorption, the physical attraction and accumulation of the removed material on the surface of the carbon. Activated carbons typically have surface areas of 500 to 1,400 sq m/g (152,700 to 427,600 sq ft/oz).

Many factors have been identified as important in describing the adsorption of materials on activated carbon. It is not appropriate for this discussion to include all of the factors relating to the nature of the carbon and its surface area, particle size, pore size, etc. Instead, the focus is on the materials in the wastewater that are to be adsorbed. Information has been developed about the molecular structure of compounds which relates to adsorbability, polarity, and degree of ionization (32). Molecular structure also is reflected in the solubility of the compound. As a result, materials that are less attracted to water tend to be more attracted to activated carbon surfaces.

In general, molecules are more readily adsorbed than ionized compounds. The aromatic compounds tend to be more readily adsorbed than the aliphatics. Larger molecules are more readily adsorbed then smaller ones, although extremely high molecular weight materials are too large to penetrate the pores in the carbon. Treatment of wastes with activated carbon is generally considered for organic rather than inorganic components, although metals and other inorganics are adsorbed on carbon surfaces or on organic solids that are removed in granular carbon filters.

The concentration of the constituents removed is important in several ways, including competition for sites with other organic materials in the water and displacement of molecules already adsorbed by compounds more favored by the carbon. An important consideration related to toxic pollutant concentration is that the behavior of many of the 129 toxic pollutants have not yet been widely studied at the concentrations that have been observed in textile wastewaters. A last but very important factor in adsorption phenomena is the pH of the solution. Usually, the lower the pH of the solution the greater the adsorption of many materials.

As pointed out by Ford (33) and others, adsorption with activated carbon has limitations and must be evaluated for particular situations. Preliminary treatment of the wastewater, such as pH adjustment, coagulation, or chemical oxidation may improve the adsorbability of some pollutants.

There are two forms of activated carbon in common use, granular and powdered. To date, the granular form has been preferred for most wastewater applications because it can be readily regenerated. Regeneration of powdered activated carbon by steam is currently under development. Granular carbon is commonly used in columns operated in series. The columns are operated downflow packed bed, upflow packed bed, or upflow expanded bed. Although the upflow expanded bed theoretically is the best alternative because of its ability to process more turbid wastewaters without clogging, operational difficulties have limited its development. The upflow packed bed offers an important advantage. The column is operated continuously, with the exhausted carbon being removed at the bottom of the column with virgin, or regenerated, carbon added at the top. This eliminates the need for an auxiliary column for use when an exhausted column is being serviced.

Spent carbon is commonly regenerated thermally at 815°C (1500°F) in a multiple hearth furnace in the presence of steam. In this process, the adsorbed organics are oxidized to gases in the form of either CO or CO_2. Some elemental carbon is lost in the process, but this is usually limited to less than 10 percent by weight. After regeneration, the carbon is returned to the columns for reuse.

An aspect of granular carbon columns that is currently receiving attention is the role and possible benefits of biological growths on the carbon surfaces. In some applications, much of the pollutant removal has been found to result from biodegradation rather than adsorption.

Powdered activated carbon (PAC) use in wastewater treatment applications has increased rapidly in the past decade. Various application points in the treatment sequence have been used, with the activated sludge aeration tank being the most common. The spent carbon is discarded without regeneration in most systems. This process results in a transfer of the pollutants from the water to the carbon. Biorefractory materials remain intact in the sludge or other residue containing the spent carbon. Treatment using powdered activated carbon is discussed as a separate topic below.

Industry Application - Only one of the mills surveyed in this study reports the use of granular activated carbon in its wastewater treatment system. Several additional textile mills also are using activated carbon as part of closed (recycle) systems for at least a part of their wastewater. However, the application at these mills is not considered typical and information on the characteristics of these systems was not obtained during this study.

Literature/Research - Activated carbon adsorption has received considerable attention as an industrial wastewater treatment technology. Much of the information available on textile wastewater has to do with treatment of individual waste streams discussed in the next section.

EPA/Industry Field Studies - In a joint research effort between EPA and the textile industry (ATMI, NTA, and CRI), pilot plant studies were conducted during 1977 and 1978 at 19 textile mills to generate performance data for alternative advanced wastewater treatment technologies. The studies were performed on secondary clarifier effluent from treatment systems using extended-aeration activated sludge. One of the pilot scale technologies was granular activated carbon adsorption using three carbon columns operated in series in the downflow mode. Each column was 2.36 m (7.75 ft) in height and 19.0 cm (7.5 in) in diameter. They were constructed of Schedule 80 PVC pipe and had a carbon capacity of 18.2 kg (40 lbs), allowing for sufficient expansion volume during backwashing. Depending on the results of isotherm testing, either Westvaco WV-L, Westvaco WV-I, or ICI Hydrodarco granular carbon was utilized.

Activated carbon was included in the treatment technology selected for further study at 18 of the 19 mills. The columns were designed to remove soluble organic material and were preceded by either multimedia filtration or chemical coagulation plus multimedia filtration. In addition to the regular pilot plant testing, sampling was conducted at selected mills to determine the performance of activated carbon in the treatment of toxic pollutants.

The data generated for granular activated carbon technology is summarized in Tables VII-66 through VII-71 of this section by subcategory grouping (wool scouring mills, wool finishing mills, and other mills). The data are presented in aggregate form without regard to location of the carbon columns in the pilot scale treatment technology. The aggregation of data is appropriate because the preceeding treatment steps sufficiently reduced the TSS in the influent to the carbon columns in all cases. Therefore, the performance of the carbon is related solely to its ability remove soluble organic material. The summaries demonstrate the effectiveness of activated carbon in the treatment of conventional, nonconventional, and toxic pollutants.

Powdered Activated Carbon (PAC) Treatment Powdered activated carbon treatment typically refers to the addition of powdered activated carbon to the activated sludge process. It is a recently developed process that has shown to upgrade effluent quality in conventional activated sludge plants. A general discussion of powdered activated carbon is provided in the previous activated carbon section. In the PACT process, the carbon concentration in the mixed liquor is generally equal to or greater than the MLSS concentration. The carbon and adsorbed substances are discarded as part of the biological sludge.

Industry Application - Three of the mills surveyed use powdered activated carbon in their wastewater treatment systems. Two mills manually add powdered carbon to the aeration basins and maintain a specified concentration of carbon in the MLSS. The other mill operates a semi-continuous system in which raw dyehouse wastewater is pumped to a tank containing a designated amount of powdered carbon, mixed to form a slurry, and pumped through a filter press. The filter cake is discarded as solid waste. The operation and effectiveness of one continuous system and the semi-continuous system are discussed as case studies in the next section.

Literature/Research - Bench-scale laboratory studies have been conducted by EPA (34) on the wastewaters from 10 textile finishing mills and the results are presented later in this section. The treatment process at one of the textile mills reporting full scale use of powdered activated carbon addition to the activated sludge process and the semi-continous system treating raw textile wastewater were sampled during this study. The results also are presented below. In addition to the field sampling, information is presented on an existing municipal PAC treatment system that treats textile mill wastewater.

TABLE VII-66
SUMMARY OF ANALYTICAL RESULTS
GRANULAR ACTIVATED CARBON ADSORPTION
TRADITIONALLY MONITORED POLLUTANTS
WOOL SCOURING MILLS

Parameter	Mill A	
Contact time, minutes	45	
	Average Effluent Concentration	Subcategory Average
BOD5, mg/l	13	13
COD, mg/l	431	431
TSS, mg/l	31	31
TOC, mg/l	191	191
Total Phenols, ug/l	-	-
Color, ADMI Units (pH 7.6)	307	307
	Average Removal, Percent	Subcategory Average
BOD5	43	43
COD	47	47
TSS	66	66
TOC	34	34
Total Phenols	-	-
Color	51	51

Source: EPA/Industry Field Studies

TABLE VII-67
SUMMARY OF ANALYTICAL RESULTS
GRANULAR ACTIVATED CARBON ADSORPTION
TOXIC POLLUTANTS
WOOL SCOURING MILLS

Parameter/Pollutant	Mill A	Subcategory Average ug/l	Subcategory Average %
Contact time, minutes	45		
	Average Effluent Concentration, ug/l (Removal,%)		
Phenol	17 (NR)	17	NR
Bis(2-ethylhexyl)Phthalate	26 (NR)	26	NR
Arsenic (Total)	42 (49)	42	49
Copper (Total)	ND (100)	ND	100
Cyanide	40 (85)	40	85
Zinc (Total)	120 (70)	120	70

Note: ND indicates "not detected."
NR indicates "no removal."

Source: EPA/Industry Field Studies

TABLE VII-68
SUMMARY OF ANALYTICAL RESULTS
GRANULAR ACTIVATED CARBON ADSORPTION
TRADITIONALLY MONITORED POLLUTANTS
WOOL FINISHING MILLS

Parameter	Mill B	Mill B	Mill B	Mill O	
Contact time, minutes	25	28	30	45	
	Average Effluent Concentration				Subcategory Average
BOD5, mg/l	8.3	11*	16	2.2	8.8
COD, mg/l	40	20	26	18	26
TSS, mg/l	2.1	4.8	0.9	2.9	2.7
TOC, mg/l	18	17	15	6.7	14
Total Phenols, ug/l	20	20	20	24	21
Color, ADMI Units (pH 7.6)	-	30*	16	29	23
	Average Removal, Percent				Subcategory Average
BOD5	61	52*	47	16	41
COD	79	75	84	84	81
TSS	57	86	28	52	56
TOC	46	68	73	80	67
Total Phenols	-	-	-	37	37
Color	-	-	-	65	65

* Value represents a single data point and was not included in calculating subcategory average.

Source: EPA/Industry Field Studies

TABLE VII-69
SUMMARY OF ANALYTICAL RESULTS
GRANULAR ACTIVATED CARBON ADSORPTION
TOXIC POLLUTANTS
WOOL FINISHING MILLS

Parameter/Pollutant	Mill B		Mill O		Subcategory Average ug/l	Subcategory Average %
Contact time, minutes	25-30		45			
	Average Effluent Concentration, ug/l (Removal,%)					
1,2,4-Trichlorobenzene	ND	(100)	ND		ND	100
Methylene Chloride	ND		27	(43)	14	43
Bis(2-ethylhexyl)Phthalate	TA	(29)	33	(41)	17	35
Toluene	ND	(100)	ND		ND	100
Antimony (Total)	TA	(17)	ND		TA	17
Arsenic (Total)	ND	(100)	TA	(NC)	TA	100
Cadmium (Total)	13	(88)	ND		TA	88
Chromium (Total)	29	(29)	TA	(93)	20	61
Copper (Total)	51	(57)	11	(91)	31	74
Lead (Total)	12	(90)	ND		TA	90
Nickel (Total)	82	(NR)	ND		41	NR
Silver (Total)	151	(4)	ND		76	4
Zinc (Total)	5964	(NR)	374	(22)	3170	11

Note: NC indicates "not able to calculate removal."
ND indicates "not detected."
NR indicates "no removal."
TA indicates "trace amount," less than 10 ug/l.

Source: EPA/Industry Field Studies

TABLE VII-70
SUMMARY OF ANALYTICAL RESULTS
GRANULAR ACTIVATED CARBON ADSORPTION
TRADITIONALLY MONITORED POLLUTANTS
OTHER MILLS

Parameter	Mill									
	K	BB	AA	D	P	P	P	T	V	Y
Subcategory	4a	4b	4c	4c	4c	4c	4c	4c	4c	4c
Contact time, minutes	35	45	45	45	15	25	45	60	45	45
	Average Effluent Concentration									
BOD_5, mg/l	9.4	19	8.8	13	8.4	15*	6.0	6	1.2	6.1
COD, mg/l	21	210	169	422	93	70*	37	411	176	33
TSS, mg/l	2.5	28	13	23	-	-	19*	16	20	2.1
TOC, mg/l	-	44	-	101	12	11*	7.0	98	36	4.4
Total Phenols, ug/l	(50)	53	20	-	20	10*	20*	237	-	-
Color, ADMI Units (pH 7.6)	59	197	167	820	51	-	-	49	79	43
	Average Removal, Percent									
BOD_5	34	20	19	44	5.0	61*	41	32	48	18
COD	70	41	44	33	7	46*	53	21	48	64
TSS	39	27	19	51	-	-	14*	28	11	42
TOC	-	53	-	37	49	56*	74	28	42	70
Total Phenols	-	28	-	-	-	-	0*	56	-	-
Color	84	41	54	4.3	60	-	-	70	72	74

* Value represents a single data point and was not included in calculating subcategory average.

Note: ( ) Indicates "less than" value.

Source: EPA/Industry Field Studies

TABLE VII-70 (Cont.)

Parameter	Mill Z	E	Q	Q	W	F	EE	S	
Subcategory	4c	5a	5a	5a	5a	6	7	7	
Contact time, minutes	49	45	22	30	45	45	45	45	
			Average Effluent Concentration						Average
BOD5, mg/l	12	3.8	1.7	2.1	1.5	5.9	(2)	6.0	6.6
COD, mg/l	346	32	74	70	19	45	29	72	133
TSS, mg/l	11	2.3	2.3	2.5	2.1	4.7	4.3	6.1	9.3
TOC, mg/l	--	5.3	--	14	2.9	4.9	10	4.4	26
Total Phenols, ug/l	--	50	(20)*	--	--	22	(20)	22	55
Color, ADMI Units (pH 7.6)	127	57	109	97	27	35	23	103	128
			Average Removal, Percent						Average
BOD5	30	62	55	55	55	16	12	19	33
COD	23	78	64	67	65	67	76	36	51
TSS	43	35	38	33	75	54	45	44	39
TOC	--	82	--	37	78	80	75	45	58
Total Phenols	--	1.5	--	--	--	32	--	--	31
Color	35	57	36	64	70	80	87	43	58

* Value represents a single data point and was not included in calculating subcategory average.

Note: ( ) Indicates "less than" value.

Source: EPA/Industry Field Studies

TABLE VII-71
SUMMARY OF ANALYTICAL RESULTS
GRANULAR ACTIVATED CARBON ADSORPTION
TOXIC POLLUTANTS
OTHER MILLS

Parameter/Pollutant	Mill K		Mill BB		Mill V		Mill E		Mill W		Average ug/l	Average %
Subcategory	4a		4b		4c		5b		5b			
Contact time, minutes	35		45		45		45		45			
	Average Effluent Concentration, ug/l (Removal, %)											
Benzene	ND		TA	(NR)	ND		ND		ND		TA	NR
Chloroform	ND		ND		ND		ND	(100)	TA	(67)	TA	84
Methylene chloride	17	(NR)	19	(NR)	ND		TA	(NC)	ND		TA	NR
Trichlorofluoro-methane	ND		ND		ND		ND		69	(NR)	14	NR
N-nitrosodi-n-propylamine	ND		ND		ND		ND	(100)	ND		ND	100
Pentachlorophenol	ND	(100)	ND		ND	(100)	ND		ND		ND	100
Phenol	ND		ND		ND	(100)	ND	(100)	ND		ND	100
Bis(2-ethylhexyl) Phthalate	TA	(33)	23	(13)	11	(NR)	38	(5)	69	(2)	30	11
Di-n-butyl Phthalate	ND	(100)	ND		TA	(NC)	ND		ND		TA	100
Trichloroethylene	ND	(100)	ND		ND		ND		TA	(NC)	TA	100
Antimony (Total)	35	(NR)	39	(27)	116	(15)	TA	(2)	747	(8)	189	10
Arsenic (Total)	TA	(NC)	ND		ND		12	(NR)	11	(NR)	TA	NR
Cadmium (Total)	ND		ND		10	(NR)	TA	(NR)	TA	(NC)	TA	NR
Chromium (Total)	TA	(NC)	93	(8)	15	(NR)	TA	(1)	ND		26	1
Copper (Total)	15	(80)	94	(8)	35	(NR)	TA	(17)	15	(36)	34	28
Cyanide	ND		TA	(86)	ND		ND		ND		TA	86
Lead (Total)	26	(8)	TA	(50)	64	(NR)	ND	(100)	54	(15)	31	35
Nickel (Total)	55	(NR)	121	(4)	32	(NR)	85	(13)	84	(18)	75	7
Selenium (Total)	ND		ND		ND		ND	(100)	ND		ND	100
Silver (Total)	15	(NR)	36	(4)	91	(NR)	28	(4)	20	(22)	38	6
Zinc (Total)	70	(66)	306	(NR)	83	(65)	19	(86)	39	(38)	103	51

Note: NC indicates "not able to calculate removal."
ND indicates "not detected."
NR indicates "no removal."
TA indicates "trace amount," less than 10 ug/l.

Source: EPA/Industry Field Studies

Case 1 is a knit fabric finishing-simple processing mill that knits, scours and dyes synthetic bolt cloth of polyester and acetate fiber. Pressure piece dyeing with dispersed dyes is performed on the total production and 20 percent of the production is scoured. During the field sampling, the wastewater discharge averaged 984 cu m/day (260,000 gpd).

Wastewater treatment at this mill consists of fine screening (vibratory), equalization (mixed, with nitrogen addition), aeration (two basins operated in series with powdered activated carbon added to the first basin), secondary clarification, sand filtration, disinfection (chlorine) and post aeration. Total detention time in the aeration basins is approximately 48 hours, and air is provided by surface aerators at a power-to-volume ratio of approximately 15.7 kw/1000 cu m (80 hp/million gal). The results presented in Table VII-72 demonstrate the effectiveness of the full-scale process in treating toxic, nonconventional and conventional pollutants.

Case 2 a carpet finishing mill that piece dyes and backs (jute using latex adhesive) carpet made from polyester and nylon fibers. The processing results in a wastewater discharge rate of 36.7 l/kg of product (4.4 gal/lb of product).

Wastewater treatment at this mill consists of coarse screening, equalization (storage tank), mixing (wastewater and powdered activated carbon) and solids separation (filter press). The results presented in Table VII-73 demonstrates the performance of the system in treating toxic pollutants.

Case 3 is a municipal PAC treatment system in the northeastern United States. A sizeable portion of the wastewater comes from a woven fabric finishing-desizing mill that desizes, scours, and dyes synthetic cloth comprised of polyester, rayon, nylon, and acetate. Wastewater discharge averages 2,840 cu m/day (0.75 mgd) at this mill. This is approximately 20 percent of the total flow to the POTW. The organic loading contributed by the textile mill is greater than 20 percent.

Wastewater treatment at the POTW consists of coarse screening, comminution, aerated grit removal, primary clarification, PAC and polymer addition, aeration (four basins), secondary clarification, filtration (dual media filters) and disinfection (chlorine). Total detention time is approximately 4.5 hours at the current flow, and air is provided by coarse bubble diffusers. Waste activated sludge and spent PAC are treated by a wet air oxidation unit that oxidizes the organic material in the sludge and regenerates the PAC. The performance of the system is shown in Table VI-74.

EPA/Industry Field Studies - As part of the joint research effort between EPA and the textile industry (ATMI, NTA, and CRI), bench-scale laboratory studies were conducted on the raw

TABLE VII-72
SUMMARY OF ANALYTICAL RESULTS
CASE 1 - PAC PROCESS
CONVENTIONAL, NONCONVENTIONAL, AND TOXIC POLLUTANTS

Parameter/Pollutant	Biological Influent*	Clarifier Effluent** Min	Max	n
Conventional & Nonconventional Pollutants				
COD, mg/l	1744	154	254	3
TSS, mg/l	204	44	60	3
Total Phenols, ug/l	34	TA	15	3
Sulfide, ug/l	50	8	20	3
Color, ADMI Units (pH 7.6)	158	75	89	3
Toxic Pollutants, ug/l				
Acrolein	199	ND	87	3
Acrylonitrile	90	ND	(100)	3
Chloroform	ND	ND	TA	3
Methylene Chloride	30	ND	28	3
Bis(2-Ethylhexyl) Phthalate	430	TA	50	3
Trichloroethylene	TA	ND	41	3
Antimony (Total)	186	81	87	3
Copper (Total)	17	TA	TA	3
Lead (Total)	99	36	44	3
Nickel (Total)	69	54	65	3
Silver (Total)	19	14	17	3
Thallium (Total)	(50)	(50)	(50)	3
Zinc (Total)	343	48	69	3

* 72-hour composite sample
** 24-hour composite samples

Notes: ND indicates "not detected."
TA indicates "trace amount," less than 10 ug/l.
( ) indicates "less than" value.

The following pollutants also were detected but at less than 10 ug/l in the biological influent or secondary clarifier effluent: Benzene; 1,2,4-Trichlorobenzene; 2,4,6-Trichlorophenol; Parachlorometacresol; 1,2-Dichlorobenzene; Ethylbenzene; Naphthalene; N-nitrosodi-n-propylamine; Pentachlorophenol; Phenol; Anthracene; Tetrachloroethylene; Toluene; Trichloroethylene; Arsenic; Beryllium; Cadmium; Chromium; Cyanide; Mercury; Selenium.

Source: EPA Field Sampling Results for Mill 50104, August 1978.

TABLE VII-73
SUMMARY OF ANALYTICAL RESULTS
CASE 2 - PAC PROCESS
TOXIC POLLUTANTS

Pollutant	Influent*	Effluent** Min	Max	n
Naphthalene	240	TA	TA	2
Phenol	67	TA	TA	2
Bis(2-ethylhexyl) Phthalate	400	TA	TA	2
Antimony (Total)	(12)	140	160	2
Zinc (Total)	20	40	120	2

* composite and grab samples during a 24-hour period; concentrations expressed in ug/l
** two grab samples during 24-hour period; concentrations expressed in ug/l

Notes: TA indicates "trace amount," less than 10 ug/l.
( ) indicates "less than" value.

The following pollutants also were detected but at less than 10 ug/l in the influent or effluent: 1,1,1-Trichloroethane; Methylene Chloride; Cadmium; Copper; Mercury.

Source: EPA Field Sampling Results for Mill 60031, December 1977.

TABLE VII-74
SUMMARY OF ANALYTICAL RESULTS
CASE 3 - PACT PROCESS
TRADITIONALLY MONITORED CONVENTIONAL AND
NONCONVENTIONAL POLLUTANTS

Pollutant	Raw Waste*	Primary Effluent**	Clarifier Effluent**
BOD5, mg/l	217	79	1.5
COD, mg/l	789	322	80
TSS, mg/l	406	97	24
Turbidity, NTU	--	50	6.5

* One month average.
** Two month average.

Source: Reference 71.

wastewater (influent to the biological aeration system) at 10 of the 19 pilot plant locations to evaluate the performance of powdered activated carbon treatment. Each textile mill shipped wastewater to the laboratory each week during a six-week study period. A description of the experimental procedures employed on the waste from each mill is summarized below.

1. Three 10-liter plexiglas bioreactors were seeded with activated sludge from the study mill and a municipal/industrial treatment plant and acclimated to the textile waste.

2. Following acclimation, the residual TOC of the bioreactor effluents was established.

3. Carbon adsorption isotherms were performed on the bioreactor effluent, and based on several considerations (the effects on residual TOC, experience gained in past studies, flow of full-scale plant, sludge age, economics), a high and low carbon make-up dosage was selected.

4. Two or three types of carbons were evaluated on an isotherm level and the most effective was used in the experiments.

5. The three bioreactors were designated as control (no carbon addition), high carbon, and low carbon, and were operated for approximately three weeks with carbon addition and sludge wastage each day.

6. Following the initial three-week period of operation (equilibrium period), two weeks of analytical data were generated to evaluate performance.

It should be stressed that the testing performed was for determination of technical feasibility and to provide an indication of the achievable effluent quality. Long term operating characteristics and costs were not considered.

Results from the laboratory studies of PACT for the treatment of conventional and nonconventional pollutants are presented in Tables VII-75 through VII-77. The data are aggregated for wool scouring mills, wool finishing mills, and all other mills.

Development of Treatment and Control Options

Many demonstrated control and treatment technologies have been discussed and information presented on their capabilities for removal of toxic, nonconventional and conventional pollutants from textile industry wastewaters. Alternative control and treatment technology options that represent a range of pollutant removal capability and cost were selected for detailed analysis. The options that were considered in determining BPT, BAT, NSPS, PSES and PSNS limitations and standards are presented below as

TABLE VII-75
SUMMARY OF ANALYTICAL RESULTS
POWDERED ACTIVATED CARBON TREATMENT
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
WOOL SCOURING MILLS

Parameter	Mill A	Subcategory Average
Carbon:		
Type	W-SC*	
Conc., mg/l (low)	2000	
(high)	10000	
Dosage, mg/l (low)	139	
(high)	694	
	Influent	
BOD5, mg/l	2580	2580
COD, mg/l	5542	5542
TSS, mg/l (control)	2977	2977
(low)	5295	5295
(high)	14837	14837
TOC, mg/l	1784	1784
Color, ADMI units (pH 7.6)	-	
	Control Reactor Effluent	
BOD5, mg/l	69	69
COD, mg/l	543	543
TSS, mg/l	568	568
TOC, mg/l	373	373
Color, ADMI units (pH 7.6)	705	705
	Low Carbon Reactor Effluent	
BOD5, mg/l	54	54
COD, mg/l	563	563
TSS, mg/l	366	366
TOC, mg/l	387	387
Color, ADMI units (pH 7.6)	629	629
	High Carbon Reactor Effluent	
BOD5, mg/l	51	51
COD, mg/l	457	457
TSS, mg/l	402	402
TOC, mg/l	336	336
Color, ADMI units (pH 7.6)	253	253

* Westvaco SC carbon

TABLE VII-75 (Cont.)

Parameter	Mill A	Subcategory Average
	Control Reactor, % Removal	
BOD_5	97	97
COD	90	90
TSS	81	81
TOC	79	79
Color	--	--
	Low Carbon Reactor, % Removal	
BOD_5	98	98
COD	90	90
TSS	93	93
TOC	78	78
Color	--	--
	High Carbon Reactor, % Removal	
BOD_5	98	98
COD	92	92
TSS	97	97
TOC	81	81
Color	--	--

Source: Reference 34.

TABLE VII-76
SUMMARY OF ANALYTICAL RESULTS
POWDERED ACTIVATED CARBON TREATMENT
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
WOOL FINISHING MILLS

Parameter	Mill B	Mill O	Subcategory Average
Carbon:			
Type	W-SA*	W-SC**	
Conc., mg/l (low)	2000	1000	
(high)	8000	5000	
Dosage, mg/l (low)	97	25	
(high)	388	125	
Influent			
BOD5, mg/l	407	247	327
COD, mg/l	1919	1098	1509
TSS, mg/l (control)	2986	3360	3173
(low)	7012	4373	5693
(high)	9774	7792	8783
TOC, mg/l	461	344	403
Color, ADMI units (pH 7.6)	71	-	71
Control Reactor Effluent			
BOD5, mg/l	27	16	22
COD, mg/l	148	102	125
TSS, mg/l	29	30	30
TOC, mg/l	41	30	36
Color, ADMI units (pH 7.6)	114	105	110
Low Carbon Reactor Effluent			
BOD5, mg/l	29	8	19
COD, mg/l	107	63	85
TSS, mg/l	33	16	25
TOC, mg/l	44	23	34
Color, ADMI units (pH 7.6)	81	66	74
High Carbon Reactor Effluent			
BOD5, mg/l	18	6.5	12
COD, mg/l	73	33	53
TSS, mg/l	23	11	17
TOC, mg/l	38	11	25
Color, ADMI units (pH 7.6)	64	43	54

* Westvaco SA carbon
** Westvaco SC carbon

TABLE VII-76 (Cont.)

Parameter	Mill B	Mill O	Subcategory Average
	Control Reactor, % Removal		
BOD5	93	94	94
COD	92	91	92
TSS	99	99	99
TOC	91	91	91
Color	0	-	0
	Low Carbon Reactor, % Removal		
BOD5	93	97	95
COD	94	94	94
TSS	(99)	(99)	(99)
TOC	90	93	92
Color	0	-	0
	High Carbon Reactor, % Removal		
BOD5	96	97	97
COD	96	97	97
TSS	(99)	(99)	(99)
TOC	92	97	95
Color	10	-	10

Note: ( ) indicates a "greater than" value.

Source: Reference 34.

TABLE VII-77
SUMMARY OF ANALYTICAL RESULTS
POWDERED ACTIVATED CARBON TREATMENT
TRADITIONALLY MONITORED CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS
OTHER MILLS

Parameter		D	P	Y	Mill E	Q	F	S	
Subcategory		4c	4c	4c	5b	5a	6	7	
Carbon:									
Type		W-SA*	W-SC#	ICI-H**	W-SC#	W-SC#	ICI-K##	W-SC##	
Conc., mg/l	(low)	3000	1000	2000	2000	1000	2000	2000	
	(high)	6000	5000	5000	5000	5000	5000	5000	
Dosage, mg/l	(low)	105	122	210	216	35	277	122	
	(high)	210	608	526	540	173	694	304	
					Influent				Average
BOD5, mg/l		1169	400	114	505	318	471	95	439
COD, mg/l		2115	572	301	1737	963	1454	956	1157
TSS, mg/l	(control)	4121	2310	1538	6086	4687	5128	3168	3863
	(low)	5686	4052	2070	5978	5435	6318	4585	4875
	(high)	8514	4610	4657	8818	6577	8488	7183	6978
TOC, mg/l		624	243	91	446	383	390	390	367
Color, ADMI units+		-	-	268	61	-	100	-	443
					Control Reactor Effluent				
BOD5, mg/l		46	8	6	57	17	11	8.5	22
COD, mg/l		556	119	98	1765	215	127	143	432
TSS, mg/l		15	30	29	26	24	43	4	24
TOC, mg/l		157	57	24	91	99	57	57	77
Color, ADMI units+		-	324	198	85	387	236	512	290
					Low Carbon Reactor Effluent				
BOD5, mg/l		24	8	5	21	14	6	8.5	12
COD, mg/l		390	96	60	103	175	67	74	138
TSS, mg/l		45	18	51	17	17	50	25	32
TOC, mg/l		113	42	12	52	56	35	35	49
Color, ADMI units+		-	293	88	36	325	125	263	188
					High Carbon Reactor Effluent				
BOD5, mg/l		24	8.5	4	21	11	4	6	11
COD, mg/l		447	82	37	69	119	40	35	118
TSS, mg/l		38	10	60	28	24	19	16	28
TOC, mg/l		105	34	9	40	44	18	18	38
Color, ADMI units+		-	236	148	49	242	77	140	149

* Westvaco SA carbon
\# Westvaco SC carbon
** ICI Hydrodarco carbon
\## ICI-KB carbon
\+ pH = 7.6

TABLE VII-77 (Cont.)

Parameter	Mill D	P	Y	E	Q	F	S	
	Control Reactor, % Removal							Average
BOD5	96	98	95	89	95	98	91	95
COD	74	79	67	0	78	91	85	68
TSS	(99)	99	98	(99)	99	99	(99)	99
TOC	75	77	74	80	74	85	85	79
Color	-	-	26	0	-	76	-	34
	Low Carbon Reactor, % Removal							
BOD5	98	98	96	96	96	99	91	96
COD	82	83	80	94	82	95	92	87
TSS	99	(99)	98	(99)	(99)	99	99	99
TOC	82	83	87	88	85	91	91	87
Color	-	-	67	41	-	88	-	65
	High Carbon Reactor, % Removal							
BOD5	98	98	96	96	97	99	94	97
COD	79	86	88	96	88	97	96	90
TSS	(99)	(99)	99	(99)	(99)	(99)	(99)	(99)
TOC	83	86	90	91	89	95	95	90
Color	-	-	45	20	-	92	-	52

Note: ( ) indicates a "greater than" value.

Source: Reference 34.

are the methodology and calculation of raw waste loads and final effluent limitations and standards for each option.

Best Practicable Control Technology Currently Available (BPT

General

Two new subcategories and a new subdivision of an existing subcategory have been identified: the nonwoven manufacturing and felted fabric processing subcategories and the water jet weaving subdivision of the low water use processing subcategory.

As stated previously, the Act establishes the requirements for the development of BPT limitations, which are generally based on the average of best existing performance within that category or subcategory. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. Limitations based on transfer technology must be supported by a conclusion that the technology is, indeed, transferable and a reasonable prediction that it will be capable of achieving the prescribed effluent limits. The best practicable control technology currently available for water jet weaving, nonwoven manufacturing and felted fabric processing has been identified as biological treatment, the technology on which BPT limitations are based for all other subcategories of the textile mills point source category.

Raw Waste Loads Raw waste loads for these two new subcategories and the new subdivision have been determined to be the medians of historical and field sampling data for mills in each subcategory/subdivision. (Table V-19). These raw waste loads have been used to calculate costs and pollutant removals.

BPT Limitations The final effluent limitations are presented in Section VIII. The general methodology for the development of these limitations is discussed below.

Water Jet Weaving Subdivision - Long-term average final effluent characteristics have been calculated as the average of the two mills where biological treatment systems are employed.

Nonwoven Manufacturing Subcategory - BPT effluent limitations are based on the transfer of the performance of biological treatment from the carpet finishing subcategory because currently existing wastewater treatment systems in the nonwoven manufacturing subcategory are not representative of best practicable control technology currently available.

Raw material and production processes are similar in the nonwoven manufacturing and carpet finishing subcategories. In addition, raw waste characteristics of wastewaters discharged from mills in the nonwoven manufacturing subcategory are similar to those discharged from mills in the carpet finishing subcategory. (As shown in Table VIII-3, BOD_5 and COD raw waste concentrations in the nonwoven manufacturing subcategory are equal to or lower than BOD_5 and COD concentrations in the carpet finishing subcategory.)

Felted Fabric Processing Subcategory - BPT effluent limitations are based on the transfer of the performance of biological treatment from the wool finishing subcategory because currently existing wastewater treatment systems in the felted fabric processing subcategory are uniformly inadequate and not representative of the best practicable control technology currently available.

Raw material and production processes are similar in the felted fabric processing subcategory and wool finishing subcategories. In addition, raw waste characteristics of wastewaters discharged from mills in the felted fabric processing subcategory are similar to those discharged from mills in the wool finishing subcategory. (As shown in Table VIII-3, BOD_5 and COD raw waste concentrations in the felted fabric processing subcategory are equal to or lower than BOD_5 and COD concentrations in the wool finishing subcategory.)

Best Available Technology Economically Achievable (BAT)

General

The factors considered in establishing best available technology economically achievable (BAT) limitations include the cost of applying the control technology, the age of process equipment and facilities, the process employed, process changes, the engineering aspects of applying various types of control techniques and environmental considerations such as air pollution, energy consumption and solid waste generation (Section 304(b)(2)(B). In general, the BAT technology level represents, at a minimum, the best existing economically achievable performance of plants of shared characteristics. Where existing performance is uniformly inadequate, BAT may be transferred from a different subcategory or industrial category. BAT may include process changes or internal controls, even when not common industry practice.

The primary determinant of BAT is effluent reduction capability using economically achievable technology. As a result of the Clean Water Act of 1977, the achievement of BAT has become the national means of controlling the discharge of toxic pollutants. Best available treatment technology must be implemented no later than July 1, 1984, for the control of toxic and nonconventional pollutants.

As a result of the toxic pollutant screening and verification sampling program, 15 toxic organics pollutants and 12 toxic metals were identified as being present at levels of 10 ug/l or greater in textile industry wastewaters. Nonconventional pollutants which were identified as being of concern included those previously regulated under BPT, and color which had been regulated under previously remanded BAT (See Section VI). In addition, EPA considered regulating TSS as an indicator of toxic pollutants during the development of the final rules. (See 44 FR 62204, October 29, 1979.)

From the control and treatment technologies previously discussed four technology options were identified for the evaluation of pollutant removal capability and calculation of costs. The four options were:

OPTION 1 - The current level of control based on biological treatment.

OPTION 2 - The level of control achievable by biological treatment (Option 1) plus the addition of multimedia filtration.

OPTION 3 - The level of control achievable by biological treatment (Option 1) plus the addition of chemical coagulation/ sedimentation.

OPTION 4 - The level of control achievable by biological treatment (Option 1) plus the addition of chemical coagulation/ sedimentation followed by multimedia filtration.

<u>Assessment of Treatment Capability</u> Options 2, 3 and 4 were based on the addition of end-of-pipe technology to treat further biologically treated effluent. The methodology for determining the capability of each technology option included identifying the effluent quality resulting from the application of biological treatment technology in each subcategory of the textile industry and then applying appropriate reductions associated with the technologies included in each treatment option.

Option 1 - Effluent characteristics for BOD5, COD, TSS and phenols in each subcategory were calculated as the product of long-term average effluent concentrations and wastewater flows for that subcategory. Effluent concentrations used were medians from each subcategory from a data base of 72 plants where biological treatment was employed.

The following criteria were used in the selection of the 72 plants to be included in the data base:

1. Biological treatment generally representative of the type that formed the basis of BPT is used.

2. Treatment system performance is characteristic of, although not necessarily achieving, BPT limitations.

3. Sufficient long-term data were available to reflect seasonal variability.

4. Overall response to the industry data request was accurately and conscientiously prepared.

5. Production and flow data were available.

This 72 plant data base is presented in Table VII-78. Table VII-79 presents the medians used for each subcategory. Because biological treatment data for mills meeting the above criteria in the hosiery products, nonwoven manufacturing and felted fabric processing subcategories is not available, concentrations were transferred from appropriate subcategories. As discussed above, and later in Section VIII, raw materials, production processes, and raw waste characteristics for these subcategories are similar to those from which the performance of biological treatment is transferred. In addition, raw waste concentrations of BOD5 and COD are equal to or less than those in the similar subcategories.

Wastewater flows used in the calculation are subcategory median flows for all the plants that submitted raw was data and are presented in Table V-11.

A similar approach was used for the development of effluent characteristics for the toxic metals total chromium, total copper and total zinc as well as total toxic metals and total toxic organics. Effluent concentrations utilized in the calculation of toxic pollutant discharge are presented in Table VII-80. The concentrations are average values rounded to the closest 10 ug/l, for the data collected during the toxic pollutant field sampling program. As presented in Tables VII-81 to VII-83, total toxic organics are the summation of all the detected toxic organics and total toxic metals are the summation of all the detected toxic metals.

