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Proposed

Development Document for Effluent Limitations Guidelines and Standards for the

Electrical and Electronic Components

Point Source Category

DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

for the

ELECTRICAL AND ELECTRONIC COMPONENTS POINT SOURCE CATEGORY

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EXECUTIVE SUMMARY

CONCLUSIONS

A study of the Electrical and Electronic Components Industrial Point Source Category was undertaken to establish discharge limitations guidelines and standards. The industry was subcategorized into 21 segments based on product type. Of the 21 subcategories, 17 have been excluded under Paragraph 8 of the NRDC Consent Decree, two have been deferred, and for two subcategories, regulations are being proposed. The last two subcategories are Semiconductors and Electronic Crystals. (A detailed discussion of the subcategories excluded and deferred is provided in Section 6 of this document.)

In the Semiconductor and Electronic Crystals subcategories, pollutants of concern include fluoride, toxic organics, arsenic, and total suspended solids. The major source of fluoride is the use of hydrofluoric acid as an etchant or cleaning agent. Toxic organics occur from the use of solvents in cleaning and degreasing operations. Arsenic is only found in significant concentrations at facilities that manufacture gallium or indium arsenide crystals; it is present in the wastewater as a result of the manufacturing process. Suspended solids are only found in significant concentrations at facilities that manufacture crystals where the solids come from cutting and grinding operations.

Several treatment and control technologies applicable to the reduction of pollutants generated by the manufacture of semiconductors and electronic crystals were evaluated, and the costs of these technologies were estimated. Pollutant concentrations achievable through the implementation of these technologies were based on industry data and transfer of technology assessments from industries with similar waste characteristics. These concentrations are presented below as proposed limitations and standards for the Semiconductor and Electronic Crystals subcategories.

PROPOSED EFFLUENT LIMITATIONS AND STANDARDS

For both subcategories, Tables 1 through 10 present proposed regulations for Best Practicable Control Technology (BPT), Best Available Control Technology (BAT), Best Conventional Pollutant Control Technology (BCT), New Source Performance Standards (NSPS), and Pretreatment Standards for New and Existing Sources (PSNS and PSES). All limitations and standards are expressed as milligrams per liter.

TABLE 1: BPT PROPOSED REGULATIONS FOR SEMICONDUCTORS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)	pH Range
Total Toxic Organics *	0.47	**	
pH			6-9

TABLE 2: BAT PROPOSED REGULATIONS FOR SEMICONDUCTORS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)
Total Toxic Organics *	0.47	**
Fluoride	32	17.4

TABLE 3: BCT PROPOSED REGULATIONS FOR SEMICONDUCTORS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)	pH Range
pH			6-9

TABLE 4: NSPS PROPOSED REGULATIONS FOR SEMICONDUCTORS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)	pH Range
Total Toxic Organics *	0.47	**	
Fluoride	32	17.4	
pH			6-9

* Total Toxic Organics is explained in Section 6.
** The Agency is not proposing 30-day average limits for total toxic organics for reasons explained in Section 8.

TABLE 5: PSES and PSNS PROPOSED REGULATIONS FOR SEMICONDUCTORS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)
Total Toxic Organics *	0.47	**

TABLE 6: BPT PROPOSED REGULATIONS FOR ELECTRONIC CRYSTALS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)	pH Range
Total Toxic Organics *	0.47	**	
Fluoride	32	17.4	
Arsenic ***	1.89	0.68	
TSS	61	22.9	
pH			6-9

TABLE 7: BAT PROPOSED REGULATIONS FOR ELECTRONIC CRYSTALS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)
Total Toxic Organics *	0.47	**
Fluoride	32	17.4
Arsenic ***	1.89	0.68

* Total Toxic Organics is explained in Section 6.

** The Agency is not proposing 30-day average limits for total toxic organics for reasons explained in Section 8.

*** The arsenic limitation applies only to plants manufacturing gallium or indium arsenide crystals.

TABLE 8. BCT PROPOSED REGULATIONS FOR ELECTRONIC CRYSTALS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)	pH Range
TSS	61.0	22.9	
pH			6-9

TABLE 9. NSPS PROPOSED REGULATIONS FOR ELECTRONIC CRYSTALS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)	pH Range
Total Toxic Organics *	0.47	**	
Fluoride	32	17.4	
Arsenic ***	1.89	0.68	
TSS	61.0	22.9	
pH			6-9

TABLE 10: PSNS AND PSES PROPOSED REGULATIONS FOR ELECTRONIC CRYSTALS

Pollutant	24-hour Maximum (mg/l)	30-day Average (mg/l)
Total Toxic Organics *	0.47	**
Arsenic ***	1.89	0.68

* Total Toxic Organics is explained in Section 6.
** The Agency is not proposing 30-day average limits for total toxic organics for reasons explained in Section 8.
*** The arsenic limitation applies only to plants manufacturing gallium or indium arsenide crystals.

SECTION 1

INTRODUCTION

The purpose of this document is to present the findings of the EPA study of the Electrical and Electronic Components (E&EC) Point Source Category. The document (1) explains which segments of the industry are regulated and which are not; (2) discusses the reasons; and (3) explains how the actual limitations were developed. Section 1 describes the organization of the document and reviews the sources of industry data that were used to provide technical background for the limitations.

1.1 ORGANIZATION AND CONTENT OF THIS DOCUMENT

Industry data are used throughout this report in support of regulating subcategories or excluding subcategories from regulation under Paragraph 8 of the NRDC Consent Decree. Telephone contacts, the literature, and plant visits provided the information used to subcategorize the industry in Section 3. These data were also considered in characterizing the industry in Section 4, Description of the Industry.

Water use and wastewater characteristics in each subcategory are described in Section 5 in terms of flow, pollutant concentration, and load. Subcategories to be regulated, excluded, or deferred are found in Section 6. The discussion in that section identifies and describes the pollutants to be regulated or presents the rationale for subcategory exclusion or deferral. Section 7 describes the technology options available. The regulatory limits and the bases for these limitations are presented in Section 8. Section 9 estimates the capital and operating costs for the treatment technologies used as the basis for limitations.

1.2 SOURCES OF INDUSTRY DATA

Data on the E&EC category were gathered from literature studies, contacts with EPA regional offices, from plant surveys and evaluations, and through contacting waste treatment equipment manufacturers. These data sources are discussed below.

Published literature in the form of books, reports, papers, periodicals, promotional materials, Dunn and Bradstreet surveys, and Department of Commerce Statistics was examined; the most informative sources are listed in Section 11, References. The researched material included product descriptions and uses, manufacturing processes, raw materials consumed, waste treatment technology, and the general characteristics of plants in the E&EC category, including number of plants, employment levels, and production.

All 10 EPA offices were telephoned for assistance in identifying E&EC plants in their respective regions.

Three types of data collection were used to supplement available information pertaining to facilities in the E&EC category. First, more than 250 plants were contacted by phone or letter to obtain basic information regarding products, manufacturing processes, wastewater generation, and waste treatment. Second, based on this information, 78 plants were visited to view their operations and discuss their products, manufacturing processes, water use, and wastewater treatment. Third, 38 plants were selected for sampling visits to determine the pollutant characteristics of their wastewater.

The sampling program at each plant consisted of up to three days of sampling. Prior to any sampling visit, all available data, such as layouts and diagrams of the selected plant's production processes and waste treatment facilities, were reviewed. In most cases, a visit to the plant was made prior to the actual sampling visit to finalize the sampling approach.

Representative sample points were then selected. Finally, before the visit was conducted, a detailed sampling plan showing the selected sample points and all pertinent sample data to be obtained was presented and reviewed.

To more completely characterize each product by the number of producers, production levels, production processes, in-plant controls, waste sources and volumes, waste treatment, and waste disposition, a major survey of each industry was necessary.

Following literature surveys, telephone contacts, and plant visits, questionnaires for obtaining the above information were prepared for each product. After review and comments by selected industry personnel, the questionnaires were mailed to all known product manufacturers. The results of these surveys provided the major sources of industrial data presented in this document.

Various manufacturers of wastewater treatment equipment were contacted by phone or were visited to obtain cost and performance data on specific technologies. Information collected was based both on manufacturers' research and on actual operation.

SECTION 2

LEGAL BACKGROUND

2.1 PURPOSE AND AUTHORITY

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," Section 101(a). Section 301(b)(1)(A) set a deadline of July 1, 1977, for existing industrial dischargers to achieve "effluent limitations requiring the application of the best practicable control technology currently available" (BPT). Section 301(b)(2)(A) set a deadline of July 1, 1983, for these dischargers to achieve "effluent limitations requiring the application of the best available technology economically achievable (BAT), which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants."

Section 306 required that new industrial direct dischargers comply with new source performance standards (NSPS), based on best available demonstrated technology. Sections 307(b) and (c) of the Act required pretreatment standards for new and existing dischargers to publicly owned treatment works (POTW). While the requirements for direct dischargers were to be incorporated into National Pollutants Discharge Elimination System (NPDES) permits issued under Section 402, the Act made pretreatment standards enforceable directly against dischargers to POTWs (indirect dischargers).

Section 402(a)(1) of the 1972 Act does allow requirements to be set case-by-case. However, Congress intended control requirements to be based, for the most part, on regulations promulgated by the Administrator of EPA. Section 304(b) required regulations that establish effluent limitations reflecting the ability of BPT and BAT to reduce effluent discharge. Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS. Sections 304(f), 307(b), and 307(c) required regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants.

Finally, Section 501(a) authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

The EPA was unable to promulgate many of these regulations by the deadlines contained in the Act, and as a result, in 1976, EPA was sued by several environmental groups. In settling this lawsuit, EPA and the plaintiffs executed a "Settlement Agreement" which was approved by the Court. This agreement required EPA to develop a program and meet a schedule for controlling 65 "priority" pollutants and classes of pollutants. In carrying out this program, EPA must promulgate BAT effluent limitations guidelines, pretreatment standards, and new source performance standards for 21 major industries. (See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833(D.D.C. 1979).

Several of the basic elements of the Settlement Agreement program were incorporated into the Clean Water Act of 1977. This law made several important changes in the Federal water pollution control program. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now set July 1, 1984, as the deadline for industries to achieve effluent limitations requiring application of BAT for "toxic" pollutants. "Toxic " pollutants here included the 65 "priority" pollutants and classes of pollutants that Congress declared "toxic" under Section 307(a) of the Act.

EPA's programs for new source performance standards and pretreatment standards are now aimed principally at controlling toxic pollutants. To strengthen the toxics control program, Section 304(e) of the Act authorizes the Administrator to prescribe "best management practices" (BMPs). These BMPs are to prevent the release of toxic and hazardous pollutants from: (1) plant site runoff, (2) spillage or leaks, (3) sludge or waste disposal, and (4) drainage from raw material storage if any of these events are associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revises the control program for non-toxic pollutants. For "conventional" pollutants identified under Section 304(a)(4) (including biochemical oxygen demand, suspended solids, fecal coliform, and pH), the new Section 301(b)(2)(E) requires "effluent limitations requiring the application of the best conventional pollutant control technology" (BCT) -- instead of BAT -- to be achieved by July 1, 1984. The factors considered in assessing BCT for an industry include the relationship between the cost of attaining a reduction in effluents and the effluent reduction benefits attained, and a comparison of the cost and level of reduction of such pollutants by publicly owned treatment works and industrial sources. For those pollutants that are neither "toxic" pollutants nor "conventional" pollutants, Sections 301(b)(2)(A) and (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or July 1, 1984, whichever is later, but not later than July 1, 1987.

The purpose of this proposed regulation is to establish BPT, BAT, and BCT effluent limitations and NSPS, PSES, and PSNS for the Electrical and Electronic Components Point Source Category.

2.2 GENERAL CRITERIA FOR EFFLUENT LIMITATIONS

2.2.1 BPT Effluent Limitations

The factors considered in defining best practicable control technology currently available (BPT) include: (1) the total cost of applying the technology relative to the effluent reductions that result, (2) the age of equipment and facilities involved, (3) the processes used, (4) engineering aspects of the control technology, (5) process changes, (6) non-water quality environmental impacts (including energy requirements), (7) and other factors as the Administrator considers appropriate. In general, the BPT level represents the average of the best existing performances of plants within the industry of various ages, sizes, processes, or other common characteristics. When existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. BPT focuses on end-of-process treatment rather than process changes or internal controls, except when these technologies are common industry practice.

The cost/benefit inquiry for BPT is a limited balancing, committed to EPA's discretion, which does not require the Agency to quantify benefits in monetary terms. See, e.g., American Iron and Steel Institute v. EPA, 526 F.2d 1027 (3rd Cir. 1975). In balancing costs against the benefits of effluent reduction, EPA considers the volume and nature of existing discharges, the volume and nature of discharges expected after application of BPT, the general environmental effects of the pollutants, and the cost and economic impacts of the required level of pollution control. The Act does not require or permit consideration of water quality problems attributable to particular point sources or water quality improvements in particular bodies of water. Therefore, EPA has not considered these factors. See Weyerhaeuser Company v. Costle, 590 F.2d 1011 (D.C.Cir. 1978); Appalachian Power Company et al. v. U.S.E.P.A. (D.C. Cir., Feb. 8, 1972).

2.2.2 BAT Effluent Limitations

The factors considered in defining best available technology economically achievable (BAT) include the age of equipment and facilities involved, the processes used, process changes, and engineering aspects of the technology process changes, non-water quality environmental impacts (including energy requirements) and the costs of applying such technology [(Section 304(b)-(2)(B)]. At a minimum, the BAT level represents the best economically achievable performance of plants of various ages, sizes, processes, or other shared characteristics. As with BPT, uniformly inadequate performance within a category or subcategory may require transfer of BAT from a different subcategory or category. Unlike BPT, however, BAT may include process changes or internal controls, even when these technologies are not common industry practice.

The statutory assessment of BAT "considers" costs, but does not require a balancing of costs against effluent reduction benefits (see Weyerhaeuser v. Costle, supra). In developing the proposed BAT, however, EPA has given substantial weight to the reasonableness of costs. The Agency has considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels. Despite this expanded consideration of costs, the primary factor for determining BAT is the effluent reduction capability of the control technology. The Clean Water Act of 1977 establishes the achievement of BAT as the principal national means of controlling toxic water pollution from direct discharging plants.

2.2.3 BCT Effluent Limitations

The 1977 Amendments added Section 301(b)(2)(E) to the Act establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those defined in Section 304(a)(4) [biological oxygen demanding pollutants (BOD), total suspended solids (TSS), fecal coliform,and pH], and any additional pollutants defined by the Administrator as "conventional" [oil and grease, 44 FR 44501, July 30, 1979].

BCT is not an additional limitation but replaces BAT for the control of conventional pollutants. In addition to other factors specified in Section 304(b)(4)(B), the Act requires that BCT limitations be assessed in light of a two-part "cost reasonableness" test. American Paper Institute v. EPA, 660 F.2d 954 (4th Cir. 1981). The first test compares the costs for private industry to reduce its conventional pollutants with the costs to publicly owned treatment works for similar levels of reduction in their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find that limitations are "reasonable" under both tests before establishing them as BCT. In no case may BCT be less stringent than BPT.

2.2.4 New Source Performance Standards

The basis for new source performance standards (NSPS) under Section 306 of the Act is the best available demonstrated technology. New plants have the opportunity to design the best and most efficient processes and wastewater treatment technologies. Therefore, Congress directed EPA to consider the best demonstrated process changes, in-plant controls, and end-of-process treatment technologies that reduce pollution to the maximum extent feasible.

2.2.5 Pretreatment Standards for Existing Sources

Section 307(b) of the Act requires EPA to promulgate pretreatment standards for existing sources (PSES) which industry must achieve within three years of promulgation. PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs.

The legislative history of the 1977 Act indicates that pretreatment standards are to be technology-based, analogous to the best available technology for removal of toxic pollutants. The General Pretreatment Regulations which serve as the framework for the proposed pretreatment standards are in 40 CFR Part 403, 46 FR 9404 (January 28, 1981).

EPA has generally determined that there is passthrough of pollutants if the percent of pollutants removed by a well-operated POTW achieving secondary treatment is less than the percent removed by the BAT model treatment system. A study of 40 well-operated POTWs with biological treatment and meeting secondary treatment criteria showed that metals are typically removed at rates varying from 20 percent to 70 percent. POTWs with only primary treatment have even lower rates of removal. In contrast, BAT level treatment by the industrial facility can achieve removal in the area of 97 percent or more. Thus, it is evident that metals do pass through POTWs. As for toxic organics, data from the same POTWs illustrate a wide range of removal, from 0 to greater than 99 percent. Overall, POTWs have removal rates of toxic organics which are less effective than BAT.

2.2.6 Pretreatment Standards for New Sources

Section 307(c) of the Act requires EPA to promulgate pretreatment standards for new sources (PSNS) at the same time that it promulgates NSPS. These standards are intended to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with a POTW. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies -- including process changes, in-plant controls, and end-of-process treatment technologies -- and to select plant sites that ensure the treatment system will be adequately installed. Therefore, the Agency sets PSNS after considering the same criteria considered for NSPS. PSNS will have environmental benefits similar to those from NSPS.

SECTION 3

INDUSTRY SUBCATEGORIZATION

This section explains how the E&EC category was developed, discusses the rationale for subcategorization, and finally provides a listing of the E&EC subcategories.

3.1 E&EC CATEGORY DEVELOPMENT

The E&EC category is derived from industries found in the Standard Industrial Classification (SIC) major group 36, Electrical and Electronic Machinery, Equipment, and Supplies. Many of the industries listed under this SIC Code were never evaluated as part of the E&EC category because EPA initially concluded that the wastewater discharges from these industries were primarily associated with the Metal Finishing Category.

3.2 RATIONALE FOR INDUSTRY SUBCATEGORIZATION

After the Agency has obtained analyses of wastewater data and process information from facilities within a category, the Clean Water Act requires EPA to consider a number of factors to determine if subcategorization is appropriate for the purpose of establishing effluent limitations and standards. These factors include: raw materials, final products, manufacturing processes, geographical location, plant size and age, wastewater characteristics, non-water quality environmental impacts, treatment costs, energy costs, and solid waste generation.

A review of each of these factors revealed that product type is the principal factor affecting the wastewater characteristics of plants within the E&EC category. Product type determines both the raw and process material requirements, and the number and type of manufacturing processes used. Plants manufacturing the same product were found to use the same wet processes and produce wastewater with similar characteristics. Other factors affected the wastewater characteristics, but were not adequate in themselves to be used as bases for subcategorization.

3.3 SUBCATEGORY LISTING

Based on product type (discussed above), EPA established the following twenty-one (21) subcategories for the E&EC category:

Semiconductors
Electronic Crystals
Electron Tubes
Phosphorescent Coatings
Capacitors, Fixed
Capacitors, Fluid Filled
Carbon and Graphite Products
Mica Paper
Incandescent Lamps
Fluorescent Lamps
Fuel Cells
Magnetic Coatings
Resistors
Transformers, Dry
Transformers, Fluid Filled
Insulated Devices, Plastic and Plastic Laminated
Insulated Wire and Cable, Nonferrous
Ferrite Electronic Parts
Motors, Generators, and Alternators
Resistance Heaters
Switchgear

SECTION 4

DESCRIPTION OF THE INDUSTRY

This section provides a general description of the subcategories presented in the previous section. It includes a discussion of the number of plants and production capacity, product lines, and manufacturing processes including raw materials used. Industry descriptions for the regulated subcategories (Semiconductors and Electronic Crystals) are presented in considerable detail, while industry descriptions are abbreviated for subcategories which have been excluded or deferred from regulation.

4.1 SEMICONDUCTORS

4.1.1 Number of Plants and Production Capacity

It is estimated that approximately 257 plants are involved in the production of semiconductor products. This estimate comes from an August 1979 listing of plant locations compiled by the Semiconductor Industry Association. Seventy-seven of the plants are direct dischargers and one hundred and eighty are indirect dischargers. The U.S. Department of Commerce 1977 Census of Manufacturers estimates that 62,000 production employees are engaged in the manufacture of semiconductor products. Plants surveyed or visited during this study employ between 30 and 2500 production employees. The majority of plants employ between 150 and 500 production employees, with a typical plant having about 350 employees. Only 9 of the 52 plants in the data base have more than 500 production employees.

The total number of semiconductor products for the year 1978 was obtained from the Semiconductor Industry Association. During that year, 8.844 billion units were produced for a total revenue of $3.123 billion.

4.1.2 Products

Semiconductors are solid state electrical devices which perform a variety of functions in electronic circuits. These functions include information processing and display, power handling, data storage, signal conditioning, and the interconversion between light energy and electrical energy. The semiconductors range from the simple diode, commonly used as an alternating current rectifier, to the integrated circuit which may have the equivalent of 250,000 active components in a 0.635 cm (1/4 inch) square.

Semiconductors are used throughout the electronics industry. The major semiconductor products are:

- o Silicon based integrated circuits which include bipolar, MOS (metal oxide silicon), and digital and analog devices. Integrated circuits are used in a wide variety of commercial and consumer electronic equipment, calculators, electronic games and toys, and medical equipment.

- o Light emitting diodes (LED) which are produced from gallium arsenide and gallium phosphide wafers. These devices are commonly used as information displays in electronic games, watches, and calculators.

- o Diodes and transistors which are produced from silicon or germanium wafers. These devices are used as active components in electronic circuits which rectify, amplify, or condition electrical signals.

- o Liquid crystal display (LCD) devices which are produced from liquid crystals. These devices are primarily used for information displays as an alternative to LEDs.

4.1.3 Manufacturing Processes and Materials

The manufacturing processes and materials used for semiconductor production are described in the following paragraphs. Each type of semiconductor with its associated manufacturing operations is discussed separately because production processes differ depending on the basis material.

[redacted] (Figure 4-1 on page 4-3). These circuits require high purity single crystal silicon as a basis material. Most of the companies involved in silicon-based integrated circuit production purchase single crystal silicon ingots (cylindrical crystals which can be sliced into wafers), slices, or wafers from outside sources rather than grow their own crystals.

When the ingot is received it is sliced into round wafers approximately 0.76mm (0.030 inches) thick. These slices are then lapped or polished by means of a mechanical grinding machine or are chemically etched to provide a smooth surface and remove surface oxides and contaminants. Commonly used etch solutions are hydrofluoric acid or hydrofluoric-nitric acid mixtures. The presence of hydrofluoric acid is generally necessary because of the solubility characteristics of silicon and silicon oxide. Other acids such as sulfuric or nitric may be used depending on

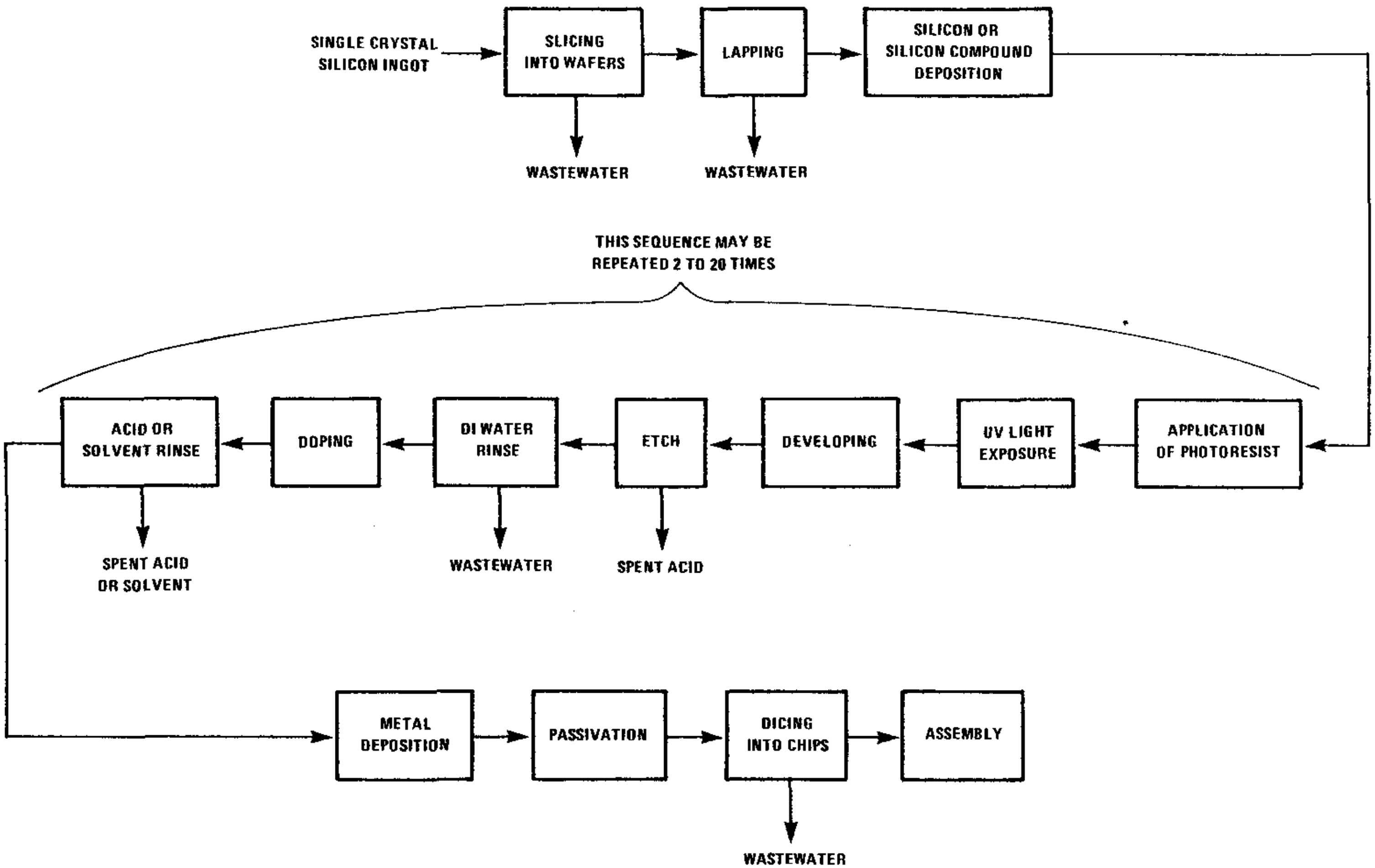

FIGURE 4-1. SILICON INTEGRATED CIRCUIT PRODUCTION

the nature of the material to be removed. Wastewater results from cooling the diamond tipped saws used for slicing, from spent etch solution, and from deionized (DI) water rinses following chemical etching and milling operations.

The next step in the process depends on the type of integrated circuit device being produced, but commonly involves the deposition or growth of a layer or layers of silicon dioxide, silicon nitride, or epitaxial silicon. For example, a silicon dioxide layer is commonly applied to bipolar devices, and an initial layer of silicon dioxide with the subsequent deposition of a silicon nitride layer is commonly applied to MOS devices.

The wafer is then coated with a photoresist, a photosensitive emulsion. The wafer is next exposed to ultraviolet light using glass photomasks that allow the light to strike only selected areas. After exposure to ultraviolet light, unexposed resist is removed from the wafer, usually in a DI water rinse. This allows selective etching of the wafer. The wafer is then visually inspected under a microscope and etched in a solution containing hydrofluoric acid (HF). The etchant produces depressions, called holes or windows, where the diffusion of dopants later occurs. Dopants are impurities such as boron, phosphorus and other specific metals. These impurities eventually form circuits through which electrical impulses can be transmitted. The wafer is then rinsed in an acid or solvent solution to remove the remainder of the hardened photoresist material.

Diffusion of dopants is generally a vapor phase process in which the dopant, in the form of a gas, is injected into a furnace containing the wafers. Gaseous phosphine and boron trifluoride are common sources for phosphorus and boron dopants, respectively. The gaseous compound breaks down into elemental phosphorus or boron on the hot wafer surface. Continued heating of the wafer allows diffusion of the dopant into the surface through the windows at controlled depths to form the electrical pathways within the wafer. Solid forms of the dopant may also be used. For example, boron oxide wafers can be introduced into the furnace in close proximity to the silicon wafers. The boron oxide sublimes and deposits boron on the surface of the wafer by condensation and then diffuses into the wafer upon continued heating.

Then a second oxide layer is grown on the wafer, and the process is repeated. This photolithographic-etching-diffusion-oxide process sequence may occur a number of times depending upon the application of the semiconductor.

During the photolithographic-etching-diffusion-oxide processes, the wafer may be cleaned many times in mild acid or alkali solutions followed by DI water rinses and solvent drying with acetone or isopropyl alcohol. This is necessary to maintain wafer cleanliness.

After the diffusion processes are completed, a layer of metal is deposited onto the surface of the wafer to provide contact points for final assembly. The metals used for this purpose include aluminum, copper, chromium, gold, nickel, platinum, and silver. The processes associated with the application of the metal layer are covered by regulations for the Metal Finishing Category. One of the following three processes is used to deposit this metal layer:

- Sputtering --
  In this process the source metal and the target wafer are electrically charged, as the cathode and anode, respectively, in a partially evacuated chamber. The electric field ionizes the gas in the chamber and these ions bombard the source metal cathode, ejecting metal which deposits on the wafer surface.

- Vacuum Deposition --
  In this process the source metal is heated in a high vacuum chamber by resistance or electron beam heating to the vaporization temperature. The vaporized metal condenses on the surface of the silicon wafer.

- Electroplating --
  In this process the source metal is electrochemically deposited on the target wafer by immersion in an electroplating solution and the application of an electrical current.

Finally, the wafer receives a protective oxide layer (passivation) coating before being back lapped to produce a wafer of the desired thickness. Then the individual chips are diced from the wafer and are assembled in lead frames for use. Many companies involved in semiconductor production send completed wafers to overseas facilities where dicing and assembly operations are less costly as a result of the amount of hand labor necessary to inspect and assemble finished products.

Light Emitting Diodes (LEDs) -- LEDs are produced from single crystal gallium arsenide or gallium phosphide wafers. These wafers are purchased from crystal growers and upon receipt are placed in a furnace where a silicon nitride layer is grown on the wafer. The wafer then receives a thin layer of photoresist, is exposed through a photomask, and is developed with a xylene-based developer. Following this, the wafer is etched using hydrofluoric acid or a plasma-gaseous-etch process, rinsed in DI water, and then stripped of resist. The wafer is again rinsed in DI water before a dopant is diffused into the surface of the wafer. A metal oxide covering is applied next, and then a photoresist is applied. The wafer is then masked, etched in a solution of aurostrip (a cyanide-containing chemical commonly used in gold stripping), and rinsed in DI water. The desired thickness is produced by backlapping and a layer of metal, usually gold, is sputtered onto the back of the wafer to provide electrical contacts. Testing and assembly complete the production process.

Diodes and Transistors -- Diodes and transistors are produced from single crystal silicon or germanium wafers. These devices, called discrete devices, are manufactured on a large scale, and their use is mainly in older or less sophisticated equipment designs, although discrete devices still play an important role in high power switching and amplification.

The single crystal wafer is cleaned in an acid or alkali solution, rinsed in DI water, and coated with a layer of photoresist. The wafer is then exposed and etched in a hydrofluoric acid solution. This is followed by rinsing in DI water, drying, and doping in diffusion furnaces where boron or phosphorus are diffused into specific areas on the surface of the wafer. The wafers are then diced into individual chips and sent to the assembly area. In the assembly area electrical contacts are attached to the appropriate areas and the device is sealed in rubber, glass, plastic, or ceramic material. Extra wires are attached and the device is inspected and prepared for shipment.

[redacted] -- A typical LCD production line begins with optically flat glass that is cut into four-inch squares. The squares are then cleaned in a solution containing ammonium hydroxide, immersed in a mild alkaline stripping solution, and rinsed in DI water. The plates are spun dry and sent to the photolithography area for further processing.

In the photolithographic process a photoresist mask is applied with a roller, and the square is exposed and developed. This square then goes through deionized water rinses and is dried, inspected, etched in an acid solution, and rinsed in DI water. A solvent drying step is followed by another alkaline stripping solution. The square then goes through DI water rinses, is spun dry, and is inspected.

The next step of the LCD production process is passivation. A silicon oxide layer is deposited on the glass by using liquid silicon dioxide, or by using silane and oxygen gas with phosphine gas as a dopant. This layer is used to keep harmful sodium ions on the glass away from the surface where they could alter the electronic characteristics of the device. Several production steps may occur here if it is necessary to rework the piece. These include immersion in an ammonium bifluoride bath to strip silicon oxide from a defective piece followed by DI water rinses and a spin dry step. The glass is then returned to the passivation area for reprocessing.

After passivation, the glass is screen printed with devitrified liquid glass in a matrix. Subsequent baking causes the devitrified glass to become vitrified, and the squares are cut into the patterns outlined by the vitrified glass boundaries. The saws used to cut the glass employ contact cooling water which is filtered and discharged to the waste treatment system.

The glass is then cleaned in an alkaline solution and rinsed in deionized water. Following inspection, a layer of silicon oxide is evaporated onto the surface to provide alignment for the liquid crystal. The two mirror-image pieces of glass are aligned and heated in a furnace, bonding the vitrified glass and creating a space between the two pieces of glass. This glass assembly is immersed in the liquid crystal solution in a vacuum chamber, air is evacuated, and the liquid crystal is forced into the space between the glass pieces. The glass is then sealed with epoxy, vapor-degreased in a solvent, shaped on a diamond wheel, inspected, and sent to assembly.

4.2 ELECTRONIC CRYSTALS

4.2.1 Number of Plants

Table 4-1 on page 4-8 presents an estimate of the number of producers of each type of crystal. Of plants manufacturing crystals at seventy sites, six are direct dischargers and sixty-four are indirect dischargers. The last fifteen years have seen an extremely rapid evolution of electronic technology. A major part of that evolution has been the development of single crystals with unique structural and electronic properties which serve as essential parts of most microelectronic devices. The production and use of gallium based crystals are expected to have a particularly rapid growth over the next decade. Gallium based crystals have certain advantages over silicon based crystals for semiconductor applications with respect to circuit speed, power consumption, and higher temperature capabilities. Consequently the crystals industry has served an expanding market with an ever-increasing list of products. Companies comprising the industry include not only those long-established, but also a large proportion founded comparatively recently by entrepreneurs. Of this latter group some companies have grown considerably, while others are very small. This growth in the number of companies is expected to continue.

TABLE 4-1

PROFILE OF ELECTRONIC CRYSTALS INDUSTRY

Product	Estimated No. of Producers[1]	Product	Estimated No. of Producers[1]
Piezoelectric Crystals:		Semi-conducting Crystals:	
Quartz	40	Silicon	8
Ceramics[2]	8	Gallium arsenide	8
YIG	3	Gallium phosphide	8
YAG	2	Sapphire	1
Lithium Niobate	3	GGG	3
		Indium arsenide	1
Liquid Crystals	2	Indium antimonide	1
		Bismuth telluride	1

(1)Several producers manufacture more than one product.
(2)Ceramics include lead zirconate, ammonium hydrogen phosphate, potassium hydrogen phosphate and lead zirconium titanate.

