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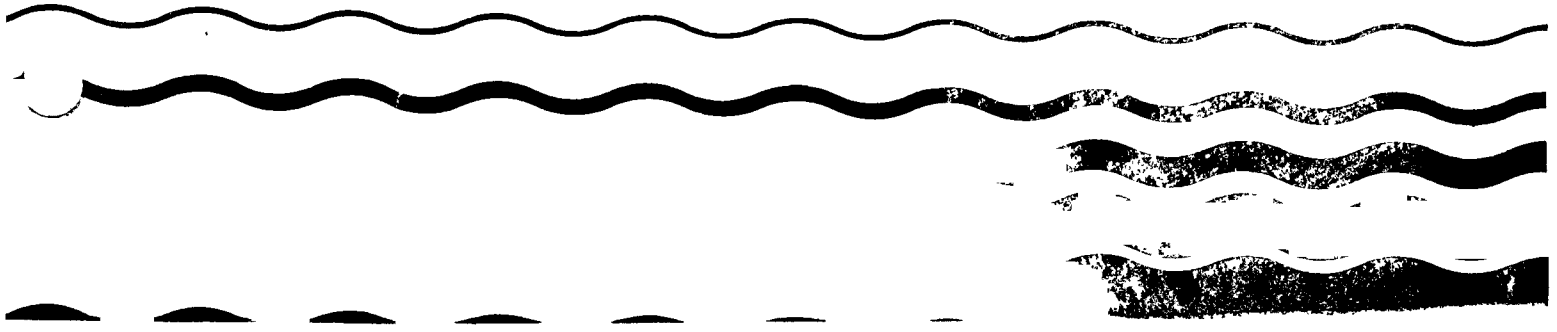
Selected Summary of Information in Support of the

Organic Chemicals, Plastic and Synthetic Fibers

Point Source Category

Notice of Availability of New Information



SELECTED SUMMARY OF INFORMATION IN SUPPORT OF THE ORGANIC CHEMICALS, PLASTICS AND SYNTHETIC FIBERS POINT SOURCE CATEGORY NOTICE OF AVAILABILITY OF NEW INFORMATION

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I. DEFINITION AND SUBCATEGORIZATION OF THE ORGANIC CHEMICALS, PLASTICS AND SYNTHETIC FIBERS POINT SOURCE CATEGORY

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1. DEFINITION OF THE ORGANIC CHEMICALS AND THE PLASTICS/SYNTHETIC FIBERS INDUSTRIES

The Consent Decree requires that effluent limitations and guidelines, including pretreatment standards, extend to 95% of the point sources within the Organic Chemicals and Plastics/Synthetic Fibers (OCPSF) industries. The Consent Decree defines the OCPSF industries to comprise the following SIC[1] codes:

2865 Cyclic (Coal Tar) Crudes, and Cyclic Intermediates, Dyes, and Organic Pigments (Lakes and Toners)

2869 Industrial Organic Chemicals, Not Elsewhere Classified

2821 Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers

2823 Cellulosic Man-Made Fibers

2824 Synthetic Organic Fibers, Except Cellulosic.

The Agency has defined the Organic Chemicals Manufacturing and Plastics/Synthetic Materials Manufacturing industries (since combined into one industry category because of their interdependence) to include all facilities within specific SIC codes: SIC 2865, Cyclic (Coal Tar) Crudes, and Cyclic Intermediates, Dyes, and Organic Pigments (Lakes and Toners); SIC 2869, Industrial Organic Chemicals, Not Elsewhere Classified; and SIC 2911, Liquified Refinery Gases (including other aliphatics) made from purchased refinery products and other Finished Petroleum Products (aromatics) made from purchased refinery products.

The products that the SIC Manual includes in the industrial organic chemical industry (SIC 286) are natural products such as gum and wood chemicals (SIC 2861), aromatic and other cyclic organic chemicals from the processing of coal tar and petroleum (SIC 2865), and the aliphatic or acyclic

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

organic chemicals (SIC 2869). These chemicals are the raw materials for products such as plastics, rubbers, fibers, protective coatings, and detergents, but have few direct consumer uses. Gum and Wood chemicals (SIC 2861) are regulated under a separate Consent Degree industrial category, Gum and Wood Chemicals Manufacturing.

The Plastics/Synthetic Materials Manufacturing category as defined by the Consent Decree comprises SIC 282, Plastic Materials and Synthetic Resins, Synthetic and Other Man-Made Fibers, except Glass. SIC 282, in turn, includes the following four-digit SIC codes:

2821 Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers

2822 Synthetic Rubber (Vulcanizable Elastomers)

2823 Cellulosic Man-Made Fibers

2824 Synthetic Organic Fibers, Except Cellulosic.

Of these codes, SIC 2822 is covered specifically by another Consent Decree industrial category, Rubber Processing. Similarly, another SIC code which might be considered as part of the Plastics industry, SIC 3079, the miscellaneous plastics products industry, is covered by the Consent Decree industrial category Plastics Molding and Forming. The Agency has defined the Plastics/Synthetic Fibers industry to include all facilities within SIC codes 2821, 2823, and 2824.

Important classes of chemicals of the Organic Chemicals Industry within SIC 2865 include: (1) derivatives of benzene, toluene, naphthalene, anthracene, pyridine, carbazole, and other cyclic chemical products; (2) synthetic organic dyes; (3) synthetic organic pigments; and (4) cyclic (coal tar) crudes, such as light oils and light oil products; coal tar acids; and products of medium and heavy oil such as creosote oil, naphthalene, anthracene (and their high homologues), and tar. Important classes of chemicals of the Organic Chemicals industry within SIC 2869 include: (1) noncyclic organic

chemicals such as acetic, chloroacetic, adipic, formic, oxalic and tartaric acids and their metallic salts; chloral, formaldehyde, and methylamine; (2) solvents such as amyl, butyl, and ethyl alcohols; methanol; amyl, butyl, and ethyl acetates; ethyl ether, ethylene glycol ether, and diethylene glycol ether; acetone, carbon disulfide, and chlorinated solvents such as carbon tetrachloride, tetrachloroethene, and trichloroethene; (3) polyhydric alcohols such as ethylene glycol, sorbitol, pentaerythritol, synthetic glycerin; (4) synthetic perfume and flavoring materials such as coumarin, methyl salicylate, saccharin, citral, cintroellal, synthetic geraniol, ionone, terpineol, and synthetic vanillin; (5) rubber processing chemicals such as accelerators and antioxidants, both cyclic and acyclic; (6) plasticizers, both cyclic and acyclic, such as esters of phosphoric acid, phthalic anhydride, adipic acid, lauric acid, oleic acid, sebacic acid, and stearic acid; (7) synthetic tanning agents such as naphthalene sulfonic acid condensates; (8) chemical warfare gases; and (9) esters, amines, etc., of polyhydric alcohols and fatty and other acids. Tables 1 and 2 list specific products of SIC 2865 and 2869, respectively.

Products produced by the Plastics/Synthetic Fibers industry are considerably more difficult to define. Within SIC 2821 important products include: cellulose plastic materials; phenolic and other tar acid resins; urea and melamine resins; vinyl resins; styrene resins; alkyd resins; acrylic resins; polyethylene resins; polypropylene resins; rosin modified resins; coumarone-indene and petroleum polymer resins; and miscellaneous resins including polyamide resins, silicones, polyisobutylenes, polyesters, polycarbonate resins, acetal resins, fluorohydrocarbon resins; and casein plastics. Table 3 lists important products of SIC 2821. Important cellulosic man-made fibers (SIC 2823) include: acetate fibers, cellulose acetate, cellulose rayon, triacetate fibers, and viscose fibers (see Table 4). Important noncellulosic synthetic organic fibers (SIC 2824) include: acrylic, acrylonitrile, casein, fluorocarbon, linear ester, modacrylic, nylon, olefin, polyester, polyvinyl, and polyvinylidene fibers. Table 5 lists important fiber products of SIC 2824.

TABLE 1. SIC 2865: CYCLIC (COAL TAR) CRUDES, AND CYCLIC INTERMEDIATES, DYES, AND ORGANIC PIGMENTS (LAKES AND TONERS)

Acid dyes, synthetic
Acids, coal tar: derived from coal tar distillation
Alkylated diphenylamines, mixed
Alkylated phenol, mixed
Aminoanthraquinone
Aminozobenzene
Aminozotoluene
Aminophenol
Aniline
Aniline oil
Anthracene
Anthraquinone dyes
Azine dyes
Azo dyes
Azobenzene
Azoic dyes
Benzaldehyde
Benzene hexachloride (BHC)
Benzene, product of coal tar distillation
Biological stains
Chemical indicators
Chlorobenzene
Chloronaphthalene
Chlorophenol
Chlorotoluene
Coal tar crudes, derived from coal tar distillation
Coal tar distillates
Coal tar intermediates
Color lakes and toners
Color pigments, organic: except animal black and bone black
Colors, dry: lakes, toners, or full strength organic colors
Colors, extended (color lakes)
Cosmetic dyes, synthetic
Creosote oil, product of coal tar distillation
Cresols, product of coal tar distillation
Cresylic acid, product of coal tar distillation
Cyclic crudes, coal tar: product of coal tar distillation
Cyclic intermediates
Cyclohexane
Diphenylamine
Drug dyes, synthetic
Dye (cyclic) intermediates
Dyes, food: synthetic
Dyes, synthetic organic
Eosine toners
Ethylbenzene
Hydroquinone
Isocyanates
Lake red C toners
Leather dyes and stains, synthetic
Lithol rubine lakes and toners
Maleic anhydride
Methyl violet toners
Naphtha, solvent: product of coal tar distillation
Naphthalene chips and flakes
Naphthalene, product of coal tar distillation
Naphthol, alpha and beta
Nitro dyes
Nitroaniline
Nitrobenzene
Nitrophenol
Nitroso dyes
Oil, aniline
Oils: light, medium, and heavy--product of coal tar distillation
Organic pigments (lakes and toners)
Orthodichlorobenzene
Paint pigments, organic
Peacock blue lake
Pentachlorophenol
Persian orange lake
Phenol
Phloxine toners
Phosphomolybdic acid lakes and toners
Phosphotungstic acid lakes and toners
Phthalic anhydride
Phthalocyanine toners
Pigment scarlet lake
Pitch, product of coal tar distillation
Pulp colors, organic
Quinoline dyes
Resorcinol
Scarlet 2 R lake
Stains for leather
Stilbene dyes
Styrene
Styrene monomer
Tar, product of coal tar distillation
Toluene, product of coal tar distillation
Toluidines
Toluol, product of coal tar distillation
Vat dyes, synthetic
Xylene, product of coal tar distillation
Xylol, product of coal tar distillation

TABLE 2. SIC 2869: INDUSTRIAL ORGANIC CHEMICALS, NOT ELSEWHERE CLASSIFIED

Accelerators, rubber processing: cyclic and acyclic
Acetaldehyde
Acetates, except natural acetate of lime
Acetic acid, synthetic
Acetic anhydride
Acetin
Acetone, synthetic
Acid esters, amines, etc.
Acids, organic
Acrolein
Acrylonitrile
Adipic acid
Adipic acid esters
Adiponitrile
Alcohol, aromatic
Alcohol, fatty: powdered
Alcohol, methyl: synthetic (methanol)
Alcohols, industrial: denatured (nonbeverage)
Algin products
Amyl acetate and alcohol
Antioxidants, rubber processing: cyclic and acyclic
Bromochloromethane
Butadiene, from alcohol
Butyl acetate, alcohol, and propionate
Butyl ester solution of 2, 4-D
Calcium oxalate
Camphor, synthetic
Carbon bisulfide (disulfide)
Carbon tetrachloride
Casing fluids, for curing fruits, spices, tobacco, etc.
Cellulose acetate, unplasticized
Chemical warfare gases
Chloral
Chlorinated solvents
Chloroacetic acid and metallic salts
Chloroform
Chloropicrin
Citral
Citrates
Citric acid
Citronellal
Coumarin
Cream of tartar
Cyclopropane
DDT, technical
Decahydronaphthalene
Dichlorodifluoromethane
Diethylcyclohexane (mixed isomers)
Diethylene glycol ether
Dimethyl divinyl acetylene (di-isopropenyl acetylene)
Dimethylhydrazine, unsymmetrical
Embalming fluids
Enzymes
Esters of phosphoric, adipic, lauric, oleic, sebacic, and stearic acids
Esters of phthalic anhydride
Ethanol, industrial
Ether
Ethyl acetate, synthetic
Ethyl alcohol, industrial (non-beverage)
Ethyl butyrate
Ethyl cellulose, unplasticized
Ethyl chloride
Ethyl ether
Ethyl formate
Ethyl nitrite
Ethyl perhydrophenanthrene
Ethylene
Ethylene glycol
Ethylene glycol ether
Ethylene glycol, inhibited
Ethylene oxide
Fatty acid esters, amines, etc.
Ferric ammonium oxalate
Flavors and flavoring materials, synthetic
Fluorinated hydrocarbon gases
Formaldehyde (formalin)
Formic acid and metallic salts
Freon
Fuel propellants, solid: organic
Fuels, high energy: organic
Geraniol, synthetic
Gylcerin, except from fats (synthetic)
Grain alcohol, industrial (non-beverage)
Hexamethylenediamine
Hexamethylenetetramine
High purity grade chemicals, organic: refined from technical grades
Hydraulic fluids, synthetic base
Hydrazine
Industrial organic cyclic compounds
Ionone
Isopropyl alcohol
Ketone, methyl ethyl
Ketone, methyl isobutyl
Laboratory chemicals, organic

TABLE 2. SIC 2869: INDUSTRIAL ORGANIC CHEMICALS, NOT ELSEWHERE CLASSIFIED (Continued)

Lauric acid esters
Lime citrate
Malononitrile, technical grade
Metallic salts of acyclic organic chemicals
Metallic stearate
Methanol, synthetic (methyl alcohol)
Methyl chloride
Methyl perhydrofluorine
Methyl salicylate
Methylamine
Methylene chloride
Monochlorodifluoromethane
Monomethylparaminophenol sulfate
Monosodium glutamate
Mustard gas
Napthalene sulfonic acid condensates
Naphthenic acid soaps
Normal hexyl decalin
Nuclear fuels, organic
Oleic acid esters
Organic acid esters
Organic chemicals, acyclic
Oxalates
Oxalic acid and metallic salts
Pentaerythritol
Perchloroethylene
Perfume materials, synthetic
Phosgene
Phthalates
Plasticizers, organic: cyclic and acyclic
Polyhydric alcohol esters, amines, etc.
Polyhydric alcohols
Potassium bitartrate
Propellants for missiles, solid: organic
Propylene
Propylene glycol
Quinuclidinol ester of benzylic acid
Reagent grade chemicals, organic: refined from technical grades
Rocket engine fuel, organic
Rubber processing chemicals, organic: accelerators and antioxidants
Saccharin
Sebacic acid
Silicones
Soaps, naphthenic acid
Sodium acetate
Sodium alginate
Sodium benzoate
Sodium glutamate
Sodium pentachlorophenate
Sodium sulfoxalate formaldehyde
Solvents, organic
Sorbitol
Stearic acid salts
Sulfonated naphthalene
Tackifiers, organic
Tannic acid
Tanning agents, synthetic organic
Tartaric acid and metallic salts
Tartrates
Tear gas
Terpineol
Tert-butylated bis (p-phenoxyphenyl) ether fluid
Tetrachloroethylene
Tetraethyl lead
Thioglycolic acid, for permanent wave lotions
Trichloroethylene
Trichloroethylene stabilized, degreasing
Trichlorophenoxyacetic acid
Trichlorotrifluoroethane tetrachlorodifluoroethane isopropyl alcohol
Tricresyl phosphate
Tridecyl alcohol
Trimethyltrithiophosphite (rocket propellants)
Triphenyl phosphate
Vanillin, synthetic
Vinyl acetate

TABLE 3. SIC 2821: PLASTICS MATERIALS, SYNTHETIC RESINS, AND NONVULCANIZABLE ELASTOMERS

Acetal resins
Acetate, Cellulose (plastics)
Acrylic resins
Acrylonitrile-butadiene-styrene resins
Alcohol resins, polyvinyl
Alkyd resins
Allyl resins
Butadiene copolymers, containing less than 50% butadiene
Carbohydrate plastics
Casein plastics
Cellulose nitrate resins
Cellulose propionate (plastics)
Coal tar resins
Condensation plastics
Coumarone-indene resins
Cresol-furfural resins
Cresol resins
Dicyandiamine resins
Diisocyanate resins
Elastomers, nonvulcanizable (plastics)
Epichlorohydrin bisphenol
Epichlorohydrin diphenol
Epoxy resins
Ester gum
Ethyl cellulose plastics
Ethylene-vinyl acetate resins
Fluorohydrocarbon resins
Ion exchange resins
Ionomer resins
Isobutylene polymers
Lignin plastics
Melamine resins
Methyl acrylate resins
Methyl cellulose plastics
Methyl methacrylate resins
Molding compounds, plastics
Nitrocellulose plastics (pyroxylin)
Nylon resins
Petroleum polymer resins
Phenol-furfural resins
Phenolic resins
Phenoxy resins
Phthalic alkyd resins
Phthalic anhydride resins
Polyacrylonitrile resins
Polyamide resins
Polycarbonate resins
Polyesters
Polyethylene resins
Polyhexamethylenediamine adipamide resins
Polyisobutylenes
Polymerization plastics, except fibers
Polypropylene resins
Polystyrene resins
Polyurethane resins
Polyvinyl chloride resins
Polyvinyl halide resins
Polyvinyl resins
Protein plastics
Pyroxylin
Resins, phenolic
Resins, synthetic: coal tar and non-coal tar
Rosin modified resins
Silicone fluid solution (fluid for sonar transducers)
Silicone resins
Soybean plastics
Styrene resins
Styrene-acrylonitrile resins
Tar acid resins
Urea resins
Vinyl resins

TABLE 4. SIC 2823: CELLULOSIC MAN-MADE FIBERS

Acetate fibers
Cellulose acetate monofilament, yarn, staple, or tow
Cellulose fibers, man-made
Cigarette tow, cellulosic fiber
Cuprammonium fibers
Fibers, cellulose man-made
Fibers, rayon
Horsehair, artifical: rayon
Nitrocellulose fibers
Rayon primary products: fibers, straw, strips, and yarn
Rayon yarn, made in chemical plants (primary products)
Regenerated cellulose fibers
Triacetate fibers
Viscose fibers, bands, strips, and yarn
Yarn, cellulosic: made in chemical plants (primary products)

TABLE 5. SIC 2824: SYNTHETIC ORGANIC FIBERS, EXCEPT CELLULOSIC

Acrylic fibers
Acrylonitrile fibers
Anidex fibers
Casein fibers
Elastomeric fibers
Fibers, man-made: except cellulosic
Fluorocarbon fibers
Horsehair, artifical: nylon
Linear esters fibers
Modacrylic fibers
Nylon fibers and bristles
Olefin fibers
Organic fibers, synthetic: except cellulosic
Polyester fibers
Polyvinyl ester fibers
Polyvinylidene chloride fibers
Protein fibers
Saran fibers
Soybean fibers (man-made textile materials)
Vinyl fibers
Vinylidene chloride fibers
Yarn, organic man-made fiber except cellulosic
Zein fibers

SIC codes have been established to classify commercial and industrial establishments by the type of activity in which they are engaged. The SIC code system is commonly employed for collection and organization of economic data (e.g., gross production, sales, number of employees, and geographic location) for U.S. industries; establishments are economic units typically engaged in a single or dominant type of economic activity for which an industry code is applicable.

A plant is assigned a primary SIC code corresponding to its primary activity, which is the activity producing its primary product or group of products. The primary product is the product having the highest total annual shipment value. The secondary products of a plant are all products other than the primary products. Frequently in the chemical industry a plant may produce large amounts of a low-cost chemical but be assigned another SIC code because of lower-volume production of a high-priced specialty chemical. Many plants are also assigned secondary, tertiary, or lower order SIC codes corresponding to plant activities beyond their primary activities. The inclusion of plants with a secondary or lower order SIC code produces a list of plants manufacturing a given class of industrial products but also includes plants that produced only minor (or in some cases insignificant) amounts of those products. While the latter plants are part of an industry economically, their inclusion may seriously distort the description of the industry's wastewater production and treatment, unless the wastewaters can be segregated by SIC codes.

For some petroleum refineries and pharmaceutical manufacturers, process wastewater from some synthetic organic chemical products are specifically regulated under the Petrochemical and Integrated Subcategories of the Petroleum Refining Point Source Category (40 CFR 419, Subparts C and E) or the Chemical Synthesis Products Subcategory of the Pharmaceuticals Manufacturing Point Source Category (40 CFR 439, Subpart C). The petroleum refineries and pharmaceutical manufacturers that produce organic chemical products that generate

process wastewaters treated in combinations with petroleum refinery or pharmaceutical manufacturing wastewaters, respectively, should consider any such organic chemical products as non-OCPSF products. However, if petroleum refineries or pharmaceutical manufacturers produce organic chemical products that generate process wastewaters that are treated in a separate wastewater treatment system, these facilities should consider any such organic chemical product as an OCPSF product. Organic chemical compounds that are produced solely by extraction from natural materials (e.g., plant and animal sources) or by fermentation processes are not considered to be OCPSF products. Thus, ethanol derived from natural sources (SIC 28095112) is not considered to be an OCPSF industry product; ethanol produced synthetically (hydration of ethene) is an OCPSF industry product. Similarly, cellophane (SIC 3079) which is produced by extrusion of viscose (chemically derived from the natural polymer cellulose) is being considered by the Agency to be an OCPSF industry product. (Both rayon and cellophane are manufactured by similar processes, differing only in the extruded form.) Cellophane would be placed in the Rayon subcategory.

Certain products of SIC groups other than 2865, 2969, 2821, 2823, and 2824 are considered to be OCPSF products. Benzene, toluene, and mixed xylenes manufactured from purchased refinery products in SIC 29110582 (in contrast to benzene, toluene, and mixed xylenes manufactured in refineries--SIC 29110558) are considered to be OCPSF products (see Table 6). Similar considerations apply to aliphatic hydrocarbons manufactured from purchased refinery products--SIC 29116324 (see Table 7).

TABLE 6. OCPSF CHEMICAL PRODUCTS LISTED AS SIC 29110582 PRODUCT CODES

Benzene

Cresylic acid

Cyclopentane

Naphthalene

Naphthenic Acid

Toluene

Xylenes, Mixed

C9 Aromatics

SOURCE: 1982 Census of Manufactures and Census of Mineral Industries. Numerical List of Manufactured and Mineral Products. U.S. Department of Commerce, Bureau of the Census, 1982.

TABLE 7. OCPSF CHEMICAL PRODUCTS LISTED AS SIC 29116324 PRODUCT CODES

C2 Hydrocarbons
Acetylene
Ethane
Ethylene
C3 Hydrocarbons
Propane
Propylene
C4 Hydrocarbons
Butadiene and butylene fractions
1,3-Butadiene, grade for rubber
n-Butane
Butanes, mixed
1-Butene
2-Butene
1-Butene and 2-butene, mixed
Hydrocarbons, C4, fraction
Hydrocarbons, C4, mixtures
Isobutane (2-Methylpropane)
Isobutylene (2-Methylpropene)
C4 Hydrocarbons, all other
Amylenes
Dibutanized aromatic concentrate
C5 Hydrocarbon, mixtures
Isopentane (2-Methylbutane)
Isoprene (2-Methyl-1,3-butadiene)
n-Pentane
1-Pentene
Pentenes, mixed
Piperylene (1,3-Pentadiene)
C5 Hydrocarbons, all other
C6 Hydrocarbons
Diisopropane
Hexane
Hexanes, mixed
Hydrocarbons, C5-C6, mixtures
Hydrocarbons, C5-C7, mixtures
Isohexane
Methylcyclopentadiene
Neohexane (2,2-Dimethylbutane)
C6 Hydrocarbons, C6, all other
n-Heptane
Heptenes, mixed
Isoheptanes
C7 Hydrocarbons
C8 Hydrocarbons
Diisobutylene (Diisobutene)
n-Octane
Octenes, mixed
2,2,4-Trimethylpentane (Isooctane)
C8 Hydrocarbons, all other
C9 and above Hydrocarbons
Dodecene
Eicosane
Nonene (Tripropylene)
Alpha Olefins
Alpha olefins, C6-C10
Alpha olefins, C11 and higher
n-Paraffins
n-Paraffins, C6-C9
n-Paraffins, C9-C15
n-Paraffins, C10-C14
n-Paraffins, C10-C16
n-Paraffins, C12-C18
n-Paraffins, C15-C17
n-Paraffins, other
Hydrocarbons, C5-C9, mixtures
Polybutene
Hydrocarbon Derivatives
n-Butyl mercaptan (1-Butanethiol)
sec-Butyl mercaptan (2-Butanethiol)
tert-Butyl mercaptan (2-Methyl-2-propanethiol)
Di-tert-butyl disulfide
Diethyl sulfide (Ethyl sulfide)
Dimethyl sulfide
Ethyl mercaptan (Ethanethiol)
Ethylthioethanol
n-Hexyl mercaptan (1-Hexanethiol)
Isopropyl mercaptan (2-Propanethiol)
Methyl ethyl sulfide
Methyl mercaptan (Methanethiol)
tert-Octyl mercaptan (2,4,4-Trimethyl-2-pentanethiol)
Octyl mercaptans
Thiophane (Tetrahydrothiophene)
Hydrocarbon derivatives: all other hydrocarbon derivatives
Hydrocarbons, C9 and above, all other, including mixtures

SOURCE: 1982 Census of Manufactures and Census of Mineral Industries. Numerical List of Manufactured and Mineral Products. U.S. Department of Commerce, Bureau of the Census, 1982.

2. SUBCATEGORIZATION

2.1 INTRODUCTION

Sections 304(b)(1)(B),304(b)(2)(B), and 304(b)(4)(B) of the Clean Water Act require EPA to consider certain factors in establishing effluent limitations guidelines based on the best practicable control technology (BPT), best conventional pollutant control technology (BCT), and best available technology (BAT). Factors to be considered include: the age of equipment and facilities involved; the process employed; the engineering aspects of the application of various types of control techniques; process changes; the cost of achieving such effluent reduction; non-water quality environmental impact (including energy requirements); and such other factors as the Administrator deems appropriate. The purpose of such consideration is to determine whether these industries (or segments of these industries) exhibit unique wastewater characteristics which support the development of separate national effluent limitations guidelines. Thus, major industry groups may require division into smaller homogeneous groups that account for the individual characteristics of different facilities.

In order to consider subcategorization on the basis of the factors listed above, it is necessary to demonstrate that significant differences among the plant wastewater quality or differences in the treatability of plant wastewaters exist. The Organic Chemicals and Plastics/Synthetic Fibers Industries (OCPSF) might be subcategorized into groups with significant differences in terms of influent and effluent quality based on the following factors:

- Products produced
- Processes employed and process changes
- Facility size (as measured by plant production and/or sales)
- Geographical location
- Age of equipment and facilities
- Engineering aspects of control technologies
- Flow
- Cost of achieving effluent reduction
- Non-water quality environmental impacts.

Each of these factors have been evaluated to determine if subcategorization is necessary or feasible. The subcategories proposed for the OCPSF industries are based primarily upon the concentrations of conventional pollutants in effluent wastewaters. Both engineering and statistical analyses were performed to determine whether pollutant data supported subcategorization; statistically significant test results implied that there were differences in wastewater quality between groups of plants that suggested a need for subcategorization. These analyses are discussed in detail in the following sections.

On March 21, 1983, the Agency proposed OCPSF effluent guidelines in which the industry was subcategorized based on products produced:

- Plastics Only; and
- Not Plastics Only (includes organics plants and plants which manufacture plastics and organics).

With the "Not Plastics Only" category, plants were subcategorized based on generic process chemistry:

- Plants with oxidation processes

- Plants with one of the following generic processes (Type I)
  - Peroxidation
  - Acid Cleavage
  - Condensation
  - Isomerization
  - Esterification
  - Hydroacetylation
  - Hydration
  - Alkoxylation
  - Hydrolysis
  - Carbonylation
  - Hydrogenation
  - Neutralization,

- Plants with none of the above generic processes.

Plants were further subdivided into normal and low flow plants, a factor added for the determination of equitable effluent discharge levels. Industry provided comments on this subcategory scheme, which beyond stating general displeasure with the proposed subcategories also discussed: the complexity and confusing nature of the subcategories; the relative size of between and within subcategory variability; and the advantage of focusing attention on effluent BOD.

The Agency agrees that the proposed subcategories were complex and confusing, not only to industry, but to permit writers as well. In order to solve this problem, the Agency has decided to focus its attention on OCPSF products produced and not on generic processes. By focusing on products produced, the Agency hopes to emphasize the inherent economic structures of the industry and the basic wastewater similarities of plants with similar products. It is clear, however, that the processes found at a plant are dictated by the products produced by the facility.

Industry comments also took exception to the statistical technique used to analyze the data for subcategorization. In particular, these comments emphasized that the proposed subcategories had greater variability within a subcategory than between subcategories, a trait which is indicative of a poorly defined subcategory. In order to remedy this problem, the Agency has used both analysis of variance (ANOVA) and Spearman's Rank Correlation to measure the efficacy of a subcategory scheme.

Finally, industry comments discuss the value of effluent BOD as a parameter of interest in determining subcategories. In particular, page 38 of the Chemical Manufacturers Association's comments states:

> "a. Between-Plant Variability Is Greater Than Between-Subcategory Variability
>
> EPA...The Agency failed, however, to use this statistical approach (referring to Terry-Hoeffding test) with median effluent BOD levels for each group. Since the establishment of effluent levels which are technically achievable by each plant in a subcategory is a legal requirement of the guideline development process, it is not appropriate for the Agency to ignore effluent levels in the subcategorization analysis." (emphasis added)

The Agency agrees that effluent BOD quality is an important factor in determining suitable OCPSF subcategories.

Wastewater load (WL) was selected as the dependent variable to be used to evaluate the significance of all of the subcategorization factors discussed in this section. WL for the purposes of subcategorization is a measure of BOD, flow, and size and was used as the basis for comparison to the other eight subcategorization factors.

Two major statistical techniques were used to determine an appropriate subcategorization scheme for the OCPSF industry: analysis of variance (ANOVA) (Appendix A) and the Spearman rank correlation (Appendix B). The Spearman rank correlation is nonparametric, thus making the fewest assumptions about the nature of the underlying data. The ANOVA is nonparametric in the

calculation of the variance but not in the use of underlying probabilities to test the adequacy of a particular hypothesis. This does not offer too much of a problem since the test is typically robust (relatively insensitive to modest deviations in the underlying distribution from normality); though the probabilities might change, the probabilities still give a good picture of the quality of the subcategorization.

The Spearman rank correlation was used to determine the existence of any relationships among the factors which must be considered for subcategorization of the OCPSF industry.

Nine factors were examined for technical significance in the development of the proposed subcategorization scheme:

- Products produced
- Processes employed and process changes
- Facility size (as measured by plant production and/or sales)
- Geographical location
- Age of equipment and facilities
- Engineering aspects of control technologies
- Flow
- Cost of achieving effluent reduction
- Non-water quality environmental impacts.

In general, the proposed subcategorization is based primarily on significant differences in wastewater characteristics, since many of the other eight factors could not be examined in appropriate technical and statistical depth due to lack of specific or appropriate data. The ideal data base (for subcategorization

analysis) would include raw wastewater and final effluent pollutant data for facilities which employ only one generic manufacturing process or multiple-product plants which segregate and treat each process raw waste stream separately. In this manner, each factor could be evaluated independently. Available information, however, consists of historical data collected by individual companies, primarily for the purpose of monitoring the performance of end-of-pipe wastewater treament technology and compliance with NPDES permit limitations. Variations in wastewater characteristics were therefore utilized to evaluate the impact of the other eight factors on subcategorization.

The OCPSF industry is primarily comprised of multi-product/process integrated facilities. Wastewaters generated from each product/process are collected in combined plant sewer systems and treated in one main treatment facility. Each plant's overall raw wastewater characteristics are affected by all of the production processes operating at the site at any given time. The contribution of each production process to the raw wastewater characteristics (e.g., BOD and toxic pollutant concentration) was not generally reported nor could they be accurately separated from all of the other site-specific processes that generate wastewaters. To overcome this difficulty, a combination of both technical and statistical methodologies was used to evaluate the significance of each of the subcategorization factors; that is, the results of the technical analysis were compared to the results of the statistical efforts to determine the usefulness of each factor as a basis for subcategorization. These technical/statistical evaluations of the nine factors are presented below.

2.2 SUBCATEGORIZATION BASED ON PRODUCT GROUPS

The purpose of subcategorization is the division of the OCPSF industry into smaller homogeneous groups that account for the individual characteristics of different facilities. The OCPSF industry (as defined by EPA) is recognized to comprise several industry groups:

- Organic Chemicals (SIC 2865/2869/2911)
- Plastic Materials and Synthetic Resins (SIC 2821)
- Cellulosic Man-made Fibers (SIC 2823).

Vertical integration of plants within these industries is common, however, blurring distinctions between organic chemical plants and plastics/synthetic fibers plants. As a practical matter, the OCPSF industry is divided among three types of plants:

- Plants manufacturing only organic chemicals (SIC 2865/2869/2911)
- Plants manufacturing only plastics and synthetic materials (SIC 2821/2823/2824)
- Integrated plants manufacturing both organic chemicals and plastics/synthetic materials (SIC 2865/2869/2911/2821/2823/2824).

Each type of plant is unique not only in terms of product type (e.g., plastics) but also in terms of process chemistry and engineering. Using raw materials provided by organic chemical plants, plastic plants employ only a small subset of the chemistry practiced by the OCPSF industry to produce a limited number of products (approximately 200). Product (reactant) recovery from process wastewaters in plastic plants is, in general, possible, thus lowering raw BOD loadings. On the other hand, plants producing organic chemicals utilize a much larger set of process chemistry and engineering to produce approximately 25,000 products; process wastewaters from these plants are (in general) not as amenable to product recovery and are generally higher in raw BOD and priority pollutant loadings.

Further divisions are possible within these broad groupings. Plastic materials and synthetic resins manufacturers can be subdivided into thermoplastic materials (SIC 28213) producers and thermosetting resin (28214)

producers. Rayon manufacturers and synthetic organic fiber manufacturers are also both unique in terms of process chemistry and engineering.

The Organic Chemicals industry produces many more products than does the Plastics/Synthetic Fibers industry and is correspondingly more complex. While it is indeed possible to separate this industry into product groups, the number of such product groups is large. Moreover, with few exceptions, plants produce organic chemicals from several product groups and thus limit the utility of such a scheme.

An alternative to a product-based scheme is a scheme based on the type of manufacturing conducted at a plant. Large plants producing primarily commodity chemicals (the basic chemicals of the industry, e.g., ethylene, propylene, benzene) comprise the first group of plants. A second tier of plants comprises plants that produce high-volume intermediates (bulk chemicals). Plants within this tier typically utilize the products of the commodity chemical plants (first tier plants) to produce more structurally complex chemicals. Bulk chemical plants are generally smaller than those in the first group but still may produce several hundred million pounds of chemicals per year (e.g., aniline, methylene dianiline, toluene diisocyanate). The third group comprises those plants that are devoted primarily to manufacture of specialty chemicals--chemicals intended for a particular end use (e.g., dyes and pigments). Specialty chemical plants use the products of the commodity and bulk chemical plants as raw materials. Generally, specialty chemicals are more complex structurally than either commodity or bulk chemicals. Plants within this group tend to be much smaller, producing tens of millions of pounds of chemicals per year.

The Agency has grouped the products of the OCPSF industries into seven categories. These product groups are:

- Rayon fibers (Census product code 2823)
- Other fibers (Census product codes 2823 and 2824)
- Thermosetting resins (Census product code 28214)
- Thermoplastic resins (Census product code 28214)
- Organic chemicals (Census product codes 2865, 2869, and 2911).

The organic chemicals group has been further divided into three groups of chemicals or chemical groups depending upon the total 1980 production volume of a chemical. These subgroups are:

- Commodity Chemicals - organic chemicals produced in amounts greater than one billion pounds per year. This list includes 37 products or product groups.
- Bulk Chemicals - organic chemicals produced in amounts less than one billion pounds per year but more than 40 million pounds per year. This list comprises 221 products or product groups.
- Specialty Chemicals - all organic chemicals not defined as Commodity or Bulk Chemicals.

Based on the information submitted to EPA as a result of the 1983 "308" Questionnaire, the Agency has compiled lists of chemicals and chemical groups by the industry segments discussed above. These industrial segments are integral parts of establishing and defining subcategories. Table I lists rayon products. Table II lists other fiber products. Thermoplastic resin products and thermoplastic resin groups are listed in Table III. Thermosetting resin products and thermosetting resin groups are listed in Table IV. Table V lists commodity organic chemicals and chemical groups. Bulk organic chemicals and chemical groups are listed in Table VI. Table VII lists specialty organic chemicals and chemical groups. Tables I - VII are in Appendix C.

It should be emphasized that the placement of products and product groups shown in Tables I - VII is not expected to be static: specific chemicals and chemical groups may (and are expected to) change classifications with time.

Furthermore, closely related chemical products may in some cases be in different subcategories because of production volume. Benzene, toluene, and xylene, for example, are defined as commodity chemicals; BTX (a product which is a mixture of benzene, toluene, and xylene) is defined as a bulk chemical product.

Based on these product groups, the Agency has identified eight subcategories.

- Rayon--plants that produce rayon products
- Fibers--plants that produce fiber products or plants which produce organics and fiber products
- Thermosets--plants which manufacture thermosets or those plants that produce organic and thermoset products
- Thermoplastics--plants that make thermoplastic products
- Thermoplastics and Organics--plants that produce organics and thermoplastic products
- Commodity--plants producing predominantly commodity chemicals
- Specialty--plants producing predominantly specialty chemicals
- Bulk Organics--plants whose production is neither commodity nor specialty organic products.

Plants are assigned to a subcategory based on the percent of total production of a product group. Plants that produce only organic chemicals or groups of organic chemicals are assigned to a subcategory based on the relative amounts of commodity, bulk, and specialty organic chemicals produced. Because relatively few OCPSF plants produce only one product group, a variety of production criteria were considered for subcategorization of OCPSF plants. Within product categories rayon fibers, other fibers, thermosetting resins, thermoplastic resins, and thermoplastic resins and organic chemicals),

four production criteria for placement of a plant into a subcategory were statistically evaluated using analysis of variance:

100 percent production of a product category;
95 percent production of a product category;
90 percent production of a product category; and
85 percent production of a product category.

For plants placed in the organic chemicals product category, four production criteria were also statistically evaluated for commodity and specialty chemicals and chemical groups. These criteria are:

95 percent commodity (specialty) chemical production;
75 percent commodity (specialty) chemical production;
60 percent commodity (specialty) chemical production; and
50 percent commodity (specialty) chemical production.

To determine the best combination of production rules the Agency used Analysis of Variance (ANOVA).

Table 8 gives the results of an ANOVA to determine which of the hypothesized subcategory combinations is adequate. The analysis focuses on four variables--influent BOD, effluent BOD, flow, and total production (size). A good subcategory scheme would magnify the variance between groups relative to the variance within groups. A measure which helps interpret how much larger the between variance is relative to the within variance is the probability that the ratio is greater than 1, listed in Table 8. Thus, the closer this probability is to 1, usually greater than 0.95, the better the subcategorization.

BOD is a measure of the wastewater's organic content. Plants that use highly soluble organic materials, or use contact waters extensively, usually have higher BOD loadings than plants that use dry process techniques or solvent-based reactions. Based on the ANOVA, influent BOD is not significant

as a variable for subcategorizing the OCPSF industry, since the ratio of between to within is less than 1 (Table 8). However, effluent BOD is a significant variable for all combinations of productions less than 100%.

Flow, for the purpose of this report, is measured in million gallons per day (MGD) and includes only process wastewater. This includes contact cooling waters, vacuum jet waters, wash waters, reaction media, and contact steam. Wastewater flow does not include storm water, noncontact cooling water, and sanitary wastewaters. Wastewater flow can be affected by facility size, efficiency of water use, methods of production (e.g., solvent or aqueous based), methods of cooling, and vacuum generation, as well as other factors.

The subcategorization is very effective when flow is the variable of interest (Table 8). The probability that the ratio of between to within variances is greater than 1 is nearly 1 in all cases. However, upon examining the table, combinations with probability of significance greater than 0.999 seem to cluster together. These combinations are production groups 95% and 90%. Thus, the combinations chosen are optimal for flow discrimination at OCPSF plants, a variable which relates to the size and construction costs of a plant's wastewater treatment system.

Production, in this analysis, is measured in million pounds per year and includes all OCPSF products. A subcategorization that discriminates well on production implies that size of plant has been successfully included as a factor in the analysis. Thus, plants of similar economic viability are grouped together. The analysis index shows that the subcategories chosen effectively group production into homogeneous groups relative to the inherent variability of production throughout the industry (Table 8). In fact, production (size) is the best variable in substantiating the subcategories. The probability that the ratio of variances is significantly different from 1 is 0.9999+ for most combinations. All combinations do well with only groups with percent commodity equal to 95% having a probability less than 0.9999+ for

most combinations. All combinations do well with only groups with percent commodity equal to 95% having a probability less than 0.9999+ (even here the probability is 0.999+). The combination with the greatest probability of significance (underlined in Table 8) is 95% organic chemical production and 75% commodity chemical production. OCPSF subcategories by product/product-groups are shown in Table 9.

TABLE 8. SIGNIFICANCE LEVELS FOR ANOVA FOR VARIOUS PRODUCTION CRITERIA vs. SELECTED DEPENDENT VARIABLES

PRODUCTION CRITERIA		SIGNIFICANCE OF DEPENDENT VARIABLES			
% PRODUCT CATEGORY	% COMMODITY (SPECIALTY)	INFLUENT BOD	EFFLUENT BOD	FLOW	TOTAL OCPSF PRODUCTION
100	50	.63	.84	.999	.9999
	60	.64	.86	.999	.9999
	75	.77	.87	.999	.9998
	95	.77	.93	.999	.9994
95	50	.38	.96	.9996	.9999
	60	.38	.97	.9995	.9999
	75	.53	.97	.9995	.9999
	95	.50	.98	.9994	.9994
90	50	.46	.96	.9996	.9999
	60	.46	.97	.9996	.9999
	75	.46	.97	.9996	.9999
	95	.45	.98	.9996	.9991
85	50	.52	.99	.9983	.9999
	60	.52	.99	.9982	.9999
	75	.57	.99	.998	.9999
	95	.49	.99	.998	.9991

TABLE 9. PERCENT PRODUCTION OF PRODUCT/PRODUCT-GROUPS BY SUBCATEGORY

PERCENT PRODUCTION

SUBCATEGORY	RAYON	OTHER FIBERS	THERMO-SETTING RESINS	THERMO-PLASTIC RESINS	COMMODITY ORGANIC CHEMICALS	BULK ORGANIC CHEMICALS	SPECIALTY ORGANIC CHEMICALS
Rayon	≥ 95	< 5	< 5	< 5	< 5	< 5	< 5
Fibers							
Fibers Only	< 5	≥ 95	< 5	< 5	< 5	< 5	< 5
Fibers and Organics	< 5	≥ 95	< 5	< 5	≥ 95	≥ 95	≥ 95
Thermosets							
Thermosets Only	< 5	< 5	≥ 95	< 5	< 5	< 5	< 5
Thermosets and Organics	< 5	< 5	≥ 95	< 5	≥ 95	≥ 95	≥ 95
Thermoplastics Only	< 5	< 5	< 5	≥ 95	< 5	< 5	< 5
Thermoplastics and Organics	< 5	< 5	< 5	< 5	≥ 95	≥ 95	≥ 95
Commodity Organic	< 5	< 5	< 5	< 5	≥ 75	< 25	< 25
Bulk Organic	< 5	< 5	< 5	< 5	Classified as Bulk if not Commodity and not Speciality		
Specialty Organic	< 5	< 5	< 5	< 5	< 25	≥ 75	≥ 75

2.3 PROCESSES EMPLOYED AND PROCESS CHANGES

An important characteristic of the Organic Chemicals and Plastics/Synthetic Fibers industry is the degree of vertical and horizontal integration between manufacturing units at individual plants. Since the bulk of the basic raw materials is derived from petroleum or natural gas, many of the commodity organic chemical manufacturing plants are either part of or contiguous to petroleum refineries; most of these plants have the flexibility to produce a wide variety of products. Relatively few organic manufacturing facilities are single product/process plants unless the final product is near the fabrication or consumer product stage. Additionally, many process units are integrated in such a fashion that amounts of related products can be varied as desired over wide ranges. There can be a wide variation in the size (production capacity) of the manufacturing complex as well as diversity of products and processes. In addition to the variations based on the design capacity and design product mix, economic and market conditions of both the products and raw materials can greatly influence the production rate and processes employed even on a relatively short-term basis.

2.3.1 Raw Materials

Synthetic organic chemicals are derivatives of naturally-occurring materials (petroleum, natural gas, and coal) which have undergone at least one chemical reaction. Given the large number of potential starting materials and chemical reactions available to the industry, many thousands of organic chemicals are produced by a potentially large number of basic processes having many variations. Similar considerations also apply to the Plastics/Synthetic Fibers industry although both the number of starting materials and processes are more limited. Both organic chemicals and plastics are commercially produced from six major raw material classifications: methane, ethane, propene, butanes/butenes, and higher aliphatic and aromatic compounds. This list can be expanded to eight by further defining the aromatic compounds to include benzene, toluene, and xylene. These raw materials are derived from

natural gas and petroleum, although a small portion of the aromatic compounds is derived from coal.

Using these eight basic raw materials (feedstocks) derived from the Petroleum Refining industry, process technologies used by the Organic Chemicals and Plastics/Synthetic Fibers industries lead to the formation of a wide variety of products and intermediates, many of which are produced from more than one basic raw material either as a primary reaction product or as a co-product. Furthermore, the reaction product of one process is frequently used as the raw material for a subsequent process. The primary products of the Organic Chemicals industry, for example, are the raw materials of the Plastics/Synthetics industry. Furthermore, the reaction products of one process at a plant are frequently the reactants for other processes at the same plant, leading to the categorization of a chemical as a product in one process and a reactant in another. This ambiguity continues until the manufacture of the ultimate end product, normally the fabrication or consumer stage. Many products/intermediates can be made from more than one raw material. Frequently, there are alternate processes by which a product can be made from the same basic raw material.

A second characteristic of the OCPSF industry which makes subcategorization by raw material difficult is the high degree of integration in manufacturing units. Most OCPSF plants use several of the eight basic raw materials derived from petroleum or natural gas to produce a single product. The choice of which raw material to choose as a basis for subcategorization is therefore ambiguous. Moreover, relatively few organic chemical manufacturing facilities are single product/process plants unless the final product is near the fabrication or consumer product stage. Therefore, subcategorization based on eight raw materials would necessitate the creation of 256 subcategories; subcategorization based on six raw materials would necessitate creation of 64 subcategories. Because of the integrated nature of the OCPSF industry, it may be concluded that subcategorization by raw materials is not feasible for the following reasons:

- The OCPSF industry is made up primarily of chemical complexes of various sizes and complexity.
- Very little, if any, of the total production is represented by single raw material plants.
- The raw materials used by a plant can be varied widely over short time spans.
- The conventional and nonconventional wastewater pollutant parameter data gathered for this study were not collected on a product/process basis, but rather represent the mixed end-of-pipe plant wastewaters.

2.3.2 Process Chemistry

Chemical and plastics manufacturing plants share an important characteristic: chemical processes never convert 100 percent of the feedstocks to the desired products, since the chemical reactions/processes never proceed to total completion. Moreover, because there is generally a variety of reaction pathways available to reactants, undesirable by-products are often generated. This produces a mixture of unreacted raw materials, products, and by-products that must be separated and recovered by operations that generate residues with little or no commercial value. These losses appear in process wastewater, in air emissions, or directly as chemical wastes. The specific chemicals that appear as losses are determined by the feedstock and the process chemistry imposed upon it. The different combinations of products and production processes distinguish the wastewater characteristics of one plant from those of another.

Manufacture of a chemical product necessarily consists of three steps: (1) combination of reactants under suitable conditions to yield the desired product; (2) separation of the product from the reaction matrix (e.g., by-products, co-products, reaction solvents); and (3) final purification of the

wastewaters: pollutants arise from the first step as a result of alternate reaction pathways; separation of reactants and products from a reaction mixture is imperfect and both raw materials and products are typically found in process wastewaters.

Though there is strong economic incentive to recover both raw materials and products, there is little incentive to recover the myriad of by-products formed as the result of alternate reaction pathways. An extremely wide variety of compounds can form within a given process. Typically, chemical species do not react via a single reaction pathway; depending on the nature of the reactive intermediate, there is a variety of pathways which lead to a series of reaction products. Often, and certainly the case for reactions of industrial significance, one pathway may be greatly favored over all others, but never to total exclusion. The direction of reactions in a process sequence is controlled through careful adjustment and maintenance of conditions in the reaction vessel. The physical condition of species present (liquid, solid, or gaseous phase), conditions of temperature and pressure, the presence of solvents and catalysts, and the configuration of process equipment dictate the kinetic pathway by which a particular reaction will proceed.

Therefore, despite the differences between individual chemical production plants, all transform one chemical to another by chemical reactions and physical processes. Though each transformation represents at least one chemical reaction, production of virtually all the industry's products can be described by one or more of 55 generalized chemical reactions/processes. Subjecting the basic feedstocks to sequences of these 55 generic processes produces most commercial organic chemicals and plastics.

Pollutant formation is dependent upon both the raw material and process chemistry, and broad generalizations regarding raw wasteater loads based solely on process chemistry are difficult at best. Additionally, OCPSF typically employs unique combinations of generic processes to produce organic chemicals and plastics/synthetic fibers that tend to blur any distinctions possible.

2.3.3 Product/Processes

Each chemical product may be made by one or more combinations of raw feedstock and generic process sequences. Specification of the sequence of product synthesis by identification of the product and the generic process by which it is produced is called a "product/process." There are, however, thousands of product/processes within the OCPSF industries. Data gathered on the nature and quantity of pollutants associated with the manufacture of specific products within the Organic Chemicals and Plastics/Synthetic Fibers industries have been indexed for 176 product/processes.

Organic chemical plants vary greatly as to the number of products manufactured and processes employed, and may be either vertically or horizontally integrated. One representative complex which is both vertically and horizontally integrated may produce a total of 45 high volume products with an additional 300 lower volume products. In contrast, a specialty chemicals plant may produce a total of 1,000 different products with 70 to 100 of these being produced on any given day.

On the other hand, specialty chemicals may involve several chemical reactions and require a fuller description. For example, preparation of toluene diisocyate from toluene (a commodity chemical) involves three synthesis steps--nitration, hydrogenation, and phosgenation. This example, in fact, is relatively simple; manufacture of other specialty chemicals is more complex. Thus, as individual chemicals become further removed from the basic feedstocks of the industry, more processes are required to produce them.

In contrast to organic chemicals, plastics and synthetic fibers are polymeric products. Their manufacture directly utilizes only a small subset of either the chemicals manufactured or processes used within the Organic Chemicals industry. Such products are manufactured by polymerization processes in which organic chemicals (monomers) react to form macromolecules or polymers,

composed of thousands of monomers units. Reaction conditions are designed to drive the polymerization as far to completion as practical and to recover unreacted monomer. Unless a solvent is used in the polymerization, by-products of polymeric product manufactures are usually restricted to the monomer(s) or to oliomers (a polymer consisting of only a few monomer units). Because the mild reaction conditions generate few by-products, there is economic incentive to recover the monomer(s) and oliomers for recycle; the principal yield loss is typically scrap polymer. Thus, smaller amounts of fewer organic chemical co-products (pollutants) are generated by the production of polymeric plastics and synthetic fibers than are generated by the manufacture of the monomers and other organic chemicals.

There are several ways by which the Organic Chemicals and Plastics/Synthetic Fibers industry might be potentially subcategorized on the basis of process chemistry. For example, subcategorization could be based upon the particular combination of product/processes in use at individual plants. Individual plants within these industries, however, are unique in terms of the numbers and types of product/processes employed and raw wastewater quality. As plants are made subject to effluent limitations or standards, pretreatment and treatment trains are uniquely designed and operated to meet pollutant removal criteria; although raw wastewater quality may differ greatly among plants, similar removal efficiencies may be obtained. Thus, a scheme that would subcategorize plants based on raw wastewater quality alone would unnecessarily separate plants that are appropriately covered by a single set of uniform requirements. Product/process is inappropriate as a basis for subcategorization.

2.4 FACILITY SIZE

The Agency has chosen total OCPSF production to define facility size. Sales volume, number of employees, area of plant site, plant capacity, and production rate have been chosen by others as a measure of facility size. In exploring the suitability of using alternate measures, the Agency concluded that none of the alternative definitions were appropriate to describe facility size for the purposes of subcategorization analysis. Total OCPSF production, however, is adequately grouped by the proposed subcategories based on products

or product groups manufactured by facility (see Table 9). Spearman rank correlations are used to further search for possible secondary effects of facility size within a subcategory.

As discussed in Appendix B, the Spearman rank correlation is a nonparametric statistical technique that measures the association between two variables, i.e., total OCPSF production and influent BOD and TSS individually. It should be noted that the Spearman rank correlation is an overly sensitive technique for determining association and that each correlation significantly greater than zero may have no practical implications on the overall regulations. Therefore, the Agency feels this technique will not miss any hidden relationships.

Table 10 gives the Spearman rank correlation coefficients (rank) for size when compared with influent BOD and influent TSS. Beneath each rank is the level of significance for the test, that is, whether the given rank is significantly different from zero. Also in this table is the sample size, the number of plants where data existed for both variables (e.g., influent BOD and size). The Rayon row of Table 10 shows N/A (not applicable) beneath both ranks. In both cases, the sample size of two is insufficient to measure significance, since for rank correlations a sample size of two yields a correlation of either +1 or -1 as an artifact of the calculations.

TABLE 10. SPEARMAN RANK CORRELATION COEFFICIENTS (R)
FOR RAW WASTE BOD AND TSS VERSUS SIZE
(5% Significance Level)

	Influent BOD		Influent TSS	
	(R)	n	(R)	n
Rayon	1.0 (N/A)	2	1.0 (N/A)	2
Other Fibers	0.77 (N.S.)	6	1.0 (0.0)	4
Thermosets	0.4 (N.S.)	5	-0.4 (N.S.)	4
Thermoplastics	-0.311 (N.S.)	20	-0.355 (N.S.)	17
Thermoplastics and Organics	-0.147 (N.S.)	16	-0.269 (N.S.)	17
Commodity Organics	-0.036 (N.S.)	7	0 (N.S.)	4
Bulk Organics	-0.193 (N.S.)	19	-0.011 (N.S.)	15
Specialty Organics	-0.309 (N.S.)	11	0.151 (N.S.)	9

The only significant correlation exists for influent TSS and size for the Other Fibers subcategory, where R = 1. Closer inspection of the data, however, suggests that this correlation results from inclusion of data from a poorly operated plant. This conclusion is based on two observations: first, the range of production for this category is between 50 and 3,000 million pounds per year, and the highest TSS is for a plant with only 400 million pounds per year, a production level easily within the coverage of all the data, while the largest production plant has the second lowest effluent TSS. Thus, a bigger plant can do better. Second, a rank correlation analysis based on effluent TSS shows a correlation of R = 0.217 with no significance (N.S.). Thus, wastewater characteristics do not seem to be correlated with production. Therefore, total OCPSF production as a measure of facility size is not a factor for further subcategorization.

2.5 GEOGRAPHICAL LOCATION

Companies in the OCPSF industry usually locate their plants based on a number of factors. These include:

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

In addition, a particular product/process may be located in an existing facility based on availability of certain types of equipment or land for expansion. Companies also locate their facilities based on the type of production involved. For example, specialty producers may be located closer to their major markets, whereas bulk producers may be centrally located to service a wide variety of markets. Also, a company may locate its plants based on its planned method of wastewater disposal. A company that has committed itself to zero discharge as its method of wastewater disposal has

the ability to locate anywhere, while direct dichargers must locate near receiving waters, and indirect dischargers must locate in a city or town which has an adequate POTW capacity to treat OCPSF wastewaters.

Because of the complexity and interrelationships of the factors affecting plant locations outlined above, no clear basis for subcategorization according to plant location could be found. Therefore, location is not a basis for subcategorization of the OCPSF industry.

In order to confirm that temperature, a surrogate for location, is not a factor, the Agency calculated rank correlation by subcategory for BOD effluent and TSS effluent versus heating degree days. This measure is typically used by power companies to estimate heating bills; as heating degree days increase, daily temperature decrease. The results of this analysis were consistent with the assumption that temperature is not a factor (Table 11). With the exception of effluent TSS for specialty chemicals, all calculated rank correlations are not significant. In the case of specialty chemicals the correlation is positive, R = 54, and significant (.0064). A positive correlation between TSS and heating degree days implies that TSS increases as temperature decreases.

From an engineering viewpoint, this result appears spurious, since one would expect TSS to increase with temperature in biological systems. Moreover, all comments directed to the temperature effects support this belief, i.e., TSS increases with increasing temperature. Therefore, the Agency believes that temperature is not a factor.

2.6 AGE OF EQUIPMENT AND FACILITY

Facility age can affect raw waste pollutant concentrations in several ways. Older plants may use open sewers and drainage ditches to collect process wastewater. These ditches may run inside the process buildings as well as between manufacturing centers. Because of their convenience and lack of other collection alternatives, cooling waters, steam condensates, wash

TABLE 11. SPEARMAN RANK CORRELATION COEFFICIENTS FOR DEGREE DAYS VERSUS EFFLUENT BOD AND EFFLUENT TSS
(5% Significance Level)

	Effluent BOD		Effluent TSS	
	R	n	R	n
Rayon	-0.50 (N.S.)	3	-0.50 (N.S.)	3
Other Fibers	-0.11 (N.S.)	10	0.32 (N.S.)	9
Thermosets	0.59 (N.S.)	10	0.35 (N.S.)	10
Thermoplastics	-0.04 (N.S.)	34	-0.13 (N.S.)	33
Thermoplastics and Organics	-0.25 (N.S.)	30	-0.20 (N.S.)	31
Commodity Organics	0.08 (N.S.)	20	-0.17 (N.S.)	18
Bulk Organics	0.03 (N.S.)	45	-0.05 (N.S.)	50
Specialty Organics	0.24 (N.S.)	23	0.54 (0.0064)	24

waters, and tank drainage waters, as well as contact wastewaters, are generally collected in these drains. Older facilities, therefore, are likely to exhibit higher wastewater discharge flow rates than newer facilities which typically segregate process contact wastewaters from noncontact process wastewaters. In addition, the inclusion of relatively clean waters (e.g., noncontact cooling waters, steam condensates) dilutes raw wastewaters. Older plants are also less amenable to recycle techniques and wastewater segregation efforts; both methods require the installation of new collection lines as well as the isolation of the existing collection ditches and are difficult to accomplish with existing piping systems.

Facility age, for the purposes of this report and as reported in the 1983 "308 Questionnaire," is defined as the oldest process in operation at the site. Because most plants within the Organic Chemicals and Plastics/Synthetic Fibers industries consist of more than one process, however, this definition fails to reflect the true age of an OCPSF plant. Moreover, production facilities are continually modified to meet current production goals and to accommodate new product lines. Actual process equipment is generally modern (i.e., 1-15 years old), while major building structures and plant sewers are not generally upgraded when the plant expands significantly by new construction. Because the age of plants within the Organic Chemicals and Plastics/Synthetic Fibers industries cannot be accurately defined, plant age is inappropriate for subcategorization.

Process equipment common to the OCPSF industries can be divided into the following general categories: vessels in which the chemical reaction takes place; equipment used to separate products from unwanted materials; equipment used to control emissions from the process train; and vessels used to store raw materials and products. Process wastewaters may be generated in this equipment as a reaction product, reaction solvent, working fluid, heat transfer medium, and maintenance/cleaning operations. Emission control equipment such as scrubbers may also generate wastewaters.

The extent to which process wastewaters are contaminated with pollutants depends mainly upon the degree of contact process water has with reactants/products, the effectiveness of the separation train, and the physico-chemical properties of those pollutants formed in the reaction. Raw wastewater quality is determined by the specific process design and chemistry. For example, water formed during a reaction, used to quench a reaction mixture, or used to wash reaction products will contain greater amounts of pollutants than water that does not come into direct contact with reactants or products. The effectiveness of a separation train is determined by the process design and the physico-chemical properties of those pollutants present (see Engineering Aspects of Control Technologies). While improvements are continually made in the design and construction of process equipment, the basic design of such equipment may be quite old. Process equipment does however, deteriorate during use and requires maintenance to ensure optimal performance. When process losses can no longer be effectively controlled by maintenance, process equipment is replaced. The maintenance schedule and useful life associated with each piece of equipment are in part determined by equipment age and process conditions. Equipment age, however, does not directly affect pollutant concentrations in influent or effluent wastewaters and is therefore inappropriate as a basis for subcategorization.

Table 12 gives the results of the Spearman rank correlations for age versus influent BOD and influent TSS. The only subcategory that was not nonsignificant was Rayon, where the sample size was two, thus guaranteeing a significant result. From a practical viewpoint, this result is not significant. The age and influent BOD for each plant are 44/175 and 32/163, respectively, different as to ranks but not practically different.

TABLE 12. SPEARMAN RANK CORRELATION COEFFICIENTS FOR AGE OF PLANT VERSUS INFLUENT BOD AND TSS (5% Significance Level)

	Influent BOD		Influent TSS	
	R	n	R	n
Rayon	+1.0 (N/A)	2	+1.0 (N/A)	2
Other Fibers	0.54 (N.S.)	6	0.40 (N.S.)	4
Thermosets	-0.80 (N.S.)	5	.00 (N.S.)	4
Thermoplastics	-0.363 (N.S.)	20	-0.182 (N.S.)	17
Thermoplastics and Organics	-0.076 (N.S.)	16	-0.289 (N.S.)	17
Commodity Organics	-0.286 (N.S.)	7	-0.80 (N.S.)	4
Bulk Organics	-0.259 (N.S.)	18	-0.207 (N.S.)	15
Specialty Organics	0.50 (N.S.)	11	0.02 (N.S.)	9

2.7 ENGINEERING ASPECTS OF CONTROL TECHNOLOGIES (TREATABILITY)

The selection of a treatment train for OCPSF industries wastewaters is done on a plant-by-plant basis. The selection is based on the desired effluent quality and thermodynamic properties of the waste stream contaminants. While the different product/process mixes which exist at individual plants are unique and result in process waste streams of widely varying quality, conventional and toxic pollutant wasteloads are treatable by commonly employed physical-chemical and biological unit operations.

Typically, the treatability of a waste stream is described in terms of its biodegradability, as biological treatment usually provides the most cost-effective means of treating a high volume, high (organic) strength industrial waste (i.e., minimum capital and operating costs). Furthermore, biodegradability serves as an important indicator of the toxic nature of the waste load upon discharge to the environment. Aerobic (oxygen-rich) biological treatment processes achieve accelerated versions of the same type of biodegradation that would occur much more slowly in the receiving water. These treatment processes accelerate biodegradation by aerating the wastewater to keep the dissolved oxygen concentration high and recycling microorganisms to maintain extremely high concentrations of bacteria, algae, fungi, and protozoa in the treatment system. Certain compounds which resist biological degradation in natural waters may be readily oxidized by a microbial population adapted to the waste. As would occur in the natural environment, organic compounds may be removed by volatization (e.g., aeration) and adsorption on solid materials (e.g., sludge) during biological treatment.

One of the primary limitations of biologial treatment of wastewater from the Organic Chemicals and Plastics/Synthetic Fibers industries is the presence of both refractory (difficult to treat) compounds as well as compounds which are toxic or inhibitory to biological processes. Compounds oxidized slowly by microorganisms can generally be treated by subjecting the wastewater to biological treatment for a longer time; thereby increasing the overall

conventional and toxic pollutant removals. Lengthening the duration of treatment, however, requires larger treatment tanks and more aeration, both of which add to the expense of the treatment. Alternatively, pollutants that are refractory, toxic, or inhibitory to biological process can be removed prior to biological treatment of wastewaters. Removal of pollutants prior to biological treatment is known as pretreatment.

The successful treatment of wastewaters of the OCPSF industries primarily depends on effective physical-chemical pretreatment of wastewater, the ability to acclimate biological organisms to the remaining pollutants in the waste stream (as in activated sludge processes), the year-round operation of the treatment system at an efficient removal rate, the resistance of the treatment system to toxic or inhibitory concentrations of pollutants, and the stability of the treatment system during variations in the waste loading (i.e., changes in product mixes).

A primary limitation of biological treatment of OCPSF process wastewaters is the great variability of toxic pollutant loadings. While microbial populations within a biological treatment system gradually acclimate to specific compounds in the waste streams from a given organic chemicals plant, the composition of a waste stream may rapidly vary as different production processes are operated. The microbial population treating a complex waste stream of widely varying composition will not be as well acclimated as a microbial population treating a relatively constant waste stream. Thus, in order to maintain desired removal rates, physical-chemical pretreatment may be required prior to the biological treatment train.

Physical-chemical technologies are commonly used by industrial manufacturers as in-process recovery and treatment steps, as a means of rendering wastewaters more amenable to treatment by biological processes, and in certain cases, as the sole end-of-pipe treatment of wastewaters where such streams are ineffectively treated by biological processes (e.g., low in BOD and COD or low in BOD and high in COD). Such operations include: equalization,

sedimentation, filtration, phase separation, solvent extraction, stripping, aeration, adsorption on a synthetic resin or activated carbon, azeotropic or extractive distillation, chemical precipitation, chemical coagulation, and polishing ponds. These techniques may be combined or repeated in sequence, as required, to achieve the desired level of treatment of the waste effluent.

Selection of the appropriate treatment train for a waste stream is almost solely dependent on the desired performance characteristics. Biological systems are based on the required residence time to achieve the desired effluent quality. Where extended residence times are infeasible (e.g., space limitations on reactor size), pretreatment upstream of the biological unit may be employed to remove toxic pollutants which slow, prevent, or interfere with the biological process.

In selecting a physical-chemical treatment unit, the thermodynamics of the operation dictate effluent quality. Steam stripping, for example, is a mass transfer operation that is used to remove volatile organic contaminants from dilute solutions. The practicality of using steam stripping to treat a particular waste stream is dependent on the solubility, vapor pressure, and the activity coefficients of pollutants to be treated. These thermodynamic properties dictate tray and steam requirements, and ultimately, column efficiencies. Excessive tray requirements to obtain the desired outlet (effluent) concentration of organic pollutants would rule out steam stripping as a desirable treatment operation.