TABLE VII-78
LONG-TERM AVERAGE EFFLUENT CONCENTRATIONS
72 SELECTED TREATMENT FACILITIES

Subcategory	Report No.	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	Total Phenols (ug/l)
1	10006	61	1443	166	-
1	10015	42	810	297	37
2	20005	24	-	49	-
2	20009	26	-	64	111
2	20011	26	212	61	45
2	20020*	12	183	23	76
2	20021	154	800	80	-
4a	40023	5	139	19	114
4a	40035	22	307	38	56
4a	40050	15	384	36	13
4a	40098	12	177	56	17
4a	40100	46	409	49	35
4a	40109	124	-	55	87
4a	40143	9	159	18	20
4b	40022	15	152	35	250
4b	40091	69	301	95	-
4b	40111	24	426	24	25
4b	40148	5	-	48	-
4b	40154	6	126	15	-
4b	40160	44	452	105	30
4c	40012	20	-	91	-
4c	40017	27	155	21	15
4c	40034	15	254	54	-
4c	40037	27	214	15	-
4c	40059	24	336	27	2
4c	40064	43	-	148	-
4c	40072	8	252	8	-
4c	40074	11	272	69	347
4c	40087	31	-	41	22
4c	40097	23	594	44	-
4c	40099	16	252	49	17
4c	40103	20	-	21	47
4c	40120	7	181	57	-
4c	40140	106	664	176	-
4c	40145	7	164	54	18
4c	40151	43	199	67	-
4c	40153	62	464	132	132

TABLE VII-78 (Cont.)

Subcategory	Report No.	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	Total Phenols (ug/l)
5a	50008	15	-	20	-
5a	50015	12	277	22	41
5a	50057	21	744	35	-
5a	50081	20	164	63	-
5a	50082	13	250	71	32
5a	50098	139	533	180	-
5a	50108	7	154	11	-
5a	50113	13	226	62	72
5a	50116	6	124	18	-
5b	50035	22	277	116	-
5b	50056	45	354	55	100
5b	50065*	63	491	52	15
5b	50099	12	174	26	83
5b	50123	6	145	27	-
5c	5H028	64	596	99	28
5c	5H029	106	592	107	21
6	60001*	21	133	25	84
6	60005	27	546	113	100
6	60013	54	311	57	80
6	60018	34	286	70	-
6	60021*	78	376	85	285
6	60034	30	227	50	128
6	60037	37	-	33	100
6	60039	38	274	91	370
7	70009	6	106	9	41
7	70031	6	124	27	186
7	70036	15	203	35	91
7	70075	8	146	36	-
7	70084	21	268	71	40
7	70087	22	148	24	56
7	70089	5	158	21	-
7	70096	29	204	24	-
7	70104	3	96	20	-
7	70106	7	119	10	-
7	70126	74	176	60	12

* Aerated Lagoon

Note: A dash indicates "no historical data available."

Source: EPA Industry Surveys, 1977 & 1980.

TABLE VII-79
MEDIAN LONG-TERM AVERAGE TREATED EFFLUENT CONCENTRATIONS

Subcategory	BOD5 (mg/l)	COD (mg/l)	TSS (mg/l)	Total Phenols (ug/l)
1. Wool Scouring	50	1,125	230	40
2. Wool Finishing	25	215	60	80
3. Low Water Use Processing				
a. General Processing	(No BAT Effluent Limitations)			
b. Water Jet Weaving	(No BAT Effluent Limitations)			
4. Woven Fabric Finishing				
a. Simple Processing	15	245	40	35
b. Complex Processing	20	300	40	30
c. Desizing	25	255	55	20
5. Knit Fabric Processing				
a. Simple Processing	15	240	35	40
b. Complex Processing	20	280	50	85
c. Hosiery Products	15*	240*	35*	40*
6. Carpet Finishing	35	285	65	100
7. Stock & Yarn Finishing	10	150	25	50
8. Nonwoven Manufacturing	35**	285**	65**	100**
9. Felted Fabric Processing	25#	215#	60#	80#

* Concentrations transferred from Knit Fabric Finishing - Simple Processing Subcategory.
** Concentrations transferred from Carpet Finishing Subcategory.
# Concentrations transferred from Wool Finishing Subcategory.

Note: All concentrations rounded to the nearest 5 units/liter.

Source: Table VII-78 and EPA Engineering Analysis.

TABLE VII-80
BIOLOGICAL TREATMENT EFFLUENT CONCENTRATIONS
AVERAGE OF FIELD SAMPLING DATA

Subcategory	Total Chromium (mg/l)	Total Copper (mg/l)	Concentration Total Zinc (mg/l)	Total Toxic Organics (mg/l)	Total Toxic Metals (mg/l)
1. Wool Scouring	0.040	0.080	0.300	0.260	2.150
2. Wool Finishing	0.360	0.020	2.320*	1.600	3.020
4. Woven Fabric Finishing					
a. Simple Processing	ND	0.090	0.250	0.190	0.450
b. Complex Processing	0.090	0.120	0.190	0.300	0.600
c. Desizing	ND	0.030	0.500	1.860	0.750
5. Knit Fabric Finishing					
a. Simple Processing	0.060	0.060	0.150	0.330	0.730
b. Complex Processing	0.030	0.040	0.610	0.920	1.320
c. Hosiery Products	0.200	0.010	0.110	0.590	0.420
6. Carpet Finishing	0.220	0.040	0.200	0.060	0.620
7. Stock & Yarn Finishing	0.070	0.090	0.340	0.230	0.810
8. Nonwoven Manufacturing	0.010	0.030	0.070	0.440	0.310
9. Felted Fabric Processing	0.035	ND	0.040	0.080	0.110

* Atypical maximum value of 38.4 mg/l was not included in the average.
# Values are for untreated wastewater since no biological treatment is performed.

Note: ND indicates "not detected."

Source: Field Sampling Program.

TABLE VII-81
SUMMARY OF POLLUTANT REMOVALS FOR ADD-ON COMPONENTS OF CONTROL OPTIONS
WOOL SCOURING MILLS

Technology	BOD5	COD	TSS	Total Phenols	Total Toxic Organics	Total Toxic Metals
Multimedia Filtration (MMF)	35	10	45	30*	50	NR
Chemical Coagulation (CC)	-	-	-	-	-	-
MMF After CC	-	-	-	-	-	-
CC + MMF After CC (CC + MMF)	-	-	-	-	-	-

* Value transferred from wool finishing data base.

Notes: 1. A dash indicates that no data are available to calculate a removal.
2. NR indicates "no removal."

Source: Table VII-50.

TABLE VII-82

SUMMARY OF POLLUTANT REMOVALS FOR ADD-ON COMPONENTS OF CONTROL OPTIONS

WOOL FINISHING MILLS

Technology	BOD_5	COD	TSS	Total Phenols	Total Toxic Organics	Total Toxic Metals
Multimedia Filtration (MMF)	55	30	80	30	55	50
Chemical Coagulation (CC)	70	70	70	25	60	15
MMF After CC	20	15	55	20	40	10
CC + MMF After CC (CC + MMF)*	75	75	85	40	75	40

* Removal for CC + MMF calculated by applying removal for MMF after CC to the percentage of each pollutant (parameter) remaining after CC, except for toxic organics and toxic metals.

Source: Tables VII-34, -35, -37, -49, -53, -54, -55, -56, -62, and Field Sampling Data for Mills BB and Q.

TABLE VII-83
SUMMARY OF POLLUTANT REMOVALS FOR ADD-ON COMPONENTS OF CONTROL OPTIONS
ALL OTHER MILLS

Technology	BOD5	COD	TSS	Total Phenols	Total Toxic Organics	Total Toxic Metals
Multimedia Filtration (MMF)	25	15	45	10	30	10
Chemical Coagulation (CC)	50	45	40	15	15	40
MMF After CC	20	20	65	25	30	NR
CC + MMF After CC (CC + MMF)*	60	55	80	35	50	40

* Removal for CC + MMF calculated by applying removal for MMF after CC to the percentage of each pollutant (parameter) remaining after CC, except for toxic organics and toxic metals.

Note: NR indicates "no removal."

Source: Tables VII-31, -32, -35, -36, -37, -45, -47, -49, -56, -57, -58, -59, -60, -61, -62, and Field Sampling Data for Mills BB and Q.

Options 2, 3 and 4 - Effluent quality for options 2, 3 and 4 were determined by applying appropriate percent removals from the biological treatment effluent quality determined to be representative of biological treatment in each subcategory.

Percent removals for each technology option are presented in Table VII-81 for wool scouring subcategory mills, Table VII-82 for wool finishing subcategory mills and in Table VII-83 for all other subcategories. The percent removals are median percent removals for mills in the EPA/Industry field studies. Percent removals for each mill and each technology are presented in Section VII. The detailed analysis is included in the record for this rulemaking.

Summary of BAT Effluent Quality - The long-term average effluent characteristics developed for each technology option in each subcategory are presented in Tables VII-84 and VII-85 for toxic, nonconventional and conventional pollutants. The design criteria for each technology option are presented in detail in Appendix-A, Cost of Treatment and Control Systems.

New Source Performance Standards (NSPS)

General

Section 306 of the Clean Water Act of 1977 requires that new source performance standards (NSPS) be established for industrial dischargers based on the best demonstrated technology. NSPS establish control of toxic, nonconventional and conventional pollutants. The same pollutants considered for control under BAT were considered for control under NSPS.

Control and treatment technologies that were considered include:

OPTION 1 - Biological treatment as demonstrated by best performing mills.

OPTION 2 - Multimedia filtration

OPTION 3 - Extended aeration activated sludge treatment (Option 1) followed by chemical coagulation/sedimentation and multimedia filtration.

Assessment of Treatment Capability The methodology and calculation of effluent characteristics for each of the NSPS control and treatment options is discussed below.

Option 1 - Long-term average effluent characteristics for BOD, COD, and TSS for option 1 were calculated as the median mass discharge of best performers in each subcategory. Using the 72 plant data base presented in Table X-2, best performers were identified as those where long-term average BOD_5, TSS and COD

TABLE VII-84

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 1 - BIOLOGICAL TREATMENT

Subcategory	BOD5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	Total Phenols (g/kkg)
1. Wool Scouring	0.59	13.16	2.70	0.47
2. Wool Finishing	7.61	65.45	18.26	24.35
3. Low Water Use Processing*				
a. General Processing	--	--	--	--
b. Water Jet Weaving	--	--	--	--
4. Woven Fabric Finishing				
a. Simple Processing	1.15	18.80	3.07	2.69
b. Complex Processing	1.95	29.28	3.90	2.93
c. Desizing	2.65	27.00	5.82	2.12
5. Knit Fabric Processing				
a. Simple Processing	1.76	28.22	4.12	4.70
b. Complex Processing	2.45	34.33	6.13	10.42
c. Hosiery Products	1.13	18.02	2.63	3.00
6. Carpet Finishing	1.63	13.31	3.04	4.67
7. Stock & Yarn Finishing	0.97	14.51	2.42	4.84
8. Nonwoven Manufacturing	1.40	11.40	2.60	4.00
9. Felted Fabric Processing	5.32	45.73	12.76	17.02

* BAT Options beyond BPT were not considered for low water use processing.

TABLE VII-84 (continued)

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 1 - BIOLOGICAL TREATMENT

Subcategory	Total Toxic Organics (g/kkg)	Total Toxic Metals (g/kkg)
1. Wool Scouring	3.05	25.24
2. Wool Finishing	487.04	919.29
4. Woven Fabric Finishing		
a. Simple Processing	14.58	34.53
b. Complex Processing	29.28	58.56
c. Desizing	196.97	79.43
5. Knit Fabric Processing		
a. Simple Processing	38.81	85.85
b. Complex Processing	112.79	161.83
c. Hosiery Products	44.31	31.54
6. Carpet Finishing	2.80	28.95
7. Stock & Yarn Finishing	22.24	78.33
8. Nonwoven Manufacturing	17.60	12.40
9. Felted Fabric Processing	17.02	23.40

TABLE VII-85

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 2 - BIOLOGICAL TREATMENT PLUS
MULTIMEDIA FILTRATION

Subcategory	BOD5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	Total Phenols (g/kkg)
1. Wool Scouring	0.38	11.85	1.49	0.33
2. Wool Finishing	3.43	45.81	3.65	17.08
3. Low Water Use Processing*				
a. General Processing	--	--	--	--
b. Water Jet Weaving	--	--	--	--
4. Woven Fabric Finishing				
a. Simple Processing	0.86	15.98	1.69	2.42
b. Complex Processing	1.46	24.89	2.15	2.64
c. Desizing	1.98	22.95	3.20	1.91
5. Knit Fabric Processing				
a. Simple Processing	1.32	23.99	2.26	4.23
b. Complex Processing	1.84	29.18	3.37	9.38
c. Hosiery Products	1.13	18.02	2.63	3.00
6. Carpet Finishing	1.23	11.31	1.67	4.20
7. Stock & Yarn Finishing	0.73	12.33	1.33	4.36
8. Nonwoven Manufacturing	1.05	9.69	1.43	3.60
9. Felted Fabric Processing	3.99	38.87	7.02	15.30

* BAT Options beyond BPT were not considered for low water use processing.

TABLE VII-85 (continued)

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 2 - BIOLOGICAL TREATMENT PLUS
MULTIMEDIA FILTRATION

Subcategory	Total Toxic Organics (g/kkg)	Total Toxic Metals (g/kkg)
1. Wool Scouring	1.53	25.0
2. Wool Finishing	21.92	45.95
4. Woven Fabric Finishing		
a. Simple Processing	10.22	31.05
b. Complex Processing	20.51	52.74
c. Desizing	137.90	71.10
5. Knit Fabric Processing		
a. Simple Processing	27.16	77.22
b. Complex Processing	78.95	145.65
c. Hosiery Products		
6. Carpet Finishing	1.96	26.06
7. Stock & Yarn Finishing	15.57	70.50
8. Nonwoven Manufacturing	12.32	11.16
9. Felted Fabric Processing	11.91	21.05

effluent discharges were less than the maximum 30-day average BPT effluent limitations for these parameters. The best performers are identified and the median subcategory long-term averages used as the basis for NSPS are presented in Table X-3. As discussed in Section VIII, insufficient data are available on the performance of biological treatment in the new nonwoven manufacturing and felted fabric processing subcategories. Long-term averages for these subcategories were, therefore, based on flow-adjusted long-term averages for the carpet finishing and wool finishing subcategories for the reasons presented in Section VIII. Similarly, as described in Section X, in the knit fabric finishing subcategory performance levels for the hosiery products subdivision have been transferred from the simple processing operations subdivision.

Options 2, and 3 - NSPS Options 2 and 3 are identical to BAT options 2 and 4. The methodology and development of effluent characteristics are presented above under BAT.

Summary of NSPS Effluent Characteristics - The long-term average effluent characteristics developed for each subcategory and each technology option are presented in Table VII-86 for conventional and nonconventional pollutants and in Table VII-87 for toxic pollutants. Design details and costs for each technology option are presented in Appendix-A, Cost of Treatment and Control Systems.

Pretreatment Standards for Existing and New Sources (PSES and PSNS)

General

The Clean Water Act requires that pretreatment standards prevent the discharge of pollutants which pass through, interfere with or are otherwise incompatible with the operation of POTWs. The Act also requires pretreatment for pollutants that limit sludge management alternatives at POTWs, including the beneficial use of sludges on agricultural lands.

Three toxic pollutants, total chromium, total copper and total zinc that can pass through POTWs or could cause sludge disposal problems have been identified in textile industry wastewaters. Two pretreatment options were considered for control of these toxic metals. They were:

OPTION 1 - Screening, equalization and/or neutralization as required to meet General Pretreatment Regulations.

OPTION 2 - Screening, equalization and/or neutralization (Option 1) plus chemical coagulation/precipitation.

TABLE VII-86

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 3 - BIOLOGICAL TREATMENT PLUS
CHEMICAL COAGULATION

Subcategory	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	Total Phenols (g/kkg)
1. Wool Scouring**	--	--	--	--
2. Wool Finishing	2.28	19.64	5.48	18.30
3. Low Water Use Processing*				
a. General Processing	--	--	--	--
b. Water Jet Weaving	--	--	--	--
4. Woven Fabric Finishing				
a. Simple Processing	0.58	10.34	1.84	2.29
b. Complex Processing	0.98	16.10	2.34	2.49
c. Desizing	1.33	14.85	3.49	1.80
5. Knit Fabric Processing				
a. Simple Processing	0.88	15.52	2.47	3.99
b. Complex Processing	1.23	18.88	3.68	8.86
c. Hosiery Products	0.56	9.91	1.58	2.55
6. Carpet Finishing	0.82	7.32	1.82	3.97
7. Stock & Yarn Finishing	0.48	7.98	1.45	4.11
8. Nonwoven Manufacturing	0.70	6.27	1.56	3.40
9. Felted Fabric Processing	2.66	24.69	7.66	14.46

* BAT Options beyond BPT were not considered for low water use processing.

** Chemical coagulation was not considered for wool scouring.

TABLE VII-86 (continued)

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 3 - BIOLOGICAL TREATMENT PLUS
CHEMICAL COAGULATION

Subcategory	Total Toxic Organics (g/kkg)	Total Toxic Metals (g/kkg)
1. Wool Scouring	--	--
2. Wool Finishing	194.80	781.20
4. Woven Fabric Finishing		
a. Simple Processing	12.41	20.70
b. Complex Processing	24.91	35.16
c. Desizing	167.45	47.40
5. Knit Fabric Processing		
a. Simple Processing	32.98	51.48
b. Complex Processing	95.87	97.10
c. Hosiery Products	37.66	18.92
6. Carpet Finishing	2.38	17.37
7. Stock & Yarn Finishing	18.90	47.00
8. Nonwoven Manufacturing	14.96	7.44
9. Felted Fabric Processing	14.46	14.04

TABLE VII-87

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 4 - BIOLOGICAL TREATMENT PLUS
CHEMICAL COAGULATION PLUS
MULTIMEDIA FILTRATION

Subcategory	BOD5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	Total Phenols (g/kkg)
1. Wool Scouring**	--	--	--	--
2. Wool Finishing	1.90	16.36	2.74	14.64
3. Low Water Use Processing*				
a. General Processing	--	--	--	--
b. Water Jet Weaving	--	--	--	--
4. Woven Fabric Finishing				
a. Simple Processing	0.46	8.46	0.61	1.75
b. Complex Processing	0.78	13.18	0.78	1.90
c. Desizing	1.06	12.15	1.16	1.38
5. Knit Fabric Processing				
a. Simple Processing	0.71	12.70	0.82	3.06
b. Complex Processing	0.98	15.45	1.23	6.77
c. Hosiery Products	0.45	8.11	0.53	1.95
6. Carpet Finishing	0.65	5.99	0.61	3.04
7. Stock & Yarn Finishing	0.39	6.53	0.48	3.15
8. Nonwoven Manufacturing	0.55	5.13	0.52	2.60
9. Felted Fabric Processing	2.13	20.58	2.55	11.06

* BAT Options beyond BPT were not considered for low water use processing.

** Option 4 not considered for wool scouring.

TABLE VII-87 (continued)

LONG-TERM AVERAGE EFFLUENT CHARACTERISTICS
OPTION 4 - BIOLOGICAL TREATMENT PLUS
CHEMICAL COAGULATION PLUS
MULTIMEDIA FILTRATION

Subcategory	Total Toxic Organics (g/kkg)	Total Toxic Metals (g/kkg)
1. Wool Scouring	--	--
2. Wool Finishing	121.80	551.40
4. Woven Fabric Finishing		
a. Simple Processing	7.30	20.70
b. Complex Processing	14.65	35.16
c. Desizing	98.50	47.40
5. Knit Fabric Processing		
a. Simple Processing	19.40	51.48
b. Complex Processing	56.40	97.10
c. Hosiery Products	22.15	18.92
6. Carpet Finishing	14.01	17.37
7. Stock & Yarn Finishing	11.12	47.00
8. Nonwoven Manufacturing	8.80	7.44
9. Felted Fabric Processing	8.51	14.04

Assessment of Treatment Capability - Under option 1 no specific limitations for toxic or nonconventional pollutants are developed beyond requirements of the General Pretreatment Regulations found at 40 CFR Part 403 (43 FR 27736, June 26, 1978; 46 FR 9462, January 28, 1981).

Final effluent characteristics resulting from the application of Option 2 were developed based on effluent concentrations determined to be representative of the application of lime settling technology in treating metals in the electroplating industry (88). These studies have demonstrated that the technology can achieve 30-day average concentrations of 0.8 mg/l for copper and 0.7 mg/l for chromium and zinc. Achievable maximum day concentrations are 2.0 mg/l for copper, 1.8 mg/l for chromium and 1.5 mg/l for zinc. Effluent limitations for each subcategory were then calculated as the product of these concentrations and median subcategory wastewater flows. PSES and PSNS effluent characteristics for Option 2 are presented in Table VII-88.

TABLE VII-88
PSES and PSNS - OPTION 2
CHEMICAL COAGULATION/PRECIPITATION
EFFLUENT CHARACTERISTICS*

	Average of 30 days Maximum			Maximum Day		
	Total Copper	Total Chromium	Total Zinc	Total Copper	Total Chromium	Total Zinc
1. Wool Scouring	9.4	8.2	8.2	23.4	21.1	17.6
2. Wool Finishing	243.5	213.1	213.1	608.8	547.9	456.6
3. Woven Fabric Finishing						
a. Simple Processing	61.4	53.7	53.7	153.4	138.1	115.1
b. Complex Processing	78.1	68.3	68.3	195.2	175.7	146.4
c. Desizing	84.7	74.1	74.1	211.8	190.6	158.9
4. Knit Fabric Finishing						
a. Simple Processing	94.1	82.3	82.3	235.2	211.7	176.4
b. Complex Processing	98.1	85.8	85.8	245.2	220.7	183.9
c. Hosiery Products	60.1	52.6	52.6	150.2	135.2	112.7
5. Carpet Finishing	37.4	32.7	32.7	93.4	84.1	70.1
6. Stock and Yarn Finishing	77.4	67.7	67.7	193.4	174.1	145.1
7. Nonwoven Manufacturing	32.0	28.0	28.0	80.0	72.0	60.0
8. Felted Fabric Processing	170.2	148.9	148.9	425.4	382.9	319.1

*Effluent characteristics in g of pollutant per kkg of product.

SECTION VIII

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

GENERAL

The best practicable control technology currently available (BPT) generally is based on the average of the best existing performance, in terms of treated effluent discharged, by plants of various sizes, ages and unit processes within an industry or subcategory. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. Limitations based on transfer of technology must be supported by a conclusion that the technology is, indeed, transferable and a reasonable prediction that it will be capable of achieving the prescribed effluent limits (see Tanners' Council of America v. Train, 540 F. 2d 1188 (4th Cir. 1976)). BPT focuses on end-of-pipe treatment technology rather than process changes or internal controls, except where such changes or controls are common industry practice.

BPT considers the total cost of the application of technology in relation to the effluent reduction benefits to be achieved from the technologies. The cost/benefit inquiry for BPT is a limited balancing, which does not require the Agency to quantify benefits in monetary terms (see, e.g., American Iron and Steel Institute v. EPA, 526 F.2d 1027 (3rd Cir. 1975)). In balancing costs in relation to effluent reduction benefits, EPA considers the volume and nature of existing discharges, the volume and nature of discharges after application of BPT, the general environmental effects of the pollutants and the costs and economic impacts of the required pollution control level. The Act does not require or permit consideration of water quality problems attributable to particular point sources or industries, or water quality improvements in particular water bodies (see Weyerhaeuser Company v. Costle, 590 F.2d 1101 (D.C. Cir. 1978)).

REGULATED POLLUTANTS

Pollutants regulated under BPT are BOD_5, TSS and pH (conventional pollutants), and COD (a nonconventional pollutant) for the water jet weaving subdivision of the low water use processing subcategory, the nonwoven manufacturing subcategory and the felted fabric processing subcategory. In addition, the nonconventional pollutants sulfide and phenols and the toxic pollutant total chromium are regulated in the nonwoven manufacturing and felted fabric processing subcategories.

IDENTIFICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

BPT for the water jet weaving subdivision of the low water use processing subcategory, the nonwoven manufacturing subcategory and the felted fabric processing subcategory has been identified as biological treatment, which is the same technology on which BPT limitations are based for all other subcategories of the textile industry.

BPT EFFLUENT LIMITATIONS

BPT effluent limitations are presented in Table VIII-1.

RATIONALE FOR THE SELECTION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

As discussed in Section IV, the Agency has identified two new subcategories (nonwoven manufacturing and felted fabric processing) and one new subdivision of an existing subcategory (water jet weaving in the low water use processing subcategory) of the textile mills point source category. The Clean Water Act requires the establishment of BCT limitations for industry subcategories from which conventional pollutants are discharged. In order to develop BCT limitations, a base level BPT determination is necessary because the "cost-reasonableness test," required as part of the BCT determination, rests on the incremental cost of removal of BOD_5 and TSS from BPT to BCT. Therefore, to aid in development of BCT limitations and to provide uniform national BPT effluent limitations for all segments of the textile industry, the Agency is establishing BPT effluent limitations for the nonwoven manufacturing subcategory, the felted fabric processing subcategory and the water jet weaving subdivision of the low water use processing subcategory.

EPA did not specifically propose BPT effluent limitations for the two new subcategories or the new subdivision; the Agency did propose BAT limitations and provided information on the pollutant removal effectiveness of biological treatment and multimedia filtration of biologically-treated effluents. Public comments on the proposed BAT limitations predominantly favored establishing BAT limitations based on the performance of biological treatment alone. As discussed in Section IX, EPA is establishing BAT effluent limitations for the textile industry based on the performance of biological treatment. Therefore, the technology basis of BPT and BAT effluent limitations for the nonwoven manufacturing and the felted fabric processing subcategory and for the water jet weaving subdivision of the low water use processing subcategory are identical.

TABLE VIII-1
BPT EFFLUENT LIMITATIONS*

Conventional Pollutants

Subcategory	Maximum for any one day BOD5	Maximum for any one day TSS	Average of daily values for 30 consecutive days BOD5	Average of daily values for 30 consecutive days TSS
Low Water Use Processing Water Jet Weaving	8.9	5.5	4.6	2.5
Nonwoven Manufacturing	4.4	6.2	2.2	3.1
Felted Fabric Processing	35.2	55.4	17.6	27.7

pH shall be within the range 6.0 to 9.0 at all times.

Toxic and Nonconventional Pollutants

Subcategory	Maximum for any one day COD	Sulfide	Phenols	Total Chromium	Average of daily values for 30 consecutive days COD	Sulfide	Phenols	Total Chromium
Low Water Use Processing Water Jet Weaving	21.3	--	--	--	13.7	--	--	--
Nonwoven Manufacturing	40.0	0.046	0.023	0.023	20.0	0.023	0.011	0.011
Felted Fabric Processing	256.8	0.44	0.22	0.22	128.4	0.22	0.11	0.11

* Expressed as kg pollutant/kkg of product (lb/1000 lb)

METHODOLOGY USED FOR DEVELOPMENT OF BPT LIMITATIONS

Water Jet Weaving Subdivision

The water jet weaving process is a recent technological development. In fact, sufficient data on which effluent limitations and standards can be based are available from only two mills. At both of these mills, biological treatment is employed. EPA is establishing BPT limitations equal to the average performance levels achieved at these two mills.

Long-term average effluent discharges for the pollutants BOD_5, TSS and COD were calculated based on treatment performance at these two mills. Maximum 30-day and maximum day effluent limitations were then calculated by multiplying long-term average effluent limitations by the variability factors determined through statistical analysis of individual conventional pollutant data. The statistical analysis is described in detail in Section X. The data on which BPT effluent limitations are based is presented in Table VIII-2.

Nonwoven Manufacturing and Felted Fabric Processing

Sufficient data on the performance of biological treatment is not available for these new subcategories. BPT effluent limitations, therefore, are based on the transfer of performance of biological treatment from subcategories with similar raw wastes.

Raw material usage and production processes are similar in (a) the nonwoven manufacturing and carpet finishing subcategories and (b) the felted fabric processing and the wool finishing subcategories. In addition, raw waste characteristics of wastewaters discharged from mills in the nonwoven manufacturing subcategory and the felted fabric processing subcategory are similar to those discharged from mills in the carpet finishing and wool finishing subcategories, respectively. (As shown on Table VIII-3, BOD_5 and COD raw waste concentrations in the nonwoven manufacturing and felted fabric processing subcategories are equal to or lower than BOD_5 and COD concentrations in the subcategories to which they are compared.)

BPT limitations were calculated as the product of median flows for the new subcategories and BPT final effluent concentrations for the subcategory used as the basis for technology transfer. The computation of BPT limitations is presented in Table VIII-4.

In making the decision to base BPT effluent limitations for these two new subcategories on the performance of technology in two existing subcategories, the Agency determined that biological treatment is clearly available and could be employed at the mills in the nonwoven manufacturing and felted fabric processing subcategories. The BPT limitations are based on the ability of biological treatment to remove the same pollutants from

TABLE VIII-2

CALCULATION OF BPT LIMITATIONS*
Water Jet Weaving Subdivision

	Long Term Average			Effluent Limitation**	
Pollutant	Mill G3114	Mill G3117	Average	Maximum	Average of 30 days maximum
BOD_5	3.54	1.91	2.72	8.9	4.6
COD	8.94	9.14	9.04	21.3	13.7
TSS	1.86	0.97	1.42	5.5	2.5

* Expressed as kg pollutant/kkg (lb pollutant/1000 lb of product)

** Effluent limitations are the product of the subcategory long-term average and the variability factors developed in Section X.

TABLE VIII-3

COMPARISON OF RAW WASTE LOADS

Felted Fabric Processing and Nonwoven Manufacturing Subcategories

Subcategory	FLOW 1/kg	BOD_5 kg/kkg	BOD_5 mg/l	COD kg/kkg	COD mg/l	TSS kg/kkg	TSS mg/l
Wool Finishing	135.0	63.6	471	204.8	1517	54.0	400
Felted Fabric Processing	212.7	70.2	330	186.0	874	301.4	1417
Carpet Finishing	70.0	25.6	366	82.3	1176	4.7	67
Nonwoven Manufacturing	40.0	6.7	168	38.4	960	2.2	55

Notes:

1. Raw waste loads in kg/kkg and flow for felted fabric processing and nonwoven manufacturing are median subcategory values from historical data base.

2. Flows for wool finishing and carpet finishing are flows upon which BPT was based.

3. Concentrations shown are calculated from mass discharge and flows presented.

TABLE VIII-4

CALCULATION OF BPT LIMITATIONS
Felted Fabric Processing and Nonwoven Manufacturing Subcategories

Subcategory	BOD_5	COD	TSS	Sulfide	Phenols	Chromium
	Maximum of 30-Day Average					
Wool Finishing	11.2	81.5	17.6	0.14	0.07	0.07
Felted Fabric	17.6	128.4	27.7	0.22	0.11	0.11
Carpet Finishing	3.9	35.1	5.5	0.04	0.02	0.02
Nonwoven Manufacturing	2.2	20.0	3.1	0.023	0.011	0.011

NOTE: 1. Felted fabric limitation is equal to (Wool Finishing Limitation)(Felted Fabric Flow/Wool Finishing Flow). In this case, Felted Fabric Limitation = Wool Finishing Limitation)(212.7/135)

Similarly, Nonwoven Manufacturing Limitation = (Carpet Finishing Limitation)(40.0/70.0)

2. Maximum day limitations are equal to two times the Maximum 30-Day Average.

wastewaters discharged from mills in the carpet finishing and wool finishing subcategories and, when applied at mills in these two subcategories, is capable of attaining the limitations presented in Table VIII-4.

COST OF APPLICATION AND EFFLUENT REDUCTION BENEFITS

The total costs (4th quarter 1979) of attainment of the BPT effluent limitations, assuming biological treatment must be installed at all mills in the two new subcategories and the new subdivision, have been estimated to be about $2.6 million dollars in capital costs with an associated total annual cost of about $1.4 million dollars per year. Five nonwoven mills, three water jet weaving mills and one felted fabric processing mill are direct dischargers.

Conventional pollutant removals from raw waste discharges from the two new subcategories and the new subdivision have been estimated to be 173 thousand kg/yr (381 thousand lbs/yr) of BOD_5 and 43 thousand kg/yr (94 thousand lbs/yr) of TSS. These represent removals of 81 percent of the BOD_5 and 56 percent of the TSS present in raw wastes discharged from mills in the two new subcategories and the new subdivision. Removal costs are about $6.48 per kg ($2.95 per lb) of conventional pollutant removed.

NONWATER QUALITY ENVIRONMENTAL IMPACTS

Energy

Attainment of BPT at mills in the two new subcategories and the new subdivision will require the use of the equivalent of 668 thousand liters (4200 barrels) of residual fuel oil per year, a 1.6 percent increase over estimated current total industry energy usage for wastewater treatment.

Solid Waste

Attainment of BPT at mills in the two new subcategories and the new subdivision will result in an additional 282 kkg/yr (311 tons/yr) of wastewater treatment solids. This represents a 0.7 percent increase in current total industry biological treatment solids generation.

Air and Noise

Attainment of BPT at mills in the two new subcategories and the new subdivision will have no measurable impact on air or noise pollution.

SECTION IX

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE EFFLUENT LIMITATIONS GUIDELINES

GENERAL

As a result of the Clean Water Act of 1977, the achievement of BAT has become the principal national means of controlling wastewater discharges of toxic pollutants. The factors considered in establishing the best available technology economically achievable (BAT) level of control include the costs of applying the control technology, the age of process equipment and facilities, the process employed, process changes, the engineering aspects of applying various types of control technologies and nonwater quality environmental considerations such as energy consumption, solid waste generation and air pollution (Section 304(b)(2)(B)). In general, the BAT technology level represents, at a minimum, the best economically-achievable performance of plants of shared characteristics. Where existing performance is uniformly inadequate, BAT technology may be transferred from a different subcategory or industrial category. BAT may include process changes or internal controls, even when not common industry practice.

The statutory assessment of BAT "considers" costs, but does not require a balancing of costs against effluent reduction benefits (see Weyerhaeuser v. Costle, 590 F.2d 1101 (D.C. Cir. 1978)). In assessing the proposed BAT, EPA has given substantial weight to the reasonableness of costs. The Agency has considered the volume and the nature of discharges, the volume and nature of discharge expected after application of BAT, the general environmental effects of the pollutants and the costs and economic impacts of the required pollution control levels. Despite this expanded consideration of costs, the primary determinant of BAT is effluent reduction capability using economically-achievable technology.

PRIOR REGULATIONS

EPA promulgated BPT and BAT limitations, NSPS and PSNS for the textile mills point source category on July 5, 1974 (39 FR 24736; 40 CFR Part 410, Subparts A-G). Pollutants regulated under BAT included the conventional pollutants BOD_5, TSS, fecal coliform and pH for all subcategories and oil and grease for the wool scouring subcategory. Nonconventional pollutants regulated included COD, total pehnols, sulfide and color in all subcategories except low water use processing (formerly dry processing), where only COD was regulated. The toxic pollutant total chromium was regulated in all subcategories except low water use processing. The technology bases for the BAT regulations included biological treatment, multimedia filtration, chemical coagulation and chlorination with variations in the respective subcategories.

Industry representatives challenged these regulations in the Fourth Circuit Court of Appeals. In response to a joint motion of petitioners and EPA to hold the case in abeyance while EPA reconsidered the BAT limitations, the Court remanded all the regulations except BPT to EPA for reconsideration. In the joint motion, petitioners withdrew their challenge to the BPT limitations and those limitations are, therefore, in effect. As a result of the Court Order, the Agency and the American Textile Manufacturers Institute (ATMI) began a joint study to collect information and data necessary to reconsider the BAT, NSPS and PSNS regulations.

As a result of the court ordered review as well as the revisions to the Clean Water Act making BAT the principal national means of controlling toxic pollutant discharges, the Agency has reassessed BAT. BAT regulations presented in this document supersede prior BAT regulations.

REGULATED POLLUTANTS

One toxic pollutant, total chromium, and three nonconventional pollutants (chemical oxygen demand (COD), sulfide and total phenols (as measured by the procedures listed in 40 CFR Part 136)) are regulated in all subcategories except the low water use processing subcategory where only COD is regulated.

IDENTIFICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

BAT limitations for toxic and nonconventional pollutants are equal to previously promulgated BPT limitations. The technology basis for BAT is, therefore, the same as the technology basis of BPT and includes preliminary screening, primary settling (wool scouring only), latex coagulation (carpet finishing and low water use processing - general processing only) and biological treatment.

BAT EFFLUENT LIMITATIONS

BAT effluent limitations are presented in Table IX-1. Allowances for manufacturing operations and fiber type are presented in Table IX-2.

RATIONALE FOR THE SELECTION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

In October of 1979, EPA published proposed BAT effluent limitations based on biological treatment followed by multimedia filtration, except in the case of the wool scouring and the wool

TABLE IX-1

BAT EFFLUENT LIMITATIONS*

Subcategory	Maximum for any one day COD	Sulfide	Phenols	Total Chromium	Average of daily values for 30 consecutive days COD	Sulfide	Phenols	Total Chromium
Wool Scouring**	138.0	0.20	0.10	0.10	69.0	0.10	0.05	0.05
Wool Finishing**	163.0	0.28	0.14	0.14	81.5	0.14	0.07	0.07
Low Water Use Processing								
General Processing	2.8	-	-	-	1.4	-	-	-
Water Jet Weaving	21.3	-	-	-	13.7	-	-	-
Woven Fabric Finishing**	60.0	0.20	0.10	0.10	30.0	0.10	0.05	0.05
Knit Fabric Finishing**	60.0	0.20	0.10	0.10	30.0	0.10	0.05	0.05
Carpet Finishing	70.2	0.08	0.04	0.04	35.1	0.04	0.02	0.02
Stock and Yarn Finishing	84.6	0.24	0.12	0.12	42.3	0.12	0.06	0.06
Nonwoven Manufacturing	40.0	0.046	0.023	0.023	20.0	0.023	0.011	0.011
Felted Fabric Processing	256.0	0.44	0.22	0.22	128.4	0.22	0.11	0.11

* Expressed as kg pollutant/kkg of product (lb/1000 lb) except for wool scouring, which is expressed as kg pollutant/kkg of wool processed and wool finishing which is expressed as kg pollutant/kkg of fiber processed.