4.2.2 Products

Based on their properties and thus their uses in the industry, electronic crystals can be divided into three types: piezoelectric, semiconducting, and liquid crystals.

Piezoelectric Crystals -- Piezoelectric crystals are transducers which interconvert electrical voltage and mechanical force. There are three principal types: quartz, ceramic, and yttrium-iron-garnet (YIG), and some other less common types.

Quartz crystals are the most widely used of the piezoelectric crystals, with applications as timing devices in watches, clocks, and record players; freqency controllers, modulators, and demodulators in oscillators; and filters. Some quartz is mined, but the main supply comes from synthesized material produced by about forty companies in the United States.

Ceramic crystals are basically fired mixtures of the oxides of lead, zirconium, and titanium. They are used in transducers, oscillators,ultrasonic cleaners, phonograph cartridges, gas igniters, audible alarms, keyboard switches, and medical electronic equipment.

YIG crystals are made by the slow crystal growth of a melt of yttrium oxide, iron oxide, and lead oxide. Their primary use is in the microwave industry for low frequency applications as in sonar. Their incorporation into microwave circuits makes wide-band tuning possible.

Other potentially useful peizoelectric crystals being developed or manufactured on a small scale include lithium niobate, bismuth germanium oxide, and yttrium-aluminum-garnet (YAG).

Semiconducting Crystals -- Semiconducting crystals have properties intermediate between a conductor and an insulator, thus allowing for a wide range of applications in the field of microelectronics. In conductors, current is carried by electrons that travel freely throughout the atomic lattice of the substance. In insulators the electrons are tightly bound and are therefore unavailable to serve as carriers of electric current. Semiconductors do not ordinarily contain free charge carriers but generate them with a modest expenditure of energy.

Silicon crystals are widely used in the manufacture of micro-electronic chips: transistors, diodes, rectifiers, other circuit elements, and solar cells. Crystals of pure silicon are poor conductors of electricity. In order to make them better conductors, controlled amounts of impurity atoms are introduced into the crystal by a process called doping.

When silicon is doped with an element whose atoms contain more or fewer valence electrons than silicon, free electrons or electron "holes" are thus available to be mobilized when a voltage is applied to the crystal. Phosphorus and boron are common dopants used in silicon crystals.

Gallium arsenide and gallium phosphide crystals were developed under the need for a transistor material with good high temperature properties. These crystals exhibit low field electron mobility, and are therefore useful at high frequencies, in such devices as the field effect transistor (FET). The technology of manufacturing high performance gallium arsenide FET's is maturing at a rapid rate and the devices are experiencing a greatly expanding role in oscillators, power amplifiers, and low noise/high gain applications.

Most gallium arsenide/phosphide is presently being used for production of light emitting diodes (LEDs) which can convert electric energy into visible electromagnetic radiation. The interconversion of light energy and voltage in gallium arsenide is reversible. Hence this material is also undergoing intensive development as a solar cell, in which sunlight is converted directly to electricity.

Indium arsenide and indium antimonide crystals, formed by direct combination of the elements, are used as components of power measuring devices. These crystals are uniquely suited to this function because they demonstrate a phenomenon known as the Hall Effect, the development of a transverse electric field in a current-carrying conductor placed in a magnetic field.

Bismuth telluride crystals demonstrate a phenomenon known as thermoelectric cooling because of the Peltier Effect. When a current passes across a junction of dissimilar metals, one side is cooled and the other side heated. If the cold side of the junction is attached to a heat source, heat will be carried away to a place where it can be conveniently dissipated. Devices utilizing this effect are used to cool small components of electrical circuits.

Sapphire crystals are used by the semiconductor industry as single crystal wafers which act as inactive substrates for an epitaxial film of silicon, that is, substrates upon which a thin layer of silicon is deposited in a single-crystal configuration. This is referred to as silicon on sapphire (SOS). In addition to being a dielectric material, single crystal sapphire exhibits a combination of optical and physical properties which make it ideal for a variety of demanding optical applications. Sapphire, the hardest of the oxide crystals, maintains its strength at high temperatures, has good thermal and excellent electrical properties and is chemically inert. Therefore, it can be used in hostile environments when optical transmission ranging from vacuum ultraviolet to near infrared is required. Sapphire crystals have found application in semiconductor substrates, infrared detector cell windows, UV windows and optics, high power laser optics, and ultracentrifuge cell windows.

Gallium Gadolinium Garnet (GGG) is the most suitable substrate for magnetic garnet films because of its excellent chemical, mechanical, and thermal stability, nearly perfect material and surface quality, crystalline structure, and the commercial availability of large diameter substrates. GGG is the standard substrate material used for epitaxial growth of single crystal iron garnet films which are used in magnetic bubble domain technology.

Liquid Crystals -- Liquid crystals are organic compounds or mixtures of two or more organic compounds which exhibit properties of fluidity and molecular order simultaneously over a small temperature range. An electric field can disrupt the orderly arrangement of liquid crystal molecules, changing the refractive properties. This darkens the liquid enough to form visible characters in a display assembly, even though no light is generated. This affect is achieved by application of a voltage and does not require a current flow. Therefore minimal use of power is required, allowing the display in battery operated devices to be activated continuously. Liquid crystals are used in liquid crystal display (LCD) devices for wrist watches, calculators and other consumer products requiring a low power display.

4.2.3 Manufacturing Processes and Materials

Piezoelectric Crystals -- The following is a description of the manufacturing processes used for growth and fabrication of the three major piezoelectric crystal types: quartz, ceramic, and yttrium-iron-garnet (YIG).

Quartz Crystals:

The growth of quartz crystals is a hydrothermal process carried out in an autoclave under high temperature and pressure. The vessel is typically filled to 80 percent of the free volume with a solution of sodium hydroxide or sodium carbonate. Particles of α-quartz nutrient are placed in the lower portion of the vessel where they are dissolved. The quartz is then transferred by convection currents through the solution and deposited on seed crystals which are suspended in the upper portion of the vessel. Seeds are thin wafers or spears of quartz about six inches long. A vessel normally contains 20 seeds. Nutrient quartz will dissolve and deposit onto the seed crystals because a small temperature gradient exists between the lower and upper portion of the autoclave, promoting the migration of quartz to the upper portion of the vessel. Upon completion of the growth cycle (45 to 60 days), crystals are removed and cleaned for the fabrication process.

The quartz crystals are cut or sliced using diamond blade saws or slurry saws. Diamond blade saws are used when one wafer at a time is cut. Slurry saws are utilized in mass production lines for cutting many wafers at a time. The crystal wafers are then lapped to the desired thickness. After lapping, the crystal is usually etched with hydrofluoric acid or ammonium bifluoride and subsequently rinsed with water. Crystal edges are then beveled using either a dry grinding grit or a water slurry. Following this, metals are deposited on the crystal by vacuum deposition. The crystal wafers are mounted on a masking plate and placed in an evacuated bell jar. Metal strips in the jar are vaporized, coating the unmasked area of the wafer. The metal coating (gold, silver, or aluminum are often used) functions as the crystal's conducting base. The metal coating operation is covered by regulations for the Metal Finishing Category. During fine tune deposition, the crystal is allowed to resonate at a specified frequency and another thin layer of metal is deposited on it. Wire leads are attached to the crystal and it is sealed in a nitrogen atmosphere. At this point the crystal is ready for sale or insertion into an electronic circuit. Figure 4-2 on page 4-13 presents a diagram of the process indicating major waste generating operations.

Ceramic Crystals:

Ceramic crystal production begins by mixing lead oxide, zirconium oxide and titanium oxide powders plus small amounts of dopants to achieve desired specifications in the final product. The powders are mixed with water to obtain uniform blending, then filtration takes place and the waste slurry is sent to disposal. This mixture is roasted, ground wet, and blended with a binder (polyvinyl alcohol) in a tank called a blundger. The mixture is then spray dried, pressed, and fired to drive off the binder, which is not recovered. Formed crystals are enclosed in alumina and refired. After this final firing crystals are polished, lapped, and sliced as in quartz production. Electrodes, usually made of silver, are then attached to the crystals. Approximately ten percent of the crystals have electrodes deposited by electroless nickel plating. This plating operation is covered by regulations for the Metal Finishing Category. Poling, the final process step, gives the crystal its piezoelectric properties. This step is performed with the crystal immersed in a mineral oil bath. Some companies sell the used mineral oil to reclaimers. After poling the

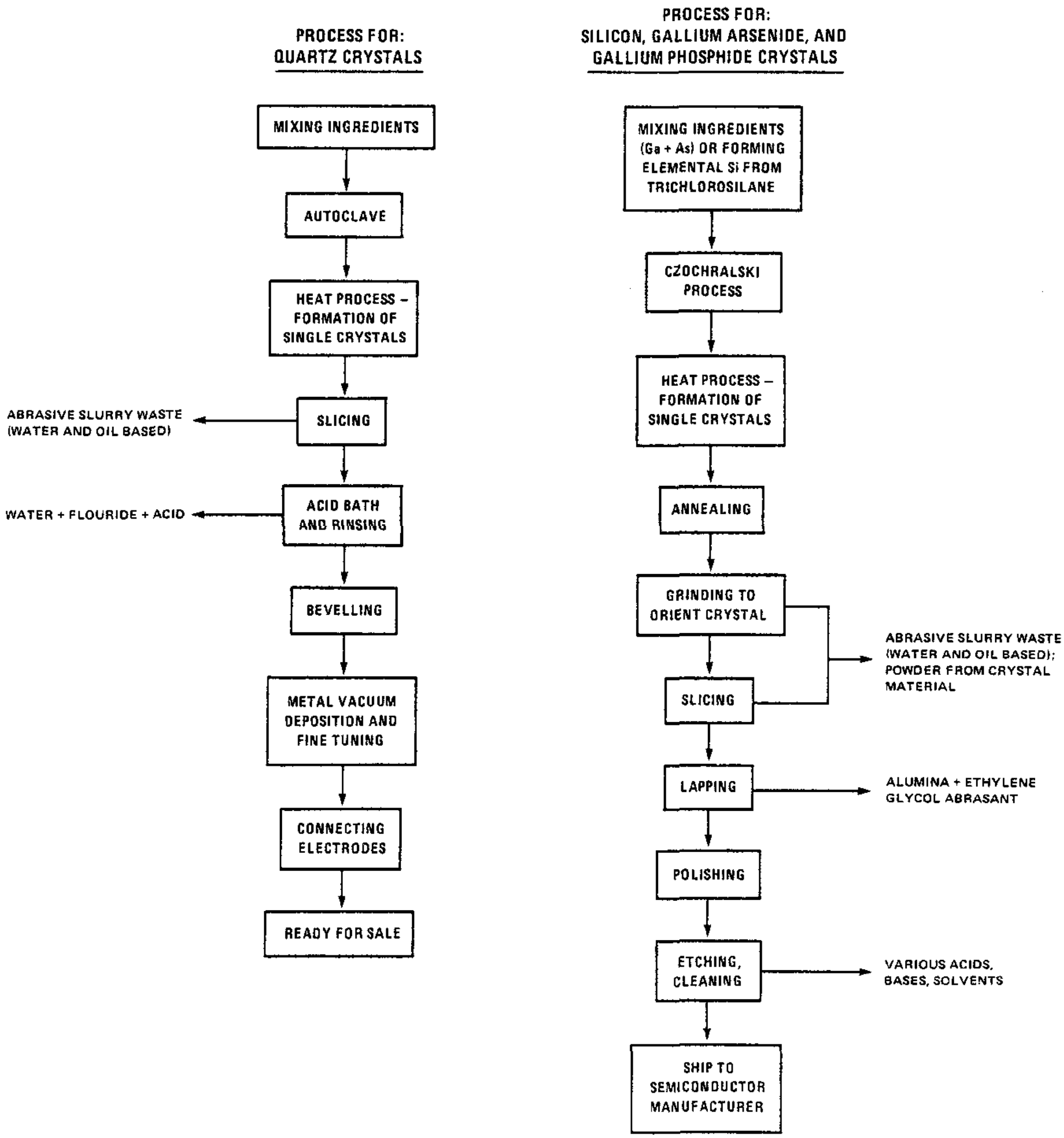

FIGURE 4-2. BASIC MANUFACTURING PROCESSES FOR ELECTRONIC CRYSTALS

crystal is ready for sale and use. Ceramic crystal production is very small.

Yttrium-Iron-Garnet (YIG) Crystals:

The production of YIG crystals involves the melting of metal compounds to form large single crystals which are processed to yield minute YIG spheres for use in microwave devices. Yttrium oxide, iron oxide and lead oxide powders are mixed, placed in a platinum crucible and melted in a furnace. After the melt equilibrates at this temperature the furnace is cooled, the slag is poured off, leaving the YIG crystals attached to the crucible. This growth process takes approximately 28 days. The crucible is soaked in hydrochloric and nitric acid to remove the crystals which are then sliced by a diamond blade saw to form cubes 0.04 inches on a side. These cubes are placed in a rounding machine, and the rounding process is followed by polishing to obtain perfectly spherical crystals for use in a microwave device.

The production of YIG and ceramic crystals with piezoelectric properties constitutes a minor portion of the piezoelectric crystal industry. The entire YIG production for the USA is less than fifteen pounds per year.

Semiconducting Crystals -- Several methods are currently in use for the production of semiconducting single crystals. An important method, the Czochralski, functions by lowering a seed crystal (a small single crystal) into a molten pool of the crystal material and raising the seed slowly (over a period of days) with constant slow rotation. Because the temperature of the melt is just above the melting point, material solidifies onto the seed crystal, maintaining the same crystal lattice. Crystals up to 6 inches in diameter and 4 feet long can be grown by this method. The Czochralski method is used to grow silicon, sapphire, GGG, and gallium arsenide.

Another method, called the Chalmers method,is used by some manufacturers to grow gallium arsenide crystals. If the molten material is contained in a horizontal boat and cooled slowly from one end, a solid/liquid interface will pass through the melt. Under controlled conditions or with the use of a seed crystal the solid will form as a single crystal.

Silicon Crystals:

The raw material used to produce silicon crystals is polycrystalline silicon. Reduction of purified trichlorosilane with hydrogen is the usual method for producing the high purity polycrystalline ("poly") silicon. Single crystals of silicon are then grown by the Czochralski method, the most common crystal growing technique for semiconductor crystals.

After a crystal has been grown, the outside diameter is ground to produce a crystalline rod of constant diameter. The ends are cut off and used to evaluate the quality of the crystal. At the same time, its orientation is determined and a flat is ground the length of the rod to fix its position. Rods are then sliced into wafers. Silicon dust and cutting oils mixed with water are waste products of the grinding and cutting operations.

Lapping is a machining operation using an alumina and ethylene glycol abrasive medium which produces a flat polished surface and reduces the thickness of the wafers. After lapping, the wafers are polished using a hydrated silica medium. The final cleaning is done with various acids, bases and solvents.

Sapphire and GGG Crystals:

To produce sapphire and gallium gadolinium garnet (GGG) crystals a raw material called crackle, (high purity alumina waste from a European gem crystal growing process) is melted in an iridium crucible. Sapphire is pure alumina. Gadolinium oxide and gallium oxide powders are added to the crucible if GGG is the desired product. These are melted using an induction furnace under a nitrogen atmosphere with a trace of oxygen added. Crystals are pulled from the melt using the Czochralski method.

These crystals are annealed in oxygen-gas furnaces after growth in order to remove internal stress and make the crystalline rods less brittle. Sapphire and GGG rods are ground and sliced using diamond abrasives and a coolant consisting of a mixture of oil and water. Wafers are lapped using a diamond abrasive compound and lubricants, and are polished with a colloidal silica slurry. GGG wafers are coated with a thin film using liquid-phase epitaxy. The film has small permanent magnetic domains, which make it useful for "magnetic bubble" memory devices. The sapphire wafers are coated with a layer of epitaxial silicon to produce the SOS substrates for microelectronic chip manufacture.

Other Semiconducting Crystals:

The formation of gallium arsenide, gallium phosphide, and indium bismuth telluride takes place by a chemical reaction which occurs in an enclosed capsule. When gallium arsenide or phosphide crystals are produced, the gallium, on one side of the capsule, is heated to more than 1200°C. The arsenic or phosphorus on the other side of the capsule is heated separately until it vaporizes. The vapor and hot metal react to form a molten compound. (In the case of phosphorus, high pressure is required.) The molten compound can then be crystallized in situ by the Chalmers technique or cooled and crystallized by the Czochralski method. These crystals undergo the fabrication operations mentioned earlier.

To produce indium antimonide, indium arsenide and bismuth telluride, the elements are mixed together, melted to form the compound and frozen into a polycrystalline ingot. These materials are used in a polycrystalline state so no crystal growing step occurs. The ingot is fabricated into wafers by normal machining operations. Because these materials are relatively soft, carbide abrasives with water cooling are sufficient for machining the ingots. The wafers are milled into small pieces and incorporated into electronic components.

Liquid Crystals -- Liquid crystals are produced by organic synthesis. Precursor organic compounds are mixed together and heated until the reacton is complete. The reacted mass is dissolved in an organic solvent such as toluene, and is crystallized and recrystallized several times to obtain a product of the desired purity. Several of these organic compounds are then mixed to form a eutectic mixture with the correct balance of properties for LCD application.

4.3 ELECTRON TUBES

Electron tubes are devices in which electrons or ions are conducted between electrodes through a vacuum or ionized gas within a gas-tight envelope which may be glass, quartz, ceramic, or metal. A large variety of electron tubes are manufactured, including klystrons, magnetrons, cross field amplifiers, and modulators. These products are used in aircraft and missile guidance systems, weather radar, and specialized industrial applications. The Electron Tube subcategory also includes cathode-ray tubes and T.V. picture tubes that transform electrical current into visual images. Cathode-ray tubes generate images by focusing electrons onto a luminescent screen in a pattern controlled by the electrical field applied to the tube. In T.V. picture tubes, a stream of high-velocity electrons scans a luminescent screen. Variations in the electrical impulses applied to the tube cause changes in the intensity of the electron stream and generate the image on the screen.

Processes involved in the manufacture of electron tubes include degreasing of components; application of photoresist, graphite, and phosphors to glass panels; and sometimes electroplating operations including etching and machining. The application of phosphors is unique to T.V. picture tubes and other cathode-ray tubes. The phosphor materials may include sulphides of cadmium and zinc and yttrium and europium oxides. The electroplating operations are covered under the Metal Finishing Category. Raw materials can include copper and steel as basis materials, and copper, nickel, silver, gold, rhodium and chromium to be electroplated. Phosphors, graphite, and protective coatings containing toluene or silicates and solders of lead oxide may also be used. Process chemicals may include hydrofluoric, hydrochloric, sulfuric, and nitric acids for cleaning and conditioning of metal parts; and solvents such as methylene chloride, trichloroethylene, methanol, acetone, and polyvinyl alcohol.

4.4 PHOSPHORESCENT COATINGS

Phosphorescent coatings are coatings of certain chemicals, such as calcium halophosphate and activated zinc sulfide, which emit light. Phosphorescent coatings are used for a variety of applications, including fluorescent lamps, high-pressure mercury vapor lamps, cathode ray and television tubes, lasers, instrument panels, postage stamps, laundry whiteners, and specialty paints. This study is restricted to those coatings which are applicable to the E&EC category, specifically to those used in fluorescent lamps and television picture tubes. The most important fluorescent lamp coating is calcium halophosphate phosphor. The intermediate powders are calcium phosphate and calcium fluoride. There are three T.V. powders: red, blue, and green. The red phosphor is yttrium oxide activated with europium; the blue phosphor is zinc sulfide activated with silver, and the green phosphor is zinc-cadmium sulfide activated with copper. The major process steps in producing phosphorescent coatings are reacting, milling, and firing the raw materials; recrystallizing raw materials, if necessary; and washing, filtering, and drying the intermediate and final products.

4.5 CAPACITORS, FIXED

The primary function of capacitors is to store electrical energy. Fixed capacitors are layered structures of conductive and dielectric materials. The layering of fixed capacitors is either in the form of rigid plates or in the form of thin sheets of flexible material which are rolled. Typical capacitor applications are energy storage elements, protective devices, filtering devices, and bypass devices. Some typical processes in manufacturing fixed capacitors are anode fabrication, formation reactions, dipping, layering, cathode preparation, welding, and electrical evaluation. All manufacturing processes are covered under the Metal Finishing category by unit operation. Fixed capacitor types are distinguished from each other by type of conducting material, dielectric material, and encapsulating material.

4.6 CAPACITORS, FLUID FILLED

As with fixed capacitors, the primary function of fluid-filled capacitors is to store electrical energy. Wet capactitors contain a fluid dielectric that separates the anode (in the center of the device) from the cathode (the capacitor shell), which also serves to contain the fluid. Fluid-filled capacitors are used for industrial applications as electrical storage, filtering, and circuit protection devices. Some typical processes in manufacturing fluid-filled capacitors are anode fabrication, formation reactions, metal can preparation, dielectric addition, soldering, and electrical evaluation. All manufacturing processes are covered under the Metal Finishing category by unit operation.

4.7 CARBON AND GRAPHITE PRODUCTS

Carbon and graphite (elemental carbon in amorphous crystalline form) products exhibit unique electrical, thermal, physical, and nuclear properties. The major carbon and graphite product areas are (1) carbon electrodes for aluminum smelting and graphite furnace electrodes for steel production, (2) graphite molds and crucibles for metallurgical applications, (3) graphite anodes for electrolytic cells used for production of such materials as caustic soda, chlorine, potash, and sodium chlorate, (4) non-electrical uses such as structural, refractory, and nuclear applications, (5) carbon and graphite brushes, contacts, and other products for electrical applications, and (6) carbon and graphite specialties such as jigs, fixtures, battery carbons, seals, rings, and rods for electric arc lighting, welding, and metal coating. The production process starts with weighing the required quantities of calcined carbon filler, binders, and additives; combining them as a batch in a heated mixer; and then forming the resulting "green" mixture by compression molding or by extrusion. Green bodies are carefully packed and baked for several weeks. After baking, the items are machined into final shape.

4.8 MICA PAPER

Mica paper is a dielectric (non-conducting) material used in the manufacture of fixed capacitors. Mica paper is manufactured in the following manner: Mica is heated in a kiln and then placed in a grinder where water is added. The resulting slurry is passed to a double screen separator where undersized and oversized particles are separated. The screened slurry flows to a mixing pit and then to a vortex cleaner. The properly-sized slurry is processed in a paper-making machine where excess water is drained or evaporated. The resulting cast sheet of mica paper is fed on a continuous roller to a radiant heat drying oven, where it is cured. From there, the mica paper is wound onto rolls, inspected, and shipped.

4.9 INCANDESCENT LAMPS

An incandescent lamp is an electrical device that emits light. Incandescent tungsten filament lamps operate by passage of an electric current through a conductor (the filament). Heat is produced in this process, and light is emitted if the temperature reaches approximately 500°C. Most lamp-making operations are highly automated. The mount machine assembles a glass flare, an exhaust tube, lead-in wires, and molybdenum filament support. A glass bulb is electrostatically coated with silica and the bulb and mount are connected at the exhaust and seal machine. The bulb assembly is annealed, exhausted, filled with an inert gas, and sealed with a natural gas flame. The finishing machine solders the lead wires to the metallic base which is then attached to the bulb assembly by a phenolic resin cement or by a mechanical crimping operation. The finished lamp is aged and tested by illuminating it with excess current for a period of time to stabilize its electrical characteristics.

4.10 FLUORESCENT LAMPS

A fluorescent lamp is an electrical device that emits light by electrical excitation of phosphors that are coated on the inside surface of the lamp. Fluorescent lamps utilize a low pressure mercury arc in argon. Through this process, the lowest excited state of mercury efficiently produces short wave ultraviolet radiation at 2,537 Angstroms. Phosphor materials that are commonly used are calcium halophosphate and magnesium tungstate, which absorb the ultraviolet photons into their crystalline structure and re-emit them as visible white light.

There are two types of fluorescent lamps: hot cathode and cold cathode. Cold cathode manufacture is primarily an electroplating operation. Hot cathode fluorescent lamp manufacturing is a highly automated process. Glass tubing is rinsed with deionized water and gravity-coated with phosphor. Coiled tungsten filaments are assembled together with lead wires, an exhaust tube, a glass flare, and a starting device to produce a mount assembly. The mount assemblies are heat pressed to the two ends of the glass tubing. The glass tubes are exhausted and filled with an inert gas. The lead wires are soldered to the base and the base is attached to the tube ends. The finished lamp receives a silicone coating solution. The lamp is then aged and tested before shipment.

4.11 FUEL CELLS

Fuel cells are electrochemical generators in which the chemical energy from a reaction of air (oxygen) and a conventional fuel is converted directly into electricity. The major fuel cell products, basically in research and development stages, are: (1) fuel cells for military applications, (2) fuel cells for power supply to vehicles, (3) fuel cells used as high power sources, and (4) low temperature and low pressure fuel cells with carbon electrodes. Some typical processes in the manufacture of fuel cells are extrusion or machining, heat treating, sintering, molding, testing, and assembling. Some typical raw materials are base carbon or graphite, plastics, resins, and Teflon.

4.12 MAGNETIC COATINGS

Magnetic coatings are applied to tapes to allow the recording of information. Magnetic tapes are used primarily for audio, video, computer, and instrument recording. The process begins with milling to create sub-micron magnetic particles. Ferric oxide particles are used almost exclusively with trace additions of other particles or alloys for specific applications. The particles are mixed, through several steps, with a variety of solvents, resins, and other additives. The coating mix is then applied to a flexible tape or film material (for example, cellulose acetate). After the coating mix is applied, particles are magnetically oriented by passing the tape through a magnetic field, and the tape is dried and slit for testing and sale.

4.13 RESISTORS

Resistors are devices commonly used as components of electric circuits to limit current flow or to provide a voltage drop. Resistors are used for television, radios, and other applications. Resistors can be made from various materials. Nickel-chrome alloys, titanium, and other resistive materials can be vacuum-deposited for thin film resistors. Glass resistors are also available for many resistor applications. Two examples of glass resistors are the precision resistor and the low power resistor.

4.14 TRANSFORMERS, DRY

A transformer is a stationary apparatus for converting electrical energy at one alternating voltage into electrical energy at another (usually different) alternating voltage by means of magnetic coupling (without change of frequency). Dry transformers use standard metal working and metal finishing processes (covered by the Metal Finishing category). The main operations in manufacturing a power transformer are the manufacture of a steel core, the winding of coils, and the assembly of the coil/core on some kind of frame or support.

4.15 TRANSFORMERS, FLUID FILLED

Wet transformers perform the same functions as dry transformers, but the former are filled with dielectric fluid. Wet tranformers use standard metal working and metal finishing processes which are covered by the Metal Finishing category. The only wet process unique to E&EC are the cleanup and management of residual dielectric fluid. The main operations in manufacturing a power transformer are the manufacture of a steel core, the winding of coils, and the assembly of the coil/core on some kind of frame or support. In the manufacture of wet transformers there is the need for a container or tank to contain the dielectric fluid.

4.16 INSULATED DEVICES, PLASTIC AND PLASTIC LAMINATED

An insulated device is a device that prevents the conductance of electricity (dielectric). Plastic and plastic laminates are types of insulators. Plastics are used in electronic applications as connectors and terminal boards. Other uses include switch bases, gears, cams, lenses, connectors, plugs, stand-off insulators, knobs, handles, and wire ties. Thermosetting plastics are melted and injected into a closed mold where they solidify. These insulating moldings include polyethylene, polyphenylene, and poly vinyl chloride. Laminates are used in transformer terminal boards, switchgear arc chutes, motor and generator slot wedges, motor bearings, structural support, and spacers. Laminates are made by bonding layers of a reinforcing web. The reinforcements consist of fiberglass, paper, fabrics, or synthetic fibers. The bonding resins are usually phenolic, melamine, polyester, epoxy, and silicone. Laminates are made by impregnating the reinforcing webs in treating towers, partially polymerizing, pressing and finally polymerizing them to shape under heat and pressure. Manufacturing processes associated with these products are studied as part of the Plastics Molding and Forming category.

4.17 INSULATED WIRE AND CABLE, NON-FERROUS

Insulated wires and cables are products containing a conductor covered with a non-conductive material to eliminate shock hazard. The major products in this segment are: (1) insulated non-ferrous wire, (2) auto wiring systems, (3) magnetic wire, (4) bulk cable appliances, and (5) camouflage netting. Typical processes used in the manufacture of insulated wire and cable are drawing, spot welding, heat treating, forming, and assembling. All manufacturing processes are included in the Metal Finishing category. Some of the basis materials are copper, carbon, stainless steel, steel, brass-bronze, and aluminum.

4.18 FERRITE ELECTRONIC PARTS

Ferrite electronic parts are electronic products utilizing metallic oxides. The metallic oxides have ferromagnetic properties that offer high resistance, making current losses extremely low at high frequencies. Ferrite electronic products include: (1) magnetic recording tape, (2) magnetic tape transport heads, (3) electronic and aircraft instruments, (4) microwave connectors and components, and (5) electronic digital equipment. Some typical processes to manufacture ferrite electronic parts are shearing, slitting, fabrication and machining. All production processes in this segment are included in the Metal Finishing category. Some typical raw materials are aluminum, magnesium, bronze, and brass.

4.19 MOTORS, GENERATORS, AND ALTERNATORS

Motors are devices that convert electric energy into mechanical energy. Generators are devices which convert an input mechanical energy into electrical energy. Alternators are devices that convert mechanical energy into electrical energy in the form of an alternating current. The major motor, generator, and alternator products are: (1) variable speed drives and gear motors, (2) fractional horsepower motors, (3) hermetic motor parts, (4) appliance motors, (5) special purpose electric motors, (6) electrical equipment for internal combustion engines, and (7) automobile electrical parts. Some typical processes are casting, stamping, blanking, drawing, welding, heat treating, assembling and machining. All production processes are included in the Metal Finishing category. Some basis materials are carbon steel, copper, aluminum and iron. These materials are used as sheet metal, rods, bars, strips, coils, casting, and tubing.

4.20 RESISTANCE HEATERS

Resistance heaters convert electrical energy into usable heat energy. Three types of resistance heaters are made; rigid encased elements used for electric stoves and ovens, bare wire heaters used in toasters and hair dryers, and insulated flexible heater wire that is incorporated into blankets and heating pads. Some typical processes used in the manufacture of resistance heaters are plating, welding or soldering, molding, and machining. These processes are included in the Metal Finishing category. Some raw materials used are steel, nickel, copper, plastic, and rubber.

4.21 SWITCHGEAR

Switchgear are products used to control electrical flow and to protect equipment from electrical power surges and short circuits. The major switchgear products are: (1) electrical power distribution controls and metering panel assemblies, (2) circuit breakers, (3) relays, (4) switches, and (5) fuses. Some typical manufacturing processes are: chemical milling, grinding, electroplating, soldering or welding, machining and assembly. All processes are included in the Metal Finishing and Plastics Processing categories. Some typical basis materials are plastic, steel, copper, brass, and aluminum.

SECTION 5

WASTEWATER CHARACTERISTICS

This section presents information related to wastewater flows, wastewater sources, pollutants found, and the sources of these pollutants. For subcategories which are excluded or deferred, the discussion of wastewater characteristics is abbreviated. A general discussion of sampling techniques and wastewater analysis is also provided.

5.1 SAMPLING AND ANALYTICAL PROGRAM

More than 250 plants were contacted to obtain data on the E&EC Category. Seventy-eight of these plants were visited for an on-site study of their manufacturing processes, water used and wastewater treatment. In addition, wastewater samples were collected at thirty-eight of the plants visited in order to quantitate the level of pollutants in the waste streams. Sampling was utilized to determine the source and quantity of pollutants in the raw process wastewater and the treated effluent from a cross-section of plants in the E&EC Category.

5.1.1 Pollutants Analyzed

The chemical pollutants sought in analytical procedures fall into three groups: Conventional, non-conventional, and toxics. The latter group comprises the 129 chemicals found in the priority pollutant list shown in Table 5-1 (p. 5-11).

Conventional pollutants are those generally treatable by secondary municipal wastewater treatment. The conventional pollutants examined for this study are:

pH
Biochemical Oxygen Demand (BOD)
Oil and Grease (O&G)
Total Suspended Solids (TSS)

Non-conventional pollutants are simply those which are neither conventional nor on the list of toxic pollutants. The non-conventional pollutants listed on page 5-2 were examined in one or more subcategories of the E&EC industry.

Bismuth	Magnanese
Europium	Vanadium
Fluoride	Boron
Gadolinium	Barium
Gallium	Molybdenum
Indium	Tin
Lithium	Cobalt
Niobium	Iron
Tellurium	Titanium
Total Organic Carbon	Xylenes
Total Phenols	Alkyl Epoxides
Yttrium	Platinum
Calcium	Palladium
Magnesium	Gold
Aluminum	

5.1.2 Sampling Methodology

During the initial visit to a facility, a selection was made of sampling points so as to best characterize process wastes and evaluate the efficiency of any wastewater treatment. The nature of the wastewater flow at each selected sampling point then determined the method of sampling, i.e., automatic composite or grab composite. The sampling points were of individual raw waste streams, or treated effluent.

Each sample was collected whenever possible by an automatic time series compositor over a single 24-hour sampling period. When automatic compositing was not possible, grab samples were taken at intervals over the same period, and were composited manually. When a sample was taken for analysis of toxic organics, a blank was also taken to determine the level of contamination inherent to the sampling and transportation procedures.

Each sample was divided into several portions and preserved, when necessary, in accordance with established procedures for the measurement of toxic and classical pollutants. Samples were shipped in ice-cooled containers by the best available route to EPA-contracted laboratories for analysis. Chain of custody for the samples was maintained through the EPA Sample Control Center tracking forms.

5.1.3 Analytical Methods

The analytical techniques for the identification and quantitation of toxic pollutants were those described in Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants, revised in April 1977.

In the laboratory, samples for organic pollutant analysis were separated by specific extraction procedures into acid (A), base/neutral (B/N), and pesticide (P) fractions. Volatile organic samples (V) were taken separately as a series of grab samples at four-hour intervals and composited in the laboratory. The analysis of these fractions included the application of strict quality control techniques including the use of standards, blanks, and spikes. Gas chromatography and gas chromatography/mass spectrometry were the analytical procedures used for the organic pollutants. Two other analytical methods were used for the measurement of toxic metals: Flameless atomic absorption and inductively coupled argon plasma spectrometric analysis (ICAP). The metals determined by each method were:

Flameless AA	ICAP
Antimony	Beryllium
Arsenic	Cadmium
Selenium	Chromium
Silver	Copper
Thallium	Lead
	Nickel
	Zinc

Mercury was analyzed by a special manual cold-vapor atomic absorption technique.

For the analysis of conventional and non-conventional pollutants, procedures described by EPA were followed. The following conventions were used in quantifying the levels determined by analysis:

- Pollutants detected at levels below the quantitation limit are reported as "less than" (<) the quantitation limit. All other pollutants are reported as the measured value.