In summary, though the design of a treatment train can be unique to each plant, by selection and proper operation of appropriate treatment technologies it is possible for individual plants to meet common effluent limitations regardless of raw wastewater quality. Indeed, the percentage removals of BOD and TSS are consistent across all subcategories. It is also possible for plants in all subcategories to achieve high percentage removals (greater than 95%) for both BOD and TSS. Therefore, based on the consistency

of BOD and TSS removal data and the ability of plants in all subcategories to achieve high removals of pollutants, the Agency concluded that subcategorization based on treatability is not justified.

2.8 FLOW

A variable of interest but not typically used in subcategorization is flow. In the last proposal (March 21, 1983) the Agency designated subcategories which used flow as a factor. Therefore, the Agency has again decided, for continuity of the analysis, to analyze whether flow is a significant factor. The results of Table 13 show that flow has been adequately incorporated into the initial eight subcategories; based on the ANOVA analysis, there was a 0.9999 significance for flow. A possibility remains that there is a secondary effect for flow within the subcategories specified. Based on Table 13, it appears that there are no secondary effects possible with the exception of the thermoset subcategory. The Spearman rank correlation for thermosets is -1 for TSS: i.e., TSS decreases with flow. This result appears to be spurious, since the two highest influents are 2,509 ppm and 740 ppm, while their flows are 0.011 MGD versus 0.018 MGD. Furthermore, the rank correlation of effluent TSS is -0.02 and is not significant. This result is based on a sample size of 10 compared to 4 for influent. Thus, flow is not a factor for further subcategorization.

TABLE 13. SPEARMAN RANK CORRELATION COEFFICIENTS FOR INFLUENT FLOW VERSUS INFLUENT BOD AND INFLUENT TSS
(5% Significance Level)

	Influent BOD		Influent TSS	
	R	n	R	n
Rayon	1. (N.A.)	2	1. (N.A.)	2
Other Fibers	0.37 (N.S.)	6	0.8 (N.S.)	4
Thermosets	-0.3 (N.S.)	5	-1.0 (0.0)	4
Thermoplastics	-0.16 (N.S.)	20	-0.38 (N.S.)	17
Thermoplastics and Organics	-0.27 (N.S.)	16	-0.39 (N.S.)	17
Commodity Organics	-0.07 (N.S.)	7	-0.37 (N.S.)	4
Bulk Organics	-0.37 (N.S.)	19	-0.21 (N.S.)	15
Specialty Organics	-0.44 (N.S.)	11	0.317 (N.S.)	9

2.9 COST OF ACHIEVING EFFLUENT REDUCTION

The waste treatment investment and operating costs for a specific chemical plant depend on several factors:

- The ability to recycle process wastewaters
- The ability to recover products from process wastewaters
- The composition and quantity (e.g. flow) of waste streams
- The geographical area within which the wastes are generated and disposed of
- The existence of POTWs to accept waste streams
- The generation of solid waste
- The nature of the chemical process
- The kind and purity of the raw materials.

The technology for pollution abatement consists mainly of the same physical and chemical separations and reaction technologies used in chemical manufacture. Wastewater streams such as process water, boiler blow-down, and runoff water may be treated separately or collectively by appropriate operations in one or more treatment stages. Streams requiring different treatment methods are segregated and subsequently combined at the point where treatment becomes similar. For example, runoff waters might be settled in a thickener; certain process waters might be separated by dissolved air flotation, steam stripped, and treated biologically; other process wastewaters might be neutralized and filtered; and the sanitary sewer flow might either be treated biologically or discharged to a POTW. All streams might then be combined for a water quality check, flow equalization, and discharge to an adjacent water body. Each of these factors is considered in this section. The composition of raw wastewaters is largely a function of the products and processes by which these products are made. The treatability of these wastewaters (as discussed earlier) is largely independent of the raw waste load; that is, by selection and proper operation of appropriate treatment technologies, it is possible

for individual plants to meet common effluent limitations. Accordingly, treatment costs are inappropriate as a basis for subcategorization. Industry-wide costs of compliance with alternative effluent limitations are analyzed in a separate companion economic impact study.

2.10 ENERGY AND NONWATER QUALITY ENVIRONMENTAL IMPACTS

Plants within the Organic Chemicals and Plastics/Synthetic Fibers industry, in addition to producing process wastewaters requiring treatment, may generate significant amounts of airborne pollutants and solid wastes. Air emissions are controlled by a wide variety of technologies including absorption, adsorption, filtration, condensation, and incineration. Absorption technologies in controlling atmospheric emissions generate both solid and liquid waste streams. Solid wastes generated by OCPSF plants are treated by technologies including coagulation, extraction, distillation, chemical reaction, chemical fixation, and incineration. Many of these technologies used to treat solid wastes also generate wastewater streams.

Generation of both airborne waste streams and solid waste streams is subject to the same considerations as process wastewaters: chemical manufacturing processes do not convert raw materials to products at 100 percent efficiency; that is, a portion of the raw materials used in a manufacturing process is inevitably converted into unwanted products. These products may potentially be discharged to the atmosphere, the aquatic environment, and the terrestrial environment depending upon the specific manufacturing configuration (e.g., use of an aqueous reaction medium, use of gaseous reactants). Both the impacts of air and solid waste emissions parallel those of wastewater and do not provide an alternate subcategorization system.

Similarly, the energy consumption of wastewater treatment technologies fails to provide meaningful subcategorization. The high energy content of raw materials and products of the OCPSF industry results in only a small fraction of the total energy used for pollution control. Specific energy

requirements are determined by the nature of the processes and by such unit operations as thermal cracking, distillation, heating of reactors, and similar processing steps. In contrast, practically all wastewater treatment technologies require a modest energy input that is a small fraction of the total plant energy requirements. The energy requirements of the wastewater treatment facility are small in comparison to the plant total.

APPENDIX A

ANALYSIS OF VARIANCE

ANALYSIS OF VARIANCE

Analysis of Variance (ANOVA) is a statistical technique which can be used to determine, for a particular variable (e.g., BOD), the relative contribution of the variance between certain groupings of this variable to the total variance of the variable. As used by the Agency and recommended by commmentors following proposal, ANOVA is used to test the hypothesis that certain fixed groups (the subcategories) explain most of the variance for variables the Agency considers as suitable measures of the adequacy of its subcategorization and appropriate for ANOVA analysis.

Typically, as explained below, there are two hypotheses: the null hypothesis (H_0) and the alternative hypothesis (H_1). In our case the Agency has tested the hypotheses that:

H_0: The subcategories determined by the Agency adequately account for all the factors which affect the variance of a variable (such as BOD concentration).

H_1: The subcategories determined by the Agency do not account for all factors which affect the variance.

The variables chosen by the Agency are Influent BOD, Effluent BOD, Total Production, and Total Flow. The statistical basis of the Agency's use of ANOVA is discussed below.

Suppose there exist k groups. Let $x_{i1}, x_{i2}, \ldots, x_{in_i}$ be independent observations from group i, $i = 1, \ldots, k$. Let $\bar{x}_{i\cdot}$ be the sample mean for group i, and let $\bar{x}_{\cdot\cdot}$ be the sample mean for all of the observations. That is,

$$\bar{x}_{i\cdot} = \frac{1}{n_i} \sum_{j=1}^{n_i} x_{ij} \quad \text{for} \quad i=1, \ldots, k, \text{ and}$$

$$\bar{x}_{\cdot\cdot} = \frac{1}{N} \sum_{i=1}^{k} \sum_{j=1}^{n_i} x_{ij}, \quad \text{where} \quad N = \sum_{i=1}^{k} n_i \ .$$

To test whether or not the null hypothesis can be rejected, the following analysis of variance table is constructed:

ANALYSIS OF VARIANCE TABLE

SOURCE	DEGREES OF FREEDOM	SUMS OF SQUARES	MEAN SQUARES
Among Groups	$k - 1$	$\sum_{i=1}^{k} n_i (\bar{x}_{i\cdot} - \bar{x}_{\cdot\cdot})^2$	$SS(Among)/(k - 1) = MS_A$
Within Groups	$N - k$	$\sum_{i=1}^{k} \sum_{j=1}^{n_i} (x_{ij} - \bar{x}_{i\cdot})^2$	$SS(Within)/(N - k) = MS_W$
Total	$N - 1$	$\sum_{i=1}^{k} \sum_{j=1}^{n_i} (x_{ij} - \bar{x}_{\cdot\cdot})^2$	

An F statistic, MS_A/MS_W, is compared with a critical value, as found in standard F tables (see Neter and Wasserman (1974)). This critical value is $F(k-1, N-k, 1-\alpha)$ with degrees of freedom k-1 and N-k and a significance level $\alpha = 0.05$. If the F statistic is larger than the critical value, the null hypothesis is rejected and the alternative hypothesis is accepted. If the F statistic is smaller than the critical value, the null hypothesis is not rejected.

Reference

Neter, J. and W. Wasserman. 1974. Applied Linear Statistical Models. Homewood, Ill.: Richard D. Irwin, Inc., pp. 807-13.

APPENDIX B

SPEARMAN RANK CORRELATION

SPEARMAN RANK CORRELATION TECHNIQUE

Let (x_1, y_1), (x_2, y_2), ..., (x_n, y_n) be a bivariate random sample of size n. The rank of x_i, $R(x_i)$, for i = 1, 2, ..., n , as compared with other X values, is the position of x_i as the X values are ordered from smallest to largest. Thus, if x_k is the smallest X value, $R(x_k) = 1$ and if x_1 is the largest X value, $R(x_1) = n$. Similarly, the values for Y can be ranked for i = 1, 2, ..., n. Once ranked, the data can be replaced with the rank pairs $(R(x_1), R(y_1))$, $(R(x_2), R(y_2))$, ..., $(R(x_n), R(y_n))$. The Spearman rank correlation coefficient (r) is calculated as follows:

$$r = \frac{\left[\sum_{i=1}^{n} R(x_i)R(y_i)\right] - [0.5(n + 1)]^2}{\frac{n(n^2 - 1)}{12}} .$$

Based on r, the rank correlation statistic, the following hypotheses can be tested:

H_0: The X and Y variables are independent (i.e., their correlation is zero)

H_1: Either (a) there is a tendency for the larger (smaller) values of X to be paired with the larger (smaller) values of Y, or (b) there is a tendency for the smaller (larger) values of X to be paired wih the larger (smaller) values of Y.

By using influent or effluent concentrations for the X's and subcategorization variables for the Y's, the above hypothesis becomes a statistical test for significant subcategorization factors.

Correlation coefficients are numbers which range between -1 and +1. Values of ± 1 indicate perfect associations or correlations, while a value of zero indicates no relationship. The Spearman rank correlation coefficient is used to identify a relationship between R(X) and R(Y), and development of the relationship between X and Y requires additional statistical techniques.

APPENDIX C

PRODUCT LISTINGS BY INDUSTRIAL SEGMENT

TABLE II

OTHER FIBERS AND FIBER GROUPS

* ACRYLIC FIBERS(85% POLYACRYLONITRILE)
* CELLULOSE ACETATE FIBERS
* FLUOROCARBON (TEFLON) FIBERS
* MODACRYLIC FIBERS
* NYLON 6 FIBERS
  NYLON 6 MONOFILAMENT
* NYLON 66 FIBERS
  NYLON 66 MONOFILAMENT
* POLYAMIDE FIBERS (QUIANA)
* POLYARAMID (KEVLAR) RESIN-FIBERS
* POLYARAMID (NOMEX) RESIN-FIBERS
* POLYESTER FIBERS
* POLYETHYLENE FIBERS
* POLYPROPYLENE FIBERS
* POLYURETHANE FIBERS (SPANDEX)

TABLE III

THERMOSETTING RESINS AND THERMOSETTING RESIN GROUPS

* ALKYD RESINS
  DICYANODIAMIDE RESIN
* EPOXY RESINS
* FUMARIC ACID POLYESTERS
* FURAN RESINS
  GLYOXAL-UREA FORMALDEHYDE TEXTILE RESIN
* KETONE-FORMALDEHYDE RESINS
* MELAMINE RESINS
* PHENOLIC RESINS
* POLYACETAL RESINS
  POLYACRYLAMIDE
* POLYURETHANE PREPOLYMERS
* POLYURETHANE RESINS
* UREA FORMALDEHYDE RESINS
* UREA RESINS

TABLE IV

THERMOPLASTIC RESINS AND THERMOPLASTIC RESIN GROUPS

* ABIETIC ACID - DERIVATIVES
* ABS RESINS
* ABS-SAN RESIN
* ACRYLATE-METHACRYLATE LATEXES
* ACRYLIC LATEX
* ACRYLIC RESINS
* CELLULOSE ACETATE BUTYRATES
  CELLULOSE ACETATE RESIN
* CELLULOSE ACETATES
* CELLULOSE ACETATES PROPIONATES
  CELLULOSE NITRATE
  CELLULOSE SPONGE
* ETHYLENE-METHACRYLIC ACID COPOLYMERS
* ETHYLENE-VINYL ACETATE COPOLYMERS
* FATTY ACID RESINS
* FLUOROCARBON POLYMERS
  NYLON 11 RESIN
* NYLON 6 - 66 COPOLYMERS
* NYLON 6 - NYLON 11 BLENDS
  NYLON 6 RESIN
  NYLON 612 RESIN
  NYLON 66 RESIN
* NYLONS
* PETROLEUM HYDROCARBON RESINS
* POLVINYL PYRROLIDONE - COPOLYMERS
* POLY(ALPHA)OLEFINS
  POLYACRYLIC ACID
* POLYAMIDES
* POLYARYLAMIDES
  POLYBUTADIENE
* POLYBUTENES
  POLYBUTENYL SUCCINIC ANHYDRIDE
* POLYCARBONATES
  POLYESTER FILM
* POLYESTER RESINS
* POLYESTER RESINS, POLYBUTYLENE TEREPHTHALATE
* POLYESTER RESINS, POLYOXYBENZOATE
  POLYETHYLENE
* POLYETHYLENE - ETHYL ACRYLATE RESINS
* POLYETHYLENE - POLYVINYL ACETATE COPOLYMERS
  POLYETHYLENE RESIN (HDPE)
  POLYETHYLENE RESIN (LDPE)
  POLYETHYLENE RESIN, SCRAP
  POLYETHYLENE RESIN, WAX (LOW M.W.)
  POLYETHYLENE RESIN,LATEX
  POLYETHYLENE RESINS
* POLYETHYLENE RESINS, COMPOUNDED
* POLYETHYLENE, CHLORINATED
* POLYIMIDES
* POLYPROPYLENE RESINS
  POLYSTYRENE (CRYSTAL)
  POLYSTYRENE (CRYSTAL) MODIFIED
* POLYSTYRENE - COPOLYMERS

TABLE IV

THERMOPLASTIC RESINS AND THERMOPLASTIC RESIN GROUPS

* POLYSTYRENE - ACRYLIC LATEXES
  POLYSTYRENE IMPACT RESINS
  POLYSTYRENE LATEX
  POLYSTYRENE, EXPANDABLE
  POLYSTYRENE, EXPANDED
* POLYSULFONE RESINS
  POLYVINYL ACETATE
* POLYVINYL ACETATE - PVC COPOLYMERS
* POLYVINYL ACETATE COPOLYMERS
* POLYVINYL ACETATE COPOLYMERS
* POLYVINYL ACETATE RESINS
  POLYVINYL ALCOHOL RESIN
  POLYVINYL CHLORIDE
  POLYVINYL CHLORIDE, CHLORINATED
* POLYVINYL ETHER-MALEIC ANHYDRIDE
* POLYVINYL FORMAL RESINS
* POLYVINYLACETATE - METHACRYLIC COPOLYMERS
* POLYVINYLACETATE ACRYLIC COPOLYMERS
* POLYVINYLACETATE-2-ETHYLHEXYLACRYLATE COPOLYMERS
  POLYVINYLIDENE CHLORIDE
* POLYVINYLIDENE CHLORIDE COPOLYMERS
* POLYVINYLIDENE-VINYL CHLORIDE RESINS
* PVC COPOLYMERS, ACRYLATES (LATEX)
* PVC COPOLYMERS, ETHYLENE-VINYL CHLORIDE
* ROSIN DERIVATIVE RESINS
* ROSIN MODIFIED RESINS
* ROSIN RESINS
* SAN RESINS
* SILICONES:SILICONE RESINS
* SILICONES:SILICONE RUBBERS
* STYRENE MALEIC ANHYDRIDE RESINS
  STYRENE POLYMERIC RESIDUE
* STYRENE-ACRYLIC COPOLYMER RESINS
* STYRENE-ACRYLONITRILE-ACRYLATES COPOLYMERS
* STYRENE-BUTADIENE RESINS
* STYRENE-BUTADIENE RESINS (<50% BUTADIENE)
* STYRENE-BUTADIENE RESINS (LATEX)
* STYRENE-DIVINYL BENZENE RESINS (ION XCHANGE)
* STYRENE-METHACRYLATE TERPOLYMER RESINS
* STYRENE-METHYL METHACRYLATE COPOLYMERS
* STYRENE, BUTADIENE, VINYL TOLUENE TERPOLYMERS
* SULFONATED STYRENE-MALEIC ANHYDRIDE RESINS
* UNSATURATED POLYESTER RESINS
* VINYL TOLUENE RESINS
* VINYL TOLUENE-ACRYLATE RESINS
* VINYL TOLUENE-BUTADIENE RESINS
* VINYL TOLUENE-METHACRYLATE RESINS
* VINYLACETATE-N-BUTYLACRYLATE COPOLYMERS

TABLE V

COMMODITY ORGANICS CHEMICALS AND CHEMICAL GROUPS

ALIPHATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

ACETALDEHYDE
ACETIC ACID
ACETIC ANHYDRIDE
ACETONE
ACRYLONITRILE
ADIPIC ACID
* BUTYLENES (BUTENES)
CYCLOHEXANE
ETHANOL
ETHYLENE
ETHYLENE GLYCOL
ETHYLENE OXIDE
FORMALDEHYDE
ISOPROPANOL
METHANOL
POLYOXYPROPYLENE GLYCOL
PROPYLENE
PROPYLENE OXIDE
UREA
VINYL ACETATE
1,2-DICHLOROETHANE
1,3-BUTADIENE

AROMATIC ORGANIC CHEMICALS

BENZENE
CUMENE
DIMETHYL TEREPHTHALATE
ETHYLBENZENE
M-XYLENE(IMPURE)
P-XYLENE
PHENOL
* PITCH TAR RESIDUES
* PYROLYSIS GASOLINES
STYRENE
TEREPHTHALIC ACID
TOLUENE
* XYLENES, MIXED
O-XYLENE

HALOGENATED ORGANIC CHEMICALS

VINYL CHLORIDE

TABLE VI

BULK ORGANIC CHEMICALS AND CHEMICAL GROUPS

ALIPHATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

* ACETIC ACID ESTERS
* ACETIC ACID SALTS
ACETONE CYANOHYDRIN
ACETYLENE
ACRYLIC ACID
* ACRYLIC ACID ESTERS
* ALKOXY ALKANOLS
* ALKYLATE
* ALPHA-OLEFINS
BUTANE (ALL FORMS)
* C-4 HYDROCARBONS(UNSATURATED)
CALCIUM STEARATE
CAPROLACTAM
CARBOXYMETHYL CELLULOSE
CELLULOSE ACETATE BUTYRATES
* CELLULOSE ETHERS
CHLORINATED PARAFFINS,35-64 PCT,CHLORINE
CITRIC ACID
CUMENE HYDROPEROXIDE
CYCLOHEXANOL
CYCLOHEXANOL, CYCLOHEXANONE(MIXED)
CYCLOHEXANONE
CYCLOHEXENE
* C12-C18 PRIMARY ALCOHOLS
* C5 CONCENTRATES
* C9 CONCENTRATES
DECANOL
DIACETONE ALCOHOL
* DICARBOXYLIC ACIDS - SALTS
DIETHYL ETHER
DIETHYLENE GLYCOL
DIETHYLENE GLYCOL DIETHYL ETHER
DIETHYLENE GLYCOL DIMETHYL ETHER
DIETHYLENE GLYCOL MONOETHYL ETHER
DIETHYLENE GLYCOL MONOMETHYL ETHER
* DIMER ACIDS
DIOXANE
ETHANE
ETHLYENE GLYCOL MONOPHENYL ETHER
* ETHOXYLATES, MISC.
ETHYLENE GLYCOL DIMETHYL ETHER
ETHYLENE GLYCOL MONOBUTYL ETHER
ETHYLENE GLYCOL MONOETHYL ETHER
ETHYLENE GLYCOL MONOMETHYL ETHER
* FATTY ACIDS
GLYCERINE(SYNTHETIC)
GLYOXAL
HEXANE
* HEXANES AND OTHER C6 HYDROCARBONS
HYDROGEN CYANIDE
ISOBUTANOL
ISOBUTYLENE

ALIPHATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

ISOBUTYRALDEHYDE
ISOPHORONE
ISOPHTHALIC ACID
ISOPRENE
ISOPROPYL ACETATE
LIGNINSULFONIC ACID, CALCIUM SALT
MALEIC ANHYDRIDE
METHACRYLIC ACID
* METHACRYLIC ACID ESTERS
METHANE
METHYL ETHYL KETONE
METHYL METHACRYLATE
METHYL TERT-BUTYL ETHER
METHYLISOBUTYL KETONE
* N-ALKANES
N-BUTYL ALCOHOL
N-BUTYLACETATE
N-BUTYLACETATE
N-BUTYRALDEHYDE
N-BUTYRIC ACID
N-BUTYRIC ANHYDRIDE
* N-PARAFFINS
N-PROPYL ACETATE
N-PROPYL ALCOHOL
NITRILOTRIACETIC ACID
NYLON SALT
OXALIC ACID
* OXO ALDEHYDES - ALCOHOLS
PENTAERYTHRITOL
PENTANE
* PENTENES
* PETROLEUM SULFONATES
PINE OIL
POLYOXYBUTYLENE GLYCOL
POLYOXYETHYLENE GLYCOL
PROPANE
PROPIONALDEHYDE
PROPIONIC ACID
PROPYLENE GLYCOL
SEC-BUTYL ALCOHOL
SODIUM FORMATE
SORBITOL
STEARIC ACID, CALCIUM SALT (WAX)
TERT-BUTYL ALCOHOL
1-BUTENE
1-PENTENE
1,4-BUTANEDIOL
ISOBUTYL ACETATE
2-BUTENE(CIS AND TRANS)
2-ETHYL HEXANOL
2-ETHYLBUTYRALDEHYDE
2,2,4-TRIMETHYL-1,3-PENTANEDIOL

AMINE AND AMIDE ORGANIC CHEMICALS AND CHEMICAL GROUPS

2,4-DIAMINOTOLUENE
* ALKYL AMINES
ANILINE
CAPROLACTAM, AQUEOUS CONCENTRATE
DIETHANOLAMINE
DIPHENYLAMINE
* ETHANOLAMINES
ETHYLAMINE
ETHYLENEDIAMINE
ETHYLENEDIAMINETETRACETIC ACID
* FATTY AMINES
HEXAMETHYLENE DIAMINE
ISOPROPYLAMINE
M-TOLUIDINE
MELAMINE
MELAMINE CRYSTAL
* METHYLAMINES
METHYLENE DIANILINE
N-BUTYLAMINE
N,N-DIETHYLANILINE
N,N-DIMETHYLFORMAMIDE
* NITROANILINES
POLYMERIC METHYLENE DIANILINE
SEC-BUTYLAMINE
TERT-BUTYLAMINE
TOLUENEDIAMINE (MIXTURE)
* TOLUIDINES
O-PHENYLENEDIAMINE
2,6-DIMETHYLANILINE
4-(N-HYDROXYETHYLETHYLAMINO)-2-HYDROXYETHYL ANILINE
4,4'-METHYLENEBIS(N,N'-DIMETHYL)-ANILINE
4,4'-METHYLENEDIANILINE

AROMATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

2-CHLORO-5-METHYLPHENOL (6-CHLORO-M-CRESOL)
A-METHYLSTYRENE
* ALKYL BENZENES
* ALKYL PHENOLS
* ALKYLBENZENE SULFONIC ACIDS, SALTS
AMINOBENZOIC ACID (META AND PARA)
ASPIRIN
B-NAPHTHALENE SULFONIC ACID
BENZENEDISULFONIC ACID
BENZOIC ACID
BIS (2-ETHYLHEXYL) PHTHALATE
BISPHENOL A
BTX-BENZENE,TOLUENE,XYLENE(MIXED)
BUTYL OCTYL PHTHALATE
COAL TAR
* COAL TAR PRODUCTS (MISC.)
CREOSOTE
* CRESOLS, MIXED
CYANURIC ACID
* CYCLIC AROMATIC SULFONATES
DIBUTYL PHTHALATE
DIISOBUTYL PHTHALATE
DIISODECYL PHTHALATE
DIISOOCTYL PHTHALATE
DIMETHYL PHTHALATE
DINITROTOLUENE (MIXED)
DITRIDECYL PHTHALATE
M-CRESOL
METANILIC ACID
METHYLENEDIPHENYLDIISOCYANATE
NAPHTHALENE
* NAPHTHAS,SOLVENT
NITROBENZENE
NITROTOLUENE
NONYLPHENOL
P-CRESOL
PHTHALIC ACID
PHTHALIC ANHYDRIDE
* TARS - PITCHES
TERT-BUTYLPHENOL
* TOLUENE DIISOCYANATES (MIXTURE)
TRIMELLITIC ACID
O-CRESOL
1-TETRALOL, 1-TETRALONE MIX
2,4-DINITROTOLUENE
2,6-DINITROTOLUENE

HALOGENATED ORGANIC CHEMICALS AND CHEMICAL GROUPS

1,4-PHENYLENEDIAMINE DIHYDROCHLORIDE
ALLYL CHLORIDE
BENZYL CHLORIDE
CARBON TETRACHLORIDE
CHLOROBENZENE
* CHLOROBENZENES (MIXED)
CHLORODIFLUOROETHANE
CHLOROFORM
* CHLOROMETHANES
* CHLOROPHENOLS
CHLOROPRENE
CYANOGEN CHLORIDE
CYANURIC CHLORIDE
DICHLOROPROPANE
DICHLOROPROPANE
EPICHLOROHYDRIN
ETHYL CHLORIDE
* FLUOROCARBONS (FREONS)
METHYL CHLORIDE
METHYLENE CHLORIDE
PENTACHLOROPHENOL
PHOSGENE
TETRACHLOROETHYLENE
TRICHLOROETHYLENE
TRICHLOROFLUOROMETHANE
VINYLIDENE CHLORIDE
1,1-DICHLOROETHANE
1,1,1-TRICHLOROETHANE
2,4-DICHLOROPHENOL

OTHER ORGANIC CHEMICALS AND CHEMICAL GROUPS

ADIPONITRILE
CARBON DISULFIDE
DITHIOPHOSPHATES, SODIUM SALT
FATTY NITRILES
* ORGANO-TIN COMPOUNDS
* PHOSPHATE ESTERS
TETRAETHYL LEAD
TETRAMETHYL LEAD
* URETHANE PREPOLYMERS
* WAXES, EMULSIONS - DISPERSIONS

TABLE VII

SPECIALTY ORGANIC CHEMICALS AND CHEMICAL GROUPS

ALIPHATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

(--)-1,2,3,4-DIEPOXYBUTANE
ACETAL
ACETALDOL
ACETYL PEROXIDE
* ACETYLENIC ALCOHOLS - DIOLS
ACROLEIN
* ACYCLIC ACID SALTS
* ADIPIC ACID ESTERS (MISC.)
ADIPIC ACID, DI(2-ETHYLHEXYL)ESTER
ADIPIC ACID, DI-ISODECYL ESTER
ADIPIC ACID, DI-TRIDECYL ESTER
ADIPIC ACID, N-OCTYL-N-DECYL ESTER
ALLYL ALCOHOL
* AMYL ACETATES
* AMYL ALCOHOLS
BIS(DIMETHYLETHYL)PEROIDE
BIS(2-ETHYLHEXYL)SEBACATE
BUTYL STEARATE
* BUTYRIC ACID ESTERS
BUTYROLACTONE
CELLULOSE SPONGE
CELLULOSE,OXIDIZED
* CHLOROFORMATES
CITRONELLOL
CROTONALDEHYDE
CROTONIC ACID
CYCLAMEN ALDEHYDE(P-ISOPROPYL-A-METHLHYDROCINNAMALDEHYDE)
CYCLONITE
CYCLOOCTADIENE
CYCLOPENTADIENE DIMER
CYCLOPENTANE
* CYCLOPROPANES
DECABORANE
DI(2-ETHYLHEXYL)-AZELATE
DI(2-ETHYLHEXYL)-PEROXY DICARBONATE
DIETHYL CARBAMAZINE CITRATE
DIETHYL CARBONATE
DIETHYLENE GLYCOL MONOBUTYL ETHER
DIETHYLENE GLYCOL MONOBUTYL ETHER ACETATE
DIETHYLENE GLYCOL MONOETHYL ETHER ACETATE
DIISOBUTYLENE
DIKETENE
DILINOLEIC ACID, AMMONIUM SALT
DIMYRISTYL THIODIPROPIONATE
DIPROPYLENE GLYCOL
DODECENE (PROPYLENE TETRAMER)
ENDRIN KETONE
* EPOXIDIZED ESTERS
ERYTHRITOL ANHYDRIDE
ETHLYENE GLYCOL MONOMETHYL ETHER ACETATE
ETHYL ACETATE
ETHYL BUTYRIC ACID

ALIPHATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

ETHYL CELLULOSE
ETHYL ORTHOFORMATE
ETHYL OXALATE
ETHYLENE CARBONATE
ETHYLENE GLYCOL DIACETATE
ETHYLENE GLYCOL MONOBUTYL ETHER ACETATE
ETHYLENE GLYCOL MONOETHYL ETHER ACETATE
ETHYLENE GLYCOL MONOPROPYL ETHER
ETHYLENEDIAMINE-N,N'-DISTEARIC ACID
* FATTY ACID ESTERS
FORMIC ACID
FUMARIC ACID
GERANIOL
GERANYL NITRILE
GLUCOHEPTANATE, SODIUM SALT
GLUTAMIC ACID, MONOSODIUM SALT
GLYCEROL TRI (POLYOXYPROPYLENE) ETHER
* GLYCERYL ESTERS, MIXED FATTY ACIDS
GLYCERYL STEARATE
GLYCIDOL
GLYCINE
GLYCOLOLNITRILE (HYDROXYACETONITRILE)
* GLYOXAL-FORMALDEHYDE MIXTURES
HEPTANE
HEPTENE
HEXADECYL ALCOHOL
HEXAHYDROPHTHALIC ANHYDRIDE
HEXAMETAPOL
HEXAMETHYLENE GLYCOL(1,6-HEXANEDIOL)
HEXANOIC ACID (CAPROIC ACID)
HEXYLENE GLYCOL
* HYDANTOINS
* HYDROCARBON SOLVENT (SHELL SOL 140)
HYDROXYACETIC ACID (GLYCOLIC ACID)
HYDROXYETHYL CELLULOSE
HYDROXYPROPYL CELLULOSE
IMINODIACETIC ACID
IONONE
ISOAMYL ALCOHOL
ISOBUTYL MALEATE-HEPTANOL-KEROSINE MIX
ISODECANOL
ISOOCTYL ALCOHOL
ISOPENTANE
ISOPROPYL STEARATE
ISOPROPYLETHER
KETENE
LACTIC ACID
LAURIC ACID
LIMONENE
MAGNESIUM METHYLATE
MALEIC ACID
MESITYL OXIDE
* METALLIC CARBOXYLATES
* METHACRYLAMIDES, DIMETHYLAMINOPROPYL
METHYL ACETATE
METHYL ACETOACETATE
METHYL BUTYNOL

METHYL CELLULOSE
METHYL ETHYL KETONE PEROXIDE
METHYL FORMATE
METHYL RED
METHYL STEARATE
METHYL-12-HYDROXYSTEARATE
METHYLAL
METHYLCYCLOHEXANE
METHYLCYCLOHEXANOL
METHYLCYCLOHEXANONE
METHYLCYCLOPENTANE
METHYLCYLOHEXYL CARBINOL
METHYLISOBUTYL CARBINAL
METHYLPENTYNOL
MICHLER'S KETONE
N-BUTYLACRYLATE
N,N-DIETHANOL STEARAMIDE
OCTANE
OLEIC ACID
P-MENTHANE-8-HYDROPEROXIDE
PARALDEHYDE
PERACETIC ACID
* PEROXYESTERS
POLYETHYLENE GLYCOL STEARATE
POLYGLYCEROL
POLYISOPRENE SOLUTION
POLYVINYL ACETATE
POLYVINYL ALCOHOL
POLYVINYL BUTYRAL
* PROPOXYLATES
PROPYLENE TETRAMER
PROPYLENE TRIMER
PROPYNE AND ALLENE
SODIUM DIBUTYLDITHIOCARBAMATE
SODIUM FORMALDEHYDE SULFOXYLATE
SODIUM LAURYLSULFATE
SODIUM METHYLATE
STEARIC ACID
STEARIC ACID, CALCIUM SALT (EMULSION)
* STEARIC ACID, METAL SALTS
STEARIC ACID, STARCH ESTER
STEARIC ACID, ZINC SALT
TERT-BUTYL PEROXYPIVALATE
TERT-BUTYLHYDROPEROXIDE
TERT-BUTYLPEROXIDE
* TETRA-ALKYL LEAD MIXTURES
TETRAETHYLENE GLYCOL
TETRAKIS(HYDROXYMETHYL)PHOSPHONIUM HYDOXIDE
TRANS CROTONALDEHYDE
TRIETHYL CITRATES
TRIETHYLENE GLYCOL
TRIETHYLENE GLYCOL DIMETHYL ETHER
TRIETHYLENE GLYCOL MONOETHYL ETHER
TRIISOBUTYLENE
TRIPHENYL PHOSPHATE
TRIPROPYLENE GLYCOL
TRIPROPYLENE OXIDE

ALIPHATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

TRIS(ISOPROPYLPHENYL) PHOSPHATE
TRIS(2-ETHYLHEXYL) PHOSPHATE
* VEGETABLE OILS, SULFATED
1,2-DIHYDRO-2,2,4-TRIMETHYL QUINOLINE
1,2-EPOXYPROPANE
1,2,4-BUTANETRIOL
1,3 BUTYLENE GLYCOL
1,4 CYCLOHEXANEDIMETHANOL
1,4-BUTENEDIOL
1,4-BUTYNEDIOL
12-HYDROXYSTEARIC ACID
2-(2-(2-METHOXYETHOXY)-ETHANOL
2-(2-BUTOXYETHOXY)-ETHANOL
2-(2-ETHOXYETHOXY)-ETHANOL
2-(2-METHOXYETHOXY)-ETHANOL
2-ETHYLHEXANOIC ACID
2-HEPTANONE
2-HEXANONE
2-METHYL-1-PENTANOL
2-METHYLPENTANE
2-METHYLPROPENAL (METHACROLEIN)
2,2-IMINODIETHANOL
2,4-PENTADIONE PEROXIDE
2,5-DIMETHYL-2,4-HEXADIENE
2,5-DIMETHYL-2,5-DI(T-BUTYL PEROXY)HEX-3-YNE
2,5-DIMETHYL-2,5-DI(T-BUTYL PEROXY)HEXANE
4-METHYL-1-POLYMETHYLPENTENE
4-METHYL-2-PENTANOL
4-NITRO-2,5-DIETHOXY CHLOROBENZENE
5-METHYL-2-HEXANONE
5-METHYL-3-HEPTANONE
9,10-EPOXY-OCTADECANOIC ACID,BUTYL ESTER

(2-METHYLPHENYL)(3-METHYL-4-AMINO)DIAZENE
ACETAMIDE
ACETANILIDE
* ACETANILIDES - COGENERS
* ACETOACETANILIDES - COGENERS
ACRYLAMIDE
ALLYLAMINE
AMINOALCOHOL SULFATE
AMINOETHYLETHANOLAMINE
AMYLAMINE
ANILINE HYDROCHLORIDE
ANISIDINE
* ARYLAMIDES AND COGENERS
AZODICARBONAMIDE
BENZAMIDE
BENZOIC ACID, M-(N,N-DIMETHYLAMINO)
BENZOTRIAZOLE
BENZYLAMINE
BIS(4-AMINO-2-SULFONIC ACID)STILBENE TRIAZINE CHLORIDE
CHLORAMINE
CYANOPYRIDINE
CYCLOHEXYLAMINE
CYCLOPHOSPHAMIDE
DIAMINOBENZOIC ACID
DIAZOACETIC ESTER
DICYCLOHEXYLAMINE
DIETHYLAMINE
DIETHYLENE TRIAMINE
DIMETHYL BUTYL AMINE
DIMETHYLAMINE
DINITROSOPENTAMETHYLENETETRAMINE
DODECYL SULFATE TRIETHANOLAMINE SALT
DODECYLAMINE
DODECYLANILINE
FORMAMIDE
HEXAMETHYLENEIMINE
HEXAMETHYLENETETRAMINE
HYDROXYLAMINE
ISATOIC ANHYDRIDE
ISOSAFROLE
* LONG-CHAIN AMIDES, N-ETHOXYSULFATE
M-DIMETHYL AMINO PHENOL
M-PHENYLENEDIAMINE
MECHLORETHAMINE
MORPHOLINE
N-CYCLOHEXYL-2-BENZOTHIAZOLESULFENAMIDE
N-ETHYL-N-PHENYL BENZYL AMINE
N-METHYLANILINE
N-PHENYL-2-NAPHTHYLAMINE
N-1-NAPHTHYL-ETHYLENEDIAMINE-DIHYDROCHLORIDE
N,N-DIMETHYL-P-NITROSOANILINE
N,N-DIMETHYLANILINE
N,N'-DIPHENYL-P-PHENYLENEDIAMINE
NIACINAMIDE
NITRAMINE
P-(PHENYLAZO)-ANILINE

AMINE AND AMIDE ORGANIC CHEMICALS AND CHEMICAL GROUPS

P-AMINOPHENOL
P-ANISIDINE
P-NITROANILINE
P-PHENETIDINE
P-PHENYLENEDIAMINE
PERYLENE TETRA CARBOXYLIC ACID DIIMIDE
PHENYLDIMETHYL AMMONIUM CHLORIDE
* PHENYLENE DIAMINES
PHENYLHYDROXYLAMINE
PHTHALIMIDE
* POLYETHYLENE POLYAMINES
* POLYOXYALKYLENE AMINES
PROPYLAMINE
* PYRIDINES, SUBSTITUTED
* PYRIMIDINES
* PYRROLIDONES
QUINALIDINE
SALICYLANILIDE
* SUBSTITUTED BENZENE DIAZONIUM CHLORIDES
* SUCCINIMIDES
TETRAETHYLENEPENTAMINE
TETRAMETHYLENEDIAMINE
TETRAMETHYLETHYLENEDIAMINE
THIAMINE PYROPHOSPHATE
THIOACETAMIDE
* THIONOCARBAMATES
TOLUENESULFONAMIDE
TOLYLTRIAZOLE
TRIALLYLAMINE
TRIETHANOLAMINE
TRIETHYLAMINE
TRIETHYLENEDIAMINE
TRIETHYLENETETRAMINE
TRIMETHYLAMINE
* TRIMETHYLAMINOETHYLETHANOLAMINE-BASED FORMULATIONS
* XYLIDINES
O-METHYL-HYDROXYLAMINE
O-NITROANILINE
O-NITROANISOLE
O-PHENETIDINE
1-AMINO-2-BROMO-4-HYDROXYANTHROQUINONE
2-AMINO-5-NITROTHIAZOLE
2-AMINO-6-METHYL PYRIDINE
2-AMINOTHIAZOLE NITRATE
2-AMINOTHIOPHENOL
2-BIPHENYLAMINE
2-BROMO-4,6-DINITROANILINE
2-DIMETHYLAMINOETHANOL
2-ETHYL-4-METHYL-IMIDAZOLE
2-NITRODIPHENYL AMINE(REFINED)
2,4-DINITROANILINE
2,4,5-TRIMETHYLANILINE
2,4'-BIPHENYLDIAMINE
2,5-DIANILINO TEREPHTHALIC ACID
2,6-TOLUENE DI(DIAZONIUM CHLORIDE)
3-AMINOPROPIONITRILE
3-DIMETHYLAMINOPHENOL

AMINE AND AMIDE ORGANIC CHEMICAL AND CHEMICAL GROUPS

3-N-BUTYLAMINO-4-METHOXY BENZENE SULFONAMIDE
4-AMINOACETANILIDE
4-BIPHENYLAMINE
4-FLUORO-3-NITROANILINE
4-ISOPROPOXYDIPHENYLAMINE
4,4'-BIS-(N,N-DIMETHYLANILINE) CARBINOL

AROMATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

(EPOXYETHYL)-BENZENE
A-NAPHTHOL
ACENAPHTHENE
ACENAPHTHYLENE
ACETOPHENONE
* ALKYLNAPHTHALENES (METHYL)
* ALPHA TOLUENESULFONIC ACIDS
ALPHA-HEXYLCINNAMALDEHYDE
AMYL PHENOL
ANISOLE
ANTHRACENE
ANTHRAQUINONE
* ARYLESTERS AND COGENERS
AZOXYBENZENE
B-NAPHTHOL
BENZALDEHYDE
BENZIL
BENZILIC ACID
BENZO-A-PYRENE
* BENZOATE ESTERS
* BENZOFURANS
BENZOIN
BENZOIN GUM (BENZOYLPHENYLCARBANOL)
BENZOPHENONE
BENZOYL PEROXIDE
BENZYL ACETATE
BENZYL ALCOHOL
BENZYL BENZOATE
BIPHENYL
BIS(ALPHA,ALPHA-DIMETHYLBENZYL)PEROXIDE
BUTYL BENZYL PHTHALATE
BUTYL PHTHALYL BUTYL GLYCOLATE
COUMARIN(BENZ-A-PYRONE)
CRESYLIC ACID
* C11-C14 PHTHALATE
* C15-C19 PHTHALATE
* C7-C10 PHTHALATE
D,L-MENTHOL
DI-N-HEXYL PHTHALATE
DI-N-OCTYL PHTHALATE
DIBENZYL AZO DICARBOXYLATE
DICYCLOHEXYL PHTHALATE
DIDECYL PHTHALATE
DIETHYL PHTHALATE
DIISONONYL-DECYL PHTHALATE
DIISOPROPYL BENZENE
DIISOPROPYL BENZENE EMULSION
DIMETHYL ETHER
DIMETHYL PHTHALATE ESTER
DIMETHYLBENZYL HYDROPEROXIDE - ALPHA,ALPHA
DIPHENYL OXIDE
DIPHENYL PHTHALATE
* DIPHENYLALKANES
DIPHENYLTHIOUREA
DIVINYLBENZENE
DODECYLBENZENE SULFONIC ACID SODIUM SALT

DODECYLPHENOL
ETHYL ACETOACETATE
EUGENOL (2-METHOXY-4-ALLYLPHENOL)
* FURFURALS
FURFURYL ALCOHOL
HYDROQUINONE
INDENO (1,2,3,-C,D) PYRENE
ISOPROPYL PHENOL
M-PHENOXYBENZALDEHYDE
M-PHENOXYBENZYL ALCOHOL
M-PHENOXYTOLUENE
METHYL SALICYLATE
* MIXED ALCOHOL PHTHALATE
N-HEPTYL-NONYL-UNDECYL PHTHALATE
N-HEXYL-(2-ETHYLHEXYL) PHTHALATE
N-HEXYL-(2-ETHYLHEXYL)-ISODECYL PHTHALATE
N-HEXYL-HEPTYL-NONYL-UNDECYL PHTHALATE
N-HEXYL-OCTYL-DECYL PHTHALATE
N-OCTYL N-DECYL PHTHALATE
NEOPENTANOIC ACID
OCTYL DECYL PHTHALATE
OCTYLPHENOL
P-BENZYL OXYPHENOL
P-HYDROXYBENZOIC ACID
P-TERT-BUTYL BENZOIC ACID
PHENOXYETHYL ISOBUTYRATE
PHENYL ACETIC ACID, POTASSIUM SALT
PHENYLACETALDEHYDE, DIMETHYLACETAL
* POLYARYL ETHERS
* POLYBENZYLALKYLBENZENES
POLYETHYL BENZENE
PYRENE
PYRIDINE
* PYRROLES
QUINONE
SALICYLALDEHYDE
SALICYLIC ACID
SODIUM BENZOATE
SODIUM CARBOXYMETHYL CELLULOSE
SODIUM PHENATE
SODIUM THIOSULFATE
SORBIC ACID
TANNIC ACID
TERT-AMYLENE-A-METHYLSTYRENE
TERT-BUTYLESTER PEROXYBENZOIC ACID
TETRAHYDROFURAN
TETRAHYDROPHTHALIC ANHYDRIDE
* TOLUIC ACIDS
TRIPHENYL CYANURATE
1,2 BENZANTHRACENE
1,2-DIPHENOXYETHANE
1,2,3,4-TETRAHYDRONAPHTHALENE
1,2,5,6 DIBENZANTHRACENE
1,3-DIMETHOXYBENZENE
1,3,5-BENZENETRICARBOXYLIC ACID
1,4-DIBUTOXYBENZENE
2-HYDROXY-4-(OCTYLOXY)BENZOPHENONE

AROMATIC ORGANIC CHEMICALS AND CHEMICAL GROUPS

2-HYDROXY-4-METHOXY-BENZOPHENONE
2-PHENOXYETHANOL
2,4 XYLENOL
2,4-DI-T-BUTYL PHENYL-8,5-DI-T-BUTYL-4-HYDROXY BENZOATE
2,4-PENTADIONE PEROXIDE
2,4,6-TRINITROPHENOL
2,5-XYLENOL
3,4-XYLENOL
3,5-XYLENOL
8-HYDROXYQUINOLINE

A-BROMOACETOXYMETHYL DIOXOLANE
A, B-EPOXY-B-METHYLHYDROCINNAMIC ACID, ETHYL ESTER
ACETYL CHLORIDE
* ACID CHLORIDES
* ALKYL BROMIDES
* ALKYL CHLORIDE CELLULOSE
AMYL CHLORIDE
BENZOTRICHLORIDE
BENZOTRIFLUORIDE
BENZOYL CHLORIDE
BENZYL DICHLORIDE
BIS (2-CHLOROETHOXY) METHANE
BIS (2-CHLOROISOPROPYL) ETHER
BIS (2-CHLROETHYL-1HYDROXYETHYL) PHOSPHONIC ACID
BIS(2-CHLOROETHYL)VINYL PHOSPHONATE
BIS(2,3-DIBRMOPROPYLETHER)TETRABROMOBISPHENOLATE
BIS(4-CHLOROPHENYL)SULFONE
BISHEXACHLOROCYCLOPENTADIENE
BORONTRIFLUORIDE-METHANOL COMPLEX
BROMOBENZENE
BROMOCHLORENDOCYCLOOCTADIENE
BROMOCHLOROMETHANE
* BROMOETHYL BENZENES (-MONO, -DI, -TRI)
BROMONAPHTHALENE
BROMOTRIFLUOROMETHANE
CARBON TETRABROMIDE
CARBON TETRAFLUORIDE
CETYL BROMIDE
CHLORAL HYDRATE
* CHLORINATED PARAFFIN SULFONATES
* CHLORINATED POLYPHOSPHATES
CHLORO-ACETALDEHYDE
CHLORO-ACETOPHENONE
CHLOROACETIC ACID
CHLOROACETONE
CHLOROBENZALDEHYDE
* CHLOROBENZOIC ACID AND ESTERS
CHLOROBENZOTRICHLORIDE (O,P)
CHLOROBENZOYL CHLORIDE
CHLORODIFLUOROMETHANE
CHLOROMETHYLMETHYL ETHER
CHLORONAPHAZINE
* CHLORONAPHTHALENES
CHLOROPICRIN (TRICHLORONITROMETHANE)
CHLOROSTYRENE
CHLOROSULFONIC ACID
CHLOROTRIFLUOROMETHANE
CHOLINE CHLORIDE
DECABROMOBIPHENYL
DECABROMOBIPHENYL ETHER
DIBROMOBUTENEDIOL
DIBROMODIFLUOROMETHANE
DIBROMOMETHANE
DIBROMONEOPENTYL GLYCOL
DICHLOROANILINE
DICHLOROBROMOMETHANE

HALOGEN ORGANIC CHEMICALS AND CHEMICAL GROUPS

DICHLORODIFLUOROMETHANE
DICHLOROFLUOROMETHANE
DICHLOROHYDRIN
DICHLOROMETHYL ETHER
DICHLORONITROBENZENE
* DICHLORONITROBENZENES
DIETHYL CHLOROETHYLAMINE
DIETHYL 2-BROMOETHYLPHOSPHONATE
DIFLUOROETHANE
ETHYL BROMIDE
ETHYL CHLOROACETATE
ETHYL IODIDE
ETHYLBENZYL CHLORIDE
ETHYLENE CHLOROHYDRIN
ETHYLENE DIBROMIDE
FLUOROACETAMIDE
FLUOROACETATE, SODIUM SALT
HEPTACHLOR EPOXIDE
HEXABROMOBENZENE
HEXABROMOBIPHENOL
HEXABROMOCYCLODODECANE
HEXACHLOROBENZENE
HEXACHLOROBUTADIENE
HEXACHLOROCYCLOPENTADIENE
HEXACHLOROETHANE
HEXAFLUOROPROPYLENE DIOXIDE
IODOMETHANE
ISOPHTHALOYL CHLORIDE
ISOPROPYL CHLORIDE
* LONG-CHAIN CHLORIDES
M-CHLOROANILINE
M-CHLORONITROBENZENE
M-CHLOROTOLUENE
M-DICHLOROBENZENE
METHALLYL CHLORIDE
METHYL BROMIDE
METHYL IODIDE
MONOCHLOROHYDRIN (3-CHLORO-1, 2-PROPANEDIOL)
N-BUTYLCHLORIDE
O-DICHLOROBENZENE
P-CHLOROANILINE
P-CHLORONITROBENZENE
P-CHLOROPHENYL ESTER ISOCYANIC ACID
P-CHLOROTOLUENE
P-DICHLOROBENZENE
PENTACHLOROBENZENE
PENTACHLORONAPTHALENE
PHENYLACETYL CHLORIDE
PHTHALOYL CHLORIDE
POLYCHLORINATED DIPHENYL ETHERS
POLYCHLORINATED TRIPHENYLS
PROPYL CHLORIDE
PROPYLENE CHLOROHYDRIN
PROPYLENE DICHLORIDE
SODIUM CHLOROACETATE
SOYBEAN OIL, BROMINATED
TEREPHTHALOYL CHLORIDE

HALOGEN ORGANIC CHEMICALS AND CHEMICAL GROUPS

TETRABROMO-TETRAMETHYL-DIHYDROXYBIPHENYL
TETRABROMOPHTHALIC ANHYDRIDE
TETRACHLOROBISPHENOL A
* TETRACHLOROETHANES
TETRACHLOROPHENOL
TETRACHLOROPHTHALIC ANHYDRIDE
TETRAFLUORODICHLOROETHANE
TETRAFLUOROETHYLENE
TETRAKIS(HYDROXYMETHYL)PHOSPHONIUM BROMIDE
TETRAKIS(HYDROXYMETHYL)PHOSPHONIUM CHLORIDE
TOLUENESULFONYL CHLORIDE
TRANS-1,4-DICHLORO-2-BUTENE
TRIBROMONEOPENTYL ALCOHOL
TRICHLOROACETIC ACID
* TRICHLOROBENZENES
TRIFLUOROACETIC ACID
TRIFLUORODICHLOROETHANE
TRIFLUOROETHANOL
TRIGLYCOL DICHLORIDE
TRIPHENYLMETHANE
TRIS(2-CHLOROETHYL) PHOSPHATE
TRIS(2,3-DIBROMOPROPYL) PHOSPHATE
TRIS(2,3-DICHLOROPROPYL) PHOSPHATE
TRIS(2,4,6-TRIBROMOPHENYL) PHOSPHATE
TRIS(4-BROMOPBENYL) PHOSPHATE
VINYL BROMIDE
0-CHLOROANILINE
0-CHLORONITROBENZENE
0-CHLOROTOLUENE
1-CHLORO-2-METHYLPROPENE
1,1,1,2-TETRACHLOROETHANE
1,1,1,3,3,3-HEXAFLUORO-2-PROPANONE
1,1,2-TRICHLORO-1,2,2-TRIFUOROETHANE
1,1,2-TRICHLOROETHANE
1,1,2,2 TETRACHLOROETHANE
1,1,2,2-TETRABROMOETHANE
1,2 TRANS-DICHLOROETHYLENE
1,2-DICHLOROETHYLENE
1,2-DICHLOROPROPANE
1,2,3-TRICHLOROBENZENE
1,2,3-TRICHLOROPROPANE
1,2,3,4-TETRACHLOROBENZENE
1,2,3,5-TETRACHLOROBENZENE
1,2,4-TRICHLOROBENZENE
1,2,4,5-TETRACHLOROBENZENE
1,3-DICHLOROPROPENE
1,3,5-TRICHLOROBENZENE
2-BROMOETHANOL
2-BROMOPYRIDINE
2-CHLORO-1,3-BUTADIENE
2-CHLORO-4-TRIFLUOROMETHYL-3-CARBOXY-4'-NITRODIPHENYL ETHER
2-CHLOROETHYL VINYL ETHER (MIXED)
2-CHLOROHYDROQUINONE
2-CHLORONAPHTHALENE
2-CHLORONITROPHENOL
2-CHLOROPHENOL
2-CHLOROPYRIDINE

HALOGEN ORGANIC CHEMICALS AND CHEMICAL GROUPS

2,2-DICHLOROETHYL ETHER
2,3-DIBROMOPROPANOL
2,3-DICHLOROQUINOXALINE
2,4,6-TRICHLORO-S-TRIAZINE
2,4,6-TRICHLOROPHENOL
3-CHLORO-2-METHYLPROPENE
3-TRICHLORO-METHYL-5-CHLORO-1,2,4-THIADIAZOLE
3,3'-DICHLOROBENZIDINE
3,4,5-TRICHLOROPHENOL
4-BROMOPHENYL PHENYL ETHER
4-CHLORO-2-AMINOPHENOL
4-CHLOROPHENYL PHENYL ETHER

A-NAPHTHALENE SULFONIC ACID
A-TERPINEOL
ACETONITRILE
* ALKYL MALEIC ANHYDRIDE, SODIUM SALT
* ALKYL NITRATES
* ALKYLNITRITES
* ALKYLTHIOLS, C14, C16, C18
ALLYLNITRILE
ALPHA-CEDRENE (VERTOFIX COEUR)
ALUMINUM ALKYLS, TRIETHYL
AMINOETHYL HYDROGEN SULFATE
AMYL MERCAPTAN
ANTHRANILIC ACID
* AROMA CHEMICALS(FRAGRACES)
B-PICOLINE
BENZENESULFONIC ACID
BENZONITRILE
BENZYL CYANIDE
BETA-MYRCENE
BIS(CHLORENDO) BICYCLOPENTADIENE
BIS(CHLORENDO) CYCLODCTADIENE
BIS(CHLORENDO) FURAN
BIS(DIBUTYLDITHIOCARBAMATO) ZINC
BIS(DIETHYLDITHIOCARBAMATO) ZINC
BIS(P-OCTYLPHENOL) SULFIDE, NICKEL SALT
CALCIUM CYANAMIDE
CAMPHENE
* CARBAMATES
CARYOPHYLLENE (4,11,11-TRIMETHYL-8-METHYLENEBICYCLO(7-7-0) UNDEC-4-ENE)
CASTOR OIL (INCLUDING USP)
CELLULOSE NITRATE
CELLULOSE TETRANITRATE
CHLORENDIC ACID
* CHLORENDIC SALTS
CHLORENDOCYCLOOCTADIENE
CRESYL DIPHENYLPHOSPHATE
CYANOACETIC ACID
DIANISIDINE
DIBENZOFURAN
DIETHYL BIS (2-HYDROXYETHYL) PHOSPHONATE
DIETHYL SULFATE
DIMETHYL HYDRAZINE
DIMETHYL SULFATE
DIMETHYL SULFIDE
DIMETHYL SULFOXIDE
* DINITROBENZENES(M,O,P)
DINITROSOBENZENE
DIOXOLANE

OTHER ORGANIC CHEMICALS AND CHEMICAL GROUPS

* DIRECT DYES
* DISILAZANES
* DITHIOCARBAMATES, SODIUM SALT
* DITHIOCARBAMATES, 2-DIMETHYLAMINO ETHYL, HYDROCHLORIDE
DODECYLMERCAPTAN
DODECYLGUANIDINE ACETATE
* DYES - DYE INTERMEDIATES
* EPOXIDIZED ALPHA-OLEFINS
ETHYL PHOSPHONOTHIOIC DICHLORIDE
ETHYL SODIUM OXALACETATE
ETHYL THIOUREA
ETHYL VANILLIN
ETHYLCYANOACETATE
* FATS, SULFURIZED
* FATTY ACID METAL SALTS
FISHER'S BASE (1,3,3-TRIMETHYL-2-METHYLENE INDOLINE)
* GUAR-STARCH DERIVATIVES
HELIOTROPIN
HEXAMETHYENE BIURET-URETHANE
HEXAMETHYLENE DIISOCYANATE
HEXYL ALCOHOL SULFATE, SODIUM SALT
HYDRAZINE
HYDRAZINE MONOACETATE, METHANOL SOLUTION
HYDRAZINE SOLUTIONS
HYDRAZOBENZENE
* ISOCYANURATES
LAUROYL PEROXIDE
LAURYL ALCOHOL SULFATE
LIGNIN DERIVATIVES
LIGNINSULFONIC ACID,FERROCHROME SALT
LINALOOL
* LONG-CHAIN ESTERS,SULFOETHOXYLATES
MALEIC HYDRAZIDE
MALIC ACID
MALONDIANILIDE
MANNITOL, CRYSTAL
MECRYLATE
METHALLYLIDENE DIACETATE
METHIONINE
* METHYL IONONES
METHYL ISOCYANATE
METHYLHYDRAZINE
MONOHYDRATEHYDRAZINE
N-BUTYRONITRILE
N-NITROSODI-N-PROPYLAMINE
N-NITROSODIMETHYLAMINE
N-NITROSODIPHENYLAMINE
* NAPHTHENIC ACID SALTS
NAPHTHENIC ACID, COPPER SALT
NAPHTHENIC ACID,COPPER SALT
NAPTHENIC ACID, LEAD SALT
NITRILOTRIS(METHYLENE) TRIPHOSPHONIC ACID
NITROBENZOIC ACID (M,O,P)
NITROETHANE
NITROMETHANE
NITROPHENOL
NITROPROPANE

OTHER ORGANIC CHEMICALS AND CHEMICAL GROUPS

NONENE(MIXED ISOMERS)
OCTYL SULFATE, SODIUM SALT
* ORGANIC PIGMENTS
* ORGANO-TIN COMPOUNDS
P-BENZOQUINONE DIOXIME
P-DIOXANE
P-NITROACETANILIDE
P-NITROANISOLE
P-NITROPHENOL - SODIUM SALT
P-NITROTOLUENE-O-SULFONIC ACID
PERCHLOROMETHYL MERCAPTAN
* PERFUMES - FLAVORS, MISC.
* PHENOLSULFONIC ACIDS
PHENYL ANTHRANILIC ACID
* PHOSPHINES--ALKYL,ARYL OR ALKOXY (MIXED)
PICRIC ACID
PIGMENT BLUE 15, ALPHA AND BETA FORMS
PIGMENT GREEN 7
PIGMENT YELLOW 12
PINANE
PINANE HYDROPEROXIDE
PINENE (ALPHA - BETA)
PIPERAZINE
POLYAZELAIC ANHYDRIDE
* POLYBENZIMIDAZOLES
* POLYBENZOTHIAZOLES
POLYNAPHTHALENE SULFONATE, SODIUM SALT
POLYPHENYLENE OXIDE
POLYPHENYLENE SULFIDE
POLYSULFIDE POLYETHER
POLYURETHANE RESINS
POLYVINYL PYRROLIDONE
POLYVINYL PYRROLIDONE IODOPHORE
POTASSIUM PYROPHOSPHATE
PYRONES
QUATERNIZED COMPLEX ETHER
QUINOLINES, COPPER-8-HYDROXYQUINOLINOLATE
* RAFFINATE
RESORCINOL
RESORCYLIC ACID
S,S,S-TRIBUTYL ESTER PHOSPHOROTRITHIOIC ACID
SACCHARIN
SELENIUM DIMETHYLDITHIOCARBAMATE
SEMICARBAZIDE HYDROCHLORIDE
SORBITAN FATTY ACID ESTERS
SPIROGERMANIUM
STILBENE
SUCCINIC ACID
SUCCINONITRILE
SULFANILIC ACID
SULFOLANE
* SULFURIZED NATURAL FATS - OILS
SYMCLOSENE
TERPENE OIL
TETRABROMOPHENYL-HEXACHLOROBICYCLOHEPTADIENE
TETRABUTYL PHOSPHONIUM SILONOLATE
TETRAKIS(DIETHYLDITHIOCARBAMATO)*SELENIUM*

OTHER ORGANIC CHEMICALS AND CHEMICAL GROUPS

TETRAKIS(HYDROXYMETHYL)PHOSPHONIUM SULFATE
THIOPHENE ACETIC ACID
THIOUREA, COMPLEX
THIRAM
TOLUENE 2,4-DIISOCYANATE
TOLUENE 2,6-DIISOCYANATE
TOXAPHENE
TRANS-BIS (N-PROPYLSULFONYL) ETHENE
TRICARBONYL 2-METHYLCYCLOPENTADIENYL
TRICYCLODECENYL PROPIONATE
TRIDECYL SULFATE, SODIUM SALT
TRITOTYL PHOSPHATE
VAT BLUE 6
* VINYL ETHERS
* XANTHOGENS
XYLENESULFONIC ACID, SODIUM SALT
* XYLENOLS(MIXED)
1-AZIRIDINEETHANOL
1-HYDROXYETHANE-1,1-DIPHOSPHONIC ACID
1-NITRONAPHTHALENE
1,1-DIMETHYLHYDRAZINE
1,1-DIPHENYLHYDRAZINE
1,1'-OXYDI-2-PROPANOL
1,12-BENZOPERYLENE
1,2-DIPHENYLHYDRAZINE
1,4-DIETHOXYBENZENE
2-(MORPHOLINO-THIO)-BENZOTHIAZOLE
2-AMINO-4-NITROPHENOL
2-METHYLAZIRIDINE
2-NITROPHENOL
* 2-PICOLINES - COGENERS
2-PINANOL
2-PYRIDINETHIONE-N-OXIDE, ZINC SALT
2,2'-DITHIOBISBENZOTHIAZOLE
2,2',4'-TRIHYDROXY-5-CHLORO AZOBENZENE-2,2'-COPPER COMPLEX, SOLUTION
2,4-DINITROPHENOL
* 3-HYDROXY-2-NAPHTHALENE CARBOXAMIDES
3-HYDROXY-2-NAPHTHALENE CARBOXYLIC ACID (HNC)
3-SULFOLENE
3,5-DINITROBENZOIC ACID
4-NITRO-O-PHENYLENEDIAMINE
4-NITROSODIPHENYLAMINE
4-NITROSOPHENOL
4-VINYL-1-CYCLOHEXENE
4,4'-DIAMINO-STILBENE-2,2-DISULFONIC ACID
4,6 DINITRO-O-CRESOL
6-NITROBEZIMIDAZOLE
7-METHYL NADIC ANHYDRIDE

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II. INDUSTRY SURVEY AND OVERVIEW

1. INDUSTRY SECTION 308 SURVEY

Since proposal, on extensive data gathering program has been conducted to improve the coverage of all types of OCPSF manufacturers. This effort included mailing Section 308 surveys to all manufacturers of OCPSF products.

For the purposes of the survey, the OCPSF industry was defined generally as all establishments that manufacture: (1) organic chemical products included within the U.S. Department of Commerce Bureau of the Census Standard Industrial Classification (SIC) major groups 2865 and 2869 and/or (2) plastics and synthetic fibers products included in SIC major groups 2821, 2823, and 2824. However, organic chemical compounds that are produced solely by extraction from natural materials, such as parts of plants and animals, or by fermentation processes are not included in this definition of the OCPSF industry even if classified in one of the OCPSF SIC classifications. Thus, any such products were considered non-OCPSF products for the purposes of the survey.

The questionnaire mailing list was compiled from many references that identify manufacturers of OCPSF products. These sources included the Economic Information Service, SRI Directory, Dun and Bradstreet, Moody's Industrial Manual, Standard and Poor's Index, Thomas Register, and Plastics Red Book as well as internal Agency sources such as the NPDES Permit Compliance System and the TSCA Inventory.

In October 1983, EPA sent the General Questionnaire to 2,829 facilities to obtain information regarding individual plant characteristics, wastewater treatment efficiency, and the statutory factors expected to vary from plant to plant. The General Questionnaire consisted of three parts: Part A (General Profile), Part B (Detailed Production Information), and Part C (Wastewater Treatment Technology, Disposal Techniques, and Analytical Data Summaries).

Some plants that received the questionnaire had OCPSF operations that were a minor portion of their principal production activities and related wastewater streams. The data collected from these facilities allows the Agency to characterize properly the impacts of ancillary (secondary) OCPSF production. Generally, if a plant's 1982 OCPSF production was less than 50 percent of the total facility production (secondary manufacturer), then only Part A of the questionnaire was completed.

Part A identified the plant, determined whether the plant conducted activities relevant to the survey, and solicited general data (plant age, ownership, operating status, permit numbers, etc.). General OCPSF and non-OCPSF production and flow information was collected for all plant manufacturing activities. This part also requested economic information including data on shipments and sales by product groups, as well as data on plant employment and capital expenditures.

Part A determined whether a respondent needed to complete Parts B and C (i.e. whether the plant is a primary or secondary producer of OCPSF products, whether the plant discharges wastewater, and, for secondary producers, whether the plant segregates OCPSF process wastewaters). For those plants returning only the General Profile, Part A identified the amounts of process wastewater generated, in-place wastewater treatment technology, wastewater characteristics, and disposal techniques. Part B, requested detailed 1980 production information for 249 specific OCPSF products, 99 specific OCPSF product groups, and any OCPSF product that constituted more than one percent of total plant production. Less detailed information was requested for the facility's remaining OCPSF and non-OCPSF production. Part B also requested information on the use and known presence of the priority pollutants for each OCPSF product/process or product group. Part C requested detailed information on plant wastewater sources and flows, treatment technology installed, treatment system performance and disposal techniques.