** For commission finishers, an additional allocation of 100% of the limitations is allowed.

TABLE IX-2

BAT ALLOWANCES*

CHEMICAL OXYGEN DEMAND (COD)

	Maximum for any one day	Average of daily values for 30 consecutive days
Simple Manufacturing Operations employing a synthetic fiber or complex manufacturing operations employing a natural fiber.		
Woven Fabric Finishing	20.0	10.0
Simple Manufacturing Operations employing a natural and synthetic fiber blend or complex manufacturing operations employing a synthetic fiber.		
Woven Fabric Finishing	40.0	20.0
Knit Fabric Finishing	20.0	10.0
Complex manufacturing Operations employing a natural and synthetic fiber blend.		
Woven Fabric Finishing	60.0	30.0
Knit Fabric Finishing	40.0	20.0
Complex Manufacturing Operations		
Carpet Finishing	20.0	10.0

* Quantities of pollutant which may be discharged by a point source in addition to the BAT limitations in Table IX-1.

finishing subcategories and the hosiery subdivision of the knit fabric finishing subcategory where limitations were based on biological treatment, chemical coagulation and dissolved air flotation and in the case of the felted fabric processing subcategory where limitations were based on biological treatment. The proposed BAT effluent limitations would have controlled three toxic pollutants (total chromium, total copper and total zinc). Three nonconventional pollutants would have been controlled (chemical oxygen demand (COD), total phenols (as measured by the procedure listed in 40 CFR Part 136, Standard Methods) and color (as measured by the method developed by the American Dye Manufacturers Institute (ADMI) and described in the proceedings of the 28th Industrial Waste Conference, Purdue University)). One conventional pollutant (total suspended solids (TSS)) was proposed as an indicator for the control of toxic organic pollutants discharged from textile mills.

Comments received on the proposed regulations questioned the need for controls more stringent than existing BPT for these pollutants. The commenters stated that the level of control proposed for existing mills was too costly in relation to the effluent reduction benefits.

After proposal, EPA completed an analysis of all available data to determine the quantity of pollutants discharged by this industry, the treatability of pollutants present in BPT effluents, the cost per pound of pollutant removed by the proposed BAT technology and the economic impact that would result from the implementation of proposed BAT limitations.

EPA determined that the amount of toxic pollutants being discharged from the textile industry when BPT limitations are attained is less than 3.2 kg (7 lbs) per day per plant and that the total industry discharge is about 209 kkg (230 tons) per year. The total chromium being discharged is less than 1.2 kg (2.7 lbs) per day per plant. The Agency calculated that attainment of proposed BAT would result in costs of over $346 per pound equivalent of total toxics removed. [A pound equivalent is calculated by multiplying the number of pounds of pollutant discharged by a weighting factor for that pollutant. The weighting factor is equal to the water quality criterion for a standard pollutant, copper, divided by the water quality criterion for the pollutant being evaluated.] This cost is significantly higher than for other industries for which BAT limitations have been established (e.g., iron and steel, inorganic chemicals). EPA has been unable to identify any reasonable, less costly, technology option. In addition, EPA has estimated that attainment of proposed BAT limitations might cause the closure of nine mills and the unemployment of some 1800 workers. The Agency found that these closures might affect the local communities in which the mills are located because of the unavailability of alternative employment.

The proposed BAT limitations were aimed at controlling 15 organic toxic pollutants and 12 toxic metals. All the other toxic pollutants were excluded from regulation under Paragraph 8 of the modified Settlement Agreement (44 FR 62218; October 29, 1979). After proposal, EPA compared the concentrations of these 27 toxic pollutants present in textile industry wastewaters to the lowest concentration of each pollutant that can reasonably be achieved by the application of known technologies. (These lowest achievable concentrations have also been called "lowest theoretical treatability levels.") EPA also determined the degree and frequency that these lowest concentrations are exceeded (see Section VI). The Agency found that of the 27 toxic pollutants of interest, 17 pollutants were found above lowest theoretical treatability levels in the raw waste only in a few isolated instances, 6 pollutants were found above lowest theoretical treatability levels in treated effluents only in a few isolated instances, 2 pollutants were detected at only a small number of sources and are uniquely related to those sources and 1 pollutant was not detectable with the use of state-of-the-art analytical methods because it is a common laboratory contaminant. The remaining pollutant, total chromium, is controlled by existing BPT effluent limitations. Establishment of BAT as proposed would result in only an estimated 10 percent reduction in the discharge of chromium (i.e., only 0.14 kg (0.3 pounds) per day per plant) at an estimated capital cost of $41 million. The costs of additional removal of chromium and the potential economic impact do not justify further control.

In reviewing all available data and information, EPA found that (1) the amounts of toxic pollutants discharged at the BPT level of control are generally low, (2) the removal costs at the proposed BAT level of control are relatively high when compared to other industries, (3) toxic pollutants are found above lowest theoretical treatability levels in only isolated instances, and (4) attainment of proposed BAT limitations might result in the closure of nine mills and the loss of 1800 jobs. Based on these findings, the Agency has determined that more stringent regulation of toxic pollutant discharges from the textile industry is not justified and that BAT effluent limitations should be established equal to BPT limitations. The Agency recently completed an environmental assessment in which we compared the predicted in-stream concentrations of toxic pollutants found in textile discharges after attainment of BPT and after attainment of proposed BAT effluent limitations with EPA's ambient water quality criteria. This analysis confirms the Agency's decision not to control toxics beyond a BPT level.

The Agency recognizes that the quantity of toxic pollutants discharged from individual mills may, in some cases, be higher than the industry average and may not be insignificant when viewed as a single point source discharge. As explained in Section VI, several toxic pollutants have been found above minimum treatability levels in a few isolated instances. These include 1,2,4-trichlorobenzene, 2,4,6-trichlorophenol, toluene and tetrachloroethylene used as dye carriers and napthalene, pentachlorophenol and ethylbenzene used in the synthesis of dyes. Permit-issuing authorities may find it necessary to require representatives of individual mills to provide information on toxic pollutant usage, to analyze for specific toxic pollutants, and/or to conduct bioassay testing prior to issuing a NPDES permit. Permit-issuing authorities may limit specific pollutants on a case-by-case basis when limitations are necessary to carry out the purposes of the Act, even if the pollutant is not controlled by BAT limitations.

EPA has also decided that the nonconventional pollutant color should be controlled on a case-by-case basis as dictated by water quality considerations, rather than through establishing uniform national standards. Color, in many instances, is an aesthetic pollutant, although in some instances color can interfere with sunlight transmission and the process of photosynthesis in the aquatic environment. Color is a mill-specific problem related to the combination of dyes and finishing chemicals used.

In addition, the Agency has found that the quantity of the nonconventional pollutants sulfide and total phenols now discharged by the textile industry are adequately controlled by existing BPT limits. Accordingly, more stringent BAT limitations are not needed. This is because of several factors including (a) substitution of sulfur dyes, (b) use of nonphenolic dye carriers and preservatives and (c) the effectiveness of biological treatment in removing these pollutants. EPA has not identified a technology option that is more effective than current industry practices. Therefore, EPA is promulgating BAT limitations equal to existing BPT limitations for sulfides and total phenols.

Furthermore, EPA has determined that it is not appropriate to establish more stringent COD limitations. Biological treatment is capable of removing on the order of 70 percent of the COD raw waste load typical of this industry. The technology on which proposed BAT limitations were based is relatively ineffective in reducing COD. (The application of multimedia filtration in addition to biological treatment increases COD removal to only about 75 percent.) The application of other technologies considered during development of the proposed rules (e.g., multimedia filtration plus granular activated carbon, or chemical coagulation, sedimentation, multimedia filtration plus granular activated carbon) can be very effective in reducing COD discharges. However, these technologies have total annual costs as much as three to six times that of the proposed BAT. EPA predicts that nine mills might close if required to attain proposed BAT limitations. In addition, if more advanced technology were required, as many as 12 to 27 mills might close. Because the costs of application of more advanced technologies to control COD are high in relation to the effluent reduction benefits and because of a potential for adverse economic impact, the Agency has determined that COD should continue to be controlled at the BPT level.

For the reasons discussed above, EPA is establishing BAT limitations for toxic and nonconventional pollutants equal to the previously promulgated BPT limitations (for the seven subcategories established in the 1974 regulations) or equal to the BPT limitations developed in Section VIII (for the two new subcategories and for the water jet weaving subdivision of the low water use processing subcategory). We expect that Federal and State permitting authorities will establish toxic and nonconventional pollutant limitations more stringent than the existing BPT, where needed, to account for unusual manufacturing or treatment circumstances or to achieve or maintain the receiving water quality.

NONWATER QUALITY IMPACTS

As BAT effluent limitations are equal to BPT effluent limitations, there are no incremental nonwater quality impacts associated with attainment of BAT effluent limitations.

SECTION X

NEW SOURCE PERFORMANCE STANDARDS

GENERAL

The basis for new source performance standards (NSPS) under section 306 of the Act is the best available demonstrated technology. At new plants, the opportunity exists to design the best and most efficient production processes and wastewater treatment facilities, so Congress directed EPA to consider the best demonstrated process changes, in-plant controls and end-of-pipe treatment technologies that reduce pollution to the maximum extent feasible.

PRIOR REGULATIONS

NSPS for the textile mills point source category were promulgated on July 5, 1974 (39 FR 24736; 40 CFR Part 410, Subparts A-G). The original NSPS established limitations for: conventional pollutants (BOD5, total suspended solids (TSS), fecal coliform and pH for all subcategories and oil and grease for the wool scouring subcategory), one toxic pollutant (total chromium) and three nonconventional pollutants (COD, total phenols and sulfide (as measured by the procedures listed in 40 CFR Part 136)). The technology basis for NSPS was biological treatment followed by multimedia filtration (except for the carpet finishing subcategory where NSPS were based on biological treatment plus chemical coagulation). However, in 1974 the Agency concluded that at most new mills, NSPS could be attained by applying in-plant controls and biological treatment.

Industry representatives challenged these regulations in the Fourth Circuit Court of Appeals. In response to a joint motion of petitioners and EPA to hold the case in abeyance while EPA reconsidered the BAT limitations, the Court remanded all the regulations except BPT to EPA for reconsideration. In the joint motion, petitioners withdrew their challenge to the BPT limitations and those limitations are, therefore, in effect. As a result of the Court Order, the Agency and the American Textile Manufacturers Institute (ATMI) began a joint study to collect information and data necessary to reconsider the BAT, NSPS and PSNS regulations.

As a result of the court ordered review as well as the revisions to the Clean Water Act, the Agency has completely reassessed NSPS. The standards presented in this document supersede NSPS contained in the 1974 regulation.

REGULATED POLLUTANTS

Pollutants regulated under NSPS include three conventional pollutants, BOD_5, TSS and pH; one toxic pollutant, total chromium; and three nonconventional pollutants, COD, total phenols and sulfide.

IDENTIFICATION OF THE TECHNOLOGY BASIS OF NSPS

The technology basis for NSPS in all nine subcategories is biological treatment as demonstrated by the best performing biological treatment systems now employed in the textile industry. As discussed in Section IV, NSPS are established for separate subdivisions of the woven fabric finishing subcategory (simple, complex and desizing operations) and the knit fabric finishing subcategory (simple, complex and hosiery operations), taking into account actual wastewater treatment performance at mills in each subcategory.

NSPS EFFLUENT LIMITATIONS

NSPS effluent limitations are presented in Table X-1.

RATIONALE FOR THE SELECTION OF NSPS

As explained previously, the regulations promulgated in 1974 were challenged by industry. In January of 1975, all of the regulations except BPT were remanded to EPA for reconsideration. After further study, EPA proposed revised NSPS for nine subcategories (44 FR 62204, October 29, 1979). The proposed standards, with one exception, were based on the performance of biological treatment followed by chemical coagulation and multimedia filtration. In the low water use processing subcategory, proposed standards were based on the performance of biological treatment only. NSPS, as proposed, would have established controls on BOD_5, COD, TSS, total phenol, total chromium, total copper, total zinc, color and pH.

Comments received on the proposed regulation questioned the need for controls more stringent than proposed BAT, which were generally based on the application of biological treatment plus the addition of multimedia filtration (see Section IX). Subsequent to proposal, the Agency evaluated all available information and determined that biological treatment provides adequate control of the discharge of toxic pollutants and results in a significant reduction of nonconventional and conventional pollutants. Application of biological treatment at new sources will not change the rate of entry into the industry or slow the industry growth rate. Therefore, the Administrator selected biological treatment as the technology basis of NSPS. Promulgated NSPS for BOD_5, COD and TSS are more stringent than BPT/BAT effluent limitations. Specific standards are generally

TABLE X-1
NEW SOURCE PERFORMANCE STANDARDS*
CONVENTIONAL POLLUTANTS**

Subcategory	Maximum for any one day		Average of daily values for 30 consecutive days	
	BOD5	TSS	BOD5	TSS
Wool Scouring	3.6	30.3	1.9	13.5
Wool Finishing	10.7	32.3	5.5	14.4
Low Water Use Processing				
General Processing	1.4	1.4	0.7	0.7
Water Jet Weaving	8.9	5.5	4.6	2.5
Woven Fabric Finishing				
Simple Operations	3.3	8.8	1.7	3.9
Complex Operations	3.7	14.4	1.9	6.4
Desizing	5.5	15.6	2.8	6.9
Knit Fabric Finishing				
Simple Operations	3.6	13.2	1.9	5.9
Complex Operations	4.8	12.2	2.5	5.4
Hosiery Products	2.3	8.4	1.2	3.7
Carpet Finishing	4.6	8.6	2.4	3.8
Stock and Yarn Finishing	3.6	9.8	1.9	4.4
Nonwoven Manufacturing	2.6	4.9	1.4	2.2
Felted Fabric Processing	16.9	50.9	8.7	22.7

* Expressed as kg pollutant/kkg of product (lb/1000 lb) except for wool scouring which is expressed as kg pollutant/kkg of wool processed and wool finishing which is expressed as kg pollutant/kkg of fiber processed.

** For all subcategories, pH within the range 6.0 to 9.0 at all times.

TABLE X-1 (cont'd)
NEW SOURCE PERFORMANCE STANDARDS*

TOXIC AND NONCONVENTIONAL POLLUTANTS

Subcategory	Maximum for any one day: COD	Maximum for any one day: Sulfide	Maximum for any one day: Phenols	Maximum for any one day: Total Chromium	Average of daily values for 30 consecutive days: COD	Average of daily values for 30 consecutive days: Sulfide	Average of daily values for 30 consecutive days: Phenols	Average of daily values for 30 consecutive days: Total Chromium
Wool Scouring	52.4	0.20	0.10	0.10	33.7	0.10	0.05	0.05
Wool Finishing	113.8	0.28	0.14	0.14	73.3	0.14	0.07	0.07
Low Water Use Processing								
General Processing	2.8	-	-	-	1.4	-	-	-
Water Jet Weaving	21.3	-	-	-	13.7	-	-	-
Woven Fabric Finishing								
Simple Operations	41.7	0.20	0.10	0.10	26.9	0.10	0.05	0.05
Complex Operations	68.7	0.20	0.10	0.10	44.2	0.10	0.05	0.05
Desizing	59.5	0.20	0.10	0.10	38.3	0.10	0.05	0.05
Knit Fabric Finishing								
Simple Operations	48.1	0.20	0.10	0.10	31.0	0.10	0.05	0.05
Complex Operations	51.0	0.20	0.10	0.10	32.9	0.10	0.05	0.05
Hosiery Products	30.7	0.20	0.10	0.10	19.8	0.10	0.05	0.05
Carpet Finishing	26.6	0.08	0.12	0.04	17.1	0.04	0.06	0.02
Stock and Yarn Finishing	33.9	0.24	0.12	0.12	21.9	0.12	0.06	0.06
Nonwoven Manufacturing	15.2	0.046	0.023	0.023	9.8	0.023	0.011	0.011
Felted Fabric Manufacturing	179.3	0.20	0.10	0.22	115.5	0.10	0.05	0.05

* Expressed as kg pollutant/kkg of product (lb/1000 lb) except for wool scouring which is based on kg/kkg of wool processed and wool finishing which is based on kg/kkg of processed fiber.

based on the median discharge levels attained at existing best performers in each subcategory of the textile industry. Exceptions occur (a) in the nonwoven manufacturing and the felted fabric processsing subcategories where, for the reasons discussed in Section VIII, NSPS are based on transfer of technology from the carpet finishing and wool finishing subcategories, respectively, and (b) for the hosiery products subdivision of the knit fabric finishing subcategory where, for the reasons discussed below, NSPS are based on transfer of technology from the simple manufacturing operations subdivision of the knit fabric finishing subcategory. The promulgated NSPS level of control represents the best demonstrated performance of existing biological treatment systems in this industry.

EPA has also decided that the nonconventional pollutant color should be controlled on a case-by-case basis as dictated by water quality considerations, rather than through establishing uniform national standards. Color, in many instances, is an aesthetic pollutant, although in some instances color can interfere with sunlight transmission and the process of photosynthesis in the aquatic environment. Color is a mill-specific problem related to the combination of dyes and finishing chemicals used.

In addition, the Agency has found that the quantity of the nonconventional pollutants sulfide and total phenols now discharged by the textile industry are adequately controlled by existing BPT limits. Accordingly, more stringent NSPS are not needed. This is because of several factors including (a) substitution of sulfur dyes, (b) use of nonphenolic dye carriers and preservatives and (c) the effectiveness of biological treatment in removing these pollutants. EPA has not identified a technology option that is more effective than current industry practices. Therefore, EPA is promulgating NSPS equal to existing BPT limitations for sulfides and total phenols.

METHODOLOGY USED FOR DEVELOPMENT OF NSPS

NSPS were calculated as the product of (a) long-term average discharge levels of each specific pollutant and (b) an appropriate variability factor for each specific pollutant.

Data Base

The data base used for the development of NSPS includes 72 mills where biological treatment is in-place that is representative of the best practicable control technology currently available. The following criteria were used in the selection of the 72 plants to be included in the data base:

1. Biological treatment generally representative of the type that formed the basis of BPT is used.

2. Treatment system performance is characteristic of, although not necessarily achieving, BPT limitations.

3. Sufficient long-term data were available to reflect seasonal variability.

4. Overall response to the industry data request was accurately and conscientiously prepared.

5. Production and flow data were available.

Long-term average BOD_5, TSS and COD discharges per unit of production for the 72 plant data base are presented in Table X-2.

Calculation of Subcategory Long-Term Average Discharge Levels

Best performers were identified as those where long-term average BOD_5, TSS and COD effluent discharges were less than the maximum 30-day average BPT effluent limitations for each parameter. For each subcategory, the median long-term average BOD_5, TSS and COD characteristic of the best performing mills forms the basis of NSPS limitations for these parameters. The best performers are identified and the median subcategory long-term averages used as the basis of NSPS are presented in Table X-3.

As discussed previously, insufficient data are available on the performance of biological treatment in the new nonwoven manufacturing and felted fabric processing subcategories. Long-term averages for these subcategories were, therefore, based on flow-adjusted long-term averages for the carpet finishing and wool finishing subcategories for the reasons presented in Section VIII.

In addition, no best performing mills have been identified in the hosiery products subdivision of the knit fabric finishing subcategory. Therefore, as explained in the Notice of Availability of Additional Information (46 FR 8590, January 27, 1981), long-term average biological treatment performance levels for the hosiery products subdivision are based on transfer of technology from the simple processing subdivision of the knit fabric finishing subcategory. This transfer is justifed because (a) manufacturing operations, raw material usage, and wastewater characteristics are similar at mills in both subdivisions, (b) biological treatment is available and can be employed at new sources in the hosiery products subdivision, and (c) biological treatment, when applied at new hosiery mills, is capable of attaining the long-term average performance levels presented in Table X-3.

Effluent Variability Analysis

Pollutant quantities discharged from a wastewater treatment system vary. This variability is accounted for in deriving

TABLE X-2

LONG TERM AVERAGE EFFLUENT DISCHARGE
BIOLOGICAL TREATMENT (72 PLANT) DATA BASE

Subcategory/Plant No.	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	Best Performer
Wool Scouring				
10006	0.40	8.93	1.00	X
10015	1.82	35.58	14.56	X
BPT Max. 30 day limit	5.30	69.0	16.10	
Wool Finishing				
20005	10.39	-	20.64	
20009	3.28	-	8.30	X
20011	6.43	52.13	14.10	X
20020	2.93	44.33	5.47	X
20021	50.5	104.7	27.5	
BPT Max. 30 day limit	11.2	81.5	17.6	
Woven Fabric (Simple Processing)				
40023	0.36	7.63	1.38	X
40035	5.05	71.71	8.95	
40050	1.84	45.99	4.43	
40098	2.59	36.22	11.26	
40100	3.44	31.02	3.92	
40109	18.77	-	8.60	
40143	1.01	17.67	2.27	X
BPT Max. 30 day limit	3.3	30.0	8.9	
Woven Fabric (Complex Processing)				
40022	4.05	42.47	10.11	
40091	5.30	23.79	7.55	
40111	3.19	55.88	3.20	X
40148	.54	-	4.83	X
40154	1.14	29.06	3.70	X
40160	5.03	44.42	11.42	
BPT Max. 30 day limit	3.3	60.0	8.9	

TABLE X-2 (continued)

LONG TERM AVERAGE EFFLUENT DISCHARGE
BIOLOGICAL TREATMENT (72 PLANT) DATA BASE

Subcategory/Plant No.	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	Best Performer
Woven Fabric (Desizing)				
40012	1.17	-	5.43	X
40017	.87	4.69	.65	X
40034	1.75	30.12	6.43	X
40037	3.17	25.17	1.84	X
40059	3.02	41.61	3.40	X
40064	3.01	-	10.62	
40072	.73	21.73	.71	X
40074	2.31	58.92	15.14	
40087	1.87	-	2.54	X
40097	.76	21.53	1.59	X
40099	2.14	32.99	6.52	X
40103	1.61	-	1.73	X
40120	.51	14.67	4.56	X
40140	4.66	29.40	7.66	
40145	1.12	25.48	8.65	X
40151	3.13	14.48	4.91	X
40153	9.76	69.36	19.38	
BPT Max. 30 day limit	3.3	60.0	8.9	
Knit Fabric (Simple Processing)				
50008	2.45	-	3.24	X
50015	2.67	64.02	5.22	
50057	2.02	71.94	3.29	
50081	.89	8.68	3.53	X
50082	1.52	28.58	8.28	X
50098	9.68	37.61	12.68	
50108	.87	20.40	1.56	X
50113	1.30	22.45	6.21	X
50116	.42	9.13	1.32	X
BPT Max. 30 day limit	2.5	30.0	10.9	
Knit Fabric (Complex Processing)				
50035	3.31	40.45	17.17	
50056	8.31	68.26	11.60	
50065	7.46	58.00	6.19	
50099	1.47	21.62	3.13	X
50123	.14	3.31	.66	X
BPT Max. 30 day limit	2.5	70.0	8.9	

TABLE X-2 (continued)

LONG TERM AVERAGE EFFLUENT DISCHARGE
BIOLOGICAL TREATMENT (72 PLANT) DATA BASE

Subcategory/Plant No.	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)	Best Performer
Knit Fabric (Hosiery Products)				
5H028	2.47	23.43	3.94	X
5H029	6.62	37.09	6.70	
BPT Max. 30 day limit	2.5	70.0	8.9	
Carpet Manufacturing				
60001	.98	6.41	.81	X
60005	1.01	19.06	3.85	X
60013	1.45	8.72	1.58	X
60018	1.37	11.27	2.80	X
60021	5.58	26.02	6.10	
60034	1.84	15.31	3.42	X
60037	1.73	-	1.64	X
60039	4.77	33.71	10.93	
BPT Max. 30 day limit	3.9	35.1	5.5	
Stock and Yarn Finishing				
70009	.94	17.24	1.56	X
70031	.57	11.24	2.43	X
70036	3.31	42.94	7.24	
70075	.55	10.17	2.61	X
70084	1.85	23.85	6.42	X
70087	1.27	8.34	1.43	X
70089	1.85	55.31	7.60	
70096	1.75	11.53	1.44	X
70104	.71	21.15	4.36	X
70106	.23	4.99	.34	X
70126	10.13	24.21	8.28	
BPT Max. 30 day limit	3.4	42.3	8.7	

TABLE X-3

CALCULATION OF NSPS LONG-TERM AVERAGE

Mill	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)
Wool Scouring			
10006	0.40	8.9	1.0
10015	1.82	35.6	14.56
MEDIAN	1.11	22.2	7.8
Wool Finishing			
20011	6.43	52.13	14.10
20009	3.28	-	8.30
20020	2.93	44.33	5.47
MEDIAN	3.28	48.23	8.30
Woven Fabric Finishing (Simple)			
40143	1.01	17.67	2.27
MEDIAN	1.01	17.67	2.27
Woven Fabric Finishing (Complex)			
40148	0.54	-	4.83
40154	1.14	29.1	3.70
MEDIAN	0.84	29.1	4.30
Woven Fabric Finishing (Desizing)			
40120	0.51	14.67	4.56
40012	1.17	-	5.43
40072	0.73	21.73	0.71
40097	0.76	21.53	1.59
40037	3.17	25.17	1.84
40151	3.13	14.48	4.91
40145	1.12	25.48	8.66
40099	2.14	32.99	6.52
40103	1.61	-	1.73
40034	1.75	30.12	6.43
40059	3.02	41.61	3.40
40087	1.87	-	2.54
MEDIAN	1.68	25.2	4.00

TABLE X-3 (continued)

CALCULATION OF NSPS LONG-TERM AVERAGE

Mill	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)
Knit Fabric (Simple)			
50008	2.45	-	3.24
50081	0.69	8.68	3.53
50108	0.87	20.40	1.56
50116	0.42	9.13	1.32
50082	1.52	28.58	8.28
50113	1.30	22.45	6.21
MEDIAN	1.10	20.4	3.4
Knit Fabric (Complex)			
50099	1.47	21.62	3.13
MEDIAN	1.47	21.62	3.13

Knit Fabric (Hosiery)

Due to insufficient data to apply the general methodology hosiery numbers were based on the simple processing group adjusted for flow (simple x 75.1/117/6).

Annual Ave.	0.69	13.0	2.16
Carpet Manufacturing			
60018	1.37	11.27	2.80
60005	1.01	19.06	3.85
60013	1.45	8.72	1.58
60037	1.73	-	1.64
60001	0.98	6.41	0.81
60034	1.84	15.31	3.42
MEDIAN	1.41	11.27	2.22

TABLE X-3 (continued)

CALCULATION OF NSPS LONG-TERM AVERAGE

Mill	BOD_5 (kg/kkg)	COD (kg/kkg)	TSS (kg/kkg)
Stock and Yarn Finishing			
70087	1.27	8.34	1.43
70096	1.75	11.53	1.44
70104	0.71	21.15	4.36
70009	0.94	17.24	1.56
70075	0.55	10.17	2.61
70031	0.57	11.27	2.43
70036	3.31	42.94	7.24
70084	1.85	23.85	6.42
MEDIAN	1.10	14.38	2.52

Non Woven Manufacturing

As in proposal the wastewater characteristics are taken from Carpet Mills adjusted for flow: (Carpet Mills) (40.0/46.7)

Annual Ave.	1.21	9.68	1.90

Felted Fabric Processing

As in proposal the wastewater characteristics are taken from Wool Finishing adjusted for flow: (Wool Finishing) (212.7/304.4)

Annual Ave.	2.66	34.4	6.00

limitations regulating the amount of pollutants that may be discharged by individual plants in the textile industry. The statistical procedures employed in analyzing variability for the conventional pollutants, BOD5 and TSS, and for the nonconventional pollutant COD are described below.

Effluent Limitations Guidelines An effluent limitation is an upper bound on the amount of pollutant discharge allowed per day or the average amount of pollutant discharge allowed for a period of 30 days. The limitations are generally determined by calculating the product of two numbers which may be derived from effluent data: one is referred to as a variability factor and the other as a long-term average. Two types of variability factors are derived for the guidelines: a daily maximum factor and a 30-day maximum factor. The daily factor is the ratio of (a) a value that would be exceeded rarely by the daily pollutant discharge to (b) the long-term average daily discharge. The 30-day factor is the ratio of (a) a value that would be exceeded rarely by the average of 30 daily discharge measurements to (b) the long-term average daily discharge. The long-term average daily discharge quantity is an expression of the long-run performance of the treatment process. Given a daily maximum variability factor for a pollutant (denoted by VF) and a plant-specific long-term average for the same pollutant (denoted by LTA), the plant-specific daily limitation is the product of the variability factor and the long-term average (VF x LTA). Similarly, given a 30-day maximum variability factor (VF_{30}), a plant specific limit for the average of 30 daily observations is VF_{30} x LTA.

Data Base The data base for the calculation of effluent variability included data for 39 of the 72 mills included in the total data base. These data were obtained in the initial industry surveys and a subsequent data request for long-term daily data sent to representatives of ten facilities.

Variability Factors Both daily maximum and maximum 30-day average variability factors were determined that are representative of the variation in treatment system performance in treating textile industry BOD5, TSS and COD discharges.

Daily Maximum Variability Factors - - Daily maximum variability factors were derived from daily effluent measurements for each of the three pollutants. Goodness-of-fit tests were performed to determine whether the data could be assumed to follow either a normal or lognormal distribution. [If data are assumed to follow either of these distributional forms, convenient estimation techniques associated with distribution theory may be applied in order to estimate variability factors.] The overall results of the goodness-of-fit tests are somewhat inconclusive in the sense that the data are not consistently normal or lognormal. This is not surprising because the small sample sizes available for some of the mills substantially reduce the probability of correctly rejecting the hypothesis under consideration. With sufficiently large numbers of observations, variability factors and limitations may be determined without making assumptions about the functional form of the underlying distribution of the data. However, because of the small sample sizes, conventional distribution-free (or nonparametric) techniques were not appropriate in this case.

The lognormal distribution was assumed for the underlying distribution of the data because plots of the empirical distribution function suggest that daily pollutant measurements are described reasonably well by the lognormal distribution. Daily maximum variability factors for BOD_5, COD and TSS at all mills in the data base are presented in Table X-4. Average and median variability factors for all mills in the data base are also shown in Table X-4. Various alternatives present reasonable possibilities for determining daily maximum variability factors to be used in establishing NSPS for this industry.

It is reasonable to expect that at new mills, personnel will be able to control effluent variability at least as well as the best 25 percent of the mills for which sufficient data are available to determine effluent variability. Overall industry variability factors were, therefore, based on the 25th percentile of individual mill values presented in Table X-4.

<u>30-Day Maximum Variability Factors</u> - - Thirty-day maximum variability factors were calculated using a modification of the Central Limit Theorem. This theorem states that the distribution of sample means of size "n" drawn from any one of a large class of different distributional forms will be approximately normally distributed. The normal distribution provides a good approximation of the distribution of the sample mean for samples as small as 25 or 30 data points (13). Sample sizes of at least 150 data points yield five successive 30-day averages and represent a reasonable minimum number of averages from which to assess the distributional form of the sample mean.

The mill-specific 30-day averages were found to fit the normal distribution on the basis of the Lilliefors goodness-of-fit test. The sample mean (X_{30}) and standard deviation (S_{30}) of each set of successive 30-day averages were computed. The 99th percentiles were estimated as $X_{30} + 2.33\ S_{30}$. The resulting maximum 30-day average variability factor is expressed as:

$$VF_{30} = \frac{X_{30} + 2.33\ S_{30}}{X}$$

TABLE X-4

MAXIMUM DAY VARIABILITY FACTORS
LOGNORMAL DATA DISTRIBUTION

	BOD		TSS		COD	
Mill Number	Number of Data Points	Maximum Day	Number of Data Points	Maximum Day	Number of Data Points	Maximum Day
10006	46	7.021	47	5.781	46	4.360
10015	93	5.428	95	6.360	95	4.661
20009	4	4.425	4	2.258	0	-
20020	46	5.492	45	4.532	46	2.871
20021	182	4.652	192	4.818	1	-
40091	15	3.805	8	4.185	15	1.600
40098	192	3.825	192	3.789	192	3.693
40099	172	3.354	173	4.010	-	-
40100	234	4.809	234	4.842	234	3.345
40140	-	-	19	1.850	19	1.810
40143	-	-	13	6.073	16	2.368
40151	8	3.942	8	5.421	8	3.570
40154	221	3.799	52	7.065	77	4.377
40160	135	2.194	140	4.257	136	2.338
50008	157	2.017	157	4.448	-	-
50015	-	-	-	-	12	1.789
50035	181	4.017	185	5.062	185	2.912
50056	140	3.298	142	5.221	95	2.370
50057	34	4.927	56	5.072	11	3.254
50065	117	3.909	115	6.719	125	2.490
50081	49	5.749	49	6.464	47	4.769
50082	173	4.122	174	4.751	174	3.336
50098	67	3.835	56	3.993	69	3.500
50099	9	2.928	4	1.685	9	2.761
50116	-	-	18	4.822	18	1.844
50123	52	1.718	52	2.292	14	1.981
5H028	24	11.253	24	8.393	24	2.723
5H029	16	2.865	13	3.098	-	-
60001	14	4.016	3	4.719	3	4.526
60018	29	4.505	29	4.315	29	3.312
60021	24	3.535	24	4.309	24	1.914
70075	16	4.708	16	5.088	16	2.567
70084	153	3.640	154	3.703	154	3.235
70087	105	4.223	105	4.577	105	3.237
70089	12	1.463	12	5.108	12	3.169
70009	51	2.870	51	2.931	51	1.381
70031	48	3.328	50	4.112	49	2.291
70106	175	3.188	180	4.094	3	2.760
70126	17	5.881	17	2.142	17	2.517
MEAN		4.14		4.54		2.93
MEDIAN		3.94		4.55		2.82
25 percentile		3.27		3.89		2.36

where X denotes the long-term mill-specific average. Table X-5 presents the maximum 30-day average variability factors for each mill for which sufficient BOD_5, TSS and COD data were available. EPA tested this method to see if it would yield a reasonable approximation of the maximum 30-day average discharge likely to occur at an individual mill. The Agency found that 100 percent of the individual 30-day averages were less than the predicted maximum 30-day average for each mill. Based on this analysis, EPA concluded that this was a reasonable method of estimating maximum 30-day average variability factors.

Maximum 30-day average variability factors for BOD_5, COD and TSS could be determined for only five to ten facilities. Because of the limited data available, the Agency based final maximum 30-day average NSPS on median maximum 30-day average variability factors, rather than 25th percentile values. Median variability factors are shown in Table X-5.

COST OF APPLICATION AND EFFLUENT REDUCTION BENEFITS

The cost of attainment of NSPS varies by subcategory as discussed in detail in Appendix A. Substantial reductions of BOD_5, COD, TSS, phenols, sulfide and total chromium will result upon attainment of NSPS at new direct discharging textile mills.

NONWATER QUALITY IMPACTS

Energy costs and the cost of disposal of solid wastes have been included in the costs of NSPS. As the technology basis for NSPS is the same as for BPT, there will be no significant impact over the energy required and solid waste generated to achieve BPT. Attainment of NSPS will have no measurable impact on noise or air pollution.

TABLE X-5

MAXIMUM 30-DAY AVERAGE VARIABILITY FACTORS FOR BOD, TSS, AND COD

Plant Number	Maximum 30-Day Average Variability Factors(a) BOD5	TSS	COD
020021	2.01 (182)	1.88 (192)	(b)
040098	1.71 (192)	1.42 (192)	1.52 (192)
004099	1.63 (174)	1.35 (173)	(b)
040100	2.49 (234)	2.39 (234)	1.67 (234)
040154	2.03 (221)	(b)	(b)
050008	1.57 (157)	1.88 (157)	(b)
050035	1.66 (181)	2.29 (185)	1.47 (185)
050082	1.51 (173)	1.35 (174)	1.38 (174)
070084	1.89 (153)	1.54 (154)	1.77 (154)
070106	1.60 (175)	1.73 (180)	(b)
Minimum Variability Factor	1.51	1.35	1.35
Maximum Variability Factor	2.49	2.39	1.77
Median Variability Factor	1.69	1.73	1.52

(a) Number of daily data points given in parentheses.
(b) Insufficient daily data for analysis, or daily data not available.

SECTION XI

PRETREATMENT STANDARDS FOR EXISTING AND NEW SOURCES

GENERAL

Section 307 (b) of the Clean Water Act of 1977 requires EPA to promulgate pretreatment standards for existing sources (PSES) that must be achieved within three years of promulgation and section 307(c) of the Act requires EPA to promulgate pretreatment standards for new sources (PSNS) at the same time that 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 control measures and end-of-pipe treatment.

Pretreatment standards for existing and new sources are designed to control the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of a publicly owned treatment works (POTW). The Clean Water Act of 1977 requires pretreatment for pollutants that pass through the POTWs in amounts that would violate direct discharger effluent limitations or interfere with the POTW's treatment process or chosen sludge disposal method. The legislative history of the 1977 Act indicates that pretreatment standards are to be technology-based, analogous to the best available technology. EPA has generally determined that there is pass through of pollutants if the percent of pollutants removed by a well-operated POTW achieving secondary treatment is less than the percent removed by the BAT model treatment system. The general pretreatment regulations, which served as the framework for the categorical pretreatment regulations, are found at 40 CFR Part 403.

PRIOR REGULATION

PSNS were promulgated on July 5, 1974 (39 FR 24739) and were equal to the standard set forth in 40 CFR Part 128 with the exception that pretreatment standards for incompatible pollutants would be equal to NSPS. Industry representatives challenged these regulations in the Fourth Circuit Court of Appeals. In response to a joint motion of petitioners and EPA to hold the case in abeyance while EPA reconsidered the BAT limitations, the Court remanded all the regulations except BPT to EPA for reconsideration. Subsequently, in a joint motion, petitioners withdrew their challenge to the BPT limitations and those limitations are, therefore, in effect. As a result of the Court Order, the Agency and the American Textile Manufacturers

Institute (ATMI) began a joint study to collect information and data necessary to reconsider the BAT, NSPS and PSNS regulations.

PSES were promulgated on May 26, 1977 (42 FR 26983) establishing general pretreatment requirements (no specific pollutants were limited) that included the elements of what later became the General Pretreatment Regulations, now included in 40 CFR Part 403.

As a result of the court ordered review as well as the revisions to the Clean Water Act, the Agency has reassessed PSES and PSNS. The standards presented in this document supersede the previously published PSES and PSNS.

REGULATED POLLUTANTS

Categorical pretreatment standards are not being established for new or existing sources; therefore, no specific pollutants are regulated.

IDENTIFICATION OF PRETREATMENT STANDARDS FOR EXISTING AND NEW SOURCES

PSES and PSNS for the textile mills point source category shall be the General Pretreatment Regulations found at 40 CFR Part 403 (43 FR 27736, June 26, 1978).

RATIONALE FOR THE SELECTION OF PRETREATMENT STANDARDS FOR EXISTING AND NEW SOURCES

As discussed previously, industry challenged the PSNS promulgated in 1974 and the regulation was remanded to the Agency for reconsideration. PSES, establishing general pretreatment requirements (no specific pollutants were limited), were promulgated in 1977 (42 FR 26983; May 26, 1977). Revised PSNS and PSES were proposed in 1979 (see 44 FR 62204, October 29, 1979). The proposed pretreatment standards would have established controls on total chromium, total copper and total zinc.