- Sample Blanks - Blank samples of organic-free distilled water were placed adjacent to sampling points to detect airborne contamination of water samples. These sample blank data are not subtracted from the analysis results, but, rather, are shown as a (B) next to the pollutant found in both the sample and the blank. The tables show data for total toxic organics, toxic and non-toxic metals, and other pollutants.

- Blank Entries - Entries were left blank when the parameter was not detected.

5.2 SEMICONDUCTORS

5.2.1 Wastewater Flows

Table 5-2 presents a summary of the quantities of wastewater generated by the Semiconductor subcategory.

TABLE 5-2

SEMICONDUCTOR SUBCATEGORY

PROCESS WASTEWATER FLOW:

Maximum 1/day (gal/day)	Minimum 1/day (gal/day)	Average 1/day (gal/day)
11,100,000 (2,940,000)	212,000 (56,000)	594,000 (157,000)

CONCENTRATED FLUORIDE WASTEWATER FLOW:

Maximum 1/day (gal/day)	Minimum 1/day (gal/day)	Average 1/day (gal/day)
5,450 (1,440)	95 (25)	678 (179)

Total Subcategory Process Water Use = 193,000,000 liters/day (51,000,000 gal/day)

5.2.2 Wastewater Sources

Contact water is used throughout the production of semiconductors. Plant incoming water is first pretreated by deionization to provide ultrapure water for processing steps. This ultrapure water or deionized (DI) water is used to formulate acids; to rinse wafers after processing steps; to provide a medium for collecting exhaust gases from diffusion furnaces, solvents, and acid baths; and to clean equipment and materials used in semiconductor production. Water also cools and lubricates the diamond saws and grinding machines used to slice, lap, and dice wafers during processing.

5.2.3 Pollutants Found and Sources of These Pollutants

The major pollutants found at facilities in the Semiconductor subcategory are as follows:

Fluoride
Toxic Organics
pH

The process steps associated with the sources of these pollutants are described in Section 4.1.3 (p. 4-2). Table 5-3 (p. 5-13) summarizes pollutant concentration data for the sampled raw waste streams. Tables 5-4 through 5-15 (pages 5-15 through 5-73) present the analytical data for twelve sampled plants in the Semiconductor subcategory.

Fluoride -- The source of fluoride is hydrofluoric acid, which is used as an etchant and a cleaner. Certain areas of the basis material are etched to provide surfaces receptive to the entry of dopants that are subsequently added to the wafer. The major source of fluoride comes from the discharge of spent hydrofluoric acid after its use in etching. (The flows of this waste steam are shown in Table 5-2.) Minor quantities of fluoride enter the plant wastewater from rinses of etched or cleaned wafers.

Toxic organics -- The sources of toxic organics are solvents used for drying the wafer after rinsing, developing of photoresist, stripping of photoresist, and cleaning. These solvents may include acetone, methanol, isopropyl alcohol, 1,1,1-trichloroethane and trichloroethylene. While residual amounts of solvents in wastewaters come from solvent rinses, their primary sources are the dumping of solvent baths. This is indicated by Table 5-16 (p. 5-74) which presents data from individual process streams and associated effluent streams at several semiconductor facilities. Concentrations of residual toxic organics in these streams range from <0.01 milligrams per liter to 0.10 milligrams per liter while the effluent streams sampled at the same plants contain toxic organic concentrations ranging from 1.613 milligrams per liter to 245.3 milligrams per liter. If total toxic organic concentrations in the effluent streams were caused by dragout on the wafer and the carrier boat (i.e., process rinse streams), the value for total toxic organics in these streams would be much higher. Because this is not the case, toxic organics must be entering the effluent stream from direct discharge of solvents.

pH -- This parameter may be very high or very low. High pH results from the use of alkalis for caustic cleaning. Low pH results from the use of acids for etching and cleaning.

Several toxic metals were found in the wastewater because of electroplating operations associated with semiconductor manufacture. These metals are chromium, copper, nickel and lead, and are regulated under the Metal Finishing Category.

5.3 ELECTRONIC CRYSTALS

5.3.1 Wastewater Flows

The following table (5-17) contains a summary of the wastewater flows generated in the Electronic Crystals subcategory.

TABLE 5-17

SUMMARY OF WASTEWATER QUANTITIES GENERATED IN THE ELECTRONIC CRYSTALS SUBCATEGORY

	No. of Plants	Wastewater Discharge Min	Max	Liters/day Mean
All Plants	49	95	1,839,800	112,400

5.3.2 Wastewater Sources

The major source of wastewater from the manufacture of electronic crystals is from rinses associated with crystal fabrication, although some wastewater may be generated from crystal growing operations. Fabrication steps generating wastewater are slicing, lapping, grinding, polishing, etching, and cleaning of grown crystals. Certain growth processees generate a large volume of wastewater from the discharge of spent solutions of sodium hydroxide and sodium carbonate after each crystal growth cycle.

5.3.3 Pollutants Found and the Sources of These Pollutants

The major pollutants of concern from the Electronic Crystals subcategory are:

Toxic Organics
Fluoride
Arsenic
TSS
pH

The process steps associated with the sources of these pollutants are described in Section 4.2.3 on page 4-10. Table 5-18 (p. 5-75) summarizes the occurrence and levels at which these pollutants are found based on the sampling and analysis of raw wastes from eight crystals facilities. Concentrations represent total raw wastes after flow-proportioning individual discharge streams. Tables 5-19 through 5-26 (p. 5-76 through p. 5-83), summarize the analytical data obtained frome each of the plants sampled and identify products produced and wastewater flows.

Toxic organics -- found in wastewater from the manufacture of electronic crystals as a result of the use of solvents such as isopropyl alcohol, 1,1,1-trichloroethane, Freon, and acetone. These materials are used for cleaning, degreasing, and drying of crystals. High concentrations of these toxic organics in waste streams are the result of uncontrolled dumping of solvent rinse tanks. Another source of toxic organics could be contaminants in oils used as lubricants in slicing and grinding operations.

Fluoride -- has as its source the use of hydrofluoric acid or ammonium bifluoride for etching electronic crystals. A minor source of fluoride is from the etch rinse process.

Arsenic -- originates from the gallium arsenide and indium arsenide used as raw material for crystals. Process steps generating wastewater containing arsenic are cleaning of the crystal-growing equipment, slicing and grinding operations, and etching and rinsing steps.

Total Suspended Solids -- common in crystals manufacturing waste streams as crystal grit from slicing and grinding operations. Grit and abrasives wastes are also generated by grinding and lapping operations.

pH -- may be very high or very low. High pH results from the presence of excess alkali such as sodium hydroxide or sodium carbonate. The alkali may come from crystal growth processes or from caustic cleaning and rinsing. Low pH results from the use of acid for etching and cleaning operations.

Several toxic metals were found in the wastewater because of electroplating operations associated with electronic crystals manufacture. These metals are chromium, copper, lead, nickel, and zinc, and are regulated under the Metal Finishing Category.

5.4 CARBON AND GRAPHITE PRODUCTS

The average flow of wastewater from these plants is 24.2 x 10^6 l/day (6,388,400 gal/day). The major pollutants found and their concentrations are presented below:

Toxic Pollutants

Pollutant	Raw Waste Load Concentration (mg/l)	Raw Waste Load kg/day (lbs/day)
Total Toxic Inorganics	0.080	1.93 (4.26)
Bis(2-ethylhexyl)phthalate	0.042	1.02 (2.24)
Methylene Chloride	0.013	0.31 (0.69)
Total Toxic Organics	0.080	1.93 (4.26)

Raw waste concentrations are based on flow weighted means from four plants. For toxic inorganics only flow weighted mean concentrations greater than or equal to 0.1 mg/l are shown. For toxic organics only flow weighted mean concentrations greater or equal to 0.01 mg/l are shown.

5.5 MICA PAPER

The average flow of wastewater from these plants is 3.50 x 10^6 l/day (926,000 gal/day). The major pollutants found and their concentrations are presented below:

Toxic Pollutants

Pollutant	Raw Waste Load Concentration (mg/l)	Raw Waste Load kg/day	(lbs/day)
Total Toxic Inorganics	0.055	0.20	(0.44)
1,1,1-Trichloroethane	0.180*	0.63	(1.39)
Methylene Chloride	0.029*	0.10	(0.22)
Total Toxic Organics	0.209	0.73	(1.61)

*Not confirmed by process or raw material usage.

Raw waste concentrations are based on raw waste data from one plant. For toxic organics only concentrations greater than or equal to 0.01 mg/l are shown.

5.6 INCANDESCENT LAMPS

The average flow of wastewater from these plants is 7.74 x 10^6 l/day (540,100 gal/day). The major pollutants found and their concentrations are described below:

Toxic Pollutants

Pollutant	Raw Waste Load Concentration (mg/l)	Raw Waste Load kg/day	(lbs/day)
Chromium	0.714	1.46	(3.22)
Copper	0.420	0.86	(1.89)
Lead	0.11	0.23	(0.50)
Total Toxic Inorganics	1.377	2.82	(6.21)
Methylene Chloride	0.048	0.05	(0.11)
Chloroform	0.024	0.10	(0.22)
Dichlorobromomethane	0.010	0.03	(0.05)
Total Toxic Organics	0.082	0.17	(0.38)

Raw waste concentrations are based on flow weighted means from three plants. For toxic inorganics only flow weighted mean concentrations greater than or equal to 0.1 mg/l are shown. For toxic organics only flow weighted mean concentrations greater than or equal to 0.01 mg/l are shown.

5.7 FLUORESCENT LAMPS

The major pollutants found in wastewaters from these plants and their concentrations or mass loadings are presented below:

Toxic Pollutants

Pollutant	Raw Waste Load Concentration (mg/l)	Raw Waste Load kg/day	(lbs/day)
Antimony	0.458	--	--
Cadmium	0.307	--	--
Total Toxic Inorganics	--	0.80	(1.76)
Methylene Chloride	0.063	--	--
Toluene	0.011	--	--
Total Toxic Organics	--	0.07	(0.16)

5.8 FUEL CELLS

Only a few plants manufacture fuel cells and these do not do so on a regular basis. In addition, all pollutants found were at quantities too low to be effectively treated.

5.9 MAGNETIC COATINGS

This subcategory discharges only a small amount of pollutants to water. The average wastewater discharge from this subcategory is 19,000 l/day (5,000 gal/day). The total toxic metals discharge for the subcategory is 0.045 kg/day (0.099 lbs/day), total toxic organics is 0.018 kg/day (0.040 lbs/day).

5.10 RESISTORS

No wastewaters result from the manufacture of resistors.

5.11 DRY TRANSFORMERS

No wastewaters result from the manufacture of dry transformers.

5.12 ELECTRON TUBES

The Agency has insufficient information to adequately characterize pollutants from this subcategory. Preliminary data indicate that wastewater flows from plants manufacturing cathode ray and T.V. picture tubes are in the range of 200,000 to 500,000 liters/day and that the major pollutants are fluoride and lead.

5.13 PHOSPHORESCENT COATINGS

Data presently available to the Agency are insufficient to adequately characterize the wastewater discharges for the Phosphorescent Coatings subcategory. Preliminary data indicate that wastewater flows from these plants range from 100,000 to 700,000 liters (30,000 to 200,000 gallons) per day; and the major pollutants are suspended solids, fluoride, cadmium, and zinc.

5.14 ALL OTHER SUBCATEGORIES

Information obtained from plant visits showed that wastewater discharges in the following subcategories result primarily from processes associated with metal finishing and, in the case of insulated plastic and plastic-laminated devices, from processes associated with the EPA study on plastics molding and forming. Because these processes are studied elsewhere, the E&EC project limited its sampling effort in these areas:

- Switchgear and Fuses
- Resistance Heaters
- Ferrite Electronic Parts
- Insulated Wire and Cable
- Fluid-filled Capacitors
- Fluid-filled Transformers
- Insulated Devices -- Plastics and Plastic Laminated
- Motors, Generators, and Alternators
- Fixed Capacitors

TABLE 5-1
THE PRIORITY POLLUTANTS

TOXIC POLLUTANT

1. Acenaphthene
2. Acrolein
3. Acrylonitrile
4. Benzene
5. Benzidine
6. Carbon Tetrachloride (Tetrachloromethane)
7. Chlorobenzene
8. 1,2,4-Trichlorobenzene
9. Hexachlorobenzene
10. 1,2-Dichlorethane
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. p-Chloro-m-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-Dimethyl Phenol
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)
47. Bromoform (Tribromomethane)
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. 1,2-Benzanthracene [Benzo(a)anthracene]
73. Benzo(a)Pyrene (3,4-Benzopyrene)
74. 3,4-Benzofluoranthene [Benzo(b)fluoranthene]
75. 11,12-Benzofluoranthene [Benzo(k)fluoranthene]
76. Chrysene
77. Acenaphthylene
78. Anthracene
79. 1,12-Benzoperylene [Benzo(ghi)perylene]
80. Fluorene
81. Phenanthrene
82. 1,2,5,6-Dibenzathracene [Dibenzo(a,h)anthracene]
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

TABLE 5-1 (continued)

91. Chlordane (Technical Mixture and Metabolites)
92. 4,4'-DDT
93. 4,4'-DDE(P,P'-DDX)
94. 4,4'-DDD(P,P'-TDE)
95. Alpha-Endosulfan
96. Beta-Endosulfan
97. Endosulfan Sulfate
98. Endrin
99. Endrin Aldehyde
100. Heptachlor
101. Heptachlor Epoxide(BHC-Hexachloro-cyclohexane)
102. Alpha-BHC
103. Beta-BHC
104. Gamma-BHC(Lindane)
105. Delta-BHC
106. PCB-1242 (Aroclor 1242)
107. PCB-1254 (Aroclor 1254)
108. PCB-1221 (Aroclor 1221)
109. PCB-1232 (Aroclor 1232)
110. PCB-1248 (Aroclor 1248)
111. PCB-1260 (Aroclor 1260)
112. PCB-1016 (Aroclor 1016)
113. Toxaphene
114. Antimony
115. Arsenic
116. Asbestos
117. Beryllium
118. Cadmium
119. Chromium
120. Copper
121. Cyanide
122. Lead
123. Mercury
124. Nickel
125. Selenium
126. Silver
127. Thallium
128. Zinc
129. 2,3,7,8-Tetrachlorodibenzo-p-dioxin(TCDD)

only data > than detection limit

TABLE 5-3

SEMICONDUCTOR
SUMMARY OF RAW WASTE DATA

Columns 02040 through 41061: Plants Not Practicing Solvent Management † (7 plants). Columns 36133 through 42044: Plants Practicing Solvent Management † (5 plants).

No./Pollutant Name	02040 mg/l	02347 mg/l	04294 mg/l	04296 mg/l	06143 mg/l			35035 mg/l			41061 mg/l	36133 mg/l	36135 mg/l	30167 mg/l		36136 mg/l	42044 mg/l		
8 1,2,4-Trichlorobenzene		0.089	27.100	4.500				4.200	5.200	5.300									
11 1,1,1-Trichloroethane	1.100				0.930*	3.200	7.700				0.630					0.013			0.130
21 2,4,6-Trichlorophenol			0.013																
23 Chloroform	0.05	0.022	0.012					0.015			0.019	0.020*					0.013		0.010
24 2-Chlorophenol				0.090															0.012
25 1,2-Dichlorobenzene	0.068	0.860	186.000	4.500			0.091				0.078						0.047	0.040	0.033
26 1,3-Dichlorobenzene			14.800	0.235															
27 1,4-Dichlorobenzene	0.410	0.170	14.800	0.235		0.044	0.015			0.018									
29 1,1-Dichloroethylene						0.020	0.071												
31 2,4-Dichlorophenol		0.017																	
38 Ethylbenzene			0.107		0.047														
44 Methylene chloride	0.095	2.400	0.101					0.022		0.011	0.051		0.037	0.021	0.016	0.049	0.056	0.044	0.070
55 Naphthalene			1.504	0.190				0.070	0.086	0.130								0.120	
57 2-Nitrophenol			0.039	0.035	0.015	0.011		0.031	0.018	0.024							0.013		0.011
58 4-Nitrophenol					0.180		0.043												
64 Pentachlorophenol			0.250																
65 Phenol	0.270	0.810	0.170	3.500	0.690	0.610	0.310	0.315	0.263	0.440	0.053						0.195	0.180	0.180
66 Bis(2-ethylhexyl) phthalate	0.019	0.013	0.012	0.050*					0.013					0.080			0.070		0.020
68 Di-n-butyl phthalate			0.017														0.050		
85 Tetrachloroethylene			0.143								0.760			0.0505	0.013			0.015	
86 Toluene	0.140								0.013				0.030	0.057					
87 Trichloroethylene		3.500	0.204					0.016			0.022	0.052*	0.011						
TOTAL TOXIC ORGANICS	2.152	7.881	245.272	13.335	1.852	3.885	8.230	4.669	5.593	5.923	1.613	0.072	0.078	0.2085	0.029	0.062	0.444	0.399	0.466

† Solvent Management means that facilities segregate and collect spent solvents for sale to reclaimers or contract disposal.
* Pollutants were also found in blanks.

TABLE 5-3. (Continued)
SEMICONDUCTOR
SUMMARY OF RAW WASTE DATA

TOXIC METALS

Parameter		Min. Conc. mg/l	Max. Conc. mg/l	Mean Conc. mg/l
114	Antimony	<0.001	0.187	0.013
115	Arsenic	<0.003	0.067	0.015
117	Beryllium	<0.001	<0.015	<0.001
118	Cadmium	<0.001	0.008	0.003
119	Chromium†	<0.001	1.150	0.146
120	Copper†	<0.005	2.588	0.570
122	Lead†	<0.04	1.459	0.135
123	Mercury	<0.001	0.051	0.003
124	Nickel†	0.005	4.964	0.500
125	Selenium	<0.002	0.045	0.015
126	Silver	<0.001	0.013	0.002
127	Tallium	<0.001	0.012	<0.001
128	Zinc	0.001	0.289	0.092
	Total Toxic Inorganics	0.063	10.848	1.496
CONVENTIONAL POLLUTANTS				
	Oil & Grease	ND	6.8	3.9
	Total Suspended Solids*	ND	14	6.9
	Biochemical Oxygen Demand	ND	30	21.3
NON-CONVENTIONAL POLLUTANTS				
	Total Organic Carbon	ND	80	55.7
	Fluoride	26.6	146.5	65.5

† These metals are associated with metal finishing operations.
ND - not detected.
* Data for TSS is from plants producing semiconductors only.

TABLE 5-4

SEMICONDUCTOR PROCESS WASTES
PLANT 02040

Stream Description	Scrubber		Quartz Tube Clean		Polish + Remove Wax		Effluent	
Flow (l/hr)	5437		29.0		2178		463505	
Duration (hrs)	24		24		24		24	
Sample ID No.	3480		3481		3477		3478	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene					<0.01		<.01	
7 Chlorobenzene							<0.01	
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane					<0.01		1.10	12.24
13 1,1-Dichloroethane							<0.01	
23 Chloroform					0.047	0.0025	0.05	0.56
24 2-Chlorophenol							<0.01	
25 1,2-Dichlorobenzene					0.012	0.0006	0.068	0.76
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene					<0.01		0.410	4.56
29 1,1-Dichloroethylene							<0.01	
31 1,2-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene							<0.01	
39 Fluoranthene								
44 Methylene Chloride					0.046	0.002	0.095	
51 Chlorodibromomethane					0.01	0.0005	<0.01	
55 Naphthalene								
57 2-Nitrophenol							<0.01	
58 4-Nitrophenol							<0.01	
65 Phenol					<0.01		0.270	3.0
66 Bis(2-ethylhexyl)phthalate					0.010	0.0005	0.019	0.21
67 Butyl benzyl phthalate								
68 Di-N-Butyl phthalate					<0.01		<0.01	
69 Di-N-Octyl phthalate							<0.01	
70 Diethyl Phthalate							<0.01	
71 Dimethyl phthalate								
85 Tetrachloroethylene								
86 Toluene					<0.01		0.14	1.56
87 Trichloroethylene					<0.01		<0.01	
121 Cyanide*							<0.005	
Total Toxic Organics					0.105	0.0055	2.057	22.88
TOXIC INORGANICS								
114 Antimony	<0.005		<0.005		<0.005		<0.005	
115 Arsenic	0.006	0.0008	0.074	0.00005	0.004	0.0002	0.01	0.11
117 Beryllium	<0.001		<0.001		<0.001		<0.001	
118 Cadmium	<0.001		0.05	0.00003	<0.001		0.002	0.02
119 Chromium	0.009	0.001	<0.001		<0.001		0.341	3.79
120 Copper	0.002	0.0003	<0.001		0.056	0.003	0.413	4.59
122 Lead	<0.001		0.25	0.0002	0.034	0.002	0.025	0.28
123 Mercury	<0.001		<0.001		0.001	0.00005	<0.001	
124 Nickel	<0.001		0.90	0.0006	<0.001		4.964	55.2
125 Selenium	<0.003		<0.003		<0.003		<0.003	

* cluded in Total Toxic Organics Figure

TABLE 5-4 (CONT)

SEMICONDUCTOR ...CESS WASTES
PLANT 02040

Stream Description	Scrubber		Quartz Tube Clean		Polish + Remove Wax		[redacted]fluent	
Flow (l/hr)	5437		29.0		2178		463505	
Sample ID No.	3480		3481		3477		3478	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT.)								
126 Silver	<0.005		<0.005		<0.005		<0.005	
127 Thallium	<0.025		<0.025		<0.025		<0.025	
128 Zinc	0.04	0.005	0.80	0.00056	0.070	0.0037	0.111	1.23
Total Toxic Inorganics	0.057	0.007	2.076	0.0014	0.165	0.0086	5.866	65.25
NON-CONVENTIONAL POLLUTANTS								
Aluminum	<0.001		16.31	0.011	0.155	0.008	0.323	3.59
Barum	0.026	0.003	0.05	0.00003	0.003	0.0002	0.024	0.27
Boron	0.267	0.035	60.66	0.04	0.251	0.013	0.690	7.68
*Calcium	36.36		45.92		1.710		46.1	
Cobalt	0.002	0.0003	0.48	0.0003	<0.001		0.147	1.64
Gold	<0.02		<0.02		<0.02		<0.02	
Iron	0.012	0.0016	0.46	0.0003	0.109	0.0057	0.813	9.04
*Magnesium	19.34		23.78		0.319		17.12	
Manganese	0.009	0.0012	<0.001		0.001	0.00005	0.014	0.16
Molybdenum	0.005	0.0007	0.57	0.0004	0.008	0.0042	0.006	0.067
Palladium	<0.08		<0.08		<0.08		<0.08	
Platinum	<0.05		<0.05		<0.05		<0.05	
*Sodium	50.52		161.57		73.021		192.501	
Tellurium	<0.02		<0.02		<0.02		<0.02	
Tin	0.016	0.0021	1.01	0.0007	0.047	0.0025	0.297	3.30
Titanium	0.001		0.03	0.00002	0.022	0.001	0.003	0.03
Vanadium	0.130	0.017	0.16	0.0001	0.003	0.00016	0.123	1.37
Yttrium	0.001		<0.001		<0.001		<0.001	
Phenols	<0.010	0.0013			0.039	0.002	6.1	67.9
Total Organic Carbon	8	1.04			26	1.36	37	411.6
Fluoride	0.46	0.06	290	0.20	0.27	0.014	52.0	578.5
CONVENTIONAL POLLUTANTS								
Oil & Grease					7.0	0.37	4	44.5
Total Suspended Solids	2	0.26			5.0	0.26	62	689.7
Biochemical Oxygen Demand	5	0.65			15	0.78	52	578.5
pH								

TABLE 5-4 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 02040

Stream Description	Machining Wastes		Crystal Growth Scrubbers	
Flow (l/hr)	10402		2580	
Duration (hrs)	24		24	
Sample ID No.	03476		03479	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS				
4 Benzene				
7 Chlorobenzene				
8 1,2,4-Trichlorobenzene				
11 1,1,1-Trichloroethane	<0.01			
13 1,1-Dichloroethane	0.01	0.003		
23 Chloroform	0.02	0.005		
24 2-Chlorophenol				
25 1,2-Dichlorobenzene	<0.01			
26 1,3-Dichlorobenzene				
27 1,4-Dichlorobenzene				
29 1,1-Dichloroethylene				
31 1,2-Dichlorophenol				
37 1,2-Diphenylhydrazine				
38 Ethylbenzene				
39 Fluoranthene				
44 Methylene Chloride	0.035	0.009		
51 Chlorodibromomethane				
55 Naphthalene				
57 2-Nitrophenol				
58 4-Nitrophenol				
65 Phenol	0.031	0.008		
66 Bis(2-ethylhexyl)phthalate	<0.01			
67 Butyl benzyl phthalate				
68 Di-N-Butyl phthalate	<0.01			
69 Di-N-Octyl phthalate				
70 Diethyl Phthalate	<0.01			
71 Dimethyl phthalate				
85 Tetrachloroethylene				
86 Toluene				
87 Trichloroethylene				
121 Cyanide*				
Total Toxic Organics	0.096	0.025		
TOXIC INORGANICS				
114 Antimony	0.007	0.002	0.017	
115 Arsenic	0.003	0.001	0.007	
117 Beryllium	<0.001		<0.001	
118 Cadmium	<0.001		<0.001	
119 Chromium	<0.001		0.011	
120 Copper	0.046	0.012	0.007	
122 Lead	0.001	0.0002	<0.001	
123 Mercury	<0.001		<0.001	
124 Nickel	<0.001		<0.001	
125 Selenium	<0.003		<0.003	

* ncluded in Total Toxic Organics figure

TABLE 5-4 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 02040

Stream Description	Machining Wastes		Growth Scrubbers	
Flow (l/hr)	10409		2580	
Duration (hrs)	24		24	
Sample ID No.	03476		03479	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)				
126 Silver	<0.005		<0.005	
127 Thallium	<0.025		<0.025	
128 Zinc	1.113	0.278	0.059	
Total Toxic Inorganics				
NON-CONVENTIONAL POLLUTANTS				
Aluminum	0.015	0.004	<0.001	
Barium	0.024	0.006	0.026	0.002
Boron	0.222	0.055	0.164	0.010
Calcium	28.040		35.830	
Cobalt	<0.001		0.003	0.0002
Gold	<0.020		<0.020	
Iron	0.169	0.042	0.047	0.003
Magnesium	13.500		19.080	
Manganese	0.006	0.002	<0.001	
Molybdenum	0.001	0.0002	0.004	0.0002
Palladium	<0.080		<0.080	
Platinum	<0.050		<0.050	
Sodium	111.601		49.711	
Tellurium	<0.020		<0.020	
Tin	0.023	0.006	0.011	0.001
Titanium	0.006	0.002	<0.001	
Vanadium	0.091	0.023	0.130	0.008
Yttrium	<0.001		<0.001	
Phenols	0.032	0.008		
Total Organic Carbon				
Fluoride			290	17.957
CONVENTIONAL POLLUTANTS				
Oil & Grease	9.0	2.248		
Total Suspended Solids	885	221.09		
Biochemical Oxygen Demand	310	77.44		
pH				

TABLE 5-5

SEMICONDUCTOR PROCESS WASTES

PLANT 02347

Stream Description	Scrubber		Effluent	
Flow (l/hr)	6099		130,688	
Duration (hrs)	24		24	
Sample ID No.	3474		3475	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS				
4 Benzene	0.190	0.028		
7 Chlorobenzene				
8 1,2,4-Trichlorobenzene			0.089	0.279
11 1,1,1-Trichloroethane	0.170	0.025	<0.01	
13 1,1-Dichloroethane				
23 Chloroform	2.6	0.38	0.022	0.069
24 2-Chlorophenol	0.011	0.0016	<0.01	
25 1,2-Dichlorobenzene	<0.01		0.860	
26 1,3-Dichlorobenzene				
27 1,4-Dichlorobenzene			0.170	0.53
29 1,1-Dichloroethylene				
31 2,4-Dichlorophenol	<0.01		0.017	0.053
37 1,2-Diphenylhydrazine			<0.01	
38 Ethylbenzene	<0.01		<0.01	
39 Fluoranthene			<0.01	
44 Methylene chloride	1.9	0.278	2.4	7.53
51 Chlorodibromomethane				
55 Naphthalene			<0.01	
57 2-Nitrophenol			<0.01	
58 4-Nitrophenol				
65 Phenol	0.220	0.032	0.810	2.54
66 Bis(2-ethylhexyl)phthalate	<0.01		0.013	0.04
67 Butyl benzyl phthalate				
68 Di-N-butyl phthalate	<0.01		<0.01	
69 Di-N-octyl phthalate			<0.01	
70 Diethyl phthalate			<0.01	
85 Tetrachloroethylene				
86 Toluene	<0.01		<0.01	
87 Trichloroethylene			3.5	10.98
121 Cyanide*				
Total Toxic Organics	5.08	0.744	7.031	22.053
TOXIC INORGANICS				
114 Antimony	<0.005		<0.005	
115 Arsenic	0.003	0.0004	0.002	0.0063
117 Beryllium	<0.001		<0.001	
118 Cadmium	<0.001		<0.001	
119 Chromium	<0.001		0.110	0.345
120 Copper	<0.001		1.182	3.71
122 Lead	<0.001		0.042	0.132
123 Mercury	0.001	0.00015	0.001	0.003
124 Nickel	<0.001		<0.001	
125 Selenium	<0.003		<0.003	

* Included in Total Toxic Organics Figure

TABLE 5-5 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 02347

Stream Description	Scrubber		[redacted]	
Flow (l/hr)	6099		130,688	
Duration (hrs)				
Sample ID No.	3474		3474	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load mg/day
TOXIC INORGANICS (CONT)				
126 Silver	<0.005		<0.005	
127 Thallium	<0.025		<0.025	
128 Zinc	0.052	0.0076	0.089	0.28
Total Toxic Inorganics	0.056	0.008	1.426	4.473
NON-CONVENTIONAL POLLUTANTS				
Aluminum	0.009	0.0013	0.02	0.063
Barium	0.003	0.0004	0.015	0.05
Boron	0.121	0.018	0.76	2.38
Calcium	42.31	--	14.31	--
Cobalt	<0.001		<0.001	
Gold	<0.02		<0.02	
Iron	0.019	0.0028	0.106	0.38
Magnesium	11.02	--	3.542	--
Manganese	<0.001		0.001	0.003
Molybdenum	0.008	0.001	<0.001	
Palladium	<0.08		<0.08	
Platinum	<0.05		<0.05	
Sodium	43.321	--	116.2	--
Tellurium	<0.02		<0.02	
Tin	0.047	0.007	0.029	0.091
Titanium	0.022	0.003	<0.001	
Vanadium	0.068	0.01	0.015	0.047
Yttrium	<0.001		<0.001	
Phenols				
Total Organic Carbon	10	1.46	38	119.2
Fluoride	1.7	0.25	50	156.8
CONVENTIONAL POLLUTANTS				
Oil & Grease				
Total Suspended Solids				
Biochemical Oxygen Demand				
pH				

TABLE 5-6

SEMICONDUCTOR PROCESS WASTES
PLANT 04294

Stream Description Flow (l/hr) Duration (hrs) Sample ID No.	Developer Rinse 3647 Concentration mg/l	Developer Rinse Mass Load kg/day	Etch Rinse 3643 Concentration mg/l	Etch Rinse Mass Load kg/day	Strip Resist Rinse 3645 Concentration mg/l	Strip Resist Rinse Mass Load kg/day	Metal Etch Rinse 3648 Concentration mg/l	Metal Etch Rinse Mass Load kg/day
TOXIC ORGANICS								
4 Benzene			<0.01		<0.01			
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane								
13 1,1-Dichloroethane								
21 2,4,6-Trichlorophenol								
23 Chloroform	0.026		<0.01		0.021			
24 2-Chlorophenol								
25 1,2-Dichlorobenzene								
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene								
29 1,1-Dichloroethylene								
31 2,4-Dichlorophenol								
34 2,4-Dimethylphenol	<0.01							
37 1,2-Diphenylhydrazine								
38 Ethylbenzene					<0.01			
39 Fluoranthene								
44 Methylene chloride	0.042				<0.01			
48 Dichlorobromomethane	<0.01		<0.01		<0.01			
51 Chlorodibromomethane	<0.01		<0.01		<0.01			
54 Isophorone	<0.01							
55 Naphthalene								
57 2-Nitrophenol								
58 4-Nitrophenol								
64 Pentachlorophenol	<0.01				<0.01			
65 Phenol								
66 Bis(2-ethylhexyl)phthalate	<0.01		<0.01		<0.01			
67 Butyl benzyl phthalate								
68 Di-N-butyl phthalate			<0.01		<0.01			
69 Di-N-octyl phthalate								
70 Diethyl phthalate	<0.01		<0.01		<0.01			
85 Tetrachloroethylene	<0.01		<0.01					
86 Toluene	0.017		<0.01		<0.01			
87 Trichloroethylene	<0.01		<0.01		<0.01			
103 Beta BHC					0.01			
104 Gamma BHC								
121 Cyanide*	<0.005		<0.005		<0.005			
Total Toxic Organics	0.085				0.021			

*Not included in Total Toxic Organics figure

TABLE 5-6 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 04294

Stream Description	Developer Rinse		Etch Rinse		Strip Resist Rinse		Metal Etch Rinse	
Flow (l/hr)								
Duration (hrs)								
Sample ID No.	3647		3643		3645		3648	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS								
114 Antimony	<0.005		0.005		<0.005			
115 Arsenic	<0.003		<0.003		<0.003			
117 Beryllium	<0.001		<0.001		<0.001			
118 Cadmium	0.003		0.003		0.001			
119 Chromium	0.004		0.003		0.001			
120 Copper	0.015		0.046		0.019			
122 Lead	0.019		0.161		0.012			
123 Mercury	<0.001		<0.001		<0.001			
124 Nickel	0.057		0.07		0.005			
125 Selenium	<0.003		<0.003		<0.003			
126 Silver	<0.003		<0.003		<0.003			
127 Thallium	<0.025		<0.025		<0.025			
128 Zinc	0.022		0.048		0.032			
Total Toxic Inorganics	0.120		0.331		0.07			
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.046		5.781		0.031			
Barium	0.004		0.011		0.006			
Calcium	1.718		2.371		0.258			
Cobalt	<0.001		<0.001		<0.001			
Gold								
Iron	0.055		0.149		0.026			
Magnesium	0.077		0.142		0.034			
Manganese	0.001		0.006		0.001			
Molybdenum	0.004		0.019		<0.001			
Palladium								
Platinum								
Sodium	0.071		18.315		0.143			
Tellurium								
Tin	0.023		0.203		0.006			
Titanium	0.002		0.036		0.001			
Vanadium	0.001		0.081		0.001			
Yttrium	0.005		<0.001		0.001			
Phenols	0.014		0.016		0.007			
Total Organic Carbon	30		<1.0		<1.0			
Fluoride	0.15		875		0.24			

TABLE 5-6 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 04294

Stream Description	Developer Rinse		Etch Rinse		Strip Resist Rinse		Metal Etch Rinse	
Flow (l/hr)								
Duration (hrs)								
Sample ID No.	3647		3643		3645		3648	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
CONVENTIONAL POLLUTANTS								
Oil & Grease	3.0		<1.0		1.0			
Total Suspended Solids	<5.0		31.0		<5.0			
Biochemical Oxygen Demand	<4.0		<4.0		<4.0			
pH								

TABLE 5-6 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 04294

Stream Description	Wafer Thinning		[redacted]	
Flow (l/hr)			6273	
Duration (hrs)			24	
Sample ID No.	3650		3652	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS				
4 Benzene				
7 Chlorobenzene				
8 1,2,4-Trichlorobenzene			27.1	4.08
11 1,1,1-Trichloroethane				
13 1,1-Dichloroethane				
21 2,4,6-Trichlorophenol			0.013	0.002
23 Chloroform			0.012	0.0018
24 2-Chlorophenol			<0.01	
25 1,2-Dichlorobenzene			186.0	28.0
26 1,3-Dichlorobenzene			14.8	2.23
27 1,4-Dichlorobenzene			14.8	2.23
29 1,1-Dichloroethylene				
31 2,4-Dichlorophenol				
34 2,4-Dimethylphenol				
37 1,2-Diphenylhydrazine				
38 Ethylbenzene			0.107	0.016
39 Fluoranthene				
44 Methylene chloride			0.101	0.015
48 Dichlorobromomethane			<0.006	
51 Chlorodibromomethane				
54 Isophorone				
55 Naphthalene			1.504	0.226
57 2-Nitrophenol			0.039	0.006
58 4-Nitrophenol				
64 Pentachlorophenol			0.250	0.038
65 Phenol			0.170	0.026
66 Bis(2-ethylhexyl)phthalate			0.012	0.0018
67 Butyl benzyl phthalate				
68 Di-N-butyl phthalate			0.017	0.0026
69 Di-N-octyl phthalate				
70 Diethyl phthalate				
85 Tetrachloroethylene			0.143	0.022
86 Toluene			<0.003	
87 Trichloroethylene			0.204	0.031
103 Beta BHC				
104 Gamma BHC				
121 Cyanide*			<0.005	
Total Toxic Organics			245.272	36.928

* Not included in Total Toxic Organics figure.