Responses to economic and sales items in Part A pertain to calendar year 1982, which were readily available since the plants were required to submit detailed 1982 information to the Bureau of the Census. This reduced the paperwork burden for responding plants. The rest of the questionnaire, however, requested data for 1980 -- a more representative production year. The Agency believed that treatment performance in 1982 would be unrepresentative of treatment during more typical production periods. This is because decreased production normally results in decreased wastewater generation. With lower volumes of wastewater being treated, plants in the industry might be achieving levels of effluent quality that they could not attain during periods of higher production. The year 1980 was selected in consultation with industry as representative of operations during more normal production periods but recent enough to identify most new treatment installed by the industry since 1977. The industry representatives did not assert that significant new treatment had been installed since 1980.

The 2,829 Section 308 questionnaires were mailed in October 1983. In February 1984, Section 308 follow-up letters were sent to 914 nonrespondents.

A total of 981 OCPSF manufacturers were used in the analysis; 1,529 responses were from facilities not covered by the regulation (sales offices, warehouses, chemical formulators, etc.); 162 were returned by the Post Office; and 159 did not respond. A follow-up telephone survey of 52 nonrespondents concluded that less than 10 percent would be covered by the OCPSF regulations.

2. INDUSTRY OVERVIEW

The OCPSF Industry is large and diverse, and many plants in the industry are highly complex. The industry includes approximately 1000 facilities which generally manufacture products under the OCPSF SIC Groups - SICs 2821, 2823, 2824, 2865, and 2869.

Some plants produce chemicals in large volumes, while others produce only small volumes of "specialty" chemicals. Large-volume production tends toward

continuous processes, while small volume production tends toward batch processes. Continuous processes are generally more efficient than batch processes in minimizing water use and optimizing the consumption of raw materials in the process.

Different products are made by varying the raw materials, chemical reaction conditions, and the chemical engineering unit processes. The products being manufactured at a single large chemical plant can vary on a weekly or even daily basis. Thus, a single plant may simultaneously produce many different products in a variety of continuous and batch operations, and the product mix may change frequently.

For the 981 facilities in the OCPSF industry data base, approximtely 76 percent of the facilities are designated as primary OCPSF manufacturers (over 50 percent of their total plant production includes OCPSF products) and approximately 24 percent of the facilities are secondary OCPSF manufacturers. Approximately 32 percent of the plants are direct dischargers, approximately 42 percent are indirect dischargers (plants that discharge to a publicly owned treatment works) and the remaining facilities use zero or alternative discharge methods. The estimated average daily process wastewater flow per plant is 1.22 MGD (millions of gallons per day) for direct dischargers and 0.24 MGD for indirect dischargers. The remainder use dry processes, reuse their wastewater, or dispose of their wastewater by deep well injection, incineration, contract hauling, or evaporation or percolation ponds.

As a result of the wide variety and complexity of raw materials and processes used and of products manufactured in the OCPSF industry, an exceptionally wide variety of pollutants are found in the wastewaters of this industry. This includes conventional pollutants (pH, BOD, TSS and oil and grease); toxic pollutants (both metals and organic compounds); and a large number of nonconventional pollutants (including the organic compounds produced by the industry for sale).

To control the wide variety of pollutants discharged by the OCPSF industry, OCPSF plants use a broad range of in-plant controls, process modifications and end-of-pipe treatment techniques. Most plants have implemented programs that combine elements of both in-plant control and end-of-pipe wastewater treatment. The configuration of controls and technologies differs from plant to plant, corresponding to the differing mixes of products manufactured by different facilities. In general, direct dischargers treat their waste more extensively than indirect dischargers.

The predominant end-of-pipe control technology for direct dischargers in the OCPSF industry is biological treatment. The chief forms of biological treatment are activated sludge and aerated lagoons. Other systems, such as extended aeration and trickling filters, are also used, but less extensively. All of these systems reduce BOD and TSS loadings, and, in many instances, incidentally remove toxic and nonconventional pollutants. Biological systems biodegrade some of the organic pollutants, remove bio-refractory organics and metals by sorption into the sludge, and strip some volatile organic compounds into the air.

Other end-of-pipe treatment technologies used in the OCPSF industry include neutralization, equalization, polishing ponds, filtration and carbon adsorption. While most direct dischargers use these physical/chemical technologies in conjunction with end-of-pipe biological treatment, some direct dischargers use only physical/chemical treatment.

In-plant control measures employed at OCPSF plants include water reduction and reuse techniques, chemical substitution and process changes. Techniques to reduce water use include the elimination of water use where practicable and the reuse and recycling of certain streams, such as reactor and floor washwater, surface runoff, scrubber effluent and vacuum seal discharges. Chemical substitution is utilized to replace process chemicals possessing highly toxic or refractory properties by others that are less toxic or more amendable to treatment. Process changes include various measures that reduce water use,

waste discharges, and/or waste loadings while improving process efficiency. Replacement of barometric condensers with surface condensers; replacement of steam jet ejectors with vacuum pumps; recovery of product or by-product by steam stripping, distillation, solvent extraction or recycle, oil-water separation and carbon adsorption; and the addition of spill control systems are examples of process changes that have been successfully employed in the OCPSF industry to reduce pollutant loadings while improving process efficiencies.

Another type of control widely used in the OCPSF industry is physical/chemical in-plant control. This treatment technology is generally used selectively on certain process wastewaters to recover products or process solvents, to reduce loadings that may impair the operation of the biological system or to remove certain pollutants that are not removed sufficiently by the biological system. In-plant technologies widely used in the OCPSF industry include sedimentation/ clarification, coagulation, flocculation, equalization, neutralization, oil/water separation, steam stripping, distillation, and dissolved air flotation.

Many OCPSF plants also use physical/chemical treatmnt after biological treatment. Such treatment is used in the majority of situations to reduce solids loadings that are discharged from biological treatment systems. The most common post-biological treatment systems are polishing ponds and multimedia filtration.

At approximately 9 percent of the direct discharging plants surveyed, either no treatment or no treatment beyond equalization and neutralization is provided. At another 14 percent, only physical/chemical treatment is provided. The remaining 77 percent utilize biological treatment. Approximately 42 percent of biologically treated effluents are further treated by post biological controls such as polishing ponds, filtration, or activated carbon.

At approximately 39 percent of the indirect discharging plants surveyed, either no treatment or no treatment beyond equalization and neutralization is provided. At another 47 percent, some physical/chemical treatment is provided. The remaining 14 percent utilize biological treatment.

The mode of discharge counts by type of questionnaire response are shown in Table 1 for each subcategory or category. As noted before, full responses were returned by primary producers of OCPSF products as well as secondary producers with dedicated OCPSF wastewater treatment systems (25 percent or less dilution of OCPSF wastewater). Part A responses were returned by zero discharge and alternative disposal plants as well as other secondary manufacturers of OCPSF products. The "mixed category" includes those plants that cannot be assigned uniquely to one subcategory. The "secondary organics and zero discharge primary organics category" includes those Part A-only-response plants whose total production is 95 percent or more organic chemicals (SICs 2865, 2869, 29110582, and 29116324); however, the Part A information is insufficient for assigning plants to a commodity, bulk, or speciality organic chemical subcategory. Subcategory and category median annual OCPSF production figures, median process wastewater flows, and in-place treatment by mode of discharge and type of questionnaire response are shown in Tables 2, 3, and 4, respectively.

TABLE 1

MODE OF DISCHARGE
PLANT COUNTS BY SUBCATEGORY AND TYPE OF QUESTIONNAIRE RESPONSE

SUBCATEGORY OR CATEGORY	DIRECT			DIRECT/INDIRECT			INDIRECT			ZERO			UNKNOWN		
	PART A ONLY	FULL RESPONSE	TOTAL	PART A ONLY	FULL RESPONSE	TOTAL	PART A ONLY	FULL RESPONSE	TOTAL	PART A ONLY	FULL RESPONSE	TOTAL	PART A ONLY	FULL RESPONSE	TOTAL
Rayon	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-
Other Fibers	-	10	10	-	-	-	-	7	7	7	-	7	-	-	-
Thermosets	4	17	21	-	1	1	20	39	59	63	-	63	-	-	-
Thermoplastic Only	7	41	48	1	2	3	15	50	65	32	3	35	2	-	2
Thermoplastic & Organics	2	34	36	1	2	3	3	17	20	5	1	6	-	-	-
Commodity	-	27	27	-	-	-	-	11	11	-	-	-	-	-	-
Bulk	-	53	53	-	3	3	-	43	43	1	-	1	-	-	-
Specialty	-	29	29	-	3	3	-	88	88	-	3	3	-	-	-
Mixed	11	24	35	-	2	2	21	35	56	48	1	49	6	-	6
Secondary Org. & Zero Primary Org.	27	-	27	1	-	1	51	-	51	85	-	85	3	-	3
Unknown	-	1	1	-	1	1	-	7	7	6	-	6	1	-	1
Total (N = 981)	51	239	290	3	14	17	110	297	407	247	8	255	12	-	12

TABLE 2

MEDIAN SUBCATEGORY
ANNUAL PRODUCTION (1,000 SHORT TONS) BY MODE OF DISCHARGE AND TYPE OF QUESTIONNAIRE RESPONSE*

	DIRECT		DIRECT/INDIRECT		INDIRECT		ZERO		UNKNOWN	
SUBCATEGORY	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE
Rayon	-	78.5	-	-	-	-	-	-	-	-
Other Fibers	-	81.6	-	-	-	2.2	4.3	-	-	-
Thermosets	3.2	68.6	-	15.5	4.6	7.3	4.8	-	-	-
Thermoplastic Only	12.7	69.4	0.1	114.7	5.3	18.6	6.5	10.0	12.1	-
Thermoplastic & Organics	60.3	467.2	39.8	260.3	10.0	14.0	2.2	195.2	-	-
Commodity	-	510.7	-	-	-	110.0	-	-	-	-
Bulk	-	97.5	-	23.7	-	16.1	-	18.8	-	-
Specialty	-	6.3	-	2.1	-	2.0	-	2.6	-	-
Mixed	-	164.8	-	12.6	7.8	17.0	8.3	26.8	2.0	-
Secondary Org. & Zero Primary Org.	25.2	-	41.2	-	2.0	-	4.9	-	1.9	-

*349 of the 422 Part A Only Responses reported production data
555 of the 559 Full Responses reported production data

TABLE 3

MEDIAN SUBCATEGORY FLOWS (MGD)
BY MODE OF DISCHARGE AND TYPE OF QUESTIONNAIRE RESPONSE*

	DIRECT		DIRECT/INDIRECT		INDIRECT		ZERO	
SUBCATEGORY	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE
Rayon	-	8.57	-	-	-	-	-	0.91
Other Fibers	-	0.852	-	-	-	0.025	0.08	0.012
Thermosets	0.058	0.082	-	1.88	0.002	0.022	0.001	0.004
Thermoplastic Only	0.081	0.302	1.26	0.643	0.006	0.049	0.002	0.011
Thermoplastic & Organics	0.985	1.46	0.08	1.75	0.083	0.043	0.150	0.907
Commodity	-	0.697	-	-	-	0.25	-	0.297
Bulk	-	0.288	-	0.570	-	0.045	-	0.006
Specialty	-	0.279	-	0.058	-	0.06	-	0.110
Mixed	0.03	0.919	-	0.046	0.006	0.038	0.003	0.013
Secondary Org. & Zero Primary Org.	0.312	-	2.3	-	0.032	-	0.031	-
Unknown	-	0.007	-	0.040	-	0.102	-	-

*278 of the 422 Part A only Responses reported flow data
547 of the 559 Full Responses reported flow a

TABLE 4

A. Direct Discharge* In-Place Treatment Plant Counts by Subcategory and Type of Questionnaire Response

Subcategory or Category	NO TREATMENT		PHYSICAL/CHEMICAL		BIOLOGICAL		BIOLOGICAL AND POST-BIOLOGICAL	
	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE
Rayon	–	–	–	1	–	2	–	–
Other Fibers	–	1	–	–	–	6	–	3
Thermosets	2	3	1	3	–	7	1	5
Thermoplastics Only	2	7	2	1	1	18	3	13
Thermoplastics and Organics	–	2	2	5	–	20	1	13
Commodity Organics	–	–	–	6	–	14	–	7
Bulk Organics	–	4	–	12	–	25	–	15
Specialty Organics	–	3	–	4	–	13	–	12
Mixed	1	1	1	1	4	16	5	8
Part A Secondary Organics	2	–	4	–	9	–	13	–
Column Subtotals	7	21	10	33	14	121	23	76
Treatment Totals (N = 305)	28		43		135		99	
(100%)	(9%)		(14%)		(45%)		(32%)	

*Includes counts for 16 combined direct/indirect discharge plants.

TABLE 4 (Continued)

B. Indirect Discharge In-Place Treatment Plant Counts by Subcategory and Type of Questionnaire Response

Subcategory or Category	NO TREATMENT		PHYSICAL/CHEMICAL		BIOLOGICAL		BIOLOGICAL AND POST-BIOLOGICAL	
	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE	PART A ONLY	FULL RESPONSE
Rayon	–	–	–	–	–	–	–	–
Other Fibers	–	5	–	1	–	–	–	1
Thermosets	8	18	10	9	2	10	–	2
Thermoplastics Only	7	13	7	28	1	6	–	3
Thermoplastics and Organics	2	8	–	6	1	2	–	1
Commodity Organics	–	6	–	3	–	2	–	–
Bulk Organics	–	15	–	25	–	3	–	–
Specialty Organics	–	37	–	37	–	12	–	2
Mixed	11	12	8	21	–	2	2	–
Part A Secondary Organics	14	–	34	–	3	–	–	–
Column Subtotals	42	144	59	130	7	37	2	9
Treatment Totals (N = 400)	156		189		44		11	
(100%)	(39%)		(47%)		(11%)		(3%)	

III. TECHNOLOGY BASIS FOR BPT OPTIONS AND DERIVATION OF EFFLUENT LIMITATIONS

III. TECHNOLOGY BASIS FOR BPT OPTIONS AND DERIVATION OF EFFLUENT LIMITATIONS

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III. TECHNOLOGY BASIS FOR BPT OPTIONS AND DERIVATION OF EFFLUENT LIMITATIONS

BPT TECHNOLOGY BASIS

Three technology options are being considered for BPT. These options focus on the primary end-of-pipe technologies used in the industry. These technologies are widely used in the industry to control conventional pollutants. To varying extents, these technologies also remove toxic and nonconventional pollutants. However, it is not possible to calculate consistent removals of specific toxic and nonconventional pollutants across the industry without carefully considering a variety of process controls and in-plant treatment technologies that are more appropriately considered to be BAT controls and technologies. Therefore, the selected BPT technologies are end-of-pipe technologies that are designed primarily to address the conventional pollutants BOD and TSS, supplemented by those in-plant controls and technologies that are commonly used to assure the proper and efficient operation of the end-of-pipe technologies.

Option I: The first BPT technology option is based on biological treatment preceded by the necessary controls to protect the biota and otherwise assure that the biological system functions effectively and consistently. Activated sludge and aerated lagoons are the primary examples of such biological treatment. Other biological systems, such as aerobic lagoons, rotating biological contractors, and trickling filters, are also used effectively at a few plants, and data from such plants were also used to develop BPT limitations based on this option.

Option II: The second BPT technology option includes, in addition to Option I technology, biological systems followed by polishing ponds. In some cases, plants originally installed biological systems that had inadequate retention times or were otherwise not designed and operated to optimally treat conventional pollutants. When these plants were required in the late 1970s to upgrade to meet BPT permit limits (established by permit writers in the absence of guidelines on a case-by-case basis, using their best engineering judgment), some chose to add polishing ponds rather than to enlarge or otherwise improve their existing biological systems.

Option III: The third BPT technology option is based on multimedia filtration as a basis for additional TSS control after biological treatment.

2. DERIVATION OF LIMITATIONS

The BPT technology assessment and derivation of limitations focussed on the 253 direct-discharge, full-response plants with sufficient production data to establish subcategory assignments.

Since the limitations apply to process wastewater only, the relative contributions of process and nonprocess wastewater were determined at the effluent sample sites. These data were used to calculate plant-by-plant "dilution factors" for use in adjusting pollutant concentrations at effluent sampling locations. For example, if BOD was reported as 28 mg/l at the final effluent sampling location with 1 MGD of process wastewater flow and 9 MGD of noncontaminated nonprocess cooling water flow, then the BOD concentration in the process wastewater was actually 280 mg/l.

Sufficient information was available for 224 direct discharge plants to assess process wastewater dilution. Of these, 111 plants diluted the process wastewater before effluent sampling sites. The remaining plants either did not dilute or provided insufficient information to make a determination. Table 1 relates the number of direct-discharge, full-response plants in their assessment to the range of dilution at the NPDES monitoring sites.

2.1 Long-Term Subcategory BOD and TSS Average

After selecting technology options, associated limitations were developed based on the "average-of-the-best" plants that use these technologies. A statistical criterion was developed to segregate the better designed and operated plants from the poorer performers. This was done to assure that the plant data relied upon to develop BPT limitations reflected the average of the best existing performers. Since the database includes many plants which are poor performers, it is necessary to develop appropriate criteria for differentiating poor plant performance from good plant performance. The criterion

TABLE 1

RANGE OF PERCENT DILUTION FOR
DIRECT-DISCHARGE, FULL-RESPONSE PLANTS

No. of Plants in Assessment (%)	Range of Dilution in Percent
113 (51%)	0
39 (17%)	>0 to 25
35 (16%)	>25 to 100
23 (10%)	>100 to 500
14 (6%)	>500 to 17,400
224 (100%)	

selected was to include in the database any plant with a biological treatment system that, on the average (1) discharged 50 mg/l or less BOD after treatment, or (2) removed 95 percent or more of the BOD that entered the end-of-pipe treatment system. This criterion reflects the performance level that is generally achieved by well-operated plants in the OCPSF industry that use the recommended BPT technologies.

These are the same performance criteria utilized at proposal. Many industry comments suggested that EPA unreasonably screened the database for establishing "average of the best" BPT technology and suggested that a more liberal indicator of performance, such as 85 percent removal, should be used.

To assess this recommendation, BOD_5 data was evaluated from the 163 Section 308 questionnaire full-response plants in the direct discharge database with biological treatment systems. After adjusting the data for nonprocess wastewater dilution, the median BOD_5 percent removal for all facilities is 95.4 percent, and the median effluent concentration is 28 mg/l.

The more liberal editing rule suggested by industry was considered for excluding plants with poorly operated or inadequate biological treatment systems. Using the industry's suggestion, plants would be retained for analysis if at least biological treatment was in place and if, on the average, the treatment system removed 85 percent or more of the BOD_5 after treatment. These criteria would retain 87 percent of all the biological treatment systems reporting BOD_5 data.

The "95 percent or more BOD_5 removal or 50 mg/l or less BOD_5 concentration after treatment" performance editing criteria retains 76 percent of all the biological treatment systems reporting BOD_5 data. The subcategory BOD and TSS median values were calculated for both performance editing rules. Using the 95 percent/50 mg/l performance edit reduces the average subcategory BOD and TSS median values for Option I treatment technology approximately 10 and 16 percent, respectively, below those obtained using the 85 percent/100 mg/l edit. Similarly, the average median values for Option II treatment technology are reduced approximately 11 and 4 percent, respectively. The

median BOD_5 percent removal for all facilities is 95.4 percent and the median effluent BOD_5 concentration is 28 mg/l. Based upon all these facts, the "95 percent/50 mg/l BOD_5" performance editing criteria is believed to provide a reasonable determination of "average of the best" BPT performance.

The long-term BOD_5 and TSS averages for each subcategory are shown in Table 2 for several technology and performance edits. The technology edits include all biological systems, biological systems without post-biological solids control, biological systems with and without polishing ponds, and all direct dischargers with data (no editing rules). The performance edits include no edits, "85 percent/100 mg/l BOD_5," and "95 percent/50 mg/l BOD_5." The last column in the table, identified as "(Mixed)," lists the median values for the 28 plants that are not uniquely covered by one subcategory. The selected BPT technology and performance edits are labled as "(Option I) and (Option II)" in the table.

3. DERIVATION OF BOD AND TSS VARIABILITY FACTORS

To establish maximum 30-day average and daily maximum BOD_5 and TSS effluent limitations for each technology option, variability factors were determined for biological treatment systems.

The OCPSF database contains daily data from 69 plants. The daily data, including flow, BOD, and TSS, were automated along with sampling site identification treatment codes. The treatment codes provided specific identification of the sampling site within the treatment plant. For example, effluent data were identified as sampled after the secondary clarifier, after a polishing pond, or after tertiary filtration.

After the database was established, the data at each sampling site were compared with the treatment system diagrams obtained in the Section 308 survey. The comparison served to verify that the data corresponded to the sampling sites indicated on the diagrams and to determine if the data were representative of the performance of OCPSF wastewater treatment systems. Nonrepresentative data were those data from (1) effluent sampling sites where the treatment plant effluent was diluted (>25 percent) with nonprocess

TABLE 2

SUBCATEGORY LONG-TERM MEDIAN CONCENTRATION VALUES (mg/l) vs. TECHNOLOGY AND PERFORMANCE EDITS*

BPT TECHNOLOGY EDITS	SUBCATEGORY																	
	3 Rayon		10 Other Fibers		18 Thermosets		43 Thermoplastics Only		36 Thermoplastics and Organics		27 Commodity Organics		56 Bulk Organics		32 Specialty Organics		28 (Mixed)	
	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
No Performance Edit																		
All Biological Systems	2 19	2 40	9 9	8 22	6 25	6 48	28 21	26 35	29 25	30 44	15 46	14 99	34 51	35 53	19 58	19 68	21 27	21 33
Biological w/ & w/o Polishing Ponds	2 19	2 40	8 10	7 25	5 34	5 46	25 21	23 35	23 28	24 50	11 46	10 122	23 40	23 53	14 58	14 80	20 26	20 33
Biological w/o Any Solids Control	2 19	2 40	6 11	5 25	4 24	4 68	18 22	18 40	16 33	17 52	9 28	8 122	21 32	21 53	11 45	11 92	15 35	15 35
Retain plant if eff BOD $\leq$ 100 mg/l or BOD % removal $\geq$ 85																		
All Biological Systems	2 19	2 40	9 9	8 22	6 25	6 48	25 18	24 31	28 24	28 44	12 34	11 79	27 40	27 41	12 35	12 44	20 25	20 33
Biological w/ & w/o Polishing Ponds	2 19	2 40	8 10	7 25	5 34	5 46	23 18	22 35	22 28	22 50	9 28	8 99	20 32	20 52	10 41	10 52	19 23	19 33
Biological w/o Any Solids Control	2 19	2 40	6 11	5 25	4 24	4 68	17 21	17 35	15 29	15 52	7 28	6 99	18 31	18 46	8 35	8 62	14 29	14 34
Retain plant if eff BOD $\leq$ 50 mg/l or BOD % removal $\geq$ 95																		
All Biological Systems	2 19	2 40	9 9	8 22	5 15	5 46	22 18	22 26	25 22	25 37	12 34	11 79	20 27	20 39	10 30	10 52	19 23	19 32
Biological w/ & w/o Polishing Ponds (BPT Option II)	2 19	2 40	8 10	7 25	4 24	4 46	20 18	20 29	19 25	19 40	9 28	8 99	16 27	16 46	8 35	8 62	18 20	18 33
Biological w/o Any Solids Control (BPT Option I)	2 19	2 40	6 11	5 25	3 14	3 46	15 18	15 34	13 28	13 52	7 28	6 99	15 25	15 40	8 35	8 62	13 23	13 35
All Direct Dischargers No Editing Rule	3 14	3 21	10 8	9 18	10 58	10 51	34 19	33 34	30 26	31 40	21 50	19 83	44 48	49 51	23 64	24 80	22 25	22 33

*Includes 253 direct-discharge, full-response plants with production data. The numbers in the upper-left corners are cell plant-counts with BOD and TSS data.

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wastewater just prior to sampling, (2) treatment systems where a significant portion of the treated wastewater (>25 percent) was nonprocess wastewater, (3) treatment systems where side streams of wastewater entered midway through the treatment system and no data were available for these wastestreams, and (4) treatment systems where the influent sampling site did not include all wastewaters entering the head of the treatment systems (example: data for a single process wastestream rather than all of the influent wastestreams).

Examination of the data available for each plant and the treatment system diagrams provided the basis for exclusion of some of the plants from further analysis. The criteria used were:

- Data do not reflect or account for OCPSF process wastewater treatment system performance as listed in items 1 through 4 above
- Insufficient data due to infrequent sampling (less than once a week while operating) or omission of one or more parameters from testing (BOD, TSS, or flow)
- Treatment plant performance far below expected performance.

Of the plants excluded from the database, most were excluded for two or more reasons. The exclusion criteria most commonly applied were nonrepresentative data and insufficient data.

Plots of concentration versus time and statistical analysis of the data revealed that most observations clustered around the mean with excursions far above or below the mean. In the case of influent data, the excursions were believed related to production factors such as processing unit startups and shutdowns or accidental spills. Effluent excursions, particularly those of several days duration were believed to be related to upsets of the treatment system, production factors, and uncorrected seasonal trends. Verification of the cause of the excursions and of the apparent outliers in each plant database was deemed necessary in order to supplement the statistical analysis of the data with engineering judgment and plant performance information. Each plant was contacted and asked to respond to a series of questions regarding their treatment system, its performance, and the data submitted. Plant contacts were asked about possible seasonal effects on the treatment system

performance and operational adjustments made to compensate, winter and summer NPDES permit limits, operation problems (slug loads, sludge bulking, plant upsets, etc.), production changes, and time of operation, plant shutdowns, and flow metering locations. Data observations which were two standard deviations above or below the mean were identified and the plants were asked to provide the cause of each excursion.

The plant contacts and analysis of the data revealed some of the strengths and weaknesses of the database. Daily data over at least a year of operation show operational trends and problems, plant upsets, and uncorrected seasonal trends which would not be apparent for plants sampled less frequently. The OCPSF industry, regardless of plant subcategory, experiences common treatment system problems. Equilization and diversion basins are commonly used to reduce the effects of slug loads on the treatment system and to prevent upsets. Influent data obtained before equilization or diversion will show high strength wastes but the effluent may not as a result of equilization and diversion. Seasonal effects tend to be more pronounced in southern climates, perhaps because original treatment systems designs and current operations do not accommodate necessary weather adjustments.

While common operational problems are observed across the industry, specific treatment systems design and operation adjustments were not always readily available or documented. Treatment systems incorporating the same unit process produced significantly different effluent quality. The reasons include strength and type of raw wastes, capacity of the treatment system (under or overloaded), knowledge and skill of operating personnel and design factors. While the raw waste type can be categorized by dividing the OCPSF industry into subcategories, the degree to which the other factors affect plant performance may not be readily apparent in the data. For instance, the daily data may not show seasonal trends because of plant design or operational adjustments which adequately compensate for cold weather.

The 46 plants deleted from the variabilty factor calculations are listed in Table 3 along with the criteria that provide the basis for each plant edit. (Some of these edits will be reassessed before promulgation. For example,

RATIONALE FOR EXCLUSION OF DAILY DATA PLANTS FROM DATABASE

Plant Number	>25% non-process wastewater dilution	Infrequent sampling or <1 year of data	Summer/ winter NPDES permit limits	Change in treatment system during period of record	Combined sampling data from parallel treatment systems	Missing influent or effluent data (BOD, TSS, or flow)	Non-representative treatment system *	Effluent data after tertiary treatment	Periods of production shutdown or cutbacks	Insufficient information for technical assessment of treatment system
83				X						
296							X			
659			X							
662			X							
866		X								
871			X							
1148								X		
1343								X		
1438	X									
1446								X		
1494									X	
1609									X	
1617			X				X	X		
1753			X				X			
2222	X									
2227			X							
2242				X					X	
2260										X
2313			X							
2376								X		
2394				X				X		
2474	X							X		
2536			X					X		
2631	X									
2693			X							
2816	X							X		
3033			X					X		
63	X				X		X			
93		X								
683	X									
851	X									
913	X				X		X			
909		X								
942	X									
1323	X					X				
1522						X				
1650							X			
1769	X									
2110						X				
500					X		X			
2315	X									
2474	X									
2531	X						X			
2690	X						X			
2770							X			
1349		X						X		

*Treatment other than activated sludge on aerated lagoon

only activated sludge and aerated lagoons were retained for variability factor calculations since they are the most representative biological treatment systems in the industry.)

After these edits, data from 23 biological treatment systems were retained to calculate variability factors using the statistical methodology developed in Appendix A. The statistical methods developed in Appendix A assume a lognormal distribution, and hypothesis tests investigating this assumption are discussed in Appendix B. Individual plant variability factors grouped by subcategory or category are listed in Tables 4 and 5 for BOD and TSS, respectively. As shown in the tables, the average BOD_5 maximum 30-day average and daily maximum variability factors are 1.41 and 3.91, respectively. The average TSS maximum 30-day average and daily maximum variability factors are 1.45 and 4.74, respectively.

4. BPT EFFLUENT LIMITATIONS

The BPT effluent limitations for Options I and II are presented in Table 6 and 7, respectively. The industry average BOD and TSS variability factors derived above for biological systems only are utilized for BPT Options I and II.

An assessment of the long-term BOD and TSS averages in Table 6 and 7 indicates that subcategory effluent quality does not necessarily improve when plants with biological treatment and polishing ponds are included in the subcategory averages. As noted above, these plants may have merely added polishing ponds to an inadequately designed or operated biological treatment system rather than enlarge or otherwise improve their existing biological treatment systems. The performance edits were utilized to segregate the better designed and operated plants from the poorer performers based on BOD performance only. The Agency has not yet conducted a performance edit based on TSS control but intends to assess TSS performance for all plants prior to promulgation.

For example, in the case of the commodity organic chemicals subcategory, the long-term TSS values are 99 mg/l in both Tables 6 and 7. The 11 commodity

TABLE 4 - BOD VARIABILITY FACTORS FOR BIOLOGICAL SYSTEMS (RETAIN PLANT IF EFFLUENT $BOD_5 \leq$ mg/l OR IF BOD_5 % REMOVAL $\geq$ 95%)

Plant No.	Subcategory or Category	BOD_5 % Removal	BOD_5 Mean Eff. Con. (mg/l)	BOD_5 Median Eff. Con. (mg/l)	No. of Observations	VF (1)	VF(30)
C2396	Rayon	-	14	12	160	4.14	1.54
C107		97	13	13	157	3.10	1.23
C1756	Other	77	20	14	357	4.35	1.62
C1010	Fibers	98	23	17	162	4.29	1.57
C247	Thermosets	95	8	6	203	3.48	1.49
C2597		99	9	8	262	3.29	1.31
C2451	Thermoplastics	-	24	22	84	3.00	1.17
C58	Only	-	4	2	122	6.12	1.39
C94	Thermoplastics	99	53	26	96	6.59	1.42
C1667	and	-	15	10	157	4.54	1.45
C2651	Organics	-	33	31	144	2.11	1.28
C2779		-	12	10	363	4.24	1.34
C1848		99	13	11	153	3.12	1.29
C1148	Commodity Organics	98	6	5	366	2.99	1.27
C1544		-	32	31	163	2.89	1.23
C1104	Bulk Orgaincs	-	16	12	154	3.90	1.44
C586		96	98	77	156	4.50	1.65
C2600		-	19	16	143	4.48	1.27
C306	Speciality	97	13	12	48	3.76	1.22
C2057	Organics	98	21	13	359	4.30	1.61
C924		93	6	5	157	2.97	1.48
C2790	Mixed	99	8	7	210	3.33	1.43
C2536		96	24	16	347	4.44	1.72
					Average BOD_5 - VFs	3.91	1.41

TABLE 5 - TSS VARIABILITY FACTORS FOR BIOLOGICAL SYSTEMS (RETAIN PLANT IF EFFLUENT $BOD_5 \leq 50$ mg/l OR IF BOD_5 % REMOVAL $\geq 95\%$)

Plant No.	Subcategory or Category	TSS % Removal	TSS Mean Eff. Con. (mg/l)	TSS Median Eff. Con. (mg/l)	No. of Observations	VF (1)	VF (30)
C2396	Rayon	-	20	17	158	4.37	1.43
C107	Other Fibers	-	30	26	363	2.79	1.39
C1756		-	8	7	366	3.35	1.31
C1010		82	53	36	151	4.80	1.40
C247	Thermosets	-	30	25	155	4.97	1.30
C2597	Thermoplastics Only	99	14	6	261	6.94	1.62
C2451		-	24	20	130	2.70	1.15
C58		92	24	15	366	5.07	1.56
C94	Thermoplastics and Organics	88	43	31	99	4.75	1.29
C1667		-	23	20	158	2.52	1.19
C2651		-	74	71	155	2.30	1.20
C2779		99	18	16	366	3.93	1.35
C1848		-	26	9	154	8.48	2.04
C1148	Commodity Organics	92	7	6	366	4.80	1.46
C1544	Bulk Organics	-	60	56	363	2.67	1.21
C1104		-	26	20	159	4.98	1.31
C586		-	139	49	251	8.43	2.29
C2600		97	14	9	146	4.87	1.30
C306	Specialty Organics	(-2)	18	13	48	5.66	1.35
C2057		84	86	28	366	7.43	1.84
C924	(Mixed)	76	10	8	347	5.19	1.40
C2790		44	28	24	362	3.95	1.38
C2536		29	66	49	365	4.08	1.49
				Average TSS VFs		4.74	1.46

TABLE 6

OPTION I BPT LIMITATIONS BASED ON
BIOLOGICAL TREATMENT WITHOUT POST-BIOLOGICAL CONTROLS

Subcategory	BOD_5 (mg/l)			TSS (mg/l)		
	Long-Term Avg	30-Day Avg	Daily Max	Long-Term Avg	30-Day Avg	Daily Max
Rayon	19	27	74	40	58	190
Other Fibers	11	16	43	25	37	119
Thermosets	14	20	55	46	67	218
Thermoplastics Only	18	25	70	34	50	161
Thermoplastics & Organics	28	39	109	52	76	246
Commodity Organics	28	39	109	99	145	469
Bulk Organics	25	35	98	40	58	190
Specialty Organics	35	49	137	62	91	294

TABLE 7

OPTION II BPT LIMITATIONS BASED ON
BIOLOGICAL TREATMENT WITH AND WITHOUT POLISHING PONDS

Subcategory	BOD_5 (mg/l)			TSS (mg/l)		
	Long-Term Avg	30-Day Avg	Daily Max	Long-Term Avg	30-Day Avg	Daily Max
Rayon	19	27	74	40	58	190
Other Fibers	10	14	39	25	37	119
Thermosets	24	34	94	46	67	218
Thermoplastics Only	18	25	70	29	42	137
Thermoplastics & Organics	25	35	98	40	58	190
Commodity Organics	28	39	109	99	145	469
Bulk Organics	27	38	106	46	67	218
Specialty Organics	35	49	137	62	91	294

organic chemical plants that utilize biological treatment (9 without polishing ponds and 2 with polishing) and that reported effluent data are located in North Carolina, Louisiana, and Texas. Application of the performance edit deletes the North Carolina plant and one Texas plant. Therefore, 9 Louisiana and Texas facilities (7 without polishing and 2 with polishing) provide the basis for the subcategory averages. Many of these high TSS plant averages are believed to be due to periods of high ambient temperatures that may cause algae blooms in holding or polishing ponds. Many industry comments discuss this TSS control problem.

Apparently, a well-operated biological treatment system (based on BOD) even with polishing ponds does not necessarily ensure adequate solids control. In those cases where biological treatment provides inadequate TSS control, additional treatment such as filtration systems should provide the basis for effluent TSS limitations. Filtration has been a well-established technology for many years in both the OCPSF industry and many other industries.

Approximately 11 percent of the plants in the direct discharge database utilize filtration in combination with either biological treatment or biological treatment and polishing ponds. If this technology provides the basis for final TSS standards, those biological systems that are not followed by adequate physical/chemical solids control systems would be deleting from the database, for TSS purposes. Based upon the present database on the performance of such biological/tertiary solids control systems, this approach would result in the TSS long-term averages shown in Table 8. Since the BOD performance edit (95 percent/50 mg/l) retains only 16 facilities with tertiary solids control, TSS data for some subcategories would be pooled.

The TSS filtration data was pooled for the plastics subcategories -- rayon, other fibers, thermosets, and thermoplastics-only. The TSS filtration data was separately pooled for the three organic chemical subcategories. The data for the thermoplastics and organics subcategory was not pooled because it had TSS filtration data from five plants in that subcategory. The prefiltration (i.e., Option II) TSS levels for plants within each of these broad groupings are believed to be within a sufficiently similar range to support pooling the filtration effluent data.

TABLE 8

LONG-TERM TSS VALUES (MG/L) FOR BIOLOGICAL SYSTEMS
(WITH OR WITHOUT POLISHING PONDS) WITH FILTRATION
(RETAIN PLANT IF EFFLUENT BOD $\leq$50 MG/L
OR IF BOD % REMOVAL $\geq$95%)

Subcategory or Category	No. of Plants with Data	Median TSS (mg/l)
1. Rayon	—	—
2. Other Fibers	2	27.5
3. Thermosets	1	50
4. Thermoplastics Only	2	22.5
5. Thermoplastics and Organics	5	37
6. Commodity Organics	3	46
7. Bulk Organics	2	29.5
8. Speciality Organics	1	9
Pooled Groups 1, 2, 3, 4	5	27
Pooled Groups 6, 7, 8	6	40

The BPT Option II TSS maximum 30-day average and daily maximum standards listed in Table 9 were calculated using the TSS variability factors established for BPT Options I and II.

TABLE 9
OPTION III TSS BPT LIMITATIONS (MG/L) BASED ON
BIOLOGICAL TREATMENT WITH FILTRATION
AND BIOLOGICAL TREATMENT WITH POLISHING AND FILTRATION

Subcategory	Long-Term Avg	3-Day Avg	Daily Max
Rayon	27	39	128
Other Fibers	27	39	128
Thermosets	27	39	128
Thermoplastics Only	27	39	128
Thermoplastics & Organics	37	54	175
Commodity Organics	40	58	190
Bulk Organics	40	58	190
Specialty Organics	40	58	190

APPENDIX A

BPT STATISTICAL METHODOLOGY

VARIABILITY FACTOR DEVELOPMENT FOR BOD AND TSS CONCENTRATIONS

1. DAILY VARIABILITY FACTORS

Assuming that the distribution of concentration values X is lognormal, then $Y = \log(X)$ is normally distributed with mean μ and variance σ^2 (Aitchison and Brown (1957)). Thus the 99th percentile on the natural log (base e) scale is

$$Y_{99} = \mu + 2.326\sigma,$$

and the 99th percentile on the concentration scale is

$$P_{99} = \exp(Y_{99}) = \exp(\mu + 2.326\sigma). \tag{1}$$

The expected value, E(X), and variance, V(X), on the concentration scale are:

$$E(X) = \exp(\mu + 0.5\sigma^2) \tag{2}$$

and

$$V(X) = \exp(2\mu + \sigma^2)(\exp(\sigma^2) - 1). \tag{3}$$

The estimates of any of the above quantities are calculated by substituting the sample mean and variance of natural logs of the observations for μ and σ^2, respectively. Hence the 99th percentile daily variability factor, VF(1), is

$$VF(1) = \frac{\widehat{P_{99}}}{\widehat{E(x)}} = \exp(2.326\hat{\sigma} - 0.5\hat{\sigma}^2), \tag{4}$$

where

$$\hat{\mu} = \sum_{i=1}^{n} \frac{y_i}{n}, \tag{5}$$

and

$$\hat{\sigma}^2 = \frac{\sum_{i=1}^{n} (y_i - \hat{\mu})^2}{n - 1}. \tag{6}$$

2. 30-DAY MEAN VARIABILITY FACTORS

Variability factors for 30-day average concentrations, VF(30), are based on the distribution of an average of values drawn from the distribution of daily values and take day-to-day correlation into account. Positive autocorrelation between concentrations measured on consecutive days means that such concentrations tend to be similar. An average of positively correlated concentration measurements is more variable than an average of independent concentrations. The following formulas incorporate the autocorrelation between concentration values measured on adjacent days.

Using the first-order autoregressive model commonly found to be appropriate in water pollution modeling, the mean and variance of an average of n daily values, where this average is denoted by $\overline{X}_n$, are approximated by:

$$E(\overline{X}_n) = E(X) = \exp(\mu + 0.5\sigma^2) \tag{7}$$

and

$$V(\overline{X}_n) = \frac{V(X)}{n} f_n(\rho), \tag{8}$$

with

$$f_n(\rho) = 1 + [(2/n) \sum_{k=1}^{n-1} (n - k)(\exp(\rho^k \sigma^2) - 1)/(\exp(\sigma^2) - 1)]. \tag{9}$$

It can be seen in (8) that $V(\overline{X}_n)$ equals the variance of an average of n uncorrelated observations, V(X)/n, multiplied by a factor, $f_n(\rho)$, that adjusts for the presence of autocorrelation, with ρ denoting the correlation between adjacent days' measurements (i.e., the lag-1 autocorrelation).

Finally, since $\overline{X}_{30}$ is approximately normally distributed by the Central Limit Theorem, the estimate of 95th percentile ($\widehat{P_{95}}$) of a 30-day mean and the corresponding 95th percentile 30-day mean variability factor (VF(30)) are approximately

$$\widehat{P_{95}} = E(\widehat{\bar{X}_{30}}) + 1.645\sqrt{V(\widehat{\bar{X}_{30}})} \tag{10}$$

and

$$VF(30) = \widehat{P_{95}}/E(\widehat{\bar{X}_{30}})$$

$$= 1 + 1.645[(\exp(\sigma^2) - 1)f_{30}(\hat{\rho})/30]^{1/2} \tag{11}$$

where $E(\bar{X}_{30})$ and $V(\bar{X}_{30})$ are calculated by setting $n = 30$ in equations (7) and (8), using $\hat{\mu}$ and $\hat{\sigma}^2$ as defined in (5) and (6), and defining $\hat{\rho}$ as the Pearson product-moment correlation coefficient between the logarithm of adjacent days' measurements (i.e., the estimated lag-1 autocorrelation).

APPENDIX B

DISTRIBUTIONAL HYPOTHESIS TESTING

GOODNESS-OF-FIT PROCEDURES

The Studentized range test was used to test the assumption that concentration values follow a lognormal distribution (i.e., the natural logarithm of the concentration values follows a normal distribution). This test was used for all plant-pollutant combinations for which variability factors were developed. The pollutants included both priority pollutants and conventional pollutants (BOD and TSS). To conduct this test, let $x_1, x_2, \ldots, x_n$ be a set of n nonzero concentration values for a particular plant-pollutant combination, and let y_i ($i = 1, \ldots, n$) be the natural logarithm of these concentrations (i.e., $y_i = \log(x_i)$, $i = 1, \ldots, n$). The Studentized range test is based on the test statistic $U = R/S$, where

$R = y_{(n)} - y_{(1)}$, where $y_{(n)}$ is the natural logarithm of the largest concentration value, and $y_{(1)}$ is the natural logarithm of the smallest concentration value,

and $S = \left[\frac{1}{n-1} \sum_{i=1}^{n} (y_i - \bar{y})^2 \right]^{1/2}$, where $\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$.

An upper tail test was used to guard against alternative distributions with heavier tails than the lognormal distribution, and a significance level of $\alpha = 0.01$ was employed for each test.

Critical values for the hypothesis test involving the U statistic are given in David, et al. (1954), and selected values are shown below (in particular, upper percentage points for $\alpha = 0.01$).

N	$U_{0.99}$	N	$U_{0.99}$
3	2.000	17	4.59
4	2.445	18	4.66
5	2.803	19	4.73
6	3.095	20	4.79
7	3.338	30	5.25
8	3.543	40	5.54
9	3.720	50	5.77
10	3.875	60	5.93
11	4.012	80	6.18
12	4.134	100	6.36
13	4.244	150	6.64
14	4.34	200	6.85
15	4.43	500	7.42
16	4.51	1000	7.80

When the hypothesis of a lognormal distribution is tested (at a significance level of $\alpha = 0.01$) for the various plant-pollutant distributions of detected priority pollutant concentration values used for variability factor analysis, only one hypothesis test (out of 68 plant-pollutant combinations investigated) shows a significant result (Copper (120), Plant P225; $n = 5$; $U = 2.813$; p value < 0.005; used for PSES standards based on physical-chemical controls). The remaining 67 distributions corresponding to the various plant-pollutant combinations used in variability factor analyses are nonsignificant at the $\alpha = 0.01$ significance level. Results of hypothesis tests of the lognormality of the distributions of conventional pollutant (BOD and TSS) concentrations (for the plants used for variability factor analyses) are given in the subsequent tables.

Reference

David, H.A., H.O. Hartley, and E.S. Pearson. 1954. The Distribution of the Ratio, in a Single Normal Sample, of Range to Standard Deviation. Biometrika 41:482-93.

GOODNESS-OF-FIT TESTS FOR BOD DAILY DATA -
NULL HYPOTHESIS OF LOGNORMAL DISTRIBUTION

Plant	Test Statistic*	n	Significance**
C58	3.85	124	N.S.
C94	4.94	96	N.S.
C107	6.49	157	N.S.
C247	4.79	203	N.S.
C306	4.68	48	N.S.
C586	5.85	156	N.S.
C924	4.36	157	N.S.
C1010	6.01	162	N.S.
C1104	6.36	154	N.S.
C1148	7.75	366	<0.005
C1544	7.29	163	<0.005
C1667	5.75	157	N.S.
C1756	5.93	357	N.S.
C1848	5.36	153	N.S.
C2057	6.48	359	N.S.
C2396	5.23	160	N.S.
C2451	4.63	84	N.S.
C2536	7.34	347	<0.005
C2597	5.87	262	N.S.
C2600	6.26	143	N.S.
C2651	6.02	144	N.S.
C2779	5.75	363	N.S.
C2790	4.62	210	N.S.

*Test Statistic U = R/S (see discussion of Studentized range test)

**N.S. indicates nonsignificant at $\alpha = 0.01$ level of significance; when results are significant at the $\alpha = 0.01$ level, an approximate p-value is given.

GOODNESS-OF-FIT TESTS FOR TSS DAILY DATA -
NULL HYPOTHESIS OF LOGNORMAL DISTRIBUTION

Plant	Test Statistic*	n	Significance**
C58	6.08	366	N.S.
C94	4.87	99	N.S.
C107	6.35	363	N.S.
C247	4.77	155	N.S.
C306	4.99	48	N.S.
C586	5.00	251	N.S.
C924	5.69	347	N.S.
C1010	6.11	151	N.S.
C1104	6.71	159	<0.01
C1148	4.23	366	N.S.
C1544	6.42	363	N.S.
C1667	5.84	158	N.S.
C1756	5.86	366	N.S.
C1848	4.35	154	N.S.
C2057	6.77	366	N.S.
C2396	6.02	158	N.S.
C2451	5.34	130	N.S.
C2536	8.39	365	<0.005
C2597	6.00	261	N.S.
C2600	5.56	146	N.S.
C2651	5.91	155	N.S.
C2779	6.38	366	N.S.
C2790	7.33	362	<0.01

*Test Statistic U = R/S (see discussion of Studentized range test)

**N.S. indicates nonsignificant at $\alpha = 0.01$ level of significance; when results are significant at the $\alpha = 0.01$ level, an approximate p-value is given.

IV. TECHNOLOGY BASIS AND DERIVATION OF BAT EFFLUENT LIMITATIONS

IV. TECHNOLOGY BASIS AND DERIVATION OF BAT EFFLUENT LIMITATIONS

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IV. TECHNOLOGY BASIS AND DERIVATION OF BAT EFFLUENT LIMITATIONS

1. INTRODUCTION

Due to the diversity of priority pollutants in the OCPSF industry, a variety of treatment technologies are employed by OCPSF plants to control priority pollutants as well as nonconventional pollutant discharges. Consequently, the selection of a particular set of BAT treatment technologies is plant-specific since the OCPSF industry is not amenable to any single BAT technology.

The range of technologies used to control priority pollutant discharges encompasses virtually the entire range of industrial wastewater treatment technology. Generally, this technology consists of a combination of in-plant control or treatment of specific wastestreams (sometimes from several different product/processes) by any of a variety of physical/chemical methods, biological treatment of combined wastestreams, and post-biological treatment.

In-plant controls frequently used by OCPSF plants for treatment of individual wastestreams include steam stripping (or distillation), carbon adsorption, chemical precipitation, solvent extraction and chemical oxidation. Biological treatment generally consists of some form of activated sludge (i.e., extended aeration, complete mix, pure oxygen) individually or in combination with other types of biological treatment, such as aerated lagoons, trickling filters, and aerobic and anerobic lagoons. Post-biological treatment for priority pollutants (and nonconventionals) is generally limited to granular activated carbon and multimedia filtration.

It should be noted that although some of the controls or technologies preceding the biological segment of the treatment system are installed for product recovery or to reduce priority pollutants, others are expressly designed into the treatment system to assure compliance with BPT effluent limitations by protecting the biological segment of the system from shock loadings and other forms of interference. Sampling results show that some plants remove certain toxic pollutants very effectively from the wastewater through in-plant control technologies. In these cases, the end-of-pipe

systems are designed primarily for BOD5 and TSS removal. However, other complete treatment systems have integrated both biological and post-biological components with in-plant components to control priority pollutants by utilizing the in-plant technologies as "roughing" controls to reduce toxic pollutant loadings to levels which can be handled by biological and post-biological technologies. It is thus inappropriate to specify any particular technology as a BAT technology in the OCPSF industry. Rather, each plant required to control priority pollutant discharges will employ a combination of in-plant controls and end-of-pipe treatment technologies that result in the desired effluent quality with respect to a wide variety of pollutant parameters of interest.

Based upon these considerations, a particular set of treatment technologies has not been specified as the basis for BAT. Rather, priority pollutant control will be based on removals achieved at OCPSF plants using different treatment configurations. Unlike the BAT editing rules used in the proposed rulemaking, a technology-based editing rule has been used to retain plant data in calculating BAT limitations rather than a performance editing rule utilizing BPT effluent parameters. These rules are discussed in detail in the BAT effluent limitations portion of this report.

2. CONCENTRATION VERSUS MASS-BASED LIMITATIONS

Two general approaches were considered for developing BAT effluent limitations. The first approach was concentration-based limitations (with appropriate requirements to prevent the substitution of dilution for treatment) based on end-of-pipe data (supported by performance data for selected in-plant control technologies) that reflect total treatment system performance. The second approach would set mass-based limitations based primarily on an evaluation of the treatability of individual product/process streams by in-plant process controls, physical/chemical treatment and biological treatment.

Serious consideration was given to the mass-based product process approach throughout the development of both the proposed regulations and those contained in the Notice of Availability. This approach would have relied

primarily on the data gathered in the verification program for the 176 product/processes and their treatability and also on the physical/chemical treatability data base. Based on these data, mass-based limitations could be determined based on the use of in-plant controls.

Under this approach, each product/process would have been considered a separate subcategory, and the regulation would have contained separate mass-based limitations for each such subcategory. Monitoring would have been separately required for each product/process effluent. However, credit could have been provided for removals by an end-of-pipe (usually biological) treatment system if sampling before and after that system demonstrated a percent reduction through the biological segment of the system.

This approach, if supported by sufficient technical information, provides some potential advantages over an end-of-pipe-based regulation:

a. By setting limits on individual product/processes, this approach would assure treatment prior to the commingling of different process wastewaters. Thus, the dilution of one process wastewater containing only pollutants A-E by another process wastewater containing only pollutants F-J could not be used as a partial substitute for treatment.

b. This approach could be expected, in practice, to result in an emphasis on process controls and in-plant physical/chemical treatment, thereby promoting the recycling and reuse of wastewater and by-prodcuts. Such an emphasis would result in a reduction of the overall pollutant release through various environmental media that might otherwise occur through a heavier reliance on end-of-pipe biological treatment. For example, biological treatment, in many instances, causes the transfer of volatile and semivolatile organic pollutants from the wastewater to the air, and the adsoprtion of some other organic pollutants, as well as metals, to the biological sludge, which is then disposed of through methods which may affect other media. While some in-plant physical/chemical controls may similarly transfer pollutants to other media (e.g., precipitation of metals often results in the transfer of metals

from wastewater to other media), other in-plant controls and treatments return at least some pollutants to the process, thereby minimizing total environmental releases.

Despite these advantages, this approach has been determined to be both technically and administratively infeasible. The difficulties with this approach are outlined below:

a. Data were collected characterizing 176 specific product/process effluents. This covers all of the high-volume products in the industry, and represents approximately 40 percent of the industry wastewater flow and approximaely 65 percent of its production. Despite this extensive coverage, thousands of minor individual product/processes are left unaddressed. In implementing BAT regulations to issue a permit under this option, a permit writer would typically be faced with the arduous task of characterizing and developing effluent limitations for those product/processes at each plant that are not explicitly addressed by the regulation. It is thus likely that this approach would substantially delay the issuance of permits to, and the installation and operation of BAT controls by, OCPSF plants.

b. Calculating mass limits requires that for each product/process, an F/P (flow divided by production volume) ratio must be calculated that is representative of good industry practice. (Multiplying F/P by concentration yields a mass pollutant loading per unit of production.) For 146 of the 176 product/processes, F/P data with corresponding final effluent data exists at only one plant. Moreover, where data exists from two or three plants, wide variation in F/P ratios often occur. (In one case the variation is a factor of 74). Causes for these disparities could be a variety of differing process controls. To establish a BAT F/P ratio, design and operating practices would have to be set for each product/process in the industry. This is far beyond the reasonable scope of the BAT project.

c. Plants often combine the raw wastewater from several product/processes prior to in-plant treatment. The piping configurations often make it impossible to sample the isolated wastewater streams before they are combined.

Undetermined mixes of several product/process effluents would confound attempts to attribute F/P ratios, raw waste loads or treatabilities to particular product/process effluents. This problem would similarly confront plants attempting to monitor individual product/process effluents in order to comply with permits implementing this option.

d. Monitoring for compliance with individual product/process limitations would be enormously expensive. Sampling and analysis for organic pollutants, unlike analysis for conventional pollutants and metals, is very expensive. Monitoring on a routine basis for organic pollutants at many different points within the plant would be exceptionally expensive. For example, if a large plant monitored 15 sample points for priority pollutants once a week, the annual cost of monitoring alone could be as high as $663,000.

Based on the discussion above, the concentration-based limitations approach was selected to develop BAT effluent limitations.

3. TECHNOLOGY OPTIONS

Throughout this project, various sources of toxic pollutant data have been used in the calculation of BAT effluent limitations for both the proposed regulations and this Notice of Availability and the collection of each of these data sets was aimed at gathering certain performance information for certain pollutants. The overall scope of each data gathering episode has greatly influenced the selection of BAT technology options due to the type of performance data each episode sought to collect. For example, plants sampled during the verification and CMA/EPA 5-plant sampling study focused on a selected set of pollutants at each plant and only sampling of the influent and effluent of the end-of-pipe treatment system (mostly biological) was performed. The in-plant controls at these plants were usually documented but seldom sampled. In addition, plants were selected for the current 12 plant sampling study based on their ability fo fill gaps in the existing toxic pollutant data base and to provide performance data for such treatment technologies as steam stripping, activated carbon, chemical precipitation and chemical oxidation as well as additional performance data for activated sludge systems.

This combined toxic pollutant data base yielded performance data on the following types of treament systems:

a. Biological treatment systems which consist primarily of activated sludge and aerated lagoons.

b. In-plant controls such as steam stripping and chemical precipitation individually and in combination with biological treatment systems.

c. Toxic pollutant polishing treatment technologies such as carbon adsorption and filtration individually and in combination with biological treatment systems.

Based on the types of performance data collected in the three data gathering efforts, the following end-of-pipe BAT technology options were selected:

Option I--Concentration-based BAT effluent limitations based on the performance of only the biological treatment component, which is usually equal to the priority pollutant limitations attained when in compliance with BPT effluent limitations.

Option II--Concentration-based BAT effluent limitations based on the performance of the biological treatment component plus in-plant control technologies which remove priority pollutants prior to discharge to the end-of-pipe treatment system. These in-plant technologies include steam stripping to remove volatile and semivolatile priority pollutants, activated carbon for various base/neutral priority pollutants, chemical precipitation for metals and cyanide and possibly multistage biological treatment for removal of polynuclear aromatic (PNA) priority pollutants.

Option III--Concentration-based BAT effluent limitations based on the performance of biological treatment, in-plant controls and post-biological activated carbon adsorption for the remaining toxic pollutants.

Option I is a low cost option which reduces some toxic pollutants utilizing the technology installed for BPT--biological treatment. However, some OCPSF facilities can comply with the BPT limitations for BOD5 and TSS without the installation of biological treatment. These facilities can comply with Option I BAT effluent limitations only by installing the in-plant controls recommended in Option II. However, this technology in some cases includes in-plant controls which have been installed to remove toxic pollutants which would interfere with or inhibit the biological treatment system's removal of BOD5 and TSS. The need for such controls for BPT purposes is likely to vary; thus some BPT plants may not be able to achieve BAT Option I without additional technology at additional cost.

Option II controls reduce large amounts of toxic pollutants from wastewater prior to discharge to surface waters. Furthermore, the installation of in-plant controls under Option II would be particularly effective in reducing the levels of volatile and semi-volatile organic toxic pollutants in all environmental media. A large portion of volatile and semivolatile organic toxic pollutants are emitted by biological systems into the surrounding air. Thus, while removing them from the wastewater, the typical biological system does not remove these pollutants from the environment but rather transfers a large portion of them to another environmental medium. The in-plant treatment of such pollutants by methods such as steam stripping reduces or eliminates the air emissions that otherwise would occur by the air stripping of the organic toxic pollutants in the biological system. Moreover, the installation of in-plant controls would also reduce the levels of certain priority pollutants which are not air stripped or otherwise removed from OCPSF wastewaters using only biological treatment. For example, the Agency's data base shows that bis(2-chloroisopropyl) ether, 2,4,6-trichlorophenol, and pentachlorophenol are not adequately removed by biological treatment systems. However, bis(2-chloroisopropyl) ether, a base/neutral compound, may be controlled through in-plant steam stripping. Similarly, 2,4,6-trichlorophenol and pentachlorophenol, acid compounds, may be controlled through in-plant absorption systems.

Option III provides slightly higher removals for a limited number of organic toxic pollutants such as 2,4-dimethyl phenol, naphthalene, and phenol.

4. CALCULATION OF CONCENTRATION-BASED BAT END-OF-PIPE EFFLUENT LIMITATIONS

For each of the technology options, end-of-pipe concentration-based BAT limitations for the entire industry will be calculated based upon end-of-pipe data that reflect the best available technology. Depending on the option selected, the BAT technology used as the basis for limitations includes combinations of process controls, in-plant physical/chemical treatment and end-of-pipe treatment. The data base includes verification plants, CMA/EPA 5-plant study plants, and recent sampling study plants; the data has been edited both technically and analytically.

Prior to calculating concentration-based limitations, consideration was given to whether the industry should be subcategorized for BAT purposes. By evaluating the same subcategorization factors which were considered for BPT, it was decided to promulgate a single set of BAT limitations which would be applicable to all OCPSF facilities. However, permits would tailor these requirements somewhat to account for the fact that most OCPSF plants routinely discharge only a subset of the pollutants covered by the BAT regulation. The available data for BAT show that plants in differing BPT subcategories can achieve similar low toxic pollutant effluent concentrations by installing the best available treatment components. Since all plants can achieve compliance with the same BAT limitations through some combination of demonstrated technology, the predominant issue relates to the cost of the required treatment technology, which has been addressed in the cost estimation methodologies and procedures used to generate BAT costs.

Having concluded that in general only one set of BAT limitations for all OCPSF facilities should be developed, BAT effluent limitations were calculated for each technology option using data collected from different combinations of BAT treatment systems during the verification, CMA/EPA 5-plant study, and current sampling program efforts as follows:

Option I--BAT effluent limitations will be calculated using sampling data from plants that have been determined to have well-operated biological treatment for the priority pollutants to be regulated. These plants may include in-plant toxic pollutant controls which were installed to ensure the performance of the biological treatment system.

Option II--BAT effluent limitations will be calculated using sampling data from plants included in Option I for certain priority pollutants. For pollutants not adequately controlled by BPT technology, limitations will be based on data from plants that have biological treatment plus in-plant controls and plants that have physical/chemical control technology applied at the end-of-pipe for the remaining priority pollutants to be regulated.

Option III--BAT effluent limitations will be calculated using sampling data from plants included in Options I and II for some pollutants plus, for certain other pollutants, plants that have been identified as having biological treatment, in-plant controls and post-biological activated carbon adsorption polishing.

The following sections discuss the procedures used to calculate the components necessary for the development of BAT effluent limitations.