Commenters argued that pollutants discharged by the textile industry do not interfere with or pass through POTWs. Following proposal, the Agency reviewed available information and determined that textile wastewaters are susceptible to treatment in and do not interfere with the operation of POTWs. Comparison of metal removal efficiencies at 20 POTWs and at textile industry biological treatment systems shows that POTW removal of copper, chromium and zinc is equal to or better than removal in industry biological treatment systems. Therefore, these pollutants do not pass through POTWs.

Accordingly, under the authority of Paragraph 8(b)(i) of the modified Settlement Agreement, this regulation does not establish categorical pretreatment standards for the textile industry. The textile industry will, however, remain subject to the General Pretreatment Regulations. Section VII includes information on the capability of various technologies applicable to controlling textile industry discharges to POTWs. We expect that operators of POTWs will be able to control the discharge of specific pollutants, if required, on a case-by-case basis and could make use of the information contained herein.

COST OF APPLICATION

As no specific pollutants are regulated under PSES and PSNS, there are no costs associated with this regulation.

NONWATER QUALITY IMPACTS

As no specific pollutants are regulated under PSES and PSNS, there are no nonwater quality impacts associated with this regulation.

SECTION XII

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SECTION XIII

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SECTION XIV

GLOSSARY

<u>Animal Hair Fibers</u>

Fibers obtained from animals for purposes of weaving, knitting, or felting into fabric; some animal fibers are alpaca, angora goat hair, camel hair, cashmere, cow hair, extract wool, fur, horse hair, llama, mohair, mungo, noil, shoddy, silk, vicuna, and wool.

<u>Anti-static Agents</u>

Functional finishes applied to fabric to overcome deleterious effects of static electricity. Compounds commonly used are PVA, styrene-base resins, polyalkylene glycols, gelatine, PAA, and polyvinyl acetate.

<u>Batch Processing</u>

Operations which require loading of discrete amounts of material, running the process to completion, and then removing the material. This is in contrast to continuous processing in which material in rope or open width form runs without interruption through one or more processes, obviating the need for loading and unloading.

<u>Best Available Technology Economically Achievable (BAT)</u>

Level of technology applicable to effluent limitations to be achieved by July 1, 1984, for industrial discharges to surface waters as defined by Section 301 (b) (2) of the Federal Water Pollution Control Act, As Amended.

<u>Best Practicable Control Technology Currently Available (BPT)</u>

The level of technology applicable to effluent limitations to be achieved by July 1, 1977, for industrial discharges to surface waters as defined by Section 301 (b) (1) (A) of the Federal Water Pollution Control Act, As Amended.

<u>Complex Processing</u>

Woven or knit fabric finishing operations that may consist of fiber preparation, scouring, functional finishing, and bleaching, dyeing, or printing.

<u>Consent Decree</u>

The Settlement Agreement entered into by EPA with the Natural Resources Defense Council and other environmental groups and approved by the U.S. District Court for the District of Columbia on June 7, 1976. One of the principal provisions of the Settlement Agreement was to direct EPA to consider an extended list of 65 classes of pollutants in 21 industrial categories, including Textile Mills, in the development of effluent limitations guidelines and new source performance standards.

Conventional Pollutants

Constituents of wastewater as determined by Section 304 (a) (4) of the Clean Water Act of 1977, including but not limited to, pollutants classified as biological oxygen demanding, suspended solids, fecal coliform, and pH.

Direct Discharger

An industrial discharger that introduces wastewater to a receiving body of water or land, with or without treatment by the discharger.

Effluent Limitation

A maximum amount per unit of production (or other unit) of each specific constituent of the effluent that is subject to limitation from an existing point source.

End-of-Pipe Technologies

Treatment processes used to remove or alter the objectionable constituents of the spent water from manufacturing operations.

Environmental Protection Agency - Sewage Treatment Plant (EPA-STP)

A sewage treatment plant construction cost index originating in 1957 with a base cost index of 100.

Environmental Protection Agency - Small City Conventional Treatment (EPA-SCCT)

A sewage treatment plant construction cost index originating in the 3rd Quarter, 1973, and based on a cost index of 100 for St. Joseph, Missouri.

Federal Water Pollution Control Act Amendments of 1972

Public Law 92-500 which provides the legal authority for current EPA water pollution abatement projects, regulations, and policies. The Federal Water Pollution Control Act was amended further in 1977 in legislation referred to as The Clean Water Act.

Functional Finish Chemicals

Substances applied to fabric to provide desirable properties such as wrinkle-resistance, water-repellency, flame-resistance, etc.

Greige Mills

Facilities which manufacture unfinished woven or knit goods (greige goods) for finishing at other locations. If process wastewater is generated, it is usually small in quantity.

Indirect Discharger

An industrial discharger that introduces wastewater to a publicly-owned collection system.

In-plant Control Technologies

Controls or measures applied within the manufacturing process to reduce or eliminate pollutant and hydraulic loadings of raw wastewater. Typical inplant control measures include chemical substitution, material reclamation, water reuse, water reduction, and process changes.

Internal Subcategorization

Divisions within a subcategory to group facilities that, while producing related products from similar raw materials, have differing raw waste characteristics due to the complexity of manufacturing processes employed.

Low-Water-Use Processing Mills

Establishments primarily engaged in manufacturing greige goods, laminating or coating fabrics, texturizing yarn, producing tire cord fabric, and similar activities in which cleanup is the primary water use or process water requirements are small.

National Pollutant Discharge Elimination System (NPDES)

A Federal program requiring industry and municipalities to obtain permits to discharge plant effluents to the nation's water courses.

New Source

Industrial facilities from which there is, or may be, a discharge of pollutants, and whose construction is commenced after the publication of the proposed regulations.

Non-Conventional Pollutants

Parameters selected for use in developing effluent limitation guidelines and new source performance standards which have not been previously designated as either conventional pollutants or priority pollutants.

Non-Water Quality Environmental Impact

Deleterious aspects of control and treatment technologies applicable to point source category wastes, including, but not limited to, air pollution, noise, radiation, sludge and solid waste generation, and energy usage.

Physical-Chemical Treatment

Processes that utilize physical (i.e., sedimentation, filtration, centrifugation, activated carbon, reverse osmosis, etc.) and/or chemical means (i.e., coagulation, oxidation, precipitation, etc.) to treat wastewaters.

Point Source Category

A collection of industrial sources with similar function or product, established by Section 306 (b) (1) (A) of the Federal Water Pollution Control Act, As Amended for the purpose of establishing Federal standards for the disposal of wastewater.

Pollutant Loading

Ratio of the total daily mass discharge of a particular pollutant to the total daily wet production of a mill expressed in terms of (kg pollutant)/(kkg wet production).

Pretreatment Standard

Industrial waste effluent quality required for discharge to a publicly-owned treatment works.

Product Line

Goods which are similar in terms of raw materials, method of manufacture, and/or function (e.g., scoured wool, wool goods, woven goods, knit goods, carpet, stock and yarn, nonwovens, felts, etc.).

Publicly-Owned Treatment Works (POTW)

A facility that collects, treats, or otherwise disposes of wastewaters, owned and operated by a village, town, county, authority, or other public agency.

Raw Waste Characteristics

A description of the constituents and properties of a wastewater before treatment.

Simple Processing

Woven or knit fabric finishing operations that may consist of fiber preparation, scouring, functional finishing, and one of the following processes applied to more than five percent of total production: bleaching, dyeing, or printing.

Standard Industrial Classification (SIC)

A numerical categorization scheme used by the U.S. Department of Commerce to denote segments of industry.

Standard of Performance

A maximum weight discharged per unit of production for each constituent that is subject to limitations. Standards of performance are applicable to new sources, as opposed to existing sources which are subject to effluent limitations.

Synthetics

As used in this report, synthetics refers to all man-made fibers, including those manufactured from naturally occurring raw materials (regenerated fibers). Strictly speaking, synthetic fibers are those that are made by chemical synthesis.

Toxic Pollutants

All compounds specifically named or referred to in the Consent Decree, as well as recommended specific compounds representative of the nonspecific or ambiguous groups or compounds named in the agreement. This list of pollutants was developed based on the use of criteria such as known occurrence in point source effluents, in the aquatic environment, in fish, in drinking water, and through evaluations of carcinogenicity, other chronic toxicity, bioaccumulation, and persistence.

Water Usage

Ratio of the spent water from a manufacturing operation to the total wet production by the mill, expressed in terms of (liters of wastewater/day)/(kilogram of wet production/day).

Wet Processing Mills

As used in this report, it refers to all manufacturing facilities having major wet manufacturing operations. Any mill in the following manufacturing segments is a wet processing mill: Wool Scouring, Wool Finishing, Woven Fabric Finishing, Knit Fabric Finishing (including Hosiery Finishing), Carpet Finishing, Stock & Yarn Finishing, Nonwoven Manufacturing, and Felted Fabric Processing.

Wet Production

Mass of textile goods that goes through one or more major wet processes in a specified time period.

APPENDIX A

COSTS OF TREATMENT AND CONTROL SYSTEMS

INRODUCTION

This appendix presents the results and methodology for the calculation of capital and annual costs for the treatment technologies that have been considered for the development of effluent limitations and standards for the control of toxic, conventional and nonconventional pollutants. The costs have been developed for the purpose of evaluation of cost versus pollutant reduction benefit and for the purposes of determination of the economic impact of the several regulatory options that have been considered for the textile mills point source category. Although, many of the technologies will not serve as the basis for promulgated effluent limitations and standards considerable time and effort has been devoted to these calculations and they represent a valuable resource for the evaluation of treatment and control technologies where additional end-of-pipe treatment may be required for water quality reasons.

GENERAL APPROACH

A model plant approach has been used for the calculation of alternative technology costs for textile mills as the resources required by the Agency and industry for specific mill cost estimates would be prohibitive. The model approach has been used successfully in several other industries to calculate technology cost. From a review of production capacity, flow per unit of production, and plant discharge data in all subcategories eight different flow models ranging from 0.05 mgd to 5.0 mgd were selected for the detailed calculation of investment and annual costs. The eight flow models selected provided a sufficient range of sizes to represent three model sizes in most subcategories and thus properly represent the range of existing plant sizes. As the model plants are flow sized models they can be related to production sizes by the respective flow per unit of production for the respective subcategories.

SUMMARY OF MODEL PLANT COSTS

The treatment and control options considered for BPT, BAT, NSPS, PSES, and PSNS were presented in section VII and are summarized here in Table A-1. The raw waste loads for each option, the methodology for calculation of effluent characteristics and the final effluent characteristics are also presented in section VII. These technology options are summarize here in Table A-1. Model plant costs for each subcategory and option are presented in Table A-2.

TABLE A-1

TREATMENT AND CONTROL OPTIONS

<u>BPT</u>

Option 1	Screening plus extended aeration activated sludge treatment.

<u>BAT</u>

Option 1	No additional treatment beyond BPT biological treatment.
Option 2	Multimedia filtration of Option 1 effluent.
Option 3	Chemical Coagulation/Sedimentation of Option 1 effluent.
Option 4	Chemical Coagulation/Sedimentation followed by multimedia filtration of Option 1 effluent.

<u>NSPS</u>

Option 1	Screening plus extended aeration activated sludge.
Option 2	Option 1 treatment plus chemical coagulation/sedimentation and multimedia filtration.

<u>PSES & PSNS</u>

Option 1	No additional treatment beyond screening and equalization.
Option 2	Option 1 plus chemical coagulation/sedimentation.

TABLE A-2

MODEL MILL COST SUMMARY
BPT OPTION 1
SCREENING AND EXTENDED AERATION ACTIVATED SLUDGE

Subcategory	Model Size Production (lb/day)	Flow (MGD)	Costs ($1000) Capital	Total Annual
Low Water Use Processing	10,600	0.11	308	161
(Water Jet Weaving)	24,100	0.25	404	204
Nonwoven Manufacturing	22,900	0.11	308	161
	52,100	0.25	404	204
Felted Fabric Processing	2,000	0.05	239	130
	4,300	0.11	308	161

TABLE A-2
(Cont'd)

MODEL MILL COST SUMMARY
BAT OPTION 2 MULTIMEDIA FILTRATION

Subcategory	Model Size Production (lb/day)	Model Size Flow (MGD)	Costs ($1000) Capital	Costs ($1000) Total Annual
Wool Scouring	35,700	0.05	93	66
	78,600	0.11	133	80
	178,600	0.25	200	104
Wool Finishing	Multimedia Filtration Not Considered			
Low Water Use Processing (Water Jet Weaving)	BAT options beyond BPT not considered.			
Woven Fabric Finishing (Simple Operations)	12,000	0.11	133	80
	65,200	0.60	297	147
	163,000	1.5	488	226
Woven Fabric Finishing (Complex Operations)	51,300	0.60	297	148
	256,400	3.00	747	333
	427,400	5.00	1,018	444
Woven Fabric Finishing (Desizing)	47,200	0.60	297	148
	118,100	1.50	488	229
	393,700	5.00	1,018	444
Knit Fabric Finishing (Simple Operations)	17,700	0.25	200	103
	70,900	1.00	387	185
	354,600	5.00	1,018	442
Knit Fabric Finishing (Complex Operations)	17,000	0.25	200	104
	40,800	0.60	297	148
	68,000	1.00	387	187
Knit Fabric Finishing (Hosiery Products)	5,600	0.05	93	66
	12,200	0.11	133	80
Carpet Finishing	44,600	0.25	200	104
	107,100	0.60	297	148
	267,900	1.50	488	229
Stock and Yarn Finishing	21,600	0.25	200	103
	51,700	0.60	297	147
	86,200	1.00	387	185
	129,300	1.50	488	226
Nonwoven Manufacturing	22,900	0.11	133	80
	52,100	0.25	200	104
Felted Fabric Processing	Multimedia Filtration Not Considered			

TABLE A-2
(Cont'd)

MODEL MILL COST SUMMARY
BAT OPTION 3 CHEMICAL COAGULATION

Subcategory	Model Size Production (lb/day)	Model Size Flow (MGD)	Costs ($1000) Capital	Costs ($1000) Total Annual
Wool Scouring	35,700	0.05	Chemical Coagulation not considered.	
	78,600	0.11		
	178,600	0.25		
Wool Finishing	16,400	0.60	365	246
	41,100	1.50	536	373
	82,200	3.00	778	556
Low Water Use Processing (Water Jet Weaving)	BAT options beyond BPT not considered.			
Woven Fabric Finishing (Simple Operations)	12,000	0.11	206	150
	65,200	0.60	365	244
	163,000	1.50	528	370
Woven Fabric Finishing (Complex Operations)	51,300	0.60	365	244
	256,400	3.00	763	555
	427,400	5.00	1,112	796
Woven Fabric Finishing (Desizing)	47,200	0.60	365	244
	118,100	1.50	528	370
	393,700	5.00	1,112	796
Knit Fabric Finishing (Simple Operations)	17,700	0.25	263	179
	70,900	1.00	447	302
	354,600	5.00	1,112	796
Knit Fabric Finishing (Complex Operations)	17,000	0.25	263	179
	40,800	0.60	365	244
	68,000	1.00	447	302
Knit Fabric Finishing (Hosiery Products)	5,600	0.05	172	134
	12,200	0.11	206	151
Carpet Finishing	44,600	0.25	263	179
	107,100	0.60	365	244
	267,900	1.50	528	370
Stock and Yarn Finishing	21,600	0.25	263	179
	51,700	0.60	365	244
	86,200	1.00	447	302
	129,300	1.50	528	370
Nonwoven Manufacturing	22,900	0.11	206	151
	52,100	0.25	263	180
Felted Fabric Processing	2,000	0.05	172	134
	4,300	0.11	206	151

TABLE A-2
(Cont'd)

MODEL MILL COST SUMMARY
BAT OPTION 4 CHEMICAL COAGULATION/SEDIMENTATION
PLUS MULTI MEDIA FILTRATION

Subcategory	Model Size Production (lb/day)	Flow (MGD)	Costs ($1000) Capital	Total Annual
Wool Scouring	35,700	0.05	Option 4 not considered	
	78,600	0.11		
	178,600	0.25		
Wool Finishing	16,400	0.60	611	329
	41,100	1.50	959	520
	82,200	3.00	1,449	784
Low Water Use Processing (Water Jet Weaving)	BAT options beyond BPT not considered.			
Woven Fabric Finishing (Simple Operations)	12,000	0.11	303	180
	65,200	0.60	611	328
	163,000	1.50	950	518
Woven Fabric Finishing (Complex Operations)	51,300	0.60	611	328
	256,400	3.00	1,434	786
	427,400	5.00	2,039	1,121
Woven Fabric Finishing (Desizing)	47,200	0.60	611	328
	118,100	1.50	950	518
	393,700	5.00	2,039	1,121
Knit Fabric Finishing (Simple Operations)	17,700	0.25	420	229
	70,900	1.00	773	416
	354,600	5.00	2,039	1,121
Knit Fabric Finishing (Complex Operations)	17,000	0.25	420	229
	40,800	0.60	611	328
	68,000	1.00	773	416
Knit Fabric Finishing (Hosiery Products)	5,600	0.05	231	152
	12,200	0.11	303	181
Carpet Finishing	44,600	0.25	420	229
	107,100	0.60	611	328
	267,900	1.50	950	518
Stock and Yarn Finishing	21,600	0.25	420	229
	51,700	0.60	611	328
	86,200	1.00	773	416
	129,300	1.50	950	518
Nonwoven Manufacturing	22,900	0.11	303	180
	52,100	0.25	420	320
Felted Fabric Processing	2,000	0.05	231	152
	4,300	0.11	303	181

TABLE A-2
(Cont'd)

MODEL MILL COST SUMMARY
NSPS OPTION 1
SCREENING PLUS AERATION ACTIVATED SLUDGE

Subcategory	Model Size Production (lb/day)	Model Size Flow (MGD)	Costs ($1000) Capital	Costs ($1000) Total Annua
Wool Scouring*	--	--	--	--
Wool Finishing	41,100	1.50	2,275	783
Low water Use Processing (Water Jet Weaving)	10,600	0.11	308	162
Woven Fabric Finishing (Simple Operations)	65,200	0.60	573	346
Woven Fabric Finishing (Complex Operations)	256,400	3.00	3,624	1,184
Woven Fabric Finishing (Desizing)	118,100	1.50	2,275	783
Knit Fabric Finishing (Simple Operations)	70,900	1.00	1,744	635
Knit Fabric Finishing (Complex Operations)	40,800	0.60	573	346
Knit Fabric Finishing (Hosiery Products)	12,200	0.11	310	210
Carpet Finishing	44,600	0.25	405	257
Stock and Yarn Finishing	51,700	0.60	573	346
Nonwoven Manufacturing	52,100	0.25	405	257
Felted Fabric Processing	9,800	0.25	405	257

*NSPS costs for the wool scouring subcategory were not calculated as no new sources are anticipated.

TABLE A-2
(Cont'd)

MODEL MILL COST SUMMARY
NSPS OPTION 2
EXTENDED AERATION ACTIVATED SLUDGE PLUS
CHEMICAL COAGULATION/SEDIMENTATION PLUS
MULTIMEDIA FILTRATION

Subcategory	Model Size Production (lb/day)	Flow (MGD)	Costs ($1000) Capital	Total Annual
Wool Scouring*	--	--	--	--
Wool Finishing	41,100	1.50	3,234	1,303
Low water Use Processing (Water Jet Weaving)	10,600	0.11	--	--
Woven Fabric Finishing (Simple Operations)	65,200	0.60	1,184	674
Woven Fabric Finishing (Complex Operations)	256,400	3.00	5,058	1,970
Woven Fabric Finishing (Designing)	118,100	1.50	3,225	1,301
Knit Fabric Finishing (Simple Operations)	70,900	1.00	2,517	1,051
Knit Fabric Finishing (Complex Operations)	40,800	0.60	1,184	674
Knit Fabric Finishing (Hosiery Products)	12,200	0.11	613	391
Carpet Finishing	44,600	0.25	825	487
Stock and Yarn Finishing	51,700	0.60	1,184	674
Nonwoven Manufacturing	52,100	0.25	825	487
Felted Fabric Processing	9,800	0.25	825	487

*NSPS costs for the wool scouring subcategory were not calculated as no new sources are anticipated.

TABLE A-2
(Cont'd)

MODEL MILL COST SUMMARY
PSES & PSNS OPTION 2
CHEMICAL COAGULATION/SEDIMENTATION

Subcategory	Model Size Production (lb/day)	Flow (MGD)	Costs ($1000) Capital	Total Annual
Wool Scouring	178,600	0.25	459	299
Wool Finishing	41,100	1.50	745	440
Low Water Use Processing (*Water Jet Weaving*)	24,100	0.25	366	207
Woven Fabric Finishing (Simple Operations)	18,100	0.25	366	207
Woven Fabric Finishing (Complex Operations)	51,300	0.60	493	289
Woven Fabric Finishing (Designing)	118,100	1.50	765	441
Knit Fabric Finishing (Simple Operations)	47,200	0.60	493	288
Knit Fabric Finishing (Complex Operations)	40,800	0.60	493	288
Knit Fabric Finishing (Hosiery Products)	12,200	0.11	293	170
Carpet Finishing	107,100	0.60	493	288
Stock and Yarn Finishing	21,600	0.25	366	207
Nonwoven Manufacturing	52,100	0.25	366	207
Felted Fabric Processing	10,000	0.25	366	207

CALCULATION OF COMPONENT TECHNOLOGY COSTS

Treatment Technologies Considered

Several distinct technologies comprise the treatment and control options considered for the textile industry. These technologies which have been selected for the detailed calculation of costs are as follows:

- Screening
- Equalization
- Activated Sludge
- Chemical Coagulation/Precipitation
- Vacuum Filtration
- Multimedia Filtration
- Dissolved Air Flotation
- Granular Activated Carbon (GAC)
- Powdered Activated Carbon (PAC)

Model Plant Cost Estimates

Total investment and annual cost estimates are prepared for the alternatives applicable to each model. The example computation sheet (Figure A-1) is used as an aid in this task. The investment costs include the cost of purchasing and installing the components of each alternative technology and allowance for contingencies and engineering. The annual costs include the cost of capital, depreciation, operation and maintenance labor, maintenance materials, sludge disposal, energy, chemicals, and monitoring.

Details of the methodology used in preparing the cost estimates are discussed below. The basic assumptions and the rationale supporting the estimates are based primarily on data collected during the industry survey and information obtained from the literature. References are cited throughout the section to provide the reader with a clear understanding of the sources of the information.

Component Technology Investment Costs

Cost curves are presented in Figures A-2 through A-11 for the component technologies used in establishing the alternative control technologies. The curves provide the total installed costs relative to flow rate and represent the following distributions between equipment and construction costs.

	Installed Cost Breakdown percent of total	
Component Technology	Equipment	Construction
Screening (BAT and NSPS)	20	80
Screening (PSES and PSNS)	35	65
Equalization (NSPS)	20	80
Equalization (PSES and PSNS)	35	65
Activated Sludge	20	80

FIGURE A-1
TEXTILE INDUSTRY BAT REVIEW
TREATMENT COST COMPUTATION SHEET

SUBCATEGORY 4a. Woven Fabric Finishing-Simple Processing REGULATION BAT

MODEL FLOW 0.6 MGD TREATMENT ALTERNATIVE F CC + MMF + AC

ANNUAL PRODUCTION C-12,200 / O-13,900 / I-13,000 KLBS ANNUAL CAPACITY 16,300 KLBS

INVESTMENT COSTS

No.	Component	Equipment	Construction	Total
1	PT AS CC VF DAF MMF	39,900	159,600	199,500
2	AS CC VF DAF MMF AC	24,700	45,800	70,500
3	CC VF DAF MMF AC OZ	39,900	159,600	199,500
4	VF DAF MMF AC OZ	452,200	452,200	904,400
5	MONITORING	20,000	None	20,000

EQUIPMENT & CONSTRUCTION COSTS (E&C)	(A)	$ 1,393,900
CONTINGENCIES (15 % OF E&C)	(B)	209,100
ENGINEERING (7 % OF A&B)	(C)	112,200

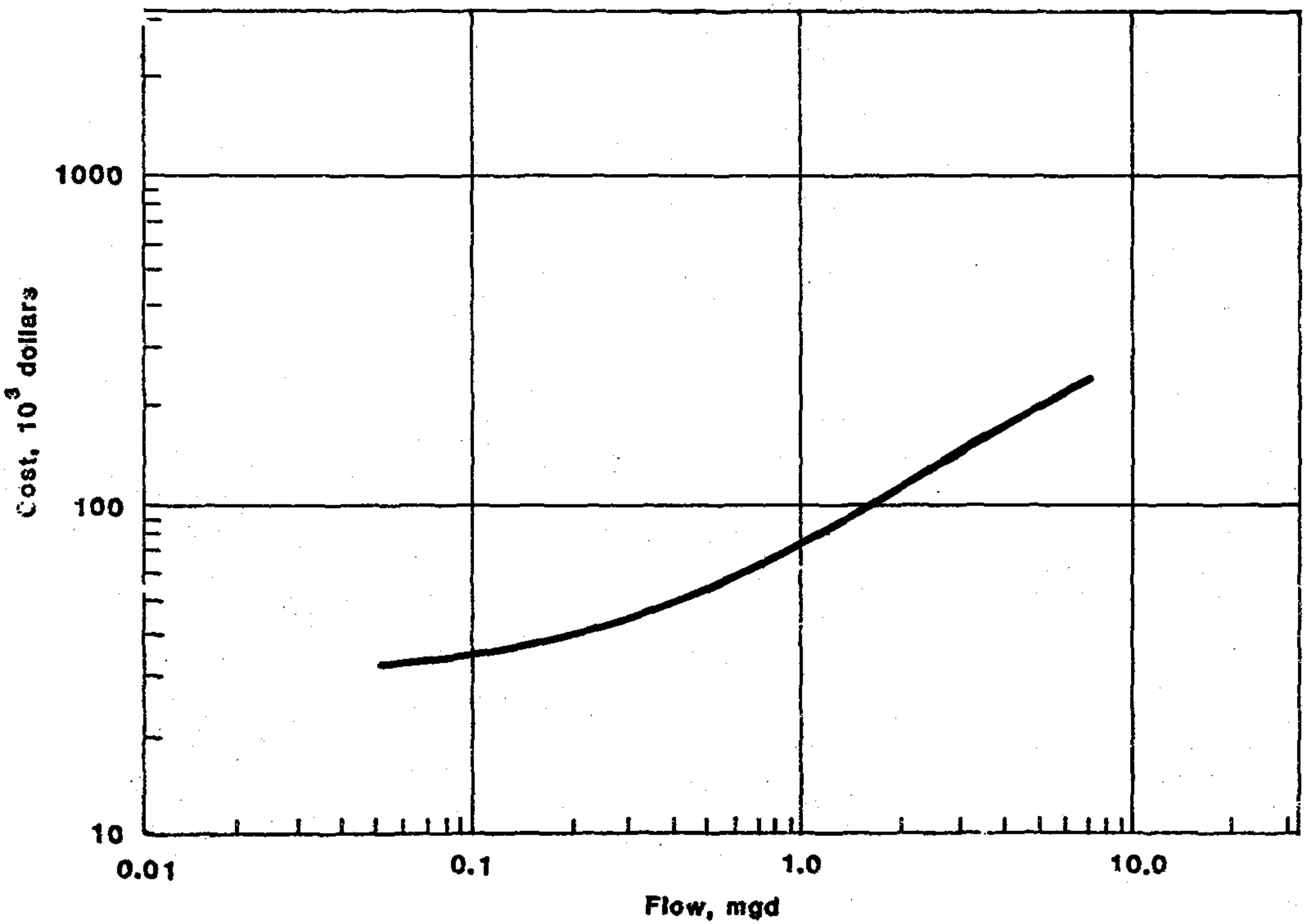
* * * * * TOTAL INVESTMENT COSTS (TIC) * * * * * $ 1,715,000

ANNUAL COSTS

COST OF CAPITAL (15 % of TIC)	257,300
DEPRECIATION ([A + B] ÷ 18 YEARS AVERAGE USEFUL LIFE)	89,100
O&M LABOR (5,140 HRS X 20 $/HR)	102,800
MAINTENANCE MATERIALS	60,500
SLUDGE DISPOSAL (359 TONS X 20 $/TON)	7,200
ENERGY & POWER (283,000 kwhr X 3.4 ¢/kwrh) +	9,600
(39,000 therms X 33 ¢/therm)	12,900
CHEMICALS: Polymer	
Alum	18,000
Carbon	59,400
MONITORING	40,500
OPERATING PERSONNEL 3.4 PERSONS	

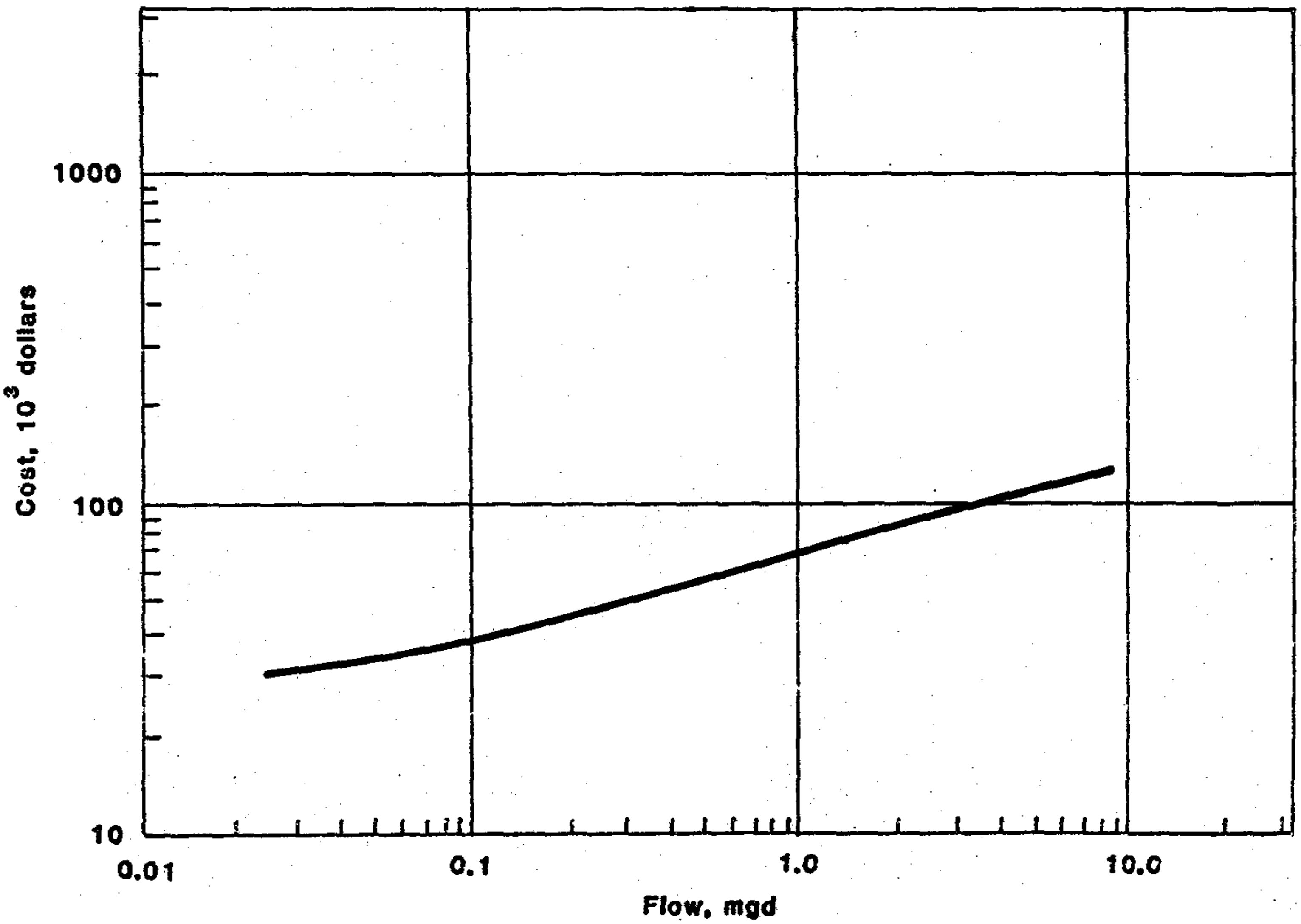
* * * * * TOTAL ANNUAL COSTS (TAC) * * * * * $ 657,000

FIGURE A-2
SCREENING-INSTALLED COST



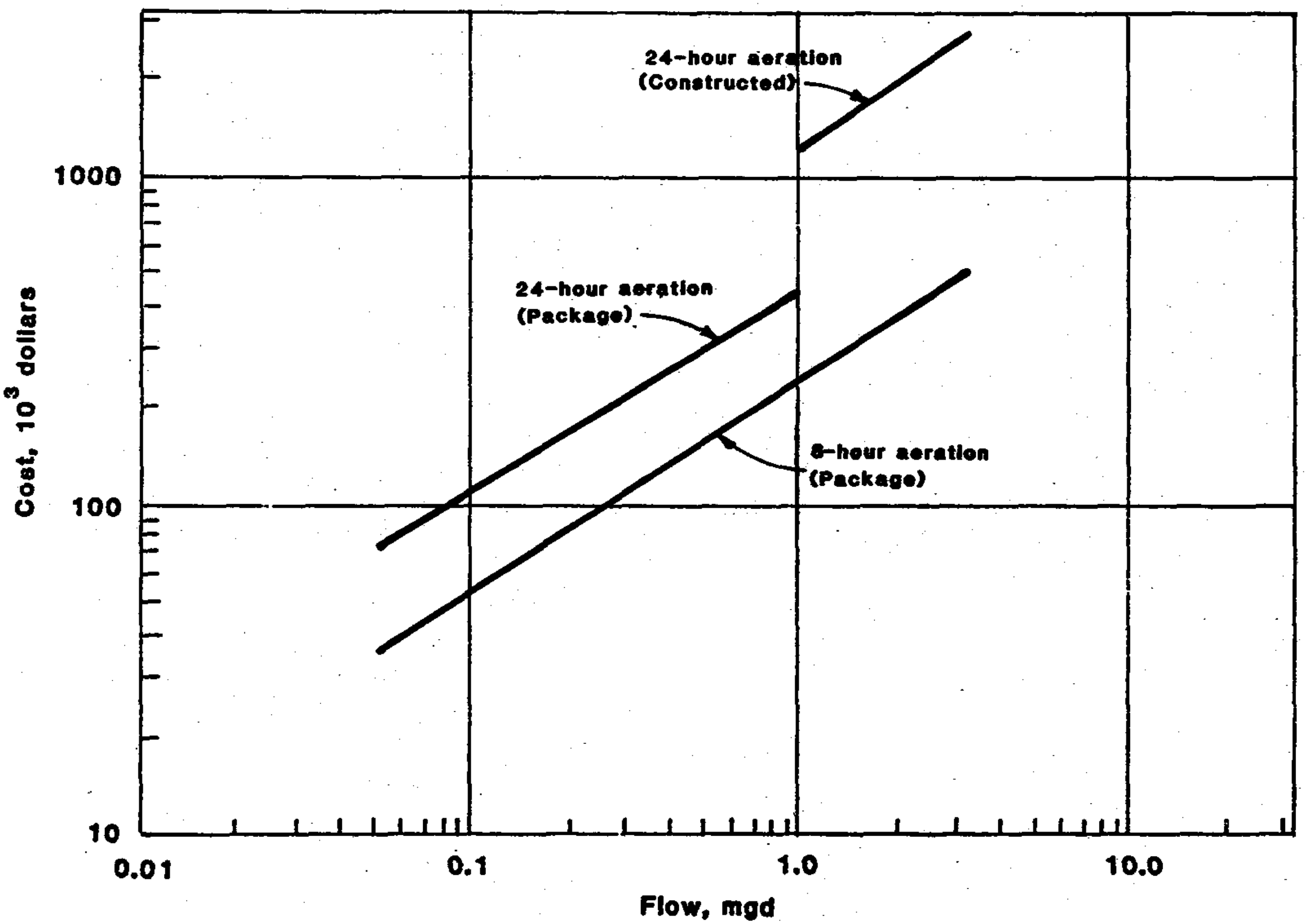
SOURCE: Reference No. 3 (4th quarter 1979 dollars)

FIGURE A-3
EQUALIZATION-INSTALLED COST



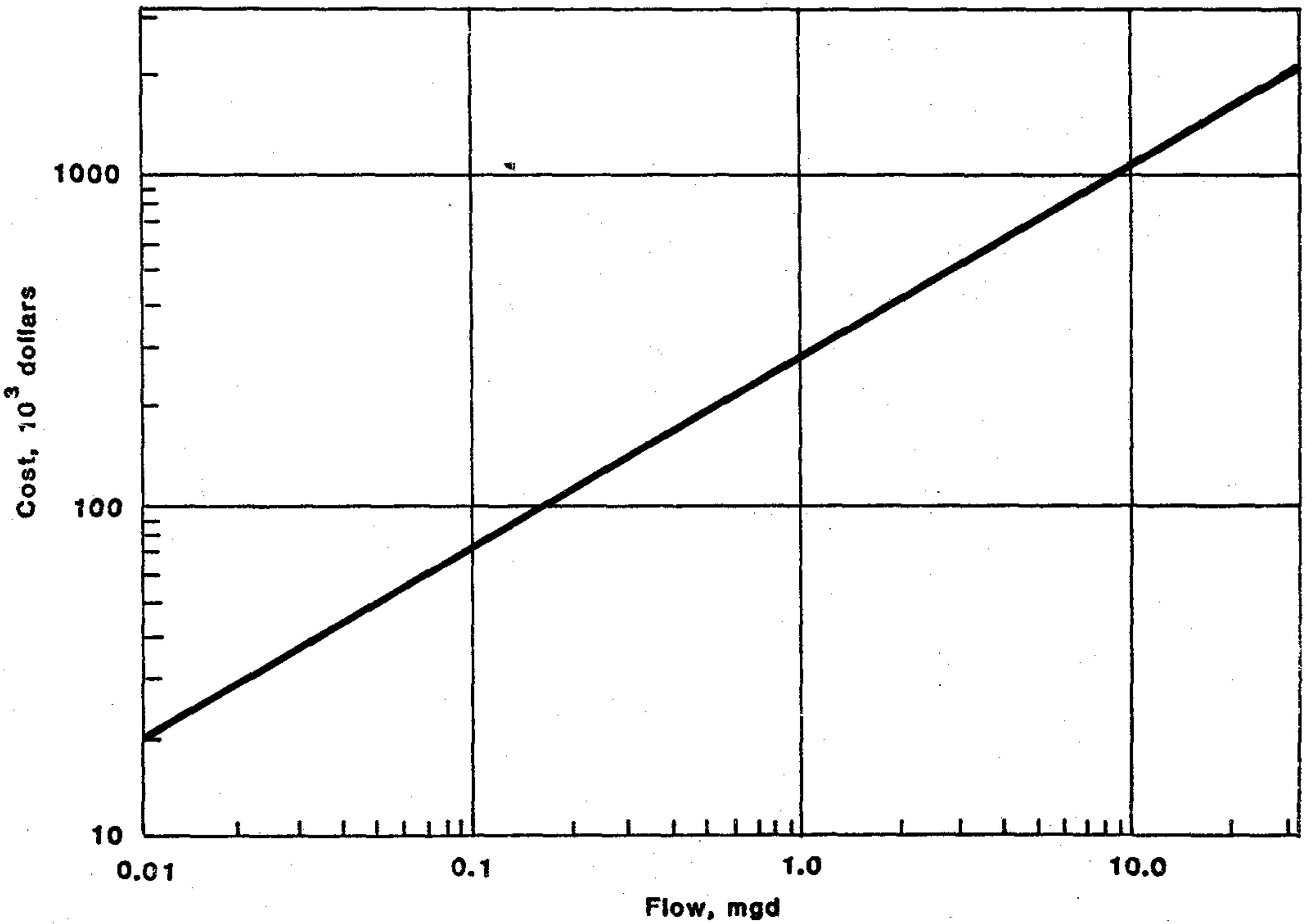
SOURCE: Reference No. 3 (4th quarter 1979 dollars)