TABLE 5-6 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 04294

Stream Description	Wafer Thinning		Effluent	
Flow (l/hr)			6273	
Duration (hrs)				
Sample ID No.	3650		3652	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS				
114 Antimony			<0.005	
115 Arsenic			<0.003	
117 Beryllium			<0.001	
118 Cadmium			0.003	0.0005
119 Chromium			0.036	0.005
120 Copper			0.103	0.016
122 Lead			0.21	0.032
123 Mercury			<0.001	
124 Nickel			0.399	0.06
125 Selenium			<0.003	
126 Silver			0.013	0.002
127 Thallium			<0.025	
128 Zinc			0.216	0.033
Total Toxic Inorganics			0.980	0.1485
NON-CONVENTIONAL POLLUTANTS				
Aluminum			0.247	0.037
Barium			0.09	0.014
Calcium			72.448	-
Cobalt			0.004	0.0006
Gold				
Iron			0.477	0.072
Magnesium			30.06	-
Manganese			0.025	0.0038
Molybdenum			0.016	0.002
Palladium				
Platinum				
Sodium			115.147	
Tellurium				
Tin			0.078	0.012
Titanium			0.006	0.0009
Vanadium			0.214	0.032
Yttrium			0.008	0.001
Phenols			1.80	0.27
Total Organic Carbon			20	3.01
Fluoride			6.9	1.04

TABLE 5-6 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 04294

Stream Description	Wafer Thinning		Effluent	
Flow (l/hr)			[redacted]	
Duration (hrs)				
Sample ID No.	3650		3652	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
CONVENTIONAL POLLUTANTS				
Oil & Grease			4.0	0.6
Total Suspended Solids			14	2.11
Biochemical Oxygen Demand			30	4.52
pH				

TABLE 5-7
SEMICONDUCTOR PROCESS WASTES
PLANT 04296

Stream Description	Supply Water		Effluent		Scrubber	
Flow (l/hr)	1798		1798		10	
Duration (hrs)	24		24		24	
Sample ID No.	M16-0-0		M16-1-1		M16-2-1	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS						
4 Benzene						
7 Chlorobenzene						
8 1,2,4-Trichlorobenzene			4.5	0.194		
11 1,1,1-Trichloroethane						
13 1,1-Dichloroethane						
23 Chloroform						
24 2-Chlorophenol			0.09	0.0039		
25 1,2-Dichlorobenzene			4.5	0.194		
26 1,3-Dichlorobenzene			0.235	0.01		
27 1,4-Dichlorobenzene			0.235	0.01		
29 1,1-Dichloroethylene						
31 2,4-Dichlorophenol			0.01	0.0004		
37 1,2-Diphenylhydrazine						
38 Ethylbenzene						
39 Fluoranthene						
44 Methylene Chloride						
51 Chlorodibromomethane						
55 Naphthalene			0.190	0.008		
57 2-Nitrophenol			0.035	0.0015	0.70	0.00017
58 4-Nitrophenol						
65 Phenol			3.5	0.151	0.045	0.00001
66 Bis(2-ethylhexyl)phthalate	0.290	0.013	0.05 B	0.002	0.750	0.00018
67 Butyl Benzyl Phthalate					0.013	0.000003
68 Di-N-Butyl Phthalate					0.280	0.00007
69 Di-N-Octyl Phthalate						
70 Diethyl Phthalate					0.080	0.000019
85 Tetrachloroethylene						
86 Toluene						
87 Trichloroethylene						
121 Cyanide	0.011	0.0005	0.002	0.0001	0.91	0.0002
Total Toxic Organics	0.290	0.013	13.345	0.575	1.868	0.00045
TOXIC INORGANICS						
114 Antimony	<0.0005		0.0007	0.00003	0.088	0.00002
115 Arsenic	<0.005		0.0068	0.00029	6.25	0.0015
117 Beryllium	<0.005		<0.005		<0.005	
118 Cadmium	<0.001		0.0003	0.00001	0.006	0.000001
119 Chromium	<0.025		1.15	0.05	1.14	0.00027
120 Copper	0.04	0.0017	0.005	0.0002	0.38	0.00009
122 Lead	0.24	0.01	0.0035	0.00015	0.42	0.0001
123 Mercury	<0.001		<0.001		<0.001	
124 Nickel	<0.025		<0.025		0.34	0.00008
125 Selenium	<0.005		<0.005		<0.005	

TABLE 5-7 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 04296

Stream Description	Supply Water		[redacted]		Scrubber	
Flow (l/hr)	1798		1798		10	
Duration (hrs)						
Sample ID No.	M16-0-0		M16-1-1		M16-2-1	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load mg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)						
126 Silver	<0.015		<0.015		<0.015	
127 Thallium	<0.0005		0.007	0.0003	0.0065	0.000002
128 Zinc	0.009	0.00039	0.029	0.0013	25.6	0.006
Total Toxic Inorganics	0.289	0.012	1.202	0.052	34.23	0.0081
NON-CONVENTIONAL POLLUTANTS						
Aluminum						
Barium						
Boron						
Calcium						
Cobalt						
Gold						
Iron						
Magnesium						
Manganese						
Molybdenum						
Palladium						
Platinum						
Sodium						
Tellurium						
Tin						
Titanium						
Vanadium						
Yttrium						
Phenols	<0.002		0.093	0.004	<0.002	
Total Organic Carbon	2.3	0.10	13.6	0.59	52	0.012
Fluoride						
CONVENTIONAL POLLUTANTS						
Oil & Grease	8.7	0.38	6.8	0.29	7.7	0.0018
Total Suspended Solids	0.4	0.017	2.4	0.104	14	0.003
Biochemical Oxygen Demand	<3.0		30.	1.295	<3.0	
pH	8.7		2.6		1.5	

TABLE 5-8

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Scrubber		Recycle		Effluent		Scrubber	
Flow (l/hr)	2,509		43,214		42,496		2,509	
Duration (hrs)	24		24		24		24	
Sample ID No.	3482		3483		3484		3485	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene	<0.01		<0.01		<0.01		<0.01[B]	
5 Benzidine								
6 Carbon Tetrachloride								
7 Chlorobenzene	<0.01						<0.01	
8 1,2,4-Trichlorobenzene					0.01			
10 1,2-Dichloroethane								
11 1,1,1-Trichloroethane	0.029	0.0017	<0.01[B]		0.93[B]	0.95	0.073	0.004
13 1,1-Dichloroethane								
14 1,1,2-Trichloroethane								
23 Chloroform	<0.01		<0.01		<0.01[B]		<0.01[B]	
24 2-Chlorophenol	<0.01				<0.01		<0.01	
25 1,2-Dichlorobenzene	0.015	0.0009					0.022	0.001
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene	<0.01						<0.01	
29 1,1-Dichloroethylene								
30 1,2-Transdichloroethylene								
31 1,2-Dichlorophenol								
34 2,4-Dimethylphenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene	<0.01		<0.01		0.047	0.048	<0.01	
39 Fluoranthene	<0.01							
44 Methylene Chloride	<0.01		<0.01		<0.01[B]		<0.01	
45 Methyl Chloride								
46 Methyl Bromide								
48 Dichlorobromomethane								
49 Trichlorofluormethane	<0.01							
51 Chlorodibromomethane					<0.01			
55 Naphthalene								
56 Nitrobenzene	<0.01							
57 2-Nitrophenol	0.011	0.00066			0.015	0.015	<0.01	
58 4-Nitrophenol	0.76	0.046			0.18	0.18	0.32	0.019
65 Phenol	1.8	0.11	0.014	0.015	0.69	0.70	1.7	0.10
66 Bis(2-ethylhexyl)phthalate	<0.01		<0.01					
67 Butyl benzyl phthalate	<0.01		<0.01					
68 Di-N-Butyl phthalate	<0.01		<0.01		<0.01		<0.01	
69 Di-N-Octyl phthalate								
70 Diethyl Phthalate	<0.01		<0.01		<0.01		<0.01	
78 Anthracene			<0.01		<0.01			
81 Phenathrene			<0.01		<0.01			
84 Pyrene	<0.01							
85 Tetrachloroethylene	<0.01		<0.01[B]		<0.01[B]			
86 Toluene	<0.01		<0.01[B]		<0.01[B]		<0.01[B]	
87 Trichloroethylene	<0.01		<0.01		<0.01			
121 Cyanide*	0.02	0.001	0.05	0.052	0.01	0.01	0.03	0.002
Total Toxic Organics	2.615	0.159	0.014	0.015	1.862	1.893	2.115	0.124

*N cluded in Total Toxic Organics figure

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TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Scrubber		Recycle		[redacted]		Scrubber	
Flow (l/hr)	2,509		43,214		42,496		2,509	
Duration (hrs)	24		24		24		24	
Sample ID No.	3482		3483		3484		3485	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS								
114 Antimony	0.002		0.002	0.0021	0.002	0.002	0.001	0.00006
115 Arsenic	0.004		0.003	0.0031	0.006	0.006	0.002	0.00012
117 Beryllium	<0.001		<0.001		<0.001		<0.001	
118 Cadmium	<0.002		<0.002		<0.002		<0.002	
119 Chromium	0.189	0.011	<0.001		<0.002		<0.001	
120 Copper	0.055	0.003	0.049	0.051	1.76	1.80	0.012	0.0007
122 Lead	<0.041		<0.038		0.362	0.369	<0.039	
123 Mercury	<0.001	–	<0.001		<0.001		<0.001	
124 Nickel	0.015	0.0009	<0.005		<0.005		<0.005	
125 Selenium	0.002	0.0001	0.002	0.002	0.006	0.006	<0.001	
126 Silver	<0.001		<0.001		<0.001		<0.001	
127 Thallium	<0.001		<0.001		<0.001		<0.001	
128 Zinc	0.062	0.0037	<0.001		0.225	0.229	0.022	0.0013
Total Toxic Inorganics	0.329	0.0187	0.056	0.582	2.361	2.412	0.037	0.0022
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.136	0.008	0.048	0.05	0.218	0.222	0.144	0.0087
Barium	0.016	0.00096	0.001		0.006	0.006	0.012	0.0007
Boron	0.069	0.004	<0.002		0.234	0.239	0.007	0.0004
Calcium	18.4		0.125		4.98		18.4	
Cobalt	<0.051		<0.048		<0.051		<0.048	
Gold	<0.001		<0.001		0.003	0.003	<0.001	
Iron	0.546	0.033	<0.001		<0.001		<0.001	
Magnesium	5.11		<0.024		1.44		5.05	
Manganese	0.025	0.0015	<0.001		0.104	0.106	0.012	0.0007
Molybdenum	<0.035		<0.033		<0.036		<0.034	
Palladium	<0.003		<0.003		<0.003		<0.003	
Platinum	<0.01		<0.01		<0.01		<0.01	
Sodium	13.4		1.5		147.0		14	
Tellurium	<0.002		0.003	0.003	0.002	0.002	<0.002	
Tin	0.027	0.002	<0.024		0.03	0.03	0.034	0.002
Titanium	<0.002		<0.002		<0.002		<0.002	
Vanadium	<0.002		<0.001		<0.002		<0.001	
Yttrium	<0.004		<0.003		<0.004		<0.003	
Phenols	18.125	1.09	0.041	0.043	2.438	2.49	0.114	0.0069
Total Organic Carbon	50.9	3.06	7.6	7.88	38	38.8	26.3	1.58
Fluoride	14.5	0.87	0.9	0.93	80	81.6	24.5	1.48

TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Scrubber		Recycle		Effluent		Scrubber	
Flow (l/hr)	2,509		43,214		42,496		2,409	
Duration (hrs)	24		24		24		24	
Sample ID No.	3482		3483		3484		3485	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
CONVENTIONAL POLLUTANTS								
Oil & Grease	1.57	0.09	3.41	3.54	5.46	5.57	12.67	0.76
Total Suspended Solids	0.3	0.018	0.3	0.31	3.3	3.37	1.4	0.08
Biochemical Oxygen Demand	22	1.32	0		16.8	17.1	12.6	0.76
pH								

TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Recycle		Effluent		Scrubber		Recycle	
Flow (l/hr)	43,214		47,701		2,509		43,214	
Duration (hrs)	24		24		24		24	
Sample ID No.	3486		3487		3488		3489	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene			<0.01[B]		<0.01[B]			
5 Benzidine							<0.01	
6 Carbon Tetrachloride					0.025	0.002		
7 Chlorobenzene			<0.01					
8 1,2,4-Trichlorobenzene			<0.01					
10 1,2-Dichloroethane			<0.01		0.011	0.0007		
11 1,1,1-Trichloroethane	0.014	0.145	3.2	3.66	0.033	0.002	0.019	0.020
13 1,1-Dichloroethane								
14 1,1,2-Trichloroethane	<0.01				<0.01			
23 Chloroform	<0.01				<0.018[B]	0.001	<0.01	
24 2-Chlorophenol					<0.01			
25 1,2-Dichlorobenzene	<0.01							
26 1,3-Dichlorobenzene			<0.01					
27 1,4-Dichlorobenzene			0.044	0.05	<0.01			
29 1,1-Dichloroethylene			0.02	0.023				
30 1,2-Transdichloroethylene					0.013	0.0008		
31 1,2-Dichlorophenol								
34 2,4-Dimethylphenol					<0.01			
37 1,2-Diphenylhydrazine					<0.01			
38 Ethylbenzene	<0.01		<0.01		0.01[B]	0.0009	<0.01	
39 Fluoranthene								
44 Methylene Chloride	<0.01		<0.01[B]		<0.01[B]		<0.01	
45 Methyl Chloride								
46 Methyl Bromide								
48 Dichlorobromomethane			<0.01					
49 Trichlorofluormethane					0.016	0.0010		
51 Chlorodibromomethane								
55 Naphthalene								
56 Nitrobenzene								
57 2-Nitrophenol			0.011	0.01	<0.01			
58 4-Nitrophenol					0.13	0.008		
65 Phenol	0.31	0.32	0.61	0.70	0.97	0.058	0.011	0.01
66 Bis(2-ethylhexyl)phthalate	<0.01		<0.01		<0.01		<0.01	
67 Butyl benzyl phthalate	<0.01				<0.01			
68 Di-N-Butyl phthalate	<0.01		<0.01		<0.01		<0.01	
69 Di-N-Octyl phthalate								
70 Diethyl Phthalate					<0.01			
78 Anthracene								
81 Phenathrene								
84 Pyrene								
85 Tetrachloroethylene	<0.01		<0.01		0.074	0.0045		
86 Toluene	<0.01		<0.01[B]		0.012[B]	0.0007	<0.01	
87 Trichloroethylene					0.08[B]	0.0048		
121 Cyanide*	0.01	0.01	0.01	0.01	0.01	0.001	0.01	0.01
Total Toxic Organics	0.460	0.465	3.885	4.443	1.379	0.084	0.030	0.030

*Not included in Total Toxic Organics figure

TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Recycle		Effluent		Scrubber		Recycle	
Flow (l/hr)	43,214		47,701		2,509		43,214	
Duration (hrs)	24		24		24		24	
Sample ID No.	3486		3487		3488		3489	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS								
114 Antimony	0.002	0.0021	<0.001		0.002	0.0001	0.001	0.001
115 Arsenic	<0.001		0.003	0.003	0.001	0.00006	0.002	0.0021
117 Beryllium	<0.001		<0.001		<0.001		<0.001	
118 Cadmium	<0.002		<0.002		<0.002		<0.002	
119 Chromium	0.310	0.322	<0.001		<0.001		<0.001	
120 Copper	0.046	0.048	0.904	1.03	0.005	0.0003	<0.002	
122 Lead	<0.039		<0.039		<0.039		<0.039	
123 Mercury	<0.001		<0.001		<0.001		<0.001	
124 Nickel	0.135	0.14	<0.005		<0.005		<0.005	
125 Selenium	0.003	0.003	0.007	0.008	0.001	0.00006	<0.001	
126 Silver	<0.001		0.001	0.001	<0.001		0.001	0.001
127 Thallium	0.001	0.001	<0.001		<0.001		<0.001	
128 Zinc	1.84	1.91	0.05	0.057	<0.001		<0.001	
Total Toxic Inorganics	2.337	2.426	0.965	1.099	0.009	0.0005	0.004	0.0041
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.041	0.043	0.572	0.655	0.148	0.0089	0.024	0.025
Barium	0.001	0.001	0.007	0.008	0.013	0.0008	<0.001	
Boron	0.058	0.06	0.908	1.04	0.009	0.0005	0.022	0.023
Calcium	0.546		7.0		18.2		0.032	
Cobalt	<0.048		<0.049		<0.049		<0.048	
Gold	<0.001		0.002	0.0023	<0.001		<0.001	
Iron	1.23	1.28	<0.001		<0.001		<0.001	
Magnesium	0.147		2.11		5.14		<0.024	
Manganese	0.024	0.025	0.029	0.045	0.031	0.002	<0.001	
Molybdenum	<0.034		<0.034		<0.034		<0.034	
Palladium	<0.003		<0.003		<0.003		<0.003	
Platinum	<0.01		<0.01		<0.01		<0.01	
Sodium	<1.5		344		13.5		<1.5	
Tellurium	0.005	0.005	<0.002		<0.002		0.005	0.0052
Tin	<0.024		<0.025		<0.024		0.024	
Titanium	<0.002		0.012	0.014	<0.002		0.002	
Vanadium	<0.001		<0.001		<0.001		0.001	
Yttrium	<0.003		<0.003		<0.003		0.003	
Phenols	0.036	0.037	0.040	0.046	4.4	0.26	0.019	0.19
Total Organic Carbon	5.3	5.5	49.8	57.0	18.8 1	1.13	5.3	5.5
Fluoride	22	22.8	1.2	1.37	30	1.81	0	1.56

TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Recycle		[redacted]		Scrubber		Recycle	
Flow (l/hr)	43,214		47,701		2,509		43,214	
Duration (hrs)	24		24		24		24	
Sample ID No.	3486		3487		3488		3489	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
CONVENTIONAL POLLUTANTS								
Oil & Grease	0		11.67	13.4	0.24	0.01	0	
Total Suspended Solids	1.6	1.66	3.0	3.43	1.6	0.096	0.8	0.83
Biochemical Oxygen Demand	22	22.8	1.2	1.37	30	1.81	0	
pH								

TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Effluent	
Flow (l/hr)	46,002	
Duration (hrs)	24	
Sample ID No.	3490	
	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS		
4 Benzene	<0.01[B]	
5 Benzidine	<0.01	
6 Carbon Tetrachloride		
7 Chlorobenzene		
8 1,2,4-Trichlorobenzene	<0.01	
10 1,2-Dichloroethane		
11 1,1,1-Trichloroethane	7.7	8.5
13 1,1-Dichloroethane		
14 1,12-Trichloroethane		
23 Chloroform	<0.01	
24 2-Chlorophenol	<0.01	
25 1,2-Dichlorobenzene	0.091	0.10
26 1,3-Dichlorobenzene	<0.01	
27 1,4-Dichlorobenzene	0.015	0.017
29 1,1-Dichloroethylene	0.071	0.08
30 1,2-Transdichloroethylene		
31 1,2-Dichlorophenol		
34 2,4-Dimethylphenol		
37 1,2-Diphenylhydrazine		
38 Ethylbenzene	<0.01[B]	
39 Fluoranthene		
44 Methylene Chloride	<0.01[B]	
45 Methyl Chloride		
46 Methyl Bromide		
48 Dichlorobromomethane		
49 Trichlorofluoromethane		
51 Chlorodibromomethane		
55 Naphthalene	<0.01	
56 Nitrobenzene		
57 2-Nitrophenol	<0.01	
58 4-Nitrophenol	0.043	0.047
65 Phenol	0.31	0.34
66 Bis(2-ethylhexyl)phthalate	<0.01	
67 Butyl benzyl phthalate	<0.01	
68 Di-N-Butyl phthalate	<0.01	
69 Di-N-Octyl phthalate		
70 Diethyl Phthalate		
78 Anthracene		
81 Phenanthrene		
85 Tetrachloroethylene		
86 Toluene	<0.01[B]	
87 Trichloroethylene		
121 Cyanide	0.01	0.01
Total Toxic Organics	8.23	9.084

TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 06143

Stream Description	Effluent	
Flow (l/hr)	[redacted]	
Duration (hrs)	24	
Sample ID No.	3490	
	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS		
114 Antimony	<0.001	
115 Arsenic	0.01	0.011
117 Beryllium	<0.001	
118 Cadmium	<0.002	
119 Chromium	<0.001	
120 Copper	1.31	1.45
122 Lead	0.282	0.311
123 Mercury	<0.001	
124 Nickel	<0.005	
125 Selenium	0.002	0.002
126 Silver	0.001	0.001
127 Thallium	<0.001	
128 Zinc	0.128	0.14
Total Toxic Inorganics	1.733	1.915
NON-CONVENTIONAL POLLUTANTS		
Aluminum	3.2	3.53
Barum	0.011	0.012
Boron	0.748	0.83
Calcium	7.62	
Cobalt	<0.05	
Gold	<0.012	
Iron	<0.001	
Magnesium	2.29	
Manganese	0.044	0.049
Molybdenum	<0.035	
Palladium	<0.003	
Platinum	<0.01	
Sodium	554	
Tellurium	<0.002	
Tin	0.057	0.063
Titanium	0.004	0.004
Vanadium	<0.001	
Yttrium	<0.003	
Phenols	1.05	1.16
Total Organic Carbon	45.1	49.8
Fluoride	213	235.2

TABLE 5-8 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 06143

Stream Description	Effluent	
Flow (l/hr)	46,002	
Duration (hrs)	24	
Sample ID No.	3490	
	Concentration mg/l	Mass Load kg/day
CONVENTIONAL POLLUTANTS		
Oil & Grease	2.44	2.69
Total Suspended Solids	3.8	4.20
Biochemical Oxygen Demand	24.4	26.9
pH		

TABLE 5-9

SEMICONDUCTOR PROCESS WASTES
PLANT 30167

Stream Description	Supply Water		Fluoride Raw		Fluoride Effluent		Total Raw	
Flow (l/hr)	205020		22583		22583		54167	
Duration (hrs)	24		24		24		24	
Sample ID No.	M19-0		M19-2		M19-3		M19-4	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene								
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane					0.013	0.007	0.011	0.014
13 1,1-Dichloroethane								
23 Chloroform					0.006	0.003		
24 2-Chlorophenol								
25 1,2-Dichlorobenzene			0.01	0.005				
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene								
29 1,1-Dichloroethylene								
31 2,4-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene								
39 Fluoranthene								
44 Methylene Chloride					0.005	0.003		
51 Chlorodibromomethane								
55 Naphthalene			0.147	0.080	0.140	0.076		
57 2-Nitrophenol								
58 4-Nitrophenol								
65 Phenol								
66 Bis(2-ethylhexyl)phthalate	0.01	0.05	0.018	0.010	0.034	0.018	0.536	0.697
67 Butyl Benzyl Phthalate								
68 Di-N-Butyl Phthalate								
69 Di-N-Octyl Phthalate							0.01	0.13
70 Diethyl Phthalate								
85 Tetrachloroethylene	0.03	0.15	0.007	0.004	0.085	0.046	0.290	0.38
86 Toluene							0.01	0.013
87 Trichloroethylene	0.009	0.04					0.0365	0.475
121 Cyanide*	0.002	0.01	0.35	0.19	0.110	0.05	<0.001	
Total Toxic Organics	0.049	0.24	0.182	0.099	0.283	0.153	0.894	1.709
TOXIC INORGANICS								
114 Antimony	<0.001		<0.002		<0.001		0.001	0.0013
115 Arsenic	<0.01		<0.01		<0.01		<0.01	
117 Beryllium	<0.01		<0.01		<0.01		<0.01	
118 Cadmium	<0.001		0.004	0.002	<0.001		<0.001	
119 Chromium	<0.005		22.8	12.36	0.055	0.03	0.025	0.033
120 Copper	<0.01		2.2	1.19	0.145	0.079	0.035	0.046
122 Lead	<0.001		5.35	2.9	0.005	0.003	0.008	0.01
123 Mercury	<0.001		<0.001		<0.001		<0.001	
124 Nickel	<0.025		0.69	0.37	0.065	0.035	0.035	0.046
125 Selenium	<0.005		<0.005		<0.005		<0.005	

*Not included in Total Toxic Organics figure

TABLE 5-9 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 30167

Stream Description	Supply Water		Fluoride Raw		Fluoride Effluent		Total Raw	
Flow (l/hr)	205020		22583		22583		54167	
Duration (hrs)								
Sample ID No.	M19-0		M19-2		M19-3		M19-4	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load mg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	<0.01		0.024	0.01	<0.01		<0.01	
127 Thallium	0.001	0.005	0.005	0.0027	0.012	0.0065	0.012	0.0156
128 Zinc	<0.01		<0.01		<0.01		<0.01	
Total Toxic Inorganics	0.001	0.541	31.07	16.83	0.282	0.154	0.116	0.152
NON-CONVENTIONAL POLLUTANTS								
Aluminum								
Barium								
Boron								
Calcium								
Cobalt								
Gold								
Iron								
Magnesium								
Manganese								
Molybdenum								
Palladium								
Platinum								
Sodium								
Tellurium								
Tin								
Titanium								
Vanadium								
Yttrium								
Phenols	<0.002		0.004	0.002	0.004	0.0022	<0.002	
Total Organic Carbon	56	275.5	414	224.4	255	135.2	47	61.1
Fluoride	4.2	20.67	760	411.9	12.6	20.05		
CONVENTIONAL POLLUTANTS								
Oil & Grease	2.0	9.84	2.8	1.52	3.1	0.168	1.0	1.3
Total Suspended Solids	1.2	5.9	5.6	3.04	71	38.5	203	263.9
Biochemical Oxygen Demand	3	14.8	<3		550	298.1	11	14.3
pH	7.8		1.2		11.9		9.4	

TABLE 5-9 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 30167

Stream Description	Effluent	
Flow (l/hr)	205020	
Duration (hrs)	24	
Sample ID No.	H19-5	
	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS		
4 Benzene		
7 Chlorobenzene		
8 1,2,4-Trichlorobenzene		
11 1,1,1-Trichloroethane	0.006	0.03
13 1,1-Dichloroethane		
23 Chloroform		
24 2-Chlorophenol		
25 1,2-Dichlorobenzene		
26 1,3-Dichlorobenzene		
27 1,4-Dichlorobenzene		
29 1,1-Dichloroethylene		
31 2,4-Dichlorophenol		
37 1,2-Diphenylhydrazine		
38 Ethylbenzene		
39 Fluoranthene		
44 Methylene Chloride	0.021	0.10
51 Chlorodibromomethane		
55 Naphthalene	0.006	0.03
57 2-Nitrophenol		
58 4-Nitrophenol		
65 Phenol		
66 Bis(2-ethylhexyl)phthalate	0.08	0.39
67 Butyl Benzyl Phthalate		
68 Di-N-Butyl Phthalate		
69 Di-N-Octyl Phthalate		
70 Diethyl Phthalate		
85 Tetrachloroethylene	0.0505	0.25
86 Toluene	0.057	0.28
87 Trichloroethylene	0.01	0.05
121 Cyanide*	0.011	0.05
Total Toxic Organics	0.231	1.14
TOXIC INORGANICS		
114 Antimony	<0.001	
115 Arsenic	<0.01	
117 Beryllium	<0.01	
118 Cadmium	<0.001	
119 Chromium	0.05	0.25
120 Copper	0.035	0.17
122 Lead	0.005	0.02
123 Mercury	<0.001	
124 Nickel	<0.025	
125 Selenium	<0.005	

*Not included in Total Toxic Organics figure

TABLE 5-9 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 30167

Stream Description	Effluent	
Flow (l/hr)	205020	
Duration (hrs)		
Sample ID No.	M19-5	
	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)		
126 Silver	<0.01	
127 Thallium	0.003	0.01
128 Zinc	<0.01	
Total Toxic Inorganics	0.093	0.46
NON-CONVENTIONAL POLLUTANTS		
Aluminum		
Barium		
Boron		
Calcium		
Cobalt		
Gold		
Iron		
Magnesium		
Manganese		
Molybdenum		
Palladium		
Platinum		
Sodium		
Tellurium		
Tin		
Titanium		
Vanadium		
Yttrium		
Phenols		
Total Organic Carbon		
Fluoride		
CONVENTIONAL POLLUTANTS		
Oil & Grease	17.4	85.62
Total Suspended Solids	350	1722.2
Biochemical Oxygen Demand	70	344.4
pH	8.8	

TABLE 5-9 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 30167

Stream Description	Industrial Effluent		Industrial Raw		Fluoride Raw		Fluoride Effluent	
Flow (l/hr)								
Duration (hrs)	189250		189250		20187		20187	
Sample ID No.	24		24		24		24	
	3314		3315		3316		3317	
	mg/l	kg/day	mg/l	kg/day	mg/l	kg/day	mg/l	kg/day
TOXIC ORGANICS								
4 Benzene	<0.001		<0.01		<0.01		<0.01	
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane	<0.01		<0.01		<0.01		<0.01	
13 1,1-Dichloroethane								
23 Chloroform								
24 2-Chlorophenol	<0.01		<0.01		<0.01		<0.01	
25 1,2-Dichlorobenzene	<0.01		<0.01		<0.01		<0.01	
26 1,3-Dichlorobenzene	<0.01		<0.01		<0.01		<0.01	
27 1,4-Dichlorobenzene	<0.01		<0.01		<0.01		<0.01	
29 1,1-Dichloroethylene								
31 2,4-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene	<0.01		<0.01		<0.01		<0.01	
39 Fluoranthene								
44 Methylene chloride	0.016	0.073	0.001	0.005	0.016	0.008	0.006	0.003
51 Chlorodibromomethane								
55 Naphthalene	<0.01		<0.01		<0.01		<0.01	
57 2-Nitrophenol	<0.01		<0.01		<0.01		<0.01	
58 4-Nitrophenol								
65 Phenol	<0.01		<0.01		<0.01		<0.01	
66 Bis(2-ethylhexyl)phthalate	<0.01		<0.01		<0.01		<0.01	
67 Butyl benzyl phthalate								
68 Di-N-butyl phthalate	<0.01		<0.01		0.001		<0.01	
69 Di-N-octyl phthalate								
70 Diethyl phthalate								
85 Tetrachloroethylene	0.013	0.059	0.012	0.055	0.047	0.023	0.042	0.020
86 Toluene	<0.01		<0.01		<0.01		<0.01	
87 Trichloroethylene	0.006	0.027	0.005	0.023	0.002	0.001	0.001	0.001
121 Cyanide*	<0.04		<0.04		<0.04		<0.04	
Total Toxic Organics	0.045	0.159	0.017	0.083	0.076	0.032	0.049	0.024
TOXIC INORGANICS								
114 Antimony	<0.003		<0.003		<0.003		<0.003	
115 Arsenic	0.014	0.064	0.010	0.045	0.004	0.002	<0.003	
117 Beryllium	0.002	0.009	0.002	0.009	0.002	0.001	<0.001	
118 Cadmium	0.015	0.068	0.018	0.082	0.030	0.015	<0.001	
119 Chromium	0.115	0.522	0.027	0.123	19.00	9.205	0.128	0.062
120 Copper	0.158	0.718	0.045	0.204	1.742	0.844	0.050	0.024
122 Lead	0.040	0.182	<0.010		3.675	1.780	0.018	0.009
123 Mercury	<0.003		0.003	0.014	0.002	0.001	0.001	0.001
124 Nickel	0.108	0.491	0.054	0.245	1.956	0.948	0.121	0.059
125 Selenium	<0.003		<0.003		<0.003		<0.003	