5. BAT DATA BASE EDITING

Certain editing rules were utilized in preparing the data base prior to calculation of individual plant long-term averages (LTA) and industry long-term medians (LTM). First, all verification, CMA/EPA 5-plant study and current 12 plant sampling study facilities were examined to determine if they fit into the three BAT technology options. Each plant-pollutant combination was assigned to a technology category as shown in Table 1, based on their in-place treatment technologies and the pollutants that were present. Plant-pollutant combinations used for BAT Options I, II, and III calculations are listed in Table 1 as Categories I; I and II; and I, II, and II, respectively. Depending on plant-specific wastewater treatment configurations, different pollutants at a plant could be assigned to different plant-pollutant categories. A total of seven verification plants were eliminated because they did

TABLE 1. CATEGORY ASSIGNMENTS

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P202	7	CHLOROBENZENE	I
P202	25	1,2-DICHLOROBENZENE	I
P202	27	1,4-DICHLOROBENZENE	I
P202	38	ETHYLBENZENE	I
P202	47	BROMOFORM	I
P202	57	2-NITROPHENOL	I
P202	58	4-NITROPHENOL	I
P202	59	2,4-DINITROPHENOL	I
P202	65	PHENOL	I
P202	66	BIS (2-ETHYLHEXYL) PHTHALATE	I
P202	86	TOLUENE	I
P202	119	CHROMIUM	I
P206	8	1,2,4-TRICHLOROBENZENE	II
P206	21	2,4,6-TRICHLOROPHENOL	I
P206	24	2-CHLOROPHENOL	I
P206	25	1,2-DICHLOROBENZENE	I
P206	26	1,3-DICHLOROBENZENE	I
P206	27	1,4-DICHLOROBENZENE	I
P206	28	3,3'-DICHLOROBENZIDINE	I
P206	31	2,4-DICHLOROPHENOL	I
P206	38	ETHYLBENZENE	I
P206	58	4-NITROPHENOL	I
P206	64	PENTACHLOROPHENOL	I
P206	78	ANTHRACENE	I
P206	81	PHENANTHRENE	I
P206	115	ARSENIC	I
P206	119	CHROMIUM	I
P206	120	COPPER	I
P206	122	LEAD	I
P206	128	ZINC	I
P208	1	ACENAPHTHENE	I
P208	34	2,4-DIMETHYLPHENOL	I
P208	39	FLUORANTHENE	I
P208	55	NAPHTHALENE	I
P208	65	PHENOL	I
P208	72	BENZO(A)ANTHRACENE	I
P208	73	BENZO(A)PYRENE	I
P208	74	BENZO(B)FLUORANTHENE	I
P208	75	BENZO(K)FLUORANTHENE	I
P208	77	ACENAPHTHYLENE	I
P208	78	ANTHRACENE	I
P208	80	FLUORENE	I
P208	81	PHENANTHRENE	I
P208	84	PYRENE	I
P208	115	ARSENIC	I
P208	119	CHROMIUM	I
P208	123	MERCURY	I
P208	128	ZINC	I
P210	65	PHENOL	I
P210	86	TOLUENE	II
P210	119	CHROMIUM (TOTAL)	II
P210	121	CYANIDE (TOTAL)	I
P210	128	ZINC (TOTAL)	II
P211	1	ACENAPHTHENE	I
P211	4	BENZENE	II

TABLE 1. CATEGORY ASSIGNMEI

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P211	34	2,4-DIMETHYLPHENOL	II
P211	38	ETHYLBENZENE	I
P211	39	FLUORANTHENE	I
P211	55	NAPHTHALENE	I
P211	65	PHENOL	I
P211	77	ACENAPHTHYLENE	I
P211	80	FLUORENE	I
P211	84	PYRENE	I
P211	86	TOLUENE	I
P211	121	CYANIDE (TOTAL)	I
P213	30	1,2-TRANSDICHLOROETHYLENE	II
P213	87	TRICHLOROETHYLENE	II
P213	119	CHROMIUM (TOTAL)	II
P213	120	COPPER (TOTAL)	II
P213	121	CYANIDE (TOTAL)	I
P215	4	BENZENE	II
P215	11	1,1,1-TRICHLOROETHANE	II
P215	23	CHLOROFORM	II
P215	38	ETHYLBENZENE	II
P215	44	DICHLOROMETHANE	II
P215	55	NAPHTHALENE	I
P215	65	PHENOL	I
P215	86	TOLUENE	II
P215	119	CHROMIUM (TOTAL)	I
P215	128	ZINC (TOTAL)	I
P217	4	BENZENE	II
P217	6	CARBON TETRACHLORIDE	II
P217	23	CHLOROFORM	II
P217	24	2-CHLOROPHENOL	I
P217	31	2,4-DICHLOROPHENOL	I
P217	65	PHENOL	I
P217	86	TOLUENE	II
P217	87	TRICHLOROETHYLENE	II
P217	119	CHROMIUM (TOTAL)	I
P217	122	LEAD (TOTAL)	I
P217	128	ZINC (TOTAL)	I
P219	4	BENZENE	II
P219	7	CHLOROBENZENE	II
P219	25	1,2-DICHLOROBENZENE (O-DICHLO	II
P219	35	2,4-DINITROTOLUENE	II
P219	36	2,6-DINITROTOLUENE	II
P219	44	DICHLOROMETHANE	II
P219	56	NITROBENZENE	II
P219	57	2-NITROPHENOL	II
P219	58	4-NITROPHENOL	II
P219	59	2,4-DINITROPHENOL	II
P219	65	PHENOL	I
P219	86	TOLUENE	II
P219	114	ANTIMONY (TOTAL)	II
P219	115	ARSENIC (TOTAL)	II
P219	118	CADMIUM (TOTAL)	II
P219	119	CHROMIUM (TOTAL)	II
P219	120	COPPER (TOTAL)	II
P219	121	CYANIDE (TOTAL)	I
P219	122	LEAD (TOTAL)	II

TABLE 1. CATEGORY ASSIGNMENTS

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P219	124	NICKEL (TOTAL)	II
P219	125	SELENIUM (TOTAL)	II
P219	128	ZINC (TOTAL)	II
P221	4	BENZENE	II
P221	34	2,4-DIMETHYLPHENOL	II
P221	38	ETHYLBENZENE	II
P221	45	CHLOROMETHANE	II
P221	55	NAPHTHALENE	I
P221	57	2-NITROPHENOL	I
P221	65	PHENOL	I
P221	86	TOLUENE	II
P221	120	COPPER (TOTAL)	I
P223	4	BENZENE	II
P223	57	2-NITROPHENOL	II
P223	58	4-NITROPHENOL	II
P223	64	PENTACHLOROPHENOL	I
P223	65	PHENOL	I
P223	86	TOLUENE	II
P223	119	CHROMIUM (TOTAL)	II
P223	120	COPPER (TOTAL)	II
P223	121	CYANIDE (TOTAL)	I
P223	124	NICKEL (TOTAL)	II
P225	6	CARBON TETRACHLORIDE	I
P225	9	HEXACHLOROBENZENE	I
P225	10	1,2-DICHLOROETHANE	I
P225	12	HEXACHLOROETHANE	I
P225	16	CHLOROETHANE	I
P225	23	CHLOROFORM	I
P225	44	METHYLENE CHLORIDE	II
P225	45	CHLOROMETHANE	II
P225	52	HEXACHLORO-1,3-BUTADIENE	I
P225	66	BIS (2-ETHYLHEXYL) PHTHALATE	I
P225	85	TETRACHLOROETHENE	I
P225	87	TRICHLOROETHENE	I
P225	88	VINYL CHLORIDE	II
P225	115	ARSENIC	II
P225	118	CADMIUM	II
P225	119	CHROMIUM	II
P225	120	COPPER	II
P225	124	NICKEL	II
P225	125	SELENIUM	II
P225	128	ZINC	II
P227	6	CARBON TETRACHLORIDE	I
P227	10	1,2-DICHLOROETHANE	I
P227	12	HEXACHLOROETHANE	I
P227	23	CHLOROFORM	I
P227	30	1,2-TRANSDICHLOROETHYLENE	I
P227	48	DICHLOROBROMOMETHANE	I
P227	52	HEXACHLOROBUTADIENE	I
P227	85	PERCHLOROETHYLENE	I
P227	87	TRICHLOROETHYLENE	I
P227	119	CHROMIUM (TOTAL)	II
P227	120	COPPER (TOTAL)	II
P229	119	CHROMIUM (TOTAL)	II
P229	120	COPPER (TOTAL)	II

TABLE 1. CATEGORY ASSIGNME

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P229	123	MERCURY (TOTAL)	II
P230	3	ACRYLONITRILE	I
P230	4	BENZENE	I
P230	38	ETHYLBENZENE	I
P230	55	NAPHTHALENE	I
P230	65	PHENOL	I
P230	72	BENZO(A)ANTHRACENE	I
P230	76	CHRYSENE	I
P230	78	ANTHRACENE	I
P230	86	TOLUENE	I
P230	119	CHROMIUM	I
P230	128	ZINC	I
P234	3	ACRYLONITRILE	II
P234	7	CHLOROBENZENE	II
P234	10	1,2-DICHLOROETHANE	II
P234	21	2,4,6-TRICHLOROPHENOL	I
P234	23	CHLOROFORM	II
P234	29	VINYLIDENE CHLORIDE	II
P234	38	ETHYLBENZENE	II
P234	44	DICHLOROMETHANE	I
P234	46	BROMOMETHANE	I
P234	48	DICHLOROBROMOMETHANE	I
P234	54	ISOPHORONE	I
P234	59	2,4-DINITROPHENOL	II
P234	65	PHENOL	I
P234	66	BIS-(2-ETHYLHEXYL) PHTHALATE	I
P234	68	DI-N-BUTYL PHTHALATE	I
P234	70	DIETHYL PHTHALATE	I
P234	71	DIMETHYL PHTHALATE	I
P234	86	TOLUENE	II
P236	114	ANTIMONY (TOTAL)	II
P236	121	CYANIDE (TOTAL)	I
P238	38	ETHYLBENZENE	I
P240	4	BENZENE	II
P240	10	1,2-DICHLOROETHANE	II
P240	11	1,1,1-TRICHLOROETHANE	II
P240	23	CHLOROFORM	II
P240	65	PHENOL	I
P240	86	TOLUENE	II
P240	119	CHROMIUM (TOTAL)	I
P240	120	COPPER (TOTAL)	I
P242	38	ETHYLBENZENE	I
P242	65	PHENOL	I
P242	86	TOLUENE	II
P242	119	CHROMIUM (TOTAL)	I
P244	4	BENZENE	II
P244	23	CHLOROFORM	II
P244	38	ETHYLBENZENE	II
P244	44	DICHLOROMETHANE	II
P244	55	NAPHTHALENE	I
P244	65	PHENOL	I
P244	77	ACENAPHTHYLENE	I
P244	80	FLUORENE	I
P244	81	PHENANTHRENE	I
P244	86	TOLUENE	II

TABLE 1. CATEGORY ASSIGNMENTS

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P244	119	CHROMIUM (TOTAL)	I
P244	120	COPPER (TOTAL)	I
P244	128	ZINC (TOTAL)	I
P246A	4	BENZENE	II
P246A	7	CHLOROBENZENE	II
P246A	10	1,2-DICHLOROETHANE	II
P246A	15	1,1,2,2-TETRACHLOROETHANE	II
P246A	16	CHLOROETHANE	II
P246A	25	1,2-DICHLOROBENZENE	II
P246A	27	1,4-DICHLOROBENZENE	II
P246A	35	2,4-DINITROTOLUENE	II
P246A	36	2,6-DINITROTOLUENE	II
P246A	44	METHYLENE CHLORIDE	II
P246A	56	NITROBENZENE	II
P246A	57	2-NITROPHENOL	II
P246A	58	4-NITROPHENOL	II
P246A	59	2,4-DINITROPHENOL	II
P246A	86	TOLUENE	II
P246A	88	VINYL CHLORIDE	II
P246A	119	CHROMIUM	II
P246A	120	COPPER	II
P246A	122	LEAD	II
P246A	124	NICKEL	II
P246A	128	ZINC	II
P246B	4	BENZENE	I
P246B	7	CHLOROBENZENE	I
P246B	10	1,2-DICHLOROETHANE	I
P246B	15	1,1,2,2-TETRACHLOROETHANE	I
P246B	16	CHLOROETHANE	I
P246B	25	1,2-DICHLOROBENZENE	I
P246B	27	1,4-DICHLOROBENZENE	I
P246B	35	2,4-DINITROTOLUENE	I
P246B	36	2,6-DINITROTOLUENE	I
P246B	44	METHYLENE CHLORIDE	I
P246B	56	NITROBENZENE	I
P246B	57	2-NITROPHENOL	I
P246B	58	4-NITROPHENOL	I
P246B	59	2,4-DINITROPHENOL	I
P246B	86	TOLUENE	I
P246B	88	VINYL CHLORIDE	I
P246B	119	CHROMIUM	II
P246B	122	LEAD	II
P246B	124	NICKEL	II
P246B	128	ZINC	II
P248	4	BENZENE	II
P248	57	2-NITROPHENOL	II
P248	65	PHENOL	II
P248	86	TOLUENE	II
P251	4	BENZENE	II
P251	23	CHLOROFORM	I
P251	25	1,2-DICHLOROBENZENE (O-DICHLO	I
P251	38	ETHYLBENZENE	I
P251	39	FLUORANTHENE	I
P251	77	ACENAPHTHYLENE	I
P251	78	ANTHRACENE	I

TABLE 1. CATEGORY ASSIGNMEI

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P251	81	PHENANTHRENE	I
P251	84	PYRENE	I
P251	86	TOLUENE	I
P251	119	CHROMIUM (TOTAL)	I
P251	121	CYANIDE (TOTAL)	I
P251	124	NICKEL (TOTAL)	I
P251	128	ZINC (TOTAL)	I
P253	4	BENZENE	II
P253	13	1,1-DICHLOROETHANE	II
P253	14	1,1,2-TRICHLOROETHANE	II
P253	15	1,1,2,2-TETRACHLOROETHANE	II
P253	23	CHLOROFORM	II
P253	29	VINYLIDENE CHLORIDE	II
P253	32	PROPYLENE CHLORIDE	II
P253	33	1,3-DICHLOROPROPENE	II
P253	38	ETHYLBENZENE	II
P253	44	DICHLOROMETHANE	II
P253	68	DI-N-BUTYL PHTHALATE	I
P253	86	TOLUENE	II
P253	87	TRICHLOROETHYLENE	II
P253	119	CHROMIUM (TOTAL)	I
P253	124	NICKEL (TOTAL)	I
P255	118	CADMIUM (TOTAL)	II
P255	119	CHROMIUM (TOTAL)	II
P255	120	COPPER (TOTAL)	II
P255	122	LEAD (TOTAL)	II
P257	4	BENZENE	II
P257	6	CARBON TETRACHLORIDE	II
P257	10	1,2-DICHLOROETHANE	II
P257	13	1,1-DICHLOROETHANE	II
P257	14	1,1,2-TRICHLOROETHANE	II
P257	15	1,1,2,2-TETRACHLOROETHANE	II
P257	16	CHLOROETHANE	II
P257	23	CHLOROFORM	II
P257	29	VINYLIDENE CHLORIDE	II
P257	30	1,2-TRANSDICHLOROETHYLENE	II
P257	32	PROPYLENE CHLORIDE	II
P257	33	1,3-DICHLOROPROPENE	II
P257	38	ETHYLBENZENE	II
P257	44	DICHLOROMETHANE	II
P257	48	DICHLOROBROMOMETHANE	II
P257	85	PERCHLOROETHYLENE	II
P257	86	TOLUENE	II
P257	87	TRICHLOROETHYLENE	II
P259	4	BENZENE	II
P259	6	CARBON TETRACHLORIDE	II
P259	11	1,1,1-TRICHLOROETHANE	II
P259	13	1,1-DICHLOROETHANE	II
P259	14	1,1,2-TRICHLOROETHANE	II
P259	15	1,1,2,2-TETRACHLOROETHANE	II
P259	16	CHLOROETHANE	II
P259	23	CHLOROFORM	II
P259	29	VINYLIDENE CHLORIDE	II
P259	32	PROPYLENE CHLORIDE	II
P259	34	2,4-DIMETHYLPHENOL	II

TABLE 1. CATEGORY ASSIGNMENTS

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P259	38	ETHYLBENZENE	II
P259	48	DICHLOROBROMOMETHANE	II
P259	55	NAPHTHALENE	I
P259	65	PHENOL	I
P259	86	TOLUENE	II
P259	119	CHROMIUM (TOTAL)	I
P259	120	COPPER (TOTAL)	I
P259	122	LEAD (TOTAL)	I
P259	128	ZINC (TOTAL)	I
P263	44	DICHLOROMETHANE	II
P263	119	CHROMIUM (TOTAL)	I
P265	1	ACENAPHTHENE	I
P265	3	ACRYLONITRILE	II
P265	4	BENZENE	II
P265	34	2,4-DIMETHYLPHENOL	I
P265	39	FLUORANTHENE	I
P265	44	DICHLOROMETHANE	II
P265	65	PHENOL	I
P265	72	BENZO(A)ANTHRACENE	I
P265	76	CHRYSENE	I
P265	77	ACENAPHTHYLENE	I
P265	78	ANTHRACENE	I
P265	81	PHENANTHRENE	I
P265	84	PYRENE	I
P265	86	TOLUENE	II
P265	115	ARSENIC (TOTAL)	I
P265	119	CHROMIUM (TOTAL)	I
P265	121	CYANIDE (TOTAL)	I
P265	123	MERCURY (TOTAL)	I
P265	125	SELENIUM (TOTAL)	I
P267	59	2,4-DINITROPHENOL	I
P267	119	CHROMIUM	I
P267	120	COPPER	I
P267	124	NICKEL	I
P267	128	ZINC	I
P274	119	CHROMIUM (TOTAL)	I
P274	124	NICKEL (TOTAL)	I
P274	128	ZINC (TOTAL)	I
P276	2	ACROLEIN	II
P276	3	ACRYLONITRILE	II
P276	88	CHLOROETHYLENE	II
P276	119	CHROMIUM (TOTAL)	II
P276	122	LEAD (TOTAL)	II
P280	10	1,2-DICHLOROETHANE	III
P280	18	BIS(2-CHLOROETHYL)ETHER	III
P280	25	1,2-DICHLOROBENZENE	III
P280	32	1,2-DICHLOROPROPANE	III
P280	34	2,4-DIMETHYLPHENOL	III
P280	55	NAPHTHALENE	III
P280	65	PHENOL	II
P280	85	TETRACHLOROETHENE	III
P280	86	TOLUENE	III
P280	115	ARSENIC	III
P280	120	COPPER	I
P280	123	MERCURY	I

TABLE 1. CATEGORY ASSIGNMEN..

PLANT	CHEMICAL NUMBER	CHEMICAL	CATEGORY
P280	128	ZINC	I
P282	65	PHENOL	II
P282	86	TOLUENE	II
P282	115	ARSENIC (TOTAL)	II
P282	119	CHROMIUM (TOTAL)	I
P282	120	COPPER (TOTAL)	I
P282	121	CYANIDE (TOTAL)	I
P282	128	ZINC (TOTAL)	I
P284	10	1,2-DICHLOROETHANE	II
P284	21	2,4,6-TRICHLOROPHENOL	I
P284	23	CHLOROFORM	II
P284	42	BIS (2-CHLOROISOPROPYL) ETHER	I
P284	44	METHYLENE CHLORIDE	II
P284	64	PENTACHLOROPHENOL	I
P284	124	NICKEL	I
P284	128	ZINC	I
P286	64	PENTACHLOROPHENOL	I
P286	65	PHENOL	I
P286	86	TOLUENE	I
P286	122	LEAD (TOTAL)	I
P286	128	ZINC (TOTAL)	I
P289	8	1,2,4-TRICHLOROBENZENE	I
P289	21	2,4,6-TRICHLOROPHENOL	I
P289	24	2-CHLOROPHENOL	I
P289	25	1,2-DICHLOROBENZENE (O-DICHLO	I
P289	31	2,4-DICHLOROPHENOL	I
P289	64	PENTACHLOROPHENOL	I
P289	65	PHENOL	I
P293	3	ACRYLONITRILE	I
P293	38	ETHYLBENZENE	I
P293	66	BIS-(2-ETHYLHEXYL) PHTHALATE	I
P293	121	CYANIDE (TOTAL)	I
P295	3	ACRYLONITRILE	II
P295	42	BIS-(2-CHLOROISOPROPYL) ETHER	I
P295	65	PHENOL	I
P295	66	BIS-(2-ETHYLHEXYL) PHTHALATE	I
P295	68	DI-N-BUTYL PHTHALATE	I
P295	70	DIETHYL PHTHALATE	I
P295	71	DIMETHYL PHTHALATE	I
P295	119	CHROMIUM (TOTAL)	II
P295	120	COPPER (TOTAL)	II
P297	4	BENZENE	II
P297	35	2,4-DINITROTOLUENE	II
P297	56	NITROBENZENE	II
P297	57	2-NITROPHENOL	II
P297	58	4-NITROPHENOL	II
P297	60	2-METHYL-4,6-DINITROPHENOL	II
P299	3	ACRYLONITRILE	I
P299	65	PHENOL	I
P299	114	ANTIMONY	I
P299	120	COPPER	I
P299	128	ZINC	I

not have an effluent sampling point, they were indirect dischargers with only their discharge points being sampled, no combined raw waste sampling point was available or they were zero dischargers with only their discharge points being sampled.

Next, analytically suspect data were either removed from the data base completely or returned to the analytical laboratories for confirmation or correction. This involved the deletion of all organic priority pollutant data from five verification plants because the analyses were performed using the GC-CD/blind spike analytical method without GC-MS confirmation of the results. Also, one of the current 12 plant sampling study facilities had all organic priority pollutant data eliminated from the data base because the analytical laboratory did not adhere to the analytical protocols.

If influent plant-pollutant concentrations were reported as nondetect then both the influent and corresponding effluent data pair were eliminated from the analysis.

The current 12-plant sampling priority pollutant analytical data were edited based on the following criteria:

- End-of-pipe influent and effluent data for both organic and heavy metal priority pollutants were edited and returned to the analytical laboratories for confirmation or correction if the detection limits were greater than 100 ppb and 50 ppb in the influent and effluent, respectively.

- In-plant control technology influent and effluent data were edited and returned to the analytical laboratories for confirmation or correction if the detection limits were greater than 1,000 ppb and 100 ppb in the respective influents and effluents for steam stripping; greater than 20 ppb in both the influents and effluents for carbon adsorption; and greater than 100 ppb and 50 ppb in the respective influents and effluents for chemical precipitation.

- Sampling point duplicates with widely divergent results were both removed from the data base and returned to the analytical laboratories for confirmation or correction.

After analytical editing of the data was performed, the remaining effluent data points with duplicate sampling dates were matched and averaged

to provide a single value for the date. Then, influent and effluent data were matched by sample date and nonmatching influent and effluent data points were excluded from the analysis. Influent-effluent matching pairs were examined and pairs with negative percent removals were excluded, too. However, it should be noted that there are a number of reasons for the presence of non-matching influent-effluent pairs and the occurrence of negative percent removals including analytical laboratory problems, analytical editing of the data and treatment system retention time lags between sampling points which may allow the inclusion of some of these data in the analysis prior to promulgation if the analytical laboratories can confirm or correct these data and if treatment system retention time can be accommodated.

After these general edits were performed, a more detailed point-by-point technical edit was performed. Table 2 presents the data points which were removed based on technical considerations and the reason for each edit. In general, data points were removed if treatment system upset conditions existed at a plant for any period of time, if single data points of high concentration appeared during a long sampling period with no other reappearance or if certain pollutants were determined to be present at a certain plant because of misidentification or analytical laboratory problems based on that plant's product mix.

It should be noted that certain plants have been sampled in more than one of the BAT sampling programs previously mentioned. For the purposes of calculating plant LTAs and industry LTMs, each sampling program at a particular plant was treated separately and had individual LTAs which are included in the calculation of the LTM for each pollutant (i.e., it is possible that LTAs have been calculated for both the verification and CMA sampling programs for a particular pollutant at a certain plant). This decision was made due to difference in time periods of each sampling program, the different analytical procedures employed, the possibility of changes in product mix and processes utilized during each time period and the fact that different sets of priority pollutants may have been analyzed for the same plant during different sampling program efforts.

TABLE 2

PLANT-POLLUTANT DATA COMBINATIONS REMOVED BASED ON TECHNICAL EDITS

PLANT	POLLUTANT(S)	REASON
P246A	56	Aniline spill at the plant left residual quantities of nitrobenzene in the carbon columns which leached out during the sampling period. All nitrobenzene data for the sampling period deleted.
P206	4 7 10 23 86	Malfunction of in-plant chemical oxidation units caused elevated levels of these pollutants in the raw waste to the end-of-pipe biological system which passed through to the final effluent. All data for these pollutants for the entire sampling period were deleted.
P230	13 20 35 37 68 70	These pollutants were determined to be present at this plant because of misidentification or analytical laboratory problems, since the product/processes at this plant would not produce these pollutants. All data for these pollutants were deleted.
P202	62	This pollutant was misidentified and later confirmed as acetone. All data for this pollutant were deleted.
P297	56 (4/01/84)	This data point was deleted because it was two orders of magnitude higher than all other effluent data points.
P297	59 (3/25/84)	Only effluent value above the detect limit (20 ppb). Since it was two orders of magnitude above all other values, it was deleted.
P263	7	Treatment efficiency for this pollutant was much lower than other pollutants at this plant which should treat similarly. All data for this pollutant were deleted pending closer exaimination of the field sampling logs.
P253	10	Same as preceeding.
P227	88	Same reason as for above two plants and pollutants.

TABLE 2

PLANT-POLLUTANT DATA COMBINATIONS REMOVED BASED ON TECHNICAL EDITS
(CONCLUDED)

PLANT	POLLUTANT(S)	REASON
P217	21	Only two influent-effluent pairs for this plant show 100% removal and 3.7% removal. Since these results were so divergent, both pairs were deleted from the analysis.
P297	114-128	Since the treatment system consists of only steam stripping and activated carbon, metals removals were considered to be misleading, so all metals data were deleted.
P248	114-128	Same as for preceeding entry.

6. CALCULATION OF THE MEDIAN OF LONG-TERM MEANS

For each pollutant at each plant in each of the sampling efforts mentioned above, a long-term weighted average (LTA) effluent concentration was calculated using only effluent data points whose corresponding end-of-pipe influent data were greater than or equal to 20 ppb or to 100 ppb depending on the type of technology used to remove a pollutant at a particular plant. For plants using in-plant controls prior to discharge to the end-of-pipe treatment system, the 20 ppb level was selected for the treated pollutants; for other pollutants, the 100 ppb level was used. These edits were designed to retain in the calculation of the limit for that pollutant only those plants that had treatable levels of a pollutant in the raw waste. The nondetected values at the plant were assigned a nominal detection limit value using detection limits associated with EPA analytical methods 1624 and 1625. The long-term weighted average was computed by a weighting scheme, which assumed that nondetected values should be assigned a relative weight in accordance with the frequency with which nondetected values for the pollutant generally were found in the daily-data plants. Long-term weighted averages are calculated for each plant-pollutant combination from the previous five-plant long-term study, the recent twelve-plant sampling study, and the verification sampling study. The long-term weighted average, m, for a plant-pollutant combination is as follows:

$$m = pD + (1-p)\frac{\sum_{i=1}^{n} Xi}{n}$$

where D is the nominal analytical method detection limit, n is the number of values that Xi is detected, and p is then the proportion of nondetect values reported from the daily data base. That is, p equals the total number of reported nondetect values from all daily data plants for a particular pollutant divided by the total number of values reported from all daily data plants for a particular pollutant. For plant-pollutant combinations with all nondetected values, the long-term average, m, equals the nominal analytical method detection limit. For plant-pollutant combinations where all values are detected, the long-term average is the arithemetic mean of all values.

Then, the median of the plants' long-term weighted averages was calculated for each pollutant. Because data were limited for certain pollutants, pollutant medians were retained for further analysis only if at least one plant-pollutant combination had three or more influent/effluent data pairs. Table 3 lists the pollutants which were eliminated based on this criterion.

7. CALCULATION OF DAILY MAXIMUM AND FOUR DAY VARIABILITY FACTORS

After developing long-term medians for each pollutant, EPA proceeded to develop two variability factors for each pollutant--a daily maximum variability factor (VF1) and a four-day variability factor (VF4). These were developed by fitting a statistical distribution to the daily data for each pollutant at each plant; deriving a 99th percentile and a mean of the daily data distributions for each pollutant at each plant; deriving a 95th percentile and a mean of the distribution of 4-day averages for each pollutant at each plant; dividing the 99th and 95th percentiles by the respective means of daily and 4-day average distributions to derive plant-specific variability factors for each pollutant; and averaging these plant-specific variability factors across all plants to derive VF1 and VF4 for each pollutant.

For certain pollutants, the amount of daily data was limited. For such pollutants, variability factors were interpolated from the variability factors for groups of pollutants expected to exhibit comparable treatment variability based upon comparison of chemical structure and characteristics. Table 4 presents these groups and the pollutants contained in each group. Each pollutant in each chemical group was then assigned a VF1 and VF4 equal to the average of the VF1s and VF4s of any pollutants in the same group.

In response to comments on the statistical aspects of the proposed limitations development, several statistical techniques were investigated for deriving limitations. This investigation found that a modification of the delta-lognormal procedures provides a reasonable approximation of the underlying empirical toxic pollutant data. The delta-lognormal distribution assumes that data are a mixture of positive lognormally distributed values and

TABLE 3

DATA DELETIONS BASED ON ONLY ONE PLANT-POLLUTANT COMBINATION

PLANT	POLLUTANT
P276	2
P257	13
P253	13
P259	13
P257	15
P259	15
P253	15
P246A	15
P280	18
P234	46
P234	54
P208	75
P255	118
P225	118

TABLE 4

PRIORITY POLLUTANT GROUPS

1. Halogenated Methanes (Cl's)

46	Methyl bromide
45	Methyl chloride
44	Methylene chloride (dichloromethane)
47	Bromoform (tribromomethane)
23	Chloroform (trichloromethane)
48	Bromodichloromethane
51	Dibromochloromethane
50	Dichlorodifluoromethane
49	Trichlorofluoromethane
6	Carbon tetrachloride (tetrachloromethane)

2. Chlorinated C2's

16	Chloroethane (ethyl chloride)
88	Chloroethylene (vinyl chloride)
10	1,2-Dichloroethane (ethylene dichloride)
13	1,1-Dichloroethane
30	1,2-trans-Dichloroethylene
29	1,1-Dichloroethylene (vinylidene chloride)
14	1,1,2-Trichloroethane
11	1,1,1-Trichloroethane (methyl chloroform)
87	Trichloroethylene
85	Tetrachloroethylene
15	1,1,2,2-Tetrachloroethane
12	Hexachloroethane

3. Chlorinated C3's

32	1,2-Dichloropropane
33	1,3-Dichloropropylene

4. Chlorinated C4

52	Hexachlorobutadiene

5. Chlorinated C5

53	Hexachlorocylopentadiene

NOTES: (1) Numbers refer to a published alphabetical listing of the priority pollutants.

REFERENCE: Wise, H.E., and P.O. Fahrenthold (1981). Occurrence and Predictability of Priority Pollutants in Wastewaters of the Organic Chemicals and Plastics/Synthetic Fibers Industrial Categories, USEPA, 1981.

TABLE 4

PRIORITY POLLUTANT GROUPS
(Continued)

6. Chloroalkyl Ethers

17	bis(chloromethyl)ether
18	bis(2-chloroethyl)ether
42	bis(2-chloroisopropyl)ether
19	2-chloroethylvinyl ether
43	bis(2-chloroethoxy) methane

7. Metals

114	Antimony
115	Arsenic
117	Beryllium
118	Cadmium
119	Chromium
120	Copper
122	Lead
123	Mercury
124	Nickel
125	Selenium
126	Silver
127	Thallium
128	Zinc

8. Pesticides

89	Aldrin
90	Dieldrin
91	Chlordane
95	alpha-Endosulfan
98	Endrin
99	Endrin aldehyde
100	Heptachlor
101	Heptachlor epoxide
102	alpha-BHC
103	beta-BHC
104	gamma-BHC (Lindane)
105	delta-BHC
92	4,4'-DDT
93	4,4'-DDE (p,p'-DDx)
94	4,4'-DDD (p,p'-TDE)
113	Toxaphene

9. Nitrosamines

61	N-Nitrosodimethyl amine
62	N-Nitrosodiphenyl amine
63	N-Nitrosodi-n-propyl amine

TABLE 4

PRIORITY POLLUTANT GROUPS
(Continued)

10.	Miscellaneous	
	2	Acrolein
	3	Acrylonitrile
	54	Isophorone
	121	Cyanide
11.	Aromatics	
	4	Benzene
	86	Toluene
	38	Ethylbenzene
12.	Polyaromatics	
	55	Naphthalene
	1	Acenaphthene
	77	Acenaphthylene
	78	Anthracene
	72	Benzo(a)anthracene (1,2-benzanthracene)
	73	Benzo(a)pyrene (e,4-benzopyrene)
	74	3,4-Benzofluoranthene
	75	Benzo(k)fluoranthene (11,12-benzofluoranthene)
	79	Benzo(ghi)perylene (1,12-benzoperylene)
	76	Chrysene
	82	Dibenzo(a,h)anthracene (1,2,5,6-dibenzanthracene)
	80	Fluorene
	39	Fluoranthene
	83	Indeno(1,2,3-cd)pyrene (2,3-o-Phenylene pyrene)
	81	Phenanthrene
	84	Pyrene
13.	Chloroaromatics	
	7	Chlorobenzene
	25	o-Dichlorobenzene
	27	p-Dichlorobenzene
	26	m-Dichlorobenzene
	8	1,2,4-Trichlorobenzene
	9	Hexachlorobenzene
14.	Chlorinated Polyaromatic	
	20	2-Chloronaphthalene
15.	Polychlorinated Biphenyls	
	106-112	Seven listed

TABLE 4

PRIORITY POLLUTANT GROUPS
(Concluded)

16. Phthalate Esters

66	bis(2-Ethylhexyl)
67	Butylbenzyl
68	Di-n-butyl
69	Di-n-octyl
70	Diethyl
71	Dimethyl

17. Nitroaromatics

56	Nitrobenzene
35	2,4-Dinitrotoluene
36	2,6-Dinitrotoluene

18. Benzidines

8	Benzidine
28	3,3'-Dichlorobenzidine
37	1,2-Diphenylhydrazine

19. Phenols

65	Phenol
34	2,4-Dimethylphenol

20. Nitrophenols

57	2-Nitrophenol
58	4-Nitrophenol
59	2,4-Dinitrophenol
60	4,6-Dinitro-o-cresol

21. Chlorophenols

24	2-Chlorophenol
22	4-Chloro-m-cresol
31	2,4-Dichlorophenol
21	2,4,6-Trichlorophenol
64	Pentachlorophenol

22. 144 TCDD (2,3,7,8-Tetrachloro-dibenzo-p-dioxin)

23. Haloaryl Ethers

40	4-Chlorophenylphenyl ether
41	4-Bromophynylphynyl ether

zero values that occur with a definite probability. Consequently, zero concentration values are modeled by a point distribution, positive concentration values follow a lognormal distribution, and the mixture of these values forms the delta-lognormal distribution. The statistical metholodgy used for testing the assumption of lognormality is found in Appendix B of the BPT Section, and the results of these hypothesis tests are also included in this Appendix.

This method provides a reasonable approach for combining quantitative concentration values with information expressed only as a nondetect, which is more qualitative in nature. For the determination of variability factors, the delta-lognormal procedure was modified by placing the point distribution at the nominal detection limit. This approach is somewhat conservative since values reported as nondetect may actually be any value between zero and the detection limit. The detection limits used for each pollutant was the nominal detection limit in EPA Analytical Methods 1624 and 1625. Assigning a nominal detection limit to non-detected values in calculating both variability factors and long-term medians for this data base tends to result in slightly higher limitations than would be derived if lower values were assumed.

8. CALCULATION OF BAT EFFLUENT LIMITATIONS

Daily maximum and four day monthly average BAT effluent limitations were calculated for each pollutant by multiplying its long-term median value by each of its two corresponding variability factors. If a pollutant had its own pair of variability factors, these were utilized rather than the pollutant group variability factors. With the exception of mercury, all priority pollutant four-day monthly average and daily maximum limitations were rounded up to the nearest 5 parts per billion. Mercury was rounded up to the nearest one-half part per billion. After rounding, if the four-day monthly average equaled the daily maximum value, then only the daily maximum limitation was listed. It should be noted that for the volatile priority pollutant bis(2-chloroisopropyl)ether, data were not available for an appropriate Option II and III treatment system. Therefore, a treatability level for bis(2-chloroisopropyl)ether of 10 ppb was selected based on the performance of steam stripping. The treatability level was determined using the methodology described later in this report for establishing in-plant, pre-biological limitations.

Since insufficient data were available to determine BAT Option I Chlorinated C1, C2, and C4 pollutant variability factors, the Chloroalkyl Ether variability factor was applied to these pollutants. For BAT Option II, the average of the variability factors for the Chlorinated C1 and C2 pollutant groups was applied to the Chlorinated C3, C4, and Chloroalkyl Ether pollutant groups. For BAT Option III, the average variability factors for the Chlorinated C1, C2, and C3 pollutant groups was applied to Chlorinated C4 and Chloroalkyl Ether groups as well. Since insufficient data were available to determine variability factors for acrylonitrile (miscellaneous pollutant group) the average of all organic pollutant groups for each option was applied to acrylonitrile.

The BAT effluent limitations for Options I, II, and III are presented in Tables 5 through 7, respectively. Derivation of the BAT statistical methodology is presented in Appendix A.

9. DEVELOPMENT OF IN-PLANT PRE-BIOLOGICAL BAT LIMITATIONS

In addition to the end-of-pipe limitations set forth above, in-plant prebiological limitations are being considered for a set of 20 volatile and semivolatile organic pollutants. The purpose of these supplementary limitations would be to assure that these pollutants are not simply transferred to the air rather than treated by the wastewater treatment system. Table 8 lists the pollutants selected for in-plant control along with their estimated air emission rates (percent air stripped) through open biological treatment systems. Supporting information and data for the determination of these air stripping figures are listed in Appendix B and available in the public record.

BAT effluent limitations would be established prior to biological treatment and would require that control authorities require compliance monitoring prior to the biological system. These in-plant limitations would be based upon the available in-plant stream stripping performance data. For the steam stripping assessment, the organic priority pollutants were divided into three groups (high, medium, and low) based on their Henry's Law Constants. For aqueous mixtures, the distribution of a pollutant between the

TABLE 5

OPTION I BAT EFFLUENT LIMITATIONS (ppb)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Halogenated Methanes (Cl's)			
6. Carbon tetrachloride	10	20	50
23. Chloroform	10	20	50
44. Methylene chloride	11.1	25	55
47. Bromoform	10	20	50
Chlorinated C2's			
10. 1,2-Dichloroethane	10.3	25	50
12. Hexachloroethane	10	20	50
16. Chloroethane	50	100	245
30. 1,2-trans-Dichloroethylene	77.5	155	375
85. Tetrachloroethylene	118.9	235	575
Chlorinated C4's			
52. Hexachlorobutadiene	10	20	50
Chloroalkyl Ethers			
42. bis(2-chloroisopropyl)ether	1,463	2,860	7,035
Metals			
114. Antimony	65	85	125
115. Arsenic	17	30	60
119. Chromium	86.7	120	195
120. Copper	21.3	35	75
122. Lead	329	860	2,585
123. Mercury	0.2	—	0.5
124. Nickel	145	235	495
125. Selenium	12	20	45
128. Zinc	52.5	90	190

TABLE 5

OPTION I BAT EFFLUENT LIMITATIONS (ppb)
(Continued)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Miscellaneous			
3. Acrylonitrile	50	105	270
121. Cyanide	64.9	120	275
Aromatics			
4. Benzene	27.1	80	245
38. Ethylbenzene	10	35	125
86. Toluene	10	40	155
Polyaromatics			
1. Acenaphthene	10	35	105
39. Fluoranthene	13.2	45	140
55. Naphthalene	10	35	105
72. Benzo(a)anthracene	10	35	105
73. Benzo(a)pyrene	10	35	105
74. 3,4-Benzofluoranthene	10	35	105
76. Chrysene	10	35	105
77. Acenaphthylene	10	35	105
78. Anthracene	10	35	105
80. Fluorene	10	35	105
81. Phenanthrene	10	35	105
84. Pyrene	12.6	40	135
Chloroaromatics			
7. Chlorobenzene	23.1	65	185
8. 1,2,4-Trichlorobenzene	42.8	70	140
9. Hexachlorobenzene	10	20	40
25. o-Dichlorobenzene	23.9	40	75
26. m-Dichlorobenzene	21.3	25	35
27. p-Dichlorobenzene	10	20	40
Phthalate Esters			
66. bis(2-Ethylhexyl)phthalate	19.6	45	130
68. Di-n-butyl phthalate	22.2	40	80
70. Diethyl phthalate	44.4	90	215
71. Dimethyl phthalate	10	20	50

TABLE 5

OPTION I BAT EFFLUENT LIMITATIONS (ppb)
(Concluded)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Nitroaromatics			
35. 2,4-Dinitrotoluene	952	1,360	2,450
36. 2,6-Dinitrotoluene	327	445	730
56. Nitrobenzene	351	950	2,965
Benzidines			
28. 3,3'-Dichlorobenzidine	262	320	450
Phenols			
34. 2,4-Dimethylphenol	10	20	35
65. Phenol	10	20	35
Nitrophenols			
57. 2-Nitrophenol	40.7	60	95
58. 4-Nitrophenol	50	75	125
59. 2,4-dinitrophenol	102	150	260
Chlorophenols			
21. 2,4,6-Trichlorophenol	65.9	115	260
24. 2-chlorophenol	10	35	125
31. 2,4-Dichlorophenol	16.9	45	130
64. Pentachlorophenol	50	65	100

TABLE 6

OPTION II BAT EFFLUENT LIMITATIONS (ppb)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Halogenated Methanes (Cl's)			
6. Carbon tetrachloride	10	15	30
23. Chloroform	10	20	40
44. Methylene chloride	10	15	20
45. Methyl chloride	50	75	130
47. Bromoform	10	15	30
48. Bromodichloromethane	10	15	30
Chlorinated C2's			
10. 1,2-Dichloroethane	13.4	35	95
11. 1,1,1-Trichloroethane	10	25	65
12. Hexachloroethane	10	25	65
14. 1,1,2-Trichloroethane	10	25	65
16. Chloroethane	50	115	315
29. 1,1-Dichloroethylene	10	25	65
30. 1,2-trans-Dichloroethylene	10	25	65
85. Tetrachloroethylene	10.7	25	65
87. Trichloroethylene	10	25	65
88. Vinyl chloride	10	25	65
Chlorinated C3's			
32. 1,2-Dichloropropane	59.4	110	265
33. 1,3-Dichloropropylene	36.9	70	165
Chlorinated C4's			
52. Hexachlorobutadiene	10	20	45
Chloroalkyl Ethers			
42. bis(2-chloroisopropyl)ether	10	20	45

TABLE 6

OPTION II BAT EFFLUENT LIMITATIONS (ppb)
(Continued)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Metals			
114. Antimony	158	200	305
115. Arsenic	25.1	50	115
119. Chromium	64.5	90	150
120. Copper	27.7	45	90
122. Lead	100	265	785
123. Mercury	2.03	2.5	3.0
124. Nickel	166	195	255
125. Selenium	12	20	40
128. Zinc	69.5	105	190
Miscellaneous			
3. Acrylonitrile	50	100	250
121. Cyanide	64.9	120	275
Aromatics			
4. Benzene	10	30	85
38. Ethylbenzene	10	30	100
86. Toluene	10	35	115
Polyaromatics			
1. Acenaphthene	10	35	105
39. Fluoranthene	13.2	45	140
55. Naphthalene	10	35	105
72. Benzo(a)anthracene	10	35	105
73. Benzo(a)pyrene	10	35	105
74. 3,4-Benzofluoranthene	10	35	105
76. Chrysene	10	35	105
77. Acenaphthylene	10	35	105
78. Anthracene	10	35	105
80. Fluorene	10	35	105
81. Phenanthrene	10	35	105
84. Pyrene	12.6	40	135

TABLE 6

OPTION II BAT EFFLUENT LIMITATIONS (ppb)
(Continued)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Chloroaromatics			
7. Chlorobenzene	15.9	40	115
8. 1,2,4-Trichlorobenzene	26.4	45	90
9. Hexachlorobenzene	10	20	40
25. o-Dichlorobenzene	52.3	80	145
26. m-Dichlorobenzene	21.3	25	35
27. p-Dichlorobenzene	10	20	40
Phthalate Esters			
66. bis(2-Ethylhexyl)phthalate	19.6	45	130
68. Di-n-butyl phthalate	22.2	40	80
70. Diethyl phthalate	44.4	90	215
71. Dimethyl phthalate	10	20	50
Nitroaromatics			
35. 2,4-Dinitrotoluene	219	310	540
36. 2,6-Dinitrotoluene	255	340	555
56. Nitrobenzene	206	285	480
Benzidines			
28. 3,3'-Dichlorobenzidine	262	320	450
Phenols			
34. 2,4-Dimethylphenol	10.6	20	35
65. Phenol	10	20	35
Nitrophenols			
57. 2-Nitrophenol	24.0	35	55
58. 4-Nitrophenol	50	70	120
59. 2,4-dinitrophenol	50	75	130
60. 4,6-Dinitro-o-cresol	20	30	50

TABLE 6

OPTION II BAT EFFLUENT LIMITATIONS (ppb)
(Concluded)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Chlorophenols			
21. 2,4,6-Trichlorophenol	65.9	115	260
24. 2-chlorophenol	10	35	125
31. 2,4-Dichlorophenol	16.9	45	130
64. Pentachlorophenol	50	65	100

TABLE 7

OPTION III BAT EFFLUENT LIMITATIONS (ppb)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Halogenated Methanes (C1's)			
6. Carbon tetrachloride	10	15	30
23. Chloroform	10	20	40
44. Methylene chloride	10	15	20
45. Methyl chloride	50	75	130
47. Bromoform	10	15	30
48. Bromodichloromethane	10	15	30
Chlorinated C2's			
10. 1,2-Dichloroethane	13	30	85
11. 1,1,1-Trichloroethane	10	25	65
12. Hexachloroethane	10	25	65
14. 1,1,2-Trichloroethane	10	25	65
16. Chloroethane	50	115	315
29. 1,1-Dichloroethylene	10	25	65
30. 1,2-trans-Dichloroethylene	10	25	65
85. Tetrachloroethylene	10.2	25	65
87. Trichloroethylene	10	25	65
88. Vinyl chloride	10	25	65
Chlorinated C3's			
32. 1,2-Dichloropropane	36.1	50	70
33. 1,3-Dichloropropylene	36.9	50	70
Chlorinated C4's			
52. Hexachlorobutadiene	10	20	40
Chloroalkyl Ethers			
42. bis(2-chloroisopropyl)ether	10	20	40

TABLE 7

OPTION III BAT EFFLUENT LIMITATIONS (ppb)
(Continued)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Metals			
114. Antimony	158	200	305
115. Arsenic	25	40	80
119. Chromium	57.6	80	130
120. Copper	27.7	45	90
122. Lead	86.7	230	680
123. Mercury	2.03	2.5	3.0
124. Nickel	145	170	225
125. Selenium	12	20	40
128. Zinc	66.1	100	190
Miscellaneous			
3. Acrylonitrile	50	95	235
121. Cyanide	64.9	120	275
Aromatics			
4. Benzene	10	25	80
38. Ethylbenzene	10	30	90
86. Toluene	10	30	100
Polyaromatics			
1. Acenaphthene	10	35	105
39. Fluoranthene	13.2	45	140
55. Naphthalene	10	35	105
72. Benzo(a)anthracene	10	35	105
73. Benzo(a)pyrene	10	35	105
74. 3,4-Benzofluoranthene	10	35	105
76. Chrysene	10	35	105
77. Acenaphthylene	10	35	105
78. Anthracene	10	35	105
80. Fluorene	10	35	105
81. Phenanthrene	10	35	105
84. Pyrene	12.6	40	135

TABLE 7

OPTION III BAT EFFLUENT LIMITATIONS (ppb)
(Continued)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Chloroaromatics			
7. Chlorobenzene	11.3	25	70
8. 1,2,4-Trichlorobenzene	26.4	45	90
9. Hexachlorobenzene	10	20	35
25. o-Dichlorobenzene	23.8	40	70
26. m-Dichlorobenzene	21.3	25	35
27. p-Dichlorobenzene	10	20	35
Phthalate Esters			
66. bis(2-Ethylhexyl)phthalate	19.6	45	130
68. Di-n-butyl phthalate	22.2	40	80
70. Diethyl phthalate	44.4	90	215
71. Dimethyl phthalate	10	20	50
Nitroaromatics			
35. 2,4-Dinitrotoluene	108	150	255
36. 2,6-Dinitrotoluene	217	285	455
56. Nitrobenzene	206	285	480
Benzidines			
28. 3,3'-Dichlorobenzidine	262	320	450
Phenols			
34. 2,4-Dimethylphenol	11.1	20	40
65. Phenol	10	20	35
Nitrophenols			
57. 2-Nitrophenol	22.6	30	50
58. 4-Nitrophenol	50	70	120
59. 2,4-dinitrophenol	50	75	130
60. 4,6-Dinitro-o-cresol	20	30	50

TABLE 7

OPTION III BAT EFFLUENT LIMITATIONS (ppb)
(Concluded)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Chlorophenols			
21. 2,4,6-Trichlorophenol	65.9	115	260
24. 2-chlorophenol	10	35	125
31. 2,4-Dichlorophenol	16.9	45	130
64. Pentachlorophenol	50	65	100

TABLE 8

VOLATILE AND SEMI-VOLATILE POLLUTANTS AND AIR STRIPPING ESTIMATES (PERCENT) THROUGH OPEN BIOLOGICAL TREATMENT SYSTEMS

Benzene	85
Carbon tetrachloride	60
Chlorobenzene	80
1,1,1-Trichloroethane	95
Chloroform	35
Toluene	85
1,1-Dichloroethylene	45
1,2-Trans-Dichloroethylene	70
Trichloroethylene	40
Tetrachloroethylene	95
Hexachloroethane	25
1,3-Dichlorobenzène	20
1,4-Dichlorobenzene	20
1,2-Dichloroethane	35
1,1,2-Trichloroethane	40
Methylene Chloride	55
1,2-Dichloropropane	90
1,2-Dichlorobenzene	20
Hexachlorobenzene	25
Vinyl chloride	75

vapor phase and water can be expressed by Henry's Law. Compounds with high vapor pressures (high Henry's Law constants) are easily stripped. By assuming that compounds in each group behave similarly, group median effluent values were calculated--a median of 11.7 ppb represents the high stripping group; nondetect represents the medium stripping group; and 1417.5 ppb, for the low stripping group. Table 9 presents the pollutants that are contained in each of these groups and the average steam stripping effluent values for the pollutants with data are noted.

The BAT in-plant limitations for Options II and III are listed in Table 10.

TABLE 9

HENRY'S CONSTANT STRIPPABILITY GROUPS
WITH AVERAGE STEAM STRIPPING EFFLUENT VALUES (ppb)

HIGH (3×10^{2} to 10^{-1})	MEDIUM (10^{-2} to 10^{-3})	LOW (10^{-4} to 10^{-8})
Benzene - 16.1	Acenaphthene	Bis(2-Chloroethyl)Ether
Carbon Tetrachloride	Acrolein	2-Chloroethyl Vinyl Ether
Chlorobenzene	Acrylonitrile	Bis(2-Chloroethoxy)Methane
1,1,1-Trichloroethane	1,2-Dichloroethane - 12	Nitrobenzene
Chloroethane - ND	Hexachloroethane	2,4-Dinitrotoluene
1,1-Dichloroethane	1,1,2-Trichloroethane-ND	2,6-Dinitrotoluene
Chloroform - ND	1,1,2,2-Tetrachloroethane	Phenol
Methyl Chloride - ND	Methylene Chloride - ND	2-Chlorophenol
Toluene	1,2-Dichloropropane	2,4-Dichlorophenol
Vinyl Chloride - 76	1,3-Dichloropropene	2,4,6-Trichlorophenol-1051
1,1-Dichloroethene- ND	Dibromochloromethane	Pentachlorophenol - 1784
1,2-Trans-Dichloroethene 14.36	Tribromomethane	2-Nitrophenol
Trichloroethylene-13.4	Bis(2-Chloromethyl)Ether	2,4-Dinitrophenol
Tetrachloroethylene	Bis(2-Chloroisopropyl) Ether	2,4-Dimethylphenol
Hexachloro-1,3-Butadiene	4-Chlorophenyl Phenyl Ether	p-Chloro-m-Cresol
Hexachlorocyclopentadiene	4-Bromophenyl Phenyl Ether	Dimethyl Phthalate
Bromomethane	1,2-Dichlorobenzene	Diethyl Phthalate
Bromodichloromethane	1,2,4-Trichlorobenzene	Di-n-Butyl Phthalate
Dichlorodifluoromethane	Hexachlorobenzene	Di-n-Octyl Phthalate
Trichlorofluoromethane	4-Nitrophenol	Bis(2-Ethylhexyl)Phthalate
1,3-Dichlorobenzene	4,6-Dinitro-o-Cresol	Butyl Benzyl Phthalate
1,4-Dichlorobenzene	Acenaphthylene	Benzo(a)Anthracene
Ethylbenzene	Anthracene	Benzo(b)Fluoranthene
	Benzo(k)Fluoranthene	Benzo(ghi)Perylene
Group	Fluorene	Benzo(a)Pyrene
Median = 11.7 ppb	Naphthalene	Chrysene
	Phenanthrene	Fluoranthene
	Dimethyl Nitrosoamine	Indeno(1,2,3-cd)Pyrene
	Diphenyl Nitrosoamine	Pyrene
		Di-n-Propyl Nitrosoamine
	Group	Benzidine
	Median = ND	3,3-Dichlorobenzidine
		1,2-Diphenylhydrazine
		Dibenzo(a,h)Anthracene
		Group
		Median = 1417.5 ppb

Henry's Law constant units are $mg/m^3/mg/m^3$

TABLE 10

BAT IN-PLANT LIMITATIONS FOR OPTIONS II AND III (ppb)

Pollutant or Pollutant Property by Priority Pollutant Classes	Median of Long-Term Weighted Means	Four Day Monthly Average	Daily Maximum
Halogenated Methanes (Cl's)			
6. Carbon tetrachloride	11.7	25	55
23. Chloroform	11.7	25	55
44. Methylene chloride	10	20	45
Chlorinated C2's			
10. 1,2-Dichloroethane	10	20	45
11. 1,1,1-Trichloroethane	11.7	25	55
12. Hexachloroethane	10	20	45
14. 1,1,2-Trichloroethane	10	20	45
29. 1,1-Dichloroethylene	11.7	25	55
30. 1,2-trans-Dichloroethylene	11.7	25	55
85. Tetrachloroethylene	11.7	25	55
87. Trichloroethylene	11.7	25	55
88. Vinyl chloride	11.7	25	55
Chlorinated C3's			
32. 1,2-Dichloropropane	10	20	45
Aromatics			
4. Benzene	11.7	25	50
86. Toluene	11.7	25	50
Chloroaromatics			
7. Chlorobenzene	11.7	25	50
9. Hexachlorobenzene	10	20	40
25. o-Dichlorobenzene	10	20	40
26. m-Dichlorobenzene	11.7	25	50
27. p-Dichlorobenzene	11.7	25	50

APPENDIX A

BAT STATISTICAL METHODOLOGY

VARIABILITY FACTOR DEVELOPMENT

In the process of developing limitations for effluent concentrations, EPA used a modification of the estimation procedure for the delta-lognormal distribution for determining variability factors. The delta-lognormal distribution (discussed in Aitchison and Brown (1957)) can be expressed as a mixture of the lognormal distribution for concentration values greater than zero, and a point distribution for concentration values of zero. That is, the delta-lognormal distribution for concentration values x can be expressed as:

$$f(x) = \delta\, I_{(x_0)} + (1 - \delta)\, g(x)$$

where $0 \leq \delta \leq 1$,

$I_{(x_0)} = 1$ for $x_0 = 0$

$= 0$ elsewhere,

and $g(x) = (2\pi\sigma^2)^{-1/2} \exp\left[\frac{-(\log x - \mu)^2}{2\sigma^2}\right]\frac{1}{x}$ for $x > 0$

$= 0$ elsewhere.

The 99th percentile of this distribution is $P_{99} = \exp(\mu + z^*\sigma)$, where $z^* = \Phi^{-1}\left(\frac{0.99 - \delta}{1 - \delta}\right)$, where Φ^{-1} represents the inverse of the standard normal cumulative distribution function.

The mean or expected value, E(X), and the variance, V(X), of the delta-lognormal distribution, are as follows:

$$E(X) = (1 - \delta) \exp(\mu + 0.5\sigma^2)$$

$$V(X) = (1 - \delta) \exp(2\mu + \sigma^2)[\exp(\sigma^2) - (1 - \delta)].$$

This distribution is appropriate when positive concentration values are lognormally distributed, and a proportion of concentration values equal to zero exist. Note that this distribution is the lognormal distribution when $\delta = 0$.

Consider now a modification of the estimation procedure for this distribution where a certain proportion of values are assumed to be at a nonnegative value D. This modification is used for a combination of positive concentration values and observations which can only be quantified as nondetect (ND) at a detection limit, D. All nondetects will be incorporated at this point D. That is:

$$f(x) = \delta\, I_{(x_0)} + (1 - \delta)\, g(x)$$

where $0 \leq \delta \leq 1$,

$I_{(x_0)} = 1$ for $x_0 = D$ (for nondetected values)

$= 0$ elsewhere,

and $$g(x) = (2\pi\sigma^2)^{-1/2} \exp\left[\frac{-(\log x - \mu)^2}{2\sigma^2}\right] \frac{1}{x} \qquad \text{for } x > 0$$

$= 0$ elsewhere.

The 99th percentile is:

$$P_{99} = \max\,(D,\ \exp(\mu + z^*\sigma)),$$

and the mean and variance are:

$$E(X) = \delta\, D + (1 - \delta)\exp(\mu + 0.5\sigma^2)$$

$$V(X) = (1 - \delta)\exp(2\mu + \sigma^2)\,(\exp(\sigma^2) - (1 - \delta)) + \delta\,(1 - \delta)\,D\,(D - 2\exp(\mu + 0.5\sigma^2)).$$

In the following sections, details on variability factor development for this method, as well as other methodologies investigated, are presented. The other methodologies are based on different distributional assumptions and are organized as follows:

Section A: Modification of the estimation procedure for the delta-lognormal distribution

Section B: Lognormal distribution with censoring

Section C: Delta-lognormal distribution for shifted concentration values

Section D: Combination of the lognormal distribution and delta-lognormal distribution for shifted concentration values.

For each of these methodologies, procedures for the development of 99th percentile daily variability factors and 95th percentile 4-day mean variability factors are presented. Daily variability factors are derived by taking the ratio of the estimated 99th percentile of the distribution of concentration values to the estimated mean of the distribution. 4-day mean variability factors are found by taking the ratio of the estimated 95th percentile of the distribution of 4-day means to the estimated mean of this distribution.

The delta-lognormal distribution and the estimation procedure used for determining variability factors are described above. For reference in the subsequent sections, the following distributions and their mathematical formulations are described below:

Lognormal:

$$g(x) = (2\pi\sigma^2)^{-1/2} \exp\left[\frac{-(\log x - \mu)^2}{2\sigma^2}\right]\frac{1}{x} \qquad \text{for } x > 0$$

$$= 0 \qquad \text{elsewhere}$$

Delta-Lognormal for Shifted Concentration Values:

$$f(x) = \delta\, I_{(x_0)} + (1 - \delta)\, g(x - D)$$

where $0 \leq \delta \leq 1$,

$I_{(x_0)} = 1$ for $x_0 = D$

$= 0$ elsewhere,

and $g(x - D)$ is the lognormal distribution for shifted concentration values; that is,

$$g(x - D) = (2\pi\sigma^2)^{-1/2} \exp\left[\frac{-(\log(x - D) - \mu)^2}{2\sigma^2}\right] \frac{1}{(x - D)} \quad \text{for } (x - D) > 0$$

$= 0$ elsewhere.

A. MODIFICATION OF THE ESTIMATION PROCEDURE FOR THE DELTA-LOGNORMAL DISTRIBUTION

A.1 DAILY VARIABILITY FACTORS

The 99th percentile of daily values was estimated by substituting the sample logmean and logvariance of concentration values and the sample proportion of nondetects into the mathematical formula for the 99th percentile of the modification of the estimation procedure for the delta-lognormal distribution described previously. The expectation of the daily values was estimated by substituting the sample logmean and logvariance of concentration values and the sample proportion of nondetects into the formula for the mean of this distribution.

Let $x_1, x_2, \ldots, x_r, x_{r+1}, \ldots, x_n$ be a random sample of size n, with r observations recorded as nondetects, and n - r observations recorded as concentration values. Assume these n - r observations come from a lognormal distribution, and let $\hat{\mu}$ and $\hat{\sigma}^2$ be the sample mean and variance, respectively, of log(X). Let $\hat{\delta}$ be the sample proportion of nondetects. Then the estimate of the mean of this distribution, based upon the modification to the estimation procedure for the delta-lognormal distribution, is:

$$\widehat{E(X)} = \hat{\delta}\, D + (1 - \hat{\delta}) \exp(\hat{\mu} + 0.5\hat{\sigma}^2) \qquad \text{(A-1)}$$

where $\hat{\mu} = \dfrac{\sum_{i=r+1}^{n} \log x_i}{n - r}$ (calculated for $r < n$), (A-2)

$$\hat{\sigma}^2 = \frac{\sum_{i=r+1}^{n} (\log x_i - \hat{\mu})^2}{n - r - 1} \qquad \text{(calculated for } r < n - 1\text{)}, \qquad \text{(A-3)}$$

and $\hat{\delta} = \dfrac{r}{n}$. (A-4)

The log(•) notation presented above represents the natural logarithm (base e), and this notation will be used in subsequent formulas. The estimate of the 99th percentile is:

$$\widehat{P_{99}} = \begin{cases} D & \hat{\delta} \geq 0.99 \\ \max\left(D, \exp(\hat{\mu} + z^*\hat{\sigma})\right) & \text{elsewhere} \end{cases} \qquad \text{(A-5)}$$

$$\text{where } z^* = \Phi^{-1}\left(\frac{0.99 - \hat{\delta}}{1 - \hat{\delta}}\right).$$

Using expressions (A-1) and (A-5) the 99th percentile daily variability factor, VF(1), is:

$$VF(1) = \frac{\widehat{P_{99}}}{\widehat{E(X)}} .$$

A.2 VARIABILITY FACTOR OF 4-DAY MEANS

The procedure for estimating the 95th percentile of 4-day means was first to substitute the sample logmean, sample logvariance, and sample proportion of nondetects into the mathematical formulas of the logmean and the logvariance of 4-day means of values, where the modification of the estimation procedure for the delta-lognormal distribution, as described previously, was used. The logmean and the logvariance of 4-day means, in turn, were used to estimate the 95th percentile of the distribution of 4-day means, based on this modification. The estimate of the expectation of 4-day means is the same as the estimate of the expectation of daily values, assuming this modification of the estimation procedure for the delta-lognormal distribution (as in section A.1), where values of the sample logmean, sample logvariance, and sample proportion of nondetects are incorporated. The 95th percentile 4-day mean variability factor was derived as the ratio of this estimate of the 95th percentile of 4-day means to this estimate of the expectation.

The mean of the distribution of concentration values, based on this modification, is

$$E(X) = \delta\ D + (1 - \delta)\ \exp(\mu + 0.5\sigma^2) \qquad \text{(A-6)}$$

Making the assumption that the approximating distribution of $\bar{X}_4$, the sample mean for a random sample of four independent concentrations, is also a derived from this modification of the estimation procedure for the delta-lognormal distribution, with the same mean as the distribution of concentration values, and with variance proportional to the variance of the distribution of concentration values (Barakat (1976)), it follows that the mean of this distribution is:

$$E(\bar{X}_4) = \delta_4\ D + (1 - \delta_4)\ \exp(\mu_4 + 0.5\sigma_4^2) \qquad \text{(A-7)}$$

Using (A-7), it can be seen that

$$\mu_4 = \log\left[\frac{E(\bar{X}_4) - \delta_4 D}{1 - \delta_4}\right] - 0.5\sigma_4^2\ . \qquad \text{(A-8)}$$

Since $E(X) = E(\bar{X}_4)$ and $\delta_4 = \delta^4$,

$$\mu_4 = \log\left[\frac{E(X) - \delta^4 D}{1 - \delta^4}\right] - 0.5\sigma_4^2\ . \qquad \text{(A-9)}$$

To derive an expression for σ_4^2, we use the following relationships:

$$V(X) = (1 - \delta)\ \exp(2\mu + \sigma^2)\ [\exp(\sigma^2) - (1 - \delta)]\ + \qquad \text{(A-10)}$$
$$\delta\ (1 - \delta)\ D\ [D - 2\ \exp(\mu + 0.5\sigma^2)]$$

$$V(\bar{X}_4) = (1 - \delta_4)\ \exp(2\mu_4 + \sigma_4^2)\ [\exp(\sigma_4^2) - (1 - \delta_4)]\ + \qquad \text{(A-11)}$$
$$\delta_4\ (1 - \delta_4)\ D\ [D - 2\ \exp(\mu_4 + 0.5\sigma_4^2)]\ .$$

Using (A-7) and (A-11) it follows that

$$\sigma_4^2 = \log\left[(1-\delta_4) + \frac{(1-\delta_4)[V(\bar{X}_4) - \delta_4(1-\delta_4)D[D - 2\exp(\mu_4 + 0.5\sigma_4^2)]]}{[E(\bar{X}_4) - \delta_4 D]^2}\right] \quad \text{(A-}$$

From (A-7), by rearranging terms,

$$\exp(\mu_4 + 0.5\sigma_4^2) = \frac{E(\bar{X}_4) - \delta_4 D}{(1-\delta_4)} \quad \text{(A-1}$$

using (A-12) and (A-13),

$$\sigma_4^2 = \log\left\{(1-\delta_4)\left[1 + \frac{V(\bar{X}_4)}{[E(\bar{X}_4) - \delta_4 D]^2} - \frac{\delta_4(1-\delta_4)D^2}{[E(\bar{X}_4) - \delta_4 D]^2} + \frac{2\,\delta_4 D}{E(\bar{X}_4) - \delta_4 D}\right]\right\} \quad \text{(A-14}$$

Since $V(X) = V(\bar{X}_4)/4$, $E(X) = E(\bar{X}_4)$, and $\delta_4 = \delta^4$, expression (A-14) can be rewritten as:

$$\sigma_4^2 = \log\left\{(1-\delta^4)\left[1 + \frac{V(X)}{4[E(X) - \delta^4 D]^2} - \frac{\delta^4(1-\delta^4)D^2}{[E(X) - \delta^4 D]^2} + \frac{2\delta^4 D}{E(X) - \delta^4 D}\right]\right\}. \quad \text{(A-15}$$

Using values of $\hat{\delta}$ (sample proportion of nondetects), $\hat{\mu}$ (sample logmean of the concentrations), and $\hat{\sigma}^2$ (sample logvariance), defined in (A-2) through (A-4) as estimates of δ, μ, and σ^2, respectively, in expressions (A-9) and (A-15) yields estimates of μ_4 and σ_4^2, denoted by $\hat{\mu}_4$ and $\hat{\sigma}_4^2$, respectively.

Using these estimates of μ_4, σ_4, and δ^4 , the estimate of the 95th percentile of $\bar{X}_4$ is

$$\widehat{P_{95}} = \begin{cases} D & \hat{\delta}^4 \geq 0.95 \\ \max(D, \exp(\hat{\mu}_4 + z_4^* \hat{\sigma}_4)) & \text{elsewhere} \end{cases} \qquad \text{(A-16)}$$

where $z_4^* = \Phi^{-1}\left(\dfrac{0.95 - \hat{\delta}^4}{1 - \hat{\delta}^4}\right)$.

Using (A-16) and (A-1), since $E(X) = E(\bar{X}_4)$, the 95th percentile 4-day mean variability factor is

$$VF(1) = \frac{\widehat{P_{95}}}{\widehat{E(X)}} \quad .$$

B. LOGNORMAL DISTRIBUTION WITH CENSORING

B.1 DAILY VARIABILITY FACTORS

Cohen's maximum likelihood estimate of the logvariance in the case of Type I censoring (fixed censoring point) was substituted into the daily variability factor, assuming a lognormal distribution. The detection limit was taken to be the censoring point. This approach assumes that concentration values which are recorded as nondetect exist, but are below the detection limit. Values falling below the detection limit (D) are considered Type I censored observations.

Assume $y_i \sim N(\mu, \sigma^2)$, $i = 1, 2, \ldots, r, r+1, \ldots, n$, where y = log(concentration value) and r nondetects are present in a sample of size n. Let $y_0 = \log D$ and let y_i, $i = r+1, \ldots n$, be the logarithm of the detected concentrations.

Letting $\gamma = s^2/(\bar{y} - y_0)^2$,

where $\bar{y} = \frac{1}{n-r} \sum_{i=r+1}^{n} y_i$, and

$$s^2 = \frac{1}{n-r} \sum_{i=r+1}^{n} (y_i - \bar{y})^2,$$

and $h = (n - r)/n$ allows one to obtain a value for λ from Cohen's Table 2 (Cohen (1961)) to be used in the estimate of σ^2. This estimate for σ^2 is

$$\hat{\sigma}^2 = s^2 + \lambda(\bar{y} - y_0)^2. \qquad \text{(B-1)}$$

The 99th percentile daily variability factor, VF(1), is calculated assuming a lognormal distribution of concentration values. That is,

$$VF(1) = \exp(2.326\hat{\sigma} - 0.5\hat{\sigma}^2), \tag{B-2}$$

where $\hat{\sigma}^2$ is Cohen's maximum likelihood estimate assuming censoring, as found in (B-1).

B.2 VARIABILITY FACTORS OF 4-DAY MEANS

The mathematical formulation of the variability factor of 4-day means of lognormally distributed values was derived in terms of the logvariance of 4-day means, which, in turn, was formulated in terms of the logvariance of daily values. The 4-day mean variability factor was estimated by substituting Cohen's maximum likelihood estimate of the logvariance for the case of Type I censoring into the resulting mathematical formulation. The detection limit was taken to be the censoring point.

The 4-day mean variability factor, assuming lognormality and independence of the observations, is derived from the following formulas, assuming X has a lognormal distribution with parameters μ and σ^2:

$$E[X] = \exp(\mu + 0.5\sigma^2) \tag{B-3}$$

$$E[\bar{X}_4] = \exp(\mu_4 + 0.5\sigma_4^2) \tag{B-4}$$

$$V[X] = \exp(2\mu + \sigma^2)(\exp(\sigma^2) - 1), \text{ and} \tag{B-5}$$

$$V[\bar{X}_4] = \exp(2\mu_4 + \sigma_4^2)(\exp(\sigma_4^2) - 1). \tag{B-6}$$

Since $E[X] = E[\bar{X}_4]$, by using (B-3) and (B-4), it follows that

$$\mu_4 = \mu + 0.5(\sigma^2 - \sigma_4^2) . \tag{B-7}$$

Since $V[\overline{X}_4] = V[X]/4$, by using (B-5), (B-6), and (B-7), the following expression results:

$$\sigma_4^2 = \log((\exp(\sigma^2) + 3)/4). \qquad \text{(B-8)}$$

Finally, the 95th percentile 4-day mean variability factor, VF(4), can be expressed as

$$VF(4) = \exp(1.645\ \hat{\sigma}_4 - 0.5\hat{\sigma}_4^2) \qquad \text{(B-9)}$$

where $\hat{\sigma}_4^2$ is found by substituting Cohen's estimate of σ^2 assuming censoring, as given in (B-1), into expression (B-8).