FIGURE A-4
ACTIVATED SLUDGE-INSTALLED COST



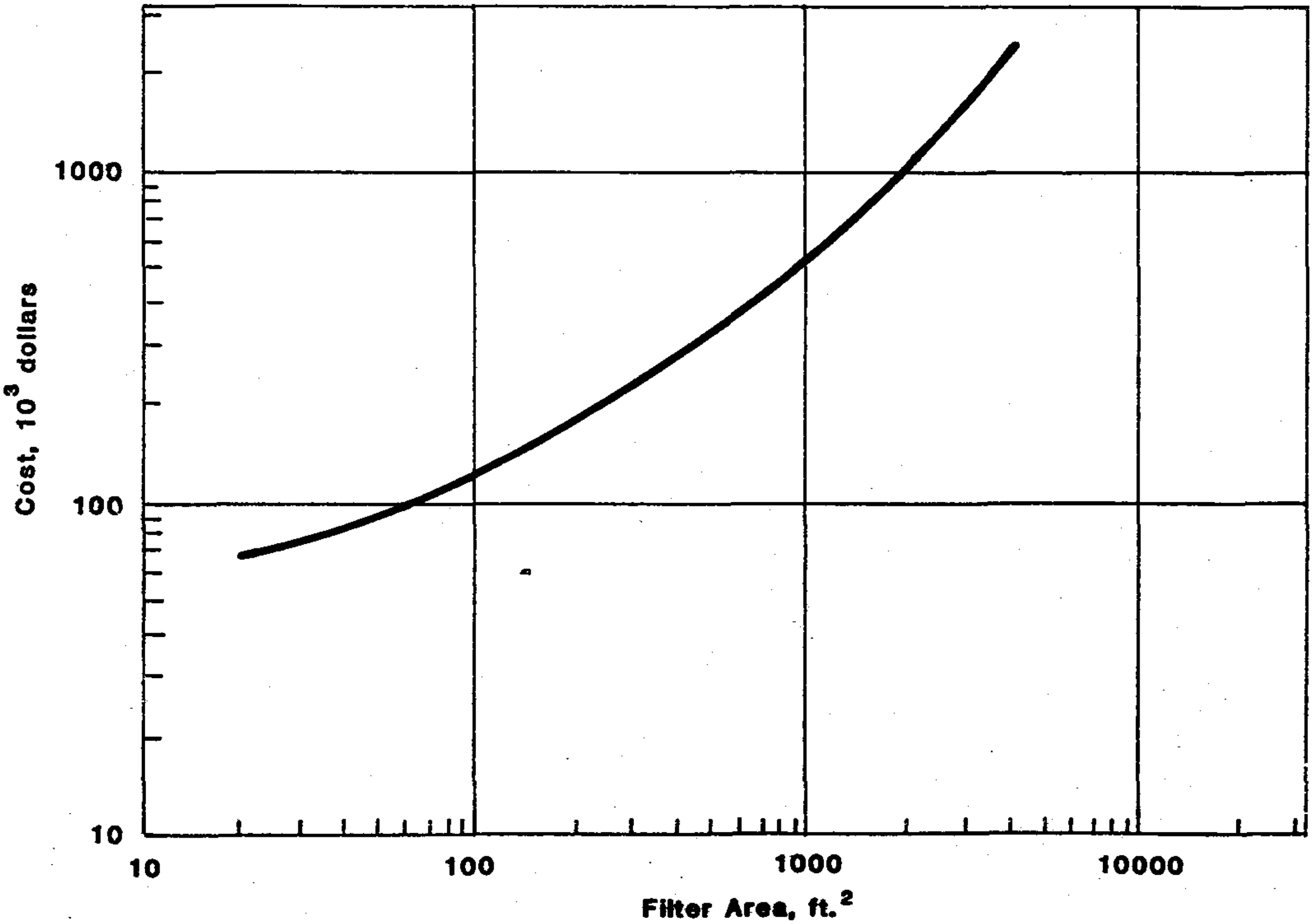
SOURCE: Reference No. 3 (4th quarter 1979 dollars)

FIGURE A-5
CHEMICAL COAGULATION-INSTALLED COST



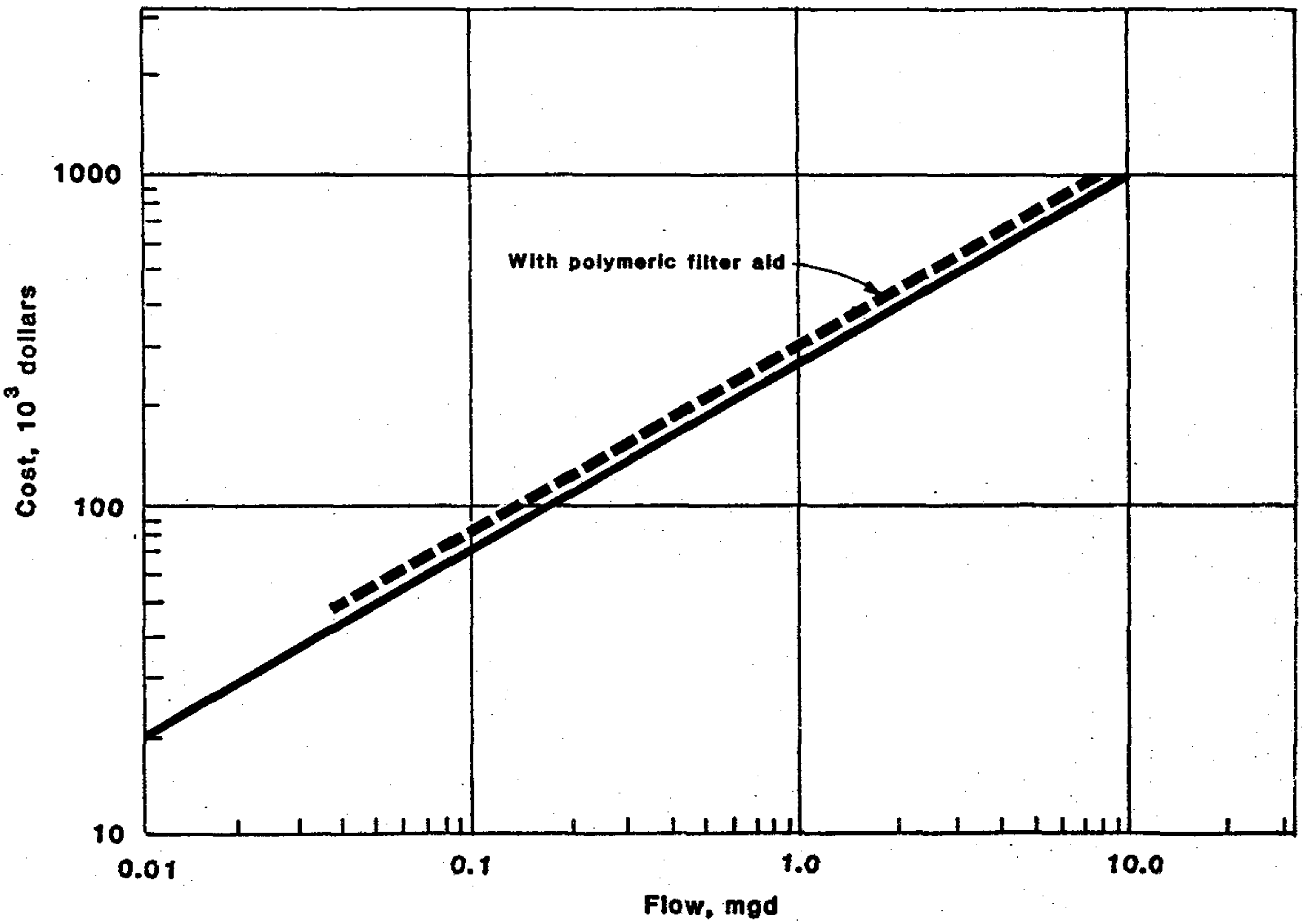
SOURCE: References 28, 30, 31 (4th quarter 1979 dollars)

FIGURE A-6
VACUUM FILTRATION-INSTALLED COST



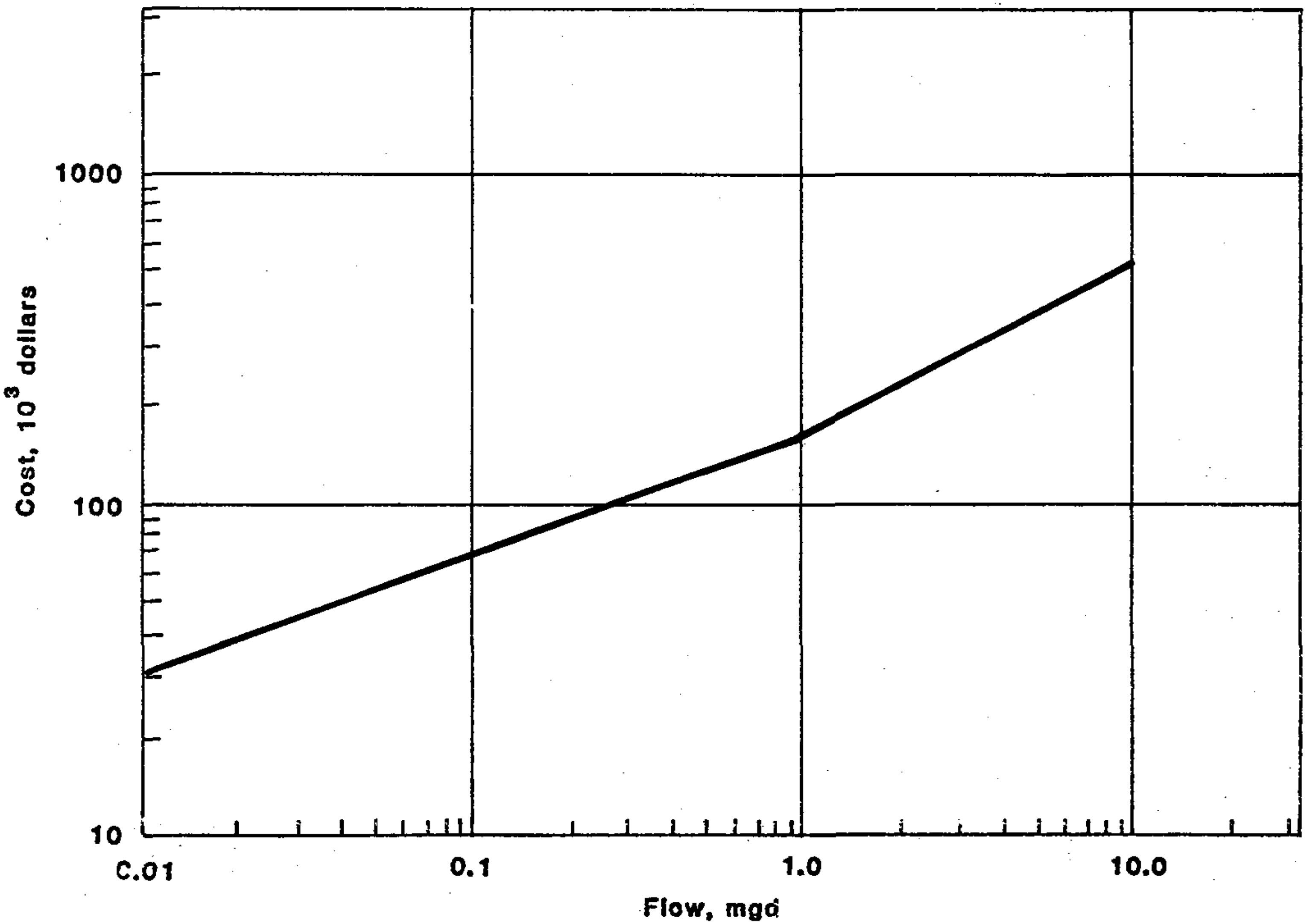
SOURCE: References 28, 30, 81, 82 (4th quarter 1979 dollars)

FIGURE A-7
MULTIMEDIA FILTRATION-INSTALLED COST



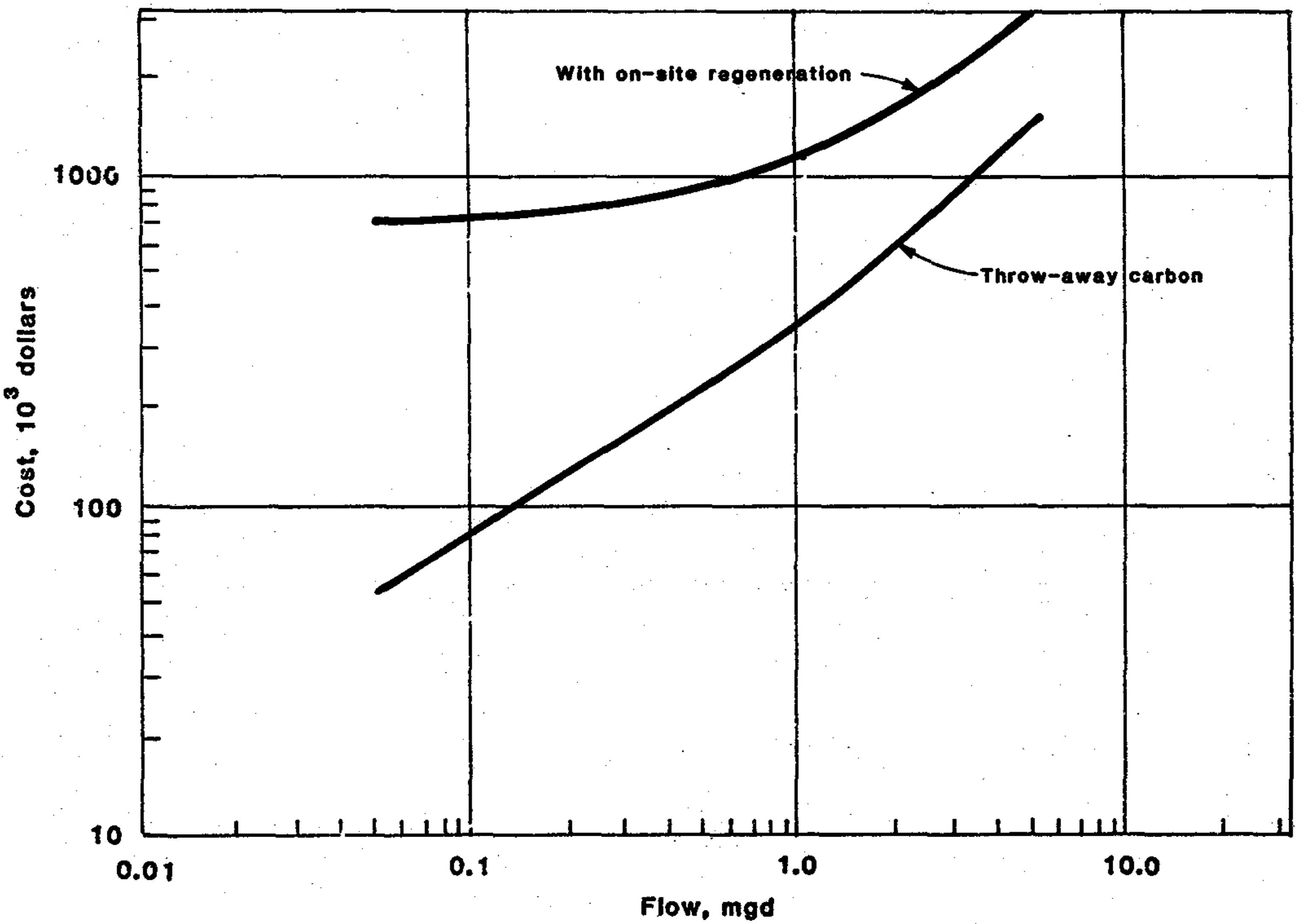
SOURCE: References 28, 30, 31, 32, 33, 34 (4th quarter 1979 dollars)

FIGURE A-8
DISSOLVED AIR FLOTATION-INSTALLED COST



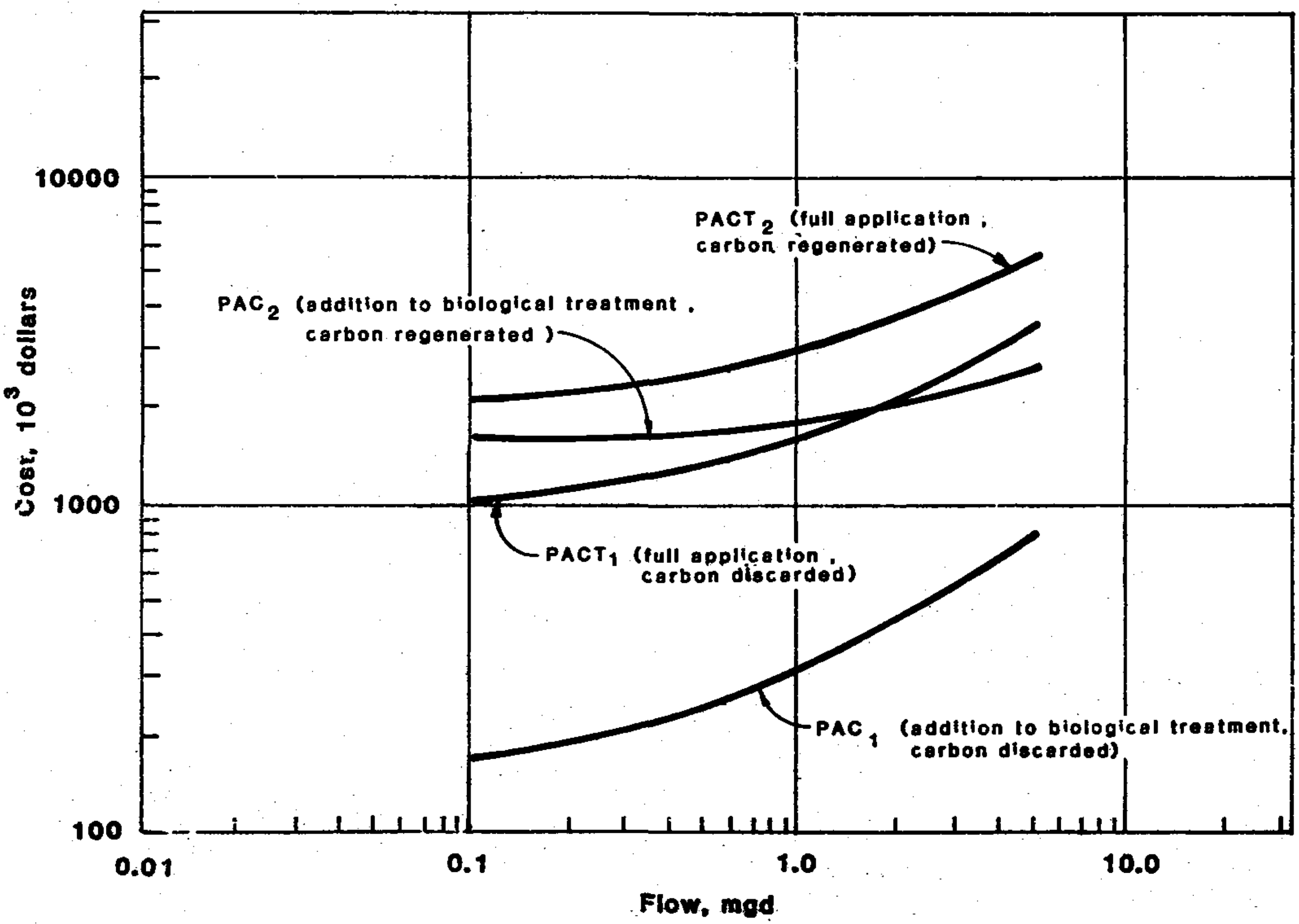
SOURCE: Reference 34 (4th quarter 1979 dollars)

FIGURE A-9
GRANULAR ACTIVATED CARBON-INSTALLED COST



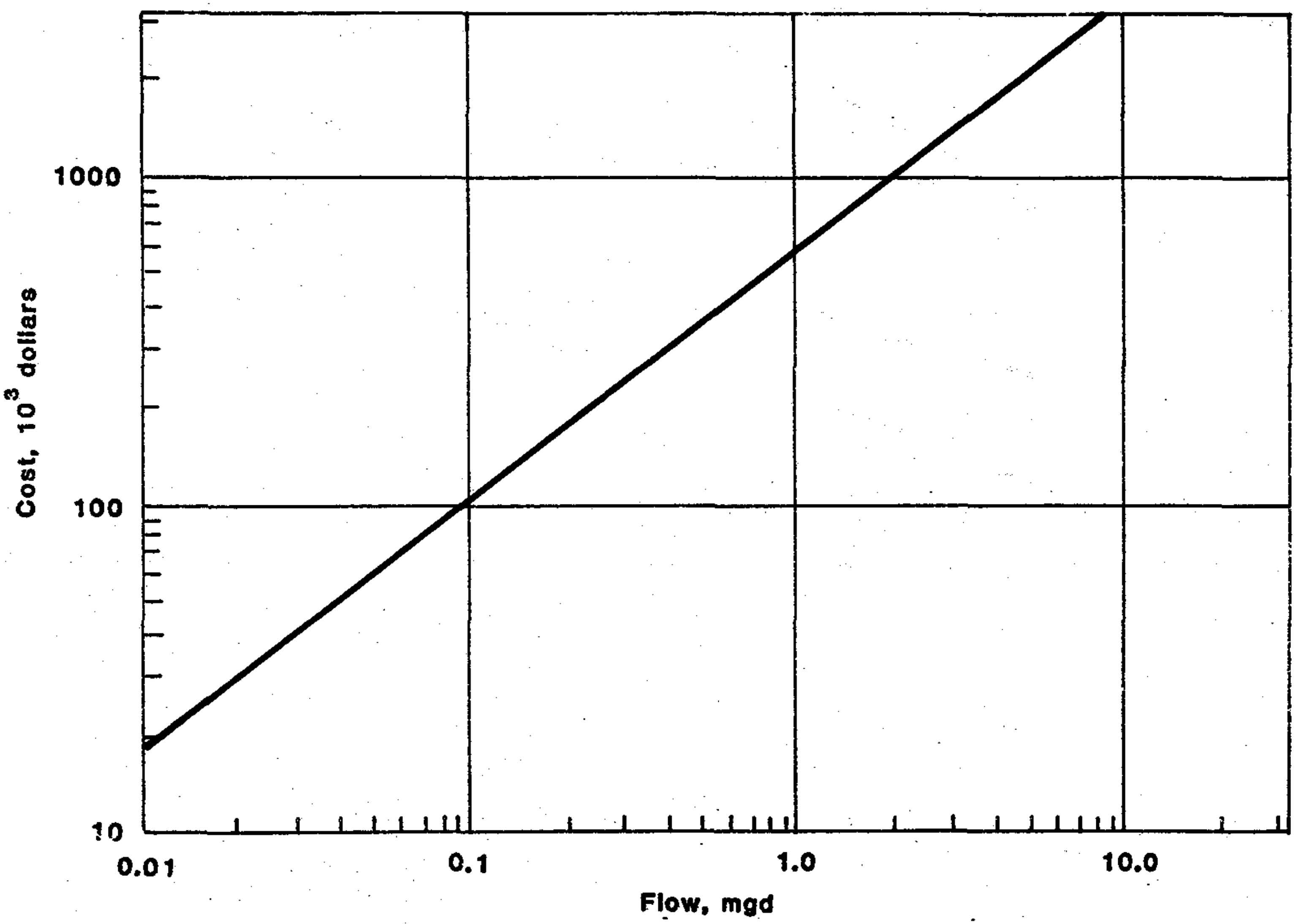
SOURCE: References 30, 31, 33, 35 (4th quarter 1979 dollars)

FIGURE A-10
POWDERED ACTIVATED CARBON-INSTALLED COST



SOURCE: Reference 83 (4th quarter 1979 dollars)

FIGURE A-11
OZONATION-INSTALLED COST



SOURCE: References 33, 37, 38, 50 (4th quarter 1979 dollars)

Chemical Coagulation/ Precipitation	20	80
Vacuum Filtration	35	65
Multimedia Filtration	20	80
Dissolved Air Flotation	35	65
Granular Activated Carbon	50	50
Powdered Activated Carbon (Not Regenerated)		
Addition to EAAS	32	68
Full Application	25	75
Powdered Activated Carbon (Regenerated)		
Addition to EAAS	45	55
Full Application	34	66
Ozonation	50	50

The features, applicable design parameters, and source of cost information for each of these technologies are described below. In all cases, the cost curves for the component technologies represent 4th Quarter 1979 dollars. The original equipment and construction costs, which were taken from the sources given for each component technology, were adjusted to achieve this uniformity. The adjustment was accomplished in two steps. The original equipment and construction cost estimates presented in the Textile Mills Point Source Category Proposed Development Document (37) were based on 4th quarter 1976 dollars. The individual cost information was updated to that time frame by establishing adjustment ratios based on the EPA-STP and EPA-SCCT indexes. These ratios varied depending on the date of the original cost information. The 4th Quarter 1976 equipment and construction costs were subsequently updated to 4th Quarter 1979 dollars by increasing the costs by one third. This increase was based on a change in the EPA-SCCT index from a 4th Quarter 1976 base city average of 119 to a 4th Quarter 1979 base city average of 162.

<u>Screening</u> Screening is used as a preliminary treatment step for new sources and is included ahead of extended aeration activated sludge for existing direct dischargers. Figure A-2 includes the costs for: site preparation; structural concrete; equipment housing; purchase and installation of mechanical screening equipment; pumps, piping, and valves; and instrumentation. Screening is used to remove lint, floc, rags, and other coarse suspended solids that tend to clog pumps, foul bearings and aerators, float in basins, and otherwise interfere with the operation of treatment plants. The costs were taken from the <u>Development Document</u> (Proposed Regulation) (4) and updated to 4th Quarter 1979 dollars.

<u>Equalization</u> Equalization is used as a preliminary treatment step for new sources. The technology includes earthen wall basins providing 12 hours detention time with mixing by surface aerators. The assumed depth is 3 meters (approximately 10 feet).

Figure A-3 includes the costs for site preparation, basin construction, wet wells, pumps, and floating mechanical aerators. The costs were taken from background calculation used in preparing the Development Document (Proposed Regulation) (4) and updated to 4th Quarter 1979 dollars.

Activated Sludge   Activated sludge is the technology in place for most existing direct dischargers. Consequently, it is not included in estimating the costs of the alternative treatment technologies for all mills. Because the Hosiery Products, Nonwoven Manufacturing, and Felted Fabric Processing Subcategories are new, and activated sludge is not generally in place, activated sludge is included, for cost purposes, as a major treatment step for existing direct dischargers. It also is included as a component technology for all new source direct discharge mills. Figure A-4 includes costs for 8- and 24-hour package aeration systems and a 24-hour detention site constructed system. The basic unit operations and processes included in the site constructed system are aeration, secondary clarification with solids recycle, sludge thickening, and vacuum filtration for sludge dewatering. The costs were taken from background calculations used in preparing the Development Document (Proposed Regulation) (3) and updated to 4th Quarter 1979 dollars.

Chemical Coagulation/Precipitations. Chemical coagulation/precipitation after biological treatment is used for direct dischargers and as pretreatment for indirect dischargers. In all applications, the technology is based on the use of alum (as $Al_2(SO_4)_3$ 18 H_2O) as the coagulant and includes sedimentation. The assumed alum dosage was based on the following conditions:

Condition	Influent TSS, mg/l	Alum Dosage, mg/l
1	700 or greater	1,000
2	less than 700	100

Figure A-5 includes the costs for site preparation, purchase of coagulation and sedimentation equipment, and installation of equipment and instrumentation. The costs were developed by averaging the costs found in References 38, 39, and 40.

Vacuum Filtration   For existing direct dischargers, vacuum filtration accompanies chemical coagulation/precipitation for sludge dewatering purposes. Backwash solids from multimedia filtration also are processed by vacuum filtration if the multimedia filter is used in conjunction with chemical coagulation. Vacuum filtration is included with all treatment alternatives for existing indirect dischargers. The cost was calculated as a function of filter area, which is determined by using a dry solids loading rate of 19.5 kg/sq m/hr (4 lb/sq ft/hr) and an operating period of ten hours per day. The specific chemical coagulation and multimedia filtration conditions given below are used in determining vacuum filter requirements.

Chemical Coagulation Condition	TSS Removed mg/l	Effluent TSS mg/l	Alum Added mg/l
1	3,200	70	1,000
2	630	70	1,000
3	120	30	100
4	60	35	100
5	25	25	100

Multimedia Filtration Condition	TSS Removed mg/l	Effluent TSS mg/l
1	40	10
2	20	10
3	5	10

Figure A-6 includes the costs of site preparation, equipment housing, purchase and installation of filtration equipment, piping, pumping, and instrumentation. The curve is based on the average of costs given in References 38, 39, 40, and 42.

Multimedia Filtration Multimedia filtration is used in the same capacity as chemical coagulation/precipitation. The technology utilizes a granular media bed of anthracite coal, sand, and gravel, with polymeric filter aid added in applications without prior chemical coagulation. In all applications, the hydraulic loading rate used is 9.8 cu m/hr/sq m (4 gpm/sq ft). Filter aid is added at a rate of 1 mg/l.

Figure A-7 includes the costs for site preparation and the purchase and installation of filtration equipment, piping, pumping, and instrumentation. The curve is based on the average of costs given in References 38, 39, 40, 43, 44, and 45.

Dissolved Air Flotation Dissolved air flotation is used to remove suspended solids and oil & grease in the Wool Scouring Subcategory. It is used in conjunction with chemical coagulation/ precipitation after the biological treatment step for direct dischargers and as a pretreatment step for indirect dischargers. In all applications, a surface hydraulic loading rate of 163.2 cu m/day/sq m (4,000 gpd/ sq ft) is used.

Figure A-8 includes the costs for purchase and installation of tanks, air pressurizing equipment, recycle pumping equipment, operating valves, instrumentation, and piping. The costs are based on those developed in EPA's Process Design Manual for Removal of Suspended Solids (45).

Granular Activated Carbon Granular activated carbon is used as a post-biological treatment step and as a pretreatment step for both existing and new sources. It is usually applied following chemical coagulation/precipitation and/or multimedia filtration. The technology utilizes granular carbon columns and on-site carbon regeneration for wastewater flows of greater than 450 cu m/day (0.12 mgd). Carbon for smaller flows is assumed to be discarded after use. An exhaustion rate of 0.66 kg/cu m (5,500 lb/mil gal) of water treated is used.

Figure A-9 includes the costs for site preparation and the purchase and installation of carbon columns, regeneration equipment, piping, pumping, and instrumentation. The curve is based on information found in References 39, 40, 44, and 46.

Powdered Activated Carbon Addition to Biological Treatment Powdered activated carbon addition to existing biological treatment systems is considered for existing direct dischargers. The technology utilizes addition of carbon to the activated sludge basin and on-site wet air oxidation for wastewater flows of greater than 7,500 cu m/day (2.0 mgd). Carbon for smaller flows is assumed to be discarded after use. An exhaustion rate of 0.14 kg/cu m (1,200 lb/mil gal) of wastewater treated is used. Figure A-10 includes the costs for site preparation; purchase of carbon and chemical feeding equipment, regeneration equipment, instrumentation; and installation of all equipment and instrumentation. The curve is based on costs found in Reference 47.

Powdered Activated Carbon Treatment Powdered activated carbon treatment is considered as a treatment technology for new direct dischargers. The technology uses screening followed by addition of carbon to an activated sludge basin. Sludge is dewatered and regenerated by wet air oxidation for wastewater flows of greater than 7,500 cu m/day (2.0 mgd). Carbon for smaller flows is assumed to be discarded after use. An exhaustion rate of 0.14 kg/cu m (1,200 lb/mil gal) of water treated is used.

Figure A-10 includes the costs for site preparation; construction of basins, clarifiers, and facilities; purchase of equipment for screening, aeration, settling, pumping, carbon feed, chemical feed, sludge handling, regeneration and instrumentation; and installation of all equipment and instrumentation. The curve is based on costs found in Reference 47.

Ozonation Ozonation is considered as a post-biological treatment step and as a pretreatment step for existing sources. It is usually applied following chemical coagulation/precipitation and/or multimedia filtration. However, for the textile industry, it is applied after biological treatment for direct dischargers. The cost calculations are based on the on-site generation of ozone and on a generation capacity of 100 mg/l of ozone.

Figure A-11 includes the costs for site preparation and the purchase and installation of ozone contactors, ozone generation equipment, piping, pumping, and instrumentation. The curve is based on the average of costs found in References 44, 48, 49, and 50. 50.

Installed Investment Costs Matrix

The installed equipment and construction investment costs for each of the component technologies are presented in Table A-3 for each model plant size. The tabulated values are the base costs taken from the component technology installed cost curves (Figures A-2 through A-11) updated to 4th Quarter 1979 dollars.

Other Investment Costs

Monitoring Equipment The investment costs for monitoring equipment are based on collecting samples of the influent and effluent streams of the treatment plant. The sampling consists of 24-hour composite samples taken at each location twice weekly for direct dischargers and once per week for indirect dischargers. For direct dischargers, grab samples are taken once per week of the receiving water both upstream and downstream of the discharge. Continuous monitoring of pH and flow is provided for the influent and effluent of all treatment plants.

The equipment items include two flow meters, two primary and one back-up refrigerated samplers, two pH meters, and refrigerated sample storage containers. The costs were based on equipment manufacturers' price lists (51, 52, and 53).

It should be noted that the equipment described here is an estimate of the requirements for a complete monitoring program for major direct and indirect dischargers. Existing facilities, especially larger direct discharge mills, normally already own most of this equipment and the investment costs incurred by these mills are considerably less.

Land Costs Because all of the alternative technologies have small space requirements, and because most plants have some land available, the cost of additional land is not included in the estimates.

Contingencies An allowance of 15 percent of the total installed costs of the alternative treatment technologies is used to cover contingencies and differences between actual systems and the costs used for estimates. No allowance is made for mill shutdown during construction.

Engineering Costs Engineering costs are estimated as a percentage of the total installed costs plus contingencies. The values used are taken from the curve presented in Figure A-12.

Annual Costs

In estimating annual costs, it is assumed that the wastewater treatment technologies will operate 300 days/year. The operation of the treatment technology should not be confused with the

TABLE A-3
INSTALLED EQUIPMENT AND CONSTRUCTION INVESTMENT COSTS FOR COMPONENT TECHNOLOGIES

Technology	Model Size, mgd (cu m/day) 0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Cost, thousands of dollars							
Screening	32	35	39	49	67	100	146	180
Equalization	32	36	44	56	64	77	88	101
Activated Sludge (8-hour)	37	54	102	173	239	293	532	-
Activated Sludge (24-hour)	68	120	193	319	1,330	1,729	2,793	-
Chemical Coagulation/ Precipitation	44	72	117	200	266	333	505	771
Vacuum Filtration								
Condition 1*	75	100	146	279	426	599	1,197	2,022
Condition 2	71	71	96	140	206	273	479	825
Condition 3	71	71	71	71	76	87	114	148
Condition 4	71	71	71	71	71	77	101	125
Condition 5	71	71	71	71	71	71	89	108
Multimedia Filtration	48	79	128	200	266	346	545	758
Filtration (with polymer)	52	84	137	216	289	371	581	803
Dissolved Air Flotation	52	71	94	133	164	192	293	383
Granular Activated Carbon (without regeneration)	53	86	146	239	333	495	958	1,585
Granular Activated Carbon (with regeneration)	718	758	798	904	1,104	1,436	2,128	3,205

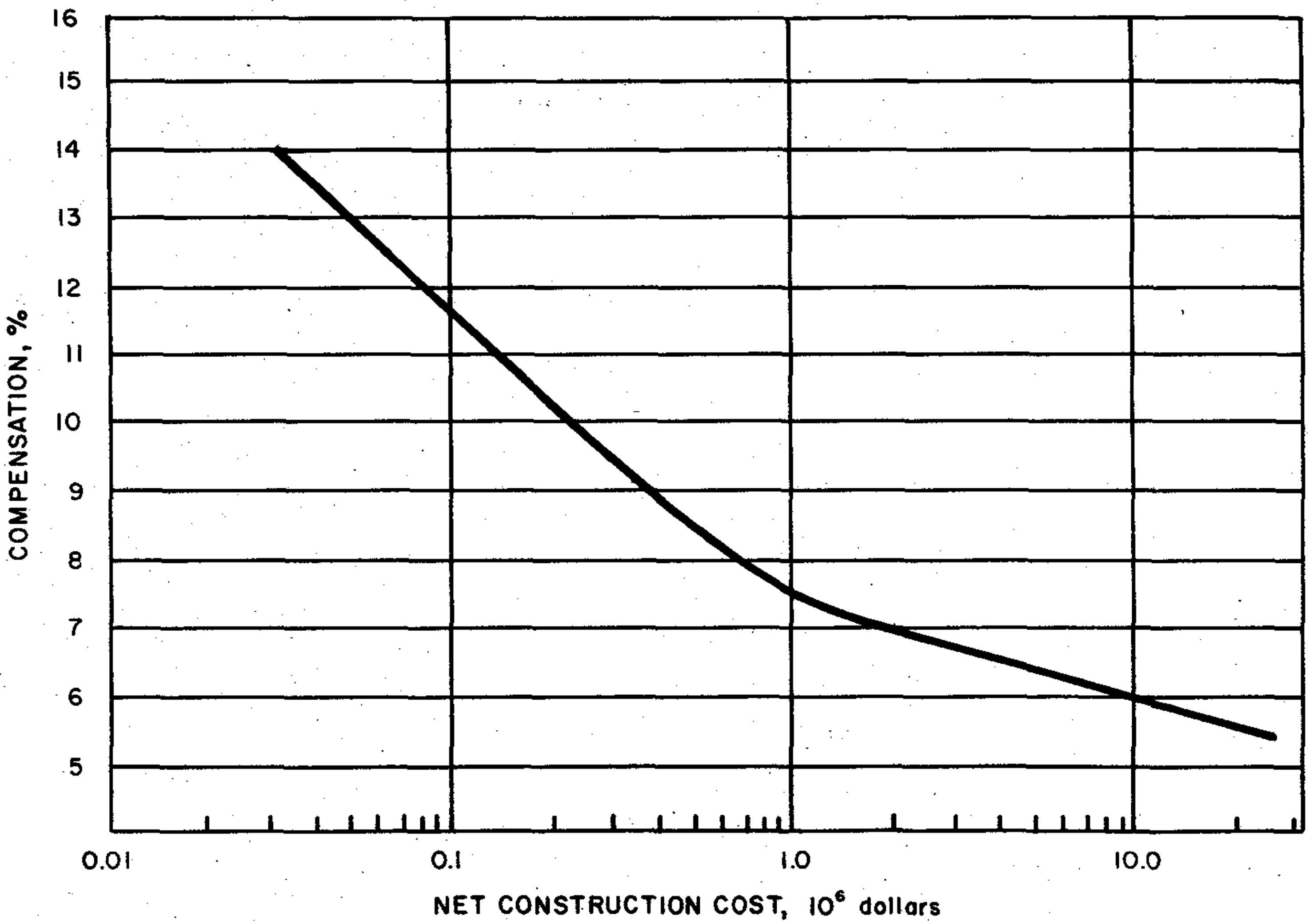
TABLE A-3 (Cont.)