*Not included in Total Toxic Organics figure

TABLE 5-9 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 30167

Stream Description	Industrial Effluent		Industrial Raw		Fluoride Raw/		Fluoride Effluent	
Flow (l/hr)	189250		189250		20187		3317	
Duration (hrs)	24		24		24		24	
Sample ID No.	3314		3315		3316		3317	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	0.025	0.114	0.015	0.068	0.011	0.005	0.020	<0.01
127 Thallium	0.120	0.545	0.05	0.227	0.040	0.019	0.19	0.092
128 Zinc	0.358	1.626	0.162	0.736	0.197	0.095	0.033	0.016
Total Toxic Inorganics	0.955	4.334	0.386	1.753	26.659	12.916	13.039	6.317
NON-CONVENTIONAL POLLUTANTS								
Aluminum	1.352	6.141	0.986	4.478	4.440	2.151	<0.001	
Barium	0.089	0.404	0.053	0.241	0.018	0.009	<0.001	
Boron	0.353	1.603	0.306	1.390	12.145	5.884	0.571	0.277
Calcium	618.62		313.02		4.155		1090.0	
Cobalt	0.050	0.227	0.042	0.191	0.041	0.202	<0.001	
Gold								
Iron	7.571	34.387	5.404	24.545	1.025	0.50	0.071	0.034
Magnesium	55.39		46.810		3.325		0.783	
Manganese	0.217	0.986	0.059	0.268	22.37	10.840	0.133	0.064
Molybdenum	0.065	0.295	0.052	0.236	0.198	0.10	0.158	0.077
Palladium								
Platinum								
Sodium	488.93		504.23		1400.0		231.73	
Tellurium								
Tin	0.121	0.550	0.106	0.481	0.270	0.131	<0.001	
Titanium	<0.030		<0.03		<0.03		0.024	0.012
Vanadium	0.385	1.75	0.339	1.540	0.134	0.065	<0.001	
Yttrium	0.064	0.291	0.056	0.254	0.069	0.033	0.005	0.002
Phenols	<0.004		<0.004		<0.004		<0.004	
Total Organic Carbon	70.0	317.94	90.0	408.78	400.0	193.80	250.0	121.12
Fluoride	1.5	6.813	1.9	8.63	306.0	148.25	9.5	4.603
CONVENTIONAL POLLUTANTS								
Oil & Grease	1.3	5.91	1.2	5.450	1.3	0.630	0.3	0.145
Total Suspended Solids	12.27	5573.03	145.0	658.59	2.0	0.970	66.2	32.073
Biochemical Oxygen Demand	91.8	477.41	116.0	526.87	704.0	341.10	452.0	219.0
pH								

TABLE 5-9 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 30167

Stream Description	Silicon Slurry	
Flow (l/hr)	2059	
Duration (hrs)	24	
Sample ID No.	3318	
	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS		
4 Benzene	<0.01	
7 Chlorobenzene		
8 1,2,4,-Trichlorobenzene		
11 1,1,1-Trichloroethane	<0.01	
13 1,1-Dichloroethane		
23 Chloroform		
24 2-Chlorophenol	<0.01	
25 1,2-Dichlorobenzene	<0.01	
26 1,3-Dichlorobenzene	<0.01	
27 1,4-Dichlorobenzene	<0.01	
29 1,1-Dichloroethylene		
31 2,4-Dichlorophenol		
37 1,2-Diphenylhydrazine		
38 Ethylbenzene	<0.01	
39 Fluoranthene		
44 Methylene chloride	0.009	<0.001
51 Chlorodibromomethane		
55 Naphthalene	<0.01	
57 2-Nitrophenol	<0.01	
58 4-Nitrophenol		
65 Phenol	<0.01	
66 Bis(2-ethylhexyl)phthalate	<0.01	
67 Butyl benzyl phthalate		
68 Di-N-butyl phthalate	<0.01	
69 Di-N-octyl phthalate		
70 Diethyl phthalate		
85 Tetrachloroethylene	0.002	<0.001
86 Toluene	<0.01	
87 Trichloroethylene	0.018	0.001
121 Cyanide*	<0.004	
Total Toxic Organics	0.029	0.001
TOXIC INORGANICS		
114 Antimony	<0.003	
115 Arsenic	<0.003	
117 Beryllium	<0.001	
118 Cadmium	<0.001	
119 Chromium	<0.020	
120 Copper	0.092	0.005
122 Lead	0.015	<0.001
123 Mercury	0.002	<0.001
124 Nickel	<0.028	
125 Selenium	<0.003	

*Not included in Total Toxic Organics figure

TABLE 5-9 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 30167

Stream Description	Silicon Slurry	
Flow (l/hr)	2059	
Duration (hrs)	24	
Sample ID No.	3318	
	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)		
126 Silver	<0.002	
127 Thallium	<0.020	
128 Zinc	0.047	0.002
Total Toxic Inorganics	0.156	0.008
NON-CONVENTIONAL POLLUTANTS		
Aluminum	<0.001	
Barium	<0.001	
Boron	1.194	0.059
Calcium	8.156	
Cobalt	<0.001	
Gold		
Iron	<0.001	
Magnesium	6.457	
Manganese	<0.001	
Molybdenum	<0.025	
Palladium		
Platinum		
Sodium	148.224	
Tellurium		
Tin	0.037	0.002
Titanium	<0.03	
Vanadium	<0.001	
Yttrium	<0.001	
Phenols	0.011	0.001
Total Organic Carbon	70.0	3.46
Fluoride	<0.10	
CONVENTIONAL POLLUTANTS		
Oil & Grease	14.1	0.697
Total Suspended Solids	344.0	17.0
Biochemical Oxygen Demand	69.0	3.41
pH		

TABLE 5-10

SEMICONDUCTOR PROCESS WASTES

PLANT 35035

Stream Description	Scrubber		Recycle		Effluent		Recycle	
Flow (l/hr)	50		6865		4778		9469	
Duration (hrs)	24		24		24		24	
Sample ID No.	3718		3719		3720		3721	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene								
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene	0.036 B	0.00004	0.0		4.20	0.482	0.0029	0.0007
11 1,1,1-Trichloroethane			0.0		0.0		0.0005	0.0001
13 1,1-Dichloroethane								
23 Chloroform	<0.01		0.0051	0.00084	0.015	0.0017	0.0063 B	0.001
24 2-Chlorophenol			0.0		0.0026	0.0003		
25 1,2-Dichlorobenzene			0.0		0.0089	0.001		
26 1,3-Dichlorobenzene			0.0		0.0			
27 1,4-Dichlorobenzene			0.0		0.0011	0.00013		
29 1,1-Dichloroethylene								
31 2,4-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene			0.0009	0.00015	0.0026	0.0003		
39 Fluoranthene								
44 Methylene chloride	<0.01		0.012	0.002	0.022	0.0025	0.012 B	0.003
51 Chlorodibromomethane								
55 Naphthalene	<0.01 B		0.0		0.07	0.008	0.047	0.011
57 2-Nitrophenol	0.097	0.0001	0.0		0.031	0.0036		
58 4-Nitrophenol	3.10	0.004						
65 Phenol	5.7 B	0.007	0.0004	0.00007	0.315	0.036	0.0008	0.0002
66 Bis(2-ethylhexyl)phthalate	<0.01		0.0		0.006	0.0007	0.0039	0.0009
67 Butyl benzyl phthalate	B							
68 Di-N-butyl phthalate	<0.01		0.001	0.00016	0.0011	0.00013	0.0012	0.0003
69 Di-N-octyl phthalate								
70 Diethyl phthalate	<0.01 B							
71 Dimethyl phthalate	<0.01							
85 Tetrachloroethylene			0.0002	0.000033	0.009	0.001	0.0005 B	0.0001
86 Toluene			0.0077	0.0013	0.0066	0.0008	0.0097 B	0.0022
87 Trichloroethylene			0.012	0.002	0.016	0.0018	0.0076 B	0.0017
121 Cyanide*	<0.005		<0.005		<0.005		<0.005	
Total Toxic Organics	8.933	0.0111	0.039	0.0066	4.707	0.540	0.0924	0.0212
TOXIC INORGANICS								
114 Antimony	0.005	0.000006	0.002	0.0003	0.187	0.02	0.002	0.0005
115 Arsenic	I		I		0.025	0.003	I	
117 Beryllium	<0.001		<0.001		<0.001		<0.001	
118 Cadmium	<0.002		<0.002		<0.002		<0.002	
119 Chromium	<0.001		<0.001		<0.002		<0.001	
120 Copper	0.014	0.00002	<0.002		0.058	0.0067	<0.002	
122 Lead	<0.04		<0.04		<0.044		<0.04	
123 Mercury	<0.001		<0.001		<0.001		<0.001	
124 Nickel	<0.005		<0.005		0.015	0.002	<0.005	
125 Selenium	<0.002		0.002	0.0003	0.045	0.005	0.004	0.0009

B = present in sample blank
I = interferences present

*Not included in Total Toxic Organics Figures

TABLE 5-10 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 35035

Stream Description	Scrubber		Recycle		Effluent*		Recycle	
Flow (l/hr)	50		6865		4778		6469	
Duration (hrs)	24		24		24		24	
Sample ID No.	3718		3719		3720		3721	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	<0.001		<0.001		0.002	0.0002	<0.001	
127 *Thallium*	*<0.001*		*<0.001*		<0.001		<0.001	
128 Zinc	<0.001		<0.001		0.035	0.004	0.014	0.003
Total Toxic Inorganics	0.019	0.000026	0.004	0.0006	0.367	0.041	0.02	0.004
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.253	0.0003	0.022	0.004	0.21	0.024	0.041	0.009
Barium	<0.001		<0.001		0.001	0.0001	<0.001	
Boron	0.372	0.0004	0.215	0.03	0.639	0.07	0.186	0.04
Calcium	5.80		<0.005		10.1		<0.005	
Cobalt	<0.05		<0.05		<0.054		<0.05	
Gold	<0.002		<0.002		I		<0.002	
Iron	<0.001		<0.001		0.04	0.005	<0.001	
Magnesium	8.33		0.077		1.82		0.121	
Manganese	0.033	0.00004	<0.001		<0.001		<0.001	
Molybdenum	<0.035		<0.035		<0.038		<0.035	
Palladium	<0.003		<0.003		0.006	0.0007	<0.003	
Platinum	<0.003		<0.003		<0.003		<0.003	
Sodium	27.20		<1.50		1860		<1.5	
Tellurium	0.01	0.00001	<0.006		<0.015		<0.006	
Tin	<0.025		<0.025		<0.027		<0.025	
Titanium	0.004	0.000004	<0.002		0.002	0.0002	<0.002	
Vanadium	0.013	0.00002	0.002	0.0003	0.006	0.0007	0.004	0.0009
Yttrium	<0.003		<0.003		<0.004		<0.003	
Lithium	0.006	0.000007	0.001	0.00016	0.063	0.007	0.001	0.0002
Phenols	135.0	0.162	<0.001		0.31	0.36	<0.001	
Total Organic Carbon	177.0	0.21	1.2	0.20	102	11.7	0.8	0.18
Fluoride	119	0.143	0.35	0.058	16.3	1.87	0.21	0.05
CONVENTIONAL POLLUTANTS								
Oil & Grease	5.0	0.006	1.4	0.23	1.2	0.138	0.0	
Total Suspended Solids	24.8	0.03	0		1.3	0.15	0.0	
Biochemical Oxygen Demand	~471	0.57	0	0	0	0		
pH								

I = interferences present

TABLE 5-10 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 35035

Stream Description	Effluent		Recycle		Effluent	
Flow (l/hr)	8740		7904		7681	
Duration (hrs)	24		24		24	
Sample ID No.	3722		3723		3724	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS						
4 Benzene						
7 Chlorobenzene						
8 1,2,4-Trichlorobenzene	5.200	1.091	0.0096	0.0018	5.300	0.977
11 1,1,1-Trichloroethane			0.0009	0.0002		
13 1,1-Dichloroethane						
23 Chloroform	0.0055	0.0012	0.0054	0.001	0.0092	0.0017
24 2-Chlorophenol	0.0015	0.0003			0.0083	0.0015
25 1,2-Dichlorobenzene						
26 1,3-Dichlorobenzene	0.0027	0.0006			0.0032	0.0006
27 1,4-Dichlorobenzene					0.018	0.003
29 1,1-Dichloroethylene						
31 2,4-Dichlorophenol						
37 1,2-Diphenylhydrazine						
38 Ethylbenzene			0.0002	0.00004	0.0005	0.00009
39 Fluoranthene						
44 Methylene chloride	0.0075	0.0016	0.013	0.0025	0.011	0.002
51 Chlorodibromomethane						
55 Naphthalene	0.086	0.018	0.046	0.0087	0.130	0.024
57 2-Nitrophenol	0.018	0.0038			0.024	0.004
58 4-Nitrophenol						
65 Phenol	0.263	0.055	0.0011	0.0002	0.44	0.081
66 Bis(2-ethylhexyl)phthalate	0.013	0.003	0.003	0.00057	0.0057	0.001
67 Butyl benzyl phthalate						
68 Di-N-butyl phthalate	0.0022	0.0005	0.0009	0.0002	0.0012	0.0002
69 Di-N-octyl phthalate						
70 Diethyl phthalate						
71 Dimethyl phthalate						
85 Tetrachloroethylene	0.0002	0.00004	0.0003	0.00006	0.0002	0.00004
86 Toluene	0.013	0.003	0.0072	0.0014	0.0085	0.0016
87 Trichloroethylene	0.0087	0.0018	0.0049	0.00093	0.0066	0.0012
121 Cyanide*	<0.005		<0.005		<0.005	
Total Toxic Organics	5.621	1.180	0.0925	0.0176	5.97	1.010
TOXIC INORGANICS						
114 Antimony	0.10	0.02	0.002	0.0004	I	
115 Arsenic	I		I		I	
117 Beryllium	<0.001		<0.001		<0.001	
118 Cadmium	0.004	0.0008	<0.002		0.002	0.00037
119 Chromium	0.005	0.001	<0.001		<0.001	
120 Copper	0.049	0.01	<0.002		0.059	0.011
122 Lead	<0.04		<0.04		<0.04	
123 Mercury	<0.001		<0.001		<0.001	
124 Nickel	0.022	0.005	<0.005		0.015	0.0028
125 Selenium	0.044	0.009	0.003	0.0006	I	

B = present sample blank
I = interferences present

*Not included in Total Toxic Organics Figure

TABLE 5-10 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 35035

Stream Description	Effluent		Recycle		Effluent	
Flow (l/hr)	8740		7904		7681	
Duration (hrs)	24		24		24	
Sample ID No.	3722		3723		3724	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)						
126 Silver	0.001	0.0002	0.002	0.0004	0.002	0.00037
127 Thallium	<0.001		<0.001		<0.001	
128 Zinc	0.184	0.039	<0.001		0.067	0.012
Total Toxic Inorganics	0.409	0.085	0.007	0.0014	0.145	0.027
NON-CONVENTIONAL POLLUTANTS						
Aluminum	0.263	0.055	<0.01		0.16	0.03
Barium	0.004	0.0008	<0.001		0.002	0.0004
Boron	0.372	0.078	0.015	0.003	0.43	0.079
Calcium	21.4		<0.005		16.10	
Cobalt	<0.05		<0.05		<0.05	
Gold	I		<0.002		I	
Iron	0.483	0.101	<0.001		0.068	0.013
Magnesium	3.79		0.089		2.76	
Manganese	0.002	0.0004	<0.001		0.002	0.0004
Molybdenum	0.046	0.0096	<0.035		<0.035	
Palladium	0.004	0.0008	<0.003		0.007	0.0013
Platinum	0.003	0.0006	<0.003		<0.003	
Sodium	1130		<1.50		1400	
Tellurium	I		<0.006		<0.006	
Tin	<0.025		<0.025		<0.025	
Titanium	0.006	0.0013	<0.002		0.005	0.0009
Vanadium	0.013	0.0027	0.003	0.00063	0.007	0.0013
Yttrium	<0.003		<0.003		<0.003	
Lithium	0.018	0.0038	0.001	0.0002	0.04	0.0074
Phenols	0.53	0.111	<0.001		0.32	0.059
Total Organic Carbon	78	16.36	0.5	0.10	36	6.64
Fluoride	8.6	1.80	0.25	0.05	11.2	2.065
CONVENTIONAL POLLUTANTS						
Oil & Grease	0.0		0.0		0.0	
Total Suspended Solids	2.4	0.503	0.0		0.0	
Biochemical Oxygen Demand	0.0	0	1.0	0.20	0.0	
pH						

I = interferences present

TABLE 5-11

SEMICONDUCTOR PROCESS WASTES

PLANT 36133

Stream Description	Fluoride Effluent		Final Effluent		Fluoride Raw		Fluoride Effluent	
Flow (l/hr)	337		272,353		189		481	
Duration (hrs)	24		24		24		24	
Sample ID No.	3779		3780		3781		3782	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene	<0.01							
7 Chlorobenzene	<0.01		<0.01					
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane								
13 1,1-Dichloroethane								
23 Chloroform	<0.01 B		0.02 B	0.13				
24 2-Chlorophenol								
25 1,2-Dichlorobenzene								
26 1,3-Dichlorobenzene	<0.01							
27 1,4-Dichlorobenzene			<0.01					
29 1,1-Dichloroethylene			<0.01					
31 2,4-Dichlorophenol								
37 1,2-Diphenylhydrazine	0.022	0.00018						
38 Ethylbenzene	<0.01							
39 Fluoranthene								
44 Methylene chloride	<0.01 B							
51 Chlorodibromomethane			<0.01					
55 Naphthalene								
57 2-Nitrophenol								
58 4-Nitrophenol								
62 N-nitrosodiphenylamine	0.039	0.00032						
65 Phenol			<0.01					
66 Bis(2-ethylhexyl)phthalate								
67 Butyl benzyl phthalate								
68 Di-N-butyl phthalate								
69 Di-N-octyl phthalate								
70 Diethyl phthalate								
85 Tetrachloroethylene			<0.01					
86 Toluene	<0.01 B		<0.01 B					
87 Trichloroethylene	0.03 B	0.00024	0.052 B	0.340				
89 Aldrin	<0.005							
90 Dieldrin	<0.005							
101 Heptachlor epoxide	<0.005							
102 Alpha BHC	<0.005							
103 Beta BHC	<0.005							
104 Gamma BHC	<0.005							
105 Delta BHC	<0.005							
121 Cyanide	0.005	0.00004	<0.005		<0.005		<0.005	
Xylene	<0.01							
Total Toxic Organics	0.091	0.00074	0.072	0.470				
TOXIC INORGANICS								
114 Antimony	<0.005		<0.005		<0.005		<0.005	
115 Arsenic	0.002	0.00002	0.001	0.007	0.119	0.0003	0.003	0.00003
117 Beryllium	<0.003		0.001	0.007	<0.003		<0.003	
118 Cadmium	<0.003		0.007	0.046	<0.003		<0.003	
119 Chromium	<0.02		0.059	0.39	408.000	1.097	1.07	0.012

TABLE 5-11 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 36133

Stream Description	Fluoride Effluent		Final Effluent		Fluoride Raw		Fluoride Effluent	
Flow (l/hr)	337		272,353		189		481	
Duration (hrs)	24		24		24		24	
Sample ID No.	3779		3780		3781		3782	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
120 Copper	0.16	0.0013	0.115	0.75	3.746	0.010	0.09	0.001
122 Lead	0.045	0.00036	0.085	0.56	0.150	0.0004	0.04	0.0005
123 Mercury	0.011	0.00009	<0.001		<0.001		<0.001	
124 Nickel	0.22	0.0018	0.531	3.47	0.20	0.0005	0.20	0.002
125 Selenium	<0.005		<0.005		0.007	0.00002	<0.005	
126 Silver	0.015	0.00012	0.005		0.03	0.00008	0.020	0.002
127 Thallium	<0.03	0	<0.03		<0.03		<0.03	
128 Zinc	0.087	0.0007	0.04	0.26	0.429	0.001	0.432	0.005
Total Toxic Inorganics	0.54	0.0044	0.844	5.49	412.28	1.109	1.855	0.023
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.411	0.003	0.231	1.51	320.06	0.86	0.411	0.005
Barium			0.023	0.15				
Boron	<3.0		0.248	1.62	697	1.87	<3.0	
Calcium	425.23		153.4	-	825.18	-	332.94	
Cobalt	<0.02		0.01	0.065	0.14	0.0004	0.02	0.0002
Gold	0.029	0.0002	0.051	0.33	<0.02		<0.02	
Iron			0.092	0.60				
Magnesium			12.6	-				
Manganese			0.011	0.072				
Molybdenum	0.042	0.0003	0.035	0.229			0.044	0.0005
Palladium	0.04	0.0003	<0.04		<0.04		<0.04	
Platinum	<0.05		<0.05		<0.05		<0.05	
Sodium			199.5					
Tellurium	<0.02		<0.02		<0.02		<0.02	
Tin			0.006	0.039				
Titanium	<0.02		0.105	0.686	11.32	0.03	<0.02	
Vanadium			0.105	0.686				
Yttrium			0.023	0.150				
Phenols	<0.001		0.021	0.137	0.103	0.00028	0.004	0.00005
Total Organic Carbon	1537	12.4	10	65.4	2777	7.465	957	11.05
Fluoride	20.1	0.16	5.42	35.4	50,000	134.4	24	0.28
CONVENTIONAL POLLUTANTS								
Oil & Grease	2.0	0.016	2.4	15.7	5.1	0.014	9.8	0.113
Total Suspended Solids	176	1.42	2	13.07	5760	15.483	1930	22.28
Biochemical Oxygen Demand	3700	29.9	18	117.7	243	0.653	2275	26.26
pH								

TABLE 5-11 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 36133

Stream Description	[redacted] Effluent		Fluoride Raw		Fluoride Effluent		[redacted]	
Flow (l/hr)	[redacted]		189		281		285,800	
Duration (hrs)	24		24		24		24	
Sample ID No.	3783		3785		3786		3787	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene								
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane								
13 1,1-Dichloroethane								
23 Chloroform								
24 2-Chlorophenol								
25 1,2-Dichlorobenzene								
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene								
29 1,1-Dichloroethylene								
31 2,4-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene								
39 Fluoranthene								
44 Methylene chloride								
51 Chlorodibromomethane								
55 Naphthalene								
57 2-Nitrophenol								
58 4-Nitrophenol								
62 N-nitrosodiphenylamine								
65 Phenol								
66 Bis(2-ethylhexyl)phthalate								
67 Butyl benzyl phthalate								
68 Di-N-butyl phthalate								
69 Di-N-octyl phthalate								
70 Diethyl phthalate								
85 Tetrachloroethylene								
86 Toluene								
87 Trichloroethylene								
xylene								
89 Aldrin								
90 Dieldrin								
101 Heptachlor epoxide								
102 Alpha BHC								
103 Beta BHC								
104 Gamma BHC								
105 Delta BHC								
121 Cyanide*	<0.005		<0.005		0.477	0.0032	<0.005	
Total Toxic Organics								
TOXIC INORGANICS								
114 Antimony	<0.005		<0.005		<0.005		<0.005	
115 Arsenic	0.002	0.013	0.055	0.0001	0.002	0.00003	0.002	0.014
117 Beryllium	0.001	0.007	<0.003		<0.003		0.001	0.007
118 Cadmium	0.006	0.04	<0.003		<0.003		0.007	0.05
119 Chromium	0.058	0.39	26.31	0.059	0.09	0.0005	0.054	0.37

*Not included in Total Toxic Organics Figure

TABLE 5-11 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 36133

Stream Description	Final Effluent		Fluoride Raw		Fluoride Effluent		Final Effluent	
Flow (l/hr)	280,020		189		281		285,800	
Duration (hrs)	24		24		24		24	
Sample ID No.	3783		3785		3786		3787	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
120 Copper	0.12	0.81	1.07	0.002	0.08	0.0004	0.134	0.92
122 Lead	0.083	0.56	<0.02		<0.02		0.10	0.69
123 Mercury	0.012	0.08	0.005	0.00001	0.01	0.00006	0.011	0.07
124 Nickel	0.523	3.51	0.09	0.00002	0.18	0.001	0.596	4.09
125 Selenium	<0.005		0.007	0.00002	<0.005		0.009	0.06
126 Silver	0.005	0.03	0.01	0.00002	0.02	0.0001	0.005	0.03
127 Thallium	<0.03		<0.003		<0.03		<0.03	
128 Zinc	0.03	0.20	0.179	0.0004	0.136	0.0008	0.038	0.26
Total Toxic Inorganics	0.84	5.64	27.726	0.062	0.518	0.0029	0.957	6.561
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.215	1.44	173.83	0.39	0.793	0.004	0.231	1.58
Barium	0.022	0.15					0.023	0.16
Boron	0.289	1.94	41.0	0.09	<3.00		0.226	1.53
Calcium	154.8		215.29		578.83		174.10	
Cobalt	0.011	0.07	<0.02		<0.02		0.009	0.06
Gold	0.056	0.38	<0.02		<0.02		0.04	0.27
Iron	0.081	0.54					0.089	0.61
Magnesium	13.22						13.55	
Manganese	0.011	0.07					0.011	0.075
Molybdenum	0.037	0.25	0.11	0.0002	0.032	0.0002	0.043	0.295
Palladium	<0.04		<0.04		<0.04		<0.04	
Platinum	<0.05		<0.05		<0.05		<0.05	
Sodium	225.62						257.12	
Tellurium	<0.02		<0.02		<0.02		<0.02	
Tin	0.002	0.013					0.0	0.0
Titanium	0.008	0.054	10.83	0.024	<0.02		0.007	0.048
Vanadium	0.105	0.71					0.109	0.75
Yttrium	0.022	0.15					0.028	0.19
Phenols	0.014	0.094	0.105	0.0002	0.015	0.0001	0.006	0.041
Total Organic Carbon	11.4	76.61	967	2.16	655	4.42	1.8	12.35
Fluoride	12	80.65	27,500	61.38	28.8	0.19	9.0	61.73
CONVENTIONAL POLLUTANTS								23.25
								18.52
Oil & Grease	4.2	28.23	3.6	0.008	5.0	0.033	3.39	82.3
Total Suspended Solids	1.0	6.72	2540	5.67	136	0.917	2.7	
Biochemical Oxygen Demand	17	114.25	87	0.19	1475	9.95	12	
pH								

TABLE 5-12

SEMICONDUCTOR PROCESS WASTES

PLANT 36135

Stream Description	Raw		[redacted]		Raw		Effluent	
Flow (l/hr)	57502		128,394		57502		129,206	
Duration (hrs)	24		24		24		24	
Sample ID No.	3763		3764		3765		3766	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene					<0.01 B		<0.01	
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane								
13 1,1-Dichloroethane								
23 Chloroform					0.015	0.021	0.01	0.03
24 2-Chlorophenol								
25 1,2-Dichlorobenzene								
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene								
29 1,1-Dichloroethylene								
31 1,2-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene								
39 Fluoranthene								
44 Methylene Chloride					<0.01 B		<0.037	0.115
51 Chlorodibromomethane								
55 Naphthalene								
57 2-Nitrophenol								
58 4-Nitrophenol								
65 Phenol								
66 *Bis*(2-ethylhexyl)phthalate					0.070	0.097		
67 Butyl benzyl phthalate								
68 Di-N-Butyl phthalate							<0.01	
69 Di-N-Octyl phthalate								
70 Diethyl Phthalate					<0.01			
85 Tetrachloroethylene					B			
86 Toluene					0.025 B	0.03	0.01	
87 Trichloroethylene					<0.01		0.011	0.034
121 Cyanide*	<0.005		0.013	0.04	<0.005	0.009	0.028	
Toxic Organics					0.11	0.148	0.058	0.179
TOXIC INORGANICS								
114 Antimony	<0.001		<0.001		<0.001		<0.001	
115 Arsenic	<0.005		<0.005		<0.005		<0.005	
117 Beryllium	0.001	0.0014	0.001	0.003	0.001	0.001	0.001	0.003
118 Cadmium	0.008	0.011	0.007	0.022	0.008	0.01	0.007	0.022
119 Chromium	0.024	0.033	0.048	0.148	0.028	0.039	0.05	0.155
120 Copper	0.232	0.32	0.051	0.157	0.347	0.479	0.05	0.155
122 Lead	0.09	0.12	0.098	0.30	0.096	0.132	0.102	0.316
123 Mercury	<0.001		<0.001		0.01	0.014	0.01	0.03
124 Nickel	1.659	2.29	0.531	1.64	0.815	1.12	0.52	1.61
125 Selenium	<0.005		<0.005		<0.005		0.01	0.03

B = present in sample blank

*Not included in Total Toxic Organics figure

TABLE 5-12 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 36135

Stream Description	Raw		Effluent		Raw		Effluent	
Flow (l/hr)	57502		128,394		57502		129,206	
Duration (hrs)	24		24		24		24	
Sample ID No.	3763		3764		3765		3766	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC METALS (CONT)								
126 Silver	<0.006		0.006	0.018	0.006	0.008	0.009	0.028
127 Thallium	<0.05		0.09	0.277	<0.05		0.09	0.279
128 Zinc	0.04	0.055	0.022	0.068	0.083	0.115	0.025	0.078
Total Toxic Inorganics	2.054	2.830	0.854	2.633	1.394	1.918	0.874	2.706
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.193	0.266	0.269	0.83	0.225	0.31	0.299	0.927
Barium	0.017	0.023	0.019	0.059	0.018	0.025	0.018	0.056
Boron	0.148	0.20	0.114	0.35	0.106	0.146	0.285	0.884
Calcium	16.4		187.700		16.29		176.40	
Cobalt	0.011	0.015	0.008	0.025	0.018	0.025	0.009	0.028
Gold								
Iron	0.874	1.21	0.086	0.27	1.296	1.79	0.076	0.236
Magnesium	5.804		13.95		5.847		13.57	
Manganese	0.01	0.014	0.006	0.018	0.013	0.018	0.006	0.019
Molybdenum	0.022	0.030	0.024	0.074	0.026	0.036	0.028	0.087
Palladium								
Platinum								
Sodium	14.74		53.68		14.68		66.18	
Tellurium								
Tin	0.033	0.046	0.016	0.05	0.018	0.025	0.011	0.034
Titanium	0.006	0.008	0.008	0.025	0.008	0.011	0.009	0.028
Vanadium	0.048	0.066	0.124	0.38	0.052	0.072	0.121	0.375
Yttrium	0.012	0.017	0.03	0.092	0.016	0.022	0.03	0.09
Phenols	0.0023	0.0032	0.0128	0.039	0.0057	0.0079	0.0019	0.0059
Total Organic Carbon	27	37.26	11	33.9	9.0	12.42	4.0	12.4
Fluoride	9.08	12.53	14.5	44.68	21.5	29.67	11.7	36.28
CONVENTIONAL POLLUTANTS								
Oil & Grease	1.0	1.38	2.8	8.63	19.8	27.3	5.8	17.99
Total Suspended Solids	1.0	1.38	1.0	3.08	<1.0		<1.0	11.16
Biochemical Oxygen Demand	1.6	2.21	7.2	22.19	<1.0	3.6	11.16	
pH								

TABLE 5-13

SEMICONDUCTOR PROCESS WASTES

PLANT 36136

Stream Description Flow (l/hr) Duration (hrs) Sample ID No.	Raw 55760 24 3595 Concentration mg/l	Mass Load kg/day	Effluent 59141 24 3596 Concentration mg/l	Mass Load kg/day	Raw 53412 24 3598 Concentration mg/l	Mass Load kg/day	[redacted] 57963 24 3599 Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene	<0.01		<0.01					
7 Chlorobenzene	<0.01							
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane	<0.01		0.013	0.018				
23 Chloroform	<0.01[B]		<0.01					
24 2-Chlorophenol			<0.01					
25 1,2-Dichlorobenzene	<0.01		<0.01					
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene								
29 1,1-Dichloroethylene								
31 1,2-Dichlorophenol	<0.01							
37 1,2-Diphenylhydrazine								
38 Ethylbenzene								
39 Fluoranthene	<0.01							
44 Methylene Chloride	0.051[B]	0.068	0.049	0.070				
51 Chlorodibromomethane								
55 Naphthalene	<0.01		<0.01					
57 2-Nitrophenol			<0.01					
58 4-Nitrophenol	0.01							
65 Phenol	0.014	0.019	<0.01					
66 Bis(2-ethylhexyl)phthalate	<0.01		<0.01					
67 Butyl benzyl phthalate	<0.01		<0.01					
68 Di-N-Butyl phthalate	<0.01		<0.01					
69 Di-N-Octyl phthalate								
70 Diethyl Phthalate	<0.01		<0.01					
85 Tetrachloroethylene	<0.01							
86 Toluene								
87 Trichloroethylene	0.027[B]	0.036	<0.01					
121 Cyanide	<0.005		<0.005		0.001	0.0013	<0.005	
Total Toxic Organics	0.092	0.123	0.062	0.088				
TOXIC INORGANICS								
114 Antimony	<0.005		0.005		0.009	0.012	<0.005	
115 Arsenic	<0.003		0.003		<0.003		<0.003	
117 Beryllium	<0.001		0.001		<0.001		<0.001	
118 Cadmium	0.006	0.008	0.003	0.004	0.006	0.0077	0.004	0.0056
119 Chromium	0.042	0.056	0.019	0.027	0.035	0.045	0.019	0.026
120 Copper	0.855	1.14	0.041	0.058	2.588	3.318	0.030	0.042
122 Lead	1.459	1.95	0.082	0.116	0.313	0.40	0.083	0.115
123 Mercury	<0.001		<0.001		<0.001		<0.001	
124 Nickel	0.323	0.432	0.844	1.2	1.03	1.32	0.703	0.978
125 Selenium	<0.003		<0.003		<0.003		<0.003	

TABLE 5-13 (CONT)

SEMICONDUCTOR PROCESS WASTES

PLANT 36136

Stream Description	Raw		Effluent		Raw		Effluent	
Flow (l/hr)	55760		59141		53412		57963	
Duration (hrs)	24		24		24		24	
Sample ID No.	3595		3596		3598		3599	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	<0.005		<0.003		<0.005		0.006	0.008
127 Thallium	<0.025		0.065	0.092	<0.025		0.035	0.049
128 Zinc	0.130	0.174	0.027	0.038	0.289	0.370	0.025	0.035
Total Toxic Inorganics	2.815	3.76	1.081	1.54	4.27	5.47	0.905	1.26
NON-CONVENTIONAL POLLUTANTS								
Aluminum	3.177	4.25	0.227	0.322	5.749	7.37	0.292	0.406
Barum	0.027	0.036	0.012	0.017	0.016	0.02	0.01	0.0139
Boron	0.132	0.177	0.102	0.145	0.431	0.552	0.198	0.275
Calcium	5.196		243.708		3.544		171.508	
Cobalt	0.013	0.017	0.014	0.02	0.016	0.02	0.007	0.0097
Gold								
Iron	3.725	4.985	0.088	0.125	3.760	4.82	0.106	0.147
Magnesium	2.132		6.794		1.5		4.93	
Manganese	0.144	0.193	0.021	0.03	0.209	0.267	0.025	0.035
Molybdenum	0.024	0.032	0.018	0.026	0.026	0.033	0.018	0.025
Palladium								
Platinum								
Sodium	140.516		38.906		21.732		98.066	
Tellurium								
Tin	0.200	0.268	0.012	0.017	0.168	0.215	0.028	0.039
Titanium	0.027	0.036	0.007	0.01	0.033	0.042	0.006	0.008
Vanadium	0.072	0.096	0.064	0.091	0.109	0.14	0.054	0.075
Yttrium	<0.001		0.002	0.003	<0.001		0.033	0.046
Phenols	0.179	0.24	0.112	0.16	0.038	0.049	0.115	0.16
Total Organic Carbon	202	270.3	191	271.1	193	247.4	130	180.8
Fluoride	99.38	133	10.50	14.9	148.75	190.68	12	16.7
CONVENTIONAL POLLUTANTS								
Oil & Grease	20.1	26.90	5.2	7.38	7.3	9.36	6.9	9.6
Total Suspended Solids	72	96.35	56	79.5	80	102.55	44	61.21
Biochemical Oxygen Demand	330	441.62	300	425.8	290	371.75	250	347.8
pH								