C. DELTA-LOGNORMAL DISTRIBUTION ON SHIFTED CONCENTRATION VALUES

C.1 DAILY VARIABILITY FACTORS

The 99th percentile of daily values was estimated by substituting the sample logmean and logvariance of shifted concentration values and the estimated proportion of nondetects into the mathematical formula for the 99th percentile of a delta-lognormal distribution (i.e., a delta-lognormal distribution with origin D). The expectation of the daily values was estimated by the Aitchison and Brown maximum likelihood equivalent method involving the Bessel function. The daily variability factor was determined as the ratio of this estimate of the 99th percentile to this estimate of the expectation.

Let $x_1, x_2, \ldots, x_r, x_{r+1}, \ldots, x_n$ be a random sample of size n from a delta-lognormal distribution with origin D and r ($r \leq n$) observations being at D. These r observations are those observations which were recorded as nondetect and placed at the detection limit D. Also, let $\hat{\mu}$ and $\hat{\sigma}^2$ be the sample mean and variance, respectively, of $\log(x - D)$, where $x > D$, and let δ be the sample proportion of nondetects.

For D = 0, it can be shown that

$$\widehat{E[X_0]} = \begin{cases} (1 - \hat{\delta}) \exp(\hat{\mu})\ \psi_{(n-r)}(\hat{\sigma}^2/2) & , r \leq n - 2 \\ x_1/n & , r = n - 1 \\ 0 & , r = n \end{cases} \qquad \text{(C-1)}$$

is a minimum variance, unbiased estimate of E[X]. For the general case, where $D \geq 0$,

$$\widehat{E[X_D]} = \widehat{E[X_0]} + D. \qquad \text{(C-2)}$$

In expression (C-1),

$$\psi_a(t) = \sum_{j=0}^{\infty} u_j(a, t), \qquad \text{(C-3)}$$

where

$$u_j(a, t) = \begin{cases} 1 & , j = 0 \\ \dfrac{(a-1)}{a}\, t & , j = 1 \\ \left[\dfrac{(a-1)^2}{ja(a+2j-3)}\, t\right] u_{j-1}(a, t) & , j \geq 2. \end{cases} \qquad \text{(C-4)}$$

Also, $\psi_a(t)$ is assumed to have converged if

$$\left|\frac{(a-1)^2}{ja(a+2j-3)}\, t\right| \leq 0.0001 \text{ for } j \geq 2. \qquad \text{(C-5)}$$

The 99th percentile of this delta-lognormal distribution with origin D is:

$$P_{99} = \begin{cases} D & , \delta \geq 0.99 \\ D + \exp(\mu + z^*\sigma), & \text{elsewhere,} \end{cases} \qquad \text{(C-6)}$$

where

$$z^* = \Phi^{-1}\left(\frac{0.99 - \delta}{1 - \delta}\right),$$

with Φ^{-1} defined as the inverse of the standard normal cumulative distribution function. An estimate of the above 99th percentile can be calculated by substituting estimates for δ, μ, and σ into expression (C-6). Here, the estimate of δ equals r/n, and the estimates of μ and σ^2 are the sample logmean and logvariance, respectively, of the shifted (x - D) concentrations. This estimate for the 99th percentile, denoted by $\widehat{P_{99}}$, is used to develop the 99th percentile daily variability factor,

$$VF(1) = \frac{\widehat{P_{99}}}{\widehat{E[X_D]}}. \qquad \text{(C-7)}$$

where $\widehat{E(X_D)}$ is defined in (C-2).

C.2 VARIABILITY FACTORS OF 4-DAY MEANS

The procedure for estimating the 95th percentile of 4-day means was first to substitute the sample logmean and sample logvariance into the mathematical formulas of the logmean and the logvariance of 4-day means of values distributed as a delta-lognormal distribution with origin D. The logmean and the logvariance of 4-day means, in turn, were used to estimate the 95th percentile from the delta-lognormal distribution of 4-day means of shifted concentration values. The estimate of the expectation of 4-day means is the same as the estimate of the expectation of daily values, assuming a delta-lognormal distribution with origin D (as in section C.1), where the Aitchison and Brown estimation method involving the Bessel function is utilized. The 4-day mean variability factor was derived as the ratio of this estimate of the 95th percentile of 4-day means to this estimate of the expectation.

Let $\bar{X}_4$ be the sample mean for a random sample of four independent concentrations. The distribution of $\bar{X}_4$ is also approximated by a delta-lognormal distribution of shifted concentration values, with origin D and parameters μ_4, σ_4, and δ_4.

The mean of this distribution is

$$E[X_D] = D + (1 - \delta) \exp(\mu + 0.5\sigma^2). \qquad \text{(C-8)}$$

It follows that the mean of $\bar{X}_4$'s approximating distribution is

$$E[\bar{X}_4] = D + (1 - \delta_4) \exp(\mu_4 + 0.5\sigma_4^2). \qquad \text{(C-9)}$$

Since $E[X_D] = E[\bar{X}_4]$ and $\delta_4 = \delta^4$, by using (C-8) and (C-9), it can be seen that

$$\mu_4 = \log\left(\frac{1 - \delta}{1 - \delta^4}\right) + \mu + 0.5(\sigma^2 - \sigma_4^2). \qquad \text{(C-10)}$$

Since $V[X_D] = V[\bar{X}_4]/4$ and $\delta_4 = \delta^4$, by using the relationships

$$V[X_D] = (1 - \delta)(\exp(\mu + 0.5\sigma^2))^2(\exp(\sigma^2) - (1 - \delta)) \text{ and} \tag{C-11}$$

$$V[\bar{X}_4] = (1 - \delta_4)(\exp(\mu_4 + 0.5\sigma_4^2))^2(\exp(\sigma_4^2) - (1 - \delta_4)), \tag{C-12}$$

it follows that

$$\sigma_4^2 = \log[[(1 - \delta^4)/4][(\exp(\sigma^2)/(1 - \delta)) + 3]]. \tag{C-13}$$

Modifying (C-6), the estimate of the 95th percentile of $\bar{X}_4$ is

$$\widehat{P_{95}} = \begin{cases} D & , \ \hat{\delta}^4 \geq 0.95 \\ D + \exp(\hat{\mu}_4 + z_4^* \hat{\sigma}_4), & \text{elsewhere} \end{cases} \tag{C-14}$$

where

$$z_4^* = \Phi^{-1}\left(\frac{0.95 - \hat{\delta}^4}{1 - \hat{\delta}^4}\right).$$

The estimates of $\hat{\mu}_4$ and $\hat{\sigma}_4^2$ are found by substituting $\hat{\mu}$ (the sample logmean of the shifted concentrations), $\hat{\sigma}^2$ (the sample logvariance of the shifted concentrations), and $\hat{\delta}$ into expressions (C-10) and (C-13).

Finally, the 95th percentile 4-day mean variability factor is

$$VF(4) = \frac{\widehat{P_{95}}}{\widehat{E[X_D]}}, \tag{C-15}$$

where $\widehat{E[X_D]}$ is given in (C-2) and $\widehat{P_{95}}$ is given in (C-14).

D. COMBINATION OF SHIFTED LOGNORMAL AND DELTA-LOGNORMAL DISTRIBUTIONS

D.1 DAILY VARIABILITY FACTORS

The methodology for estimating daily variability factors used in the Development Document was also applied to the new data base. The procedure is the same as that of section C except that a combination of the lognormal and the delta-lognormal distribution of shifted concentration values was employed to derive the mathematical formulation of the 99th percentile and the expectation of daily values; that is, the formulation is similar to that for the delta-lognormal distribution of shifted concentration values (with shift D), except that estimation of the expectation is based only on detected values.

The mean of X_0, where X_0 has a lognormal distribution, is

$$E[X_0] = \exp(\mu + 0.5\sigma^2) \quad . \tag{D-1}$$

The mean of X_D, where X_D is a lognormal distribution with origin D, is

$$E(X_D) = D + \exp(\mu + 0.5\sigma^2) \quad . \tag{D-2}$$

An estimate of $E(X_D)$ is computed by substituting $\hat{\mu}$ and $\hat{\sigma}^2$, the sample mean and logvariance, respectively, of $\ln(x - D)$, into expression (D-2). Substituting this estimate of $E(X_D)$, denoted by $\widehat{E(X_D)}$, into (C-7) yields the 99th percentile daily variability factor for this methodology. This variability factor is

$$VF(1) = \frac{\widehat{P_{99}}}{\widehat{E(X_D)}} \quad ,$$

where $\widehat{P_{99}}$ is the same quantity as used in (C-7).

D.2 ESTIMATION OF VARIABILITY FACTOR OF 4-DAY MEANS

This procedure is the same as that of section C.2 except that a combination of the lognormal distribution and the delta-lognormal distribution of shifted concentration values was employed to derive the mathematical formulation of the 95th percentile and the expectation of the distribution of 4-day means. The formulation is similar to that for the delta-lognormal distribution of shifted concentration values, except that estimation of the expectation is based only on detected values. However, the formulation of the variance of a 4-day mean was adjusted for the random number of each set of four values that may fall above the detection limit. This adjustment was based on binomial probabilities.

A formula for the 4-day mean variability factor is found when the mean of $\bar{X}_4$, assuming a lognormal distribution with origin D, is

$$E[\bar{X}_4] = D + \exp(\mu_4 + 0.5\sigma_4^2) \ . \qquad \text{(D-3)}$$

Since $E[X_D] = E[\bar{X}_4]$, by using (D-2) and (D-3), it follows that

$$\mu_4 = \mu + 0.5(\sigma^2 - \sigma_4^2). \qquad \text{(D-4)}$$

Also, for this distribution,

$$V(X_D) = \exp(2\mu + \sigma^2)(\exp(\sigma^2) - 1) \qquad \text{(D-5)}$$

and $$V[\bar{X}_4] = \exp(2\mu_4 + \sigma_4^2)(\exp(\sigma_4^2) - 1). \qquad \text{(D-6)}$$

With the presence of detected and nondetected observations, between zero and four values can be detected in any group of four observations. In particular, assume M out of four values are greater than D (M = 1, 2, 3, 4). Then,

$$V[\bar{X}_4] = V[X_D]/M, \tag{D-7}$$

where M is a random variable with a binomial probability density function and parameter $(1 - \delta)$. In other words,

$$Pr[M = m] = \binom{4}{m} (1 - \delta)^m \delta^{4-m}, \; m = 0, 1, 2, 3, 4, \; 0 < \delta < 1. \tag{D-8}$$

Using (D-7) and (D-8) to calculate an expression for $V(\bar{X}_4)$,

$$V[\bar{X}_4] = f(\delta)V[X_D]$$

$$= f(\delta) \exp(2\mu + \sigma^2) (\exp(\sigma^2) - 1), \tag{D-9}$$

where $f(\delta) = (1 - \delta^4)^{-1} \sum_{m=1}^{4} Pr[M = m]/m, \; 0 < \delta < 1$, and

$f(\delta) = 1/4$ for $\delta = 0$.

Solving for σ_4^2, using expressions (D-4), (D-6), and (D-9), results in

$$\sigma_4^2 = \log[1 + f(\delta)(\exp(\sigma^2) - 1)]. \tag{D-10}$$

The original estimates of μ, σ, and δ, as described in section C.1, can now be used to estimate μ_4, σ_4^2, and δ^4, and consequently P_{95} can be estimated as

$$\widehat{P_{95}} = D + \exp(\hat{\mu}_4 + z_4^{*}\hat{\sigma}_4^2) \tag{D-11}$$

where $z_4^{*} = \Phi^{-1}\left(\dfrac{0.95 - \hat{\delta}^4}{1 - \hat{\delta}^4}\right)$, and

$\hat{\mu}_4$ and $\tilde{\sigma}_4^2$ are these estimates of μ_4 and σ_4^2. Finally, the 95th percentile 4-day mean variability factor, VF(4), is given as:

$$VF(4) = \frac{\hat{P}_{95}}{\hat{E}[X_D]} \qquad \text{(D-}$$

where $\hat{P}_{95}$ is shown in (D-11), and $\hat{E}[X_D]$ is found by substituting estimates of μ and σ, the sample logmean and logvariance of the shifted concentrations, into (D-2).

Using the methodology described in section A, daily and 4-day mean variability factors were calculated for plant-pollutant combinations in the CMA/EPA 5-plant study and the recent 12-plant sampling study which have at least three single-day averages for which concentration values are recorded. Average daily and 4-day mean variability factors for each pollutant were calculated by averaging plant-pollutant variability factors across all plants for each pollutant for which variability factor information was present. For some pollutants, variability information was limited. For these pollutants, variability factors were extrapolated from the variability factors for groups of pollutants with related chemical structure and thus comparable treatment variability. This extrapolation involved using the average variability factor of all existing pollutant variability factors in the group.

LONG-TERM MEANS AND LIMITATIONS

To calculate long-term means for each plant-pollutant combination in the CMA/EPA 5-plant study, the recent 12-plant sampling study, and the Verification study, the Agency has calculated long-term means (m) as follows:

$$m = \hat{\delta}D + (1 - \hat{\delta}) \left[\frac{\sum_{i=1}^{n_1} x_i}{n_1} \right] ,$$

where x_i, $i = 1, \ldots, n_1$, denotes the n_1 detected observations, D is the pollutant-specific detection limit, and $\hat{\delta}$ is an estimate of the proportion of nondetects. For those plant-pollutant combinations for which all nondetects are present, $m = D$, and for those combinations for which all detects are present, m is the arithmetic average of these observations. The Agency believes that the value of $\hat{\delta}$, derived from the proportion of nondetects present in the daily data, is the best estimate of the percent of nondetect values reported. That is, $\hat{\delta}$, the best estimate of the proportion of nondetect values, is

$$\hat{\delta} = \frac{\begin{array}{c}\text{total number of reported nondetect values} \\ \text{from all daily data plants} \\ \text{for a particular pollutant}\end{array}}{\begin{array}{c}\text{total number of values reported from all} \\ \text{daily data plants for a particular pollutant}\end{array}}$$

After calculating plant-pollutant long-term means in this fashion, the median value of plant means for a given pollutant is determined, and this median of long-term means is multiplied by the average pollutant daily variability factor to determine daily limitations for each pollutant. The average 4-day mean variability factor is multiplied by this median to determine 4-day mean limitations for each pollutant.

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APPENDIX B

DOCUMENTATION FOR TOXIC POLLUTANT AIR EMISSION RATE ESTIMATES FROM WASTEWATER TREATMENT SYSTEMS

TABLE B1

ESTIMATES OF AIR EMISSIONS FROM
WASTEWATER TREATMENT UNIT OPERATIONS (PERCENT STRIPPED)

		KINCANNON & GAUDY		IEC	HWANG	STRIER
VOLATILES		NON-BIO AERATOR	BIO CLOSED REACTOR	(DRAFT) BIO	OPEN BIO	OPEN BIO
4	benzene	99	16	15	100	85
6	carbon tetrachloride			59		80
7	chlorobenzene			5	100	80
10	1,2-dichloroethane	96	(97.5)(99)	35	100	
11	1,1,1-trichloroethane	100	(99)(100)	62		
14	1,1,2-trichlorethane			25		40
15	1,1,2,2-tetrachloroethane		(100)	27		
23	chloroform			34	79	
29	1,1-dichloroethylene			43		
30	1,2-trans-dichloroethylene			72		
32	1,2-dichloropropane	99	89	32	99	
44	methylene chloride	99	7	54	12	
85	tetrachloroethylene		95	27		50
86	toluene			20	100	85
87	trichlorethylene			41		
88	vinylchloride				75	

See Table B3 for cites.

TABLE B2

CORRELATION OF PERCENT REMOVAL BY VOLATILIZATION
AND HENRY'S LAW CONSTANT DURING SECONDARY TREATMENT

Compound	Percent Removal by Volatization at Activated Sludge Tank	H (ATM-m^3/mole)
PCE, Tetrachlorethane	82.5	0.38
1,1,2-Trichlorethane	75.7	0.74
Bromodichloromethane	98.4	2.12
Dibromochloromethane	86.3	2.12
Dichloropropane	95.7	2.8
Methylene Chloride	94.8	3.19
Chloroform	94.7	3.93
Chlorobenzene	92.2	3.93
1,1,1-Trichloroethane	96.6	4.92
Benzene	96.5	5.55
Toluene	93.7	5.93
Ethylbenzene	86.3	6.44
Trichloroethylene	93.9	11.7
Dichloroethene	98.1	15
Carbon Tetrachloride	98.5	30.2

Source: Petrasek et al. (1983).

From: Versar, Inc. Memo, Dixon & Bremen to Reinhardt, October 11, 1984.

TABLE B3

Selected Public Record Documentation

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V. TECHNOLOGY BASIS AND DERIVATION OF PSES EFFLUENT LIMITATIONS

V. TECHNOLOGY BASIS AND DERIVATION OF PSES EFFLUENT LIMITATIONS

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V. TECHNOLOGY BASIS AND DERIVATION OF PSES EFFLUENT LIMITATIONS

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V. TECHNOLOGY BASIS AND DERIVATION OF PSES EFFLUENT LIMITATIONS

1. INTRODUCTION

As discussed in the previous sections for the BAT effluent limitations, the selection of a particular set of PSES treatment technologies is also plant-specific for indirect dischargers in the OCPSF industry. As with the direct dischargers subject to BAT effluent limitations, treatment technologies applicable to indirect dischargers subject to PSES can consist of in-plant control or treatment of specific (or combined) wastestreams by a number of physical/chemical methods sometimes in combination with biological treatment of combined wastestreams where effluent levels from in-plant control technologies still pass through, interfere with or inhibit publicly-owned treatment works. In-plant control and biological treatment technologies utilized by indirect dischargers are the same as those employed by direct dischargers as discussed in the previous sections.

Prior to proposal, sufficient priority pollutant removal data for in-plant control technologies which could be utilized to calculate PSES limitations for indirect discharges were not available since previous sampling efforts focused on complete end-of-pipe treatment systems rather than on individual technology components. A new sampling program was initiated after proposal at 12 OCPSF facilities to collect toxic pollutant removal data for selected in-plant control technologies as well as end-of-pipe technologies which could be applied to indirect discharges. Data are available for certain in-plant controls as well as applicable end-of-pipe technologies for EPA to establish PSES limitations for certain toxic pollutants which pass through the POTW or interfere with the POTW operation.

2. CONCENTRATION VERSUS MASS-BASED LIMITATIONS AND PSES SUBCATEGORIZATION

As in the case of the BAT effluent limitations, both concentration-based and mass-based PSES effluent limitations were considered and for the same reasons mentioned previously, concentration-based PSES effluent limitations were established.

Similarly, subcategorization of the industry for PSES purposes was considered and, for the same reasons described for BAT, one set of PSES limitations which are applicable to all plants was established.

3. TECHNOLOGY OPTIONS

As in the proposed regulations, it was decided that limitations would be equal to BAT effluent limitations and would differ only in the set of toxic pollutants regulated. Therefore, PSES limitations can span the entire range of BAT Options I through III.

Two major PSES options are being considered for selection of pollutants to be regulated:

- PSES Option I--Establish PSES limitations for pollutants failing EPA's standard pass-through analysis
- PSES Option II--Add to Option I a set of volatile and semi-volatile organic toxic pollutants based on POTW interference as well as pass-through.

4. PSES PASS-THROUGH ANALYSIS

The general methodology for performing a pass-through analysis for pretreatment standard setting purposes is to compare, on a pollutant-by-pollutant basis, the percentage of a pollutant removed by well-operated POTWs (those meeting secondary treatment requirements) with the percentage removed by direct dischargers complying with BAT. If BAT removes more than POTWs,the pollutant is deemed to pass through POTWs and a PSES limitation is established for the pollutant.

At proposal, this was modified for assessing pass through. Cognizant of the analytical variability typical of organic toxic pollutants in POTWs and OCPSF plants, pass-through was determined to occur only if BAT removes at least 5 percent more than a well-operated POTW removes. This approach is additionally supported by the fact that POTW influent organic toxic pollutant concentrations are typically much lower than industry treatment system influent concentrations; many POTW effluent samples are below detection,

precluding a complete accounting of all pollutants removed by the POTW. This approach has been retained for the Notice of Availability. Table 1 lists all pollutants which had BAT percent removals along with their associated POTW and BAT percent removals.

Table 2 presents the PSES Option I limitations for the pollutants which pass through based on the 5 percent criteria that would apply if BAT Option II were adopted. However, it should be noted that if a different BAT option were selected, PSES limitations would be revised accordingly.

Under PSES Option II, EPA would additionally regulate the volatile and semivolatile organic toxic pollutants listed in Table 3. (This table also lists the PSES limitations that would apply if BAT Option II were adopted). These polluants interfere with the normal operation of POTWs by presenting safety hazards due to volatilization of toxic organics in POTW's headworks. While the severity of such hazards may depend on a variety of factors, the potential for harm is considerable. For example, one state that has a large number of OCPSF plants submitted comments on the proposal that attributed POTW employee deaths to the volatilization in POTW sewers of organic pollutants discharged by industrial contributors. In addition, these pollutants are believed to pass through POTWs. As discussed in the BAT section, these polluants volatilize to the atmosphere from biological treatment systems. Since POTWs are biological systems, large proportions of volatile and semi-volatile pollutants are removed from wastewaters entering POTWs by air stripping rather than treatment. Thus, the standard pass-through analysis comparing POTW and BAT removals is inappropriate for these pollutants. Therefore, for the same reason that in-plant BAT effluent limitations are being considered, control of these pollutants under PSES Option II is being considered to ensure that pollutants not adequately treated by biological treatment are properly pretreated. Thus PSES Option II is supported by considerations of pass-through as well as interference.

5. CORRECTION TO PSES COST ESTIMATES AND ECONOMIC IMPACTS

In the initial cost estimation activities for PSES for the notice, PSES costs were based on the installation of only in-plant control technologies

TABLE 1

RESULTS OF PASS-THROUGH ANALYSIS COMPARISON OF
BAT AND POTW PERCENT REMOVALS

POLLUTANT NUMBER	BAT % REMOVAL	POTW % REMOVAL	± DIFFERENCE	REMARKS
1	98.9	95.0	+3.9	--
2	--	--	--	Not regulated for BAT
3	99.8	--	--	PSES required
4	99.3	97.6	+1.7	--
5	--	--	--	Not regulated for BAT
6	96.5	91.4	+5.1	PSES required
7	95.8	98.4	-2.6	--
8	86.4	93.0	-6.6	--
9	97.1	--	--	PSES required
10	98.6	87.8	+10.8	PSES required
11	93.5	90.9	+2.6	--
12	97.1	--	--	PSES required
13	--	--	--	Not regulated for BAT
14	59.7	88.9	-29.2	--
15	--	--	--	Not regulated for BAT
16	95.2	--	--	PSES required
17	--	--	--	No longer a priority pollutant
18	--	--	--	Not regulated for BAT

TABLE 1

RESULTS OF PASS-THROUGH ANALYSIS COMPARISON OF
BAT AND POTW PERCENT REMOVALS
(Continued)

POLLUTANT NUMBER	BAT % REMOVAL	POTW % REMOVAL	± DIFFERENCE	REMARKS
19	--	--	--	Not regulated for BAT
20	--	--	--	Not regulated for BAT
21	57.3	--	--	PSES required
22	--	--	--	Not regulated for BAT
23	94.8	82.7	+12.1	PSES required
24	97.7	--	--	PSES required
25	91.1	93.1	-2.0	--
26	91.0	100.0	-9.0	--
27	92.2	83.3	+8.9	PSES required
28	86.4	--	--	PSES required
29	89.0	84.4	+4.6	--
30	81.5	94.9	-13.4	--
31	98.7	60.7	+38.0	PSES required
32	97.5	94.3	+3.2	--
33	92.9	99.0	-6.1	--
34	98.9	53.3	+45.6	PSES required
35	88.1	--	--	PSES required
36	64.7	--	--	PSES required
37	--	--	--	Not regulated for BAT

TABLE 1

RESULTS OF PASS-THROUGH ANALYSIS COMPARISON OF
BAT AND POTW PERCENT REMOVALS
(Continued)

POLLUTANT NUMBER	BAT % REMOVAL	POTW % REMOVAL	± DIFFERENCE	REMARKS
38	98.4	95.0	+3.4	—
39	97.7	73.0	+24.7	PSES required
40	—	—	—	Not regulated for BAT
41	—	—	—	Not regulated for BAT
42	76.2	—	—	PSES required
43	—	—	—	Not regulated for BAT
44	85.3	70.9	+14.4	PSES required
45	60.4	89.6	-29.2	—
46	—	—	—	Not regulated for BAT
47	60.5	90.5	-30.0	—
48	86.5	71.4	+15.1	PSES required
49	—	—	—	No longer a priority pollutant
50	—	—	—	No longer a priority pollutant
51	—	—	—	Not regulated for BAT
52	96.3	—	—	PSES required
53	—	—	—	Not regulated for BAT
54	—	—	—	Not regulated for BAT

TABLE 1

RESULTS OF PASS-THROUGH ANALYSIS COMPARISON OF
BAT AND POTW PERCENT REMOVALS
(Continued)

POLLUTANT NUMBER	BAT % REMOVAL	POTW % REMOVAL	± DIFFERENCE	REMARKS
55	98.8	89.7	+9.1	PSES required
56	96.8	—	—	PSES required
57	95.3	—	—	PSES required
58	85.0	—	—	PSES required
59	83.8	—	—	PSES required
60	99.8	—	—	PSES required
61	—	—	—	Not regulated for BAT
62	—	—	—	Not regulated for BAT
63	—	—	—	Not regulated for BAT
64	59.2	45.0	+14.2	PSES required
65	98.6	97.8	+0.8	—
66	93.5	76.2	+17.3	PSES required
67	—	—	—	Not regulated for BAT
68	97.4	89.9	+7.5	PSES required
69	—	—	—	Not regulated for BAT
70	94.2	88.7	+5.5	PSES required
71	92.0	55.9	+36.1	PSES required
72	96.8	—	—	PSES required

TABLE 1

RESULTS OF PASS-THROUGH ANALYSIS COMPARISON OF
BAT AND POTW PERCENT REMOVALS
(Continued)

POLLUTANT NUMBER	BAT % REMOVAL	POTW % REMOVAL	± DIFFERENCE	REMARKS
73	95.4	--	--	PSES required
74	96.0	--	--	PSES required
75	--	--	--	Not regulated for BAT
76	99.3	--	--	PSES required
77	97.9	--	--	PSES required
78	97.8	90.4	+7.4	PSES required
79	--	--	--	Not regulated for BAT
80	94.0	--	--	PSES required
81	99.6	--	--	PSES required
82	--	--	--	Not regulated for BAT
83	--	--	--	Not regulated for BAT
84	96.4	80.0	+16.4	PSES required
85	98.4	89.8	+8.6	PSES required
86	99.6	96.5	+3.1	--
87	92.9	95.0	-2.1	--
88	99.8	89.0	+10.8	PSES required
89 - 113	--	--	--	Not regulated for BAT
114	52.6	66.2	-13.6	--
115	82.4	38.9	+43.5	PSES required

TABLE 1

RESULTS OF PASS-THROUGH ANALYSIS COMPARISON OF
BAT AND POTW PERCENT REMOVALS
(Concluded)

POLLUTANT NUMBER	BAT % REMOVAL	POTW % REMOVAL	± DIFFERENCE	REMARKS
116	--	--	--	Not regulated for BAT
117	--	--	--	Not regulated for BAT
118	--	--	--	Not regulated for BAT
119	79.5	77.8	+1.7	--
120	83.2	85.0	-1.8	--
121	79.9	68.6	+11.3	PSES required
122	69.9	58.6	+11.3	PSES required
123	92.1	60.0	+32.1	PSES required
124	35.1	45.5	-10.4	--
125	94.0	--	--	PSES required
126	--	--	--	Not regulated for BAT
127	--	--	--	Not regulated for BAT
128	84.8	76.0	+8.8	PSES required
129	--	--	--	Not regulated for BAT

TABLE 2

PSES OPTION I LIMITATIONS FOR POLLUTANTS
SELECTED BASED ON THE 5 PERCENT PASS-THROUGH
CRITERIA AND THE USE OF BAT OPTION II LIMITATIONS

Pollutant or Pollutant Property by Priority Pollutant Classes	Four Day Monthly Average (ppb)	Daily Maximum (ppb)
Halogenated Methanes (C1's)		
6. Carbon tetrachloride	15	30
23. Chloroform	20	40
44. Methylene chloride	15	20
48. Bromodichloromethane	15	30
Chlorinated C2's		
10. 1,2-Dichloroethane	35	95
12. Hexachloroethane	25	65
16. Chloroethane	115	315
85. Tetrachloroethylene	25	65
88. Vinyl chloride	25	65
Chlorinated C4's		
52. Hexachlorobutadiene	20	45
Chloroalkyl Ethers		
42. bis(2-chloroisopropyl)ether	20	45
Metals		
115. Arsenic	50	115
122. Lead	265	785
123. Mercury	2.5	3.0
125. Selenium	20	40
128. Zinc	105	190

TABLE 2

PSES OPTION I LIMITATIONS FOR POLLUTANTS
SELECTED BASED ON THE 5 PERCENT PASS-THROUGH
CRITERIA AND THE USE OF BAT OPTION II LIMITATIONS
(Continued)

Pollutant or Pollutant Property by Priority Pollutant Classes	Four Day Monthly Average (ppb)	Daily Maximum (ppb)
Miscellaneous		
3. Acrylonitrile	100	250
121. Cyanide	120	275
Polyaromatics		
39. Fluoranthene	45	140
55. Naphthalene	35	105
72. Benzo(a)anthracene	35	105
73. Benzo(a)	35	105
74. 3,4-Benzofluoranthene	35	105
76. Chrysene	35	105
77. Acenaphthylene	35	105
78. Anthrcene	35	105
80. Fluorene	35	105
81. Phenanthrene	35	105
84. Pyrene	40	135
Chloroaromatics		
9. Hexachlorobenzene	20	40
27. p-Dichlorobenzene	20	40
Phthalate Esters		
66. bis(2-Ethylhexyl)phthalate	45	130
68. Di-n-butyl phthalate	40	80
70. Diethyl phthalate	90	215
71. Dimethyl phthalate	20	50
Nitroaromatics		
35. 2,4-Dinitrotoluene	310	540
36. 2,6-Dinitrotoluene	340	555
56. Nitrobenzene	285	480

TABLE 2

PSES OPTION I LIMITATIONS FOR POLLUTANTS
SELECTED BASED ON THE 5 PERCENT PASS-THROUGH
CRITERIA AND THE USE OF BAT OPTION II LIMITATIONS
(Concluded)

Pollutant or Pollutant Property by Priority Pollutant Classes	Four Day Monthly Average (ppb)	Daily Maximum (ppb)
Benzidines		
28. 3,3'-Dichlorobenzidine	320	450
Phenols		
34. 2,4-Dimethylphenol	20	35
Nitrophenols		
57. 2-Nitrophenol	35	55
58. 4-Nitrophenol	70	120
59. 2,4-dinitrophenol	75	130
60. 4,6-Dinitro-o-cresol	30	50
Chlorophenols		
21. 2,4,6-Trichlorophenol	115	260
24. 2-chlorophenol	35	125
31. 2,4-Dichlorophenol	45	130
64. Pentachlorophenol	65	100

TABLE 3

POLLUTANTS CONTROLLED BY PSES OPTION II
ON THE BASIS OF POTW INTERFERENCE

Pollutant or Pollutant Property by Priority Pollutant Classes	Four Day Monthly Average (ppb)	Daily Maximum (ppb)
Halogenated Methanes (C1's)		
6. Carbon tetrachloride	15	30
23. Chloroform	20	40
44. Methylene chloride	15	20
Chlorinated C2's		
10. 1,2-Dichloroethane	35	95
11. 1,1,1-Trichloroethane	25	65
14. 1,1,2-Trichloroethane	25	65
29. 1,1-Dichloroethylene	25	65
30. 1,2-trans-Dichloroethylene	25	65
85. Tetrachloroethylene	25	65
87. Trichloroethylene	25	65
88. Vinyl chloride	25	65
Chlorinated C3's		
32. 1,2-Dichloropropane	110	265
Aromatics		
4. Benzene	30	85
86. Toluene	35	115
Chloroaromatics		
7. Chlorobenzene	40	115
9. Hexachlorobenzene	20	40
25. o-Dichlorobenzene	80	145
26. m-Dichlorobenzene	25	35
27. p-Dichlorobenzene	20	40

such as steam stripping, activated carbon, and chemical precipitation. This was done based on the receipt of preliminary sampling data which indicated that pollutant removals for in-plant controls approximated pollutant removals obtained by BAT treatment systems. However, upon receipt of the entire toxic pollutant data base, it became apparent that for 13 of the 58 PSES Option II priority pollutants, demonstrated physical/chemical effluent concentrations were essentially higher than BAT treatment effluent concentrations. Table 4 lists the 13 pollutants and their respective BAT and PSES effluent concentrations. Because of this incorrect assumption, additional treatment would be required (and costed) to achieve BAT level PSES for these 13 pollutants.

In an attempt to estimate the actual costs which will be incurred for compliance with the PSES effluent limitations and the associated economic impacts, a random sample of 30 indirect dischargers was selected and each plant's estimated raw waste toxic pollutant loading was examined to determine the pollutants which would require additional treatment because the plant's effluent levels were greater than the PSES Option II effluent limitations. Since PSES Option II regulates more pollutants than PSES Option I, the use of PSES Option II provides the most conservative approach which would yield the highest potential costs and impacts. The costing scenario included in-plant treatment costs as well as costs for certain additional treatment technologies for the 13 pollutants--eight organic toxic pollutants, four toxic pollutant heavy metals and cyanide. Table 5 lists the treatment technologies which were costed to estimate the increase in costs due to these 13 pollutants. For 5 of the 30 plants, biological treatment (activated sludge) was costed in addition to the appropriate in-plant controls because at least one of the eight organic toxic pollutants or cyanide appeared in the plant's effluent at greater than BAT effluent levels. Multimedia filtration was costed in addition to chemical precipitation for 19 plants because at least one of the four toxic pollutant heavy metals appeared above the BAT effluent levels. Table 6 presents the costs generated which were used to estimate the increase due to these 13 pollutants. The average cost increases in adding the technolgies for the 13 pollutants across the 30 plant sample are 226 percent for land costs, 56 percent for capital equipment, and 11 percent for operation and maintenance costs. Sludge costs were not projected to increase. These increases were

TABLE 4

TOXIC POLLUTANTS WITHOUT OCPSF PHYSICAL/CHEMICAL TECHNOLOGY PERFORMANCE DATA OR OCPSF PHYSICAL/CHEMICAL CONTROL HIGHER THAN BAT

	POLLUTANTS	BAT LONG-TERM MEDIAN (PPB)	PSES LONG-TERM MEDIAN (PPB)
24.	2-Chlorophenol	10.0	175
34.	2,4-Dimethyphenol	10.6	175
59.	2,4-Dinitrophenol	50.0	175
72.	Benzo(a)anthracene	10.0	1,418
73.	Benzo(a)pyrene	10.0	175
74.	3,4-Benzofluoranthene	10.0	175
76.	Chrysene	10.0	1,418
84.	Pyrene	12.6	1,418
121.	Cyanide	64.9	--
122.	Lead	100.0	--
123.	Mercury	1.03	--
125.	Selenium	12	--
128.	Zinc	69.5	107

TABLE 5

TECHNOLOGIES COSTED FOR PSES 30 PLANT
INDIRECT DISCHARGER COST CORRECTIONS

PLANT	ORIGINAL PHYSICAL/CHEMICAL TREATMENT COSTED FOR PSES OPTION II	REVISED TREATMENT SYSTEM COSTED FOR PSES OPTION II
71	SS, CP, AC	SS, CP, AC, F
423	CP	CP, F
749	SS, AC, CP	SS, AC, CP, F
797	CP, SS, AC	CP, SS, AC, BIO
830	SS	SS
845	CP	CP, F
862	SS, CP	SS, CP, F
997	SS	SS
1126	SS, AC, CP	SS, AC, CP, + BIO
1181	SS, AC, CP	SS, AC, CP, F
1188	NO COSTS	NO COSTS
1219	SS, AC, CP	SS, AC, CP, F
1237	SS, AC	SS, AC
1322	SS, AC	SS, AC
1426	SS, AC, CP	SS, AC, CP, + (BIO)
1528	SS	SS
1534	SS, CP	SS, CP, F
1621	CP	CP, F
1773	SS, CP	SS, CP, F
1861	CP	CP, F
2070	SS, AC, CP	SS, AC, CP, F
2129	SS, AC, CP	SS, AC, CP, + BIO
2300	SS, CP	SS, CP, F
2346	CP	CP, F
2411	CP	CP, F
2609	CP	CP, F
2635	SS, AC	SS, AC
2679	CP	CP + F
2714	CP	CP + F
2776	SS, AC, CP	SS, AC, CP, + BIO

NOTE: SS - STEAM STRIPPING
CP - CHEMICAL PRECIPITATION
AC - ACTIVATED CARBON
F - MULTIMEDIA FILTRATION
BIO - ACTIVATED SLUDGE

COSTS FOR PSES 30 PLANT INDIRECT DISCHARGER COST CORRECTIONS

PLANT	FLOW	ORIGINAL COSTS			REVISED COSTS			ANNUAL SLUDGE* DISPOSAL COSTS ($/YR)	ANNUAL MONITORING* COSTS ($/YR)
		CAPITAL ($)	O&M ($/YR)	LAND ($)	CAPITAL ($)	O&M ($/YR)	LAND ($)		
71	.032	536,898	269,394	29,122	754,750	294,797	32,440	24,256	3,240
423	.375	404,240	57,864	6,962	885,080	105,096	12,278	284,250	4,080
749	.040	583,857	200,582	14,608	817,284	227,454	17,949	30,320	3,240
797	.010	366,723	101,664	10,050	505,001	117,086	159,450	7,580	4,080
830	.00074	208,734	3,607	8,754	208,734	3,607	8,754	--	3,240
845	.0371	118,908	16,686	834	346,731	43,053	4,164	28,122	4,080
862	.060	414,210	133,515	14,468	680,289	163,278	17,913	45,480	3,240
997	.0135	241,861	34,884	8,277	241,861	34,884	8,277	--	4,080
1126	.510	3,949,813	991,296	78,287	9,264,430	1,210,886	405,287	227,460	7,080
1181	.025	486,873	140,936	36,375	687,431	164,807	39,696	18,950	4,080
1188	.065	0	0	0	0	0	0	--	4,080
1219	.353	2,715,282	583,864	92,717	3,186,826	630,382	97,917	267,574	3,240
1237	.00702	290,981	43,210	97,570	290,981	43,210	97,570	--	4,080
1322	.1625	808,333	421,003	62,686	808,333	421,003	62,686	--	3,240
1426	.00374	298,353	34,250	19,684	376,469	48,778	463,684	2,805	4,080
1528	.00121	214,006	5,297	5653	214,006	5,297	5,653	--	3,240
1534	.004	730,161	85,706	7,513	1,279,486	138,111	13,779	252,614	4,080
1621	.150	248,967	35,359	6,734	606,656	72,853	10,762	113,700	4,080
1773	.004	263,992	18,523	2,915	813,317	70,928	9,181	3,032	3,240
1861	.0567	148,816	20,960	2,931	410,079	50,302	6,356	42,979	4,080
2070	.260	2,607,971	584,024	82,859	3,035,180	627,092	87,549	197,080	4,080
2129	.049	667,426	386,049	45,757	957,785	402,611	445,357	37,142	4,080
2300	2.936	1,518,364	2,514,884	19,376	2,452,875	2,594,218	34,779	422,784	4,080
2346	1.087	709,783	102,531	7,762	1,387,806	164,292	16,302	156,528	7,080
2411	.511	476,131	68,335	13,611	1,007,499	119,398	19,611	227,906	7,080
2609	.0469	134,604	18,927	1,225	380,339	46,899	4,596	35,550	4,080
2635	.935	3,707,276	1,123,319	69,625	3,707,276	1,123,319	69,625	--	4,080
2679	.225	308,524	43,970	8,603	716,248	85,497	13,090	170,550	4,080
2714	.00073	14,886	2,020	349	78,965	11,818	9,143	544	4,080
2776	.0581	718,155	445,936	48,539	1,118,185	463,624	448,139	44,040	4,080

*Annual sludge disposal and annual monitoring costs did not change.

applied for all plants. The projected economic impacts are presented in the appropriate supporting documents.

For the organic toxic pollutants and cyanide, biological treatment plus in-plant controls forms the principal technology basis for BAT Option II and therefore, should accurately reflect the costs necessary to attain PSES. The addition of multimedia filtration after chemical precipitation is a proven method of reducing heavy metals concentrations in the metal finishing, inorganic chemicals and other industries which generate heavy metals in their raw wastewaters. Data from the metal finishing industry show incremental percent removals with the addition of filtration of 44 percent for total chromium, 55 percent for total copper, 32 percent for total lead, 42 percent for total nickel and 55 percent for total zinc. Therefore, the costing of filtration is felt to be an adequate cost estimation technology which can lower the in-plant control effluent values for chemical precipitation to within an acceptable range of the BAT effluent levels.

For all other pollutants, as noted, the costing procedures assumed that in-plant treatment would be sufficient to achieve compliance with the PSES limitations. The treatment capability of steam stripping has already been discussed with respect to BAT. For the activated carbon assessment, the organic priority pollutants were divided into three groups (high, medium, and low) based on their in-plant carbon usage rates--pounds of pollutant adsorbed per pound of carbon. Table 7 presents the pollutants that are contained in each of these groups and the average carbon adsorption effluent values for the pollutants with data are noted. By assuming that compounds in each group behave similarly, group median effluent vaues were calculated for costing purposes--a median of nondetect represents both the high and medium adsorption groups since data was available for the medium group only and a median of 175 ppb represents the low adsorption group.

For the 52 organic toxic pollutants regulated at PSES Option II, the steam stripping and activated carbon assessment demonstrates that these controls can achieve the same or lower long-term concentrations for 33 organics, essentially the same concentrations (within 2 ppb) for 11 others

TABLE 7

PRIORITY POLLUTANTS GROUPED ACCORDING TO IN-PLANT TREATMENT CARBON USAGE RATES WITH AVERAGE CARBON ADSORPTION EFFLUENT VALUES (PPB)

High (11.3 to 0.2)	Medium (0.19 to 0.091)	Low (0.090 to 0.00059)
Bis (2-Ethylhexyl) Phthalate	Acenapthene	2,4-Dimethylphenpol
Butyl Benzyl Phthalate	4,4' Methylene-Bis (2-Choroaniline)	4-Nitrophenol-50
Fluoranthene	Benzo (k) Fluoranthene	Dibenzo (a,h) Anthracene
Hexachlorobenzene	4,6-Dinitro-O-Cresol-ND	Nitrobenzene-175
Anthracene	2,4-Dichlorophenol	3,4-Benzo Fluoranthene
Fluorene	1,2,4-Trichlorobenzene	Ethylbenzene
3,3-Dichlorobenzidine	2,4,6-Trichlorophenol	2-Chlorophenol
2-Chloronaphthalene	Pentachlorophenol	Tetrachloroethene
Hexachlorobutadiene	2,4-Dinitrotoluene-ND	Benzo (a) Pyrene
Benzidine Dihydrochloride	2,6-Dinitrotoluene-ND	2,4-Dinitrophenol-611
N-Butyl Phthalate	4-Bromophenyl Phenyl Ether	Isophorone
N-Nitrosodiphenylamine	Naphthalene	Trichloroethene
Phenanthrene	1,2-Dichlorobenzene	Toluene
	1,4-Dichlorobenzene	N-Nitrosodi-N-Propylamine
Group	1,3-Dichlorobenzene	Bis (2-Chloroisopropyl) Ether
Median = Assumed Not Detect Based on Median of Medium Group	Acenaphthylene	Phenol
	Diethyl Phthalate	Benzo (a) Anthracene
	4-Chlorophenyl Phenyl Ether	Bromoform
	2-Nitrophenol-ND	Carbon Tetrachloride
	Dimethyl Phthalate	Bis (2-Chloroethoxy) Methane
	Hexachloroethane	Benzo (ghi) Perylene
	Chlorobenzene	1,1,2,2-Tetrachloroethane
		Dichlorobromomethane
	Group	1,2-Dichloropropane
	Median = Not Detect	1,1,2-Trichloroethane
		1,1-Dichloroethylene
		2-Chloroethyl Vinyl Ether
		1,2-Dichloroethane
		1,2-Trans-Dichloroethene
		Chloroform
		1,1,1-Trichloroethane
		1,1-Dichloroethane
		Acrylonitrile
		Methylene Chloride
		Acrolein
		Benzene
		Chloroethane
Carton usage rate units are lbs of pollutant adsorbed per lb of carbon		Group Median = 175 ppb

(benzene, carbon tetrachloride, 1,1,1-trichloroethane, chloroform, 1,1-dichloroethylene, 1-2-trans-dichloroethylene, dichlorobromomethane, tetrachloroethylene, toluene, trichloroethylene, and vinyl chloride) and higher concentrations (ranging from 125 to 1,418 pbb) for the remaining 8 organics (2,4-dimethylphenol, 2-chlorophenol, 2,4-dinitrophenol, and 5 polyaromatics--benzo(a)anthracene, benzo(a)pyrene, 3,4-benzofluoranthene, chrysene, and pyrene). In the case of the polyaromatics, biological treatment may provide more cost-effective control than steam stripping or activated carbon (depending on the specific compound or combination of compounds in the wastewater)--at least one indirect discharge facility for which toxic pollutant data exist, has installed biological treatment to achieve long-term effluent concentrations at or near the analytical method detection levels.

For cyanide and the 5 toxic pollutant metals regulated at PSES Option II, OCPSF physical/chemical performance data is available only for arsenic and zinc. Data for chemical precipitation demonstrates that physical/chemical treatment alone can achieve lower concentrations for arsenic than BAT control; however, for zinc, chemical precipitation performance is 38 ppb higher than the BAT long-term average.

A third PSES option which may be employed if PSES Option II proves to be economically unachievable is to set PSES at levels achievable by physical/chemical treatment alone. Under this option, PSES would equal BAT for most pollutants but would be higher (less stringent) for the 13 priority pollutants discussed above. Table 8 presents the PSES Option III limitations that would apply to these 13 pollutants.

The long-term averages for benzo(a)anthracene, chrysene and pyrene in Table 8 are based on the steam stripping median value for the low Henry's Law constant pollutant group. For benzo(a)pyrene, 3,4-benzofluoranthene, 2,4-dimethylphenol, 2,4-dinitrophenol and 2-chlorophenol, the long-term averages are based on the in-plant carbon adsorption median value for the low carbon usage rate pollutant group. The zinc long-term average is based on the OCPSF industry chemical precipitation data. The long-term averages for lead, mercury, selenium and cyanide are based on chemical precipitation performance

TABLE 8

PSES OPTION III LIMITATIONS THAT WOULD APPLY TO
POLLUTANTS WITH HIGHER PHYSICAL/CHEMICAL EFFLUENTS THAN BAT

Pollutant or Pollutant Property by Priority Pollutant Classes	Long-Term Average	Four-Day Monthly Average	Daily Maximum
Polyaromatics			
72. Benzo(a)anthracene	1,418	1,795	2,710
73. Benzo(a)pyrene	175	300	570
74. 3,4-Benzofluoranthene	175	300	570
76. Chrysene	1,418	1,795	2,710
84. Pyrene	1,418	1,795	2,710
Phenols			
34. 2,4-Dimethylphenol	175	300	570
Nitrophenols			
59. 2,4-Dinitrophenol	175	300	570
Chlorophenols			
24. 2-Chlorophenol	175	300	570
Metals			
122. Lead	122	215	495
123. Mercury	1	2	4.5
125. Selenium	162	285	660
128. Zinc	107	180	380
Miscellaneous			
121. Cyanide	46	85	190

information from the inorganic chemicals, paint and ink, and steam electric power generating industries. These values were obtained by comparing OCPSF median raw waste levels of these pollutants to other industries looking for similar raw waste levels in industries which were comparable in wastewater matrices to the OCPSF industry. Appendix A contains the summary sheets from the EPA Treatability Manual which most favorably compare to OCPSF raw waste levels. The corresponding variability factors for the stream stripping systems are averages transferred from 2,4,6-trichlorophenol and pentachlorophenol. The carbon adsorption variability factors are transferred from nitrobenzene. The OCPSF industry zinc chemical precipitation variability factors were used for zinc, while averages for arsenic, chromium, copper and zinc were transferred to lead, mercury, selenium, and cyanide.

APPENDIX A

SELECTED SUMMARY SHEETS
FROM THE EPA TREATABILITY MANUAL
EPA 600/8-80-042e, JULY 1980

TREATMENT TECHNOLOGY: Sedimentation with Chemical Addition (Alum, Lime)

Data source: Effluent Guidelines

Data source status:

Engineering estimate	___
Bench scale	___
Pilot scale	___
Full scale	x

Point source category: Paint manufacturing
Subcategory:
Plant: 4
References: A4, Appendix G

Use in system: Primary
Pretreatment of influent: None

DESIGN OR OPERATING PARAMETERS

Unit configuration:
Wastewater flow:
Chemical dosage(s):
Mix detention time:
Mixing intensity (G):
Flocculation (GCt):
pH in clarifier:
Clarifier detention time:
Hydraulic loading:
Weir loading:
Sludge underflow:
Percent solids in sludge:
Scum overflow:

REMOVAL DATA

Pollutant/parameter	Concentration,[a] Influent	Effluent	Percent removal
Conventional pollutants, mg/L:			
BODs	3,300	3,900	(18)
COD	147,000	7,970	95
TOC	13,000	2,300	82
TSS	14,000	480	97
Oil and grease	830	<16	>98
Total phenol	1.1	1.3	(18)
Toxic pollutants, µg/L:			
Copper	500	60	88
Cyanide	150	30	80
Lead	370	<200	50
Mercury	7	2	71
Zinc	170,000	1,100	>99
Di-n-butyl phthalate	6,500	ND	~100
Phenol	1,300	47	96
Benzene	92	46	50
Ethylbenzene	1,230	22	98
Toluene	1,900	72	96
Naphthalene	54	16	70
Carbon tetrachloride	12	ND	~100
Chloroform	16	74	(363)
1,2-Dichloropropane	968	400	59
Methylene chloride	2,300	2,000	13
1,1,2,2-Tetrachloroethane	50	35	30
Tetrachloroethylene	270	13	95

[a] Average of several samples.

Note: Blanks indicate information not specified.

Date: 6/8/79

From the EPA Treatability Manual, EPA 600/8-80-042e, July, 1980.

TREATMENT TECHNOLOGY: Sedimentation with Chemical Addition (Ferrous sulfate, lime)

Data source: Effluent Guidelines
Point source category: Steam electric power generating
Subcategory:
Plant: 5409
References: A2, p. 24 (Appendix)

Data source status:
Engineering estimate ___
Bench scale ___
Pilot scale x
Full scale ___

Use in system: Secondary
Pretreatment of influent: Ash pond

DESIGN OR OPERATING PARAMETERS

Unit configuration:
Wastewater flow:
Chemical dosage(s):
Mix detention time:
Mixing intensity (G):
Flocculation (GCt):
pH in clarifier: 11.5
Clarifier detention time:
Hydraulic loading:
Weir loading:
Sludge underflow:
Percent solids in sludge:
Scum overflow:

REMOVAL DATA

Sampling period:

Pollutant/parameter	Concentration, µg/L Influent	Effluent	Percent removal
Toxic pollutants:			
Antimony	5.0	3.5	30
Arsenic	74	<1	>99
Copper	26	18	31
Nickel	2.5	2.0	20
Selenium	42	32	24
Silver	1.0	1.1	0[a]
Thallium	9.0	7.0	22
Zinc	11	<2.0	>82

[a]Actual data indicate negative removal.

Note: Blanks indicate information was not specified.

TREATMENT TECHNOLOGY: Sedimentation with Chemical Addition (Lime)

Data source: Effluent Guidelines
Point source category: Inorganic chemicals
Subcategory: Hydrofluoric acid
Plant: 167
References: A29, p. 227

Data source status:
Engineering estimate ___
Bench scale ___
Pilot scale ___
Full scale x

Use in system: Primary
Pretreatment of influent:

DESIGN OR OPERATING PARAMETERS

Unit configuration: 47% of effluent is recycled
Wastewater flow: 127 m^3/kkg[a]
Chemical dosage(s):
Mix detention time:
Mixing intensity (G):
Flocculation (GCt):
pH in clarifier:
Clarifier detention time:
Hydraulic loading:
Weir loading:
Sludge underflow:
Percent solids in sludge:
Scum overflow:

[a]Value is for total raw waste from HF only.

REMOVAL DATA

Sampling period: Three 24-hr composite samples

Pollutant/parameter	Concentration,[a] µg/L Influent	Effluent	Percent removal
Toxic pollutants:			
Antimony	46	<200	0[b]
Arsenic	150	<24	>84
Cadmium	-	<2.4	-
Chromium	470	250	47
Copper	120	79	34
Lead	87	37	57
Mercury	27	<1.2	>96
Nickel	1,100	610	45
Selenium	63	87	0[b]
Thallium	-	7.9	-
Zinc	240	180	25

[a]Values are combined for wastes from HF and AlF_3. Concentration data is calculated from pollutant flow in m^3/kkg and pollutant loading in kg/kkg.

[b]Actual data indicate negative removal.

Note: Blanks indicate information was not specified.

Date: 8/30/79

VI. EVALUATION OF THE VALIDITY OF USING FORM 2C DATA TO CHARACTERIZE PROCESS AND FINAL EFFLUENT WASTEWATER

FINAL

EVALUATION OF THE VALIDITY OF USING FORM 2C DATA TO CHARACTERIZE PROCESS AND FINAL EFFLUENT WASTEWATER

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VI. EVALUATION OF THE VALIDITY OF USING FORM 2C DATA TO CHARACTERIZE PROCESS AND FINAL EFFLUENT WASTEWATER

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1.0 INTRODUCTION

1.1 BACKGROUND

Industry comments on the March 21, 1983, proposed OCPSF regulations stated that the toxic pollutant loadings were overestimated and suggested that the Agency rely on the NPDES permit application Form 2C toxic pollutant data for determining toxic pollutant loadings. Industry representatives also questioned the need to establish BAT Limitations on a wide range of toxic pollutants. They maintain that available NPDES Permit application Form 2C data constitute the most appropriate and extensive data base for predicting the extent of occurrence of priority pollutants in the OCPSF industry. They argue that NPDES Form 2C data submitted by OCPSF manufacturers indicate that only a few priority pollutants are detected in treated discharges and conclude that existing treatment systems, installed principally for the control of conventional pollutants, do an excellent job of controlling priority pollutant discharges.

The purpose of this report is to evaluate the validity of the industry's interpretation of effluent data in general and NPDES Form 2C toxic pollutant data in particular.

1.2 SUMMARY AND CONCLUSIONS

Since the OCPSF regulations apply to process wastewater only, the Agency determined the relative contributions of process and nonprocess wastewater at the effluent sample sites. This data was used to calculate plant-by-plant "dilution factors" for use in adjusting or assessing analytical data at effluent sampling locations. This information was used to determine if reported Section 308 and Form 2C final effluent concentration data could be used to adequately characterize actual process wastewater pollutant parameter concentrations. For example, if a pollutant was reported as 30 ppb at the final effluent sampling location

with 1 MGD of process wastewater flow and 9 MGD of noncontaminated nonprocess cooling water flow, then the concentration of the pollutant in the process wastewater was actually 300 ppb. Similarly, if the same plant reported that another pollutant was not detected at the same sampling location and the analytical method detection limit was 10 ppb, then the other pollutant concentration in the process wastewater could be as high as 90 ppb without being detected in the diluted final effluent.

One hundred-six plants reported Form 2C toxic pollutant data in the 1983 Section 308 Questionnaire. Of these, 70 plants diluted the process wastewater before the effluent Form 2C sampling point. The following table relates the number of plants with Form 2C data to the range of dilution at the effluent sampling point.

No. of Plants with Form 2C Data (%)	Range of Dilution in Percent
36 (34%)	0
20 (19%)	>0 to 25
20 (19%)	>25 to 100
17 (16%)	>100 to 500
13 (12%)	>500 to 6,054

The Agency was also able to identify 12 facilities that reported measured toxic pollutant concentrations of treated process wastewater both before and after dilution with nonprocess wastewater. In general, analyzing the diluted effluents yielded underestimated or undetected values for organic toxic pollutants that were measured in the undiluted process wastewater. However, this was not generally the case for toxic pollutants metals such as cadmium, chromium, lead, and cyanide. These metals are commonly found in cooling water additives that may be utilized to inhibit biological growth or the formation of rust and scale in cooling equipment. Therefore, the presence of a portion of these metals in the diluted effluent seems to be caused by the nonprocess cooling

water. Therefore, the assumption that the nonprocess dilution wastewater is relatively clean seems to apply to the organic toxic pollutants but not necessarily to all of the toxic metal parameters.

In conclusion, the use of unqualified plant effluent data which includes dilution with nonprocess wastewater, does not provide an adequate assessment of process wastewater pollutant constituents and concentrations. The use of unqualified industry supplied Form 2C data tends to underestimate organic toxic pollutant constituents and concentrations in process wastewater and may actually overestimate metal toxic pollutant constituents and concentrations. Furthermore, keeping these constraints in mind, process wastewater pollutant concentrations can be predicted on a case-by-case basis (especially for conventional pollutant parameters) using a dilution factor and the overall plant effluent quality.

1.3 SELECTION OF PLANTS WITH FORM 2C APPLICATION AND 308 QUESTIONNAIRE DATA

308 Questionnaires were reviewed and all direct discharging plants (249) submitting full responses were separated from all other types of plants (indirects, zeros). One hundred and thirteen (113) of these plants did not dilute their process wastewaters at all, while 70 plants that submitted Form 2C application data and 66 plants that submitted questionnaire data had some form of dilution.

There were 100 plants that did not submit toxic pollutant data, (only conventional pollutants) but had their process wastewaters diluted. Conventional pollutants for these plants were adjusted to reflect the changes resulting from dilution.

1.4 SELECTION OF INDUSTRIAL FACILITIES

Industrial facilities were selected for inclusion in this study if data were available for both final effluent (Form 2C), and intermediate process streams. The availability of both sets of data for a facility made it possible to compare overall effluent quality and process effluent quality. In addition facilities showing substantial additions of nonprocess wastewater to process effluents immediately upstream of monitoring points were also included for consideration. These facilities proved useful in demonstrating the effect of nonprocess waters upon the characterization of process effluents.

Facilities meeting the preceding criteria were obtained by reviewing 308 Questionnaire data submitted by organic chemical manufacturers, and Draft Engineering Reports prepared by JRB for the development of BAT and BPT permit limitations for industrial facilities in New Jersey. A total of thirteen industrial facilities were obtained for use in this study. Four of the facilities included are from JRB's permit development files, and the remaining nine are from the OCPSF 308 Questionnaire data.

2.0 METHODOLOGY CALCULATIONS AND DATA ANALYSIS

2.1 GENERAL METHODOLOGY

2.1.1 Sampling Data

The approach used in determining the viability of using overall plant effluent quality to characterize process wastewater discharges was to compare data for process effluents only and total discharges for each facility. In this manner it was possible to discern whether data obtained at a final outfall truly reflected the contribution and strength of process wastewater flow. The comparison was of particular importance if the overall effluent showed a pollutant to be below the level of detection, while the process effluent reported higher levels.

2.1.2 Dilution Factor: Definition and Calculations

In order to collect data that would most accurately characterize process effluents in the absence of actual data, a term called the dilution factor was developed. It is equal to the quotient of the nonprocess flow divided by the process flow. The dilution factor (plus one) for each facility multiplied by the corresponding reported final effluent concentration, generated an adjusted concentration which was considered to characterize, in an approximate manner, the process effluent before the addition of other flows. This assumed no contamination of the nonprocess wastewaters or minimal background of pollutants. Other minor contaminated nonprocess wastewaters, such as boiler blowdown, were not considered appropriate for inclusion because of their unknown quality. Table 1 presents the miscellaneous wastewaters that were considered process and nonprocess wastewaters for the purposes of calculating the dilution factor.

2.1.3 Plants with Dilution of their Process Wastewaters

Two hundred and forty-nine (249) plants in the OCPSF industry that submitted full responses (parts A, B, and C) to the 308 questionnaires are direct dischargers. These plants are presented in Table 2. The purpose of this study was to determine what plants diluted their process wastewaters with nonprocess waters as defined in Table 1. A total of 113 facilities either did not dilute their process wastewaters or did not provide accurate treatment system information to determine if dilution was occurring.

A review of the 308 questionnaires indicates that certain plants submitted Form 2C application data (for toxic pollutants) in questions C13 to C16 of the questionnaire (Table 4). Seventy of these plants diluted their process wastewaters with nonprocess water (Table 5).

Other plants submitted only questionnaire toxic pollutant data for questions C13 to C16 (Table 6). Sixty-six of these plants diluted their process wastewater streams, they are presented in Table 7.

As mentioned earlier, some plants did not report toxic pollutant data when they submitted their 308 Questionnaires, but were found to have diluted their process wastewater streams. There are 100 plants with conventional pollutant data; these are presented in Table 8.

There were 106 plants that submitted Form 2C toxic pollutant data of which 70 diluted their process wastewaters. This represents 66% of all plants that submitted Form 2C data. Likewise 109 plants submitted questionnaire toxics data but only 66 plants with dilution. This represents 61% of all plants that submitted questionnaire data (Tables 9 and 10).

Bar graphs are presented to illustrate the range of percent dilution for the Form 2C, questionnaire, and conventional pollutant data discussed earlier (Bar graphs 1, 2, and 3 and Tables 11 to 13). This data indicates that 29 to 35% of all plants are diluted in the range 0-25 while 33 to 48% of all plants are diluted greater than 100%.

Table 14 presents dilution factors developed from 308 questionnaire data covering a variety of OCPSF product/processes for the parameters TOC, COD, TSS, and BOD_5. Dilution factors range from 0.00031 to 2,519; and the adjusted pollutant concentrations are affected accordingly. This table also shows the variability in concentrations between the adjusted and reported conventional pollutant parameters.

These results indicate that there can be considerable differences between the reported and actual pollutant concentrations submitted by OCPSF plants, and that there is considerable dilution of process wastewaters with nonprocess waters by plants that submitted priority pollutant, and conventional pollutant data. Approximately 55% of all plants that submitted toxic data were found to have diluted their process wastewaters with nonprocess water.

2.1.4 Draft Engineering Permit Report Data

Intermediate and final discharge data were obtained for four industrial facilites from JRB's files. The facilities are listed below:

1. Plant number A - An Oil Refinery Facility
2. Plant number B - A Bulk Organics Facility
3. Plant number C - A Pharmaceuticals Facility
4. Plant number D - A Speciality Organics Plant

Data for these facilities are presented in Tables 15 through 20. In general, the data present for the facilities show that concentrations of pollutant parameters measured at combined outfalls which include nonprocess flow are markedly lower than the levels measured directly at process outfalls. This is a good indication that pollutant data obtained from a final outfall is not truly indicative of the effluent quality of a process discharge.

Data presented in Tables 16 and 18, are of particular importance because several pollutant parameters which were reported in the final outfalls at concentration levels below those of detection were present at concentration levels above detection at isolated process discharge points. Nominal detection levels for pollutant parameters are presented in Appendix B. These occurrences are especially meaningful because they indicate that analyses of combined outfall effluents do not necessarily provide a true characterization of process wastewater quality.

2.1.5 308 Questionnaire Data

308 Questionnaire Data was reviewed to obtain facilities with available intermediate and final effluent data. These facilities are presented in Tables 21 through 28. As mentioned before, facilities were selected on the basis of their process flows undergoing dilution with nonprocess flows immediately preceding sampling sites. The data tabulated includes pollutant levels reported at final outfalls, and calculated adjusted concentrations which represent isolated process flows.

2.2 DATA ANALYSIS

2.2.1 Analysis of OCPSF Section 308 Information

Plant data from the 1983 Section 308 Questionnaires were analyzed by comparing total facility effluent quality with process effluent quality before

mixing. Tables 15 through 26 present the data obtained. Examination and comparison of the data for each plant indicates that the final facility effluent quality is not truly indicative of process effluent quality. Final discharge concentrations are noticeably lower than concentrations in undiluted process streams. In those cases where total effluent concentrations are below detection limits, virtually no indication of process quality is provided. This is illustrated in Table 18. Chloroform, ethylbenzene, and 1,4-dichlorobenzene were all reported to be undetected in the overall facility effluent, but were reported in varying quantities in the process effluent. In this case, the overall effluent quality is not indicative of the process effluent quality. Additionally the variations in the concentrations of the three pollutants in the process discharge indicate that the application of a dilution factor based on process and total flows, to project process effluent quality, is not totally accurate for this particular facility. It is also true for Plant A whose data were presented in Table 15. Concentrations reported at Plant A's treatment plant, representative of process effluent, were greater than those reported at the main outfall for BOD_5, TSS, phenols, oil & grease, and zinc. However, calculation of a dilution factor, based on reported concentrations, yields values ranging from 3.12 to 7.39. The actual dilution factor calculated for the facility, based on flow data, is 17.875. For those pollutants reported at higher concentrations in the main outfall than in the treatment plant effluent, it is no longer reasonable to speak about dilution with respect to the process effluent. For these pollutants, which include cadmium, chromium, lead, and cyanide, it is actually the cooling water that is being diluted with process effluent. Table 15 also indicates that pollutant loadings may be primarily caused by contributions from nonprocess sources. The loading attributable to the noncontact cooling water, which mixes with the treatment plant effluent prior to the main outfall sampling point, was calculated using the appropriate flow based dilution factor.

Therefore, the strict use of a dilution factor to project process effluent quality is not reliable in all cases and its limitations should be known on a plant-by-plant basis. It also may not be advisable to assume that noncontact cooling water is devoid of pollutants in all cases.