Technology	0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Model Size, mgd (cu m/day)							
	Cost, thousands of dollars							
Powdered Activated Carbon (without regeneration)								
Added to EAAS	162	169	186	239	293	352	525	812
Full Application	-	1,131	1,144	1,330	1,543	1,862	2,653	-
Powdered Activated Carbon (with regeneration)								
Added to EAAS	1,556	1,583	1,609	1,649	1,729	1,756	2,022	2,252
Full Application	-	2,075	2,261	2,660	2,926	3,259	4,256	-
Ozonation	61	112	213	399	612	825	1,397	2,062

* These conditions are defined in the section on vacuum filtration.

<u>Source</u>: Figures A-2 to A-11 updated to 4th quarter 1979 dollars.

FIGURE A-12
ESTIMATED ENGINEERING COMPENSATION



SOURCE: Reference No. 40

operation of the textile mill, which is assumed to be 250 days/year.

Capital Costs The cost of money is assumed to be 15 percent of the total investment.

Depreciation Estimated lives for the components of each alternative are established and related to the investment costs to determine the estimated design life for the alternative. The installed cost is depreciated by the straight-line method for the calculated life.

Operation and Maintenance (O&M) Labor Estimates of the annual man-hours required to operate and maintain the various component technologies are presented in Table A-4 for each model plant size. The estimates are developed from information in References 49, 54 and 47. Man-hour requirements for laboratory, supervisory, administrative, and clerical activities also are presented in Table A-7 for the various levels of control. Total O&M labor includes the cost of operating and maintaining the component technologies and the cost of laboratory, supervisory, administrative, and clerical requirements. A productive work value of 6.5 hr/day/person, or 1950 hr/yr/person, is assumed and a rate of $20/hr is used as the total cost for wages, benefits, and payroll processing expenses when converting the hours to dollar costs.

Maintenance Materials Estimates of the costs of materials and parts needed to maintain each component technology are presented in Table A-5. The requirements are developed from information in References 39, 49, and 47 and from contact with equipment manufacturers. manufacturers.

Sludge Disposal The costs for sludge disposal include the hauling and deposition of dewatered sludge and exhausted activated carbon in an approved sanitary landfill. The costs are developed by estimating the quantities of sludge that are generated by the various component technologies, determining the total quantity of sludge requiring disposal for each treatment alternative, and applying an estimated unit cost (dollars/ton of sludge) applicable to the total quantity of sludge requiring disposal.

A matrix of the estimated sludge quantities by model size for the various component technologies is presented in Table A-6. Estimates of the sludge generated by screening are based on data collected from the textile industry in 1976 (4). Estimates for activated sludge are based on established typical generation rates available in References 20 and 24. A value of 150 mg of dry solids per liter of wastewater is used. The estimates for chemical coagulation/precipitation, multimedia filtration, and dissolved air flotation are based on the quantity of suspended solids removed by the technologies. Values are presented for the

TABLE A-4
ANNUAL OPERATION AND MAINTENANCE MAN-HOURS

Technology	Model Size, mgd (cu m/day) 0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Hours to Operate & Maintain Technology							
Screening	560	560	580	590	600	600	640	750
Equalization	460	520	620	720	780	840	950	1,050
Activated Sludge	660	970	1,450	2,230	2,900	3,550	5,000	6,500
Chemical Coagulation/ Precipitation	126	192	298	482	640	810	1,180	1,580
Vacuum Filtration	2,270	2,310	2,360	2,510	2,685	2,900	3,555	4,425
Multimedia Filtration	56	113	225	450	625	780	1,150	1,525
Dissolved Air Flotation	144	221	325	515	675	830	1,220	1,610
Granular Activated Carbon (without regeneration)	46	80	145	280	400	550	950	1,430
Granular Activated Carbon (with regeneration)	250	400	700	1,250	1,850	2,400	4,100	6,350
Powdered Activated Carbon (without regeneration)								
Added to EAAS	1,810	1,850	2,260	2,645	2,820	2,950	3,285	3,450
Full Application	-	5,375	5,905	6,780	7,633	8,490	11,400	-

TABLE A-4 (Cont.)

Technology	Model Size, mgd (cu m/day) 0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Hours to Operate & Maintain Technology							
Powdered Activated Carbon (with regeneration)								
Added to EAAS	1,840	1,916	2,410	3,005	3,420	3,850	5,085	6,450
Full Application	-	5,441	6,055	7,140	8,233	9,390	13,200	-
Ozonation	840	940	1,100	1,240	1,340	1,450	1,600	1,800
Regulation	Hours for Laboratory, Supervisory, Administrative, & Clerical Requirements							
BAT	15	65	100	440	600	750	1,100	1,500
PSES, NSPS, PSNS	35	125	210	830	1,150	1,505	2,400	3,370

Source: References 30 and 83.

TABLE A-5
ANNUAL MAINTENANCE MATERIALS COSTS

Technology	Model Size, mgd (cu m/day)							
	0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Cost, thousands of dollars							
Activated Sludge	2,300	3,900	7,100	13,200	19,500	25,500	43,500	63,000
Chemical Coagulation/ Precipitation	1,500	3,300	7,500	18,000	27,800	42,800	84,000	136,500
Vacuum Filtration	4,400	5,400	7,500	11,300	15,000	19,500	31,500	46,500
Multimedia Filtration	3,900	6,800	11,700	21,000	30,000	40,500	64,500	91,500
Dissolved Air Flotation	1,800	3,200	5,700	11,100	16,500	22,500	36,000	54,000
Granular Activated Carbon (without regeneration)	900	2,000	4,400	10,200	16,500	25,500	49,500	82,500
Powdered Activated Carbon (without regeneration)								
Add to EAAS	1,800	1,800	2,600	3,400	1,400	2,100	5,400	6,000
Full Application	-	15,200	18,200	24,700	31,000	40,200	63,000	-
Powdered Activated Carbon (with regeneration)								
Add to EAAS	1,900	2,100	3,300	5,200	4,500	6,700	14,600	24,400
Full Application	-	15,500	19,000	26,500	34,000	44,800	72,200	-
Ozonation	300	600	1,800	3,500	5,600	8,700	16,700	27,600

Source: References 30, 37, 38, and 83 updated to 4th quarter 1979 dollars.

TABLE A-6
ESTIMATED ANNUAL SLUDGE QUANTITIES FOR COMPONENT TECHNOLOGIES

Technology	Model Size, mgd (cu m/day) 0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Dewatered Sludge, tons							
Screening	25	50	100	240	380	570	960	1,300
Activated Sludge	70	150	320	740	1,200	1,800	3,400	5,600
Chemical Coagulation/Precipitation								
Condition 1*	870	1,920	4,360	10,460	17,440	26,160	52,320	87,200
Condition 2	335	735	1,670	4,010	6,690	10,030	20,060	33,430
Condition 3	45	98	223	535	891	1,337	2,673	4,435
Condition 4	32	71	162	391	651	976	1,952	3,253
Condition 5	24	52	118	284	472	709	1,417	2,361
Dissolved Air Flotation	2	5	11	26	44	66	132	219
Multimedia Filtration								
Condition 1*	13	28	63	150	250	375	750	1,250
Condition 2	6	14	31	75	125	188	375	625
Condition 3	2	3	8	19	31	47	94	156
Granular Activated Carbon (without regeneration)	120	270	620	1,500	2,500	3,700	7,400	12,400
Powdered Activated Carbon (without regeneration)								
Add to EAAS	34	75	171	411	685	1,028	2,055	3,425
Full Application	-	213	471	1,131	1,865	2,798	5,415	-
Powdered Activated Carbon (with regeneration)								
Add to EAAS	-	-	-	-	-	-	-	-
Full Application	-	50	100	240	380	570	960	-

* These conditions are defined in the section on vacuum filtration.

Source: Technical Contractor Engineering Analysis

TABLE A-7
ESTIMATED ANNUAL POWER REQUIREMENTS FOR COMPONENT TECHNOLOGIES

Technology	Model Size, mgd (cu m/day) 0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Power, thousands of kilowatt-hours							
Screening	4.2	5.6	10.0	23.0	39.0	58.0	115.0	195.0
Equalization	4.8	4.8	5.8	11.0	18.0	30.0	62.0	104.0
Activated Sludge	190.0	280.0	430.0	670.0	870.0	1,070.0	1,530.0	2,000.0
Chemical Coagulation/ Precipitation	9.0	19.8	45.0	108.0	180.0	270.0	540.0	900.0
Vacuum Filtration								
Condition 1*	20.4	38.3	68.9	140.0	212.0	288.0	577.0	990.0
Condition 2	20.4	20.4	33.2	64.0	100.0	135.0	232.0	408.0
Condition 3	20.4	20.4	20.4	20.4	20.4	25.5	48.5	68.9
Condition 4	20.4	20.4	20.4	20.4	20.4	23.0	38.3	51.0
Condition 5	20.4	20.4	20.4	20.4	20.4	20.4	25.5	43.4
Multimedia Filtration	1.2	2.6	6.0	14.4	24.0	36.0	72.0	120.0
Dissolved Air Flotation	35.0	39.0	59.0	110.0	155.0	205.0	310.0	375.0
Granular Activated Carbon (without regeneration)	6.0	13.0	30.0	70.0	120.0	180.0	350.0	600.0
Granular Activated Carbon (with regeneration, kwh)	12.0	26.0	65.0	140.0	235.0	355.0	700.0	1,200.0
Granular Activated Carbon (with regeneration, therm/yr)	3.3	6.9	15.4	38.5	65.0	97.0	185.0	330.0

* These conditions are defined in the section on vacuum filtration.

TABLE A-7 (Cont.)

Technology	0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Model Size, mgd (cu m/day)							
	Power, thousands of kilowatt-hours							
Powdered Activated Carbon (without regeneration)								
Add to EAAS	16.1	20.1	57.7	103.6	165.2	318.3	575.8	809.7
Full Application	-	93.0	183.0	356.0	606.0	920.0	1,713.0	-
Powdered Activated Carbon (with regeneration, kwh)								
Add to EAAS	26.1	34.1	87.7	163.6	285.2	488.3	875.8	1,319.7
Full Application	-	107.0	213.0	416.0	726.0	1,090.0	2,013.0	-
Powdered Activated Carbon (with regeneration, therms/yr)								
Add to BPT	344.0	352.0	361.0	378.0	404.0	430.0	482.0	559.0
Full Application	-	352.0	361.0	378.0	404.0	430.0	482.0	-
Ozonation	175.0	385.0	875.0	2,101.0	3,502.0	5,252.0	10,505.0	17,508.0

Source: References 36, 41, 45, 46, 47, 48, 49, 50, and 83 updated to 4th quarter 1979 dollars.

conditions noted earlier under the discussion of vacuum filtration. It is assumed that the solids concentration for all sludges is 20 percent by weight. The estimates for the quantity of spent granular activated carbon are based on the carbon containing its own weight plus an equivalent weight of water. When powdered activated carbon is regenerated, it is assumed that only screening operation sludges are generated.

The estimated costs to haul and deposit dewatered sludge in an approved sanitary landfill are graphically presented in Figure A-13. The curve is developed from information obtained during the survey of the textile industry and represents the best fit polynomial for the data points noted.

<u>Energy and Power</u> The costs for energy and power represent the expense of purchasing electricity and fuel to operate equipment and facilities. The costs are developed by estimating power requirements for the various component technologies for each model size and applying unit costs for electric power and fuel. It was assumed that fuel oil would be used for the regeneration of activated carbon. All other treatment components were assumed to be powered by electricity.

A matrix of the estimated power requirements for the various component technologies is presented in Table A-7. The values are established from information in References 55, 51, 56, 57, 58, 59, 60, 50, and 47. It is assumed that all equipment, with the exception of the vacuum filters, will operate 24 hr/day and 300 days/yr. Vacuum filters are sized to operate 10 hr/day. An electric motors efficiency of 88 percent is assumed.

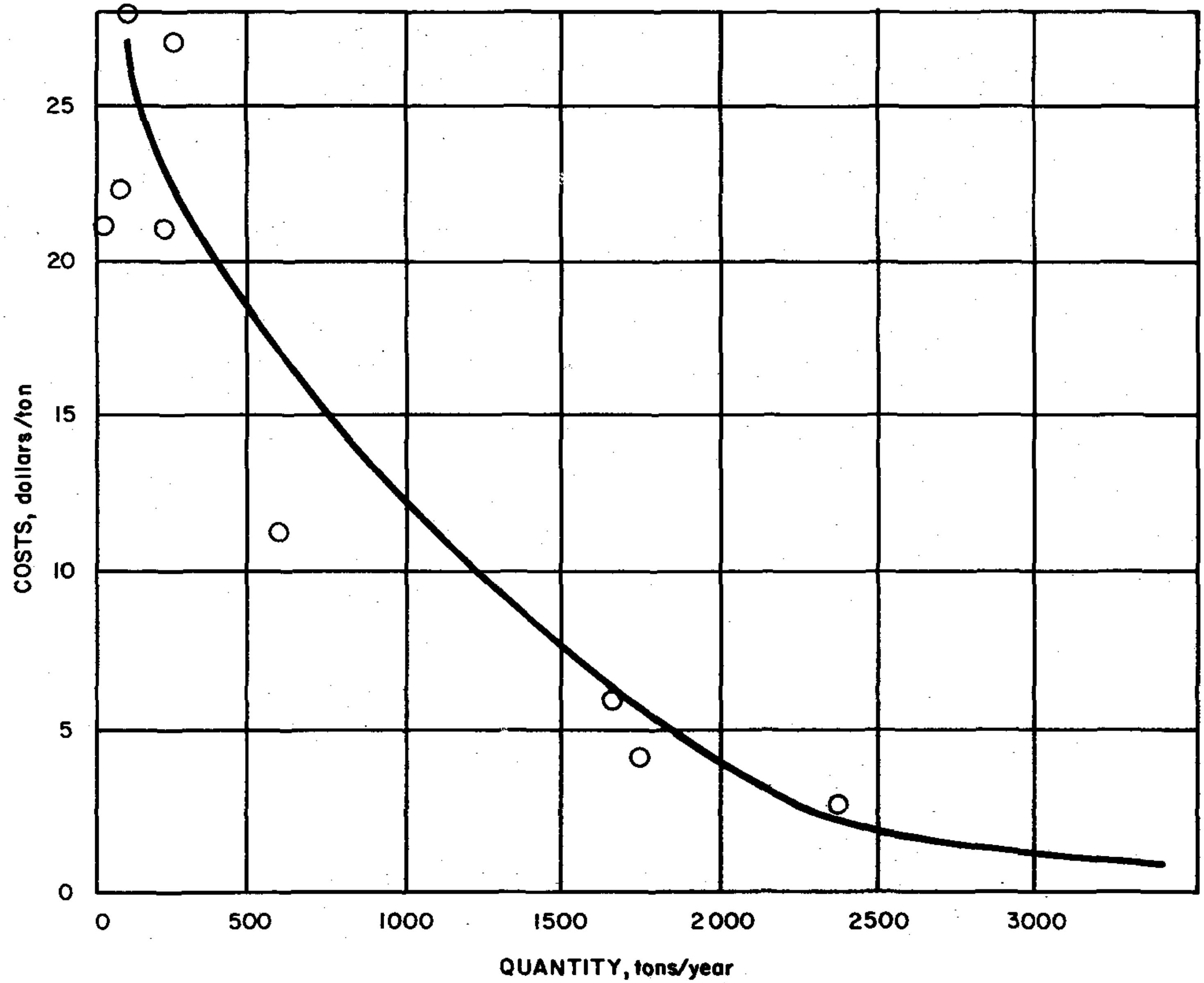
For most of the component technologies, energy consumption is based solely on flow. For vacuum filtration, flow (quantity of sludge) as well as sludge characteristics (such as solids content and dewaterability) affects energy consumption.

In converting power requirements to dollars, the cost for electricity is assumed to be 3.4 cents/kwh. The cost represents a typical value taken from the industry survey responses for the southeastern region of the U.S. updated to represent 4th quarter 1979 dollars. This region was chosen because the majority of the country's textile mills are located there (see Table III-1).

Fuel oil is assumed to cost 33 cents/therm. This cost, which represents 4th quarter 1979 dollars, is taken from the industry survey responses and Reference 46. It also represents costs for the southeastern region of the U.S.

<u>Chemicals</u> The costs for the chemicals required to operate the various component technologies are given by model size in Table A-8. They are developed by applying 4th quarter 1979 unit costs to estimated quantities of the chemicals required.

FIGURE A-13
COST FOR HAULING AND DISPOSING DEWATERED SLUDGE



SOURCE: EPA Industry Survey, 1977; updated to 4th quarter 1979 dollars

TABLE A-8
ESTIMATED ANNUAL CHEMICAL COSTS FOR COMPONENT TECHNOLOGIES

Technology	Model Size, mgd (cu m/day) 0.05 (189)	0.11 (416)	0.25 (946)	0.60 (2,271)	1.0 (3,785)	1.5 (5,678)	3.0 (11,355)	5.0 (18,925)
	Cost, thousands of dollars							
Chemical Coagulation/Precipitation								
Condition 1 (1000 mg/l alum)	15.0	33.0	75.0	180.0	300.0	450.0	900.0	1,500.0
Condition 2 (1000 mg/l alum)	15.0	33.0	75.0	180.0	300.0	450.0	900.0	1,500.0
Condition 3 (100 mg/l alum)	1.5	3.3	7.5	18.0	30.0	45.0	90.0	150.0
Condition 4 (100 mg/l alum)	1.5	3.3	7.5	18.0	30.0	45.0	90.0	150.0
Condition 5 (100 mg/l alum)	1.5	3.3	7.5	18.0	30.0	45.0	90.0	150.0
Multimedia Filtration	0.2	0.4	0.9	2.3	3.8	5.7	11.3	18.8
Granular Activated Carbon (without regeneration)	61.5	136.5	310.5	667.5	1,237.5	1,857.0	3,712.5	6,187.5
Granular Activated Carbon (with regeneration)	5.0	11.0	24.8	59.4	99.0	148.5	297.0	495.0
Powdered Activated Carbon (without regeneration)								
Add to EAAS	10.5	23.0	52.3	125.6	209.3	313.9	627.9	1,046.5
Full Application	-	24.1	54.7	131.4	218.9	328.4	656.9	-
Powdered Activated Carbon (with regeneration)								
Add to EAAS	2.0	4.3	9.8	23.5	39.2	58.7	117.5	195.8
Full Application	-	5.4	12.2	29.3	48.8	73.2	146.4	-

Source: Reference 52.

For chemical coagulation, alum is the coagulant of choice based on its proven effectiveness and reasonable cost. A dosage of 1000 mg/l (as alum) is was assumed for coagulation conditions 1 and 2, and a dosage of 100 mg/l was assumed for conditions 3, 4, and 5. These coagulation conditions are defined earlier in this section under the discussion of vacuum filtration. For multimedia filtration, 1 mg/l of polymeric filter aid is included whenever filtration is not preceded by chemical coagulation. For granular activated carbon, an exhaustion rate of 0.66 kg/cu m (5,500 lb/mil gal) is assumed when regeneration is practiced. An exhaustion rate of 0.14 kg/cu m (1,200 lb/mil gal) is used for powdered activated carbon.

The unit costs used in developing the chemical costs are as follows:

Chemical	Unit Cost
Alum (technical)	\$0.26-0.28 per kg (\$0.12-0.13 per lb)
Polymer	\$3.30 per kg (\$1.50 per lb)
Carbon (granular)	\$1.65 per kg (\$0.75 per lb)
Carbon (powdered)	\$1.10 per kg (\$0.50 per lb)

Monitoring Monitoring costs include outside laboratory analytical charges and time for reporting results to regulatory agencies. The costs associated with collecting and delivering samples are included under operation and maintenance labor.

Separate monitoring costs were developed for direct and indirect dischargers. Direct dischargers were assumed to sample in order to comply with a discharge permit. This entails regular sampling of influent and effluent waste streams and receiving waters. Samples for the conventional pollutants are collected twice per week, and nonconventional pollutants are collected once per week. Samples for toxic pollutants are collected semiannually. Indirect dischargers are assumed to sample in order to comply with the local sewer ordinances. Conventional and nonconventional pollutants are collected weekly and toxic pollutants semiannually.

Laboratory cost estimates are based on commercial laboratory price lists (53, 61, 62, 63, 64, 65, 66, and 67) updated to 4th Quarter 1979 dollars. Reporting costs were based on \$20/hr and allowed 1 hr/week for compiling data plus 8 hr/month for preparing reports.

Annual monitoring costs are based on a complete program for major direct and indirect dischargers. As mentioned under "Monitoring Equipment," many of the larger facilities have existing programs that would result in considerably less additional cost in this area. The monitoring frequencies are assumed for cost estimation purposes only and are not intended to provide a model for compliance monitoring.

CALCULATION OF MODEL PLANT COSTS

Example Calculation

Using the component investment and annual costs presented in Tables A-6 through A-8 and the methodology presented in Figure A-1 the costs for several possible treatment options can be calcualted for each model plant. As an example of the use of the methodology model will costs for a 470 kkg wool finishing model mill are presented in Table A-9 for four treatment options which are, as follows:

BAT Option 2 Multimedia FIltration

BAT Option 3 Chemical Coagulation followed by Multimedia Filtration

BAT Option 4 Chemical Coagulation, Multimedia Filtration and Granular Activated Carbon

Cost Curves

In the analysis of treatment alternatives for regulatory options selection costs were calculated for a sufficient range of model sizes to plot curves of costs versus model flow. These cost curves relating investment and annual costs to flow for each of the treatment alternatives are presented in Figures A-14 through A-32. As noted in earlier discussion, the curves represent the best fit of the cost estimates developed for the various model plants. The curves provide the means for quickly estimating the investment and annual costs for a range of treatment plants (based on flow size) covering existing and anticipated new facilities.

The following index is provided as an aid to the user in locating specific curves.

Figure	Treatment Alternatives
A-14	Screening and Extended Aeration Activated Sludge
A-15	Chemical Coagulation/Sedimentation and Multimedia Filtration
A-16	Multimedia Filtration
A-17	Chemical Coagulation/Sedimentation and Multimedia Filtration
A-18	Multimedia Filtration and Granular Activated Carbon
A-19	Chemical Coagulation/Sedimentation, Multimedia Filtration, and Granular Activated Carbon
A-20	Ozonation
A-21	Chemical Coagulation/Sedimentation

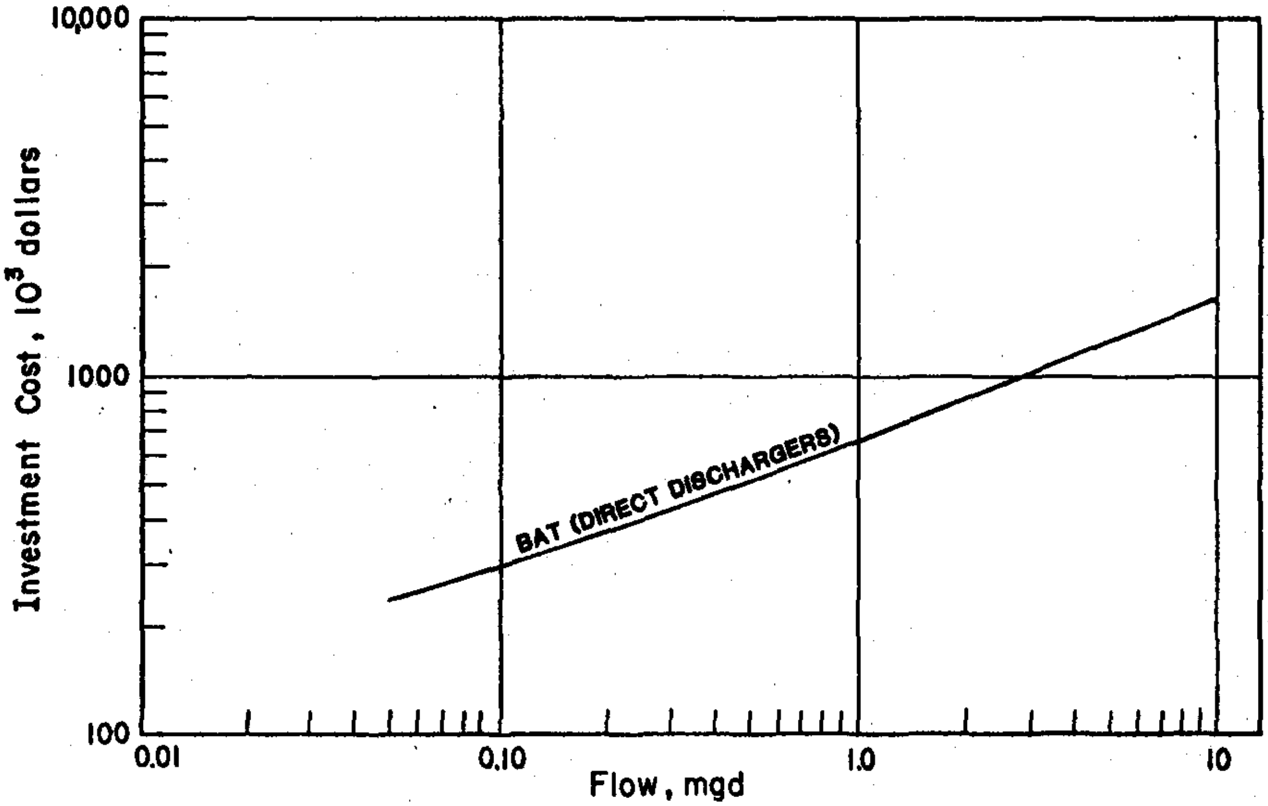
TABLE A-9
MODEL PLANT CONTROL COST SUMMARY
BAT: 5,678 CU M/DAY (1.5 MGD) MODEL

Subcategory: WOOL FINISHING

Daily Production Capacity: 18,700 kg

	BAT Option		
	2	3	4
INVESTMENT COSTS	Cost, thousands of dollars		
Chemical Coagulation			
Equipment	66.5	66.5	66.5
Construction	266.0	266.0	266.0
Vacuum Filtration			
Equipment	27.0	27.0	27.0
Construction	50.1	50.1	50.1
Multimedia Filtration			
Equipment	-	69.2	69.2
Construction	-	276.6	276.6
Granular Carbon			
Equipment	-	-	718.2
Construction	-	-	718.2
Ozonation			
Equipment	-	-	-
Construction	-	-	-
Powdered Carbon			
Equipment	-	-	-
Construction	-	-	-
Monitoring	20.0	20.0	20.0
Engineering	42.0	66.9	178.1
Contingencies	64.4	116.3	331.8
Total Investment	536.0	958.6	2,721.7
ANNUAL COSTS			
Capital	80.4	143.9	408.3
Depreciation	33.0	59.4	141.3
Useful Life (years)	15	15	18
O&M Labor	89.2	104.8	152.8
Employees (persons)	3.0	3.5	5.1
Maintenance	62.3	102.8	128.3
Sludge Disposal	12.2	12.8	12.8
Energy & Power	10.0	11.2	55.2
Chemicals: Polymer	-	-	-
Alum	45.0	45.0	45.0
Carbon	-	-	148.5
Monitoring	40.5	40.5	40.5
Total Annual	372.6	520.4	1,132.7

FIGURE A-14
ALTERNATIVE A: SCREENING AND EXTENDED AERATION ACTIVATED SLUDGE
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



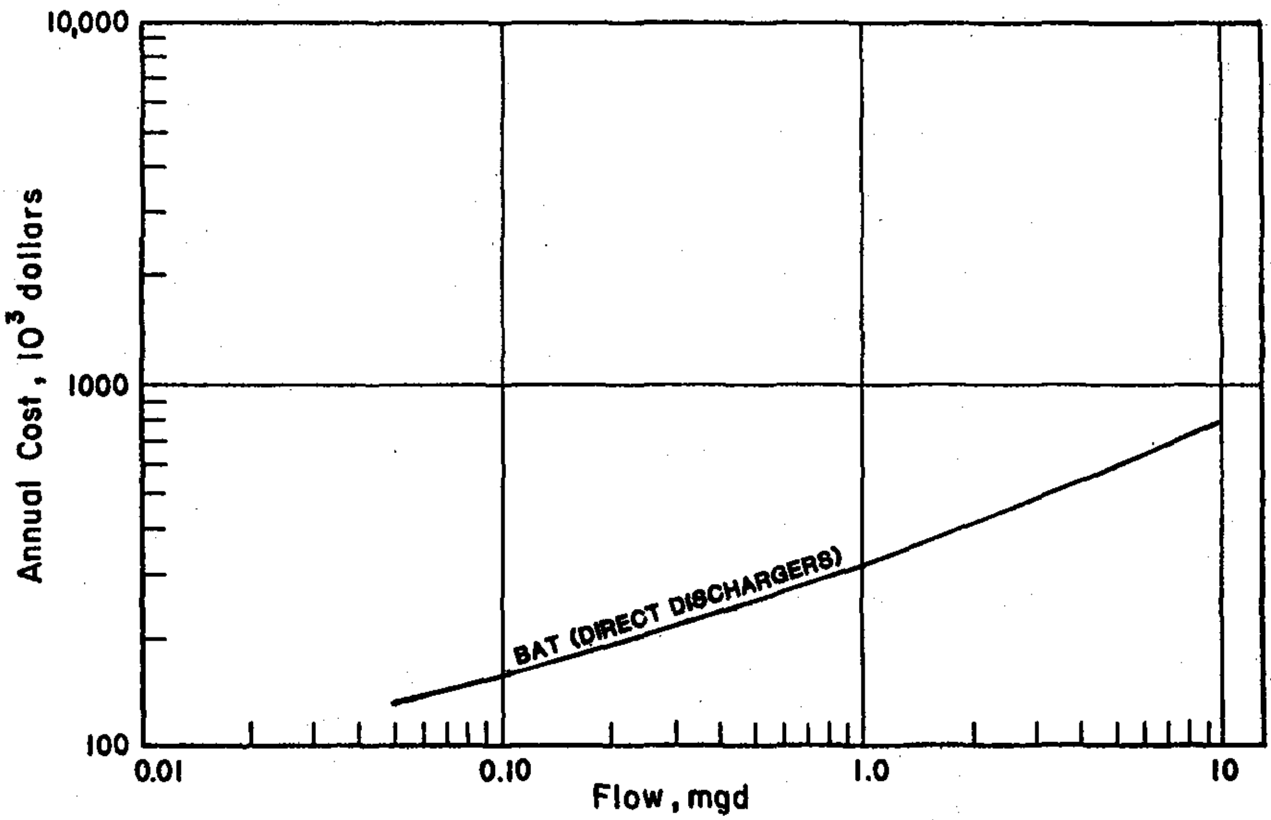
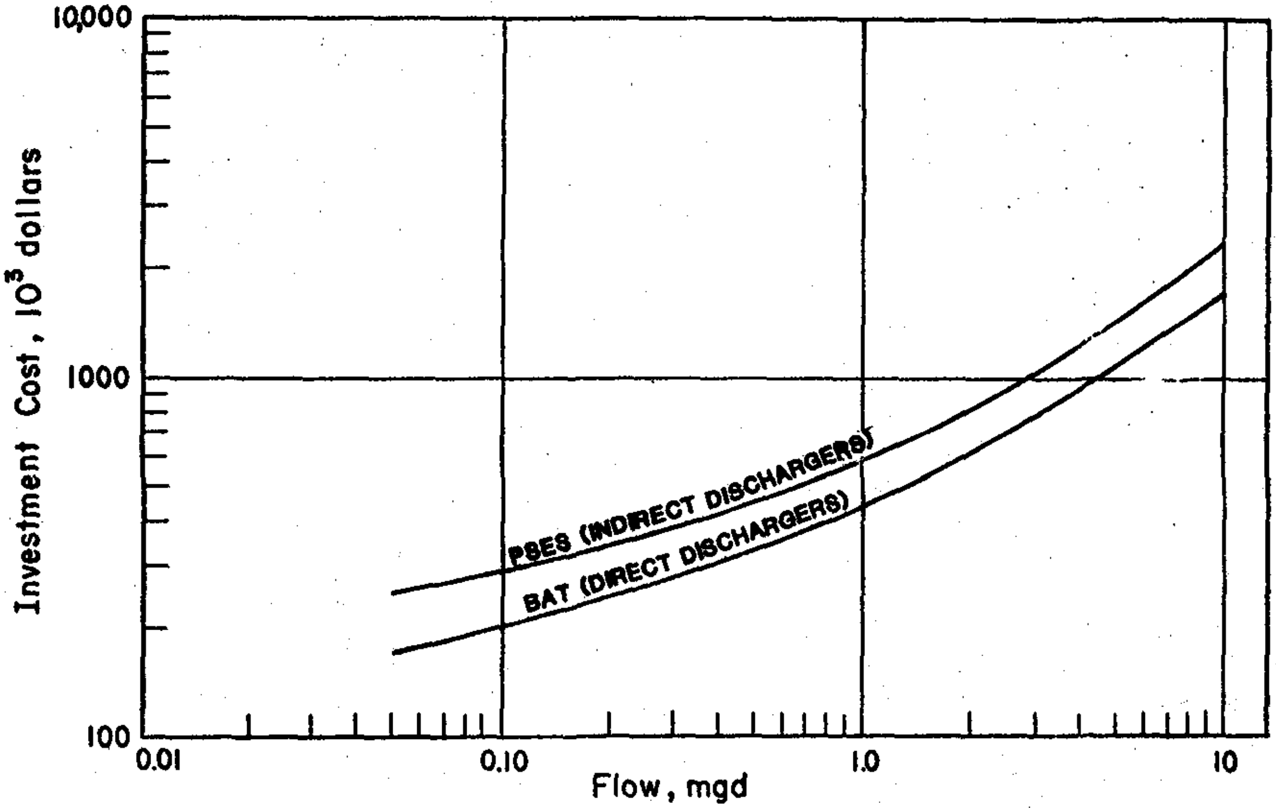