TABLE 5-13 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 36136

Stream Description	Raw		[redacted]	
Flow (l/hr)	61225		61211	
Duration (hrs)	24		24	
Sample ID No.	85110		85111	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS				
4 Benzene				
7 Chlorobenzene				
8 1,2,4-Trichlorobenzene				
11 1,1,1-Trichloroethane				
13 1,1-Dichloroethane				
23 Chloroform				
24 2-Chlorophenol				
25 1,2-Dichlorobenzene				
26 1,3-Dichlorobenzene				
27 1,4-Dichlorobenzene				
29 1,1-Dichloroethylene				
31 1,2-Dichlorophenol				
37 1,2-Diphenylhydrazine				
38 Ethylbenzene				
39 Fluoranthene				
44 Methylene Chloride				
51 Chlorodibromomethane				
55 Naphthalene				
57 2-Nitrophenol				
58 4-Nitrophenol				
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				
85 Tetrachloroethylene				
86 Toluene				
87 Trichloroethylene				
121 Cyanide*	<0.005		<0.005	
Total Toxic Organics				
TOXIC INORGANICS				
114 Antimony	<0.005		<0.005	
115 Arsenic	<0.003		<0.003	
117 Beryllium	<0.001		<0.001	
118 Cadmium	0.007	0.010	0.002	0.003
119 Chromium	0.038	0.056	0.019	0.028
120 Copper	0.691	1.02	0.033	0.048
122 Lead	0.175	0.257	0.06	0.088
123 Mercury	<0.001		0.003	0.004
124 Nickel	1.039	1.527	0.576	0.846
125 Selenium	<0.003		<0.003	

*Not included in Total Toxic Organics figure

TABLE 5-13 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 36136

Stream Description	Raw		Effluent*	
Flow (l/hr)	61225		61211	
Duration (hrs)	24		24	
Sample ID No.	85110		85111	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)				
126 Silver	<0.005		0.006	0.0088
127 Thallium	<0.025		0.065	0.095
128 Zinc	0.183	0.269	0.031	0.046
Total Toxic Inorganics	2.133	3.14	0.795	1.17
NON-CONVENTIONAL POLLUTANTS				
Aluminum	2.838	4.17	0.253	0.37
Barum	0.047	0.069	0.013	0.019
Boron	0.233	0.34	0.144	0.212
Calcium	7.6		253.408	
Cobalt	0.008	0.012	0.012	0.018
Gold				
Iron	2.065	3.03	0.146	0.214
Magnesium	2.507		6.462	
Manganese	0.126	0.185	0.023	0.034
Molybdenum	0.026	0.038	0.015	0.022
Palladium	<0.025		<0.025	
Platinum	<0.03		<0.03	
Sodium	125.816		52.456	
Tellurium	<0.02		<0.02	
Tin	0.076	0.112	0.02	0.029
Titanium	0.020	0.029	0.007	0.01
Vanadium	0.071	0.10	0.06	0.088
Yttrium	<0.001		0.028	0.041
Phenols	0.114	0.168	0.181	0.266
Total Organic Carbon	76	111.67	136	199.8
Fluoride	83.75	123.1	17.50	25.7
CONVENTIONAL POLLUTANTS				
Oil & Grease	7.1	10.4	7.8	11.46
Total Suspended Solids	72	105.8	60	88.14
Biochemical Oxygen Demand	140	205.7	330	484.8
pH				

TABLE 5-14

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description Flow (l/hr) Duration (hrs) Sample ID No.	Cleaning Solution Rinse 3263 Concentration mg/l	Mass Load kg/day	Oxide Etch Rinse 3262 Concentration mg/l	Mass Load kg/day	Resist Strip Rinse 3260 Concentration mg/l	Mass Load kg/day	Metal Etch Rinse 3264 Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene			<0.01		<0.01			
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane								
13 1,1-Dichloroethane								
23 Chloroform			0.034		<0.01		0.066	
24 2-Chlorophenol								
25 1,2-Dichlorobenzene								
26 1,3-Dichlorobenzene			<0.01					
27 1,4-Dichlorobenzene								
29 1,1-Dichloroethylene								
31 1,2-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene					<0.01			
39 Fluoranthene								
44 Methylene Chloride			<0.01		<0.01		<0.01	
51 Chlorodibromomethane								
55 Naphthalene								
57 2-Nitrophenol								
58 4-Nitrophenol					<0.01			
65 Phenol			<0.01		<0.01			
66 Bis(2-ethylhexyl)phthalate			<0.01		<0.01		<0.01	
67 Butyl benzyl phthalate			<0.01		<0.01		<0.01	
68 Di-N-Butyl phthalate			<0.01		<0.01		<0.01	
69 Di-N-Octyl phthalate			<0.01				<0.01	
70 Diethyl Phthalate			<0.01		<0.01		<0.01	
85 Tetrachloroethylene								
86 Toluene			<0.01		<0.01		<0.01	
87 Trichloroethylene								
121 Cyanide*	<0.006		<0.005		<0.005		<0.005	
Total Toxic Organics			0.034				0.066	
TOXIC INORGANICS								
114 Antimony			<0.002		<0.002		<0.002	
115 Arsenic			<0.003		<0.003		<0.003	
117 Beryllium								
118 Cadmium			<0.003		<0.003		<0.003	
119 Chromium			<0.02		<0.02		<0.02	
120 Copper			<0.003		<0.003		<0.003	
122 Lead			<0.01		<0.01		<0.01	
123 Mercury			<0.001		<0.001		<0.001	
124 Nickel			<0.025		<0.025		<0.025	
125 Selenium								

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description Flow (l/hr) Duration (hrs) Sample ID No.	Cleaning Solution Rinse 3263 Concentration mg/l	Mass Load kg/day	Oxide Etch Rinse 3262 Concentration mg/l	Mass Load kg/day	Resist Strip Rinse 3260 Concentration mg/l	Mass Load kg/day	Metal Etch Rinse 3264 Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver			<0.002		<0.002		<0.002	
127 Thallium			<0.02		<0.02		<0.02	
128 Zinc			0.005		0.002		0.002	
			0.094		0.091		0.091	
Total Toxic Inorganics			0.005		0.002		0.002	
NON-CONVENTIONAL POLLUTANTS								
Aluminum								
Barum								
Boron								
Calcium								
Cobalt								
Gold								
Iron								
Magnesium								
Manganese								
Molybdenum								
Palladium								
Platinum								
Sodium								
Tellurium								
Tin								
Titanium								
Vanadium								
Yttrium								
Phenols	0.02		<0.01		0.026		<0.01	
Total Organic Carbon								
Fluoride								
CONVENTIONAL POLLUTANTS								
Oil & Grease								
Total Suspended Solids								
Biochemical Oxygen Demand								
pH								

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	Raw		Scrubber		Effluent		Raw	
Flow (l/hr)	6000		4500		439110		6000	
Duration (hrs)	24		24		24		24	
Sample ID No.	3251		3250		3252		3255	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene			<0.01					
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene	<0.01				<0.01			
11 1,1,1-Trichloroethane					0.63	6.64		
13 1,1-Dichloroethane								
23 Chloroform	0.020	0.0029	<0.01		0.019	0.200		
24 2-Chlorophenol								
25 1,2-Dichlorobenzene			<0.01		0.078	0.822		
26 1,3-Dichlorobenzene					<0.01			
27 1,4-Dichlorobenzene					<0.01			
29 1,1-Dichloroethylene								
31 1,2-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene					<0.01			
39 Fluoranthene	<0.01		<0.01					
44 Methylene Chloride	<0.01		0.013	0.0014	0.051	0.537		
51 Chlorodibromomethane					<0.01			
55 Naphthalene	<0.01		<0.01		<0.01			
57 2-Nitrophenol			0.02	0.0022				
58 4-Nitrophenol								
65 Phenol			0.025	0.0027	0.053	0.559		
66 Bis(2-ethylhexyl)phthalate	<0.01		<0.01 B		<0.01			
67 Butyl benzyl phthalate	<0.01		<0.01		<0.01			
68 Di-N-Butyl phthalate	<0.01		<0.01 B		<0.01			
69 Di-N-Octyl phthalate	<0.01		<0.01 B		<0.01			
70 Diethyl Phthalate	<0.01		<0.01		<0.01			
85 Tetrachloroethylene			<0.01		0.760	8.009		
86 Toluene	<0.01		<0.01		<0.01			
87 Trichloroethylene					0.022	0.232		
121 Cyanide*	0.013	0.0019	<0.005		<0.005		<0.005	
Total Toxic Organics	0.020	0.0029	0.058	0.0063	1.613	16.999		
TOXIC INORGANICS								
114 Antimony	<0.002		0.025	0.003	<0.002		<0.002	
115 Arsenic	<0.003		<0.003		0.011	0.116	<0.003	
117 Beryllium								
118 Cadmium	<0.003		<0.003		0.003	0.032	<0.003	
119 Chromium	<0.02		<0.02		0.129	1.36	<0.02	
120 Copper	0.01	0.0014	0.024	0.003	1.06	11.17	<0.003	
122 Lead	0.018	0.0026	<0.01		0.116	1.22	<0.01	
123 Mercury	<0.001		<0.001		0.006	0.063	0.001	0.0001
124 Nickel	<0.025		<0.025		0.575	6.06	<0.025	
125 Selenium	<0.003						<0.003	

*Not included in Total Toxic Organics figure

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	Raw		Scrubber		Effluent		Raw	
Flow (l/hr)	6000		4500		439110		6000	
Duration (hrs)	24		24		24		24	
Sample ID No.	3251		3250		3252		3255	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	<0.002		<0.002		0.008	0.084	<0.002	
127 Thallium	<0.02		<0.02		<0.02		<0.02	
128 Zinc	0.006	0.0009	0.021	0.002	0.088	0.93	0.004	0.006
Total Toxic Inorganics	0.034	0.0049	0.07	0.008	2.0	21.04	0.005	0.0061
NON-CONVENTIONAL POLLUTANTS								
Aluminum								
Barum								
Boron								
Calcium								
Cobalt								
Gold								
Iron								
Magnesium								
Manganese								
Molybdenum								
Palladium								
Platinum								
Sodium								
Tellurium								
Tin								
Titanium								
Vanadium								
Yttrium								
Phenols	0.01	0.0014	<0.3	0.113	<0.013		<0.01	
Total Organic Carbon	3	0.432	34	3.67	11	115.9		
Fluoride	215	30.96	39	4.21	34	358.3		
CONVENTIONAL POLLUTANTS								
Oil & Grease	<1.0		<1		1.24	13.07		
Total Suspended Solids	1	0.144	15	1.62	52	548.0		
Biochemical Oxygen Demand								
pH								

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	Scrubber		[redacted]		Raw		Scrubber	
Flow (l/hr)	4500		439110		6000		4500	
Duration (hrs)	24		24		24		24	
Sample ID No.	3254		3256		3259		3258	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene								
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane								
13 1,1-Dichloroethane								
23 Chloroform								
24 2-Chlorophenol								
25 1,2-Dichlorobenzene								
26 1,3-Dichlorobenzene								
27 1,4-Dichlorobenzene								
29 1,1-Dichloroethylene								
31 1,2-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene								
39 Fluoranthene								
44 Methylene Chloride								
51 Chlorodibromomethane								
55 Naphthalene								
57 2-Nitrophenol								
58 4-Nitrophenol								
65 Phenol								
66 Bis(2-ethylhexyl)phthalate								
67 Butyl benzyl phthalate								
68 Di-N-Butyl phthalate								
69 Di-N-Octyl phthalate								
70 Diethyl Phthalate								
85 Tetrachloroethylene								
86 Toluene								
87 Trichloroethylene								
121 Cyanide*	0.006	0.0006	<0.005		<0.005		<0.005	
Total Toxic Organics								
TOXIC INORGANICS								
114 Antimony	0.028	0.003	<0.02		<0.02		0.02	0.002
115 Arsenic	<0.003		0.017	0.179	<0.003		<0.003	
117 Beryllium								
118 Cadmium	<0.003		<0.003		<0.003		<0.003	
119 Chromium	<0.02		0.116	1.22	0.02	0.003	<0.02	
120 Copper	0.026	0.003	1.333	14.05	<0.003		0.024	0.003
122 Lead	<0.01		0.04	0.422			<0.01	
123 Mercury	0.003	0.003	0.001	0.011	<0.01		<0.001	
124 Nickel	<0.025		0.355	3.74	<0.025		<0.025	
125 Selenium					<0.003			

*Not included in Total Toxic Organics figure

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	Scrubber		Effluent		Raw		Scrubber	
Flow (l/hr)	4500		439110		6000		4500	
Duration (hrs)	24		24		24		24	
Sample ID No.	3254		3256		3259		3258	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	<0.002		0.002	0.021	<0.002		<0.002	
127 Thallium	<0.02		<0.02		<0.02		<0.02	
128 Zinc	0.012	0.001	0.016	0.169	<0.001		0.01	0.001
Total Toxic Inorganics	0.07	0.007	1.88	19.81	0.02	0.003	0.054	0.006
NON-CONVENTIONAL POLLUTANTS								
Aluminum								
Barum								
Boron								
Calcium								
Cobalt								
Gold								
Iron								
Magnesium								
Manganese								
Molybdenum								
Palladium								
Platinum								
Sodium								
Tellurium								
Tin								
Titanium								
Vanadium								
Yttrium								
Phenols	0.428	0.046	0.012	0.126	0.026	0.0037	0.436	0.047
Total Organic Carbon								
Fluoride								
OTHER POLLUTANTS								
Oil & Grease								
Total Suspended Solids								
Biochemical Oxygen Demand								
pH								

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	GaAs		Effluent		Effluent		City Water	
Flow (l/hr)			439110*		439110*		439110*	
Duration (hrs)	24		24		24		24	
Sample ID No.	3267		41-33-FE1		41-33-FE2		41-33-CW1	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene	<0.01						0.015	0.158
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane	<0.01		3.0	31.62				
13 1,1-Dichloroethane								
23 Chloroform	0.012		0.015	0.158			0.025	0.263
24 2-Chlorophenol								
25 1,2-Dichlorobenzene			0.185	1.95	0.605	6.376		
26 1,3-Dichlorobenzene	<0.01							
27 1,4-Dichlorobenzene	<0.01							
29 1,1-Dichloroethylene			0.015	0.158				
31 1,2-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene	0.019		0.005	0.053				
39 Fluoranthene								
44 Methylene Chloride	0.220		1.00	10.54				
51 Chlorodibromomethane			0.005	0.053			0.005	0.053
55 Naphthalene								
57 2-Nitrophenol					0.105	1.107		
58 4-Nitrophenol								
65 Phenol			0.225	2.37	0.605	6.376		
66 Bis(2-ethylhexyl)phthalate	<0.01		0.008	0.084	0.009	0.095	0.475	5.006
67 Butyl benzyl phthalate	<0.01							
68 Di-N-Butyl phthalate	<0.01		0.006	0.063				
69 Di-N-Octyl phthalate	<0.01							
70 Diethyl Phthalate	<0.01							
85 Tetrachloroethylene	<0.01		0.80	8.43				
86 Toluene	<0.01							
87 Trichloroethylene			0.01	0.105				
121 Cyanide**								
Total Toxic Organics	0.251		5.27	55.58	1.324	13.95	0.52	5.48
TOXIC METALS								
114 Antimony	<0.002		<0.10				<0.02	
115 Arsenic	<0.003		0.067	0.706			<0.01	
117 Beryllium			<0.015				<0.015	
118 Cadmium	<0.003		0.004	0.042			0.002	0.021
119 Chromium	<0.02		0.265	2.79			<0.05	
120 Copper	0.003		1.230	12.96			0.28	2.95
122 Lead	<0.01		0.095	1.001			<0.05	
123 Mercury	<0.001		0.051	0.537			0.038	0.40
124 Nickel	<0.025		0.205	2.16			<0.05	
125 Selenium			<0.01				<0.01	

*Estimated Flow Rate

**Not included in Total Toxic Organics figure

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	GaAs		Effluent		Effluent		City Water	
Flow (l/hr)			439110*		439110*		439110*	
Duration (hrs)	24		24		24		24	
Sample ID No.	3267		41-33-FE1		41-33-FE2		41-33-CW1	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	<0.002		<0.015				<0.015	
127 Thallium	<0.02		<0.002				<0.002	
128 Zinc	0.002		0.093	0.98			0.755	7.96
Total Toxic Inorganics	0.005		2.01	21.18			1.075	11.33
NON-CONVENTIONAL POLLUTANTS								
Aluminum								
Barum								
Boron								
Calcium								
Cobalt								
Gold								
Iron								
Magnesium								
Manganese								
Molybdenum								
Palladium								
Platinum								
Sodium								
Tellurium								
Tin								
Titanium								
Vanadium								
Yttrium								
Phenols								
Total Organic Carbon			14.7	154.9			3.70	38.99
Fluoride								
CONVENTIONAL POLLUTANTS								
Oil & Grease								
Total Suspended Solids			39.0	411.0			<0.01	
Biochemical Oxygen Demand			51.0	537.5			41.0	432.1
pH			9.6				8.2	

*Estimated Flow Rate

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	[redacted]	
Flow (l/hr)	439110	
Duration (hrs)	24	
Sample ID No.	3266	
	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS		
4 Benzene		
7 Chlorobenzene		
8 1,2,4-Trichlorobenzene		
11 1,1,1-Trichloroethane		
13 1,1-Dichloroethane		
23 Chloroform		
24 2-Chlorophenol		
25 1,2-Dichlorobenzene		
26 1,3-Dichlorobenzene		
27 1,4-Dichlorobenzene		
29 1,1-Dichloroethylene		
31 1,2-Dichlorophenol		
37 1,2-Diphenylhydrazine		
38 Ethylbenzene		
39 Fluoranthene		
44 Methylene Chloride		
51 Chlorodibromomethane		
55 Naphthalene		
57 2-Nitrophenol		
58 4-Nitrophenol		
65 Phenol		
66 Bis(2-ethylhexyl)phthalate		
67 Butyl benzyl phthalate		
68 Di-N-Butyl phthalate		
69 Di-N-Octyl phthalate		
70 Diethyl Phthalate		
85 Tetrachloroethylene		
86 Toluene		
87 Trichloroethylene		
121 Cyanide*	0.009	0.095
Total Toxic Organics		
TOXIC INORGANICS		
114 Antimony	<0.002	
115 Arsenic	0.018	0.190
117 Beryllium		
118 Cadmium	<0.003	
119 Chromium	0.098	1.03
120 Copper	0.558	5.88
122 Lead	0.048	0.506
123 Mercury	0.001	0.011
124 Nickel	0.03	0.316
125 Selenium		

*Not included in Total Toxic Organics figure

TABLE 5-14 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 41061

Stream Description	Effluent	
Flow (l/hr)	439110	
Duration (hrs)	24	
Sample ID No.	3266	
	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)		
126 Silver	0.002	0.021
127 Thallium	<0.02	
128 Zinc	0.012	0.126
Total Toxic Inorganics	0.767	8.08
NON-CONVENTIONAL POLLUTANTS		
Aluminum		
Barum		
Boron		
Calcium		
Cobalt		
Gold		
Iron		
Magnesium		
Manganese		
Molybdenum		
Palladium		
Platinum		
Sodium		
Tellurium		
Tin		
Titanium		
Vanadium		
Yttrium		
Phenols		
Total Organic Carbon		
Fluoride		
CONVENTIONAL POLLUTANTS		
Oil & Grease		
Total Suspended Solids		
Biochemical Oxygen Demand		
pH		

TABLE 5-15

SEMICONDUCTOR PROCESS WASTES
PLANT 42044

Stream Description	Recycle		Effluent		Recycle		Effluent	
Flow (l/hr)	34505		40504		33774		36907	
Duration (hrs)	24		24		24		24	
Sample ID No.	3668		3671		3672		3673	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS								
4 Benzene								
7 Chlorobenzene								
8 1,2,4-Trichlorobenzene								
11 1,1,1-Trichloroethane			0.003	0.0029				
13 1,1-Dichloroethane								
23 Chloroform	0.006	0.005	0.013	0.013	0.005	0.004	0.004	0.0035
24 2-Chlorophenol			0.003	0.0029				
25 1,2-Dichlorobenzene	0.009	0.007	0.047	0.046	0.001	0.0008	0.040	0.035
26 1,3-Dichlorobenzene							0.005	0.004
27 1,4-Dichlorobenzene	<0.01				<0.01		<0.01	
29 1,1-Dichloroethylene								
31 1,2-Dichlorophenol								
37 1,2-Diphenylhydrazine								
38 Ethylbenzene								
39 Fluoranthene								
44 Methylene Chloride	0.101	0.084	0.056	0.054	0.049	0.040	0.044	0.039
51 Chlorodibromomethane								
55 Naphthalene	0.006	0.005					0.120	0.106
57 2-Nitrophenol	0.002	0.0017	0.013	0.013			0.006	0.005
58 4-Nitrophenol								
65 Phenol	0.011	0.009	0.195	0.190			0.180	0.159
66 Bis(2-ethylhexyl)phthalate	0.002	0.0017	0.07	0.068	0.011	0.009	0.007	0.006
67 Butyl benzyl phthalate								
68 Di-N-Butyl phthalate	0.004	0.003	0.05	0.049	0.003	0.002	0.005	0.004
69 Di-N-Octyl phthalate								
70 Diethyl Phthalate								
85 Tetrachloroethylene			0.005	0.0049			0.015	0.013
86 Toluene	0.002	0.0017	0.002	0.0019	0.002	0.0016	0.002	0.002
87 Trichloroethylene								
121 Cyanide*	0.030	0.025	0.030	0.029	0.005	0.0041	0.008	0.0071
Total Toxic Organics	0.143	0.118	0.457	0.446	0.071	0.057	0.428	0.377
TOXIC INORGANICS								
114 Antimony	<0.001		<0.005 I		<0.001		0.001	0.009
115 Arsenic	0.003	0.0025	0.046	0.045	0.002	0.0016	0.006	0.005
117 Beryllium	<0.001		<0.001		<0.001		<0.001	
118 Cadmium	<0.002		0.003	0.003	<0.002		0.003	0.0027
119 Chromium	<0.001		0.152	0.15	0.005	0.004	0.154	0.136
120 Copper	<0.002		0.022	0.021	0.004	0.003	0.011	0.01
122 Lead	<0.04		0.052	0.051	<0.04		<0.04	
123 Mercury	<0.001		<0.011		<0.001		<0.001	
124 Nickel	<0.005		0.009	0.0087	<0.005		0.012	0.011
125 Selenium	0.003	0.0025	0.175 I	0.170	0.001	0.0008	0.032	0.028

*Not included in Total Toxic Organics figure

TABLE 5-15 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 42044

Stream Description	Recycle		Effluent*		Recycle		Effluent*	
Flow (l/hr)	34505		40504		33774		36907	
Duration (hrs)	24		24		24		24	
Sample ID No.	3668		3671		3672		3673	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)								
126 Silver	<0.001		0.007	0.007	<0.001		0.002	0.0018
127 Thallium	<0.001		0.001	0.001	<0.001		<0.001	
128 Zinc	0.157	0.13	0.025	0.024	0.006	0.005	0.019	0.017
	0.218		0.499		0.07	0.057	0.283	
Total Toxic Inorganics	0.163	0.135	0.492	0.481	0.018	0.014	0.24	0.221
NON-CONVENTIONAL POLLUTANTS								
Aluminum	0.066	0.055	0.744	0.72	0.10	0.08	0.603	0.53
Barium	0.003	0.0025	0.057	0.055	0.004	0.003	0.048	0.04
Boron	0.264	0.219	0.922	0.90	0.046	0.037	0.695	0.62
Calcium	<0.005		38.6		0.013		33	
Cobalt	<0.05		<0.052		0.062	0.05	0.081	0.72
Gold	0.002	0.0017	0.02 I	0.019				
Iron	0.138	0.114	0.382	0.37	0.047	0.038	0.207	0.18
Magnesium	<0.025		10.3		0.036		9.54	
Manganese	<0.001		0.007	0.0068	0.001	0.0008	0.004	0.0035
Molybdenum	<0.035		<0.037		<0.035		0.062	0.055
Palladium	<0.003		<0.003					
Platinum	<0.01		<0.01					
Sodium	<1.5		1860		3.35		1090	
Tellurium	0.008	0.0066	0.004	0.0039				
Tin	<0.025		0.036	0.035	<0.025		<0.025	
Titanium	<0.002		<0.002		<0.002		0.005	0.004
Vanadium	<0.001		<0.002		0.002	0.0016	0.005	0.004
Yttrium	<0.003		<0.004		<0.003		<0.003	
Lithium	<0.001		0.075	0.073				
Phenols	<0.001		0.023	0.022	<0.001		0.004	0.0035
Total Organic Carbon	3.0	2.48	33	32.1	12.0	9.73	53.0	46.95
Fluoride	4.80	3.97	46.0	44.72	4.10	3.32	46.0	40.75
CONVENTIONAL POLLUTANTS								
Oil & Grease	<1.0		<1.0		<1.0		<1.0	
Total Suspended Solids	4.0	3.3	17	16.5	3.0	2.43	14.0	12.4
Biochemical Oxygen Demand	<1.0		<1.0		<1.0		12.4	10.98
pH								

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TABLE 5-15 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 42044

Stream Description	Recycle		LCD Raw Waste		Effluent	
Flow (l/hr)	30001		7319		34533	
Duration (hrs)	24		24		24	
Sample ID No.	3674		3669		3675	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC ORGANICS						
4 Benzene			<0.01			
7 Chlorobenzene						
8 1,2,4-Trichlorobenzene						
11 1,1,1-Trichloroethane			<0.01		0.130	0.108
13 1,1-Dichloroethane						
23 Chloroform	0.004	0.003	<0.01		0.010	0.008
24 2-Chlorophenol					0.012	0.010
25 1,2-Dichlorobenzene	0.002	0.001			0.033	0.027
26 1,3-Dichlorobenzene			<0.01		0.005	0.004
27 1,4-Dichlorobenzene	<0.01		<0.01		<0.01	
29 1,1-Dichloroethylene						
31 1,2-Dichlorophenol						
37 1,2-Diphenylhydrazine						
38 Ethylbenzene						
39 Fluoranthene						
44 Methylene Chloride	0.067	0.048	0.040	0.007	0.070	0.058
51 Chlorodibromomethane						
55 Naphthalene						
57 2-Nitrophenol					0.011	0.009
58 4-Nitrophenol						
65 Phenol	0.001	0.0004			0.180	0.149
66 Bis(2-ethylhexyl)phthalate	0.012	0.0086	0.010	0.0018	0.020	0.0166
67 Butyl benzyl phthalate.						
68 Di-N-Butyl phthalate	0.006	0.004	<0.01		0.004	0.003
69 Di-N-Octyl Phthalate						
70 Diethyl Phthalate			<0.01			
85 Tetrachloroethylene					0.001	0.0008
86 Toluene	0.002	0.0014	<0.01			
87 Trichloroethylene						
121 Cyanide*	<0.001		0.017	0.003	0.004	0.0033
Total Toxic Organics	0.094	0.066	0.050	0.0088	0.476	0.393
TOXIC INORGANICS						
114 Antimony	0.001	0.007	<0.001		<0.001	
115 Arsenic	<0.01 I		0.004	0.0007	0.12	0.10
117 Beryllium	<0.001		<0.001		<0.001	
118 Cadmium	<0.002		<0.002		0.003	0.0025
119 Chromium	<0.001		0.029	0.005	0.205	0.170
120 Copper	<0.002		0.003	0.0005	0.012	0.01
122 Lead	<0.04		<0.04		0.049	0.041
123 Mercury	<0.001		<0.001		<0.001	
124 Nickel	<0.005		<0.005		0.009	0.0075
125 Selenium	<0.001		<0.001		0.046	0.038

*Not included in Total Toxic Organics figure

TABLE 5-15 (CONT)

SEMICONDUCTOR PROCESS WASTES
PLANT 42044

Stream Description	Recycle		LCD Raw Waste		Effluent	
Flow (l/hr)	30001		7319		34533	
Duration (hrs)	24		24		24	
Sample ID No.	3674		3669		3675	
	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day	Concentration mg/l	Mass Load kg/day
TOXIC INORGANICS (CONT)						
126 Silver	<0.001		0.001	0.0002	<0.001	
127 Thallium	<0.001		<0.001		<0.001	
128 Zinc	<0.001		0.008	0.0014	0.01	0.008
Total Toxic Inorganics	0.001	0.0007	0.044	0.0078	0.445	0.287
NON-CONVENTIONAL POLLUTANTS						
Aluminum	0.053	0.038	0.038	0.0067	0.895	0.74
Barium	0.002	0.0014	0.006	0.001	0.048	0.0398
Boron	0.172	0.12	0.499	0.088	0.753	0.62
Calcium	<0.005		0.124		35	
Cobalt	<0.05		<0.05		0.058	0.048
Gold						
Iron	0.023	0.017	0.028	0.0049	0.352	0.29
Magnesium	<0.025		<0.025		9.98	
Manganese	<0.001		0.002	0.0004	0.005	0.004
Molybdenum	<0.035		<0.035		0.042	0.035
Palladium						
Platinum						
Sodium	1.5		3.24		1030	
Tellurium						
Tin	<0.025		<0.025		0.027	0.022
Titanium	<0.002		<0.002		0.005	0.004
Vanadium	<0.001		<0.001		0.006	0.005
Yttrium	<0.003		<0.003		<0.003	
Lithium						
Phenols	0.005	0.0036	0.006	0.001	0.002	0.0017
Total Organic Carbon	2.0	1.44	109.0	19.1	46.0	38.12
Fluoride	5.8	4.18	0.17	0.03	64.5	53.46
CONVENTIONAL POLLUTANTS						
Oil & Grease	1.2	0.86	4.0	0.70	1.0	0.83
Total Suspended Solids	1.0	0.72	5.0	0.88	11.0	9.117
Biochemical Oxygen Demand	1.4	1.01	15.0	2.6	10.2	8.45
pH						

TABLE 5-16

SEMICONDUCTOR SUBCATEGORY
TTO* ANALYSIS-INDIVIDUAL PROCESS STREAMS
AND ASSOCIATED EFFLUENT STREAMS

Plant	Process Stream	Rinse Concentration TTO (mg/l)	Effluent Concentration TTO (mg/l)
04294	Photoresist Developing	0.085	
	Etching	<0.01	245.272
	Photoresist Stripping	0.021	
41061	Oxide Etching	0.034	
	Photoresist Stripping	<0.01	1.613
	Metal Etching	0.066	
	Cleaning	<0.01	
02040	Polishing & Wax Removal	0.105	2.152

* Total Toxic Organics.

TABLE 5-18
ELECTRONIC CRYSTALS
SUMMARY OF RAW WASTE DATA

	Toxic Organics Parameter	Plant Practicing Solvent Management mg/1	Plant Not Practicing Solvent Management mg/1
8	1,2,4-trichlorobenzene	ND	3.66
11	1,1,1-trichloroethane	0.170	ND
25	1,2-dichlorobenzene	ND	132.6
26	1,3-dichlorobenzene	ND	1.96
27	1,4-dichlorobenzene	ND	52.6
37	1,2-diphenylhydrazine	0.014	ND
55	naphthalene	0.038	ND
68	di-n-butyl phthalate	ND	0.046
78	anthracene	0.015	ND
85	tetrachloroethylene	ND	1.4
87	trichloroethylene	ND	0.02
	TOTAL TOXIC ORGANICS	0.237	192.286

ND - not detected

Toxic Metals	Min. Conc. mg/1	Max. Conc. mg/1	Mean Conc. mg/1
Antimony	<0.001	0.91	0.122
Arsenic*	1.75	3.03	2.39
Beryllium	<0.001	0.001	<0.001
Cadmium	<0.005	0.040	0.009
Chromium†	0.008	6.95	0.948
Copper†	0.024	7.92	1.23
Lead	0.004	0.308	0.085
Mercury	<0.001	0.001	<0.001
Nickel†	<0.025	2.74	0.454
Selenium	<0.002	0.129	0.016
Silver	<0.005	0.025	0.005
Thallium	<0.001	0.050	0.008
Zinc†	0.040	4.23	0.654
Conventional Pollutants			
Oil and Grease	8.0	94	31.5
Total Suspended Solids	7.0	2900	616
Biochemical Oxygen Demand	4	27	19
Non-Conventional Pollutants			
Fluoride	28	378	129.7

these seem to be multiple plants

* Data for arsenic are from plants producing gallium arsenide crystals.
† These metals are associated with metal finishing operations.

used this data ... they used it in summary table 5-18

TABLE 5-19

RESULTS OF WASTEWATER ANALYSIS
PLANT 301

TYPE OF PRODUCTION: GROWING QUARTZ RODS; PREPARATION OF BLANK QUARTZ CRYSTAL WAFERS

Concentrations mg/l

Pollutant	Final Discharge Point 1	Cutting and Lapping Point 2*
Flow, l/day	18,900	200
Classicals		
pH	9.6	7.8
Suspended Solids	36	320
Oil and Grease	94	20%
TOC	2.6	7600
BOD	27	25
Fluoride	44	3.3
Priority Metals (>0.1 mg/l)		
antimony	-	0.20
copper	-	0.63
nickel	-	0.14
zinc	0.64	-
Priority Organics (>0.01 mg/l)		
2,4 dinitrophenol	-	0.187
4,6 dinitro-o-cresol	-	0.070
pentachlorophenol	-	0.016
n-nitrosodiphenylamine	-	0.051
bis(2-ethylhexyl) phthalate	-	0.011
anthracene	0.015	0.048
fluorene	-	0.013
benzene	-	0.029
1,1,1-trichloroethane	0.170	0.035
chloroform	-	0.190
methylene chloride	-	0.360
1,2-diphenylhydrazine	0.014	-
naphthalene	0.038	-

- Indicates less than 0.1 mg/l for priority metals and less than 0.01 mg/l for priority organics.

* This sample includes oily waste that is hauled.

TABLE 5-20

RESULTS OF WASTEWATER ANALYSIS
PLANT 304

TYPE OF PRODUCTION: FABRICATION OF QUARTZ WAFERS FROM PURCHASED RODS; ASSEMBLY OF ELECTRONIC DEVICES

CONCENTRATIONS mg/l

Pollutant	Influent Settling Tanks Point 1	Influent Settling Tanks Point 2	Discharge Point 3
Flow l/day	28,400	28,400	56,800
Classicals			
pH	6.3	6.3	5.9
Suspended Solids	2000	3400	2900
Oil and Grease	41		
TOC	460	NA	350
BOD	5	3	6
Fluoride	30	1.2	120
Priority Metals (>0.1 mg/l)		NA	
chromium	1.15		0.52
copper	-		7.9
lead	0.60		0.3
nickel	6.06		2.7
zinc	1.73		4.2
Priority Organics (>0.01 mg/l)		NA	
1,1,1-trichloroethane	1.40		0.140
1,1,2-trichloroethane	-		0.075
1.1-dichloroethylene	-		2.2
tetrachloroethylene	-		0.015
toluene	0.016		0.025
anthracene	-		0.014
methylene chloride	0.015		0.060

NA Not analyzed.
\- Indicates less than 0.1 mg/l for priority metals and less than 0.01 mg/l for priority organics.