2.2.2 308 Questionnaire Data Analysis

Data from those industrial facilities obtained from a review of 308 Questionnaire information, were analyzed by projecting adjusted concentrations based on reported concentrations and appropriate dilution factors. Although the dilution factor is not considered rigorously applicable to the accurate calculation of process pollutant concentrations, as discussed in Section 2.2.1, it was deemed reasonable to use it to estimate such concentrations, lacking additional data, and keeping in mind its limitations. Comparison of reported and adjusted concentrations for the nine industrial facilities presented in Tables 21 through 28 shows adjusted concentrations with the degree of difference being dependent upon the associated dilution factor. Large dilution factors resulted in larger adjusted concentrations than smaller dilution factors, given equal reported concentrations. Dilution factors for the facilities that submitte toxic pollutant data ranged from 0.748 to 60.54.

TABLE 1

Miscellaneous Wastewater Generation

#	Process	Non-Process (Dilution)
1	Air Pollution Control Wastewater	Non-Contact Cooling Water (one pass)
2	Sanitary (receiving biological trt.)	Sanitary (no biological trt., direct disch
3	Boiler blowdown	Cooling Tower Blowdown
4	Sanitary (indirect discharge)	Stormwater Site Runoff
5	Steam Condensate	Deionized Water Regeneration
6	Vacuum Pump Seal Water	Miscellaneous Wastewater (conditional)
7	Wastewater Stripper Discharge	Softening Regeneration
8	Biol. from Vertac	Ion Exchange Regeneration
9	Boiler Feedwater Lime	River Water Intake
10	Softener Blowdown	Make-up Water
11	Contaminated Water Offsite	Fire Water Make-up
12	Condensate	Tank Dike Water
13	Storage, Labs, Shops	Demineralizer Regenerant
14	Laboratory Waste	Dilution Water
15	Steam Jet Condensate	Condensate Losses
16	Water Softener Backwashing	Shipping Drains
17	Misc. Lab Wastewater	Water Treatment Blowdown
18	Raw Water Clarification	Cooling Tower Overflow
19	Landfill Leachate	Chilled Water Sump Overflow
20	Water Treatment	Air Compressor and Conditioning Blowdown
21	Technical Center	Firewall Drainings
22	Scrubber Water	Other Non-Contact Cooling
23	Utility Streams	Misc. Leaks and Drains
24	Washdown N-P Equipment	Boiler House Softeners
25	Contact Cooling Water	Fire Pond Overflow
26	Vacuum Steam Jet Blowdown	Boiler Regeneration Backwash
27	Densator Blowdown	Groundwater (Purge)
28	Bottom Ash-Quench Water	Firewater Discharge
29	Demineralizer Washwater	Freeze Protection Water
30	Water Softening Backwash	H_2 and CO Generation
31	Lab Drains	Demineralizer Spent Regenerants
32	Closed Loop Equipment Overflow	Lime Softening of Process
33	HVAC Blowdown	Miscellaneous Service Water
34	Filter Backwash	Recirculating Cooling System
35	Demineralizer Wastewater	
36	Laboratory Offices	
37	Demineralizer Blowdown	
38	Utility Clarifier Blowdown	
39	Steam Generation	
40	RO Rejection Water	

TABLE 1 (Cont.)

Miscellaneous Wastewater Generation

#	Process	Non-Process (Dilution)
41	Power House Blowdown	
42	Inert Gas Gen. Blowdown	
43	Contaminated Groundwater	
44	Potable Water Treatment	
45	Unit Washes	
46	Non-Contact Floor Cleaning	
47	Slop Water from Dist. Facilities	
48	Laboratory and Vacuum Truck	
49	Ion Bed Regeneration	
50	Tankcar Washing (HCN)	
51	Film Wastewater	
52	Generator Blowdown	
53	Ash Sluice Water	
54	Research and Development	
55	Quality Control	
56	Steam Desuperheating	
57	Pilot Plant	
58	Other DuPont Off-site Waste	
59	Ion Exchange Resin Rinse	
60	Iron Filter Backwash	
61	Area Washdown	
62	Vacuum Pump Wastewater	
63	Garment Laundry	
64	Hydraulic Leaks	
65	Grinder Lubricant	
66	Utility Area Process	
67	Contact Rainwater	

TABLE 2

DIRECT DISCHARGERS SUBMITTING FULL 308 QUESTIONNAIRE RESPONSES

PLANT NUMBER

1	387	682	984	1414	1767	2206	2447
12	392	683	990	1438	1774	2221	2450
61	394	695	991	1439	1776	2222	2461
63	399	709	1012	1446	1802	2227	2471.1
83	412	727	1020	1464	1839	2228	2471.2
87	415	741	1038	1494	1869	2236	2474
101	443	758	1059	1520	1881	2241	2527
102	444	775	1061	1522	1890.1	2242	2528
114	447	802	1062	1532	1890.2	2254	2531
154	481	811	1067	1569	1905	2268	2533
155	486	819	1133	1572	1911.1	2272	2536
159	500	825	1137	1593	1911.2	2296	2541
177	502	844	1139	1609	1928	2307	2551
180	523	851	1148	1616	1943	2313	2556
183	525	859	1149	1618	1973	2315	2573
225	536	866	1157	1624	1977	2328.1	2590
227	569	871	1203	1643	1986	2328.2	2592
250	580	876	1241	1647	2009	2345	2606
254	602	883	1267	1650	2020	2353	2626
260	608	888	1299	1656	2026	2360	2631
267	626	908	1319	1684	2049	2364	2633
269	633	909	1323	1688	2055	2365	2668
284	657	913	1327	1695	2062	2368	2673
294	659	915	1340	1698	2073	2376	2678
296	662	938	1343	1714	2090	2390	2680
352	663	942	1389	1717	2110	2394	2692
373	664	948	1407	1753	2148	2399	2693
384	669	970	1409	1766	2181	2400	2695
					2198	2430	
						2445	

TABLE 2 (continued)

2701
2711
2735
2763
2764
2767
2770
2771
2786
2795
2816
2818
3033
4002
4010
4017
4021
4037
4040
4051
4055

TABLE 3
PLANTS WITHOUT DILUTION

PLANT NUMBER

1	741	1624	2307
101	758	1643	2345
102	775	1647	2364
180	825	1650	2365
227	851	1656	2394
254	888	1684	2400
260	942	1714	2447
267	970	1753	2461
296	991	1769	2471.1
373	1059	1774	2471.2
392	1133	1776	2527
412	1139	1881	2541
415	1148	1905	2551
444	1157	1928	2556
481	1203	1973	2573
502	1267	1977	2590
523	1299	1986	2592
536	1327	2020	2606
569	1343	2049	2631
608	1349	2055	2701
626	1407	2073	2770
633	1414	2198	2816
659	1438	2206	3033
662	1446	2221	4002
663.1	1464	2236	4021
663.2	1520	2254	4037
664	1522	2272	4055
669	1572	2296	
683	1593		
709			

TABLE 4

PLANTS WITH 2C DATA

1	844	1656	2450
63	859	1688	2461
83	876	1717	2474
102	883	1753	2531
114	887	1853	2551
154	909	1869	2556
159	913	1881	2573
183	942	1891	2590
269	984	1943	2626
294	990	2009	2633
296	992	2026	2635
352	1012	2055	2668
373	1020	2073	2673
387	1069	2090	2680
394	1137	2148	2692
399	1149	2228	2693
415	1241	2268	2701
500	1319	2272	2711
536	1407	2300	2735
601	1532	2315	2786
657	1569	2328	2795
669	1572	2353	2818
717	1616	2364	3033
722	1617	2390	4010
727	1618	2430	4021
811	1643	2445	4040
	1647		4051

TABLE 5

2C DATA PLANTS WITH DILUTION

Plant #	Dilution Factor
63	.16308
83	.0720
102	.02792
114	.74803
154	.5480
159	.3477
183	3.1667
269	.4440
294	5.61905
352	.31071
373	.730
387	.00091
394	.0011
399	.01590
500	3.9113
657	.2254
727	14.46667
811	.6273
844	.6288
859	6.27
876	2.791
883	.3462
909	2.087
913	.2632
942	3.0
984	.3595
990	.3113
1012	4.6139
1020	.88268
1137	.05932
1149	.02664
1241	2.35163
1319	9.5652
1532	10.00
1569	1.0
1616	.45045
1618	.2210
1688	1.3514
1717	1.346
1869	.0977
1943	.58594
2009	.1111
2090	.2495
2148	.05106
2228	5.298
2268	14.5143
2315	3.62
2328	2.36318/2.35714
2353	2.37
2390	.02812
2430	.28351
2445	.60737
2450	16.7129
2474	52.94

TABLE 5 (continued)

2C DATA PLANTS WITH DILUTION

Plant #	Dilution Factor
2531	11.0651
2626	.1963
2633	.150
2668	33.6515
2673	1.4074
2680	.375
2692	1.0833
2693	.2069
2711	60.5439
2735	.1478
2786	.53127
2795	.1455
2818	1.184
4010	9.9867
4040	2.00
4051	3.30

Note: In addition to 2C data all of the above plants have questionnaire data except: 114
913
2711
4010

TABLE 6

PLANTS WITH ONLY QUESTIONNAIRE DATA

12	682	1323	2026	2678
61	683	1327	2049	2695
87	695	1340	2062	2763
155	709	1343	2110	2764
177	775	1389	2181	2767
225	802	1409	2222	2770
227	819	1414	2227	2771
250	825	1439	2236	2816
254	851	1446	2241	4017
259	866	1464	2242	
267	871	1494	2313	
284	908	1522	2360	
384	915	1593	2368	
417	938	1609	2376	
443	948	1695	2399	
447	970	1698	2447	
486	976	1766	2527	
502	1038	1769	2528	
523	1061	1774	2533	
525	1062	1802	2536	
580	1067	1839	2541	
602	1133	1877	2554	
608	1139	1890	2592	
659	1203	1911	2631	
662	1299	1928	2647	

TABLE 7

QUESTIONNAIRE DATA PLANTS WITH DILUTION

Plant #	Dilution Factor
12	7.147
61	10.0
87	0.308
155	1.215
177	3.67
225	0.530
250	1.190
284	0.2868
384	1.2123
443	48.571
447	84.8165
486	250.0
525	0.0912
580	.00047
602	9.000
682	6.4393
695	0.012
802	0.933
819	0.0591
866	0.8406
871	1.910
908	0.0016
915	0.0645
938	5.5069
948	0.0164
1038	1.0564
1061	0.0113
1062	1.6573
1067	15.90
1323	2.1177
1340	0.1720
1389	0.10337
1409	2.3516
1439	69.333
1494	0.2638
1609	0.0727
1695	0.1543
1698	1.0909
1766	0.6084
1802	1.290
1839	2518.9
1890	1.480/.5174
1911	4.1667

TABLE 8

PLANTS WITH DILUTION THAT DID NOT SUBMIT TOXICS DATA

PLANT NUMBER			
30	888	1936	2507
94	944	1977	2556
199	962	1986	2573
203	990	1993	2578
214	1053	2055	2590
220	1059	2073	2609
249	1086	2108	2631
254	1117	2177	2635
259	1139	2221	2679
260	1188	2243	2736
303	1237	2254	2756
312	1238	2261	2776
392	1432	2288	2793
444	1437	2293	3033
449	1438	2296	4002
481	1504	2307	4007
494	1539	2328	4008
543	1579	2345	4017
614	1621	2365	4023
663	1624	2394	4037
669	1643	2400	4040
683	1657	2402	4051
709	1714	2436	
717	1740	2447	
720	1764	2471	
771	1776	2485	
851	1838	2487	
887	1891	2495	

TABLE 9

PLANT TOTALS

	Total Number of Plants
1. Direct Dischargers	249
2. Plants Submitting Form 2C Data	106
3. Plants Submitting Only Questionnaire Data	109
4. Plants With 2C Data and Questionnaire Data	65

TABLE 10

PERCENT OF TOTAL PLANTS SUBMITTING DATA

	Total Number of Plants	As Percent
1. Form 2C Plants With Dilution	70	66[1]
2. Questionnaire Data Plants With Dilution	66	60.6[2]
3. Plants Submitting Only Conventional Pollutant Data	100	

[1] As percent of total plants submitting Form 2C toxics data.

[2] As percent ot total plants submitting questionnaire data.

TABLE 11

TABLE OF 2C DATA PLANTS WITH DILUTION
(AS PERCENT)

0-25%		25-50		50-75		75-100		100-500		>500	
Plant #	%	Plant #	%	Plant #	%	Plant #	%	Plant #	%	Plant #	
63	16	159	35	114	75	1020	88	183	317	294	
83	7	269	44	154	55	1569	100	500	391	727	1
102	3	352	31	373	73			876	279	859	
387	.09	883	35	811	63			909	209	1319	
394	.11	913	26	844	63			942	300	1532	1
399	16	984	36	1943	59			1012	461	2228	
657	23	990	31	2445	61			1241	235	2268	1
1137	6	1616	45	2786	53			1688	135	2450	1
1149	3	2430	28					1717	135	2474	5
1618	22	2680	38					2315	362	2531	1
1869	10							2328	236	2668	3
2009	11							2353	237	2711	6
2090	25							2673	141	4010	
2148	5							2692	108		
2390	3							2818	118		
2626	20							4040	200		
2633	15							4051	330		
2693	21										
2735	15										
2795	15										

TABLE 12

TABLE OF QUESTIONNAIRE DATA PLANTS WITH DILUTION
(AS PERCENT)

0-25%		25-50		50-75		75-100		100-500		>500	
Plant #	%	Plant #	%	Plant #	%	Plant #	%	Plant #	%	Plant #	%
525	9.1	87	308	225	53.0	802	933	155	120.15	12	714.7
580	.047	284	28.7	1766	60.8	866	84.1	177	367	61	1000
695	1.2	1494	26.4	1890.2	51.7	2062	81.8	250	119.0	443	4857
819	5.9	2242	25.5	2368	54.6			384	121.2	447	8481.6
908	.16	2763	28.95	2376	50.8			871	191.0	486	25000
915	6.45							1038	105.6	602	900
948	1.64							1062	165.7	682	643.9
1061	1.1							1323	211.8	938	550.7
1340	17.2							1409	235.2	1067	1590
1389	10.3							1698	109.1	1439	6933
1609	7.27							1802	129.0	1839	251900
1695	15.4							1890.1	148	2222	1446.7
2026	1.4							1911	416.7	2678	1156.5
2181	3.95							2110	186.1		
2227	2.51							2360	194.4		
2241	12.3							2399	188		
2313	19.37							2533	108.0		
2528	6.86							2764	118.2		
2536	.031							2767	159.0		
2695	4.66										
2771	8.33										
4016	15.06										

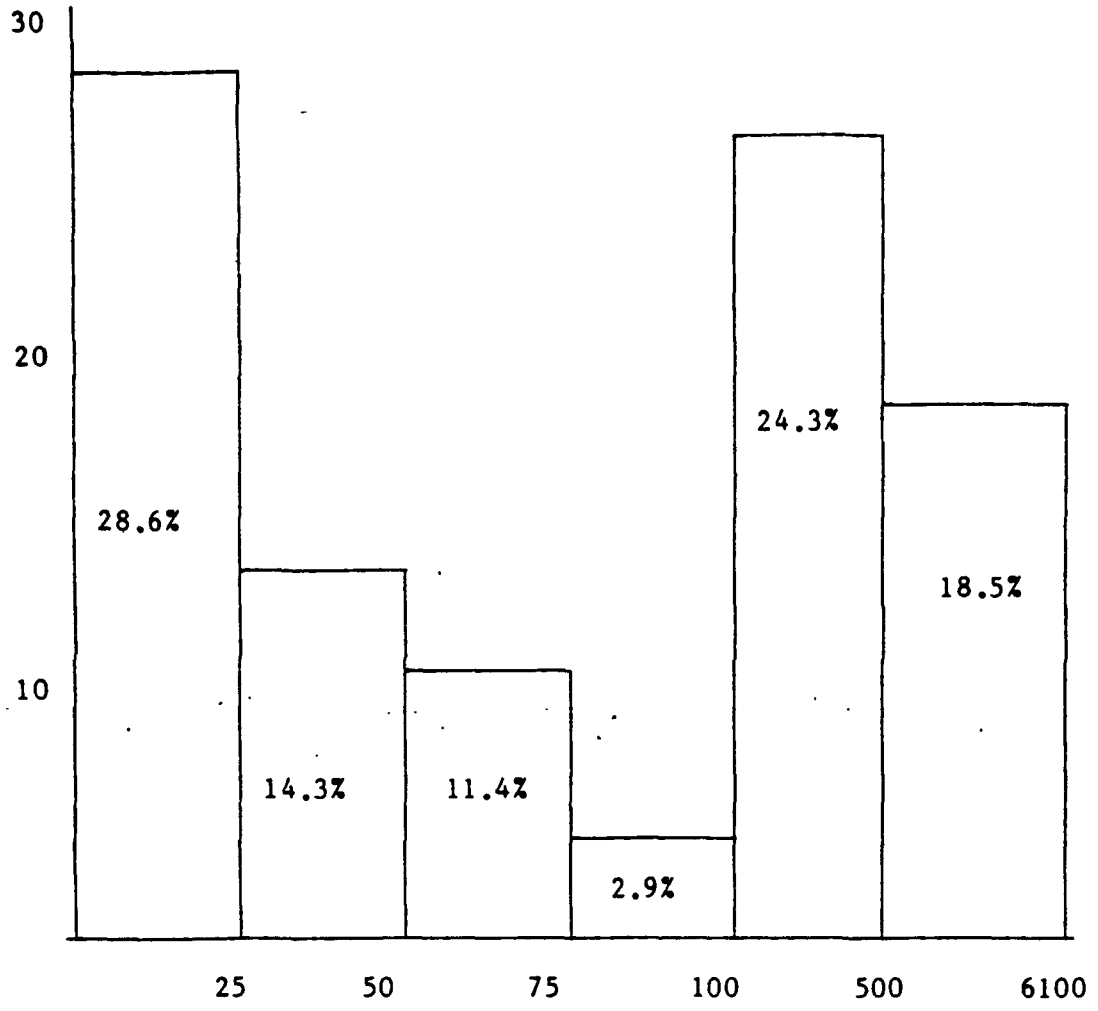
TABLE 13

Table of Questionnaire Data Plants with Dilution of Conventional Pollutants (as percent)

0 - 25%		25 - 50		50 - 75%		75 - 100%		100 - 500%		>500%	
30	6	203	27	162	74	614	80	249	109	259	17405
199	00	214	30	260	66	2177	83	303	426	481	3000
199	4			444	50	2345	80	392	186	669	916
220	9	494	49	962	66			543	108	709	1532
254	0	663.1	34	2296	50			887	140	944	715
312	20	663.2	34	2394	55			888	163	1624	8929
449	11	771	33	2590	58			1117	150	1776	1167
683	19	851	26	2631	64			1437	140	1986	6063
717	23	990.2	31	2679	50			1438	164	2055.2	2552
720	7	1238	33	4073	60			1643	331	2307	2170
990.1	0	1539	41					1838	217	2400	2250
1053	5	1621	29					2108	192	2447	17400
1059	.2	1657	37					2243	335	2578	654
1086	14	1714	27					2254	112	2776	
1139	1	1740	33					2288	200		
1188	8	1891	33					2328	236		
1237	2	1936	42					2365	100		
1432	6	2073	40					2556	212		
1504	20	2293	35					2635	119		
1579	17	2471.1	25					2793	325		
1764	7	2471.2	39					4002	167		
1977	8	2573	42					4040	200		
1993	12	2609	43					4051	330		
2055.1	7										
2221	.5										
2261	18										
2402	.4										
2436	14										
2485	20										
2487	10										
2495	21										
2507	5										
2736	3										
2756	2										
3033	5										
4007	.1										
4008	24										
4017	15										
4023	.2										

GRAPH 1

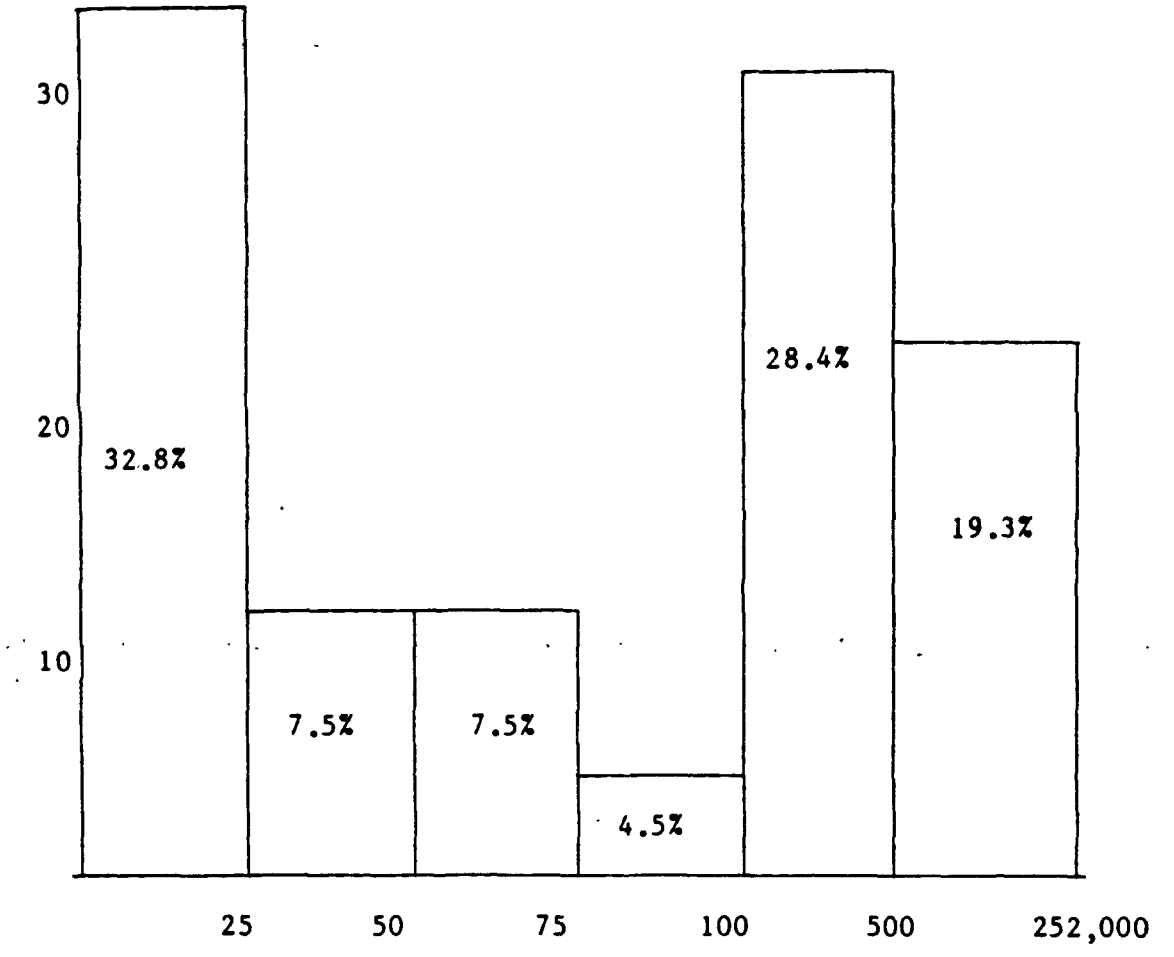
2C Data Plants



PERCENT DILUTION

GRAPH 2

Questionnaire Data Plants



GRAPH 3

Questionnaire Data Plants with Dilution of Conventional Pollutants Only

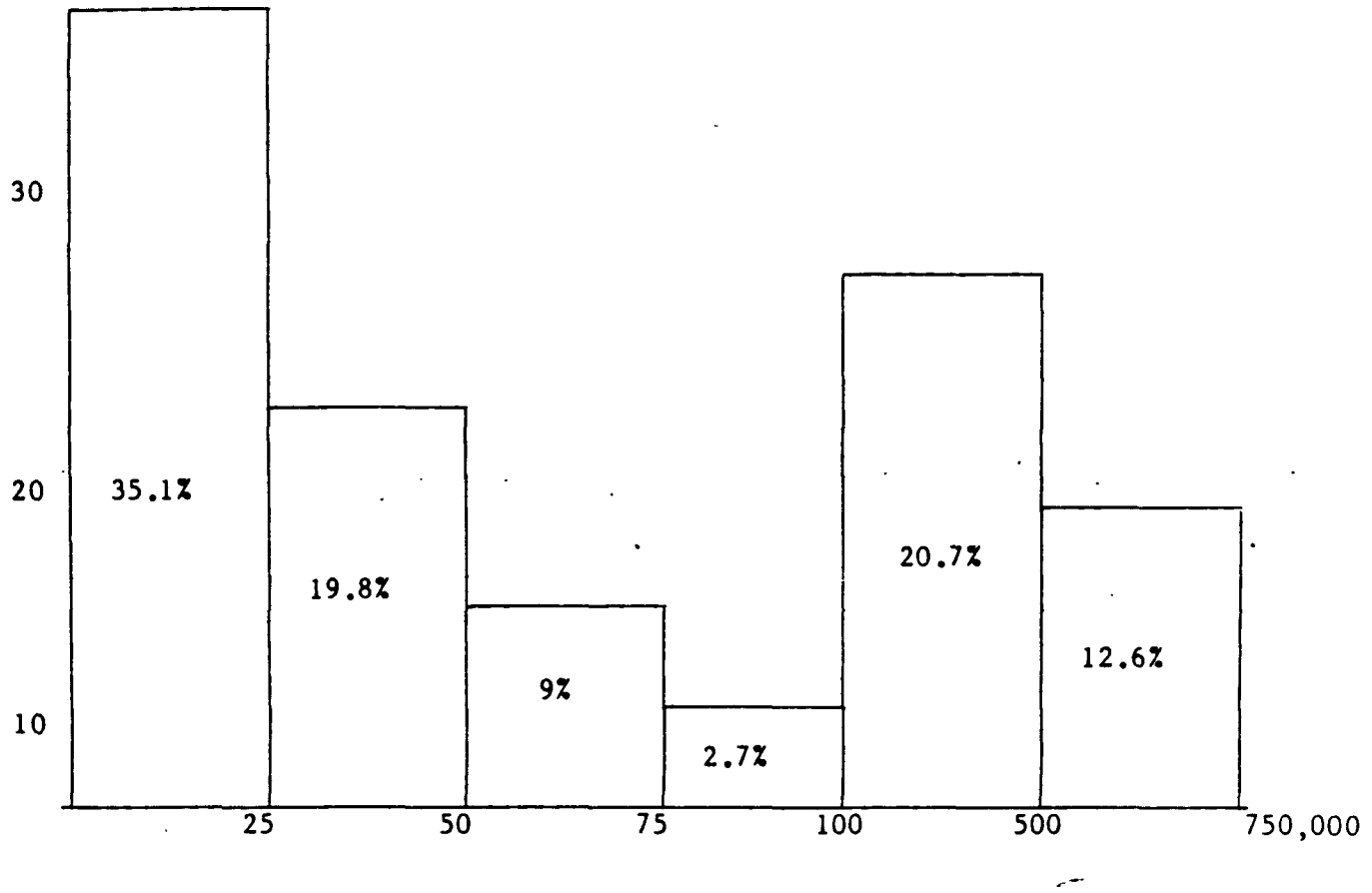


Table 14

RAW WATER QUALITY PARAMETERS, DILUTION FACTOR AND ADJUSTED WATER QUALITY PARAMETERS.

PLANT #	ACTUAL BOD	ACTUAL COD	ACTUAL TSS	ACTUAL TOC	DILUTION FACTOR	ADJUSTED BOD	ADJUSTED COD	ADJUSTED TSS	ADJUSTED TOC
12	-1.0	-1.0	-1.0	66.0	7.14700	-1.0	-1.0	-1.0	537.7
30	1218.0	-1.0	1024.0	-1.0	0.05720	1287.6	-1.0	1082.5	-1.0
61	196.0	-1.0	-1.0	-1.0	10.00000	2156.0	-1.0	-1.0	-1.0
63	5.0	35.0	5.4	-1.0	0.16308	5.8	40.7	6.2	-1.0
83	35.0	144.0	17.0	-1.0	0.07200	37.5	154.3	18.2	-1.0
87	716.0	1079.0	34.1	-1.0	0.30830	928.8	1411.6	44.6	-1.0
94	-1.0	1761.0	234.0	-1.0	0.20000	-1.0	2113.2	280.8	-1.0
102	6.4	241.0	17.2	-1.0	0.02790	6.5	268.2	17.6	-1.0
114	8.6	31.0	51.0	-1.0	0.74803	15.0	54.1	89.1	-1.0
154	7.0	-1.0	15.4	28.0	0.54800	10.8	-1.0	23.8	43.3
155	-1.0	900.0	128.0	-1.0	1.20150	-1.0	1981.3	281.7	-1.0
159	318.0	615.0	-1.0	317.0	0.34770	428.5	828.8	-1.0	427.2
162	-1.0	-1.0	30.0	-1.0	0.73600	-1.0	-1.0	52.0	-1.0
177	27.0	-1.0	57.0	27.0	3.67000	126.0	-1.0	266.1	126.0
183	-1.0	-1.0	-1.0	-1.0	3.16667	-1.0	-1.0	-1.0	-1.0
199	549.0	-1.0	372.0	0.0	0.03920	570.5	-1.0	386.5	0.0
203	30.0	90.0	28.0	-1.0	0.26700	38.0	114.0	35.4	-1.0
214	648.0	-1.0	800.0	-1.0	0.29500	839.1	-1.0	1036.0	-1.0
220	58297.0	16097.0	23.0	-1.0	0.69200	63660.3	17577.9	25.1	-1.0
225	13.6	22.4	8.5	-1.0	0.53000	20.8	34.2	9.9	-1.0
249	986.0	2058.0	47.0	-1.0	1.08500	2055.8	4290.9	97.9	-1.0
250	56.0	1.0.0	105.0	-1.0	1.19000	127.0	262.8	229.9	-1.0
254	0.0	0.0	0.0	-1.0	0.00000	0.0	0.0	0.0	-1.0
259	1.8	-1.0	-1.0	-1.0	174.05060	315.0	-1.0	-1.0	-1.0
266	11.8	40.3	5.4	9.0	0.66034	19.5	66.9	8.9	14.9
269	116.0	259.0	37.0	104.0	0.44400	167.5	373.9	53.4	150.1
284	16.0	43.0	10.0	-1.0	0.28680	20.5	55.3	12.8	-1.0
294	8.6	55.0	18.0	9.2	5.61905	56.9	364.0	119.1	60.8
303	401.0	718.0	96.0	-1.0	4.26000	2109.2	3776.6	504.9	-1.0
312	340.0	9781.0	3181.0	-1.0	0.19500	406.3	11686.2	3801.2	-1.0
352	34.0	600.0	31.0	-1.0	0.31071	44.5	1048.5	40.6	-1.0
373	8.2	39.9	20.1	-1.0	5.73000	63.3	308.4	155.3	-1.0
384	3.6	45.3	8.6	-1.0	1.21231	6.6	100.2	19.0	-1.0
387	14.0	83.0	21.0	-1.0	0.00091	14.0	83.0	21.0	-1.0
392	12.0	46.0	16.0	-1.0	1.85900	34.3	131.5	45.7	-1.0
394	8.8	62.5	19.4	21.4	0.00110	8.8	62.5	19.4	21.4
399	24.0	79.0	58.0	30.0	0.01590	24.3	80.2	58.9	30.4
443	20.2	102.0	37.5	-1.0	48.57140	1001.3	5056.2	1858.9	-1.0
444	16.0	-1.0	27.0	19.0	0.49670	23.9	-1.0	40.4	28.4
447	2492.0	10046.0	2415.0	3442.0	84.81646	213854.6	862112.1	207246.7	295380.2
449	-1.0	10370.0	3616.0	-1.0	0.11100	-1.0	11521.0	4017.3	-1.0
481	12.5	-1.0	1.0	-1.0	30.00000	387.5	-1.0	31.0	-1.0
486	-1.0	845.0	-1.0	-1.0	250.00000	-1.0	212095.0	-1.0	-1.0
494	-1.0	770.0	65.0	-1.0	0.49100	-1.0	1148.0	96.9	-1.0
500	10.0	67.0	16.0	38.0	3.91130	49.1	329.0	78.5	186.6
525	6.0	-1.0	30.0	-1.0	0.09120	8.7	-1.0	32.7	-1.0
543	-1.0	3942.0	40.0	-1.0	1.08000	-1.0	8199.3	83.2	-1.0
580	45.0	283.0	133.0	-1.0	0.00047	45.0	283.1	133.0	-1.0

Table 14 (Cont.)

RAW WATER QUALITY PARAMETERS, DILUTION FACTOR AND ADJUSTED WATER QUALITY PARAMETERS.

PLANT #	ACTUAL BOD	ACTUAL COD	ACTUAL TSS	ACTUAL TOC	DILUTION FACTOR	ADJUSTED BOD	ADJUSTED COD	ADJUSTED TSS	ADJUSTED TOC
602	105.2	-1.0	-1.0	476.0	9.00000	1052.0	-1.0	-1.0	4760.0
614	-1.0	-1.0	-1.0	-1.0	0.79274	-1.0	-1.0	-1.0	-1.0
657	13.0	60.0	14.0	19.0	0.22540	15.9	73.5	17.1	23.2
663	5.0	54.0	35.0	54.0	0.34100	6.7	72.4	46.9	72.4
663	4.0	54.0	35.0	53.0	0.33870	5.3	72.2	46.8	70.9
669	56.0	-1.0	42.0	-1.0	9.15790	568.8	-1.0	426.6	-1.0
682	9.8	77.6	35.3	36.0	6.43930	72.9	577.2	262.6	267.8
683	10.0	-1.0	10.0	20.0	0.19178	11.9	-1.0	11.9	23.8
695	20.0	153.0	51.0	74.0	0.01200	20.2	154.8	51.6	74.8
709	5.7	69.3	6.0	17.0	15.32353	93.0	1131.2	97.9	277.5
717	25.0	83.0	11.0	-1.0	0.22500	30.6	101.6	13.4	-1.0
720	268.0	500.0	18.0	-1.0	0.07140	287.1	535.7	19.2	-1.0
727	5.4	-1.0	7.0	-1.0	14.46667	83.5	-1.0	108.2	-1.0
771	374.0	598.0	149.0	-1.0	0.33300	498.5	797.1	198.6	-1.0
802	6.0	21.0	8.0	-1.0	0.93300	11.5	40.5	15.4	-1.0
811	13.6	92.1	18.4	35.6	0.62730	22.1	149.6	29.9	57.9
819	-1.0	-1.0	121.0	-1.0	0.05910	-1.0	-1.0	128.1	-1.0
844	3.0	111.0	32.0	23.0	0.62880	4.8	180.7	52.1	37.4
851	23.5	182.4	128.1	-1.0	0.25913	29.5	229.6	161.2	-1.0
859	31.0	-1.0	601.0	-1.0	6.27000	225.3	-1.0	4369.2	-1.0
866	6.5	107.0	17.3	-1.0	0.84060	11.9	196.9	31.8	-1.0
871	12.0	52.6	31.6	-1.0	1.91000	34.9	153.0	91.9	-1.0
876	24.0	245.0	20.0	47.0	2.79100	90.9	928.7	75.8	178.1
883	15.0	-1.0	20.0	-1.0	0.34620	20.1	-1.0	26.9	-1.0
887	14733.0	5697.0	104.0	-1.0	1.39500	35285.5	13644.3	249.0	-1.0
888	-1.0	1423.0	-1.0	-1.0	1.63000	-1.0	3742.4	-1.0	-1.0
908	53.0	335.0	40.0	80.0	0.00160	53.0	335.5	40.0	80.1
909	9.0	115.0	18.0	-1.0	2.08757	27.7	355.0	55.5	-1.0
913	3.0	103.0	43.0	1.2	0.26320	3.7	130.1	54.3	1.5
915	14.0	69.0	12.0	-1.0	0.06450	14.9	73.4	12.7	-1.0
938	-1.0	-1.0	27.0	45.0	5.50690	-1.0	-1.0	175.6	292.8
942	17.8	93.1	16.4	28.1	3.00000	71.2	372.4	65.6	112.4
944	28.0	467.0	7.0	-1.0	7.15000	228.2	3806.0	57.0	-1.0
948	12.1	-1.0	32.2	59.0	0.01640	12.2	-1.0	32.7	59.9
962	10.0	-1.0	15.0	-1.0	0.66000	16.6	-1.0	24.9	-1.0
984	16.0	182.0	25.0	92.0	0.35950	21.7	247.4	33.9	125.0
990	0.0	0.0	0.0	0.0	0.00000	0.0	0.0	0.0	0.0
990	12.4	126.0	15.9	-1.0	0.31130	16.2	165.2	20.8	-1.0
990	15.9	0.0	0.0	0.0	0.00000	15.9	0.0	0.0	0.0
1012	3.6	22.0	-1.0	-1.0	4.61392	20.2	123.5	-1.0	-1.0
1038	5.0	56.0	11.0	-1.0	1.05640	10.2	115.1	22.6	-1.0
1053	-1.0	8610.0	321.0	-1.0	0.05370	-1.0	9072.3	338.2	-1.0
1059	32.0	354.0	30.0	-1.0	0.00203	32.0	354.7	30.0	-1.0
1061	6.1	29.5	15.1	-1.0	0.01130	6.1	29.8	15.2	-1.0
1062	9.0	80.0	23.0	-1.0	1.65730	23.9	212.5	61.1	-1.0
1067	4.0	90.0	10.7	-1.0	15.90000	67.6	1521.0	180.8	-1.0
1086	-1.0	-1.0	321.0	-1.0	0.14200	-1.0	-1.0	366.5	-1.0
1117	650.0	-1.0	13.3	-1.0	1.50000	1625.0	-1.0	33.2	-1.0

Table 14 (Cont.)

RAW WATER QUALITY PARAMETERS. DILUTION FACTOR AND ADJUSTED WATER QUALITY PARAMETERS.

PLANT #	ACTUAL BOD	ACTUAL COD	ACTUAL TSS	ACTUAL TOC	DILUTION FACTOR	ADJUSTED BOD	ADJUSTED COD	ADJUSTED TSS	ADJUSTED TOC
1137	22.0	-1.0	72.0	56.0	0.05930	23.3	-1.0	76.2	59.3
1139	36.0	197.0	33.0	-1.0	0.01010	36.3	198.9	33.3	-1.0
1149	20.0	157.0	57.0	40.0	0.02664	20.5	161.1	58.5	41.0
1188	345.0	607.0	12.5	-1.0	0.07750	371.7	654.0	13.4	-1.0
1237	69.0	-1.0	42.0	-1.0	0.01500	70.0	-1.0	42.6	-1.0
1238	-1.0	9100.0	-1.0	-1.0	0.33200	-1.0	12121.2	-1.0	-1.0
1241	19.4	-1.0	38.7	100.6	0.62300	31.4	-1.0	62.8	163.2
1319	19.0	-1.0	22.0	-1.0	9.56522	200.7	-1.0	232.4	-1.0
1323	48.1	135.4	16.2	-1.0	2.11765	149.9	422.1	50.5	-1.0
1340	5.4	68.0	17.4	-1.0	0.17204	6.3	79.6	20.3	-1.0
1389	33.0	303.0	65.0	-1.0	0.10337	36.4	334.3	71.7	-1.0
1409	5.0	40.0	7.0	-1.0	2.35163	16.7	134.0	23.4	-1.0
1432	-1.0	2446.0	104.0	-1.0	0.06160	-1.0	2596.6	110.4	-1.0
1437	342.5	-1.0	29.1	-1.0	1.40000	342.0	-1.0	69.8	-1.0
1438	11.0	114.0	12.0	-1.0	1.63768	29.0	300.6	31.6	-1.0
1439	4.3	-1.0	20.8	-1.0	69.33333	302.4	-1.0	1462.9	-1.0
1494	49.0	285.0	105.0	85.0	0.26380	61.9	360.1	132.6	107.4
1504	-1.0	921.0	114.0	-1.0	0.20000	-1.0	1105.2	136.8	-1.0
1532	10.1	-1.0	-1.0	-1.0	10.00000	111.1	-1.0	-1.0	-1.0
1539	1637.0	-1.0	336.6	-1.0	0.40770	2304.4	-1.0	473.8	-1.0
1569	9.2	50.0	21.7	-1.0	1.00000	18.4	100.0	43.4	-1.0
1579	13.7	99.0	9.8	-1.0	0.17400	16.0	116.2	11.5	-1.0
1609	61.0	-1.0	57.0	100.0	0.07273	65.4	-1.0	61.1	107.2
1616	60.0	323.0	54.0	429.0	0.45045	87.0	468.4	78.3	622.2
1618	3.0	14.0	9.3	8.0	0.22100	3.6	17.0	11.3	9.7
1621	1011.0	2882.0	31.0	-1.0	0.28500	1299.1	3703.3	39.8	-1.0
1624	10.2	63.8	16.0	-1.0	89.28571	920.9	5760.2	1444.5	-1.0
1643	18.0	154.0	45.0	0.0	3.31000	77.5	663.7	193.9	0.0
1657	1641.0	-1.0	119.0	-1.0	0.37330	2253.5	-1.0	163.4	-1.0
1688	60.5	171.8	19.5	177.0	1.35140	142.2	403.9	45.8	416.1
1695	14.3	-1.0	22.6	-1.0	0.15429	16.5	-1.0	26.0	-1.0
1698	32.6	274.0	21.9	-1.0	1.09091	68.1	572.9	45.7	-1.0
1714	14.6	147.0	90.0	-1.0	0.26900	18.5	186.5	114.2	-1.0
1717	21.0	198.0	14.4	123.0	1.34615	49.2	464.5	33.7	288.5
1740	11.0	38.0	18.0	-1.0	0.33100	14.6	50.5	23.9	-1.0
1764	242.0	4130.0	2863.0	-1.0	0.06590	257.9	4402.1	3051.6	-1.0
1766	103.0	419.0	75.0	220.0	0.60841	165.6	673.9	120.6	353.8
1776	0.0	0.0	7.9	-1.0	11.66667	0.0	0.0	100.0	-1.0
1802	22.0	51.0	43.0	-1.0	1.29000	50.3	116.7	98.4	-1.0
1838	-1.0	-1.0	3495.0	-1.0	2.17000	-1.0	-1.0	11079.1	-1.0
1839	0.0	0.0	0.0	20.0	2518.86730	0.0	0.0	0.0	50397.3
1869	16.0	57.0	4.0	-1.0	0.09770	17.5	62.5	4.3	-1.0
1890	19.0	230.0	37.0	-1.0	1.48196	47.1	570.8	91.8	-1.0
1890	8.0	71.0	6.0	-1.0	0.51736	12.1	107.7	9.1	-1.0
1891	45.0	339.0	-1.0	-1.0	0.32900	59.8	450.5	-1.0	-1.0
1911	14.0	195.0	74.0	72.0	4.16667	72.3	1007.5	382.5	372.0
1936	110.0	-1.0	30.0	-1.0	0.41900	156.0	-1.0	42.5	-1.0
1943	14.0	58.0	10.0	-1.0	0.58594	22.2	91.9	15.8	-1.0

Table 14 (Cont.)

RAW WATER QUALITY PARAMETERS, DILUTION FACTOR AND ADJUSTED WATER QUALITY PARAMETERS.

PLANT #	ACTUAL BOD	ACTUAL COD	ACTUAL TSS	ACTUAL TOC	DILUTION FACTOR	ADJUSTED BOD	ADJUSTED COD	ADJUSTED TSS	ADJUSTED TOC
1977	25.0	186.0	145.0	130.0	0.07605	26.9	200.1	156.0	139.8
1986	12.4	65.3	17.6	-1.0	60.62500	764.1	4024.1	1084.6	-1.0
1993	-1.0	3075.0	68.2	-1.0	0.11800	-1.0	3437.8	76.2	-1.0
2009	74.0	3480.0	130.0	-1.0	0.11111	82.2	3866.6	144.4	-1.0
2026	39.0	133.0	51.0	-1.0	0.01353	39.5	134.7	51.6	-1.0
2055	158.0	565.0	-1.0	-1.0	0.06452	168.1	601.4	-1.0	-1.0
2055	120.0	27.0	-1.0	-1.0	25.51950	3182.3	716.0	-1.0	-1.0
2062	-1.0	-1.0	-1.0	140.0	0.81818	-1.0	-1.0	-1.0	254.5
2073	4.4	12.8	28.6	8.5	0.39996	6.1	17.9	40.0	11.8
2090	690.0	2959.0	40.0	-1.0	0.24953	862.1	3697.3	49.9	-1.0
2108	183.0	509.0	61.0	-1.0	1.92000	534.3	1486.2	178.1	-1.0
2110	38.5	193.3	46.9	-1.0	1.86140	110.1	553.1	134.1	-1.0
2148	5.0	114.0	12.0	42.0	0.05106	5.2	119.8	12.6	44.1
2177	190.0	410.0	110.0	-1.0	0.83300	348.2	751.5	201.6	-1.0
2181	4.0	154.0	34.0	74.0	0.03947	4.1	160.0	35.3	76.9
2221	15.0	-1.0	20.0	-1.0	0.00522	15.0	-1.0	20.1	-1.0
2222	7.6	23.2	29.5	-1.0	14.46670	117.5	358.8	456.2	-1.0
2227	73.2	-1.0	155.6	165.5	0.02513	75.0	-1.0	159.5	169.6
2228	841.8	959.0	117.1	793.0	5.29801	5301.6	6039.7	737.4	4994.3
2241	-1.0	23819.0	37.0	-1.0	0.12300	-1.0	26748.7	41.5	-1.0
2242	13.0	125.0	30.0	52.0	0.25530	16.3	156.9	37.6	65.2
2243	2550.0	-1.0	155.0	-1.0	3.35000	11092.5	-1.0	674.2	-1.0
2254	89.0	357.0	113.0	-1.0	1.12000	188.6	756.8	239.5	-1.0
2261	1728.0	1690.0	-1.0	-1.0	0.17500	2030.4	1985.7	-1.0	-1.0
2268	-1.0	193.0	17.0	-1.0	14.51429	-1.0	2994.2	263.7	-1.0
2288	757.0	2013.0	27.0	-1.0	2.00000	2271.0	6039.0	81.0	-1.0
2293	-1.0	2709.0	187.0	-1.0	0.34800	-1.0	3651.7	252.0	-1.0
2296	12.0	64.0	51.0	-1.0	0.49517	17.9	95.6	76.2	-1.0
2307	15.8	-1.0	11.6	-1.0	21.70000	358.6	-1.0	263.3	-1.0
2313	204.0	1098.0	1718.0	108.0	0.19372	243.5	1310.7	2050.8	128.9
2315	2.0	46.0	9.0	16.0	3.62000	9.2	212.5	41.5	73.9
2328	6.0	88.0	11.0	39.0	2.36318	20.1	295.9	36.9	131.1
2328	3.0	9.1	10.0	9.0	2.35714	10.0	30.5	33.5	30.2
2345	28.0	-1.0	15.9	90.0	0.79484	50.2	-1.0	28.5	161.5
2353	166.0	258.0	58.0	-1.0	12.37000	2219.4	3449.4	775.4	-1.0
2360	2.0	25.0	6.0	-1.0	1.94444	5.8	73.6	17.6	-1.0
2365	20.0	263.0	46.0	-1.0	1.00100	40.0	526.2	92.0	-1.0
2368	30.0	-1.0	25.0	48.0	0.54598	46.3	-1.0	38.6	74.2
2376	18.0	46.0	21.0	-1.0	0.50849	27.1	69.3	31.6	-1.0
2390	55.0	528.0	46.4	495.0	0.02812	56.5	542.8	47.7	508.9
2394	41.0	387.0	25.0	76.0	0.55200	63.6	600.6	38.8	117.9
2399	25.0	64.0	19.0	21.0	1.88000	72.0	184.3	54.7	60.4
2400	240.0	1200.0	50.0	-1.0	22.50000	5640.0	28200.0	1175.0	-1.0
2402	12592.0	37329.0	110.0	-1.0	0.00400	12642.3	37478.3	110.4	-1.0
2430	6.0	81.0	6.8	33.0	0.28351	7.7	103.9	8.7	42.3
2436	-1.0	-1.0	147.0	-1.0	0.13900	-1.0	-1.0	167.4	-1.0
2445	30.1	165.0	71.0	36.0	0.60737	48.3	265.2	114.1	57.8
2447	13.1	43.3	13.3	-1.0	174.00000	2292.5	7577.5	2327.5	-1.0

Table 14 (Cont.)

RAW WATER QUALITY PARAMETERS, DILUTION FACTOR AND ADJUSTED WATER QUALITY PARAMETERS.

PLANT #	ACTUAL BOD	ACTUAL COD	ACTUAL TSS	ACTUAL TOC	DILUTION FACTOR	ADJUSTED BOD	ADJUSTED COD	ADJUSTED TSS	ADJUSTED TOC
2450	5.0	54.0	14.0	-1.0	16.71290	88.5	956.4	247.9	-1.0
2471	42.9	-1.0	52.0	-1.0	0.24560	53.4	-1.0	64.7	-1.0
2471	13.8	41.0	21.0	14.7	0.38890	19.1	56.9	29.1	20.4
2474	8.0	82.0	23.0	19.0	52.94000	431.5	4423.0	1240.6	1024.8
2485	2302.0	4503.0	109.0	-1.0	0.19700	2755.4	5390.0	130.4	-1.0
2487	390.5	-1.0	336.5	-1.0	0.09980	429.4	-1.0	370.0	-1.0
2495	1200.0	1596.0	880.0	-1.0	0.20600	1447.2	1924.7	1061.2	-1.0
2507	464.0	-1.0	1477.0	-1.0	0.05000	487.2	-1.0	1550.8	-1.0
2528	33.0	158.0	74.0	88.0	0.06860	35.2	168.8	79.0	94.0
2531	53.0	80.0	12.0	48.0	11.06510	639.4	965.2	144.7	579.1
2533	-1.0	51.0	15.0	-1.0	1.08000	-1.0	106.0	31.2	-1.0
2536	3.3	48.4	17.9	-1.0	0.00031	3.3	48.4	17.9	-1.0
2556	6.0	49.0	31.0	-1.0	2.11765	18.7	152.7	96.6	-1.0
2573	200.0	304.0	88.0	131.0	0.42009	284.0	431.7	124.9	186.0
2578	3209.0	-1.0	9.9	-1.0	7500.00000	0.0	-1.0	74259.9	-1.0
2590	10.0	22.0	8.0	139.0	0.57730	15.7	34.7	12.6	219.2
2609	694.0	1435.0	26.5	-1.0	0.42800	991.0	2049.1	37.8	-1.0
2626	11.5	247.0	18.5	-1.0	0.19630	13.7	295.4	22.1	-1.0
2631	14.0	170.0	14.0	2.0	0.63630	22.9	278.1	22.9	3.2
2633	79.0	123.0	107.0	-1.0	0.15000	90.8	141.4	123.0	-1.0
2635	10.6	70.9	23.3	-1.0	1.16500	23.1	154.9	50.9	-1.0
2668	4.1	16.9	25.0	230.0	233.65152	962.0	3965.6	5866.2	53969.8
2673	42.0	235.0	38.0	72.0	1.40741	101.1	565.7	91.4	173.3
2678	6.3	-1.0	7.6	-1.0	11.56540	79.1	-1.0	95.4	-1.0
2679	233.0	-1.0	124.0	-1.0	0.50000	349.5	-1.0	186.0	-1.0
2680	34.9	104.8	19.2	-1.0	0.37500	47.9	144.1	26.4	-1.0
2692	2.0	4.0	11.0	26.0	1.08330	4.1	8.3	22.9	54.1
2693	71.0	166.0	43.0	68.0	0.20690	85.6	200.3	51.8	82.0
2695	24.0	42.0	15.0	19.0	0.04660	25.1	43.9	15.6	19.8
2711	16.0	25.0	12.0	-1.0	60.54390	984.7	1538.5	738.5	-1.0
2735	7.0	52.0	18.0	-1.0	0.14780	8.0	59.6	20.6	-1.0
2736	-1.0	3648.0	921.0	-1.0	0.03040	-1.0	3758.8	959.3	-1.0
2756	562.0	1316.0	-1.0	-1.0	0.02380	575.3	1347.3	-1.0	-1.0
2763	3.0	-1.0	11.0	-1.0	0.28946	3.8	-1.0	14.1	-1.0
2764	14.0	56.0	45.0	-1.0	1.18200	30.5	122.1	98.1	-1.0
2767	6.3	-1.0	12.1	22.0	1.59000	16.3	-1.0	31.3	56.9
2771	-1.0	67.0	12.0	19.0	0.08333	-1.0	72.5	12.9	20.5
2776	4600.0	10870.0	-1.0	-1.0	6.53600	34665.6	81916.3	-1.0	-1.0
2786	52.0	216.0	36.0	53.0	0.53127	79.6	330.7	55.1	81.1
2793	-1.0	1005.0	51.0	-1.0	3.25000	-1.0	4271.2	216.7	-1.0
2795	23.0	388.0	49.0	-1.0	0.14550	26.3	444.4	56.1	-1.0
2818	23.0	174.0	134.0	68.0	1.18400	50.2	380.0	292.6	148.5
3033	171.0	645.0	19.2	233.0	0.05396	180.2	679.8	20.2	245.5
4002	41.0	267.0	31.0	-1.0	1.67000	109.4	712.8	82.7	-1.0
4007	2358.0	-1.0	151.8	-1.0	0.00125	2360.9	-1.0	151.9	-1.0
4008	-1.0	550.0	83.0	-1.0	0.24100	-1.0	682.5	103.0	-1.0
4010	-1.0	83.0	16.0	29.0	9.98669	-1.0	911.8	175.7	318.6
4017	3.6	33.3	17.4	-1.0	0.15063	4.1	38.3	20.0	-1.0

Table 14 (Cont.)

RAW WATER QUALITY PARAMETERS, DILUTION FACTOR AND ADJUSTED WATER QUALITY PARAMETERS.

PLANT #	ACTUAL BOD	ACTUAL COD	ACTUAL TSS	ACTUAL TOC	DILUTION FACTOR	ADJUSTED BOD	ADJUSTED COD	ADJUSTED TSS	ADJUSTED TOC
4023	1179.0	-1.0	538.0	-1.0	0.00151	1180.7	-1.0	538.8	-1.0
4037	3.0	-1.0	10.0	-1.0	0.59620	4.7	-1.0	15.9	-1.0
4040	65.0	85.0	88.0	-1.0	2.00000	195.0	255.0	264.0	-1.0
4051	6.2	36.0	22.0	-1.0	3.30000	26.6	154.8	94.6	-1.0

TABLE 15

Plant A

Parameter	DISCHARGE 001 (MAIN OUTFALL) Mass Load (kg/day)	DISCHARGE 001 (MAIN OUTFALL) Concentration (mg/l)	DISCHARGE 002 (TREATMENT PLANT EFFLUENT) Mass Load (kg/day)	DISCHARGE 002 (TREATMENT PLANT EFFLUENT) Concentration (mg/l)	COOLING WATER(1) Mass Load (kg/day)	COOLING WATER(1) Concentration (mg/l)
BOD_5	5,949.58	10.00	1,041.80	31.3	4,907.78	8.73
COD	-	NA	-	NA	-	-
TSS	11,304.20	19.00	2,962.31	89.00	8,341.89	14.85
Oil and Grease	1,368.40	2.30	565.83	17.00	802.57	1.43
Phenols	11.30	0.019	3.66	0.110	7.64	0.014
TOC	-	NA	-	NA	-	-
Arsenic	-	NA	3.33	0.100	-	-
Aluminum	-	NA	0.07	0.002	-	-
Beryllium	-	NA	0.13	0.004	-	-
Cadmium	16.06	0.027	0.07	0.002	15.99	0.028
Chromium(2)	60.69	0.102	0.77	0.023	59.92	0.107
Copper	-	NA	0.90	0.027	-	-
Lead(2)	113.04	0.190	2.66	0.080	110.38	0.20
Mercury	-	NA	0.03	0.001	-	-
Nickel	-	NA	1.36	0.041	-	-
Selenium	-	NA	5.33	0.160	-	-
Zinc(2)(3)	83.89	0.141	14.68	0.441	69.21	0.123
Cyanide(2)(3)	8.33	0.014	0.43	0.013	7.89	0.014

Flows: Discharge 001: 157.3 MGD;
Discharge 002: 8.8 MGD

(1) Calculated by mass balance
(2) 1977 Data for Discharge 001
(3) 1977 Data for Discharge 002

TABLE 16

Plant A

Parameters (ug/l)	Discharge 002 (WWTP Effluent)			Discharge 001 (Main Outfall)			Salt Water Inlet		
	6/79	12/79	2/81	6/79	12/79	2/81	6/79	12/79	2/81
Bromoform	<1	<0.1	39	<10	<0.1	<10	<10	<10	<10
Chlorobenzene	<0.1	<0.1	19	<1	<0.1	<10	<1	<0.1	<10
Chlorodibromomethane	<10	<0.1	60	<0.1	<1	<10	<1	<0.1	<10
Chloroform	<10	23	<10	<10	<10	<10	<10	<10	<10
Dichlorobromomethane	<1.0	<0.1	25	<0.1	<0.1	<10	<0.1	<0.1	<10
Toluene	<0.1	<0.1	<10	<0.1	<0.1	38	<10	<0.1	<10
2,4,6-Trichlorophenol	<10	21	<10	<1	<1	<10	<1	<1	<10
Bis(2-Ethylhexyl) phthalate	<10	16	<10	<1	<10	16	<1	<10	60
Diethyl phthalate	<1	<10	<10	<1	<1	14	<1	<1	<10
Isophorone	35	180	<10	<10	<1	<10	<1	<1	<10
Antimony	NT	500	<50	NT	800	<50	NT	700	<50
Cadmium	NT	<5	<10	NT	20	<10	NT	30	<10
Chromium	NT	<20	36	NT	<20	13	NT	<20	18
Copper	NT	<20	69	NT	<20	47	NT	<20	34
Lead	NT	<50	25	NT	<50	<15	NT	<50	<15
Nickel	50	<40	41	200	<40	52	200	120	34
Silver	NT	<20	<3	NT	30	8	NT	30	8
Thallium	NT	<100	20	NT	<100	<10	NT	<100	110
Zinc	670	70	360	1300	80	250	1300	120	110

NT: Not Tested

TABLE 17

Discharge Monitoring Report (DMR) Data

Plant A

Month	Parameter	DISCHARGE 001 (MAIN OUTFALL) Mean Flow (MGD)	Mass Load (kg/day)	Concentration (mg/l))	DISCHARGE 002 (TREATMENT PLANT EFFLUENT) Mean Flow (MGD)	Mass Load (kg/day)	Concentratio (mg/l)
Feb. 1982	Total Organic Carbon (TOC)	132	1,110	2.22	10.05	783	20.60
March 1982	TOC	132	1,231	2.46	9.41	1,336	37.54
April 1982	TOC	130	956	1.94	9.54	1,010	27.99
May 1982	TOC	132	549	1.10	7.50	748	26.37
June 1982	TOC	147	1,009	1.81	9.01	756	22.18
July 1982	TOC	151	740	1.30	7.76	516	17.79
August 1982	TOC	150	655	1.15	7.76	554	18.87
Sept. 1982	TOC	141	549	1.03	7.98	589	19.51
Oct. 1982	TOC	126	593	1.24	7.37	536	19.23
Nov. 1982	TOC	122	725	1.57	8.32	776	24.65
Dec. 1982	TOC	129	860	1.76	9.5	827	23.01
Jan. 1983	TOC	143	909	1.68	10.01	888	23.45
Average	TOC	136.3	824	1.61	8.68	776	23.43

TABLE 18

Plant B

Parameter	Wastewater Treatment Plant Effluent Stream (ug/l)	Outfall 001 (ug/l)
Bromoform	100.0	19.0
Chloroform	51.0	ND
Ethylbenzene	6.5	ND
Methylene Chloride	18.0	7.6
Toluene	4.1	2.2
1,4-dichlorobenzene	470.0	ND
Phenol	17.7	1.4

ND - Not Detected; Limit of Detection is 5 ppb.

TABLE 19

Plant C

Month (1980)	Parameter	INDUSTRIAL PLANT EFFLUENT Mean Flow[1] (MGD)	Concentration (mg/l)	Mass Load (kg/day)	DISCHARGE 001 Mean flow (MGD)	Concentration (mg/l)	Mass Load (kg/day)
Jan.	Chemical Oxygen Demand (COD)	0.072	117	31.9	0.41	0.02	0.3
Feb.	COD	0.072	140	38.2	0.41	NA	-
March	COD	0.072	126	34.3	0.40	38	57.4
April	COD	0.072	119	32.4	0.39	25	36.8
May	COD	0.072	123	33.4	0.43	NA	-
June	COD	0.072	137	37.3	0.36	21	28.5
July	COD	0.072	169	46.0	0.39	41	60.4
August	COD	0.072	158	43.1	0.31	30	35.1
September	COD	0.072	110	29.9	0.36	18	24.5
October	COD	0.072	94	25.5	0.31	32	37.6
November	COD	0.072	80	21.8	0.30	42	47.6
December	COD	0.072	103	28.1	0.29	42	46.1
Average	COD	0.072	123	33.5	0.36	28.1	37.4

(1) Estimated

TABLE 20

Plant D
Final and Intermediate Wastewater Data

Parameter	Treatment Plant Effluent (1) (mg/l)	Treatment Plant Effluent (1) (kg/day)	Final Effluent (2) (mg/l)	Final Effluent (2) (kg/day)	Calculated Cooling Water Quality(3) (mg/l)	Calculated Cooling Water Quality(3) (kg/day)
BOD	169.67	76.77	145.82	115.51	132.69	104.69
TSS	94.69	42.85	47.15	37.34	-	-
COD	396.14	179.25	145.12	114.95	1.47	1.16

(1) Flow: 119,633 GPD
(2) Flow: 329,058 GPD
(3) Dilution Factor = 1.7505

TABLE 21

308 Questionnaire Data
Plant E

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l)(1)
Aluminum	140	245
Boron	ND	16
Barium	70	122
BOD_5	8,600	15,033
Cobalt	ND	16
COD	31,000	54,188
Iron	570	996
Magnesium	5,300	9,264
Manganese	40	70
Molybdenum	ND	16
Nitrogen, Ammonia	70	122
Nitrogen, Nitrate	850	1,486
Oil & Grease	2,600	4,545
Phenols	ND	0.80
Tin	140	245
Ti	10	18
Organic Nitrogen	430	752
TSS	51,000	89,148
Antimony	28	49
Arsenic	60	105
Cadmium	8	14
Chromium (Total)	5	9
Copper	65	114
Lead	6	11
Nickel	27	47
Selenium	7	12
Thallium	3	5
Zinc	78	136
Toluene	15	26
Vinyl Chloride	19	33
Priority Pollutants reported as ND (2)	ND	1.6-399.3

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this plant is 0.748

(2) Priority pollutants reported as ND are presented in Appendix A. Detection levels are presented in Appendix B.

TABLE 22

308 Questionnaire Data
Plant F

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l)(1)
BOD_5	25,000	165,475
COD	55,000	364,045
Oil & Grease	1,000	6,619
TOC	9,700	64,204
TSS	29,000	191,951
Antimony	11	73
Arsenic	36	238
Beryllium	3.8	25
Cadmium	7.4	49
Chromium (Total)	74	490
Copper	37	245
Lead	28	185
Mercury	3	20
Nickel	21	139
Selenium	28	185
Silver	8	53
Thallium	72	477

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this facility is 5.619

TABLE 23

308 Questionnaire Data
Plant G

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l)(1)
Mercury	0.20	1.45
Zinc	190	1,378
Acrylonitrile	49,000	355,250
Ethylbenzene	640	4,640
Benzene	54	392
Bis(2-ethylhexyl)phthalate	12	87
Toluene	270	1,958

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this facility is 6.27

TABLE 24

308 Questionnaire Data
Plant H

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l)(1)
Mercury	0.4	2.1
Ethylbenzene	10	56
Bis(2-ethylhexyl)phthalate	36	202

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this facility is 4.6139

TABLE 25

308 Questionnaire Data
Plant I

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l)(1)
Arsenic	10	46
Cadmium	3	14
Chromium (Total)	340	1,571
Copper	70	323
Nickel	50	231
Selenium	12	55
Silver	40	185
TCDD(2)	26	120

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this facility is 3.620

(2) 2,3,7,8-Tetrachlorodibenzo-p-dioxin

TABLE 26

308 Questionnaire Data
Plant J

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l) (1)
Cyanide (Total)	366	4,416
Mercury	300	3,620
Selenium	100	1,207
Thallium	400	4,826
Antimony	<110	1,328
Beryllium	<110	1,328
Cadmium	<110	1,328
Chromium	<110	1,328
Copper	<110	1,328
Lead	<110	1,328
Nickel	<110	1,328
Silver	<100	1,207
Zinc	<110	1,328
2,4-Dinitrophenol	<250	3,016
4,6-Dinitro-o-cresol	<250	3,016
Priority Pollutant Organics(2)	<10	121
Priority Pollutant Organics(3)	<25	302

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this facility is 11.065

(2) Pollutants are presented in Appendix A.

(3) Pollutants are presented in Appendix A.