FIGURE A-15
ALTERNATIVE B: CHEMICAL COAGULATION/SEDIMENTATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



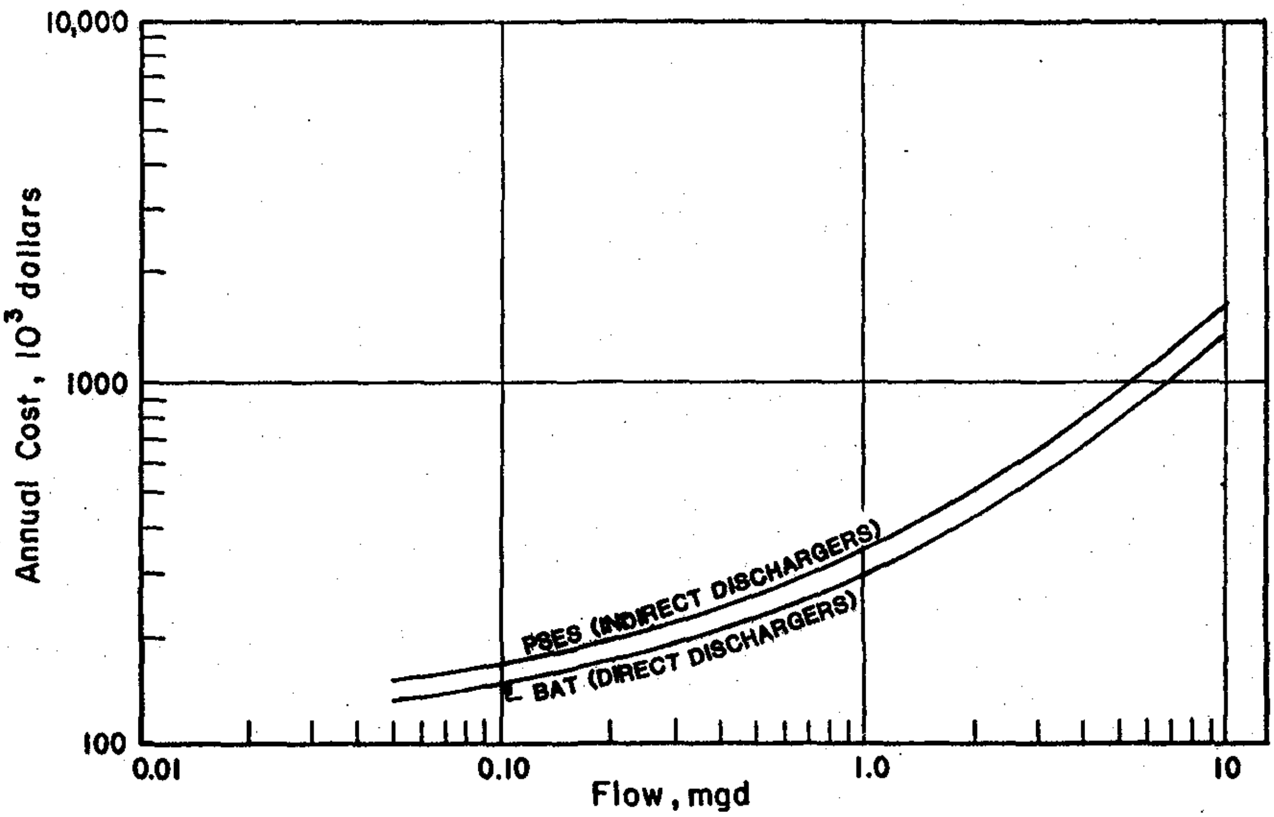
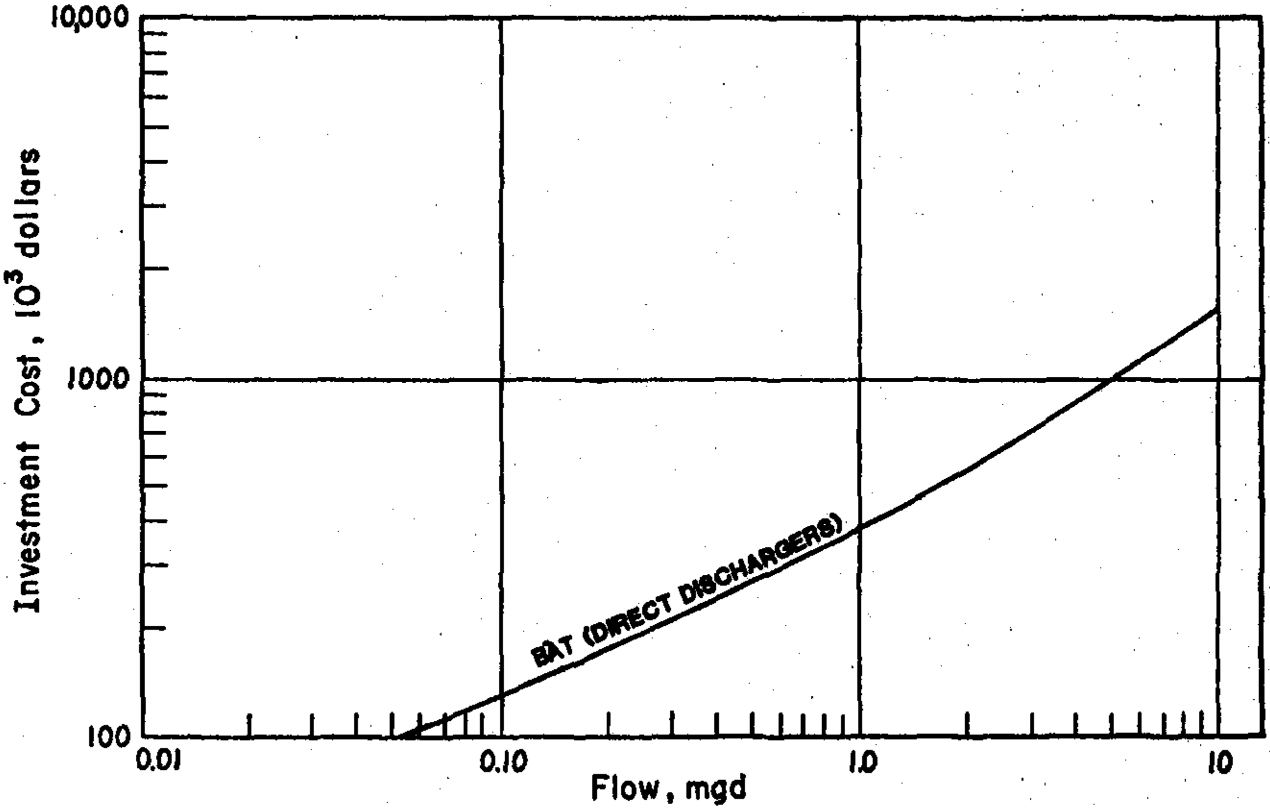


FIGURE A-16
ALTERNATIVE C: MULTIMEDIA FILTRATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



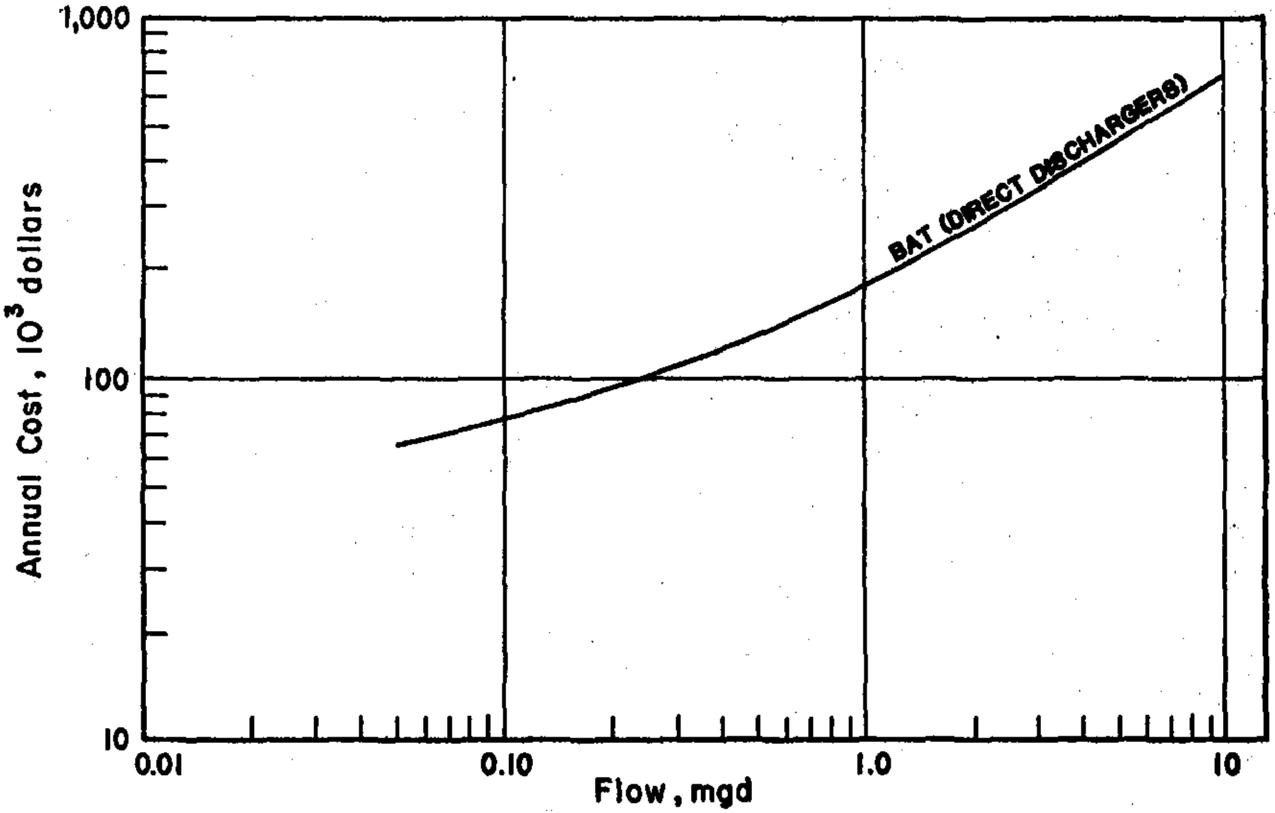
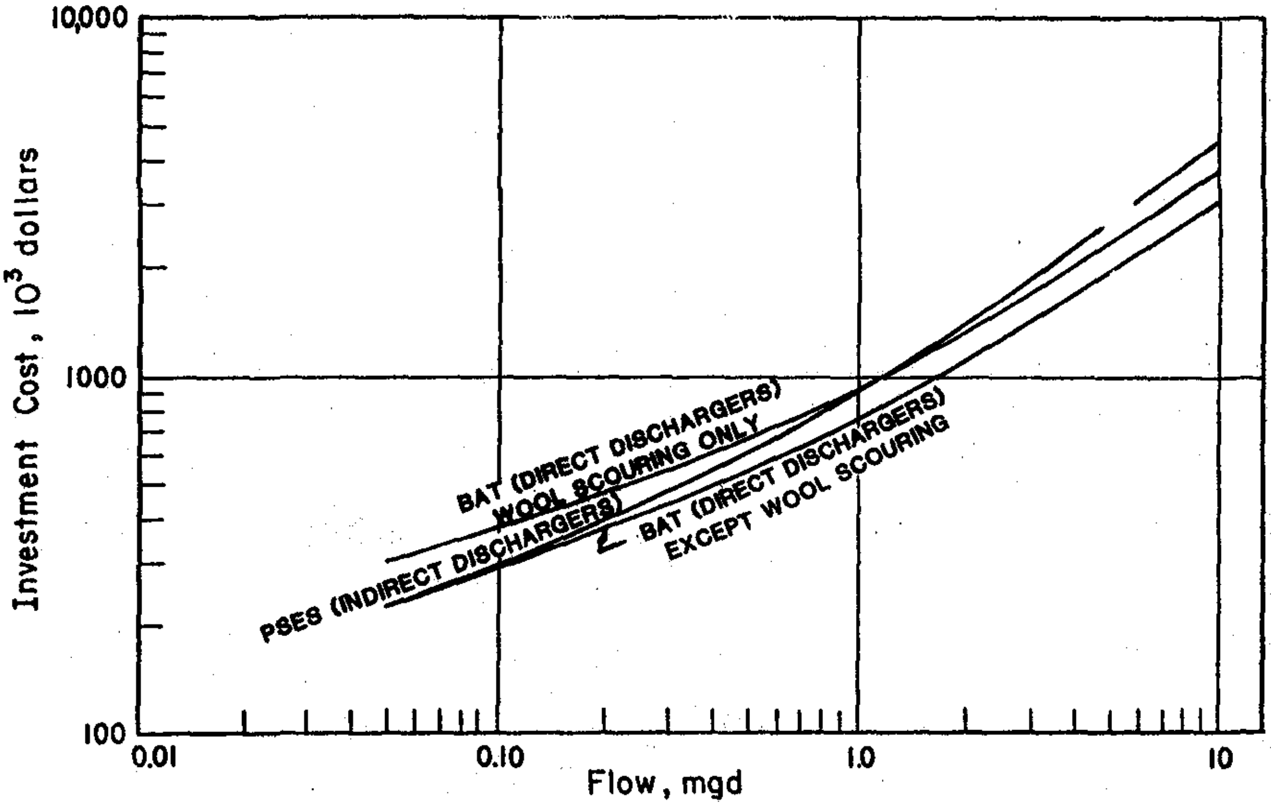


FIGURE A-17
ALTERNATIVE D: CHEMICAL COAGULATION/SEDIMENTATION
AND MULTIMEDIA FILTRATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



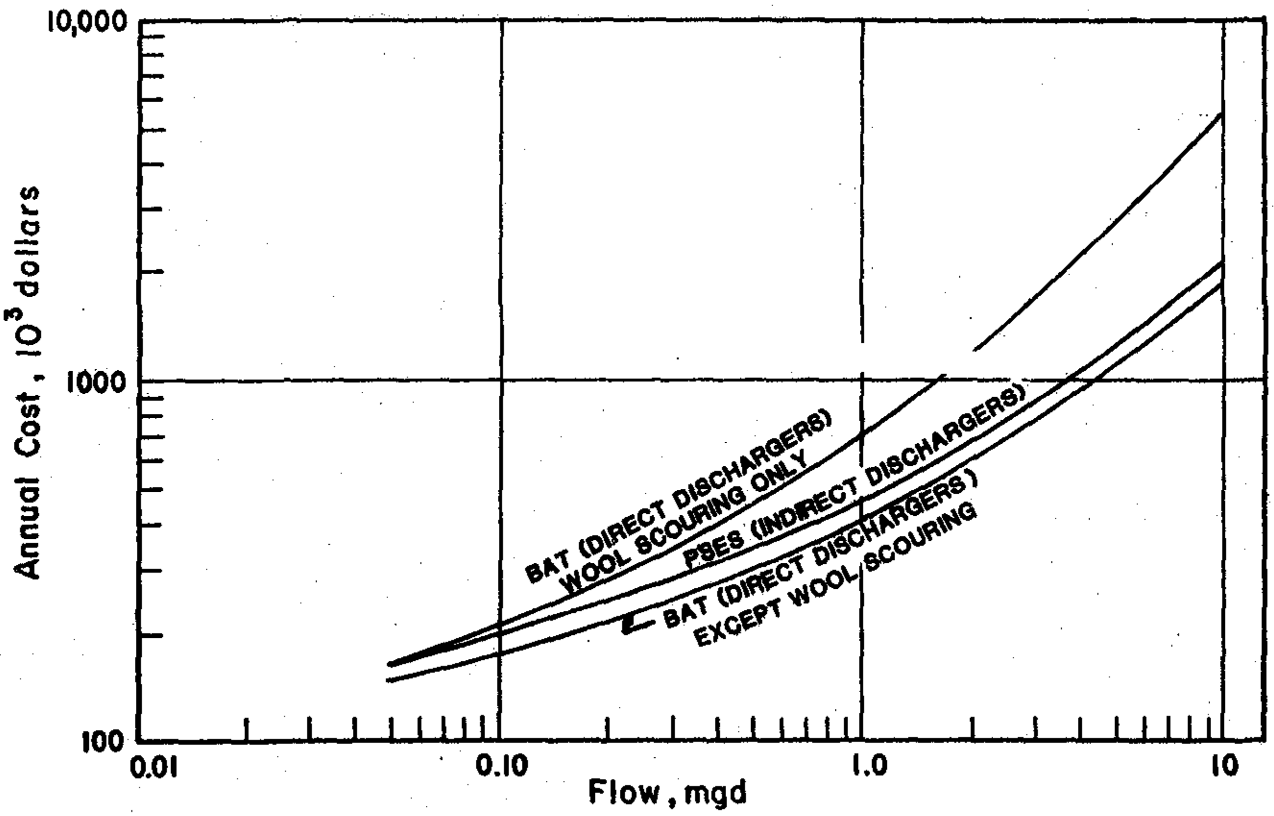
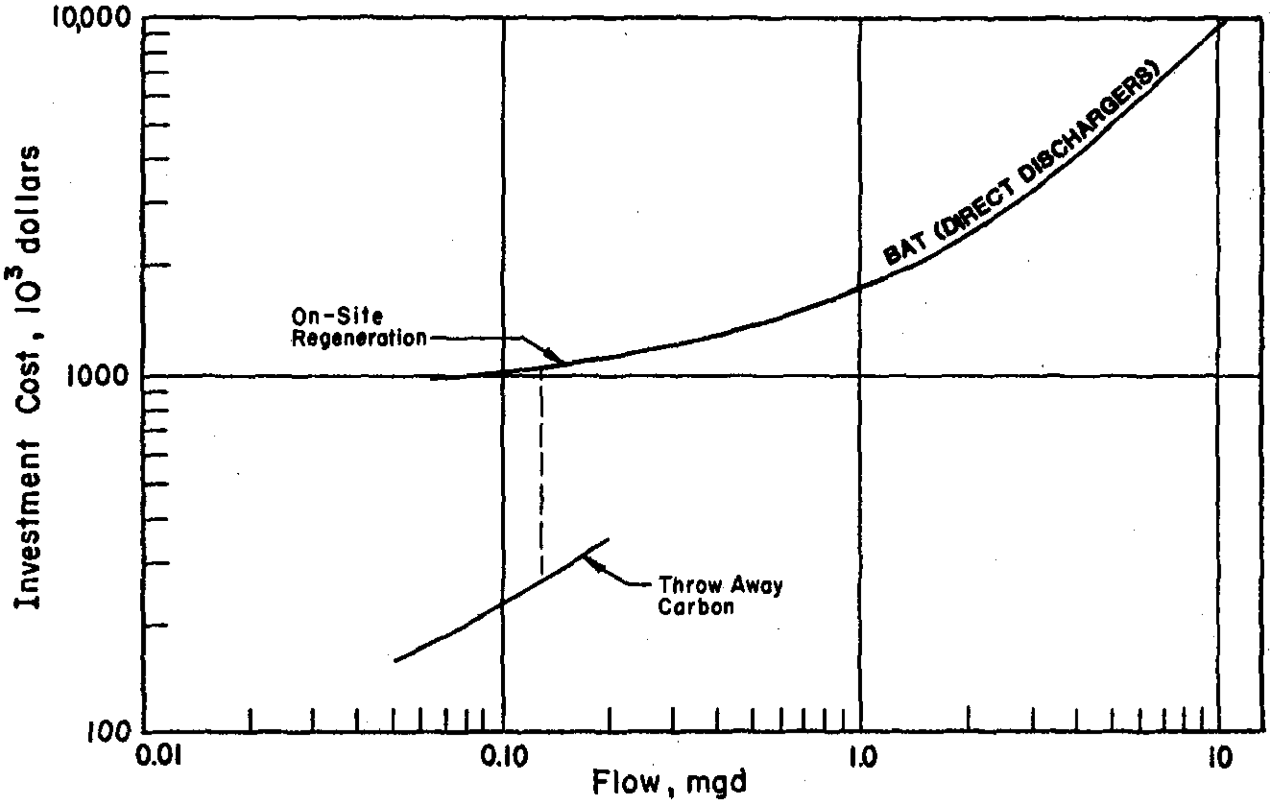


FIGURE A-18
ALTERNATIVE E: MULTIMEDIA FILTRATION AND GRANULAR ACTIVATED CARBON
INVESTMENT AND ANNUAL COST FOR EXISTING MILLS



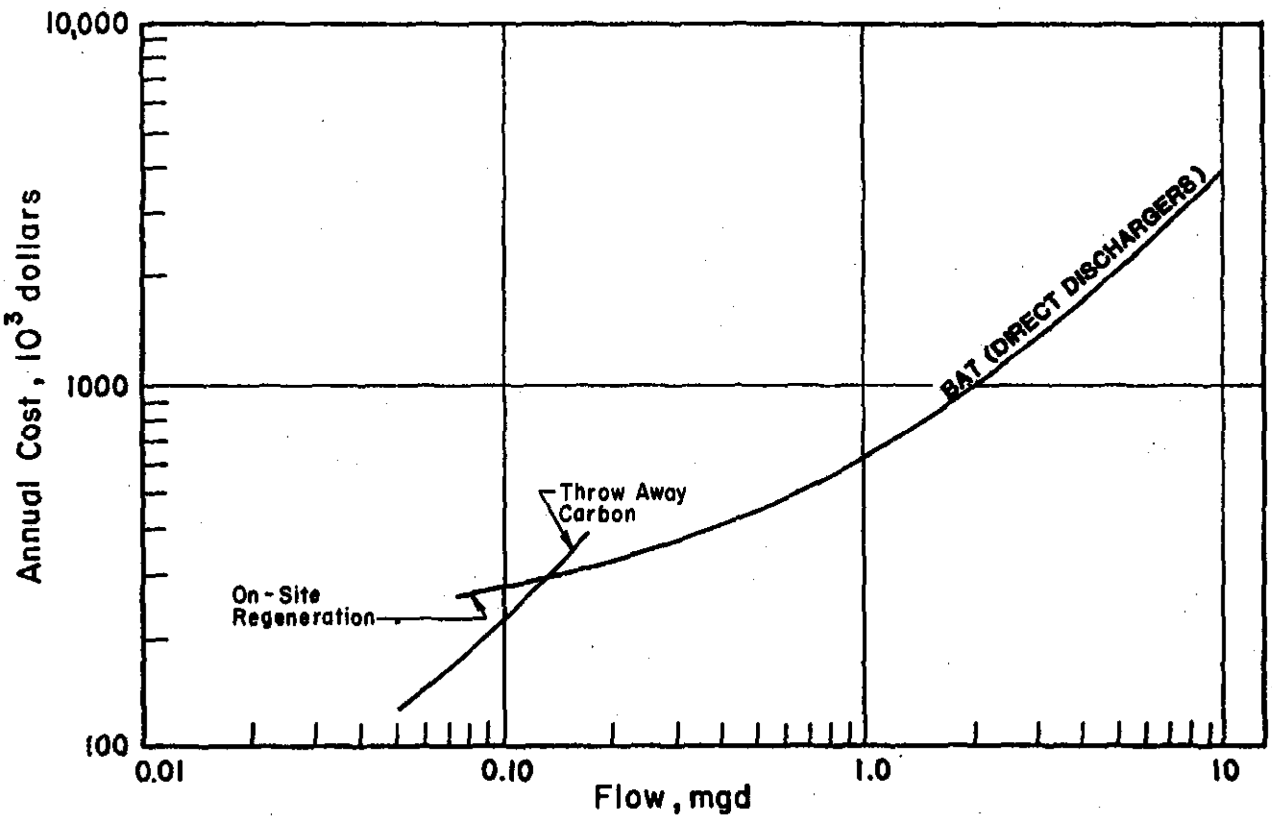
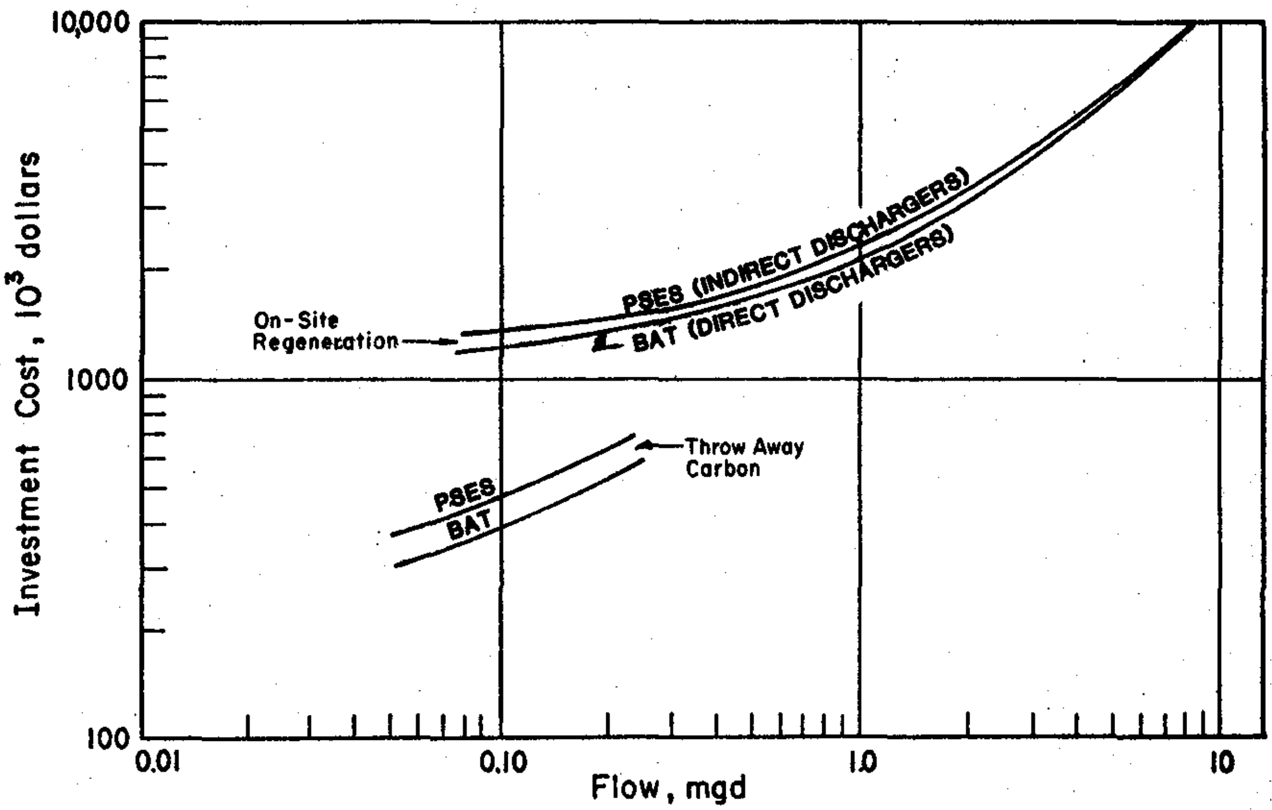


FIGURE A-19
ALTERNATIVE F: CHEMICAL COAGULATION/SEDIMENTATION, MULTIMEDIA FILTRATION, AND GRANULAR ACTIVATED CARBON
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



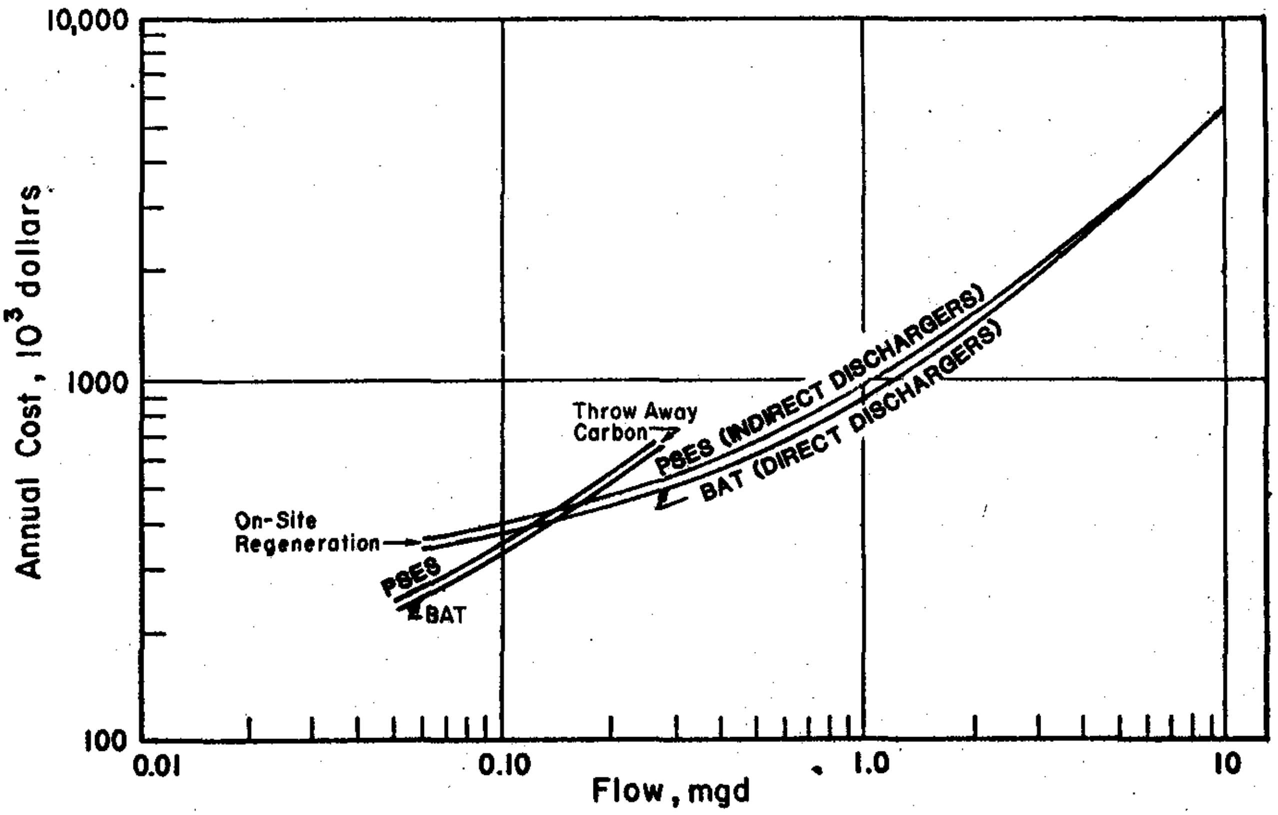
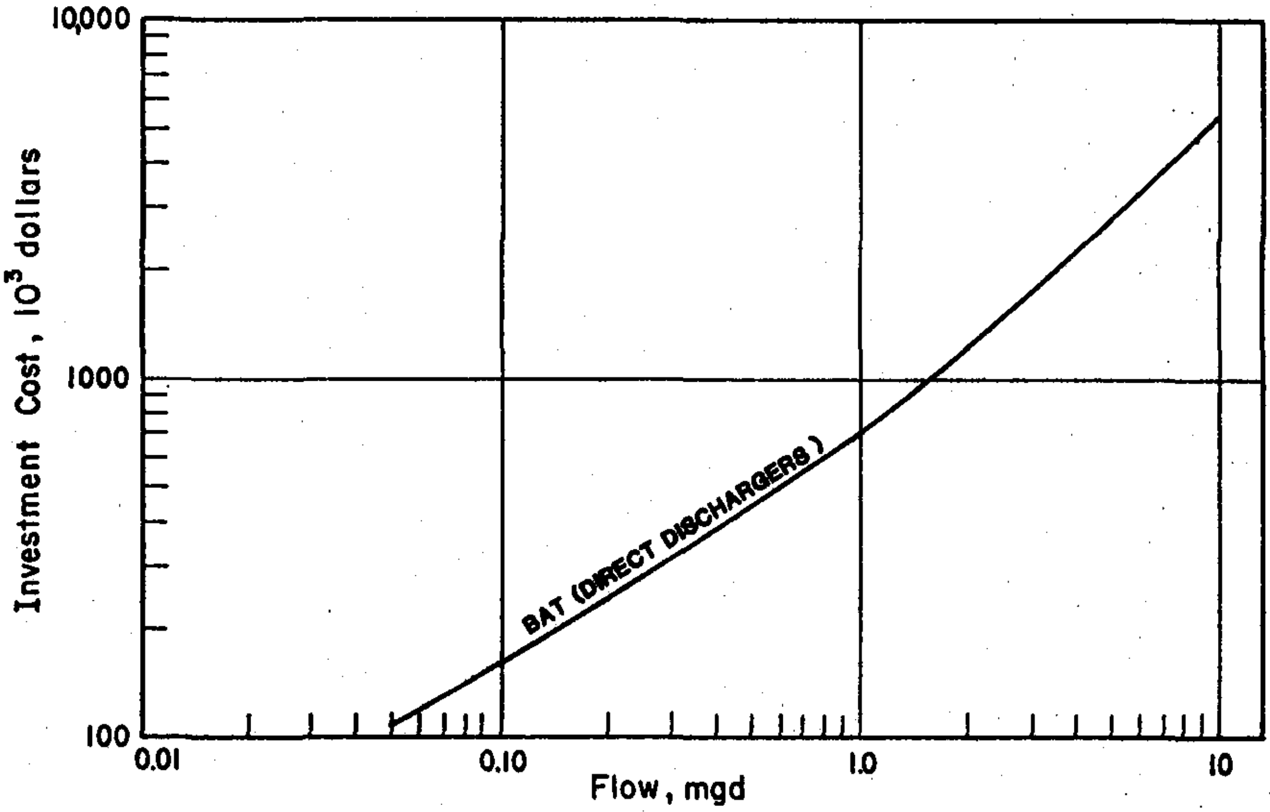


FIGURE A-20
ALTERNATIVE G: OZONATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



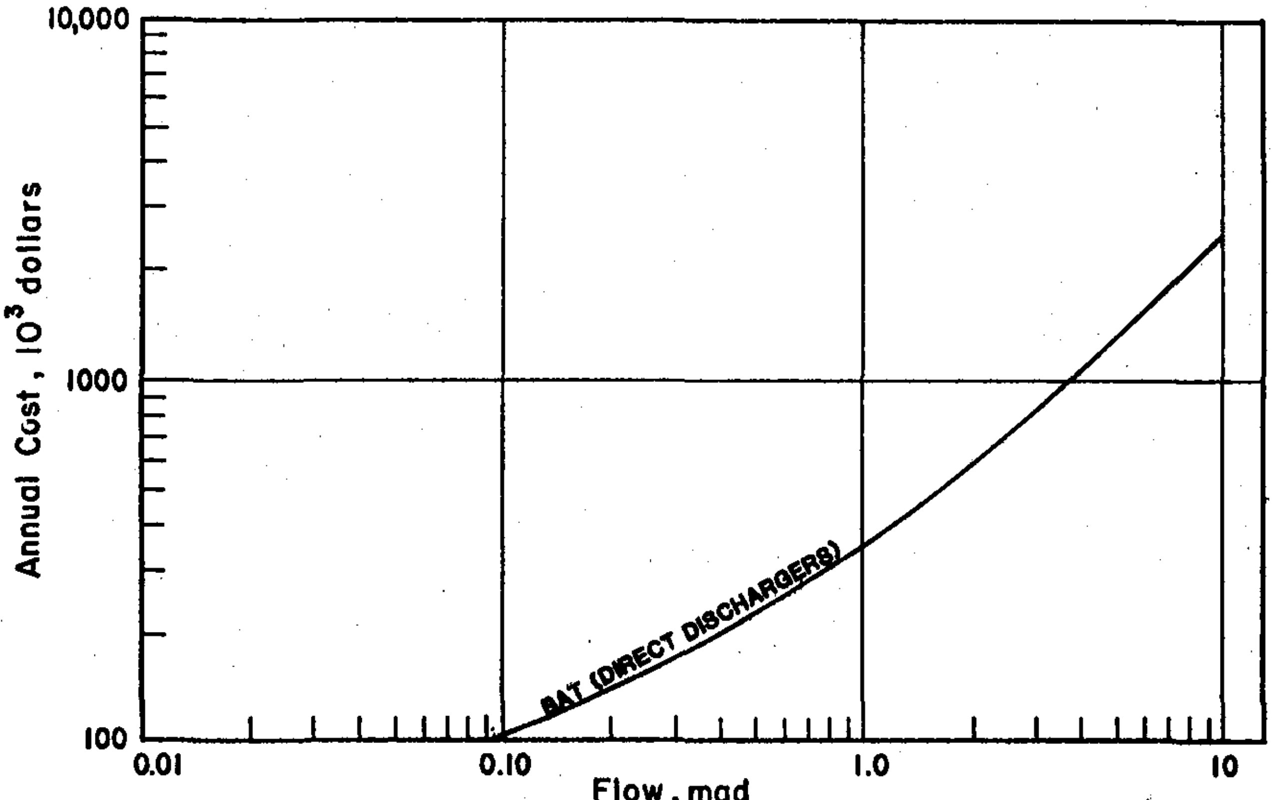
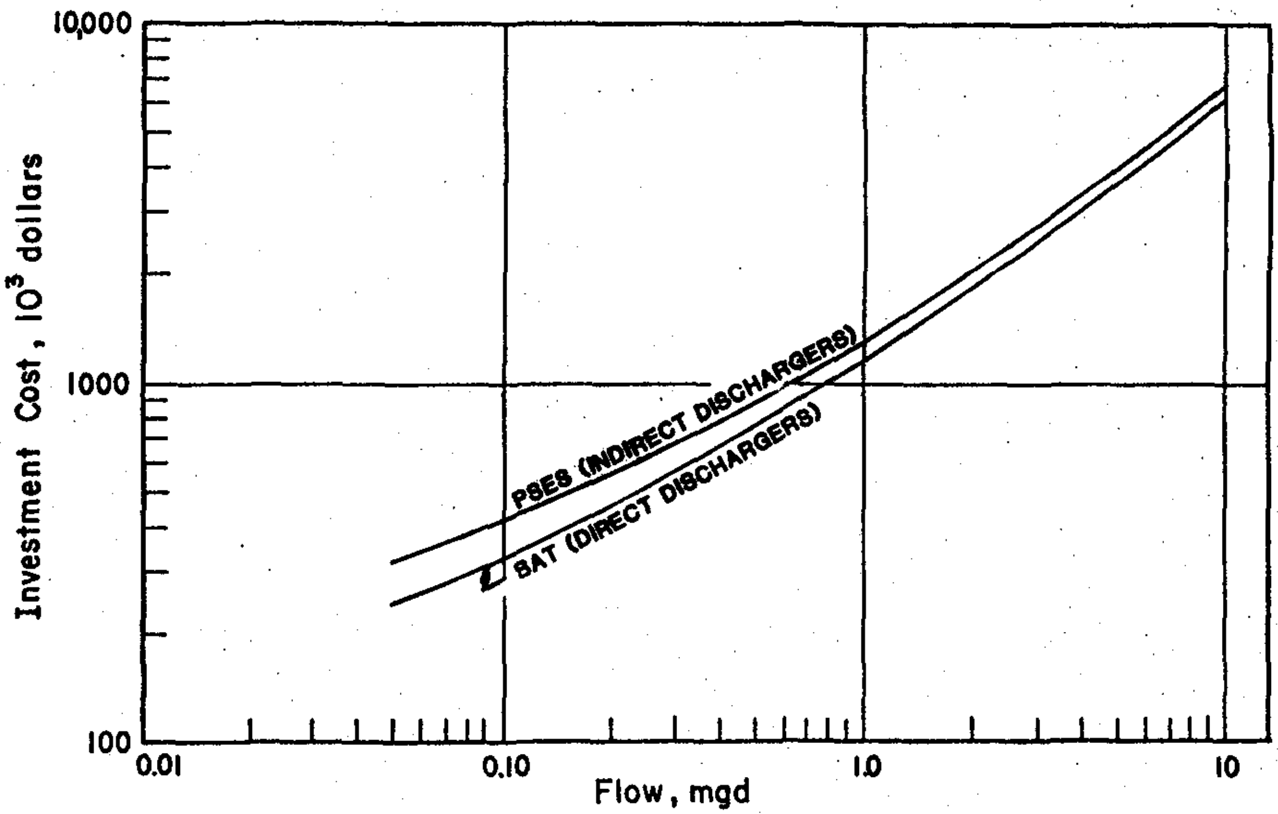


FIGURE A-21
ALTERNATIVE H: CHEMICAL COAGULATION/SEDIMENTATION AND OZONATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