TABLE 5-21

RESULTS OF WASTEWATER ANALYSIS
PLANT 380

TYPE OF PRODUCTION: FABRICATION OF QUARTZ CRYSTALS FROM RODS

	Concentration mg/l	
	Wafer Fabrication Point 2	Wash and Rinse Point 1
Pollutant Flow, l/day	10,500	4000
Classicals		
pH	3.0	7.6
Suspended Solids	1.2	577
Oil and Grease	8.4	9.6
TOC	5.4	47
BOD	NA	26
Priority Metals (>0.1 ug/l)		
copper	0.18	-
Priority Organics (>0.01 mg/l)		
1,2,4-trichlorobenzene	3.66	-
1,2-dichlorobenzene	132.6	1.44
1,3-dichlorobenzene	1.96	0.014
1,4-dichlorobenzene	52.6	0.049
methylene chloride	-	0.026
di-n-butyl phthalate	0.046	-
tetrachloroethylene	1.4	0.040
trichloroethylene	0.02	-
1,2-dichloroethane	-	0.40
1,1,1-trichloroethane	-	0.32
bis(2-ethylhexyl)phthalate	-	0.077

\- Indicates less than 0.1 mg/l for priority metals and less than 0.01 mg/l for priority organics.

TABLE 5-22
RESULTS OF ANALYSIS PLANT 401
CONCENTRATIONS mg/l

TYPE OF PRODUCTION: GROWING GALLIUM GADOLINIUM GARNET CRYSTALS; FABRICATING GGG AND SAPPHIRE CRYSTALS

Pollutant	Slicing Waste Point 6	Buffing Waste Point 7	Neutralized Acid Point 3	Scrubber Waste Point 1
Flow, l/day:	19	42	91	11
Classicals				
pH	9.5	8.5	4.0	5.5
Suspended Solids	1200	2100	110	0.4
Oil and Grease	990	14	NA	NA
TOC	NA	NA	56	9.3
Fluoride	0.7	0.8	33	0.6
Priority Metals (>0.1 mg/l)				
copper	11.3	-	0.20	-
lead	0.40	0.17	0.13	-
nickel	0.28	-	0.27	0.12
zinc	0.78	-	-	-
Priority Organics (>0.01 mg/l)			NA	NA
2,4-dichlorophenol	0.230	-		
isophorone	0.130	-		
bis(2-ethylhexyl)phthalate	0.30	-		
di-n-butyl phthalate	0.140	0.023		
anthracene	0.018	-		
1,1,1-trichloroethane	0.089	-		
chloroform	0.013	-		
toluene	0.178	0.035		
methylene chloride	0.020	0.039		
Other Metals				
gallium	12	2	1.8	0.55
gadolinium	10	6	3.4	1.6
niobium	5	45	2.8	1.4
lithium	0.09	4.8	0.04	0.02

- Indicates less than 0.1 mg/l for priority metals and less than 0.01 mg/l for priority organics.
NA Not analyzed.

TABLE 5-23

RESULTS OF WASTEWATER ANALYSIS
PLANT 402

TYPE OF PRODUCTION: SYNTHESIS OF LIQUID CRYSTAL CHEMICALS, MANUFACTURE OF LIQUID CRYSTAL DEVICES

Concentrations mg/l

Pollutant	Glassware Cleaning Stream 1	Plant Effluent Stream 2
Flow, l/day:	22,700	151,400
Classicals		
pH	6.5	6.5
Oil and Grease	5.1	9.8
TOC	58	820
Fluoride	1.2	1.2
Priority Metals (>0.1 mg/l)		
lead	0.10	-
nickel	0.30	-
zinc	0.18	-
Priority Organics (>0.01 mg/l)		
none		

\- Indicates less than 0.1 mg/l for priority metals and less than 0.01 mg/l for priority organics.

TABLE 5-24
RESULTS OF ANALYSIS
PLANT 403
CONCENTRATIONS mg/l

TYPE OF PRODUCTION: MANUFACTURE OF INDIUM ARSENIDE, INDIUM ANTIMONIDE, AND BISMUTH TELLURIDE CRYSTALS

Pollutant	Composite (Streams 2, 3, 4, & 5)	Milling Stream 2	Slicing Stream 3	Polishing #1 Stream 4	Polishing #2 Stream 5	Rinse Stream 6
Flow, l/day:		114	4	114	114	1140
Classicals						
pH	NA	7.5	8.8	6.7	7.4	3.0
Suspended Solids	NA	14	40	49	18	4.0
Oil and Grease	NA	12	160	27	50	12
TOC	440	NA	NA	NA	NA	NA
Fluoride	NA	0.4	0.9	0.3	0.6	36
Priority Metals (>0.1 mg/l)						
antimony		1.18	187.5*	-	3.30	-
arsenic	-	0.27	-	0.22	0.11	0.32
copper	0.14	NA	NA	NA	NA	NA
nickel	0.11	NA	NA	NA	NA	NA
selenium	0.13	NA	NA	NA	NA	NA
Priority Organics (>0.01 mg/l)		NA	NA	NA	NA	NA
chloroform	0.040					
methylene chloride	0.050					
Other Metals	NA					
bismuth		0.36	0.23	-	-	-
indium		0.57	0.72	9.0	0.34	0.57
tellurium		3.20	17.7	0.12	0.12	0.17

\- Indicates less than 0.1 mg/l for priority metals and less than 0.01 mg/l for priority organics.
NA Not analyzed.
* The high levels of antimony occur in the slicing machine coolant, which is recirculated, and then hauled for disposal.

SECTION 6

SUBCATEGORIES AND POLLUTANTS TO BE REGULATED, EXCLUDED OR DEFERRED

This section cites the E&EC subcategories which are being (1) regulated, (2) excluded from regulation, and (3) deferred for future study. In addition, this section explains, for those subcategories being regulated, which pollutants are being regulated and which pollutants are being excluded from regulation.

6.1 SUBCATEGORIES TO BE REGULATED

Based on wastewater characteristics presented in Section 5, discharge effluent regulations are being proposed for the Semiconductor and the Electronic Crystals subcategories.

6.1.1 Pollutants To Be Regulated

The specific pollutants selected for regulation in these subcategories are pH, total suspended solids, fluoride, total toxic organics, and arsenic. Arsenic is to be regulated only in the Electronic Crystals subcategory and only at facilities that produce gallium arsenide or indium arsenide crystals. Total suspended solids are also only to be regulated in the Electronic Crystals subcategory. The rationale for regulating these pollutants is presented below.

(pH) Acidity or Alkalinity

During semiconductor manufacture, alkaline wastes result from alkaline cleaning solutions; and during electronic crystal manufacture, alkaline wastes result from the use of hydroxides and carbonates from crystal growth and cleaning and rinsing operations. Acid wastes occur in both subcategories from the use of acids for cleaning and etching operations. The pH in the raw waste can range from 1.1 to 11.9 from these operations.

Although not a specific pollutant, pH is a measure of acidity or alkalinity of a wastewater stream. The term pH is used to describe the hydronium ion balance in water. Technically, pH is the negative logarithm of the hydrogen ion concentration. A pH of 7 indicates neutrality, a balance between free hydrogen and free hydroxyl ions. A pH above 7 indicates that the solution is alkaline, while a pH below 7 indicates that the solution is acidic.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and such corrosion can add constituents to drinking water such as iron, copper, zinc, cadmium, and lead. Low pH waters not only tend to dissolve metals from structures and fixtures, but also tend to redissolve or leach metals from sludges and bottom sediments. Waters with a pH above 9.9 can corrode certain metals, are detrimental to most natural organic materials, and are toxic to living organisms.

Total Suspended Solids

Suspended solids are found in wastewaters from electronic crystals manufacturers at an average concentration of 616 milligrams per liter. Suspended solids result from slicing, lapping, and grinding operations performed on the crystal. Some abrasives used for these operations may also enter the wastewaters.

Suspended solids increase the turbidity of water, reduce light penetration, and impair the photosynthetic activity of aquatic plants. Solids, when transformed to sludge deposit, may blanket the stream or lake bed and destroy the living spaces for those benthic organisms that would otherwise occupy the habitat.

Fluoride

Hydrofluoric acid is commonly used as an etchant in providing proper surface texture for application of other materials and creating depressions for dopants in device manufacture. Fluoride concentrations have been observed as high as 147 milligrams per liter in raw wastes from semiconductor manufacture, and as high as 378 milligrams per liter in raw wastes from electronic crystals manufacture.

Although fluoride is not listed as a priority pollutant, it can be toxic to livestock and plants, and can cause tooth mottling in humans. The National Academy of Sciences recommends: (1) two milligrams per liter as an upper limit for watering livestock and, (2) one milligram per liter for continuous use as irrigation water on acid soils to prevent plant toxicity and reduced crop yield. Although some fluoride in drinking water helps to prevent tooth decay, EPA's National Interim Primary Drinking Water Regulations set limits of 1.4 to 2.4 milligrams per liter in drinking water to protect against tooth mottling.

Arsenic

Arsenic is being regulated only in the Electronic Crystals subcategory and only at facilities that produce gallium arsenide or indium arsenide crystals. The manufacture of gallium arsenide and indium arsenide crystals generates arsenic wastes from slicing, grinding, lapping, etching, and cleaning operations. Concentrations in raw wastes from crystals manufacture have been observed as high as 80 milligrams per liter.

Certain compounds of arsenic are toxic to man both as poisons and as carcinogenic agents. The carcinogenic effects have only recently been discovered and little is known about the mechanism. Arsenic can be ingested, inhaled, or absorbed through the skin. The EPA 1980 water quality criterion for protection of aquatic life is 0.44 milligrams per liter.

Total Toxic Organics

Toxic organic pollutants were frequently found in wastewaters from semiconductor and electronic crystal facilities. The sources of these organics are solvent cleaning operations. The high concentrations observed (as high as 245 milligrams per liter) indicate probable dumping of solvent cleaning baths.

Because of the wide variety of solvents used in the manufacture of semiconductors and electronic crystals, and the subsequent large number of toxic organics found in process wastewaters, the Agency is proposing that total toxic organics (TTO) be used as the pollutant parameter for discharge limitations. TTO is the sum of the concentrations of toxic organics listed in Table 6-1 (which is found on page 6-4) and found at concentrations greater than 0.01 milligrams per liter. This recommendation is based on the fact that solvent discharges can be reduced to a minimum with good housekeeping practices and solvent management techniques.

TABLE 6-1
POLLUTANTS COMPRISING TOTAL TOXIC ORGANICS

Toxic Pollutant No.		Toxic Pollutant No.	
8	1,2,4-trichlorobenzene	54	isophorone
11	1,1,1-trichloroethane	55	naphthalene
21	2,4,6-trichlorophenol	57	2-nitrophenol
23	chloroform	58	4-nitrophenol
24	2-chlorophenol	64	pentachlorophenol
25	1,2-dichlorobenzene	65	phenol
26	1,3-dichlorobenzene	66	bis(2-ethylhexyl)phthalate
27	1,4-dichlorobenzene	67	butyl benzyl phthalate
29	1,1-dichloroethylene	68	di-n-butyl phthalate
31	2,4-dichlorophenol	78	anthracene
37	1,2-diphenylhydrazine	85	tetrachloroethylene
38	ethylbenzene	86	toluene
44	methylene chloride	87	trichloroethylene

6.2 TOXIC POLLUTANTS AND SUBCATEGORIES NOT REGULATED

The Settlement Agreement, explained in Section 2, contained provisions authorizing the exclusion from regulation, in certain circumstances, of toxic pollutants and industry categories and subcategories. These provisions have been rewritten in a Revised Settlement Agreement which was approved by the District Court for the District of Columbia on March 9, 1979, NRDC v. Costle, 12 ERC 1833.

6.2.1 Exclusion of Pollutants

One hundred and two toxic pollutants are being excluded from regulation for both the Semiconductor and Electronic Crystals subcategories. The basis for exclusion for eighty-nine of these pollutants is Paragraph 8(a)(iii) which allows exclusion for pollutants which are not detectable with state-of-the-art analytical methods. The basis of exclusion for another nine of these pollutants is also provided by Paragraph 8(a)(iii) which allows exlusion of pollutants which are present in amounts too small to be effectively reduced. Four toxic pollutants are being excluded from regulation because these polluants are already subject to effluent limitations and standards being promulgated under the Metal Finishing Category. This is permitted by Paragraph 8(a)(i).

In addition to the exclusion of the one hundred and two pollutants for both subcategories, another toxic pollutant is being excluded for the Semiconductor subcategory only. This pollutant is arsenic and is being excluded under Paragraph 8(a)(iii) because it was found in amounts too small to be effectively treated.

The nine toxic pollutants that are being excluded under Paragraph 8(a)(iii) are: antimony, beryllium, cadmium, mercury, selenium, silver, thallium, zinc, and cyanide.

The four toxic pollutants which are being excluded under Paragraph 8(a)(i) are as follows: nickel, copper, chromium, and lead.

The eighty nine pollutants which are being excluded under 8 (a)(iii) because they were not detected are presented in Table 6-2 on page 6-7.

6.2.2 Exclusion of Subcategories

All subcategory exclusions are based on either paragraph 8(a)(i), or Paragraph 8(a)(iv) of the Revised Settlement Agreement. Paragraph 8(a)(i) permits exclusion of a subcategory for which "equally or more stringent protection is already provided by an effluent, new source performance, or pretreatment standard or by an effluent limitation . . ." Paragraph 8(a)(iv) permits exclusion of a category or subcategory where "the amount and the toxicity of each pollutant in the discharge does not justify developing national regulations . . ." These exclusions are supported by data and information presented in Section 5.

Subcategories being excluded under Paragraph 8(a)(iv) are as follows: Resistors, Dry Transformers, Fuel Cells, Magnetic Coatings, Mica Paper, Carbon and Graphite Products, Fluorescent Lamps, and Incandescent Lamps.

Subcategories being excluded under Paragraph 8(a)(i) are as follows: Switchgear, Resistance Heaters, Ferrite Electronic Parts, Insulated Wire and Cable, Fixed Capacitors, Fluid Filled Capacitors, Transformers (Fluid Filled), Insulated Devices - Plastics and Plastic Laminated, and the subcategory of Motors, Generators, and Alternators.

6.3 CONVENTIONAL POLLUTANTS NOT REGULATED

BOD, fecal coliform, and oil and grease are not being regulated for either subcategory because they were found at concentrations below treatability. BOD was found at an average of 19 milligrams per liter in electronic crystals plants and 21 milligrams per liter in semiconductor plants; oil and grease was found at an average concentration of 31.5 milligrams per liter in electronic crystals plants and 4 milligrams per liter in semiconductor plants; and fecal coliform was not present in the process discharge from either subcategory.

Total suspended solids (TSS) is not being regulated in the case of semiconductors because it was found at an average concentration of 6.9 milligrams per liter which is below treatability.

6.4 SUBCATEGORIES DEFERRED

Two subcategories of the E&EC category are being deferred. These subcategories are Electron Tubes, and Phosphorescent Coatings.

The information currently available to the Agency for these subcategories is insufficient not only to make a determination of the need for regulation, but also to accurately describe the wastewater characteristics. Preliminary data indicate that the major pollutants found in the discharges from Electron Tubes are lead, cadmium, and chromium. For Phosphorescent Coatings, preliminary data indicate that the major pollutants are fluoride, cadmium, and zinc.

TABLE 6-2
Toxic Pollutants Not Detected

TOXIC POLLUTANT

1. Acenaphthene
2. Acrolein
3. Acrylonitrile
4. Benzene
5. Benzidine
6. Carbon Tetrachloride (Tetrachloromethane)
7. Chlorobenzene
9. Hexachlorobenzene
10. 1,2-Dichlorethane
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
22. p-Chloro-m-cresol
28. 3,3'-Dichlorobenzidine
30. 1,2-Trans-Dichloroethylene
32. 1,2-Dichloropropane
33. 1,3-Dichloropropylene(1,3-Dichloropropene)
34. 2,4-Dimethyl Phenol
35. 2,4-Dinitrotoluene
36. 2,6-Dinitrotoluene
39. Fluoranthene
40. 4-Chlorophenyl Phenyl Ether
41. 4-Bromophenyl Phenyl Ether
42. Bis(2-chloroisopropyl)ether
43. Bis(2-chloroethoxy)methane
45. Methyl Chloride(Chloromethane)
46. Methyl Bromide (Bromomethane)
47. Bromoform (Tribromomethane)
48. Dichlorobromomethane
49. Trichlorofluoromethane
50. Dichlorodifluoromethane
51. Chlorodibromomethane
52. Hexachlorobutadiene
53. Hexachlorocyclopentadiene
56. Nitrobenzene
59. 2,4-Dinitrophenol
60. 4,6-Dinitro-o-cresol
61. N-Nitrosodimethylamine
62 N-Nitrosodiphenylamine
63. N-Nitrosodi-n-propylamine
69. Di-n-octyl Phthalate
70. Diethyl Phthalate
71. Dimethyl Phthalate
72. 1,2-Benzanthracene [Benzo(a)anthracene]
73. Benzo(a)Pyrene (3,4-Benzopyrene)
74. 3,4-Benzofluoranthene [Benzo(b)fluoranthene]
75. 11,12-Benzofluoranthene [Benzo(k)fluoranthene]
76. Chrysene
77. Acenaphthylene
79. 1,12-Benzoperylene [Benzo(ghi)perylene]
80. Fluorene
81. Phenanthrene
82. 1,2,5,6-Dibenzathracene [Dibenzo(a,h)anthracene]
83. Indeno(1,2,3-cd)pyrene (2,3-O-Phenylenepyrene)
84. Pyrene
88. Vinyl Chloride (Chloroethylene)
89. Aldrin
90. Dieldrin

TABLE 6-2 (continued)

91. Chlordane
    (Technical Mixture and Metabolites)
92. 4,4'-DDT
93. 4,4'-DDE(P,P'-DDX)
94. 4,4'-DDD(P,P'-TDE)
95. Alpha-Endosulfan
96. Beta-Endosulfan
97. Endosulfan Sulfate
98. Endrin
99. Endrin Aldehyde
100. Heptachlor
101. Heptachlor Epoxide(BHC-Hexachloro-cyclohexane)
102. Alpha-BHC
103. Beta-BHC
104. Gamma-BHC(Lindane)
105. Delta-BHC
106. PCB-1242 (Aroclor 1242)
107. PCB-1254 (Aroclor 1254)
108. PCB-1221 (Aroclor 1221)
109. PCB-1232 (Aroclor 1232)
110. PCB-1248 (Aroclor 1248)
111. PCB-1260 (Aroclor 1260)
112. PCB-1016 (Aroclor 1016)
113. Toxaphene
116. Asbestos
129. 2,3,7,8-Tetrachlorodibenzo-p-dioxin(TCDD)

SECTION 7

CONTROL AND TREATMENT TECHNOLOGY

The wastewater pollutants of concern in the manufacture of semiconductors and electronic crystals, as identified in Section 6, are pH, suspended solids, fluoride, arsenic, and total toxic organics. A discussion of the treatment technologies currently practiced and most applicable for the reduction of these pollutants is presented below, followed by an identification of six treatment system options.

7.1 CURRENT TREATMENT AND CONTROL PRACTICES

Wastewater treatment techniques currently used in the semiconductor and electronic crystal industries include both in-process and end-of-pipe waste treatment. In-process waste treatment is designed to remove pollutants from contaminated manufacturing process wastewater at some point in the manufacturing process. End-of-pipe treatment is wastewater treatment at the point of discharge.

7.1.1 Semiconductor Subcategory

In-process Control -- In-process control techniques with widespread use in this subcategory are collection of spent solvents for resale or reuse, and treatment or contract hauling of the concentrated fluoride wastestream. Contract hauling, in this instance, refers to the industry practice of contracting a firm to collect and transport wastes for off-site disposal.

An estimated 75 percent of semiconductor facilities collect spent solvents for either contractor disposal or reclaim. Fifteen of 45 plants surveyed either treat or have contract-hauled the concentrated fluoride stream.

Rinse water recycle (as much as 85%) is practiced at three of the plants that were sampled. The pollutants present in the reused process wastewater are removed in the deionized water production area. Although reuse conserves water and decreases wastewater discharge, certain facilities have found recycle to result in frequent process upsets and subsequent product contamination. Because of these problems, the use of this technology on a nationwide basis is limited.

End-of-pipe treatment -- End-of-pipe controls consist primarily of neutralization which is practiced by all dischargers. One plant also uses end-of-pipe precipitation/clarification for control of fluoride.

7.1.2 Electronic Crystals Subcategory

In-Process Control -- In-plant control techniques similar to those in the Semiconductor subcategory are being practiced to some degree at most electronic crystals plants. These techniques primarily involve the segregation for contract hauling (or reclaiming) of specific wastes such as solvents and cutting oils.

An estimated 70 to 80 percent of the facilities practice solvent management, and these practices were observed at most of the plants visited. But at two small facilities, plant personnel indicated that unauthorized discharge of solvent wastes occurs. Sampling results verified this.

Of eight plants visited, two treat their concentrated fluoride stream; one has the fluoride waste contract hauled.

End-of-Pipe Treatment -- Treatment technologies currently being used at electronic crystals plants include neutralization and precipitation/clarification.. All six direct dischargers treat to control pH, suspended solids and fluoride. One direct discharger also treats end-of-pipe to reduce arsenic.

7.2 APPLICABLE TREATMENT TECHNOLOGIES

7.2.1 pH Control

Acids and bases are commonly used in the manufacture of semiconductors and electronic crystals and result in process waste streams exhibiting high or low pH values. Sodium hydroxide and sodium carbonate are used in some crystal growth processes and for caustic cleaning. Sulfuric, nitric and hydrofluoric acids are used for etching and acid cleaning operations.

Several methods can be used to treat acidic or basic wastes. Treatment is based upon chemical neutralization usually to pH 6-9. Methods include: mixing acidic and basic wastes, neutralizing high pH streams with acid or low pH streams with bases. The method of neutralization used is selected on a basis of overall cost. Process water can be treated continuously or on a batch basis. When neutralization is used in conjunction with precipitation of metals it may be necessary to use a batch method regardless of flow-rate.

Hydrochloric or sulfuric acid may be used to neutralize alkaline wastewaters; sulfuric acid is most often chosen because of its lower cost.

Sodium hydroxide (caustic soda), sodium carbonate (soda ash), or calcium hydroxide (lime) may be used to neutralize acidic wastewater. The factors considered in selection include price, neutralization rate, storage and equipment costs, and neutralization end products. Sodium hydroxide is more expensive than many other alkalis but is often selected due to its ease of storage, rapid reaction rate and the general solubility of its end product.

7.2.2 Fluoride Treatment

Fluoride appears in semiconductor and electronic crystals wastewater because of the use of hydrofluoric acid and ammonium bifluoride as etching and cleaning agents. Basically two options are available to reduce fluoride in wastewaters from these facilities: Chemical precipitation of fluoride followed by solids removal, or isolation for contract hauling of strong fluoride wastes.

The most usual treatment procedure practiced today in the United States for reducing the fluoride concentration in wastewater is precipitation by the addition of lime followed by clarification. Calcium fluoride is formed:

$$Ca(OH)_2 + 2F^- = CaF_2 + 2OH^-$$

The solubility of calcium fluoride in water is 7.8 mg fluoride ion per liter at 18°C. The precipitate forms slowly, requiring about 24 hours for completion and the solubility of calcium fluoride soon after its formation is about ten milligrams of fluoride per liter.

Data from the Semiconductor subcategory indicate that plants using precipitation and clarification treatment technologies are achieving an average effluent concentration of 14 milligrams per liter fluoride.

Hydroxide precipitation has proven to be an effective technique for removing many pollutants from industrial wastewater. Metal ions are precipitated as hydroxides and fluoride is precipitated as insoluble calcium fluoride. The system operates at ambient conditions and is well suited to automatic control. Lime is usually added as a slurry when used in hydroxide precipitation. The slurry must be kept well mixed and the addition lines periodically checked to prevent blocking, which may result from a buildup of solids. The use of hydroxide precipitation does produce sludge requiring disposal following precipitation.

The performance of a precipitation system depends on several variables. The most important factors affecting precipitation effectiveness are:

1. Addition of sufficient excess chemicals to drive the precipitation reaction to completion. If treatment chemicals are not present in slight excess concentrations, some pollutants will remain dissolved in the waste stream.

2. Maintenance of an alkaline pH throughout the precipitation reaction and subsequent settling.

3. Effective removal of precipitated solids.

Removal of suspended solids or precipitates by gravitational forces may be conducted in a settling tank, clarifier, or lagoon, but the performance of the unit is a function of the retention time, particle size and density, and the surface area of the sedimentation chamber. Accumulated sludge can then be removed either periodically or continuously as in the case of a clarifier.

The effectiveness of a solids settling unit can often be enhanced by the addition of chemical coagulants or flocculants which reduce the repulsive forces between ions or particles and allow them to form larger flocs which are then removed more easily. Commonly used coagulants include ferric sulfate and chloride; commonly used flocculants are organic polyelectrolytes.

An applicable technology for further reduction of fluoride is filtration of the waste stream following precipitation and clarification. Filtration is commonly used in water and wastewater treatment for the removal of finely suspended particles not removed by gravity separation.

A filtration unit commonly consists of a container holding a filter medium or combination of media such as sand or anthracite coal, through which is passed the liquid stream. The unit can operate by gravity flow or under pressure. Periodic backwashing or scraping of the media is necessary to remove particles filtered from the liquid stream and prevent clogging of the filter. The proper design of a filtration unit considers such criteria as filter flow rate (gpm/sq. ft.), media grain size, and density.

For the Electrical and Electronic Components category, the usefulness of filtration technology is questionable. An evaluation of the effectiveness of precipitation and clarification technologies in this industry has shown an average effluent concentration of approximately 14 milligrams per liter fluoride. Addition of a filtration unit would not further reduce the fluoride concentration significantly (only approximately three percent) since this level of fluoride is approximately what would be expected as dissolved calcium fluoride soon after the formation. Insoluble filterable calcium fluoride would probably constitute only a small fraction of the 14 milligrams per liter fluoride.

7.2.3 Arsenic Treatment

Arsenic is found in the wastewaters of plants fabricating crystals of gallium arsenide and indium arsenide. These wastes are produced when the crystals are sliced, lapped, and polished, in the form of powdered gallium arsenide or indium arsenide, and also when the crystals are etched. The aim of wastewater treatment for arsenic is to remove arsenic from the water in the form of an insoluble sludge, which may then be disposed of in a manner which keeps it permanently segregated from the environment.

Probably the most common technique used today for arsenic treatment, as discussed in the wastewater treatment literature, is alkaline precipitation with lime followed by clarification. This has been reported to reduce arsenic concentrations to the 1-10 milligrams per liter range. The addition of coagulants such as ferric sulfate or ferric chloride can further reduce the concentration of arsenic; levels of 0.05 milligrams per liter have been reported in the literature. Some additional removal can then be achieved using a filtration polishing step.

A general discussion of the technologies of precipitation, clarification and filtration was presented in the previous subsection dealing with the treatment of fluoride in wastewater. The use of filtration technology has not been demonstrated at any plant, in this industry and, as with fluoride, the technology would be expected to provide only minimal further reduction of arsenic in plant effluents.

7.2.4 Total Toxic Organics Treatment

The sources of toxic organics in the Semiconductor subcategory are solvents used for drying of wafers, developing photoresist, stripping of photoresist, and cleaning. In the Electronic Crystals subcategory, the source of toxic organics is the use of solvents for cleaning, degreasing and drying of crystals.

The primary technique in these industries for controlling the discharge of toxic organics is the segregation of spent solvents for contract hauling (disposal) or for sale to companies which purify the solvents in bulk for resale. This control technology of solvent management also includes good housekeeping practices such as controlling leaks and spills.

Data from the Semiconductor subcategory has indicated that the control technology of solvent management will control the discharge of total toxic organics. Figure 7-1 graphically presents total toxic organic concentrations of raw waste streams sampled at twelve semiconductor plants (reference Table 5-3). Those plants which were observed to have good solvent collection and disposal procedures had total organic discharge concentrations of 0.47 milligrams per liter or less. Some organic solvents and chemicals will be discharged as dragout on the rinsed wafer; however, the dragout concentrations of organics are minimal as evidenced by the low concentrations of total toxic organics discharged when effective collection and disposal is used. Those plants that were known to have a less effective procedure for solvent collection and disposal had total toxic organic concentrations of 1.6 milligrams per liter and greater.

To further point out the need for effective solvent management, Table 7-1 presents data from individual process streams and associated effluent streams sampled at two semiconductor facilities. Concentrations of total toxic organics in these streams range from less than 0.01 milligrams per liter to 0.085 milligrams per liter. The effluent streams sampled at the same plants for the same sampling period have total toxic organic concentrations of 1.613 and 245.3 milligrams per liter. If total toxic organic concentrations in the effluent streams were caused by dragout on the wafer and the carrier boat (i.e. process rinse streams), the value for total toxic organics in these streams would be much higher. Since this is not the case, toxic organics must be entering the effluent stream from direct solvent discharge.

TABLE 7-1
TTO ANALYSIS OF PROCESS STREAMS
AND EFFLUENT STREAMS

Plant 04294	TTO mg/l	Plant 41061	TTO mg/l
Develop Rinse	0.085	Oxide Rinse	0.034
Etch Rinse	<0.01	Resist Strip Rinse	<0.01
Resist Strip Rinse	0.021	Metal Etch Rinse	0.066
Effluent	245.3	Cleaning Solution Rinse	<0.01
		Effluent	1.613

Treatment of toxic organics from wastewater prior to discharge can be accomplished by the technology of carbon adsorption.

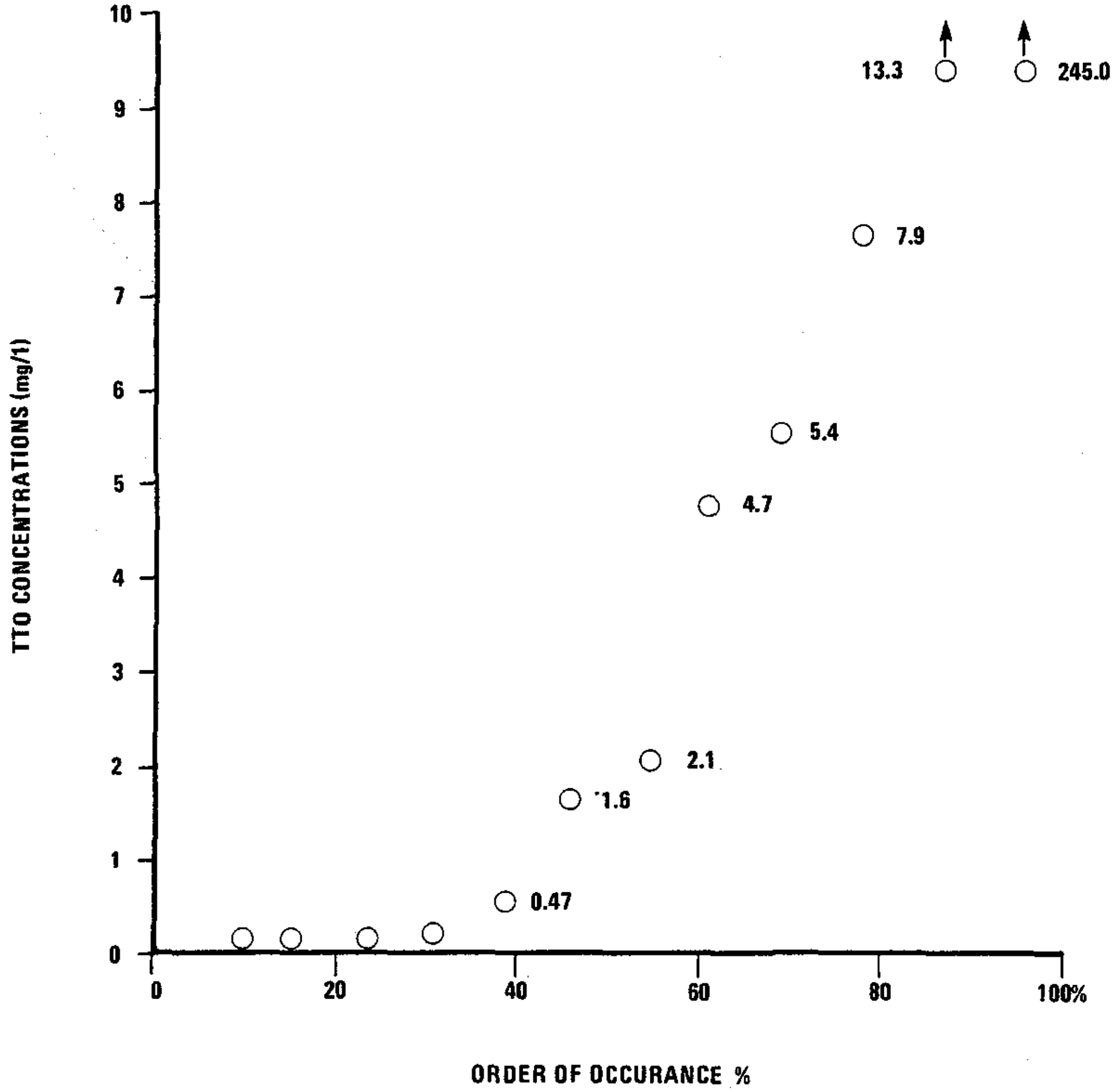

FIGURE 7-1 TOTAL TOXIC ORGANICS IN RAW WASTE AT TWELVE SEMICONDUCTOR PLANTS

Frequently used in advanced wastewater treatment, adsorption is a process in which soluble substances become chemically or physically bonded to a solid surface. In operation, wastewater, relatively free of suspended matter, is passed through a chamber containing activated carbon which has a high capacity for adsorbing organic substances from the stream. Once the capacity of the carbon is exhausted, it must be replaced or regenerated.

The effectiveness of carbon in removing specific organics varies and is dependent on molecular weight and polarity of the molecules, and on operating conditions such as contact time, temperature and carbon surface area. EPA isotherm tests have indicated that activated carbon is very effective in adsorbing 65 percent of the toxic organic pollutants and is reasonably effective for another 22 percent. However such treatment can only reduce any specific organic to between 0.05 and 0.1 milligrams per liter, and TTO for the E&EC category consists of the sum of more than 20 organic compounds. Therefore at plants practicing good solvent management, only minimal, if any, further reduction of TTO could be expected using activated carbon because at these plants the total of all toxic organics would only be 0.47 milligrams per liter.