TABLE 27

308 Questionnaire Data
Plant K

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l)(1)
Barium	100	3,465
Iron	580	20,998
Magnesium	520	18,019
Manganese	50	1,733
NO_2 as N	100	3,465
NO_3 as N	900	31,186
Oil & Grease	1,400	48,512
Phosphorous	280	9,702
SO_4	29,000	1,004,894
Total Kjeldahl Nitrogen	1,200	41,582
TOC	23,000	796,985
1,1,1-Trichloroethane	9	312
Cadmium	0.9	31
Chromium (Total)	1.1	38
Copper	6.5	225
Benzene	9	312
N-nitrosodiphenylamine	1	35
Phenol	8	277
Bis(2-ethylhexyl)phthalate	4	139
Diethyl phthalate	0.1	4

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this facility is 33.6515

TABLE 28

308 Questionnaire Data
Plant L

Pollutant	Reported Concentration (ug/l)	Actual Concentration (ug/l)(1)
BOD_5	16,000	984,640
COD	25,000	1,538,500
TSS	12,000	738,480
Phenol	15	923

(1) Adjusted concentrations were generated through a mass balance, using the reported concentrations for combined process and dilution waters; and calculating an actual process water concentration through the use of a term designated as the dilution factor. The dilution factor was calculated by dividing dilution water flow by the process flow. The equation developed is as follows: Actual Concentration = Reported Concentration (1 + Dilution Factor)

The dilution factor for this facility is 60.54

APPENDIX A

Pollutants Reported at or below Levels of Detection

Industrial Facility	Pollutants[1]
Plant E	1-8; 10-16; 18-26; 28-49; 51-85; 87; 89-113; 117; 121; 123; 126
Plant J Reported as <10 ug/l	1; 4; 5; 7-30; 32; 33; 35-56; 61-63; 66-78; 80; 81; 84-113
Reported as <25 ug/l	31; 34; 57; 58; 64; 65; 79; 82; 83

(1) Pollutants are presented by number in Appendix C

APPENDIX B

Limits of Detection for Priority Pollutants

Code No.	Pollutants	Detection Limit (ug/l) Plant 114	Plant 2531
1	Acenaphthene	10	<10
2	Acrolein	100	-
3	Acrylonitrile	100	-
4	Benzene	10	<10
5	Benzidene	10	<10
6	Carbon tetrachloride (tetrachloromethane)	10	-
7	Chlorobenzene	10	<10
8	1,2,4-trichlorobenzene	10	<10
9	Hexachlorobenzene	-	<10
10	1,2-dichloroethane	10	<10
11	1,1,1-trichloroethane	10	<10
12	Hexachloroethane	10	<10
13	1,1-dichloroethane	10	<10
14	1,1,2-trichloroethane	10	<10
15	1,1,2,2-tetrachloroethane	10	<10
16	Chloroethane	10	<10
17*	~~bis-(chloromethyl)-ether~~	-	<10
18	Bis (2-chloroethyl) ether	10	<10
19	2-chloroethyl vinyl ether (mixed)	20	<10
20	2-chloronaphthalene	10	<10
21	2,4,6-trichlorophenol	25	<10
22	Para-chloro meta-cresol	25	<10
23	Chloroform (trichloromethane)	10	<10
24	2-chlorophenol	25	<10
25	1,2-dichlorobenzene	10	<10
26	1,3-dichlorobenzene	10	<10
27	1,4-dichlorobenzene	-	<10
28	3,3'-dichlorobenzidine	10	<10
29	1,1-dichloroethylene	10	<10
30	1,2-trans-dichloroethylene	10	<10
31	2,4-dichlorophenol	25	<25
32	1,2-dichloropropane	10	<10
33	1,3-dichloropropylene (1,3-dichloropropene)	10	<10
34	2,4-dimethylphenol	25	<25
35	2,4-dinitrotoluene	10	<10
36	2,6-dinitrotoluene	10	<10
37	1,2-diphenylhydrazine	10	<10
38	Ethylbenzene	10	<10
39	Fluoranthene	10	<10
40	4-chlorophenyl phenyl ether	10	<10
41	4-bromophenyl phenyl ether	10	<10
42	Bis (2-chloroisopropyl) ether	10	<10
43	Bis (2-chloroethoxy) methane	10	<10
44	Methylene chloride (dichloromethane)	10	<10

* Delisted 46 FR 10723

APPENDIX B (Cont.)

Code No.	Pollutants	Detection Limit (ug/l) Plant 114	Plant 2531
45	Methyl chloride (chloromethane)	10	<10
46	methyl bromide (bromomethane)	10	<10
47	Bromoform (tribromemethane)	10	<10
48	Dichlorobromomethane	10	<10
49**	Trichlorofluoromethane	10	<10
50**	Dichlorodifluoromethane	-	<10
51	Chlorodibromomethane	10	<10
52	Hexachlorobutadiene	10	<10
53	Hexachlorocyclopentadiene	10	<10
54	Isophorone	10	<10
55	Naphthalene	10	<10
56	Nitrobenzene	10	<10
57	2-nitrophenol	25	<25
58	4-nitrophenol	25	<25
59	2,4-dinitrophenol	25	-
60	4,6-dinitro-o-cresol	250	-
61	N-nitrosodimethylamine	10	<10
62	N-nitrosodiphenylamine	10	<10
63	N-nitrosodi-n-propylamine	10	<10
64	Pentachlorophenol	25	<25
65	Phenol	25	<25
66	Bis (2-ethylhexyl) phthalate	10	<10
67	Butyl benzyl phthalate	10	<10
68	Di-n-butyl phthalate	10	<10
69	Di-n-octyl phthalate	10	<10
70	Diethyl phthalate	10	<10
71	Dimethyl phthalate	10	<10
72	Benzo (a)anthracene (1,2-benzanthracene)	10	<10
73	Benzo (a)pyrene (3,4-benzopyrene)	10	<10
74	3,4-benzofluoranthene	10	<10
75	Benzo(k)fluoranthene (11,12-benzofluoranthene)	10	<10
76	Chrysene	10	<10
77	Acenaphthylene	10	<10
78	Anthracene	10	<10
79	Benzo(ghi)perylene (1,12-benzoperylene)	25	<25
80	Fluorene	10	<10
81	Phenanthrene	10	<10
82	Dibenzo (a,h)anthracene (1,2,5,6-dibenzanthracene)	25	<25
83	Indeno (1,2,3-cd)pyrene (2,3-o-phenylenepyrene)	25	<25
84	Pyrene	10	<10
85	Tetrachloroethylene	10	<10
86	Toluene	-	<10
87	Trichloroethylene	10	<10
88	Vinyl chloride (chloroethylene)	-	<10
89	Aldrin	10	<10

** Delisted 46 FR 2266

APPENDIX B (Cont.)

Code No.	Pollutants	Detection Limit (ug/l) Plant 114	Plant 2531
90	Dieldrin	10	<10
91	Chlorodane (technical mixture and metabolities)	10	<10
92	4,4'-DDT	10	<10
93	4,4'-DDE (p,p'DDX)	10	<10
94	4,4'-DDD (p,p'TDE)	10	<10
95	A-endosulfan-Alpha	10	<10
96	A-endosulfan-Beta	10	<10
97	Endosulfan sulfate	10	<10
98	Endrin	10	<10
99	Endrin aldehyde	10	<10
100	Heptachlor	10	<10
101	Heptachlor epoxide	10	<10
102	A-BHC-Alpha	10	<10
103	B-BHC-Beta	10	<10
104	R-BHC (lindane)-Gamma	10	<10
105	G-BHC-Delta	10	<10
106	PCB-1242 (Arochlor 1242)	10	<10
107	PCB-1254 (Arochlor 1254)	10	<10
108	PCB-1221 (Arochlor 1221)	10	<10
109	PCB-1232 (Arochlor 1232)	10	<10
110	PCB-1248 (Arochlor 1248)	10	<10
111	PCB-1260 (Arochlor 1260)	10	<10
112	PCB-1016 (Arochlor 1016)	10	<10
113	Toxaphene	10	<10
114	Antimony	-	-
115	Arsenic	-	-
116	Asbestos (Fibrous)	-	-
117	Beryllium	1	-
118	Cadmium	-	-
119	Chromium (Total)	-	-
120	Copper	-	-
121	Cyanide (Total)	50	-
122	Lead	-	-
123	Mercury	5	-
124	Nickel	-	-
125	Selenium	-	-
126	Silver	1	-
127	Thallium	-	-
128	Zinc	-	-
129	2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	-	-

APPENDIX C

List of 129 Priority Toxic Pollutants

Code No.	Pollutant
1	Acenaphthene
2	Acrolein
3	Acrylonitrile
4	Benzene
5	Benzidene
6	Carbon tetrachloride (tetrachloromethane)
7	Chlorobenzene
8	1,2,4-trichlorobenzene
9	Hexachlorobenzene
10	1,2-dichloroethane
11	1,1,1-trichloroethane
12	Hexachloroethane
13	1,1-dichloroethane
14	1,1,2-trichloroethane
15	1,1,2,2-tetrachloroethane
16	Chloroethane
17*	~~bis-(chloromethyl)-ether~~
18	Bis (2-chloroethyl) ether
19	2-chloroethyl vinyl ether (mixed)
20	2-chloronaphthalene
21	2,4,6-trichlorophenol
22	Para-chloro meta-cresol
23	Chloroform (trichloromethane)
24	2-chlorophenol
25	1,2-dichlorobenzene
26	1,3-dichlorobenzene
27	1,4-dichlorobenzene
28	3,3'-dichlorobenzidine
29	1,1-dichloroethylene
30	1,2-trans-dichloroethylene
31	2,4-dichlorophenol
32	1,2-dichloropropane
33	1,3-dichloropropylene (1,3-dichloropropene)
34	2,4-dimethylphenol
35	2,4-dinitrotoluene
36	2,6-dinitrotoluene
37	1,2-diphenylhydrazine
38	Ethylbenzene
39	Fluoranthene
40	4-chlorophenyl phenyl ether
41	4-bromophenyl phenyl ether
42	Bis (2-chloroisopropyl) ether
43	Bis (2-chloroethoxy) methane
44	Methylene chloride (dichloromethane)
45	Methyl chloride (chloromethane)
46	methyl bromide (bromomethane)

* Delisted 46 FR 10723

APPENDIX C (Cont.)

Code No.	Pollutant
47	Bromoform (tribromemethane)
48	Dichlorobromomethane
49**	Trichlorofluoromethane
50**	Dichlorodifluoromethane
51	Chlorodibromomethane
52	Hexachlorobutadiene
53	Hexachlorocyclopentadiene
54	Isophorone
55	Naphthalene
56	Nitrobenzene
57	2-nitrophenol
58	4-nitrophenol
59	2,4-dinitrophenol
60	4,6-dinitro-o-cresol
61	N-nitrosodimethylamine
62	N-nitrosodiphenylamine
63	N-nitrosodi-n-propylamine
64	Pentachlorophenol
65	Phenol
66	Bis (2-ethylhexyl) phthalate
67	Butyl benzyl phthalate
68	Di-n-butyl phthalate
69	Di-n-octyl phthalate
70	Diethyl phthalate
71	Dimethyl phthalate
72	Benzo (a)anthracene (1,2-benzanthracene)
73	Benzo (a)pyrene (3,4-benzopyrene)
74	3,4-benzofluoranthene
75	Benzo(k)fluoranthene (11,12-benzofluoranthene)
76	Chrysene
77	Acenaphthylene
78	Anthracene
79	Benzo(ghi)perylene (1,12-benzoperylene)
80	Fluorene
81	Phenanthrene
82	Dibenzo (a,h)anthracene (1,2,5,6-dibenzanthracene)
83	Indeno (1,2,3-cd)pyrene (2,3-o-phenylenepyrene)
84	Pyrene
85	Tetrachloroethylene
86	Toluene
87	Trichloroethylene
88	Vinyl chloride (chloroethylene)
89	Aldrin
90	Dieldrin
91	Chlorodane (technical mixture and metabolities)

** Delisted 46 FR 2266

APPENDIX C (Cont.)

Code No.	Pollutant
92	4,4'-DDT
93	4,4'-DDE (p,p'DDX)
94	4,4'-DDD (p,p'TDE)
95	A-endosulfan-Alpha
96	A-endosulfan-Beta
97	Endosulfan sulfate
98	Endrin
99	Endrin aldehyde
100	Heptachlor
101	Heptachlor epoxide
102	A-BHC-Alpha
103	B-BHC-Beta
104	R-BHC (lindane)-Gamma
105	G-BHC-Delta
106	PCB-1242 (Arochlor 1242)
107	PCB-1254 (Arochlor 1254)
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
114	Antimony
115	Arsenic
116	Asbestos (Fibrous)
117	Beryllium
118	Cadmium
119	Chromium (Total)
120	Copper
121	Cyanide (Total)
122	Lead
123	Mercury
124	Nickel
125	Selenium
126	Silver
127	Thallium
128	Zinc
129	2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

VII. CALCULATION OF PRIORITY POLLUTANT WASTE LOADS

VII. CALCULATION OF PRIORITY POLLUTANT WASTE LOADS

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VII. CALCULATION OF PRIORITY POLLUTANT WASTE LOADS

1. INTRODUCTION

Plants within the Organic Chemical and Plastics/Synthetic Fibers industries use water for a wide variety of purposes: direct process contact uses (e.g., waste streams from reactors, raw material recovery, solvent recovery, product separation and refining); indirect process contact uses (e.g., in pumps, seals, and vacuum jet and steam ejector systems); maintenance, equipment cleaning, work area washdowns; air pollution control; waste transport; noncontact cooling; and noncontact ancilliary uses (e.g., boilers and utilities). With the exception of noncontact waters, wastewater from these industries is potentially contaminated to a greater or lesser degree with priority pollutants. Because the Organic Chemicals and Plastics/Synthetic Fibers (OCPSF) industry use large amounts of water in the manufacture of products (~ 17 percent of the total water consumed by all manufacturing establishments in 1978) these industries generate raw wastewaters that contain significant concentrations of priority pollutants.

Most of this wastewater receives some treatment to reduce pollutant concentrations prior to environmental discharge, either as an individual process wastestream or in a wastewater treatment plant serving combined wastestreams from the entire facility. To determine what pollutants merit regulation, as well as determining the costs and benefits of removing regulated priority pollutants, the Agency has acquired extensive analytical data on priority pollutant concentrations in industry wastewaters.

In principle, there are a variety of ways by which priority pollutant loads may be estimated. Previously, the Agency had estimated raw, current, projected BPT effluent, projected PSES effluent and projected BAT effluent priority pollutant waste loadings for the entire OCPSF industrial category using data developed as part of the Regulatory Impact Analysis of these proposed regulations. These data are presented in the February 18, 1983, draft report from EPA's Office of Water Regulations and Standards, Monitoring and Data Support Division (MDSD), entitled "Summary of Priority Pollutant Loadings for the Organic Chemicals, Plastics, and Synthetics Industry."

The MDSD draft report estimated raw, current, projected BPT, projected PSES and projected BAT effluent waste loadings for the OCPSF industry based on 176 product/processes that account for ~ 60% of the industry production. The Agency then extrapolated these loadings by flow to cover all the product/processes comprising OCPSF production, as follows: the MDSD flow estimates for the 176 product/processes were 222.4 MGD for direct dischargers and 96.6 MGD for indirect dischargers. Assuming 520 direct dischargers at 2.31 MGD each, total industry direct discharge flow is 1,201.2 MGD. Assuming 468 indirect dischargers at 0.80 MGD each, total industry indirect discharge flow is 374.4 MGD. The direct waste loads for the total industry were estimated by multiplying the MDSD waste loads for the 176 product/processes by 1,201.2/222.4 = 5.40. The indirect waste loads for the total industry were estimated by multiplying the MDSD waste loads for the 176 product/processes by 374.4/96.6 = 3.88.

This analysis was shown to overestimate annual toxic pollutant discharges based upon information received by the Agency after proposal. Upon the receipt of 1983 "308" questionnaire data, the Agency determined that calculation of plant-specific toxic pollutant waste loads was practicable.

The Agency has estimated raw, current, projected BPT effluent, projected PSES effluent, and projected BAT effluent priority pollutant waste loadings for the OCPSF industries. These loadings have been calculated on a plant-by-plant basis using both industry generated data (i.e., 1983 "308" questionnaire data) as well as analytical data acquired by the Agency in various sampling studies. OCPSF industry waste loadings are presented in Appendix A. The following sections briefly describe the methodology used to calculate waste loads from the OCPSF industries.

2. METHODOLOGY FOR WASTE LOAD CALCULATION

This section presents the approach taken by the Agency for waste load calculations. A general methodology is presented first. Analytical data for

toxic pollutants are discussed next. Flow data and the assumptions used to calculate product/process flow are presented. Plant specific waste load calculations are presented last.

There are four distinct levels at which toxic pollutant waste loads from a plant can be calculated. The first level is at an aggregated product/process level (or plant level) where wastestreams from several processes are combined. If toxic pollutant concentration and flow are known for the aggregate raw wastestream (i.e., prior to any treatment that may affect toxic pollutant removal) and the final wastestream (after the current treatment system), then both raw and current waste loads may be calculated as:

$$RWL_i = [P_i]F_i$$

$$CWL_e = [P_e]F_e$$

where RWL_i = raw waste load for a pollutant
CWL_e = current waste load for a pollutant
$[P_i]$ = concentration of a pollutant in raw wastewater
$[P_e]$ = concentration of a pollutant in final discharge
F_i = raw wastewater flow
F_e = final discharge wastewater flow.

If more than one aggregated wastewater stream exists at a plant, toxic pollutant loadings are summed to determine the total waste load.

The second level at which toxic pollutant waste loads from a plant can be calculated is at a product/process or production unit level. The Agency has sampled the raw wastewaters of 176 product/processes employed by the OCPSF industries to produce high production volume organic chemicals, plastics, and synthetic fibers. These processes (see Tables 1 and 2) comprise approximately 60% of the OCPSF industries' total production. This collection of product/process data is known as the Master Process File (MPF) (see Appendix B).

TABLE 1. MAJOR PRODUCTS BY PROCESS OF THE ORGANIC CHEMICALS INDUSTRY

PRODUCT	PROCESS (FEEDSTOCK)
Acetaldehyde	By-product (Acrolein/Propene/Oxidation) Oxidation (Ethene)
Acetic Acid	By-product (Polyvinyl Alcohol) Carbonylation (Methanol) Co-product (Terephthalic Acid) Oxidation (Acetaldehyde) Oxidation (Butane)
Acetic Anhydride	Addition (Acetic Acid/Ketene)
Acetone	Oxidation (Isopropanol/H202) Peroxidation/Acid Cleavage (Cumene)
Acetonitrile	By-product (Acrylonitrile/Ammoxidation/Propene)
Acetylene	By-product (Propane Pyrolysis) Hydrolysis (Calcium Carbide) Oxidation (Methane)
Acrolein	Oxidation (Propene)
Acrylamide	Hydration (Acrylonitrile) Formlyation/Hydration (Acetylene/Carbon Monoxide/Water) Oxidation (Acrolein) Oxidation (Propene)
Acrylic Acid Esters	Esterification (Miscellaneous Alcohols)
Ethyl Acrylate	Esterification (Acrylic Acid/Ethanol)
Ethylhexyl Acrylate	Esterification (Acrylic Acid/2-Ethylhexanol)
Isobutyl Acrylate	Esterification (Acrylic Acid/Isobutanol)
n-Butyl Acrylate	Esterification (Acrylic Acid/n-Butanol)
Acrylonitrile	Ammoxidation (Propene)
Adipic Acid	Oxidation (Cyclohexane) Oxidation (Cyclohexanol) Oxidation (Cyclohexanone)
Adiponitrile	Ammonolysis/Dehydration (Adipic Acid) Chlorination/Cyanation (Butadiene) Electrohydrodimerization (Acrylonitrile)
Alkyl Amines	Hydrogenation (Fatty Nitriles)

TABLE 1. MAJOR PRODUCTS BY PROCESS OF THE ORGANIC CHEMICALS INDUSTRY
(Continued)

PRODUCT	PROCESS (FEEDSTOCK)
Alkyl Phenols	Alkylation (Phenol)
Allyl Alcohol	Reduction (Acrolein/Aluminum Butoxide)
Amyl Acetates	Esterification (Acetic Acid/Amyl Alcohols)
Aniline	Hydrogenation (Nitrobenzene)
Benzene	Distillation (BTX Extract Cat Reformate) Distillation (BTX Extract - Coal Tar Light Oil) Distillation (BTX Extract - Pyrolysis Gasoline) Hydrodealkylization (Toluene/Xylene)
Benzoic Acid	Oxidation (Toluene)
Benzyl Alcohol	Hydrolysis (Benzyl Chloride)
Benzyl Chloride	Chlorination (Toluene)
Bisphenol-A	Condensation (Acetone/Phenol)
BTX	Pyrolysis (Gasoline)
1,3-Butadiene	Extractive Distillation (C-4 Pyrolyzates)
Butenes	Extractive Distillation (C4 Pyrolyzates)
n-Butyl Alcohol	Hydrogenation (n-Butyraldehyde/Oxo Process)
sec-Butyl Alcohol	Hydration (Butenes)
Caprolactam	Rearrangement (Cyclohexanone Oxime)
Carbon Tetrachloride	Chlorination (Carbon Disulfide) Chlorination (Methane) Chlorination (Methyl Chloride) Co-product (Tetrachloroethene)
Cellulose Butyrates	Esterification (Cellulose)
Cellulose Acetate/Propionate	Esterification (Cellulose)
Chlorobenzene	Chlorination (Benzene)
Chlorodifluoromethane	Hydrofluorination (Chloroform)
Chloroform	Chlorination (Methane) Chlorination (Methyl Chloride)
3-Chloronitrobenzene	Chlorination (Nitrobenzene)

TABLE 1. MAJOR PRODUCTS BY PROCESS OF THE ORGANIC CHEMICALS INDUSTRY
(Continued)

PRODUCT	PROCESS (FEEDSTOCK)
Coal Tar	Coking (Coal)
Creosote	Distillation (Coal Tar Light Oil)
Cumene	Alkylation (Benzene/Propene)
Cyclohexane	Hydrogenation (Benzene)
Cyclohexanol/One (Mixed)	Oxidation (Cyclohexane)
Cyclopentadiene Dimer	Extractive Distillation (C5 Pyrolyzates)
1,2-Dichlorobenzene	Chlorination (Benzene)
1,4-Dichlorobenzene	Chlorination (Benzene)
Dichlorodifluoromethane	Hydrofluorination (Carbon Tetrachloride)
1,2-Dichloroethane	Direct Chlorination (Ethene) Oxychlorination (Ethene)
Diethylene Glycol	Co-product (Ethylene Glycol)
Diisopropyl Benzene	Alkylation of Benzene (Cumene)
Diketene	Dimerization (Ketene/Acetic Acid)
Dimethyl Terephthalate	Esterification (Terphthallic Acid) Oxidation/Esterification (P-Xylene)
Dinitrotoluene (Mixed)	Nitration (Toluene)
Dyes and Dye Intermediates	----------
Epichlorohydrin	Epoxidation (Allyl Chloride/Chlorohydrination)
Ethanol	Hydration (Ethene)
Ethoxylates, Alkylphenol	Etherification (Phenol/Ethylene Oxide)
Ethoxylates, Alkyl	Etherification (Linear Alcohols/Ethlene Oxide)
Ethylamine	Ammonolysis (Ethanol)
Ethylbenzene	Alkylation (Benzene) Distillation (BTX Extract)
Ethene	Pyrolysis (Ethane/Propane/Butane/LPG) Pyrolysis (Naphtha/Gas Oil) Pyrolysis (Ethane/Propane/Butane/Naphtha)

TABLE 1. MAJOR PRODUCTS BY PROCESS OF THE ORGANIC CHEMICALS INDUSTRY
(Continued)

PRODUCT	PROCESS (FEEDSTOCK)
Ethylene Diamine	Amination (1,2-Dichloroethane)
Ethylene Glycol	Hydrolysis (Ethylene Oxide)
Ethylene Oxide	Epoxidation (Ethylene Chlorohydrin) Oxidation (Ethene)
2-Ethylhexanol	Condensation/Hydrogenation (n-Butaldehyde)
Formaldehyde	Oxidation (Methanol-Silver Catalyst)
Formic Acid	By-product (Butane Oxidation)
Glycerine (Synthetic)	Hydration (Allyl Alcohol) Hydrolysis (Epichlorohydrin)
Hexamethylenediamine	Depolymerization (Nylon 66) Hydrogenation (Adiponitrile)
Hydroquinone	Oxidation (Aniline)
Hydroxyethyl Cellulose	Etherification (Cellulose)
Hydroxypropyl Cellulose	Etherification (Cellulose)
Isobutanol	Hydrogenation (Isobutyraldehyde-Oxo Process)
Isobutylene	Dehydration (tert-Butanol) Extraction (C4 Pyrolyzate)
Isoprene	Extractive Distillation (C5 Pyrolyzate)
Isopropanol	Hydration (Propene)
Maleic Anhydride	Oxidation (Benzene)
Methacrylic Acid	Hydrolysis (Acetone Cyanohydrin)
Methacrylic Acid Esters	Esterification (Methacrylic Acid/Alcohols)
Methanol	Oxidation (H.P. Synthesis Natural Gas/Synthetic Gas) Oxidation (L.P. Synthesis Natural Gas/Synthetic Gas)
Methyl Chloride	Chlorination (Methane) Hydrochlorination (Methanol)
Methyl Ethyl Ketone	Reduction (Acrolein/Aluminum Butoxide)

TABLE 1. MAJOR PRODUCTS BY PROCESS OF THE ORGANIC CHEMICALS INDUSTRY
(Continued)

PRODUCT	PROCESS (FEEDSTOCK)
Methyl Isobutyl Carbinol	Condensation (Acetone)
Methyl Isobutyl Ketone	Hydrogenation (Mesityl Oxide)
Methyl Methacrylate	Methanolysis (Acetone Cyanohydrin)
Methyl Salicylate	Esterification (Salicylic Acid)
Methylamines	Ammination (Methanol/Ammonia)
Methylene Chloride	Chlorination (Methane) Chlorination (Methyl Chloride)
Methylstyrene	By-product (Acetone/Phenol by Cumene Oxidation)
Naphthalene	Distillation (Pyrolysis Gas) Separation (Coal Tar Distillate)
Neopentanoic Acid	Oxidation (Isobutylene Via Oxo Process)
Nitrobenzene	Nitration (Benzene)
4-Nitrophenol & Sodium Salt	Nitration (Phenol)
Nonyl Phenol	Alkylation (Phenol)
Nylon Salt	Condensation (Adipic Acid/Hexamethylene Diamine)
Oxo Aldehydes/Alcohols	Oxidation (Hydrocarbons - Oxo Process)
Pentachlorophenol	Chlorination (Phenol)
Phenol	Peroxidation/Acid Cleavage (Cumene)
Phosphate Esters	Phosgenation (Phosphoryl Chloride/Phenol/ Isodecanol)
Phthalate Ester, Bis 2-Ethylhexyl	Alcoholysis (Phthalic Anhydride/2-Ethylhexanol)
Butylbenzyl	Alcoholysis (Phthalic Anhydride/Butanol/ Benzylchloride)
C11-C14	Alcoholysis (Phthalic Anhydride/C11-C14 Alcohols)
Diethyl	Alcoholysis (Phthalic Anhydride/Ethanol)
Diphenyl	Esterification (Phenol/Phthalyl Chloride)

TABLE 1. MAJOR PRODUCTS BY PROCESS OF THE ORGANIC CHEMICALS INDUSTRY (Continued)

PRODUCT	PROCESS (FEEDSTOCK)
Phthalic Anhydride.	Oxidation (Naphthalene) Oxidation (o-Xylene)
Pitch Tar Residue	Separation (Coal Tar Light Oil distillate)
Polyethylene Glycol	Polymerization (Ethylene Oxide)
Polyethylene Polyamines	Amination (Ethylene Diamine/2,3-Dichloroethane/NH3)
Polymeric Methylene Dianiline	Condensation (Aniline/Formaldehyde)
Polymeric Methylene Diphenyl Diisocyanate	Phosgenation (Polymethylene Dianiline)
Polyoxyethylene Glycol	Condensation (Propylene Glycol/Propylene Oxide)
Polyoxypropylene Glycol	Propoxylation (Glycerine)
Propene	Pyrolysis (Ethane/Propane/Butane/LPG) Pyrolysis (Naphtha and/or Gas Oil) Pyrolysis (Naphtha, Propane, Ethane, Butane)
Propionaldehyde	Hydroformylation (Ethene-Oxo Process)
Propionic Acid	Oxidation (Propionaldehyde)
n-Propyl Acetate	Esterification (Acetic Acid/Propanol)
n-Propyl Alcohol	Hydrogenation (Propionaldehyde)
Propylene Oxide	Epoxidation (Propene via Chlorohydrin)
Salicylic Acid	Carboxylation (Sodium Phenolate)
Styrene	Dehydrogenation (Ethylbenzene)
Terephthalic Acid	Catalytic Oxidation (p-Xylene)
Tetrachloroethene	Chlorination (1,2-Dichloroethane/Other Chlorinated Hydrocarbons) Chlorination (Acetylene) Chlorination (Hydrocarbons)
Tetrachlorophthalic Anhydride	Chlorination (Phthalic Anhydride)
Tetraethlene Glycol	Co-product (Ethylene Glycol)
Tetraethyl Lead	Alkylation (Ethyl Chloride/Sodium-Lead Alloy)

TABLE 1. MAJOR PRODUCTS BY PROCESS OF THE ORGANIC CHEMICALS INDUSTRY (Continued)

PRODUCT	PROCESS (FEEDSTOCK)
Tetramethyl Lead	Alkylation (Methyl Chloride/Sodium-Lead Alloy)
Toluene	Distillation (BTX Extract - Cat Reformate) Distillation (BTX Extract - Coal Tar Light Oil) Distillation (BTX Extract - Pyrolysis Gasoline)
Toluenediamine (Mixture)	Hydrogenation (Dinitrotoluenes)
2,4-Toluenediamine	Hydrogenation (Dinitrotoluene)
Toluene Diisocyanates (Mixture)	Phosgenation (Toluenediamines)
2,4-Toluene Diisocyanate	Phosgenation (2,4-Toluenediamine)
Trichloroethene	Chlorination (1,2-Dichloroethane/Other Hydrocarbons) Chlorination (Acetylene)
Trichlorofluoromethane	Hydrofluorination (Carbon Tetrachloride)
Triethylene Glycol	Co-product (Ethylene Glycol/Ethylene Oxide) Recovery from Ethylene Glycol Still Bottoms
Vinyl Acetate	Esterification (Acetylene/Acetic Acid Esterification (Ethene/Acetic Acid Gas Phase) Esterification (Ethene/Acetic Acid Liquid Phase)
Vinyl Chloride	Dehydrochlorination (1,2-Dichloroethane) Dehydrochlorination (1,2-Dichloroethane - Balanced Process)
Vinylidene Chloride	Dehydrochlorination (Trichloroethane)
Xylenes, Mixed	Extraction (Cat Reformate) Extraction (Coal Tar Light Oil) Extraction (Pyrolysis Gasoline) Separation (Xylene Bottoms)
m-Xylene	Fractionation (Mixed Xylenes)
o-Xylene	Distillation (Mixed Xylenes)
p-Xylene	Isomerization/Crystallization (Mixed Xylenes)

TABLE 2. MAJOR PRODUCTS BY PROCESS OF THE PLASTICS/SYNTHETIC FIBERS INDUSTRY

PRODUCT	PROCESS (FEEDSTOCK)
ABS Resin	Emulsion Polymerization
ABS/San Resin	Emulsion/Suspension Polymerization
Acrylic Fiber (85% Polyacrylonitrile)	Suspension Polymerization - Wet Spinning
Acrylic Latex	Emulstion Polymerization
Acrylic Resins	Solution Polymerization
Alkyd Resins	Condensation/Polymerization
Cellulose Acetate Fibers	Spinning from Acetylated Cellulose
Cellulose Acetate Resin	Acetylation (Cellulose)
Epoxy Resins	Condensation (Epichlorohydrin/Novolak Resins) Condensation (Epichlorohydrin/Bisphenol A) Condensation (Polyols/Epichlorohydrin) Epoxidation (Polymers)
Melamine Resins	Condensation (Melamine/Formaldehyde)
Modacrylic Fiber	Spinning
Nylon 6 Resin	Condensation (Caprolactam)
Nylon 66 Resin	Condensation (Nylon Salt)
Petroleum Hydrocarbon Resins	Condensation (C5-C8 Unsaturates)
Phenolic Resins	Condensation (Phenol/Formaldehyde)
Polycarbonates	----------
Polyester Fibers	Melt Spinning (DMT/Ethylene Glycol) Melt Spinning (TPA/Ethylene Glycol)
Polyester Resins	Condensation (TPA/Ethylene Glycol) Condensation (DMT/Ethylene Glycol)
Polyethylene Resins	High Pressure Polymerization (LDPE) Solution Polymerization (HDPE)
Polypropylene Resin	Solution Polymerization

TABLE 2. MAJOR PRODUCTS BY PROCESS OF THE PLASTICS/SYNTHETIC FIBERS INDUSTRY (Continued)

PRODUCT	PROCESS (FEEDSTOCK)
Polystyrene and Copolymers	Bulk Polymerization
Polyvinyl Acetate Resins	Emulsion Polymerization
Polyvinyl Alcohol Resin	Hydrolysis (Polyvinyl Acetate) Solution Polymerization (Vinyl Acetate/ Hydrolysis of Polymer)
Polyvinyl Chloride	Bulk Polymerization Emulsion Polymerization Suspension Polymerization
Rayon	Viscose Process
San Resins	Suspension Polymerrization
Silicones	Hydrolysis (Chlorosilanes)
Silicone Fluids	Hydrolysis/Cyclization (Chlorosilanes)
Silicone Resins	Hydrolysis/Cyclization (Chlorosilanes)
Silicone Rubbers	Hydrolysis/Cyclization (Chlorosilanes)
Styrene-Butadiene Resin	Emulsion Polymerization
Unsaturated Polyester Resin	Condensation (Maleic and Phthalic Anhydrides/ Glycols)
Urea Resins	Condensation (Urea/Formaldehyde)

Given toxic pollutant concentrations for a given production process and using wastewater flow specific to that product/process, toxic pollutant waste load can be calculated as before. The total waste load from a plant is the sum of the individual product/process waste loads generated at an OCPSF plant.

A third level at which toxic pollutant waste loads from a plant can be calculated is at the product level. This approach entails averaging toxic pollutant concentrations from the MPF by product rather than product/process. One hundred and twenty-one specific products are covered by the MPF comprising 86 percent of the OCPSF industries' total production. Using toxic pollutant concentration for a specific product and using wastewater flow specific to that product, product specific waste loads can be calculated as before. Again, the total waste load from a plant is calculated as the sum of individual product waste loads.

The last and most general level at which plant specific waste loads can be calculated is at the generic process level. This approach entails averaging toxic pollutant concentrations from the MPF by generic process rather than by product/process; each product/process reported by the OCPSF industries has been assigned a generic chemical process. Table 3 lists the generic chemical processes employed by the OCPSF industry. Ninety-eight percent of all products produced by the OCPSF industries are covered by generic chemical process calculations. Using generic process toxic pollutant concentrations for a specific product and using wastewater flow specific to that product, product specific waste loads are calculated as before. Again, the total waste load from a plant is calculated as the sum of individual product waste loads.

3. POLLUTANT CONCENTRATION DATA

A variety of studies has been undertaken by EPA to collect toxic pollutant concentrations in the OCPSF industries' wastewaters. Studies which have produced significant data on raw and current wastewater characteristics include the 1983 "308" Survey, the Screening Studies (Phases I and II), the

TABLE 3. GENERIC CHEMICAL PROCESSES

Acid Cleavage
Acylation
Addition
Alcoholysis
Alkoxylation
Amination
Ammoxidation

Bromination

Carbonylation
Chlorination
Chlorohydrination
Condensation
Crystallization/Distillation
Cyanation

Decarboxylation
Dehydration
Dehydrogenation
Dehydrohalogenation
Depolymerization
Diazotization
Dimerization
Distillation

Electrohydrodimerization
Epoxidation
Esterification
Etherification
Extraction
Extractive Distillation

Fiber Production
Fluorination

Hydration
Hydroacetylation
Hydrocyanation
Hydrogenation
Hydrohalogenation
Hydrolysis
Hydroxylation

Iodination
Isomerization

Neutralization
Nitration
Nitrosation
Oxidation
Oxidation/Reduction
Oximation
Oxyhalogenation

Peroxidation
Phosgenation
Phosphonation
Polymerization
Pyrolysis

Rearrangement

Sulfation
Sulfonation

Transesterification

Verification Study, and the CMA Five-Plant Study. Toxic and conventional pollutant data collected at the product/process level from these studies make up the Master Process File. These studies are summarized in Table 4 and discussed below. Toxic pollutant concentration data used for calculation of raw waste loads are listed in Appendix C.

3.1 308 Questionnaire Data

In September, 1983, the Agency requested new information on current manufacturing processes and wastewater control/treatment practices related to the production of organic chemicals and/or plastics and synthetic fibers. Data were collected at two levels: primary Organic Chemical and Plastics/ Synthetic Fibers plants (plants whose manufacture of OCPSF products was more than 50 percent of total plant production in 1982; plants whose OCPSF wastewaters were segregated; plants whose OCPSF process wastewaters represented 75 percent or more of total process wastewater flow treated in a treatment facility) provided a general profile of the plant, detailed production data, detailed wastewater treatment data, detailed disposal techniques, and analytical data summaries. Secondary OCPSF plants (plants not meeting the above criteria) provided only general profile data.

With regard to toxic pollutant data, the Agency requested 1980 average priority pollutant concentration data from primary organic and plastics producers for the following sample points:

- Influent and effluent data for in-plant wastewater control or treatment unit operations;
- Influent to the main (end-of-pipe) wastewater treatment system;
- Intermediate sampling points within the main (end-of-pipe) wastewater treatment system;
- The effluent sampling point from the main (end-of-pipe) wastewater treatment system; and
- The effluent sampling point if the wastewater is discharged without treatment.

TABLE 4. OVERVIEW OF WASTEWATER STUDIES INCLUDED IN BAT RAW WASTESTREAM DATA BASE

ELEMENT	STUDY		
	SCREENING		
	PHASE I	PHASE II	VERIFICATION
Dates	August 1977 to March 1978	December 1979	1978 to 1980
Number of Plants	131	40	37
Direct Dischargers	-	14	30
Indirect Dischargers	-	24	5
Other Dischargers	-	2	2
Sampling Locations	Raw water. Treatment influent and effluent. Some product/process effluents.	Same as Phase I.	Product/process influents and effluents in 29 plastic, 147 organic. Raw water.
Sampling Duration (a)	1 day	1 day	3 days
Pollutants Tested	All priority pollutants but asbestos.	Same as Phase I	Specific pollutants from specific product/ processes
Analytical methods for organic pollutants	GC/MS, 1977 QA/QC protocol; 4-AAP for phenols.	GC/MS, 1979 QA/QC protocol.	GC/CD with confirmatory GC/MS on 10% of samples.
Labs Participating	EPA Regions VII, VI, IV; Envirodyne, Midwest Research Institute (MRI).	Environmental Science & Engineering	Labs: Envirodyne, MRI, Southwest Research Institute, Gulf South Research Institute, Jacobs (PJB Labs), Acurex.

(a) Generally, samples were 24-hour composites; cyanide, phenols, and volatile organics were generally grab samples or a series of grab samples.

Average concentrations for toxic pollutant parameters were to be calculated as follows:

- o All not detected (ND), trace (TR), and less than (LT) the detection limit values were not be included in the calculation of average concentrations;
- o All greater than (GT) the detection limit values were included in the calculation of average concentrations as the detection limit; and
- o All "ND," "TR," and "LT the detection limit" values were counted in the "Number of Observations Below the Detection Limit".

It is important to realize that no new analytical data were to be generated by this data request; additionally, data generated for design analysis or similar purposes were not to be reported. Of the five hundred and forty-five plants requested to submit analytical data, forty plants submitted data useful for the calculation of raw waste loads.

3.2 Screening Phase I.

The wastewater quality data reported in the 1976 308 Questionnaires were the result of monitoring and analyses by each of the individual plants and their contract laboratories. To expand its priority pollutant data base and improve data quality by minimizing the discrepancies among sampling and analysis procedures, EPA in 1977 and 1978 performed its Phase I Screening Study. The Agency and its contractors sampled at 131 plants, chosen because they operated product/processes that produce the highest volume organic chemicals and plastics/synthetic fibers.

Samples were taken of the raw plant water, some product/process influents and effluents, and influents and effluents at the plant wastewater treatment facilities. Samples were analyzed for all priority pollutants except asbestos, and for several conventional and nonconventional pollutants. Screening

samples were collected in accordance with procedures described in an EPA Screening Procedures Manual (EPA 1977). Samples for liquid-liquid extraction (all organic pollutants except the volatile fraction) and for metals analyses were collected in glass compositing bottles over a 24-hour period, using an automatic sampler generally set for a constant aliquot volume and constant time, although flow- or time-proportional sampling was allowed. For metals analysis, an aliquot of the final composite sample was poured into a clean bottle. Some samples were preserved by acid addition in the field, in accordance with the 1977 manual; acid was added to the remaining samples when they arrived at the laboratory.

For purge and trap (volatile organic) analysis, wastewater samples were collected in 40- or 125-ml vials, filled to overflowing, and sealed with Teflon-faced rubber septa. Where dechlorination of the samples was required, sodium thiosulfate or sodium bisulfite was used.

Cyanide samples were collected in 1-liter plastic bottles as separate grab samples. These samples were checked for chlorine by using potassium-iodide starch test-paper strips, treated with ascorbic acid to eliminate the chlorine, then preserved with 2 ml of 10N sodium hydroxide/liter of sample (pH 12).

Samples for total (4AAP) phenol colorimetric analysis were collected in glass bottles as separate grab samples. These samples were acidified with phosphoric or sulfuric acid to pH 4, then sealed.

All samples were maintained at 4°C for transport and storage during analysis. Where sufficient data were available, other sample preservation requirements (e.g., those for cyanide, phenol, and VOAs by purge and trap as described above) were deleted as appropriate (e.g., if chlorine was known to be absent). No analysis was performed for asbestos during the screening and verification efforts. A separate program was subsequently undertaken for determination of asbestos.

3.3 Screening Phase II.

In December, 1979, samples were collected from an additional 40 plants (known as Phase II facilities) manufacturing products such as dyes, flame retardants, coal tar distillates, photographic chemicals, flavors, surface active agents, aerosols, petroleum additives, chelating agents, microcrystalling waxes, and other low volume specialty chemicals. As in the Phase I Screening study, samples were analyzed for all the priority pollutants except asbestos. The 1977 EPA Screening Procedures Manual was followed in analyzing priority pollutants. As in Screening Phase I, some samples for metals analysis were preserved by addition of acid in the field (in accordance with the 1977 Manual) and acid was added to the remaining samples when they arrived at the laboratory. In addition, the organic compounds producing peaks not attributable to priority pollutants with a magnitude of at least one percent of the total ion current were identified by computer matching.

Intake, raw influent, and effluent samples were collected for nearly every facility sampled. In addition, product/process wastewaters which could be isolated at a facility were also sampled, as were influents and effluents from some treatment technologies in place. Fourteen direct dischargers, 24 indirect dischargers, and 2 plants discharging to deep wells were sampled. Table 5 lists the product/process and other waste streams sampled at each plant.

3.4 Verification Program.

The Verification Program was designed to verify the occurrence of specific priority pollutants in waste streams from individual product/processes. Product/processes to be sampled were chosen to maximize coverage of the product/processes used to manufacture major organic chemicals and plastics. The priority pollutants selected for analysis in the waste stream from each product/process were chosen to meet either of two criteria:

TABLE 5. PHASE II SCREENING - PRODUCT/PROCESS AND OTHER WASTE STREAMS SAMPLED AT EACH PLANT

Plant Number	Waste Streams Sampled
1	Combined raw waste (fluorocarbon)
2	Anthracene Coal tar pitch
3	Combined raw wastes (dyes)
4	Combined raw wastes (coal tar)
5	Combined raw wastes (dyes)
6	Oxide Polymer
7	Freon
8	Freon
9	Ethoxylation
10	Nonlube oil Additives Lube oil Additives
11	Combined raw wastes (dyes)
12	Combined raw wastes (flavors)
13	Combined raw wastes (speciality chemicals)
14	Combined raw wastes (flavors)
15	Hydroquinone
16	Esters Polyethylene Sorbitan monosterate
17	Dyes
18	Combined raw wastes (surface active agents)
19	Fatty acids

TABLE 5. PHASE II SCREENING - PRODUCT/PROCESS AND OTHER WASTE STREAMS SAMPLED AT EACH PLANT (Continued)

Plant Number	Waste Streams Sampled
20	Organic pigments Salicylic acid Fluorescent brightening agent
21	Surfactants
22	Dyes
23	Combined raw wastes (flavors)
24	Chlorination of paraffin
25	Phthalic anhydride
26	Combined raw waste (unspecified)
27	Dicyclohexyl phthalate
28	Plasticizers Resins
29	Combined raw waste (unspecified)
30	Polybutyl phenol Zinc Dialkyldithiophosphate Calcium phenate Mannich condensation product Oxidized co-polymers
31	Tris (β-chloroethyl) phosphate
32	Ether sulfate sodium salt Lauryl sulfate sodium salt Xylene distillation
33	Dyes
34	Maleic anhydride Formox formaldehyde Phosphate ester Hexamethylenetetramine

TABLE 5. PHASE II SCREENING - PRODUCT/PROCESS AND OTHER WASTE STREAMS SAMPLED AT EACH PLANT (Continued)

Plant Number	Waste Streams Sampled
35	Acetic acid
36	Combined raw waste (coal tar)
37	"680" Brominated fire retardants Tetrabromophthalic anhydride Hexabromocyclododecane
38	Hexabromocyclododecane
39	Fatty acid amine ester Calcium sulfonate in solvent (alcohol) Oil field deemulsifier blend (aromatic solvent) Oxylakylated phenol--formaldehyde resin Ethoxylated monyl phenol Ethoxylated phenol--formaldehyde resin
40	Combined raw waste (surface active agents)

(1) They were believed to be raw materials, precursors, or products in the product/process, according to the process chemistry employed by the plant; or

(2) They had been detected in the grab samples taken several weeks before the three-day Verification exercise (see below) at concentrations exceeding the threshold concentrations listed in Table 6.

The threshold concentrations listed in Table 6 were selected as follows. The concentrations for pesticides, PCBs, and other organics are approximate quantitative detection limits. The concentration for arsenic, cadmium, chromium, lead, and mercury are one half the national Drinking Water Standard (Federal Register, Vol. 40, No. 248, December 24, 1975, pp. 59566-74).

The Agency sampled at six integrated manufacturing facilities for the pilot program to develop the "Verification Protocol." Thirty-seven plants were eventually involved in the Verification effort. Samples were taken from the effluents of 147 product/processes manufacturing organic chemicals and 29 product/processes manufacturing plastics/synthetic fibers, as well as from treatment system influents and effluents at each facility.

Each plant was visited about four weeks before the three-day verification sampling to discuss the sampling program with plant personnel, to determine in-plant sampling locations and to take a grab sample at each designated sampling site. These samples were analyzed to develop the analytical methods used at each plant for the three-day verification exercise and to develop the target list of pollutants described above for analyses at each site during the three-day sampling. Some pollutants that had been put on the list for verification since they were believed to be raw materials, precursors, or coproducts were not detected in the verification program grab samples. If such a pollutant was also not detected in the sample from the first day of the three-day verification sampling, it was dropped from the analysis list for that sample location. Other compounds were added to the analysis list since they were found in the Verification grab sample at a concentration

TABLE 6. SELECTION CRITERIA FOR TESTING PRIORITY POLLUTANTS IN VERIFICATION SAMPLES

Parameter	Criterion (µg/l)
Pesticides and PCBs	0.1
Other Organics	10
Total Metals:	
Antimony	100
Arsenic	25
Beryllium	50
Cadmium	5
Chromium	25
Copper	20
Lead	25
Mercury	1
Nickel	500
Selenium	10
Silver	5
Thallium	50
Zinc	1,000
Total Cyanides	20

exceeding the threshold criteria in Table 6. Priority pollutants known by plant personnel to be present in the plant's wastewater were also added to the Verification list.

At each plant, Verification samples generally included: Process water supply; product/process effluents; and treatment facility influent and effluent. Water being supplied to the process was sampled to establish the background concentration of priority pollutants. The product/process effluent waste loads were later corrected for these influent waste loadings. Product/process samples were taken at locations that would best provide representatives samples. At various plants, samples were taken at the influent to and effluent from both "in-process" and "end-of-pipe" wastewater treatment systems.

Samples were taken on each of three days during the Verification exercise. As in Phase I and II Screening studies, 24-hour composite samples for extractable organic compounds and metals were taken with automatic sampling equipment. Where automatic sampling equipment would violate plant safety codes requiring explosion-proof motors, equal volumes of sample were collected every two hours over an 8-hour day and manually composited in a glass (2.5-gallon) container. Raw water supply samples were typically collected as daily grab samples because of the low variability of these waters.

Samples for cyanides analysis were collected in plastic bottles (either as a single grab sample each day or as an equal-volume, 8-hour composite) and were preserved as in the screening program. Samples for analysis of volatile organic compounds were also collected and preserved as in the screening program, in headspace-free sealed vials; where headspace analysis of volatile organic compounds was planned, sample bottles were filled half way. No 4-AAP phenol analyses were run during verification.

The temperature and pH of the sample, the measured or estimated wastewater flow at the time of sampling, and the process production levels were

all recorded. Weather and plant operating conditions during the sampling period were also recorded, particularly in connection with operational upsets (in the production units or wastewater treatment facilities) that could yield a sample not of typical operation.

Analytical methods for cyanides were the same as those used in Phases I and II of Screening. Analytical methods for heavy metals conformed to the 1977 Manual; all samples were preserved by addition of acid in the field. For organic compounds, however, gas chromatography with conventional detectors was used instead of the GC/MS that was used in the Screening program. GC/MS analysis was used on about ten percent of the samples to confirm the presence or absence of pollutants whose GC peaks overlapped other peaks. The analytical methods finally developed were usually applicable (with minor modifications) to all sampling sites at any given plant.

Because GC/MS was used only on samples whose GC peaks overlapped other peaks, industry has questioned the extent of false positive values reported in these data. As part of the Master Process File validation, individual product/processes in the MPF were reviewed as to the likelihood of the presence or absence to reported toxic pollutants on the basis of process chemistry. This effort resulted in the inclusion/exclusion of toxic pollutants in the MPF (see Appendix D); generally the concentrations of pollutants eliminated were $\leq$ 100 ppb. At no time were toxic pollutant concentrations changed in the Master Process File.

4. FLOW DATA

Flow data are derived exclusively from the 1983 "308" Questionnaire responses. Wastewater flow data from primary organic chemical and plastics facilities are provided for individual product/process by wastewater source (e.g., an aqueous waste stream resulting from quenching of a reaction product, washdown of process equipment); for product groups at in-plant, preliminary, secondary, and tertiary treatment processes (i.e., wastewater effluent flows

through these treatment processes); for miscellaneous wastewaters entering the main treatment system; and for final effluent discharge. These data allow waste loads to be calculated for individual product/processes, product groups, or total plant effluent for primary organic chemical and plastics producers provided that corresponding toxic pollutant data are available (see Appendix A).

In some instances, primary organic chemical and plastic plants reported data for combined product/processes; moreover certain plants did not provide product/process specific data. In such cases, product/processes flows were estimated by production in weighting either product group flow, if available, or total waste flow, if product group flow was unavailable. For plants that did not provide production data, total process flow was apportioned equally between product/processes. Product/process flow data are shown in Appendix E.

Secondary OCPSF plants provided only general data regarding plant operations. These data include 1982 production data by eight-digit Census product code, OCPSF process and nonprocess wastewater flow, total plant wastewater flow, OCPSF process wastewater disposal methods, treatment technologies, and pollutant summaries. Wastewater flow was not reported by product/process for secondary plants. Total OCPSF wastewater flow for secondary plants is shown in Appendix A.

5. WASTE LOAD CALCULATION

It is obvious from the preceding discussion that primary OCPSF plant specific waste loads can be calculated in more than one way depending on the availability of toxic pollutant concentration data and flow data. For primary plants that have provided 1983 "308" toxic pollutant data, waste loads for individual pollutant may be estimated using these data. Waste loads can be calculated for a given plant on the basis of either product/process employed by that plant or the products manufactured by that plant. Waste loads can also be calculated on the basis of the generic processes employed by a plant.

Secondary OCPSF plant toxic pollutant waste loads must be calculated in a fundamentally different way and extrapolated from primary OCPSF plant toxic pollutant waste loads.

There are limitations to each waste load calculation approach. Although waste load calculations using plant specific toxic pollutant concentrations (either from 1983 "308" data or screening data) are likely to be most accurate, such data are available for relatively few plants. Waste load calculation using Master Process File toxic pollutant concentrations can be made for all plants employing product/process contained in the MPF. The MPF can be generalized to products allowing even greater coverage of the OCPSF industry. Most generally waste loads may be generated on the basis of the generic process chemistry employed by a plant.

Rather than select any one method for waste load calculation, the Agency determined all waste load calculation methods would be used when appropriate, thus providing maximum coverage of the industry with the greatest accuracy possible. The following hierarchy of data sources was established:

1. Where "308" toxic pollutant data were available, these data would be used to calculate raw waste loads for those toxic pollutants.

2. Where the combined raw wastewaters of a plant had been sampled in either Phase I or Phase II Screening studies, these toxic pollutant concentration data would be used to calculate the raw waste loads from these plants.

3. Raw waste loads would next be calculated using Master Process File toxic pollutant concentration data for product/process covered by the MPF. Where product/process waste load could not be calculated at a plant, product specific waste laods were calculated using the "Product Averaged Master Process File."

4. For plants producing products that could not be calculated by the above methods, generic process raw waste loads were calculated using the "Generic Process Averaged Master Process File." Because the Generic Process method necessarily generated extraneous pollutants for any given product, raw waste loads from these plants were extensively reviewed; those pollutants believed to be inconsistent with

process chemistry practiced at a plant were deleted from the raw waste load file. Pollutants deleted from the generic process averaged waste load are shown in Appendix F.

Exhibit 1 summarizes the methodology used to calculate raw waste loads.

Waste loads for secondary OCPSF plants were extrapolated from the waste loads calculated for primary OCPSF plants in the following way:

1. Flow weighted toxic pollutant concentrations were calculated for each subcategory using data from primary OCPSF plants:

$$\bar{C}_{i,k} = \sum_{j=1}^{n} RWL_{i,j,k} / \sum_{j=1}^{n} F_{j,k}$$

where $\bar{C}_{i,k}$ = the mean toxic pollutant concentration of pollutant i for subcategory k

$RWL_{i,j,k}$ = the raw waste load for pollutant i at plant j of subcategory k

$F_{j,k}$ = the total process flow for plant j of subcategory k.

2. Plant specific raw waste loads are calculated from mean subcategory toxic pollutant concentration and the OCPSF process flow at a plant:

$$RWL_{i,j'} = \bar{C}_{i,k}(F_{j'})$$

where $RWL_{i,j'}$ = the raw waste load for toxic pollutant i at plant j' (where ' denotes a secondary OCPSF plant)

$F_{j'}$ = the total OCPSF process at plant j'.

5.1 BPT, BAT, and Current Waste Load Calculations

BPT, BAT, and current waste load of individual plants were calculated for those toxic pollutants found in the raw waste load as follows (See Exhibit 2):

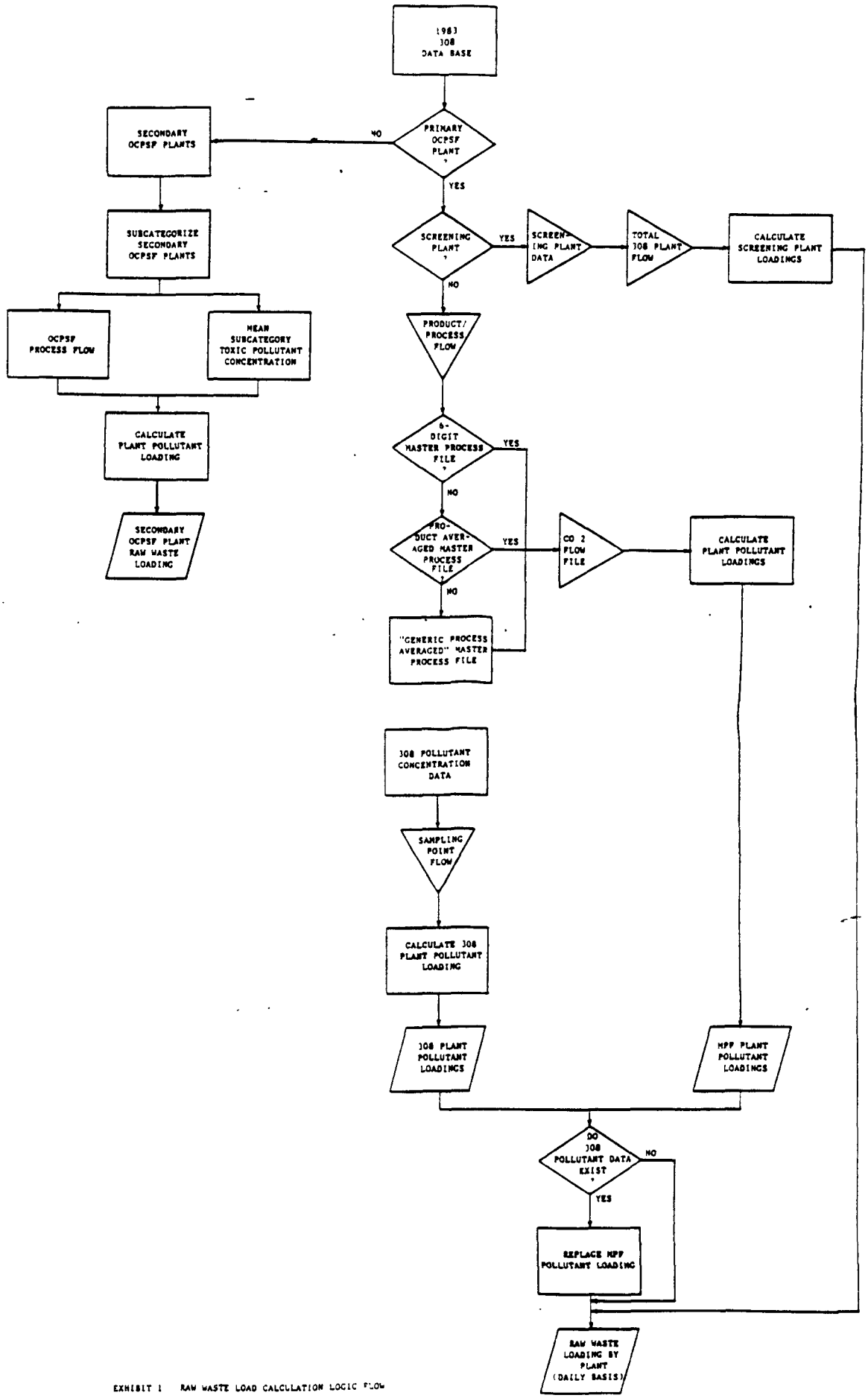

EXHIBIT 1 RAW WASTE LOAD CALCULATION LOGIC FLOW

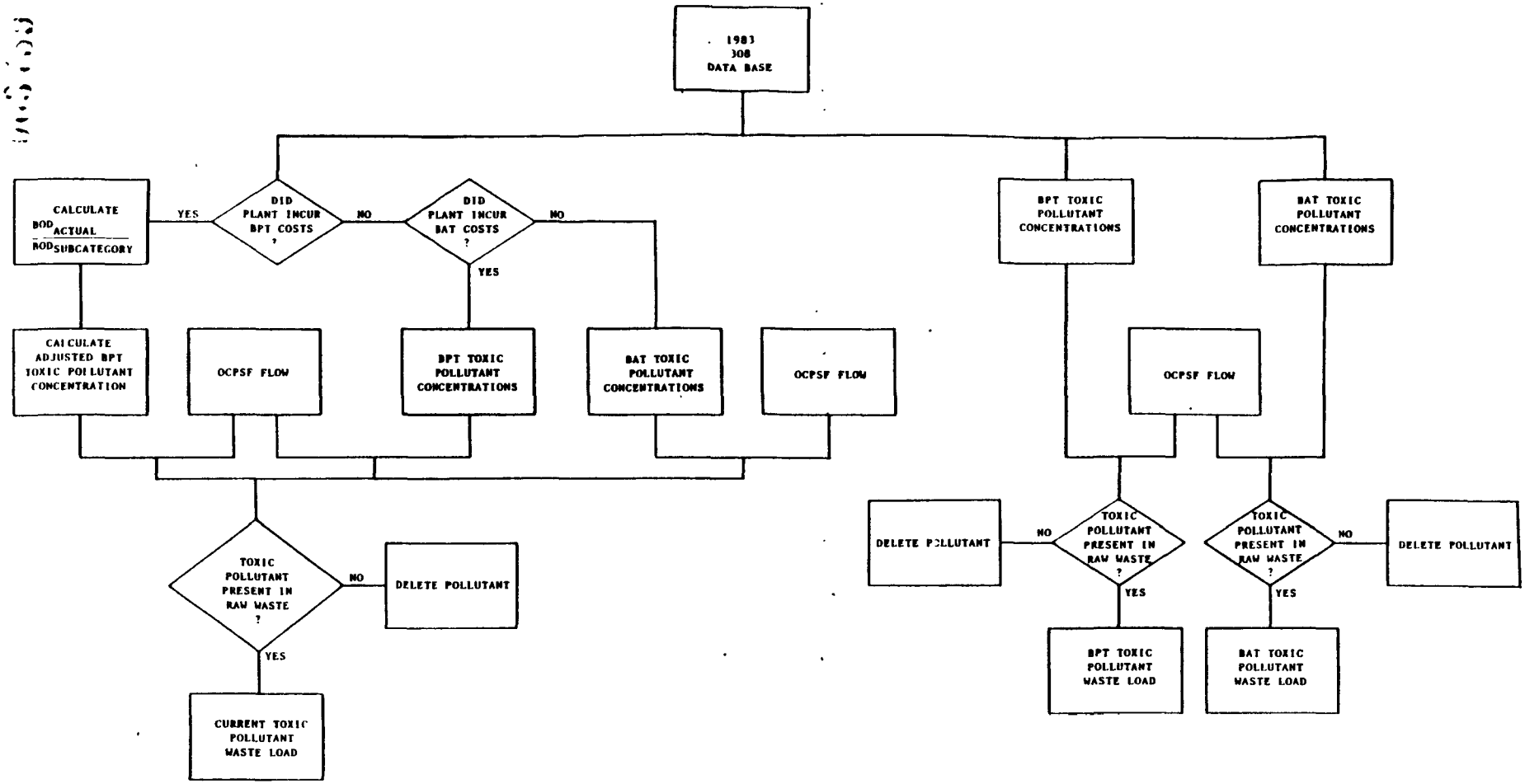

EXHIBIT 2 BPT, BAT, AND CURRENT WASTE LOAD CALCULATION LOGIC FLOW

1. Average toxic pollutant concentrations were calculated using the sampling data base (i.e., verification data, CMA 5-plant, and new sampling data). Separate toxic pollutant concentrations were calculated by subcategory for both BPT and BAT plants (i.e., those plants currently meeting proposed BPT and BAT criteria respectively).

2. Pollutant concentrations were adjusted for those plants which incurred BPT costs by the ratio of actual BOD to the target BOD for that subcategory (20 mg/l for rayon, other fibers, thermoset, and thermoplastics only; 45 mg/l for thermoplastics and organics, commodity, bulk, and specialty organics). Plants that did not incur BPT costs were assigned BPT toxic pollutant concentrations by subcategory. Plants that did not incur either BPT or BAT costs were assigned BAT toxic pollutant concentrations.

3. Effluent concentrations of toxic pollutants as derived above were multiplied by total process flow to calculate current waste loads.

5.2 PSES Waste Load Calculations

PSES waste loads were calculated in a manner analogous to current waste loads. If a plant was costed for PSES treatment, then toxic pollutant concentrations were considered to be equal to raw waste toxic pollutant concentrations. If a plant was not costed for PSES, then toxic pollutant concentrations were assumed to be equal to "Current" toxic pollutant concentrations. Effluent concentrations of toxic pollutants as derived above were multiplied by total process flow to calculate PSES load. Because "Current" toxic pollutant concentrations are industry averages by subcategory in some cases "Current" toxic pollutant concentrations exceeded those in the raw waste. In such cases, ($\leq$ x percent of the PSES waste load calculated by individual pollutant) the toxic pollutant load was deleted from the PSES waste load file. Exhibit 3 summarizes the methodology used to calculate PSES wasteloads.

5.3 Annualized Waste Load

Product/process flow data provided by primary OCPSF plants in the 1983 "308" questionnaire are reported in millions of gallons per day when operating. Primary plants have also provided total annual production data and operating

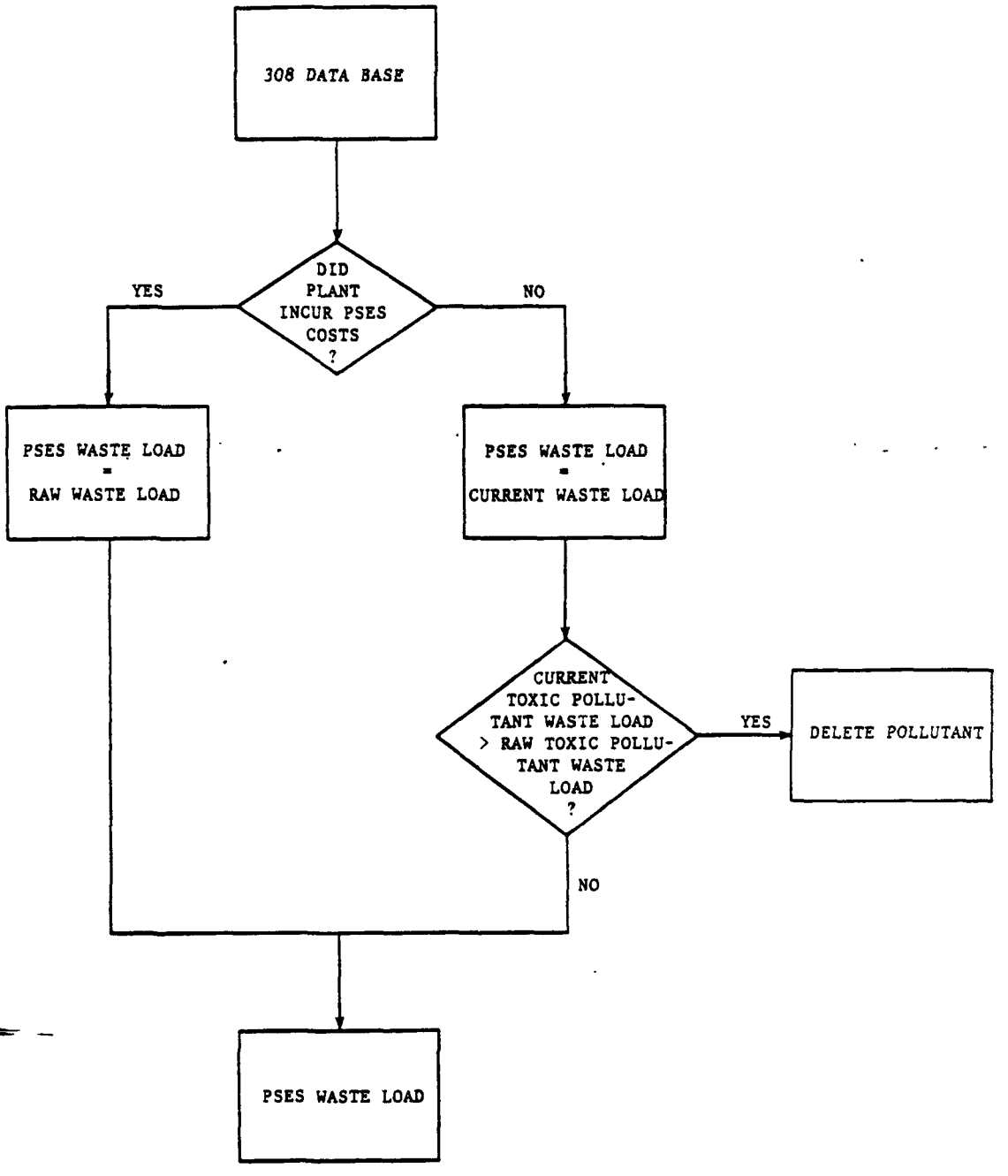

EXHIBIT 3. PSES WASTE LOAD CALCULATION

rate data by product/process. The Agency has calculated operating days for each product/process at each primary OCPSF plant by dividing the annual product/process production by the product/process operating rate. Multiplication of daily product/process waste load by product/process operating days yields annualized product/process waste loads. Toxic pollutant waste loads from individual product/processes at a plant are then summed by pollutant to yield total waste load for individual plants. Appendix G lists product/process operating days.