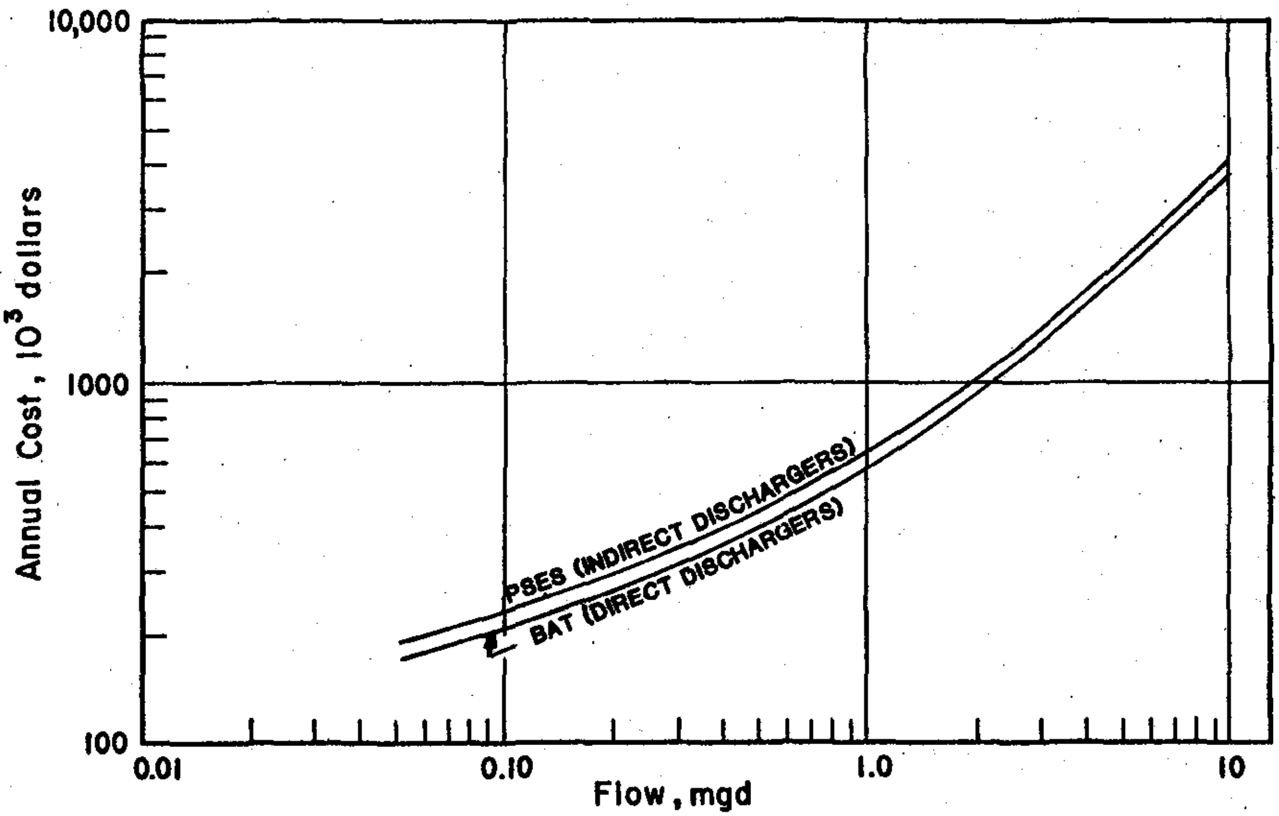


FIGURE A-22

ALTERNATIVE I: POWERED ACTIVATED CARBON ADDITION TO BIOLOGICAL TREATMENT

INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS

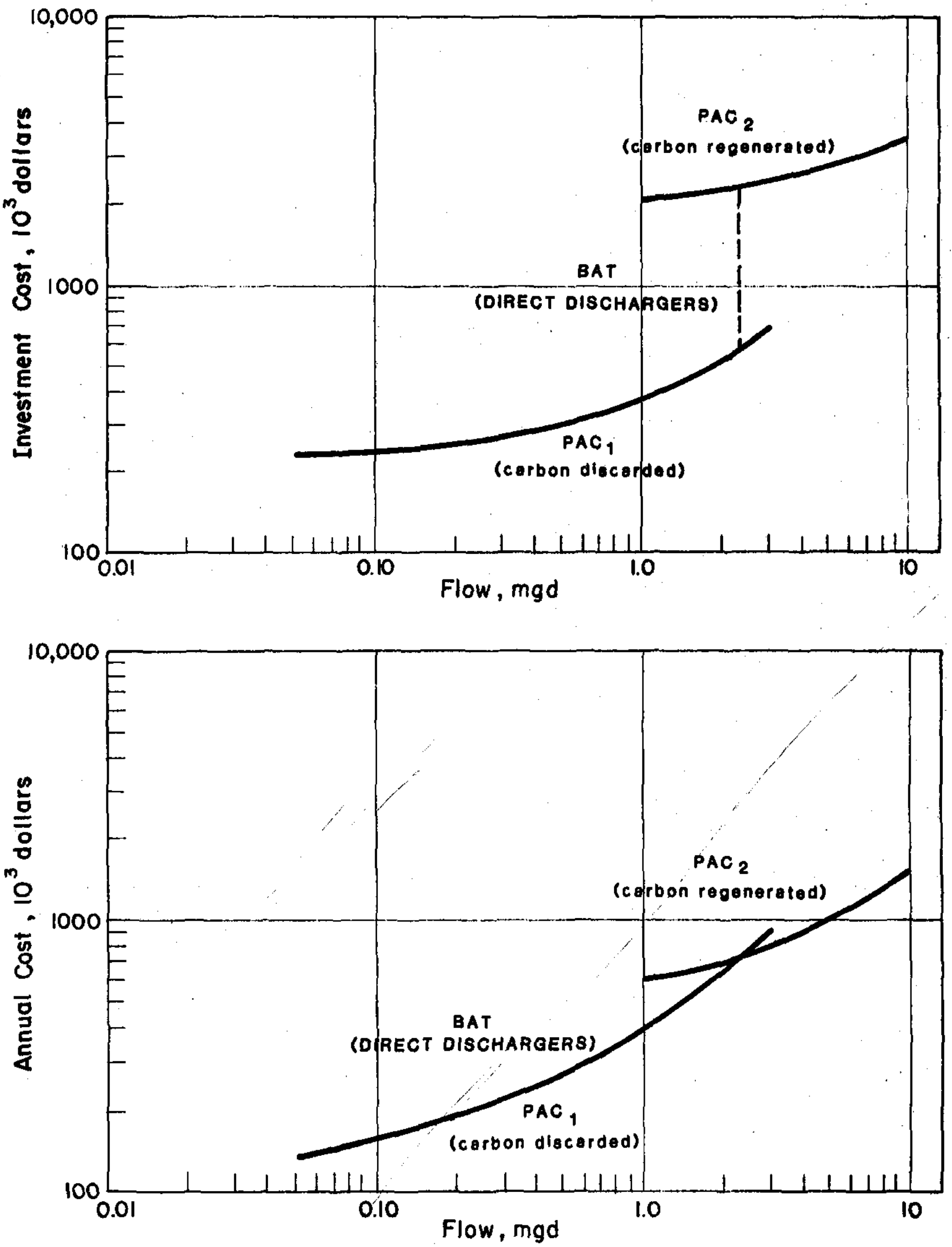
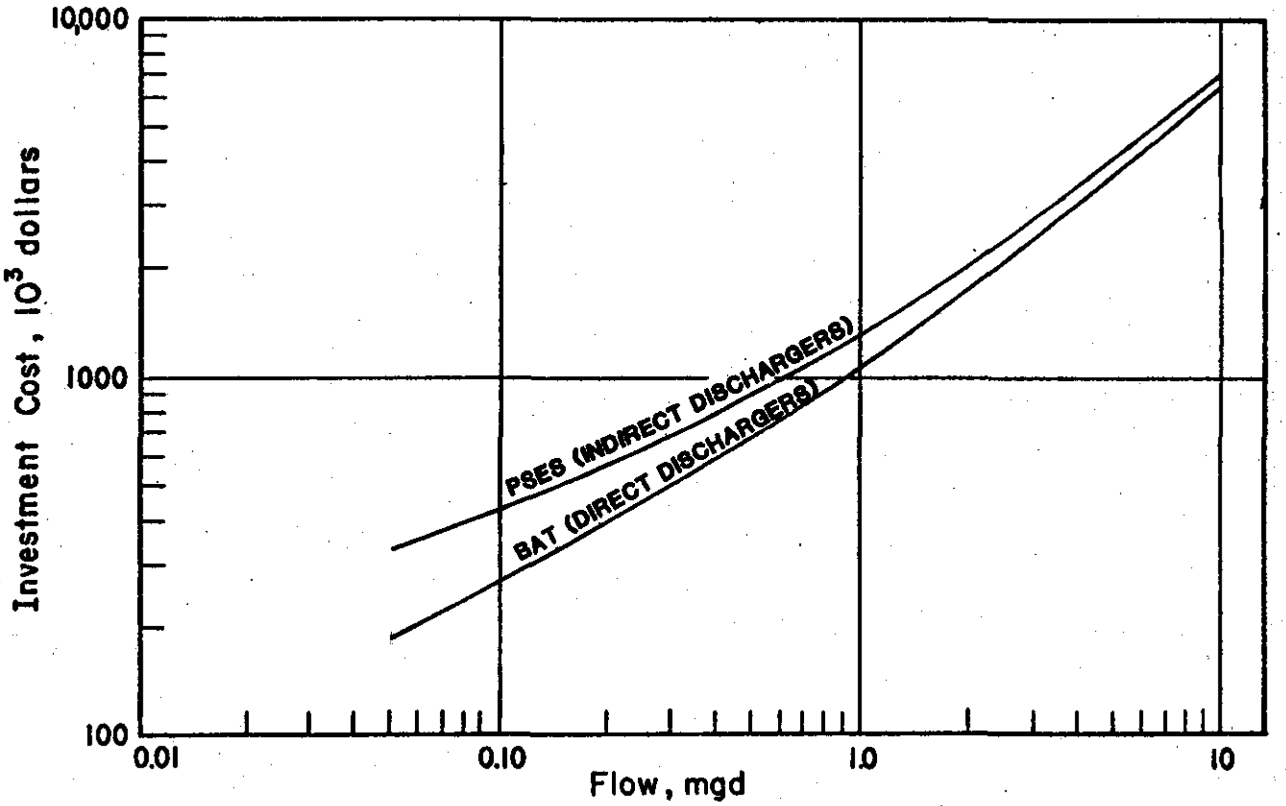


FIGURE A-23
ALTERNATIVE J: MULTIMEDIA FILTRATION AND OZONATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



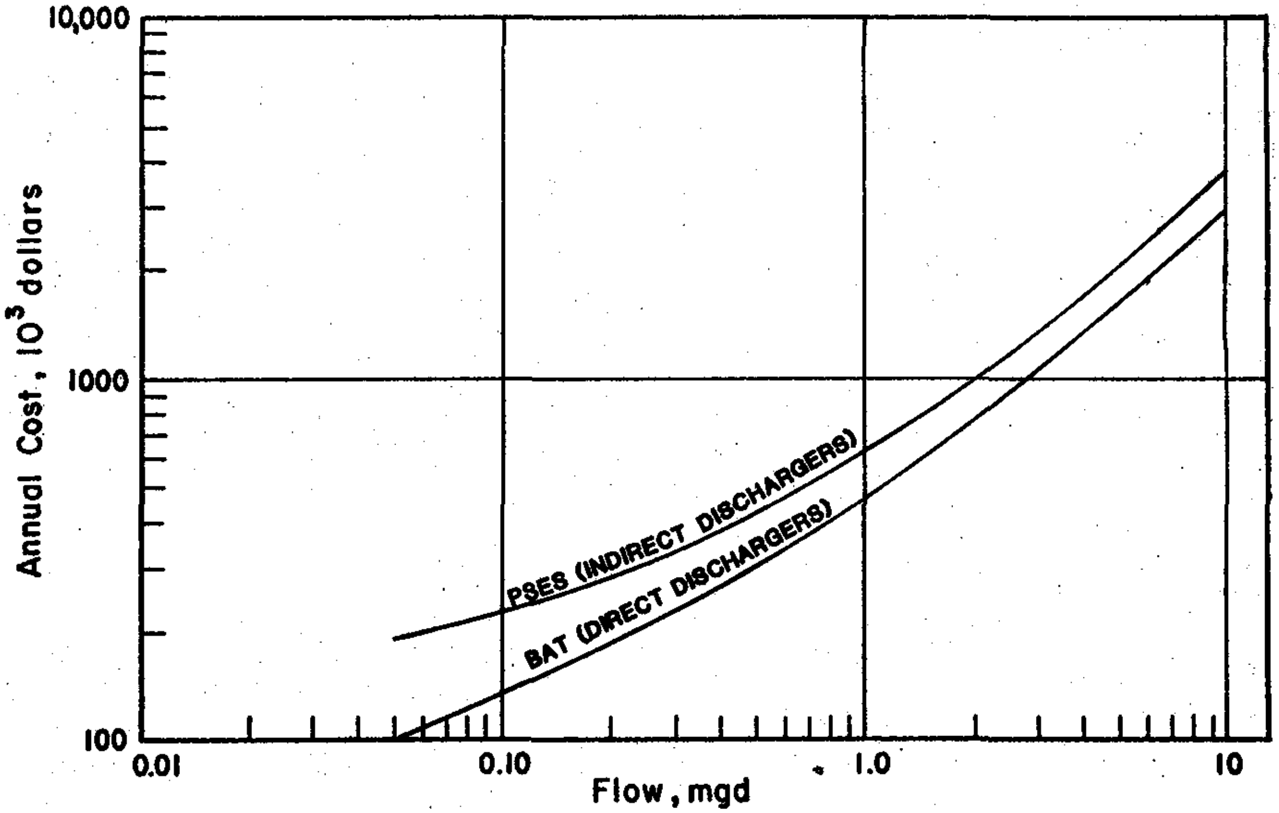
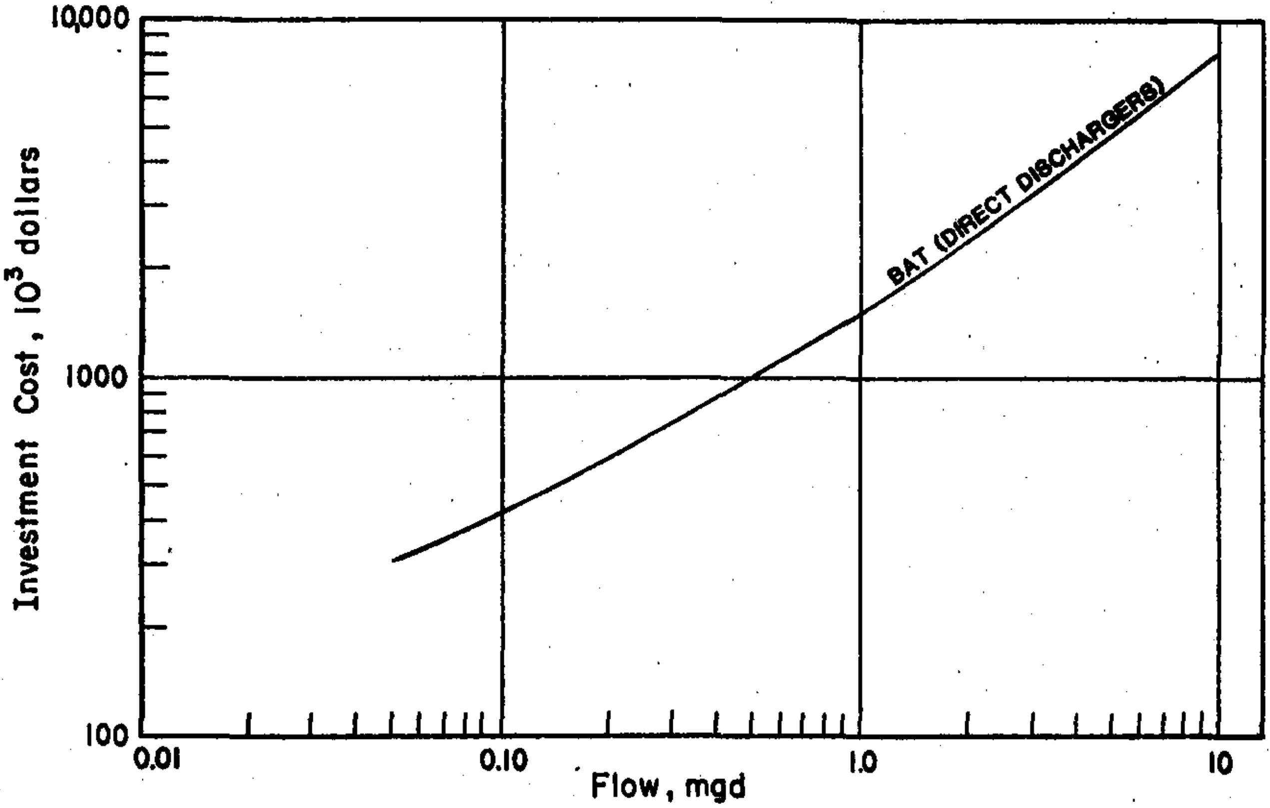


FIGURE A-24
ALTERNATIVE K: CHEMICAL COAGULATION/SEDIMENTATION, MULTIMEDIA FILTRATION AND OZONATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



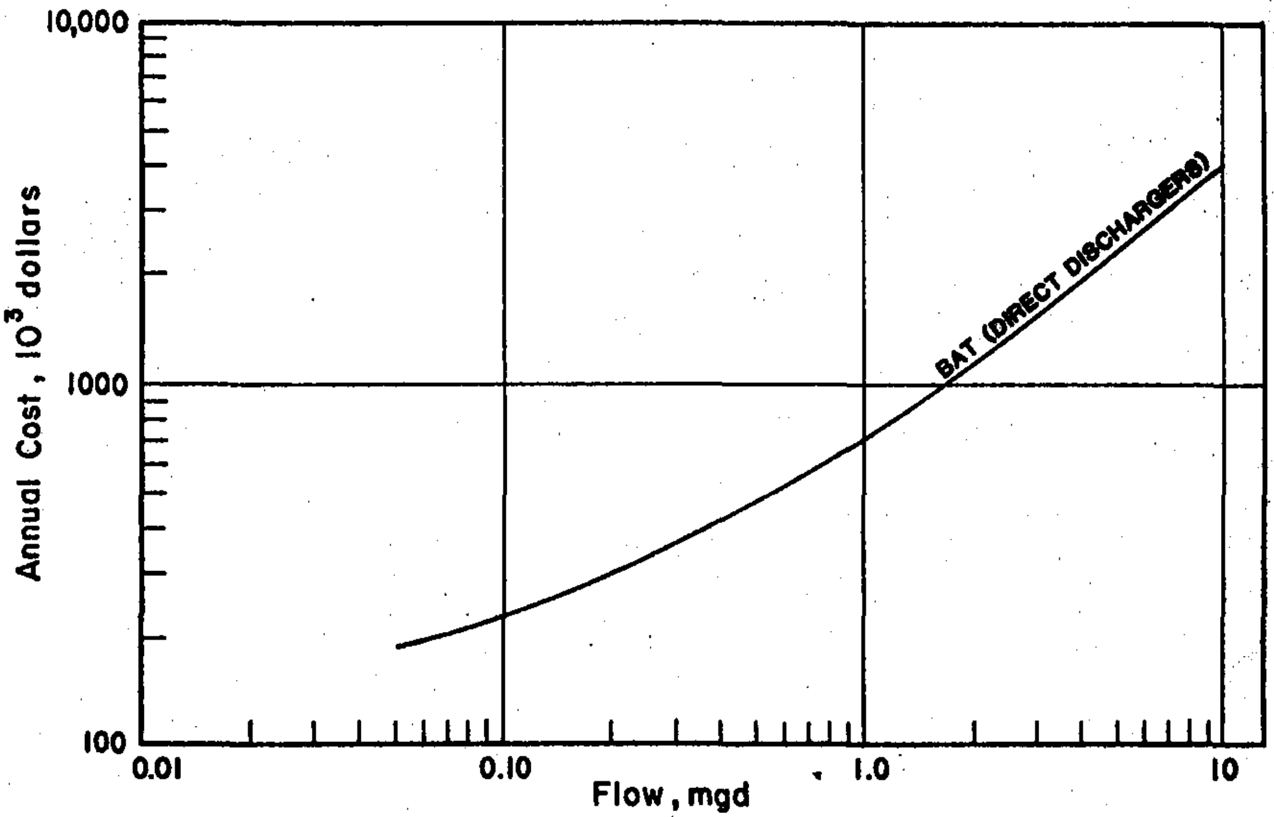


FIGURE A-25
ALTERNATIVE M: CHEMICAL COAGULATION AND DISSOLVED AIR FLOTATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS

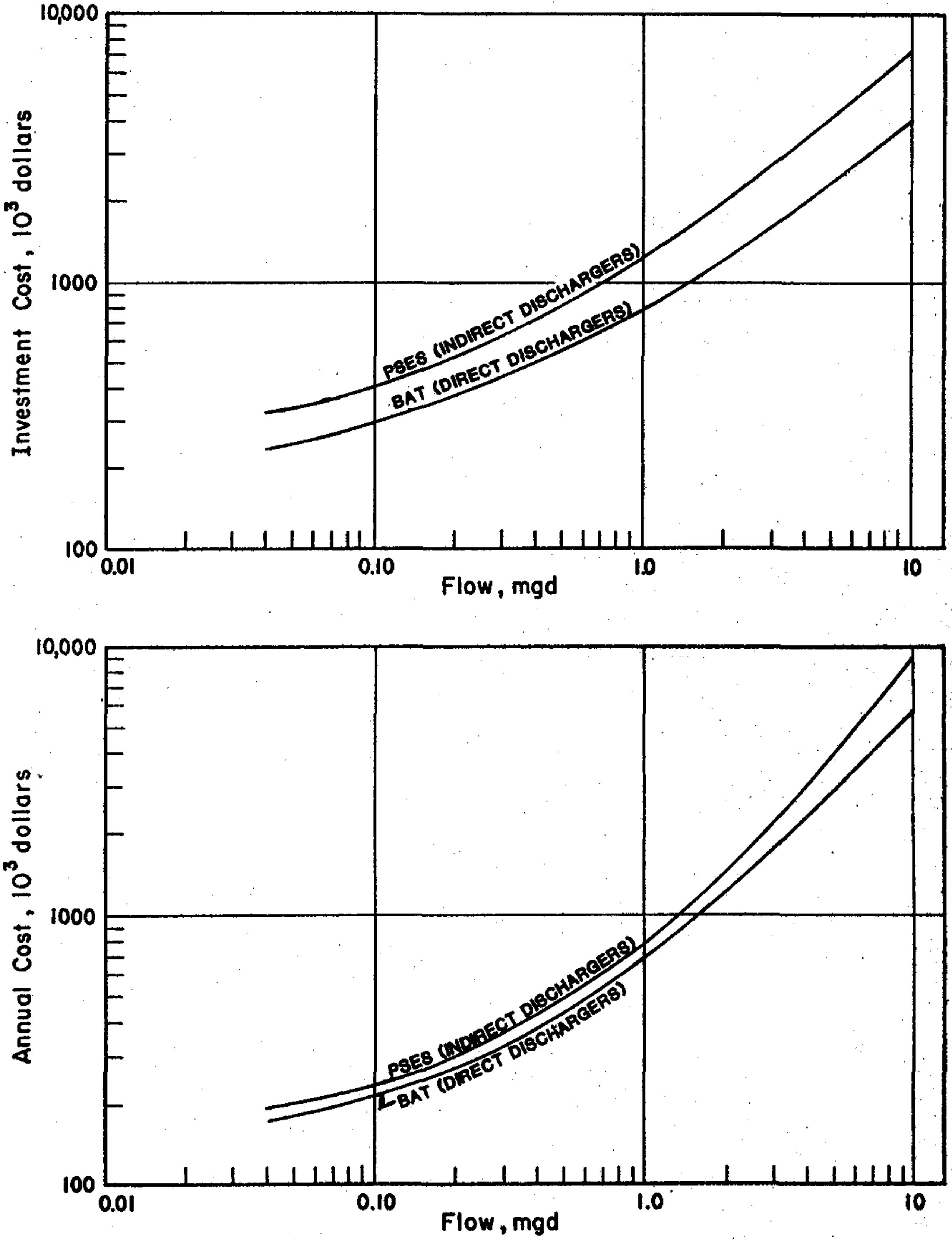
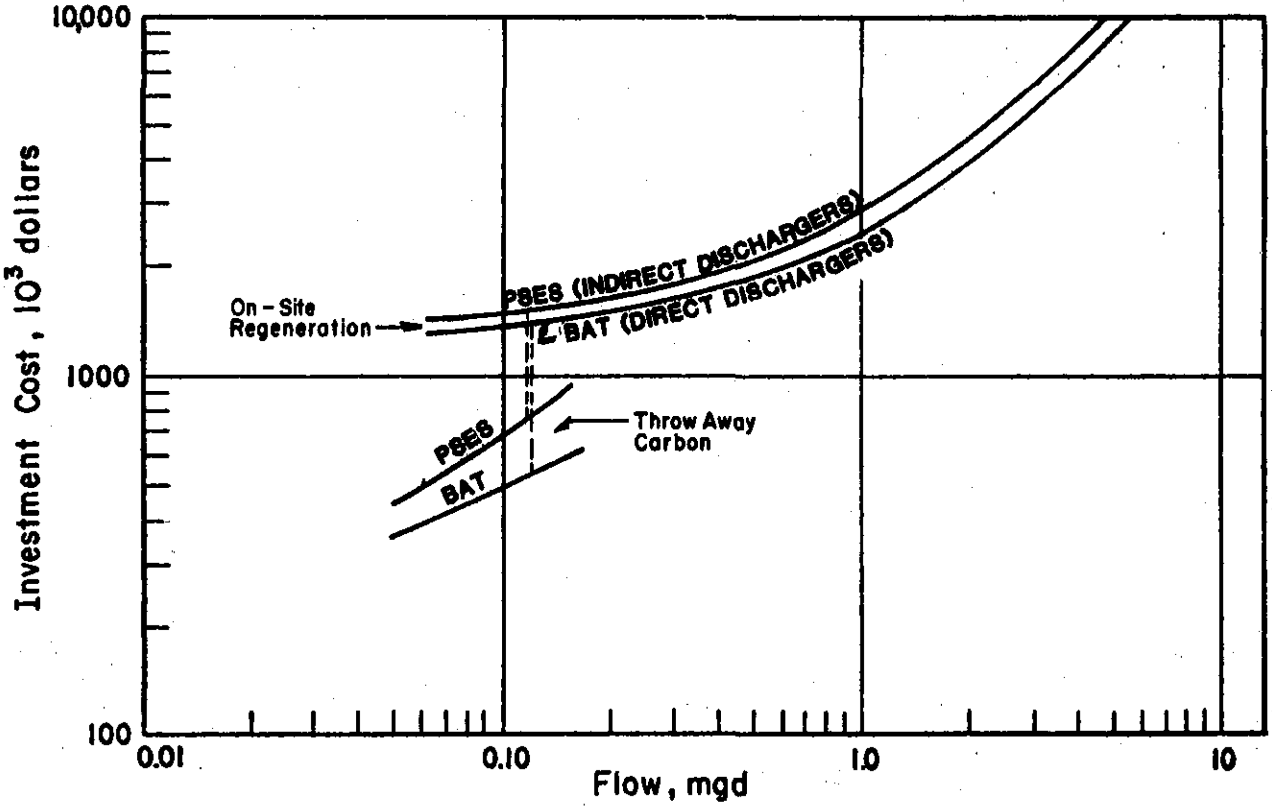


FIGURE A-26
ALTERNATIVE N: CHEMICAL COAGULATION, DISSOLVED AIR FLOTATION, MULTIMEDIA FILTRATION, AND GRANULAR ACTIVATED CARBON
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS



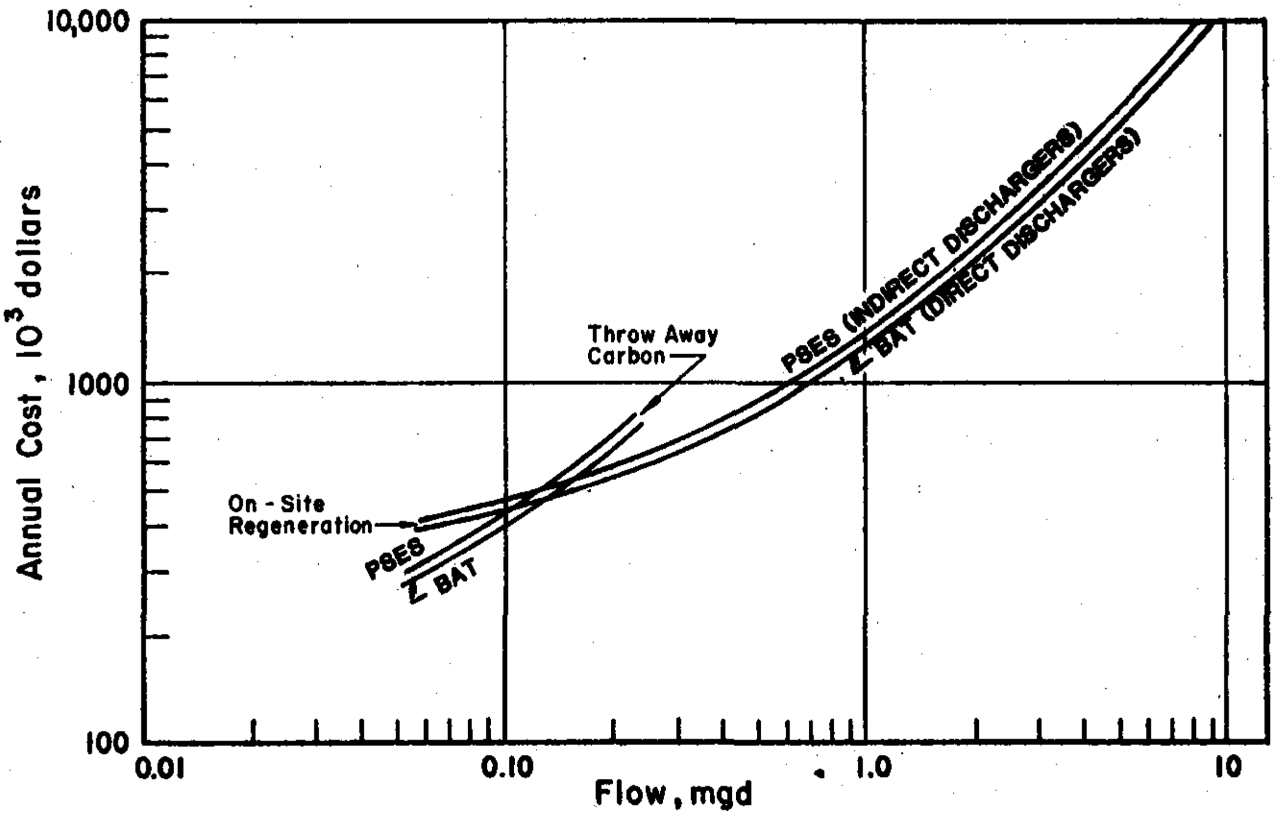
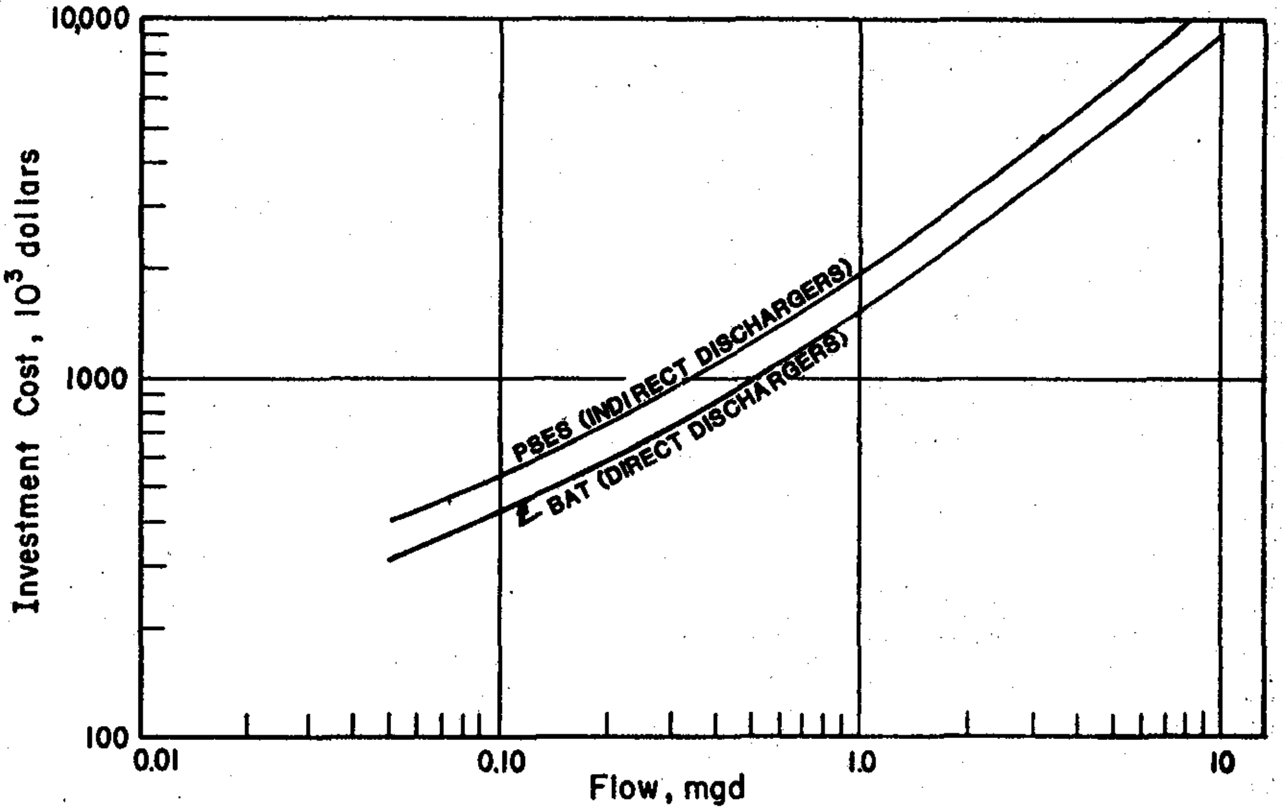
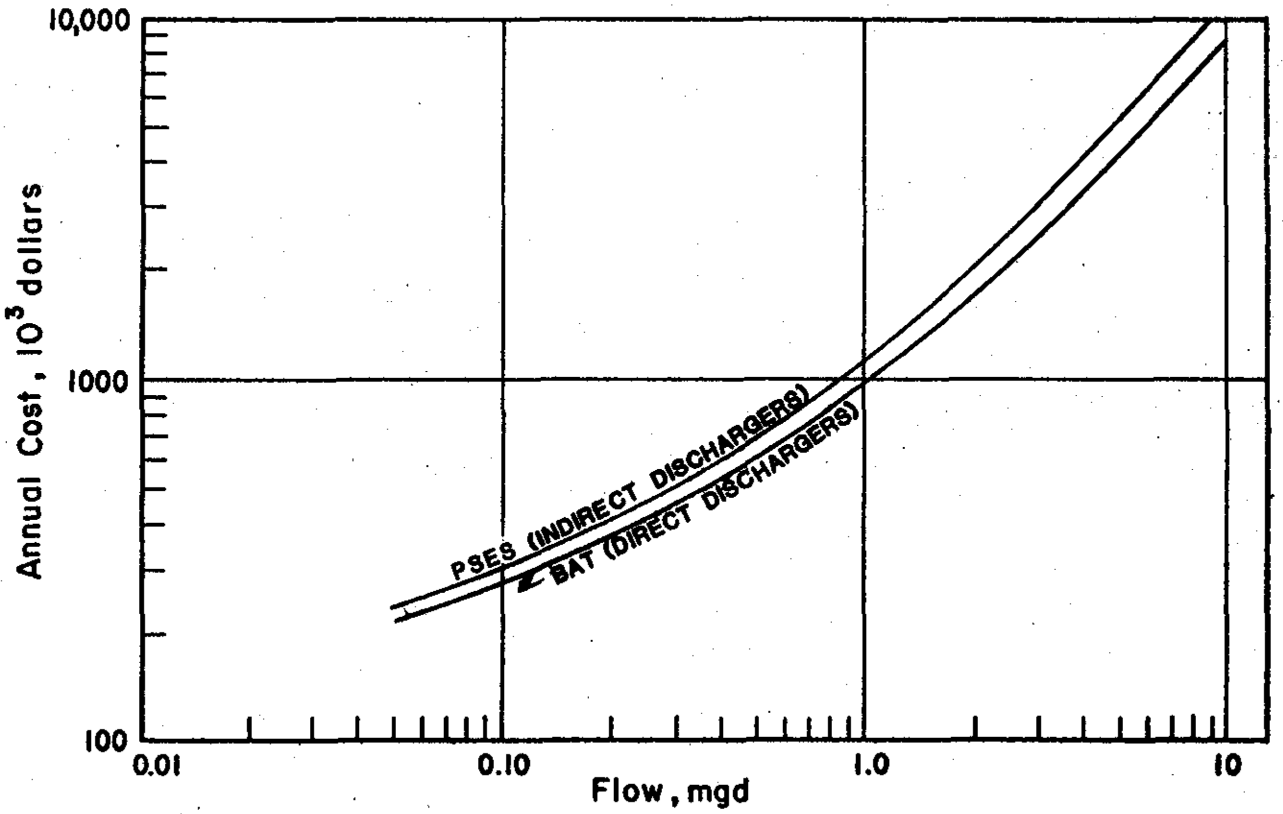


FIGURE A-27
ALTERNATIVE P: CHEMICAL COAGULATION, DISSOLVED AIR FLOTATION, AND OZONATION
INVESTMENT AND ANNUAL COSTS FOR EXISTING MILLS





CONVERSION TABLE

Multiply (English Units)		By	To Obtain (Metric Units)	
English Unit	Abbreviation	Conversion	Abbreviation	Metric Unit
acre	ac	0.405	ha	hectares
acre-feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram-calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories per kilogram.
cubic feet per minute	cfm	0.028	cu m/min	cubic meters per minute
cubic feet per second	cfs	1.7	cu m/min	cubic meters per minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Farenheit	°F	0.555(°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liter
gallon per minute	gpm	0.0631	l/sec	liters per second
gallon per ton	gal/ton	4.173	l/kkg	liters per metric ton
horsepower	hp	0.7457	kw	kilowatts
inches	in	2.54	cm	centimeters
pounds per square inch	psi	0.06803	atm	atmospheres (absolute)

(continued)

Multiply (English Units)		By	To Obtain (Metric Units	
English Unit	Abbreviation	Conversion	Abbreviation	Metric Unit
million gallons per day	MGD	3.7 x 10-3	cu m/day	cubic meters per day
pounds per square inch (gauge)	psi	(0.06805 psi + 1)*	atm	atmospheres
pounds	lb	0.454	kg	kilograms
board feet	b.f.	0.0023	cu m, m3	cubic meters
ton	ton	0.907	kkg	metric ton
mile	mi	1.609	km	kilometer
square feet	ft2	.0929	m2	square meters

* Actual conversion, not a multiplier.