Product/process production data are unavailable for secondary OCPSF producers and annual waste loads cannot be calculated in a manner analogous to those estimated for primary OCPSF plants. Annual waste loadings from secondary OCPSF plants were estimated from daily waste loads by assuming that OCPSF product/processes generating wastewaters operated four days per week or 208 days per year.

6. RAW WASTE LOAD VALIDATION

Where Organic Chemicals and Plastics/Synthetic Fibers plants have provided toxic pollutant data (i.e., 1983 "308" analytical data summaries) or OCPSF plants were sampled during the Phase I or Phase II screening studies, it has been possible to compare these toxic pollutants raw waste loads with those calculated using the Master Process File. Differences between toxic pollutant waste loads calculated from 1983 "308" toxic pollutant concentrations were calculated and then compared statistically using the t-Test (see Appendix H). Raw waste loads calculated from Screening data were similarly compared to raw waste loads calculated using the Master Process File (see Appendix I). In neither case were significant differences found between calculation methods.

APPENDIX A

SUMMARY LOADING TABLES

TABLE A-1

Direct Discharge
Annual Priority Pollutant Loadings
(1,000 pounds/year)

	VOLATILES	SEMIVOLATILES	METALS & CN	TOTAL
Raw Waste	82,746	39,079	35,491	157,316
Current	248	208	730	1,186
BPT/BAT-I	218	180	628	1,026
BAT-II	59	80	104	243
BAT-III	56	62	102	220

TABLE A-2

Indirect Discharge
Annual Priority Pollutant Loadings
(1,000 pounds/year)

	VOLATILES	SEMIVOLATILES	METAL & CN	TOTAL
Raw Waste	12,655	192,316	28,796	233,767
Current	4,313	96,180	6,309	106,802
PSES-II	133	44	588	765

TABLE A-3

DEFINITION OF CODES USED IN THE FOLLOWING TABLES

Fractions

A	=	Acid Fraction
B	=	Base/Neutral Fraction
M	=	Metals and Cyanide
V	=	Volatile Fraction
T	=	A + B + V
G	=	A + B + V + M

Column Headings (Direct Dischargers)

YBATEFF1	=	BAT Option II, yearly effluent load (lb/year)
YBATEFF2	=	BAT Option III, yearly effluent load (lb/year)
YARWLOAD	=	Yearly raw waste load (lb/year)
YCURREFF	=	Yearly current effluent load (lb/year)
YBPTEFF	=	Yearly BPT effluent load (lb/year)
ARWLOAD	=	Daily raw waste load (lb/day)
TOTFLOW	=	Total flow (MGD)
AVGCONC	=	Average effluent concentration (ppm)

Column Headings (Indirect Dischargers)

YRAWASTE	=	Yearly raw waste load (lb/year)
YCURREFF	=	Yearly current effluent load (lb/year)
YPSESEFF	=	Yearly PSES effluent load (lb/year)
RAWLOAD	=	Daily raw waste load (lb/day)
TOTFLOW	=	Total flow (MGD)

PART A ONLY
SUMMATION FOR ALL DIRECT DISCHARGERS

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OBS	SUBCAT	FRACTION	YARWLOAD	YCURREFF	YBPTEFF	YBATEFF1	YBATEFF2	ARWLOAD	TOTFLOW
1	ORGANICS	A	1507802	16205	14947	6560.6	4349.1	7249	208.81
2	ORGANICS	B	6167653	59532	55132	19852.8	13129.1	29652	727.46
3	ORGANICS	G	52213191	241917	223942	62246.8	51358.1	251025	1687.09
4	ORGANICS	M	6843975	114292	105977	23473.0	21954.4	32904	249.63
5	ORGANICS	T	45369216	127625	117965	38773.8	29403.8	218121	1437.46
6	ORGANICS	V	37693761	51888	47886	12360.5	11925.5	181220	501.19
7	OTHERS	A	42928	324	321	173.0	149.5	206	6.76
8	OTHERS	B	8522	760	744	384.2	303.2	41	9.93
9	OTHERS	G	402792	4764	4693	1625.6	1500.5	1937	39.40
10	OTHERS	M	166770	2093	2068	696.2	696.2	802	6.89
11	OTHERS	T	236023	2672	2625	929.5	804.3	1135	32.51
12	OTHERS	V	184573	1588	1560	372.2	351.6	887	15.82
13	THERMOPLASTICS	A	64421	170	92	72.0	68.7	310	3.77
14	THERMOPLASTICS	B	5807	1160	986	480.0	346.8	28	10.44
15	THERMOPLASTICS	G	325762	10704	8607	2773.6	2509.8	1566	49.32
16	THERMOPLASTICS	M	29299	7934	6679	1895.7	1768.3	141	18.60
17	THERMOPLASTICS	T	296463	2770	1927	877.9	741.4	1425	30.73
18	THERMOPLASTICS	V	226236	1440	850	325.9	325.9	1088	16.51
19	THERMOPLASTICS & ORGANICS	A	25493	159	159	156.2	153.1	123	7.20
20	THERMOPLASTICS & ORGANICS	B	17224	665	665	661.0	498.5	83	28.72
21	THERMOPLASTICS & ORGANICS	G	1285233	4119	4119	3687.2	3356.0	6179	93.52
22	THERMOPLASTICS & ORGANICS	M	486863	2352	2352	2032.7	1901.4	2341	21.60
23	THERMOPLASTICS & ORGANICS	T	798370	1767	1767	1654.5	1454.6	3838	71.92
24	THERMOPLASTICS & ORGANICS	V	755653	944	944	837.3	803.0	3633	36.00
25	THERMOSETS	A	2127803	194	63	42.0	38.5	10230	2.02
26	THERMOSETS	B	13628	5973	1945	295.0	242.4	66	8.10
27	THERMOSETS	G	3514323	34304	11181	2066.2	1898.0	16896	48.54
28	THERMOSETS	M	738498	20637	6730	1098.5	1000.4	3550	12.17
29	THERMOSETS	T	2775825	13667	4451	967.7	897.6	13345	36.37
30	THERMOSETS	V	634394	7500	2442	630.7	616.7	3050	26.24

PART A ONLY
SUMMATION FOR ALL DIRECT DISCHARGERS

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OBS	FRACTION	YARWLOAD	YCURREFF	YBPTEFF	YBATEFF1	YBATEFF2	ARWLOAD	TOTFLOW	AVGCONC
1	T	49475897	148501	128735	43203.4	33301.7	237865	1608.98	17.7155
2	A	3768448	17052	15581	7003.9	4758.9	18118	228.56	9.4989
3	B	6212832	68089	59472	21672.9	14520.1	29869	784.66	4.5616
4	M	8265404	147307	123806	29196.0	27320.7	39738	308.88	15.4163
5	V	39494617	63360	53682	14526.6	14022.7	189878	595.77	38.1920
6	G	57741301	295808	252541	72399.4	60622.4	277602	1917.87	17.3452

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SUMMATION FOR ALL INDIRECT DISCHARGERS

OBS	SUBCAT	FRACTION	YRAWLOAD	YCURREFF	YPSESEFF	RAWLOAD	TOTFLOW
1	ORGANICS	A	98418662	83983284	2104	473167	34.22
2	ORGANICS	B	369597	317360	12651	1777	130.54
3	ORGANICS	G	101874767	86939800	51330	489783	326.06
4	ORGANICS	M	1700586	1454820	25019	8176	58.66
5	ORGANICS	T	100174181	85484980	26311	481607	267.41
6	ORGANICS	V	1385922	1184335	11556	6663	102.65
7	OTHERS	A	160365	157354	47	771	1.95
8	OTHERS	B	4010	3938	156	19	3.90
9	OTHERS	G	374591	367640	4508	1801	25.35
10	OTHERS	M	58879	57846	3914	283	10.72
11	OTHERS	T	315712	309794	594	1518	14.62
12	OTHERS	V	151337	148502	391	728	8.77
13	THERMOPLASTICS	A	190	190	8	1	0.25
14	THERMOPLASTICS	B	166	166	29	1	0.51
15	THERMOPLASTICS	G	14788	14772	1314	71	5.56
16	THERMOPLASTICS	M	4763	4758	1015	23	2.78
17	THERMOPLASTICS	T	10025	10014	299	48	2.78
18	THERMOPLASTICS	V	9669	9657	262	46	2.02
19	THERMOPLASTICS & ORGANICS	A	3594	3594	10	17	0.33
20	THERMOPLASTICS & ORGANICS	B	425	425	38	2	0.67
21	THERMOPLASTICS & ORGANICS	G	100894	100894	992	485	7.66
22	THERMOPLASTICS & ORGANICS	M	67189	67189	673	323	2.00
23	THERMOPLASTICS & ORGANICS	T	33705	33705	319	162	5.66
24	THERMOPLASTICS & ORGANICS	V	29686	29686	271	143	4.66
25	THERMOSETS	A	80534807	421308	4886	387187	201.05
26	THERMOSETS	B	648323	22273	19019	3117	301.58
27	THERMOSETS	G	112121549	1221478	645031	539046	2814.72
28	THERMOSETS	M	22787222	629686	514513	109554	1206.31
29	THERMOSETS	T	89334327	591792	130517	429492	1608.41
30	THERMOSETS	V	8151197	148211	106612	39188	1105.78

PART A ONLY 11:11 THURSDAY, JUNE 13, 1985 2
SUMMATION FOR ALL INDIRECT DISCHARGERS

OBS	FRACTION	YRAWLOAD	YCURREFF	YPSESEFF	RAWLOAD	TOTFLOW	AVGCONC
1	T	189867950	86430284	158040	912827	1898.88	57.605
2	A	179117619	84565730	7056	861142	237.80	433.942
3	B	1022521	344163	31893	4916	437.19	1.347
4	M	24618638	2214300	545134	118359	1280.47	11.077
5	V	9727811	1520391	119092	46768	1223.89	4.579
6	G	214486588	88644584	703174	1031186	3179.35	38.866

	CNEWCAT	FRACTION	YRAWASTE	YCURREFF	YBPTEFF	YBATEFF1	YBATEFF2	RAWLOAD	TOTFLOW
1	BULK ORGANICS	A	4332462	13350	12043	5709.5	3217.4	16471.5	182.91
2	BULK ORGANICS	B	2497432	36286	32818	5078.6	4453.2	10110.3	281.28
3	BULK ORGANICS	G	14903061	190671	156687	39555.8	35909.6	59418.4	1243.49
4	BULK ORGANICS	M	2798589	75347	52121	16646.4	16485.8	11431.4	237.27
5	BULK ORGANICS	T	12104473	115324	104565	22909.4	19423.8	47987.0	1006.22
6	BULK ORGANICS	V	5274578	65687	59704	12121.2	11753.2	21405.2	542.02
7	CELLULOSICS	A	7572	1326	1233	822.2	753.7	20.8	22.58
8	CELLULOSICS	G	10157572	249310	232940	10784.4	10690.0	27949.2	91.68
9	CELLULOSICS	M	10149327	247580	231370	9625.9	9625.9	27926.6	60.56
0	CELLULOSICS	T	8245	1730	1570	1158.5	1064.1	22.7	31.12
1	CELLULOSICS	V	673	404	336	336.3	310.4	1.9	8.54
2	COMMODITY ORGANICS	A	427100	3279	3139	1775.4	1607.5	1686.9	58.97
3	COMMODITY ORGANICS	B	2028532	11521	10858	7169.9	5483.8	8684.2	206.82
4	COMMODITY ORGANICS	G	25679325	52971	49405	20448.7	18436.1	94913.3	509.29
5	COMMODITY ORGANICS	M	756621	14116	12771	4786.6	4782.7	2663.1	40.87
6	COMMODITY ORGANICS	T	24922703	38855	36634	15662.2	13653.5	92250.2	468.42
7	COMMODITY ORGANICS	V	22467071	24055	22637	6716.9	6562.2	81879.1	202.63
8	FIBERS	A	311660	719	273	181.8	166.6	911.6	5.47
9	FIBERS	B	109	28	28	28.0	28.0	0.4	1.18
0	FIBERS	G	1427090	7446	6664	2864.0	2848.9	3979.9	38.04
1	FIBERS	M	600070	5279	5079	2219.8	2219.8	1641.9	16.53
2	FIBERS	T	827020	2168	1585	644.2	629.1	2337.9	21.51
3	FIBERS	V	515251	1421	1285	434.5	434.5	1425.9	14.86
4	OTHER	A	1353983	6465	4921	2532.3	2231.2	6441.7	80.55
5	OTHER	B	101430	15400	8778	4089.7	3647.2	371.2	79.28
6	OTHER	G	10480551	138039	120760	21892.5	20924.2	34643.5	405.15
7	OTHER	M	6395119	90079	86701	10167.7	10167.7	17620.0	83.76
8	OTHER	T	4085432	47960	34059	11724.8	10756.6	17023.5	321.40
9	OTHER	V	2630019	26095	20360	5102.8	4878.2	10210.5	161.58
0	SPECIALTY ORGANICS	A	205389	583	427	161.9	154.0	574.8	5.79
1	SPECIALTY ORGANICS	B	60284	3241	2579	840.8	518.1	244.3	18.67
2	SPECIALTY ORGANICS	G	3148510	36782	23936	5382.6	4924.0	12239.2	98.60
3	SPECIALTY ORGANICS	M	1550952	29132	17697	3265.0	3148.7	6179.1	39.17
4	SPECIALTY ORGANICS	T	1597558	7650	6240	2117.7	1775.3	6060.2	59.43
5	SPECIALTY ORGANICS	V	1331886	3826	3234	1114.9	1103.1	5241.1	34.97
6	THERMOPLASTICS	A	713272	1000	571	387.6	355.3	1961.2	12.16
7	THERMOPLASTICS	B	8163	1749	1468	1084.7	813.8	29.3	14.76
8	THERMOPLASTICS	G	1612217	15270	10636	5344.6	5033.1	4765.6	89.63
9	THERMOPLASTICS	M	72412	9035	5897	2660.4	2652.1	217.0	24.66
0	THERMOPLASTICS	T	1539805	6235	4739	2684.2	2381.0	4548.6	64.97
1	THERMOPLASTICS	V	818370	3486	2700	1212.0	1212.0	2558.1	38.05
2	THERMOPLASTICS & ORGANICS	A	1557096	6512	6207	4497.6	4289.9	4714.2	134.44
3	THERMOPLASTICS & ORGANICS	B	675288	18340	18079	16703.1	13838.9	2038.9	481.87
4	THERMOPLASTICS & ORGANICS	G	14359452	168283	162429	60515.7	56901.3	66721.4	1443.75
5	THERMOPLASTICS & ORGANICS	M	3429827	88854	85265	23414.7	23323.8	18397.6	262.69
6	THERMOPLASTICS & ORGANICS	T	10929626	79430	77164	37101.0	33577.5	48323.8	1181.06
7	THERMOPLASTICS & ORGANICS	V	8697242	54578	52878	15900.4	15448.7	41570.7	564.76
8	THERMOSETS	A	14808924	1882	350	253.9	232.7	48451.9	9.56
9	THERMOSETS	B	9453	1186	1094	135.0	135.0	28.6	5.20
0	THERMOSETS	G	17807579	32684	10092	3321.1	3224.6	57885.6	62.01
1	THERMOSETS	M	1473238	23823	7420	2262.9	2190.5	5004.1	23.29
2	THERMOSETS	T	16334341	8861	2672	1058.2	1034.1	52881.5	38.72
3	THERMOSETS	V	1515964	5793	1228	669.4	666.4	4401.0	23.96

OBS	FRACTION	YRAWASTE	YCURREFF	YBPTEFF	YBATEFF1	YBATEFF2	RAWLOAD	TOTFLOW	AVGCONC
1		99575358	891457	773549	170110	158892	362516	3981.65	10.9103
2	A	23717457	35115	29165	16322	13008	81235	512.43	18.9967
3	B	5380691	87752	75702	35130	28918	21507	1089.06	2.3665
4	M	27226155	583246	504320	75049	74597	91081	788.80	13.8368
5	T	72349203	308211	269229	95060	84295	271435	3192.85	10.1874
6	V	43251055	185344	164362	43608	42369	168693	1591.36	12.7029

FULL RESPONSE 11:26 THURSDAY, JUNE 13,
SUMMATION FOR ALL INDIRECT DISCHARGERS

OBS	CNEWCAT	FRACTION	YRAWASTE	YCURREFF	YPSESEFF	RAWLOAD	TOTFLOW
1	BULK ORGANICS	A	1969467	1717894	518.9	5893.5	11.6401
2	BULK ORGANICS	B	83432	83253	1230.0	280.6	6.6653
3	BULK ORGANICS	G	3020903	2750850	14676.1	9573.0	69.8616
4	BULK ORGANICS	M	446685	444615	11103.5	1682.2	25.1888
5	BULK ORGANICS	T	2574218	2306235	3572.6	7890.8	44.6728
6	BULK ORGANICS	V	521319	505088	1823.6	1716.7	26.3674
7	COMMODITY ORGANICS	A	14845	12216	247.9	49.0	6.8646
8	COMMODITY ORGANICS	B	30206	18447	656.9	89.6	27.2012
9	COMMODITY ORGANICS	G	2295124	2197540	13159.6	7371.8	92.6593
10	COMMODITY ORGANICS	M	745049	746671	6655.9	2437.3	18.5949
11	COMMODITY ORGANICS	T	1550075	1450868	6503.8	4934.5	74.0644
12	COMMODITY ORGANICS	V	1505025	1420205	5599.0	4795.8	39.9986
13	FIBERS	A	24905	25078	9.4	82.9	0.1862
14	FIBERS	B	762	762	61.6	2.1	0.1126
15	FIBERS	G	50873	51039	1076.9	157.3	3.5733
16	FIBERS	M	20654	20649	863.7	58.7	1.8822
17	FIBERS	T	30220	30389	213.2	98.5	1.6911
18	FIBERS	V	4553	4550	142.2	13.5	1.3923
19	OTHER	A	1009679	982022	181.5	3195.3	4.1078
20	OTHER	B	9003	7589	160.8	37.5	3.4913
21	OTHER	G	1482817	1432816	4007.9	4837.3	38.3999
22	OTHER	M	17846	17355	1979.6	54.8	7.8089
23	OTHER	T	1464971	1415461	2028.3	4782.5	30.5910
24	OTHER	V	446289	425850	1686.0	1549.7	22.9919
25	SPECIALTY ORGANICS	A	4514692	4011568	163.4	17730.6	5.0339
26	SPECIALTY ORGANICS	B	46753	49132	1803.2	229.0	15.3255
27	SPECIALTY ORGANICS	G	7603649	7016537	15712.1	31517.9	79.8125
28	SPECIALTY ORGANICS	M	2816370	2712080	10547.0	12473.8	25.0642
29	SPECIALTY ORGANICS	T	4787279	4304457	5165.1	19044.1	54.7483
30	SPECIALTY ORGANICS	V	225834	243757	3198.5	1084.5	34.3889
31	THERMOPLASTICS	A	3120	2883	125.9	9.5	2.6237
32	THERMOPLASTICS	B	1020	830	378.2	4.3	3.8481
33	THERMOPLASTICS	G	94527	103416	5572.8	405.0	34.9356
34	THERMOPLASTICS	M	18960	17356	3628.4	55.7	9.1762
35	THERMOPLASTICS	T	75567	86059	1944.4	349.3	25.7594
36	THERMOPLASTICS	V	71427	82346	1440.3	335.5	19.2876
37	THERMOPLASTICS & ORGANICS	A	6142	5889	23.8	30.5	0.5879
38	THERMOPLASTICS & ORGANICS	B	398	62	54.3	1.8	0.3860
39	THERMOPLASTICS & ORGANICS	G	63000	60781	6042.3	227.5	19.8780
40	THERMOPLASTICS & ORGANICS	M	14390	14431	5768.4	50.6	16.1473
41	THERMOPLASTICS & ORGANICS	T	48611	46350	274.0	176.9	3.7307
42	THERMOPLASTICS & ORGANICS	V	42071	40399	195.8	144.6	2.7568
43	THERMOSETS	A	4458542	4349591	87.7	18257.9	4.8054
44	THERMOSETS	B	2613	2518	46.2	23.2	4.6979
45	THERMOSETS	G	4668575	4545069	2836.8	19720.8	38.6181
46	THERMOSETS	M	96695	122095	2426.0	1000.9	14.8025
47	THERMOSETS	T	4571880	4422974	410.8	18719.9	23.8156
48	THERMOSETS	V	110725	70864	276.9	438.7	14.3123

FULL RESPONSE 11:26 THURSDAY, JUNE 13,
SUMMATION FOR ALL INDIRECT DISCHARGERS

OBS	FRACTION	YRAWASTE	YCURREFF	YPSESEFF	RAWLOAD	TOTFLOW	AVGCONC
1	T	15102820	14062793	20112.2	55996.5	259.073	25.901
2	A	12001391	11107142	1358.5	45249.1	35.850	151.251
3	B	174186	162593	4391.3	668.2	61.728	1.297
4	M	4176648	4095254	42972.3	17814.1	118.665	17.989
5	V	2927243	2793058	14362.3	10079.2	161.496	7.479
6	G	19279469	18158047	63084.5	73810.6	377.738	23.415

APPENDIX B	See Public Record Pages 004080 - 004257
APPENDIX C	See Public Record Pages 004258 - 004273
APPENDIX D	See Public Record Pages 004274 - 004307
APPENDIX E	See Public Record Pages 004308 - 004419
APPENDIX F	See Public Record Pages 004420 - 004446
APPENDIX G	See Public Record Pages 004447 - 004557
APPENDIX H	See Public Record Pages 004558 - 004559
APPENDIX I	See Public Record Pages 004560 - 004564

VIII. COSTING DOCUMENTATION AND NOTICE OF NEW INFORMATION REPORT

Note: Table of Contents, List of Tables, and Section 2 (New Costing Methodology) follow; entire report is included in the public record.

FINAL

COSTING DOCUMENTATION
AND
NOTICE OF NEW INFORMATION REPORT

PREPARED FOR:

The Industrial Technology Division
U.S. Environmental Protection Agency
301 M. Street, S.W.
Washington, D.C. 20460

By:

SAIC/JRB Associates
One Sears Drive
Paramus, New Jersey 07652

June 12, 1985

EPA Contract No. 68-01-6947
JRB Project No. 2-835-07-688-01

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APPENDICES

2.0 NEW COSTING METHODOLOGY

2.1 INTRODUCTION AND OVERVIEW

The development of effluent guidelines limitations involves the following elements:

- o Identification of technologies available for reducing the pollutant loads in industry effluents.
- o Quantifications of the pollutant reduction attainable by each technology or groups of technologies.
- o Identification of the costs associated with the application of each technology or group of technologies.

A hypothetical summary of this analysis would be as follows:

BAT options for Pollutant X

Technology Option	Effluent Quality Pollutant X ug/l	Industry Pollutant Reduction Attainable, Pounds per year	Industry Costs, $/yr
1	1,000	1,000	300,000
2	100	10,000	800,000
3	10	100,000	2,000,000

The results of these analyses are then used to determine which option should be chosen as the basis for the regulation.

The discussions presented below summarize the technologies available to the OCPSF industry for reducing conventional, non-conventional, and toxic pollutants. Detailed assessments of these technologies will be presented in other reports and ultimately in the Control and Treatment Technology section of the Development Document.

After a review of the available technologies, technology-based regulatory options for BPT, BAT, and PSES are presented. A costing methodology is then included which can be used for determining the cost for meeting each regulatory option on a plant-by-plant basis.

2.2 TECHNOLOGIES AVAILABLE TO THE OCPSF INDUSTRY

The following discussions outline the technologies available to the OCPSF industry, the pollutants removed by each, and the number of plants that currentl use each technology.

2.2.1 In-Plant Controls

Solvent Recovery

The recovery of waste solvents has become a common practice among plants using solvents in their manufacturing processes. However, several plants have instituted further measures to reduce the amount of waste solvents discharged. Such measures include incineration of solvents that cannot be recovered economically, incineration of bottoms from solvent recovery units, and design and construction of better solvent recovery columns to strip solvents beyond the economical recovery point. The economical recovery point has been reached when the cost of recovering additional solvent (less the value of the recovered solvent) is greater than the cost of treating or disposing of the remaining wast solvent.

- Pollutants Treated - Solvents such as Benzene, Toluene, Methylene Chloride, etc.

Activated Carbon Adsorption

Adsorption on granular activated carbon (GAC) is an effective and, moreover, a commercially established means of removing dissolved organic specie from aqueous waste streams. Contaminants are removed from solution by a three-

step process involving (1) transport to the exterior of the carbon, (2) diffusion within the pores of the activated carbon, and (3) adsorption on the interior surfaces bounding the pore and capillary spaces of the activated carbon. Eventually the surface of the carbon is saturated and when this occurs, replacement of the adsorber system with fresh (i.e., virgin or reactivated) carbon is required.

Both powdered activated carbon (PAC) and GAC are capable of efficiently removing many pollutants, including toxic and refractory organics. Powdered carbon is most frequently added to biological treatment processes and is not recovered.

o Pollutants Treated - BOD, COD, TOC, and all organic priority pollutants.

Steam Stripping

Steam stripping is a variation of distillation whereby steam is used as both the heating medium and the driving force for the removal of volatile materials. For employment of steam stripping, steam is introduced into the bottom of a tower. As it passes through the wastewater, the steam vaporizes and removes volatile materials from the waste and then exits via the top of the tower. Although commonly employed as an in-plant technology for solvent recovery, steam stripping is also used as a wastewater treatment process.

o Pollutants Treated - All volatile organic pollutants.

Oxidation

Oxidation as a treatment practice is accomplished by either wet or chemical oxidation. Wet oxidation is a common process in which an aqueous waste can be oxidized in a closed, high-temperature, high-pressure vessel. Wet oxidation has been used to treat a variety of wastes including pumping waste and acrylonitrile liquor. This process is applicable particularly as in-plant

and end-of-pipe treatments of wastes with a high organic content. Chemicals com used as oxidizing agents include chlorine, hypochlorite, hydrogen peroxide, potassium permanganate, ozone, and chlorine dioxide.

- Pollutants Treated - cyanide, sulfide, ammonia, and most organic compounds.

Precipitation/Coagulation/Flocculation

Gravity clarification may be supplemented by precipitation, coagulation or flocculation which provides enhanced heavy metals and suspended solids remova Precipitation, coagulation or flocculation may also be used as a primary treatme step to protect biological secondary treatment processes from upset caused by toxic metallic pollutants.

Simple clarification is usually accomplished with standard sedimentation tanks (either rectangular or circular). If additional solids removal, removal of colloidal solids, or removal of dissolved metallic ions is required, precipitation, coagulation or flocculation is added. Coagulation is usually accomplished by adding an appropriate chemical (alum, lime, etc.) followed by a rapid mix and finally a slow agitation to promote floc particle growth. A polymeric coagulant aid is sometimes used in these systems.

- Pollutants Removed - Suspended solids and any other pollutants in suspension.

2.2.2 End-of-Pipe Treatment

Equalization

Equalization consists of a wastewater holding vessel or a pond large enou to dampen flow and/or pollutant concentration variation which provides a nearly constant discharge rate and wastewater quality. The holding tank or pond capacity is determined by wastewater volume and composition variability. The equalization basin may be agitated or may utilize a baffle system to prevent

short circuiting. Equalization is employed prior to wastewater treatment processes that are sensitive to fluctuations in waste composition or flow.

- o Pollutants Treated - Improves the treatment efficiencies of downstream technologies.

Neutralization

Neutralization is practiced in industry to raise or lower the pH of a wastewater stream. Alkaline wastewater may be neutralized with hydrochloric acid, carbon dioxide, sulfur dioxide, and most commonly, sulfuric acid. Acidic wastewaters may be neutralized with limestone or lime slurries, soda ash, caustic soda, or anhydrous ammonia. Often a suitable pH can be achieved through the mixing of acidic and alkaline process wastewaters. Selection of neutralizing agents is based on cost, availability, ease of use, reaction by-products, reaction rates, and quantities of sludge formed.

- o Pollutants Treated - pH.

Clarification

Clarification, in this context, is defined as the removal of solid particles from a wastewater through gravity settling. The nature of the solids and their concentration are the major factors affecting the settling properties.

- o Pollutants Removed - Suspended solids and any other pollutants in suspension.

Flotation

Flotation is used to remove oils and other suspended substances with densities less than that of water or, in the case of dissolved air flotation, particles that may be slightly heavier than water. As with conventional clarifiers, flocculants are frequently employed to enhance the efficiency of the flotation units. Although flotation is often referred to in the context of dissolved air flotation, other technologies such as oil/liquid skimming and

solids skimming are also flotation operations, and are sometimes an integral part of standard clarification.

- o Pollutants Treated - Suspended solids, oil and grease, and any other pollutants in suspension.

Biological Treatment

All biological treatment systems are designed to expose wastewater containing biologically degradable organic compounds to a suitable mixture of microorganisms in a controlled environment which contains sufficient essential nutrients for the biological reaction to proceed. Under these conditions the reduction of biologically assimilable pollutants will take place in a reasonably predictable manner. Biological treatment is based on the ability of microorgani to utilize organic carbon as a food source. The treatment is classified as eith aerobic, anaerobic, or facultative. Aerobic treatment requires the availability of free dissolved oxygen for the bio-oxidation of the waste. Anaerobic treatmen is intolerant of free dissolved oxygen and utilizes "chemically bound" oxygen (such as sulfates) in breaking down the organic material. Facultative organisms can function under aerobic or anaerobic conditions as the oxygen availability dictates.

Although the definitions of the processes are distinct, in practice both aerobic and anaerobic conditions may exist in the same treatment unit, depending on degeneration, degree of mixing, effects of photosynthesis, and other factors which contribute to the supply and distribution of oxygen to the treatment system. Facultative lagoons are designed to utilize both aerobic and anaerobic mechanisms as a means of reducing the net sludge production.

Biological treatment processes are widely used and, if properly designed and operated, are capable of high BOD removal efficiencies. Such systems given

sufficient reaction time can reduce the concentration of any degradable organic material to a very low concentration. Any organic material which will respond to the standard BOD test procedure is by definition a degradable substrate.

- o Pollutants Treated - BOD, TSS, COD, TOC, and certain priority pollutants.

2.2.3 Secondary Effluent Polishing Technologies

In some instances, where secondary treatment does not produce a satisfactory effluent, polishing processes are utilized. Depending on the nature of the pollutant to be removed and the degree of removal required, the polishing treatment system can consist of a one unit operation or multiple-unit operations in series.

Polishing Ponds

Polishing ponds can be used following other biological treatment processes. They primarily serve the purpose of reducing suspended solids. Water depth generally is limited to two or three feet. Polishing ponds are commonly used as a final process.

- o Pollutants Treated - TSS and any other pollutant in suspension.

Powdered Activated Carbon Treatment

Powdered activated carbon treatment (PAC) refers to the addition of powdered carbon to the aeration basin in the activated sludge process. It is a recently developed process that has been shown to upgrade effluent quality in conventional activated sludge plants. In the PAC treatment process the carbon concentration in the mixed liquor is generally equal to or greater than the volatile mixed liquor suspended solids level. The carbon and adsorbed substances are removed as part of the waste biological sludge.

- o Pollutants Treated - BOD, COD, TOC, and certain priority pollutants.

Activated Carbon Adsorption

The use of activated carbon adsorption can be confined to the removal of specific compounds or classes of compounds from wastewater streams, or for the removal of such parameters as COD, BOD and color. Although more common as in-process treatment, it is also used as a polishing treatment technology.

An aspect of granular carbon columns that is currently receiving attention is the role and possible benefits of biological growth on the carbon surfaces. In some applications much of the removal has been found to result from biodegradation rather than from adsorption.

o Pollutants Treated - BOD, COD, TOC, and certain priority pollutants.

Filtration

Filtration may be employed to polish an existing biological effluent, to prepare wastewater for a subsequent advanced treatment process, or to enable direct reuse of a discharge.

o Pollutants Treated - TSS and any other pollutants in suspension.

2.2.4 Zero or Alternate Discharge

Zero or alternate discharge is defined as no discharge at the OCPSF plant of contaminated process wastewater to either surface water bodies or to POTWs. Means by which zero or alternate discharge may be achieved are described in the following paragraphs.

Deep Well Disposal

Deep well injection is a method frequently used for disposal of highly contaminated or very toxic wastes not easily treated or disposed of by other methods. Deep well injection is limited geographically because of the geologic requirements of the system. There must be a substantial and extensive impervio

caprock strata overlying a porous strata which is not used as a water supply or for other withdrawal purposes.

Because of the potential hazard of contaminating usable aquifers, some states prohibit the use of deep well disposal. Contamination of these aquifers can occur (1) from improperly sealed well casings which allow the waste to flow up the bore hole, and (2) from unknown faults and fissures in the caprock which allow the waste to escape into the usable stratum. The latter is conceivable even though the fault may be miles from the well and the migration of the waste material to the fault might take many years. This problem could be intensified by the increased subterranean pressure created by the injection well and could be further intensified if a substantial withdrawal of water from the usable aquifer were made in the vicinity of the caprock flow.

Deep wells are drilled through impervious caprock layers into such unusable strata as brine aquifers. The wells are usually more than 3,000 ft. deep and may reach levels over 15,000 ft. Pretreatment of the waste for corrosion control and especially for the removal of suspended solids is normally required to avoid plugging of the receiving strata. Additional chemical conditioning could be required to prevent the waste and the constituents of the receiving strata from reacting and causing plugging of the well.

Because of the relatively high pressures required for injection and dispersion of the waste, high pumping costs for deep well disposal may be incurred.

Contract Hauling

Another method of achieving zero discharge is contract removal and

disposal. This method involves paying a contract hauler/disposer to pick up the wastes at the generation site and to haul them to another site for treatment or disposal. The hauling may be accomplished by truck, rail or barge.

Contract hauling is usually limited to low volume wastes, many of which may require highly specialized treatment technologies for proper disposal. Although plants utilizing this technology are defined as zero dischargers, an impact on the environment may not be eliminated since the wastes are relocated only from the generating site and may be treated and discharged elsewhere.

Offsite Treatment

Offsite treatment refers to wastewater treatment at a cooperative or privately owned centralized facility. Offsite treatment and disposal are used by plants that do not choose to install and operate their own treatment facilities. The rationale for utilization of offsite treatment usually is economically oriented and governed by the accessibility of suitable treatment facilities willing to treat the wastes (usually on a toll basis). Sometimes adjacent plants find it more feasible to install a centralized facility to handle all wastes from their facilities. The capital and operating costs usually are shared by the participants on a pro-rata basis.

Depending on the nature of the waste and/or restrictions imposed by the receiving treatment plant, wastes sent for offsite treatment may require pretreatment at the generating plant.

Incineration

Incineration is a frequently used zero-discharge method in the OCPSF industry. Depending upon the heat value of the material being incinerated, incinerators may or may not require auxiliary fuel. The gaseous combustion or

composition products may require scrubbing, particulate removal, or another treatment to capture materials that cannot be discharged to the atmosphere. This treatment may generate a waste stream that ultimately will require some degree of treatment. Residue left after oxidation will also require some means of disposal.

Incineration is usually used for the disposal of flammable liquids, tars, solids, and/or hazardous waste materials of low volume which are not amenable to the usual EOP treatment technologies.

Evaporation

Evaporation is used in the OCPSF industry to reduce the volume of waste water and thereby concentrate the organic content to render it more suitable for incineration or disposal to landfill. This technology is normally used as in-plant treatment or pretreatment for incineration or landfill.

Evaporation equipment can range from simple open tanks to large, sophisticated, multi-effect evaporators capable of handling large volumes of liquid. Typically, steam or some other external heat source is required to effect vaporization. Therefore, the major limitation to mechanical evaporation is the amount of energy required.

Impoundment

Impoundment generally refers to wastewater storage in large ponds. Alternate or zero discharge from these facilities relies on the natural losses by evaporation, percolation into the ground, or a combination thereof. Evaporation is generally feasible if precipitation, temperature, humidity and wind velocity combine to cause a net loss of liquid in the pond. If a net loss does not exist, recirculating sprays, heat or aeration can be used to enhance

the evaporation rate to provide a net loss. The rate of percolation of water into the ground is dependent on the subsoil conditions of the area of pond construction. Since there is a great potential for contamination of the shallow aquifer from percolation, impoundment ponds are frequently lined or sealed. Solids which accumulate over a period of time in these sealed ponds will eventually require removal. Land area required for impoundment is a major factor limiting the amount of flow disposed by this method.

Land Disposal

There are two basic types of land disposal: landfilling and land application (or spray irrigation). Landfilling consists of dumping the wastes into a pit and subsequently burying them. Land application requires spraying the wastes over land. Both disposal methods require care in selecting the site to avoid any possibility of contaminating ground and surface water. The type of pollutant being disposed by land application also must be considered. For instance, if the land is to be used for growing crops at a later time, some of the pollutants present at the time of application may persist in the soil for long durations and later may be assimilated by the crops and find their way int the food chain.

2.3 CURRENT TREATMENT PRACTICES IN THE OCPSF INDUSTRY

All of the Treatment Technologies discussed above are in use in the OCPSF industry. Table 2.1 presents a summary of treatment practices identified in th new 308 data base, Table 2.2 presents the technologies included in the daily da plants, and Table 2.3 presents the technologies associated with the 12 new toxi field sampling plants.

TABLE 2.1

TECHNOLOGIES USED BY PLANTS IN THE NEW 308 DATA BASE

Technology	Number of Plants
Steam Stripping	75
Flocculator	49
In-plant Carbon Adsorption	16
All Other In-plant Controls	260
Biological Treatment	122
One or more In-plant Controls plus Biological Treatment	55
Biological Treatment plus Filtration	77
Biological Treatment plus Polishing Ponds	34
Biological Treatment plus Activated Carbons	24
Zero or Alternative Discharge Technologies	331

TABLE 2.2

TECHNOLOGIES USED BY THE DAILY DATA PLANTS FROM NEW 308 QUESTIONNAIRE

Technology	Number of Plants
Activated Carbon without Biological Treatment	2
Metals Removal	14
Ion Exchange	2
Steam Stripping	21
Solvent Extraction	5
Biological Treatment	48
Biological Treatment plus Polishing Ponds	4
Biological Treatment plus Activated Carbons	4
Zero or Alternative Discharge Technologies	11

TABLE 2.3

TOXIC SAMPLING DATA FROM NEW FIELD SAMPLING EFFORT

Technology	Number of Plants
Activated Carbon	1
Steam Stripping	4
Metals Removed	2
Biological Treatment	10
Biological Treatment plus Polishing Ponds	1
Biological Treatment plus Filtration	3
Biological Treatment plus Activated Carbon	2

2.4 TECHNOLOGY OPTIONS AND COST CURVE DEVELOPMENT

2.4.1 Technology Options

A minimum of three technology options have been identified for each regulat Table 2.4 presents a summary of these options. Each technology option must be considered and separately evaluated for each subcategory in the industry. For example, the final BAT regulations can be based on Option 1 for one subcategory, Option 3 for another, and Option 4 (contract hauling) for subcategories with low flow rates or hard to treat effluents.

2.4.2 Cost Curve Development

In order to derive costs associated with the technology options, cost curves for the following technologies were developed:

- o Activated Sludge (CAPDET)
- o Biological Treatment Upgrade
- o Steam Stripping
- o In-plant and End-of-Pipe Carbon Adsorption
- o Coagulation Flocculation
- o Chemically Assisted Clarification
- o Filtration
- o Polishing Ponds
- o Contract Hauling
- o Monitoring
- o Sludge Disposal (Incineration)

Chapter 3 presents the detailed development of the costs for each of these technologies; however, the following list presents the general approach used:

- o All costs are derived in 1982 dollars. Where data were collected for other years, they were corrected to 1982 dollars using the ENR index.
- o Actual plant cost data were used, where possible, to derive the cost curves. Where they were not sufficient, the data that was available was used to benchmark the cost curves derived.
- o CAPDET was used to derive costs or cost curves for biological treatment, upgrade activated sludge, activated carbon and filtration. The resultant cost curves were benchmarked with actual plant data.
- o The design bases for filtration were based upon industry practice.

OCPSF TECHNOLOGY OPTIONS

Regulation	Option 1 Technology	Option 1 Treatment Levels	Option 2 Technology	Option 2 Treatment Levels	Option 3 Technology	Option 3 Treatment Levels	Option 4 Technology	Option 4 Treatment Levels
BPT	Biological Treatment (or equiv. P/C)	*	Biological plus Polishing Ponds or Filtration	*	Biological plus Activated Carbon	*		
BAT	Biological Treatment (or equiv. P/C)	*	Steam Stripping, Activated Carbon, Coagulation/Flocculation plus Biological Treatment	*	Option 2 plus Activated Carbon	*	Contract Hauling	0
PSES	NO PSES	*	Coagulation/Flocculation, Steam Stripping, Activated Carbon	*	Contract Hauling	*		0

Notes

* The treatment levels for each technology option will be available upon completion of the analyses of all the daily data and new sampling data.

- o The design bases for activated carbon were based on industry practice, and included actual priority pollutant removal data.
- o Polishing ponds, coagulation/flocculation, chemically assisted clarification, contract hauling, sludge disposal (incineration) and monitoring costs were based on actual manufacturer quotations.
- o Steam stripping costs are based on actual plant data.

2.5 DETAILED COSTING PROCEDURES OCPSF INDUSTRY

2.5.1 Introduction

The purpose of this procedure is to provide the basis for the determinatio of costs for meeting various regulatory options applicable to the OCPSF Industr The methodology outlined below will allow for the calculation of capital and operating costs on a plant-by-plant basis using actual plant operating conditio The costs developed in this analysis are in 1982 dollars. Section 2.5.2 outlin the data that must be collected before the plant-by-plant analysis can begin, and Section 2.5.3 presents the Technology Assessment Analysis for determining which technology options can be costed for achieving each regulatory option.

2.5.2 Data Needs

Prior to starting the costing estimates, the following data must be collected for each OCPSF Facility:

1)	Production Characteristics	a) All product processes b) Plant subcategory c) Plant costing cell
2)	Flow Data	a) Effluent flow b) Total influent flow c) Flow rates by product process d) Flow rates for all in-plant contr
3)	Treatment Technology in place:	a) In-plant b) End-of-Pipe
4)	Current (1980) Performance Data	a) Effluent data for BOD and TSS. If there are no BOD or TSS data, assessment of the treatment in place must be undertaken.

b) Effluent data for toxics. If there are no toxic data for the plant, the predictions for the presence of priority pollutants must be obtained.

Table 2.5 presents a Cost Worksheet that should be used with each plant-by-plant analysis.

2.5.3 Technology Assessment Analysis

The following presents the methodology for costing BPT and BAT:

2.5.3.1 BPT

Regulatory Options 1 and 2:

I. ACTIVATED SLUDGE IN PLACE

	SYSTEM TO COST
A. Δ BOD 0-3 mg/l and;	
1. Δ TSS 0-3 mg/l	0 COSTS
2. Δ TSS > 3 and Target TSS > 20	Tertiary Clarifier (Filter/ Polishing Pond* if T.C. in place)
3. Δ TSS > 3 and Target TSS ≤ 20	Tertiary Clarifier and Filter/ Polishing Pond*(if T.C. in place cost only Filter/Polishing Pond)
B. Δ BOD > 3-15 mg/l and,	
1. Δ TSS 0-3 mg/l	Improved Operating Procedures
2. Δ TSS > 3 and Target TSS > 20	Imp. Op. Procedures and Tertiary Clarifier (Filter/Polishing Pond* if T.C. in place)
3. Δ TSS > 3 and Targe TSS ≤ 20	Imp. Op. Procedures, Tertiary Clarifier and Filter/Polishing Pond* (if T.C. in place cost only Filter/Polishing Pond)
C. Δ BOD > 15-25 mg/l and;	
1. Δ TSS 0-3 mg/l	Imp. Op. Procedures and Tertiary Clarifier (Filter/Polishing Pond* if T.C. in place)

	SYSTEM TO COST
2. Δ TSS > 3 and Target TSS > 20	Imp. Op. Procedures and Tertiar Clarifier (Filter/Polishing Pon if T.C. in place)
3. Δ TSS > 3 and Target TSS ≤ 20	Imp. Op. Procedures, Tertiary C and Filter/Polishing Pond* (if in place cost only Filter/Polis Pond)
D. Δ BOD > 25 mg/l and;	
1. Δ TSS 0-3 mg/l	Second stage biological
2. Δ TSS > 3 and Target TSS > 20	Second stage biological
3. Δ TSS > 3 and Target TSS ≤ 20	Second stage biological and Fil Polishing Pond (if filter is in place cost only Secondary Biological)
II. ACTIVATED SLUDGE NOT IN-PLACE	
A. Δ BOD 0-3 mg/l and;	
1. Δ TSS 0-3 mg/l	0 COSTS
2. Δ TSS > 3 and Target TSS > 20	Tertiary Clarifier (Filter/ Polishing Pond* if T.C. in plac
3. Δ TSS > 3 and Target TSS ≤ 20	Tertiary Clarifier and Filter/ Polishing Pond* (if T.C. in pla cost only Filter/Polishing Pond
B. Δ BOD > 3-15 mg/l and,	
1. Δ TSS 0-3 mg/l	Tertiary Clarifier (Filter/ Polishing Pond* if T.C. in plac
2. Δ TSS > 3 and Target TSS > 20	Tertiary Clarifier (Filter/ Polishing Pond* if T.C. in plac
3. Δ TSS > 3 and Target ≤ 20	Tertiary Clarifier and Filter/ Polishing Pond* (if T.C. in pla cost only Filter/Polishing Pond
C. Δ BOD > 15 mg/l and;	
1. Δ TSS 0-3 mg/l	Activated Sludge
2. Δ TSS > 3 and Target TSS > 20	Activated Sludge
3. Δ TSS > 3 and Target TSS ≤ 20	Activated Sludge and Filter/Pol Pond (if a filter is in place cost only Activated Sludge)

* If the maximum monthly average temperature is greater than 25°C add a filter, otherwise add a polishing pond.

TABLE 2.5

COST WORKSHEET INFORMATION

#	PRODUCT GROUP NAME	PROCESS NAME	TYPE AND NUMBER OF PROCESS WASTEWATER	TREATMENT WASTE STREAM CODE	FLOW (MGD)
	PVC Resin	Susp. Polymer of Vinyl Chloride	A1 1a A2 1b	001	.327
	Polyvinyl Acetate	Emulsion Polymer of Vinyl Acetate	A1 2a	002	.040
	Vinyl Acetate-Acrylic Resins	Emulsion Polymer of Vinyl Acetate & N-Butyl Acrylate	A1 3a	003	0.14

LANT CONTROLS TREATMENT

EATMENT WASTE STREAM CODE	TYPE OF TECHNOLOGY	AVG. PROCESS WASTEWATER(MG
001	C5a	.06 .131
002	C5a	

OF-PIPE TREATMENT

ELIMINARY TREATMENT ASTE STREAM CODE	TYPE OF TECHNOLOGY	AVG. PROCESS WASTEWATER(MG
001	D1a, D2a, D11a, D9a, D12a,	.06
002	D1b, D2b	.130
003	D1a, D2a, D11a, D9a, D12a	.192

CONDARY TREATMENT ASTE STREAM CODE	TYPE OF TECHNOLOGY	AVG. PROCESS WASTEWATER(MG
001, 003	E1, E11a, E11b	.252
002	E11b	.131

RTIATY TREATMENT ASTE STREAM CODE	TYPE OF TECHNOLOGY	AVG. PROCESS WASTEWATER(MG
001, 002, 003	F1a	.382

TABLE 2.5 (cont.)

MISC. WASTEWATER CODE	LOCATION AT WHICH WASTEWATER ENTERS MAIN TREATMENT SYSTEM	VOLUME OF MISC. WASTEWATER (MGD
B2	D1a	.09
B5	D1b, E1a	.026

DATA

IN-PLANT CONTROL TREATMENT

POLLUTANTS	TREATMENT TECHNOLOGY	INFLUENT CONCENTRATION	EFFLUENT CONCE
2	C5	400 ppm	1.0 ppm
BOD_5	E1a	372 ppm	
TSS	E1a	17 ppm	
BOD_5	H1a		7 ppm
TSS	H1a		15.4 ppm
2	H1a		.03 ppm
3	H1a		.03 ppm
4	H1a		2.0 ppb
86	H1a		50.0 ppb
TOC	H1a		28.0 ppm
114	H1a		.01 ppm
117	H1a		.01 ppm
127	H1a		.01 ppm
121	H1a		.01 ppm

EFFLUENT TARGETS (REGULATORY OPTION)

TABLE 2.5 (cont.)

'ERENCE BETWEEN ACTUAL PERFORMANCE AND EFFLUENT TARGETS

BPT (BOD and TSS)

) a) BAT or

b) Pollutants to be Treated Based on Product/Process Evaluation

HNOLOGY REQUIRED BASED ON FLOW, POLLUTANT, ETC.

) BPT

) BAT

DESIGN CRITERIA USED FOR COSTING (By Technology):

1) Flow

2) Other

TREATMENT COSTS (By Technology):

1) Capital Costs

2) Operating Costs

TOTAL TREATMENT COSTS

1) Capital Costs

2) Operating Costs

Note: The following represents the definitions of the various wastestream and treatment codes used in this example of the cost worksheet:

A1 - Aqueous wastestream from reactors, raw material recovery and solvent recovery
A2 - Non-aqueous wastestream from reactors, raw material recovery and solvent recovery
C5 - Steam Stripping
D2 - Neutralization
D1 - Equalization
H1 - Direct Discharge
B2 - Cooling Tower Blowdown
D11 - Flocculation
D9 - Primary Clarification
D12 - Nutrient Addition
E1 - Activated Sludge
E11 - Secondary Clarification
F1 - Polishing Pond
B5 - Air Pollution Control Wastewater

Regulatory Option 3:

A. In addition to the costs determined in 2.5.3.1, an end-of-pipe activated carbon system should be costed for each facility, if there is not one already present.

B. As an alternative, the costs for contract hauling should also be determined.

2.5.3.2 BAT

Regulatory Option 1:

No additional costs to those calculated in 2.5.3.1.

Regulatory Option 2:

A. Alternative 1

In addition to the costs calculated in 2.5.3.1, the following additional costs should be determined:

a) For plants with metals in their RWL, coagulation/flocculation should be costed (only if this technology is not already in place).

b) For plants with volatile organic pollutants in their RWL, steam stripping should be costed (only if this technology is not already in place).

c) For plants with base-neutral or acid priority pollutants, in-plant activated carbon should be costed (only if this technolo is not already in place).

B. Alternative 2

As an alternative, the costs for contract hauling should also be determined.

Regulatory Option 3:

A. Alternative 1

The costs for this Regulatory Option are the summation of the costs determined for BPT options 1 and 3, and BAT option 2.

B. Alternative 2

As an alternative, the costs for contract hauling should also be determined.

Regulatory Option 4:

A. Contract hauling should be costed for all facilites.

2.5.3.3 PSES

Regulatory Option 1:

There are no costs associated with this Regulatory Option.

Regulatory Option 2:

A. Alternative 1

a) For plants with metals in their RWL, coagulation/flocculation should be costed (only if this technology is not already in place).

b) For plants with volatile organic pollutants in their RWL, steam stripping should be costed (only if this technology is not already in place).

c) For plants with base-neutral or acid priority pollutants, in-plant activated carbon should be costed (only if this technology is not already in place).

B. Alternative 2

As an alternative, the costs for contract hauling should also be determined.

Regulatory Option 4:

Contract hauling should be costed for all facilities.

2.5.4 Additional Cost Factors

2.5.4.1 Temperature (Biological Treatment Processes)

In order to take into account the affect of temperature, the following factor has been derived:

$$\text{Temperature Correction Factor} = \left(\frac{k_B}{k_S}\right)^{0.7}$$

where k_B = Base Line k
k_S = k rate estalished for each State
0.7 = Cost Scale Factor

The ratio $\frac{k_B}{k_S}$ is derived from the following general equation:

$$k_S = k_B \times 0^{(T_S - T_B)}$$

where $0 = 1.07$
and $T_B = 20°C$

Therefore,

$$\frac{k_S}{k_B} = 1.07^{(T_S - T_B)}$$

Thus, the temperature correction factor is:

$$\frac{k_B}{k_S}\ 0.7 = \left(1.07^{-(T_S - T_B)}\right)0.7$$

Table 2.6 presents T_s and the corresponding cost factor for each State.

These values are based upon the state's actual minimum monthly average ambient temperature. In order to account for the fact that wastewater only approaches ambient temperature but never actually reaches ambient conditions, a 5°C differential was used to calculate T_s, with 5°C being the lowest water temperature attainable. It should be noted that some plant's wastewater are actually hot 12 months per year. 20°C will be the highest T established.

Table 2.6 also presents each state's average monthly maximum ambient temperature. Warm temperatures can cause algae blooms in polishing ponds; therefore, plants in states with average maximum ambient temperatures over 25°C will have filtration systems rather than polishing ponds.

The T values shown in Table 2.6 will be used when running CAPDET for activ sludge. The cost factors shown on Table 2.6 will be used to adjust the biologi upgrade costs.

TABLE 2.6

State	Minimum Monthly Average Temperature (°C) (1)	Maximum Monthly Average Temperature (°C) (1)	T (°C)	Cost Factor
Alabama	8	27	13	1.4
Alaska	-13	12	5	2.0
Arizona	6	28	11	1.5
Arkansas	4	28	9	1.7
California	8	21	13	1.4
Colorado	-6	23	5	2.0
Connecticut	-2	23	5	2.0
Delaware	0	24	5	2.0
Florida	16	28	20	1.0
Georgia	7	27	12	1.5
Hawaii	22	26	20	1.0
Idaho	-2	23	5	2.0
Illinois	-4	24	5	2.0
Indiana	-6	24	5	2.0
Iowa	-7	23	5	2.0
Kansas	-2	26	5	2.0
Kentucky	0	25	5	2.0
Louisiana	10	28	15	1.3
Maine	-12	23	5	2.0
Maryland	1	25	6	1.9
Massachusetts	-3	22	5	2.0
Michigan	-5	21	5	2.0
Minnesota	-13	20	5	2.0
Mississippi	8	27	13	1.4
Missouri	-1	26	5	2.0
Montana	-8	21	5	2.0
Nebraska	-6	24	5	2.0
Nevada	-1	25	5	2.0
New Hampshire	-6	21	5	2.0
New Jersey	0	24	5	2.0
New Mexico	2	25	7	1.8
New York	-3	23	5	2.0
North Carolina	6	25	11	1.5
North Dakota	-14	21	5	2.0
Ohio	-3	23	5	2.0
Oklahoma	3	28	8	1.8
Oregon	2	19	7	1.8
Pennsylvania	-2	23	5	2.0
Puerto Rico	24	27	20	1.0
Rhode Island	-1	21	5	2.0
South Carolina	8	27	13	1.4
South Dakota	-9	23	5	2.0
Tennessee	4	27	9	1.7
Texas	8	28	13	1.4
Utah	-3	24	5	2.0
Vermont	-8	23	5	2.0
Virginia	3	25	8	1.8
Washington	-3	21	5	2.0
West Virginia	0	23	5	2.0
Wisconsin	-8	21	5	2.0
Wyoming	-6	21	5	2.0

(1) Source of Data: National Oceanic and Atmospheric Administration, Comparison Climatic Data for the United Stated through 1979(thirty years of data), Environmental Data and Information Service, Asheville, North Carolina

2.5.4.2 Land Cost

Due to continuing urbanization, the cost of land available for wastewater treatment plant sites has increased substantially in recent years, and can be a signifacant part of the initial plant cost.

The area required for the plant site depends upon plant capacity, type of treatment, treatment components, site topography and requirements for anticipated plant expansions. The area of land actually purcahsed may also be influenced by the size of tracts available at the selected plant location.

Since land costs may vary widely from place to place, it is difficult to obtain a nationwide average figure. However, based on an industrial real estat market survey report (prepared by the Society of Industrial Realtors in 1983), average land costs for suburban sites of each state can be obtained. The results are presented in Table 2.5.1 and 2.5.2.

Table 2.5.1 shows the estimated unit land prices for the unimproved suburb sites of major cities and the average for each state. The unimproved sites are also in the top 25 percent of overall desirability of the existing inventory and zoned for industrial use. Streets and utilities may not yet be installed but are reasonably close and available. Rail serice may, or may not be available. Table 2.5.2 is a summary of the estimated land prices for each state. For those states that have no land prices available, the regional average figures were used. For example, in the Northeast region, no land price are available for the states of Maine, Rhode Island and Virginia, therefore the regional average figure of $24,700 was used for these states. Table 2.5.2 also indicates that, in general, the average land price for the North Central region is the least expensive one with an average of approximately $20,600. The

Northeast and South regions have average land prices of $24,700 and $27,000, respectively. The averge land prices for the West region seems to be the most expensive, ranging from $19,600 to $190,400 with an average of $72,600.

2.5.4.3 RCRA Baseline Costs for Surface Improvements

In November, 1984, the RCRA Reauthorization bill was signed. As a result, costs must be determined for upgrading surface impoundments to comply with this law. Facilities that have "aggressive biological treatment processes" are exempt from the requirements. Aggressive Biological Treatment Facility means a system if surface impoundment in which the initial impoundment of the secondary treatment segment of the facility utilizes intense mechanical Aeration to enhance biological activity to degrade wastewater pollutants and:

1. The hydraulic retention time in such initial impoundment is no longer than five days under normal operating conditions on an annual average basis;

2. The hydraulic retention time in such an initial impoundment is no longer than 30 days under normal operating conditions on an annual average basis, provided that the sludge in such an impoundment does not constitute a hazardous waste as identified by the extraction procedure toxicity characteristic in effect on the date of enactment of the hazardous and solid waste amendments of 1984; or

3. Such a system utilizes activated sludge treatment in the first portion of secondary treatment.

This includes all activated sludge and aerated lagoon systems. Therefore, RCRA baseline costs will only have to be determined for facilities with aerobic lagoons, facultative lagoons, and anaerobic lagoons.

Section 3.12 describes the procedure used in developing baseline costs for the above mentioned facilities.

TABLE 2.5.1

Land Costs for Suburban Areas
Region: NORTHEAST

(Unimproved, 10-100 Acre Land Price in Suburb Areas)
(From: Industrial Real Estate Market Survey, 1983)

MA	Land Price ($/ft^2) 1982	NY	Land Price ($/ft^2) 1982	CT	Land Price ($/ft^2) 1982	NH	Land Price ($/ft^2) 1982	NJ	Land Price ($/ft^2) 1982	PA	Land Price ($/ft^2) 1982
Boston	1.62	Buffalo Suburbs	0.11 0.83	Hartford	0.48	Nashua	0.38	Northern Suburbs	1.02	Philadelphia	0.39
Springfield	0.18	*Syracuse	0.20	New Haven	0.45					Pittsburgh	0.15
AVERAGE	0.90 or $39,200/Acre		0.38 or $16,600/Acre		0.46 or $20,000/Acre		0.38 or $16,600/Acre		1.02 or $44,400/Acre		0.27 or $11,800/Acre

Regional Average: $24,700

TABLE 2.5.1 (Cont.)

Region: NORTHCENTRAL

(Unimproved 10-100 Acre Land Price in Suburb Areas)

OH	Land Price ($/ft²) 1982	IL	Land Price ($/ft²) 1982	IA	Land Price ($/ft²) 1982	MI	Land Price ($/ft²) 1982	IN	Land Price ($/ft²) 1982	MO	Land Price ($/ft²) 1982
Akron	0.18	Chicago	0.75	Davenport	0.18	Detroit	0.30	Evansville	0.17	St. Louis	$0.75
Cleveland	0.18			Des Moines	0.15	Grand Rapids	0.19	Fort Wayne	0.16		
Columbus	0.15			Sioux City	0.18			Indianapolis	0.35		
Toledo	0.90							South Bend	0.15		
								Terre Haute	0.50		
AVERAGE (1982)	0.35 or $15,200/Acre		0.75 or $32,700/Acre		0.17 or $7,400/Acre		0.24 or $10,500/Acre		0.27 or $11,800/Acre		0.75 or $32,700/Acre

WI	Land Price ($/ft²) 1982	MN	Land Price ($/ft²) 1982	NE	Land Price ($/ft²) 1982	KS	Land Price ($/ft²) 1982
Milwaukee	$0.90	Minneapolis - St. Paul	0.50	Omaha*	0.70	Wichita	0.10
AVERAGE	0.90 or $39,200/Acre		0.50 or $21,800/Acre		0.70 or $30,500/Acre		0.10 or $4,360/Acre

*Less than 10 Acres
Regional Average: $20,600/Acre

TABLE 2.5.1 (Cont.)

Region: SOUTH

GA	Land Price ($/ft^2) 1982	TX	Land Price ($/ft^2) 1982	MD	Land Price ($/ft^2) 1982	SC	Land Price ($/ft^2) 1982	NC	Land Price ($/ft^2) 1982	FL	Land Price ($/ft^2) 1982
Atlanta	$1.00	Austin	0.70	Baltimore	0.45	Charleston	0.20	Charlotte	0.25	Fort Lauderdale	1.25
		Dallas	1.35			Greenville	0.33	Greensboro	0.50	Jacksonville	0.34
		Fort Worth	0.37							Miami	1.31
		Houston	2.25							Orlando	0.50
		San Antonio	0.75							Tampa	0.80
AVERAGE	1.00 or $43,600/Acre		1.08 or $47,000/Acre		0.45 or $19,600/Acre		0.27 or $11,800/Acre		0.38 or $16,600/Acre		0.84 or $36,600/Acre

AR	Land Price ($/ft^2) 1982	TN	Land Price ($/ft^2) 1982	AL	Land Price ($/ft^2) 1982	LA	Land Price ($/ft^2) 1982	VA	Land Price ($/ft^2) 1982	OK	Land Price ($/ft^2) 1982
Fort Smith	0.50	Memphis	0.35	Mobile	0.15	New Orleans	1.00	Richmond	0.45	Oklahoma City	0.43
										Tulsa	0.55
AVERAGE	0.50 or $21,800/Acre		0.35 or $15,200/Acre		0.15 or $6,500/Acre		1.00 or $43,600/Acre		0.45 or $19,600/Acre		0.49 or $21,300/Acre

Washington D.C.	Land Price ($/ft^2) 1982	DE	Land Price ($/ft^2) 1982
	1.50	Wilmington	0.36
AVERAGE	1.50 or $65,300/Acre		0.36 or $15,700/Acre

Region: WEST

NM	1982 Price ($/ft²)	CO	1982 Price ($/ft²)	CA	1982 Price ($/ft²)	AZ	1982 Price ($/ft²)	OR	1982 Price ($/ft²)	NV	1982 Price ($/ft²)
Albuquerque	0.45	Denver	0.88	LA (Orange County)	6.25	Phoenix	1.50	Portland	1.67	Reno	0.80
				LA (South Bay)	6.50						
				Oakland	2.00						
				San Diego	3.00						
				San Francisco	8.00						
				San Joaquin Cty	0.46						
AVERAGE	0.45 or $19,600/Acre		0.88 or $38,300/Acre		4.37 or $190,400/Acre		1.50 or $65,300/Acre		1.67 or $72,700/Acre		0.80 or $34,800/Acre

WA	1982 Price ($/ft²)
Seattle	2.00
AVERAGE	2.00 or $87,100/Acre

Regional Average: $72,600

TABLE 2.5.2

Summary of Land Costs in the United States

Region	State	Estimated Land Price ($/Acre)
Northeast	Connecticut	20,000
	*Maine	24,700
	Massachusetts	39,200
	New Hampshire	16,600
	New Jersey	44,400
	New York	16,600
	Pennsylvania	11,800
	*Rhode Island	24,700
	*Virginia	24,700
	AVERAGE	$24,700
North Central	Illinois	32,700
	Indiana	11,800
	Iowa	7,400
	Kansas	4,360
	Michigan	10,500
	Minnesota	21,800
	Missouri	32,700
	*New Mexico	20,600
	Ohio	15,200
	Nebraska	30,500
	*North Dakota	20,600
	*South Dakota	20,600
	Wisconsin	39,200
	AVERAGE	$20,600
South	Alabama	6,500
	Arkansas	21,800
	Delaware	15,700
	Florida	36,600
	Georgia	43,600
	*Kentucky	27,000
	Louisianna	43,600
	Maryland	19,600
	*Mississippi	27,000
	North Carolina	16,600
	Oklahoma	21,300
	South Carolina	11,800
	Tennessee	15,200
	Texas	47,000
	Virginia	19,600
	Washington D.C.	65,300
	*West Virginia	27,000
	AVERAGE	$27,000

TABLE 2.5.2 (Cont.)

Region	State	Estimated Land Price ($/Acre)
West	*Alaska	72,600
	Arizona	65,300
	California	190,400
	Colorado	38,300
	*Hawaii	72,600
	*Idaho	72,600
	*Montana	72,600
	Nevada	34,800
	New Mexico	19,600
	Oregon	72,700
	*Utah	72,600
	Washington	87,100
	Wyoming	72,600
	AVERAGE	$72,600

* Obtained from Regional Average Price

IX. SUPPLEMENT TO COSTING DOCUMENTATION AND NOTICE OF NEW INFORMATION REPORT

Note: Table of Contents and List of Tables follow;
entire Supplement is included in the Public Record

FINAL

SUPPLEMENT TO COSTING DOCUMENTATION AND NOTICE OF NEW INFORMATION REPORT

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FINAL SUPPLEMENT TO COSTING DOCUMENT
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