7.3 TREATMENT AND CONTROL OPTIONS

For the purpose of establishing effluent limitations and evaluating the costs of wastewater treatment and control for the industry, the Agency considered the previously described technologies and identified the following six system options:

- Option 1: Neutralization for pH control and solvent management for control of toxic organics. Solvent management is not a treatment system, but rather an in-plant control which consists of minor piping modifications to collect used solvents for resale or contract disposal.
- Option 2: Option 1 plus end-of-pipe precipitation/clarification for treatment of arsenic, fluoride, and total suspended solids (TSS).
- Option 3: Option 1 plus in-plant treatment (precipitation/clarification) of the concentrated fluoride stream.
- Option 4: Option 2 plus recycle of the treated effluent stream to further reduce fluoride.
- Option 5: Option 2 plus filtration for reduction of fluoride, arsenic, and suspended solids.
- Option 6: Option 5 plus carbon adsorption to reduce toxic organic concentrations.

These options do not, in all cases, apply to both subcategories.

SECTION 8

SELECTION OF APPROPRIATE CONTROL AND TREATMENT TECHNOLOGIES AND BASES FOR LIMITATIONS

Proposed discharge regulations for the Semiconductor subcategory and the Electronic Crystals subcategory are presented in this section. The technology basis and the numerical basis are also presented for each regulation, in addition to the statistical methodology used to develop limitations.

8.1 SEMICONDUCTOR SUBCATEGORY

8.1.1 Best Practicable Control Technology Currently Available (BPT)

TABLE 8-1

PROPOSED BPT LIMITATIONS
SEMICONDUCTORS

Pollutant	Long-term Average (LTA) (mg/l)	30-day Average		Daily Maximum	
		VF	Limit (mg/l)	VF	Limit (mg/l)
pH in range 6-9					
Total Toxic Organics			*		0.47

* The Agency is not proposing 30-day limitations for reasons presented below.

EPA is proposing BPT based on Option 1 which consists of neutralization and solvent management. Solvent management is widely practiced and will reduce the amount of toxic organics presently being discharged by approximately 80,000 kilograms per year. For the approximately twenty-five percent (25%) of the facilities which do not already collect used solvents, compliance costs should be minimal because the solvents can be sold to reclaimers. Neutralization is practiced by all facilities subject to BPT and therefore facilities will not incur additional costs for compliance.

Option 2 was not selected because, in the Semiconductor subcategory, Option 3 can be substituted for and is also less expensive than Option 2. Fluoride in this industry is primarily generated from a particular process stream, hydrofluoric acid etching, and in-plant treatment eliminates the need for end-of-pipe treatment of all process wastewater as in Option 2. Option 3 was not selected because it is more appropriately reserved for consideration under BAT. Options 4, 5, and 6 were not selected for the reasons provided under the BAT discussion.

pH -- Properly operated end-of-pipe neutralization of wastewater will ensure discharges in the pH range of 6 to 9.

Total Toxic Organics (TTO) -- Sampling of wastewaters from the Semiconductor subcategory has indicated that the control technology of solvent management will control the discharge of total toxic organics. Data presented in Section 7 showed a distinct increase in TTO at plants not practicing good solvent management.

The Agency has used the data in Table 5-3 (p.5-13) as the basis for proposing BPT limitations for TTO. The daily maximum limit for TTO is thus being proposed at 0.47 milligrams per liter. This limit reflects the highest effluent concentration of TTO found at plants practicing solvent management. The Agency has chosen not to establish a 30-day average limitation primarily because solvent management is not a treatment technology and with proper solvent management effluent concentrations would not be expected to vary significantly from the daily maximum. For example, three days of effluent sampling at one plant practicing good solvent management showed TTO concentrations of 0.44, 0.40, and 0.47 milligrams per liter. In addition, no long-term monitoring data are available for toxic organics in this industry.

8.1.2 Best Available Technology Economically Achievable (BAT)

TABLE 8-2
PROPOSED BAT LIMITATIONS
SEMICONDUCTORS

Pollutant	LTA (mg/l)	30-day Average VF	30-day Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
Total Toxic Organics					0.47
Fluoride	14.5	1.2	17.4	2.2	32

For BAT, EPA is proposing limitations based on Option 3. This technology consists of neutralization and solvent management (Option 1) plus in-plant precipitation/clarification of the concentrated fluoride stream. Contract hauling of the concentrated fluoride stream is an acceptable alternative to treatment as a means of achieving compliance.

Option 4 (Option 1 plus end-of-pipe precipitation/clarification followed by a recycle of the treated effluent) was not selected because very few facilities have been able to solve serious operational problems associated with recycling. Therefore Option 4 is not demonstrated in this industry. However, facilities located in areas which experience water shortages are encouraged to investigate this technology option. Option 5 (Option 1 plus end-of-pipe precipitation/clarification followed by filtration) was not selected because it will only achieve a three (3) percent increase in fluoride reduction while at the same time significantly increasing treatment costs to the facilities. Option 6 (Option 5 plus carbon adsorption) was not selected because the vast majority of facilities practicing solvent management would not discharge treatable concentrations of toxic organics.

The bases for pH and total toxic organics (TTO) limitations were presented in Section 8.1.1. These limits do not change for BAT. The basis for fluoride limits is presented below.

Fluoride -- Proposed fluoride limitations are based on long term self-monitoring data submitted by one semiconductor facility (Plant 30167) utilizing a hydroxide precipitation/clarification system. A statistical analysis of daily concentrations of fluoride in the effluent was conducted to derive the long term average concentration and variability factors for use in establishing proposed limitations. The statistical methodology is presented in Section 8.3. Table 8-3 summarizes the analysis of the historical performance data.

TABLE 8-3
HISTORICAL PERFORMANCE DATA ANALYSIS OF EFFLUENT FLUORIDE WITH HYDROXIDE PRECIPITATION/CLARIFICATION SYSTEM

Number of Data Points	Average Concentration mg/l	Variability Factors Daily	Variability Factors 30-Day
281	14.5	2.2	1.2

8.1.3 Best Conventional Pollutant Control Technology (BCT)

TABLE 8-4

PROPOSED BCT LIMITATIONS
SEMICONDUCTORS

Pollutant	LTA (mg/l)	30-day Average VF	30-day Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
pH in range 6-9					

For BCT, EPA is proposing to regulate pH based on the BPT technology, because BPT achieves the maximum feasible control for pH. Since BPT is also the minimal level of control required, no possible application of the BCT cost test could result in BCT limitations more stringent than those proposed. There are no other conventional pollutants of concern in the Semiconductor subcategory as discussed in Section 6.

8.1.4 New Source Performance Standards (NSPS)

TABLE 8-5

PROPOSED NSPS LIMITATIONS
SEMICONDUCTORS

Pollutant	LTA (mg/l)	30-day Average VF	30-day Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
pH in range 6-9					
Total Toxic Organics					0.47
Fluoride	14.5	1.2	17.4	2.2	32

For NSPS, the Agency is proposing limitations based on solvent management, neutralization, and precipitation/clarification of the concentrated fluoride stream (Option 3). These technologies are equivalent to BAT for control of toxic organics and fluoride, and BCT for control of pH. Other options were not selected for reasons previously presented under BAT.

Proposed NSPS limitations are the same as those proposed for BAT with the inclusion of pH in the range of 6 to 9. The bases for those limitations were presented in Section 8.1.2.

8.1.5 Pretreatment Standards for New and Existing Sources (PSES and PSNS)

TABLE 8-6

PROPOSED PSES AND PSNS LIMITATIONS
SEMICONDUCTORS

Pollutant	LTA (mg/l)	30-day Average VF	30-day Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
Total Toxic Organics					0.47

For PSES and PSNS, the Agency is proposing TTO (total toxic organics) limitations based on solvent management. Since biological treatment at POTWs does not achieve removal equivalent to BAT for TTO, pass through occurs. Accordingly, EPA is proposing PSES and PSNS based on technology equivalent to BAT for reduction of TTO. The Agency is not proposing pretreatment standards for fluoride.

Proposed PSES and PSNS limitations are the same as those proposed for BPT/BAT except that pH is not regulated for pretreatment. The basis for TTO limitations was presented in Section 8.1.1.

8.2 ELECTRONIC CRYSTALS SUBCATEGORY

8.2.1 Best Practicable Control Technology Currently Available (BPT)

TABLE 8-7

PROPOSED BPT LIMITATIONS
ELECTRONIC CRYSTALS

Pollutant	LTA (mg/l)	30-day Average VF	30-day Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
pH in range 6-9					
Total Toxic Organics					0.47
Arsenic*	0.51	1.3	0.68	3.7	1.89
Total Suspended Solids	18.2	1.26	22.9	3.35	61.0
Fluoride	14.5	1.2	17.4	2.2	32

* Arsenic limitations are applicable only to producers of gallium arsenide and indium arsenide crystals.

EPA is proposing BPT based on Option 2. This technology consists of Option 1 (solvent management and end-of-pipe neutralization) plus end-of-pipe precipitation/clarification. These technologies control pH, toxic organics, total suspended solids (TSS), fluoride, and arsenic. With the exception of solvent management, these treatment technologies have already been installed at all electronic crystal facilities subject to BPT. Therefore, since facilities can sell used solvents to reclaimers, compliance with BPT should result in minimal or no costs.

Arsenic is only being regulated at facilities which manufacture gallium or indium arsenide crystals. Total toxic organic limitations, rather than limitations on each toxic organic pollutant, will be set for the same reasons explained under BPT for the Semiconductor subcategory.

Option 3 was not selected because this technology is an in-plant control for only one process stream, hydrofluoric acid etching, and as such, will not control all wastewater sources of arsenic and TSS.

Option 4 (Option 1 plus end-of-pipe precipitation/clarification followed by a recycle of the treated effluent) was not selected because very few facilities have been able to solve serious operational problems associated with recycling. Therefore Option 4 is not demonstrated in this industry. However, facilities located in areas which experience water shortages are encouraged to investigate this technology option. Option 5 (Option 1 plus end-of-pipe precipitation/clarification followed by filtration) was not selected for arsenic because the Agency has no data available to demonstrate that filtration will further reduce arsenic discharges. This option was also not selected for fluoride because, as previously stated under BAT for Semiconductors, filtration would only reduce fluoride by three percent while significantly increasing treatment costs to the facilities. Option 6 (Option 5 plus carbon adsorption) was not selected because the vast majority of facilities practicing solvent management would not discharge treatable concentrations of toxic organics.

The bases for pH, total toxic organics (TTO) and fluoride limitations were presented in Section 8.1. for the semiconductor subcategory. The bases for arsenic and suspended solids limitations are presented below.

Arsenic -- Only limited data are available from the Electronic Crystals subcategory for the treatment of arsenic-bearing wastes. Therefore, transfer of technology from the Non-Ferrous Metals industrial category is being used for proposing arsenic limitations.

The rationale for transferring technology from this industry is (1) the treatment technology used in the Non-Ferrous Metals industry for reduction of arsenic is the same as that proposed for electronic crystals, and (2) the raw waste arsenic concentrations (1-10 milligrams per liter) found in non-ferrous metals wastewater compare reasonably with those found in electronic crystals wastes.

Monitoring data were submitted from one non-ferrous metals plant using a lime precipitation/clarification treatment system to control arsenic discharge, the same technology as Option 2. Excluded from the data base were data where pH was less than 7.0 or TSS was greater than 50 milligrams per liter; data points where the treated value was greater than the raw value; and data points where the raw value was too low to ensure pollutant removal. A statistical analysis of daily concentrations of arsenic in the treated effluent was conducted to derive long-term average concentration and variability factors for use in proposing limitations. Table 8-8 summarizes the analysis of the monitoring data.

TABLE 8-8

HISTORICAL PERFORMANCE DATA ANALYSIS OF EFFLUENT ARSENIC WITH HYDROXIDE PRECIPITATION/CLARIFICATION

Number of Data Points	Long-Term Average	Variability Factors Daily	Variability Factors 30-Day
111	0.51	3.7	1.3

Total Suspended Solids -- Proposed TSS limitations in Table 8-6 represent a transfer of technology from the Metal Finishing industrial category. The rationale for transferring technology from this industry is (1) the raw waste TSS concentrations are similar to those found in electronic crystals wastes, (2) the treatment technology used for solids reduction in the metal finishing industry is the same as that proposed for electronic crystals, and (3) several electronic crystals facilities also conduct metal finishing operations.

The average effluent concentration of 18.2 milligrams per liter was derived from EPA sampling data from numerous metal finishing plants practicing solids removal by clarification technology. Excluded from the data base were effluent TSS concentrations greater than 50 milligrams per liter, since this represents a level above which no well-operated treatment plant in this industry should be operating. The variability factors of 1.26 and 3.35 each represent the median of variability factors from 17 metal finishing plants with long-term data.

8.2.2 Best Available Technology Economically Achievable (BAT)

TABLE 8-9

PROPOSED BAT LIMITATIONS ELECTRONIC CRYSTALS

Pollutant	LTA (mg/l)	30-day Average VF	30-day Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
Total Toxic Organics					0.47
Arsenic*	0.51	1.3	0.68	3.7	1.89
Fluoride	14.5	1.2	17.4	2.2	32

* Arsenic limitations are applicable only to producers of gallium arsenide and indium arsenide crystals.

For BAT, EPA is proposing limitations based on the BPT technology (Option 2). Option 3 was not selected for the same reason presented above. Options 4, 5, and 6 were not chosen for reasons explained under BPT (Section 8.2.1).

The bases for arsenic, fluoride, and total toxic organics (TTO) limitations were presented in Section 8.2.1 under BPT. These limitations do not change for BAT.

8.2.3 Best Conventional Pollutant Control Technology (BCT)

TABLE 8-10

PROPOSED BCT LIMITATIONS
ELECTRONIC CRYSTALS

Pollutant	LTA (mg/l)	30-day Average		Daily Maximum	
		VF	Limit (mg/l)	VF	Limit (mg/l)
pH in range 6-9					
Total Suspended Solids	18.2	1.26	22.9	3.35	61.0

For BCT, EPA is proposing to regulate pH and TSS based on the BPT technology. For pH, BPT is equal to BCT for the same reason discussed under the Semiconductor subcategory.

For TSS, the Agency considered the addition of filtration to BPT (Option 5), but rejected this technology option because of the minimal additional reduction of total suspended solids. Based on BPT, the average removal of TSS for each of the six(6) direct dischargers will be approximately 5400 kilograms per year. Filtration would only increase this amount by 100 kilograms per year (0.4 kgs/day) or by less than two percent (2%). Since there is no other technology option which would remove significant amounts of TSS, EPA is setting BCT equal to BPT. Accordingly there is no need to conduct the BCT cost test.

8.2.4 New Source Performance Standards (NSPS)

TABLE 8-11

PROPOSED NSPS LIMITATIONS
ELECTRONIC CRYSTALS

Pollutant	LTA (mg/l)	30-day Average		Daily Maximum	
		VF	Limit (mg/l)	VF	Limit (mg/l)
pH in range 6-9					
Total Toxic Organics					0.47
Arsenic*	0.51	1.3	0.68	3.7	1.89
Fluoride	14.5	1.2	17.4	2.2	32
Total Suspended Solids	18.2	1.26	22.9	3.35	61.0

* Arsenic limitations are applicable only to producers of gallium arsenide and indium arsenide crystals.

For NSPS, EPA is proposing limitations based on solvent management, neutralization, and end-of-pipe precipitation/clarification. These technologies are equivalent to BAT for toxic pollutants plus fluoride, and are equivalent to BPT/BCT for conventional pollutants. Other options were not selected for reasons presented under BAT.

Proposed NSPS discharge limitations for electronic crystals producers are the same as those proposed for BPT/BAT for toxic pollutants and fluoride and BPT/BCT for pH and suspended solids. The bases for those limitations are presented in Sections 8.2.1 and 8.2.3.

8.2.5 Pretreatment Standards for New and Existing Sources (PSNS and PSES)

TABLE 8-12

PROPOSED PSES AND PSNS LIMITATIONS
ELECTRONIC CRYSTALS

Pollutant	LTA (mg/l)	30-day Average VF	30-day Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
Total Toxic Organics					0.47
Arsenic*	0.51	1.3	0.68	3.7	1.89

* Arsenic limitations are applicable only to producers of gallium arsenide and indium arsenide crystals.

For PSES and PSNS, EPA is proposing limitations based on solvent management, neutralization, and end-of-pipe precipitation/clarification (Option 2) for the facilities which manufacture gallium or indium arsenide crystals. For facilities which only manufacture other types of crystals, PSES and PSNS are based on solvent management. Option 2 will control both toxic organics and arsenic, while solvent management will control toxic organics. Both TTO and arsenic will be removed to a greater extent by BAT than by biological treatment at POTWs. Therefore, PSES and PSNS are required to prevent pass through. The Agency is not proposing pretreatment standards for fluoride.

Proposed PSES and PSNS limitations for electronic crystals producers are the same as those proposed for BPT except that pH and TSS are not regulated for pretreatment. The bases for limitations were presented in Section 8.2.1.

8.3 STATISTICAL ANALYSIS

Statistical analysis of discharge monitoring data allows a quantitative assessment of the variability of effluent concentrations following wastewater treatment. Long term data, collected on a daily basis, reflect the fact that even properly operating treatment systems experience fluctuations in pollutant concentrations discharged. These fluctuations result from variations in process flow, raw waste loading of pollutants, treatment chemical feed, mixing effectiveness during treatment, and combinations of these or other factors.

It is found that the day-to-day variability in effluent concentrations includes occasional large changes while averages for each month's data experience smaller fluctuations. The variability in the monthly average is usually found to be well described by the normal distribution, with values evenly distributed around the mean. However daily fluctuations are most often described by a lognormal or asymmetric distribution. This reflects the fact that an effluent value may rise considerably from the mean level but may fall only to the value of zero.

In the development of effluent limitations and standards, allowance for the variation in the effluent concentration of a pollutant is accounted for by the establishment of a variability factor which is always greater than 1.0. This factor, calculated based on the type of distribution of daily or monthly average concentrations, is then multiplied by the mean pollutant concentration to yield a performance standard or effluent limitation that is reasonable for a particular treatment technology and a particular type of waste.

The following paragraphs describe the statistical methodology used to calculate the variability factors and to establish limitations for pollutant concentrations.

8.3.1 Calculation of Variability Factors

Variability factors are used to account for effluent concentration fluctuations in the establishment of reasonable effluent limitations. Calculation of these factors is discussed here, while their application is discussed under the next heading.

Daily Pollutant Level Measurements -- These calculations were based on the following three assumptions: (1) the daily pollutant concentration data are lognormally distributed; (2) monitoring was conducted in a responsible fashion, such that the resulting measurements can be considered statistically independent and amenable to standard statistical procedures; (3) treatment facilities and monitoring techniques were substantially constant throughout the monitoring period. The lognormality assumption is well established for daily sampling and has been demonstrated in the analysis of effluent samples from many industries. The other two assumptions, which concern self-consistency of the data, were supported by direct examination of the data and by consideration of supplemental information accompanying the data.

The variability factor is especially useful with lognormally distributed pollutant levels because its value is independent of the long-term average, and depends only upon the day-to-day variability of the treatment process and the expected number of unusually high discharge periods. For a lognormal population the variability factor (P/A), the performance standard P, and the long-term average A, are related by

$$\ln (P/A) = S'(Z - S'/2)$$

where ln represents the natural logarithm, S' is the estimated standard deviation of the natural logarithms of pollutant concentrations, and Z is a factor derived from the standard normal distribution.

The value of Z selected for the calculation of daily performance standards is 2.326, which corresponds to the 99th percentile of the lognormal distribution. Thus only one percent of pollutant concentrations is expected greater than the performance standard P. This assumes the continued proper operation of the wastewater treatment procedures, and is equivalent to allowing a plant in normal operation 3 or 4 exceedances per year.

To estimate the variability factor for a particular set of monitoring data, where the method of moments is used, S' is calculated as the square root of $\ln (1.0 + (CV^2))$. Here CV is the sample coefficient of variation, and is the ratio of sample standard deviation to sample mean.

30-Day Averages Of Pollutant Levels -- While individual pollutant concentrations are assumed to be lognormally distributed, 30-day averages are not assumed to fit this model. Instead, the statistical "Central Limit Theorem" provides justification for using the normal distribution as the appropriate model. Thus the 30-day average values are expected to behave approximately as random data from a normal distribution, with mean A and standard deviation S''.

For any probability (k percent) that a particular monthly average will not exceed the performance standard P, there corresponds a value Z such that

$$P = A + Z (S'')$$

The variability factor is

$$P/A = 1.0 + Z(S''/A)$$

and is estimated by

$$P/A = 1.0 + Z(CV)$$

In this equation, Z is frequently given the value of 1.64, to correspond with a probability, k, of 95 percent that a monthly average is within guidelines. CV is the estimated coefficient of variation of the 30-day averages. It may be computed by Sx/A, where S is the standard deviation of sample measurements and x is the mean of sample measurements.

Hence one obtains the performance standard P by multiplying the mean of the 30-day averages by the variability factor. An interpretation is that for the selected value of Z = 1.64 corresponding to the 95th percentile of a normal distribution, 19 of every 20 30-day averages will not exceed P.

8.3.2 Calculation of Effluent Limitations

The effluent limitations are based on the premise that a plant's treatment system can be operated to maintain average (mean) effluent concentrations equal to those determined from the sampled data from visited plants. As explained in the introduction, the day-to-day concentrations will fluctuate below and above these average concentrations. Thus the effluent daily limitations must be set far enough above the average daily concentrations that plants with properly operated treatment systems will not exceed them (99 percent of the time), and the 30-day average limitations must be set sufficiently above the mean of 30-day averages so that no more than 5 percent of 30-day averages will exceed the limitations, again assuming a properly operated treatment system. The effluent limitations were obtained for each parameter by multiplying the average concentration (based on visit data) by the appropriate daily and 30-day variability factors (based on historical data) to obtain the effluent limitations. Expressed as equations,

Daily maximum limitation = VF_D x A
30-day average limitation = VF_{30} X A

In these equations, VF_D is the daily maximum variability factor, VF_{30} is the 30-day average variability factor, and A is the average concentration based on plant visit data.

SECTION 9

COST OF WASTEWATER TREATMENT AND CONTROL

This section presents estimates of the costs of implementation of wastewater treatment and control systems for the Semiconductor and Electronic Crystals subcategories of the Electrical and Electronic Components category. The systems for which cost estimates are presented are those options selected by the Agency as the technical bases for discharge regulations as presented in Section 8. The cost estimates then provide the basis for probable economic impact of regulation on the industry.

The general approach or methodology for cost estimating is presented below followed by the treatment and control option costs. Finally, this section addresses non-water quality aspects of wastewater treatment and control including air pollution, noise pollution, solid wastes and energy considerations.

9.1 COST ESTIMATING METHODOLOGY

Costs involved in setting up and operating a wastewater treatment unit are comprised of investment costs for construction, equipment, engineering design, and land, and operating costs for energy, labor, and chemicals. There are also costs for disposing of sludge and for routine analysis of the treated effluent.

The costs presented in this section are based on model plants which closely resemble the types and capacities of waste treatment facilities needed for each product subcategory. Model plants are not set up as exemplary plants, but as typical of sufficient design to represent the range of plants and treatment facilities present in the industry. Data are based on plant visits and contacts with industries to verify treatment practices and to obtain data on size, wastewater flow, and solid waste disposal systems. The differences in treatment capacities are reflected in the choice of model plants which are presented for different flow rates covering the existing range of flows at average concentrations of pollutants.

Unit process equipment costs were assembled from vendors and other commercial sources. Information on the costs of equipment, the present costs of chemicals and average costs for hauling sludge was developed with data from industry, engineering firms, and equipment suppliers. Appropriate factors were applied to determine total investment costs and annual costs.

The costs which will actually be incurred by an individual plant may be more or less than presented in the cost estimate. The major variations in treatment costs between plants result from differences in pollutant concentrations and site dependent conditions, as reflected in piping lengths, climate, land availability, water and power supply and the location of the point of final discharge. In addition, solids disposal costs and material costs will vary depending on geographical locations.

The following assumptions were employed in the cost development:

1. All non-contact cooling water was excluded from treatment and treatment costs.

2. Source water treatment, cooling tower and boiler blowdown discharges were not considered process wastewater.

3. Sanitary sewage flow is excluded.

4. The treatment facilities were assumed to operate 8 hrs/day, 260 days per year for small plants (below 60,000 GPD); 24 hrs/day, 260 days per year for medium-sized plants (60,000 GPD to 200,000 GPD); and 24 hrs/day 350 days per year for large plants (greater than 200,000 GPD).

5. Excluded from the estimates were any costs associated with permits, reports or hearings required by regulatory agencies.

Investment costs are expressed in end of year 1979 dollars to construct facilities at various wastewater flow rates. Operation, maintenance, and amortization of the investment are expressed as base level annual costs.

<u>9.1.1 Direct Investment Costs for Land and Facilities</u>

Types of direct investment costs for waste treatment facilities and criteria for estimating major components of the model plants are presented below.

Construction Costs -- Construction costs include site preparation, grading, enclosures, buildings, foundations, earthworks, roads, paving, and concrete. Since few if any buildings will be utilized, construction costs have been calculated using a factor of 1.15 applied to the installed equipment cost or 2.0 applied to the equipment cost.

Equipment Cost -- Equipment for wastewater treatment consists of a combination of items such as pumps, chemical feed systems, agitators, flocculant feed systems, tanks, clarifiers and thickeners. Cost tables for these items were developed from vendor's quotations for a range of sizes, capacities and motor horsepowers. Except for large size tanks and chemical storage bins, the cost represents packaged, factory-assembled units.

Critical equipment is assumed to be installed in a weatherproof structure. Chemical storage feeders and feedback controls include such items as probes, transmitters, valves, dust filters and accessories. Critical pumps are furnished in duplicate as a duty and a spare each capable of handling the entire flow.

Installation Costs -- Installation is defined to include all services, activities, and miscellaneous material necessary to implement the described wastewater treatment and control system, including piping, fittings, and electrical work. Many factors can impact the cost of installing equipment modules. These include wage rates, manpower availability, who does the job (outside contractor or regular employees), new construction versus modification of existing systems, and site-dependent conditions (e.g., the availability of sufficient electrical service). In these estimates, installation costs were chosen for each model based upon average site conditions taking into consideration the complexity of the system being installed. An appropriate cost is allowed for interconnecting piping, power circuits and controls.

Monitoring Equipment -- It is assumed that monitoring equipment will be installed at the treated effluent discharge point. It will consist of an indicating, integrating, and recording type flow meter, pH meter, sensor, recorder, alarms, controls and an automatic sampler.

Land -- Land availability and cost of land can vary significantly, depending upon geographical location, degree of urbanization and the nature of adjacent development. Land for waste treatment is assumed to be contiguous with the production plant site. For the purpose of the report land is valued at $12,000 per acre.

Investment Costs for Supporting Services -- Engineering design and inspection are typical services necessary to advance a project from a concept to an operating system. Such services broadly include laboratory and pilot plant work to establish design parameters, site surveys to fix elevation and plant layout, foundation and groundwater investigation, and operating instructions, in addition to design plans, specifications and inspection during construction. These costs, which vary with job conditions, are often estimated as percentages of construction costs, with typical ranges as follows:

Preliminary survey and construction surveying	1 to 2 %
Soils and groundwater investigation	1 to 2 %
Laboratory and pilot process work	2 to 4 %
Engineering design and specifications	7 to 12%
Inspection during construction	2 to 3 %
Operation and maintenance manual	1 to 3 %

From these totals of 14 to 26 percent, a mid-value of 20 percent of in-place construction (installed equipment and construction) cost has been used in this study to represent the engineering and design cost applied to model plant cost estimates.

The contractor's fee and contingency, usually expressed as a percentage of in-place construction cost, includes such general items as temporary utilities, small tools, field office overhead and administrative expense. The contractor is entitled to a reasonable profit on his activities and to the cost of interest on capital tied up during construction. Although not all of the above cost will be incurred on every job, an additional 50 percent of the in-place construction cost has been used to cover related cost broadly described as contractor's fees, incidentals, overhead, and contingencies.

9.1.2 Annual Costs

Operation and Maintenance Costs -- Annual operation and maintenance costs are described and calculated as follows:

Labor and Supervision Costs:

Personnel costs are based on an hourly rate of $20.00. This includes fringe benefits and an allocated portion of costs for management, administration and supervision. Personnel are assigned for specific activities as required by the complexity of the system, ranging from 1-8 hours per day.

Energy Costs:

Energy costs are based on the cost of \$306.00 per horsepower operating 24 hours per day and 350 days per year. For batch processes appropriate adjustments were made to suit the production schedule. The cost per horsepower year is computed as follows:

$$Cy = 1.1\ (0.745\ HP \times Hr. \times Ckw)/(E \times P)$$

where Cy = Cost per year
HP = Total Horsepower Rating of Motor (1 HP = 0.7457 kw)
kw)
E = Efficiency Factor (0.9)
P = Power Factor (1.00)
Hr. = Annual Operating Hours (350 x 24 = 8400)
Ckw = Cost per Kilowatt-Hour of Electricity (\$0.040)

Note: The 1.1 factor in the equation represents allowance for incidental energy used such as lighting, etc. It is assumed that no other forms of energy are used in the waste treatment system.

Chemicals:

Prices for the chemicals were obtained from vendors and the Chemical Marketing Reporter. Unit costs of common chemicals delivered to the plant site are based on commercial grade of the strength or active ingredient percentage with prices as follows:

Hydrated Lime (Calcium Hydroxide) Bulk	\$80/Ton
Flocculant	\$ 2/Lb

Maintenance:

The annual cost of maintenance is estimated as ten percent (10%) of the investment cost, excluding land.

Taxes and Insurance:

An annual provision of three percent of the total investment cost has been included for taxes and insurance.

Residual Waste Disposal:

Sludge disposal costs can vary widely. Chief cost determinants include the amount and type of waste. Off-site hauling and disposal costs are taken as $\$20/YD^3$ for bulk hauling, with appropriate increases for small quantities in steel containers. Information available to the Agency indicates that the selected technologies for controlling pollutants in this industry will not result in hazardous wastes as defined by RCRA.

Monitoring, Analysis and Reporting

The manpower requirements covered by the annual labor and supervision costs include those activities associated with the operation and maintenance of monitoring instruments, recorder and automatic samplers as well as the taking of periodic grab samples. Additional costs for analytical laboratory services have been estimated for each subcategory assuming that sampling takes place three times a week at the point of discharge. A cost of $7500/year has been used for monitoring analyses and reporting.

Amortization -- Amortization of capital costs (investment costs) are computed as follows:

$$CA = B\ (r(1+r)^n)/((1+r)^n-1)$$

where CA = Annual Cost
B = Initial amount invested excluding cost of land
r = Annual interest rate (assumed 13 percent)
n = Useful life in years

The multiplier for B in equation (1) is often referred to as the capital recovery factor and is 0.2843 for the assumed overall useful life of 5 years. No residual or sludge value is assumed.

9.1.3 Items not Included in Cost Estimate

Although specific plants may encounter extremes of climate, flood hazards and lack of water, the cost of model plants have been estimated for average conditions of temperature, drainage and natural resources. It is assumed that any necessary site drainage, roads, water development, security, environmental studies and permit costs are already included in production facilities costs. Therefore, the model costs are only for facilities, suppliers and services directly related to the treatment and disposal of waterborne wastes, including land needed for treatment and on-site sludge disposal. Air pollution control equipment is not included, except for dust collectors associated with treatment, chemical transfer and feeding. Raw wastes from various sources are assumed to be delivered to the treatment facility at sufficient head to fill the influent equalization basin, and final effluent is discharged by gravity. Cost of pumps, pipes, lines etc., necessary to deliver raw wastewater to the treatment plant or to deliver the treated effluent to the point of discharge are not included in the cost estimates.

9.2 COST ESTIMATES FOR TREATMENT AND CONTROL OPTIONS

Table 9-1 summarizes the treatment and control options selected as the bases for effluent limitations and standards for the Semiconductor and Electronic Crystals Subcategories.

TABLE 9-1 TREATMENT AND CONTROL OPTIONS SELECTED AS BASES FOR EFFLUENT LIMITATIONS

Subcategory	BPT	BAT	BCT/NSPS		Pretreatment
Semiconductors	1	3	1	3	1
Electronic Crystals	2	2	2	2	1+2

9.2.1 Option 1

This treatment option is defined as neutralization of plant discharge and solvent management to control toxic organics. Since all direct dischargers in both the Semiconductor and Electronic Crystals subcategories currently neutralize their discharges, no costs of neutralization will be incurred by the industry. Also, minimal, if any, costs are associated with solvent management for the following reasons:

1) Information shows that many facilities can sell spent solvents to reclaimers;

2) The Agency is not requiring monitoring for TTO (which could be expensive) in cases where facilities certify that they do not dump spent solvents.

Based on the above, the costs to a plant for implementation of Option 1 are assumed to be zero.

9.2.2 Option 2

The capital and annual costs of this end-of-pipe precipitation/clarification system are presented in Table 9-2. The range of model plant wastewater flows reflect the range of flows that currently exist for the subcategory. Figure 9-1 graphically presents the annual costs versus plant wastewater flow for this option.

9.2.3 Option 3

The capital and annual costs of this in-plant precipitation/clarification treatment system for fluoride acid wastes are presented in Table 9-3. The range of model plant waste flows reflects the range of flows for this stream as they currently exist in both subcategories. Figure 9-2 graphically presents the annual costs versus waste stream flow for this option.

9.2.4 Option 5

The capital and annual costs of adding filtration to end-of-pipe precipitation/clarification (Option 2) are presented in Table 9-4. These costs are incremental and therefore only reflect the additional costs of adding filtration technology.

9.3 ENERGY AND NON-WATER QUALITY ASPECTS

Compliance with the proposed regulations will have no effect on air, noise, or radiation pollution and will only result in minimal energy usage. The amount of solid waste generated will be 7700 metric tons per year. Available information indicates that the solid waste generated will not be hazardous as defined in the Resource Conservation and Recovery Act (RCRA). Energy requirements associated with these regulations will be 100,000 kilowatt-hours per year or only 7.5 killowatt-hours per day per facility.

Based on the above non-water quality impacts from these regulations, EPA has concluded that the proposed regulation best serves overall national environmental goals.

TABLE 9-2

MODEL PLANT TREATMENT COSTS
OPTION 2

	Flow, gpd (l/day)				
	2,000 (7,570)	10,000 (37,850)	60,000 (227,000)	150,000 (568,000)	200,000 (757,000)
A. INVESTMENT COSTS					
Construction........	$ 2,500	$ 7,000	$ 12,000	$ 17,000	$ 20,200
Equipment in place including piping, fittings, electrical work and controls...	28,000	83,000	142,000	202,500	244,600
Monitoring equipment in place............	6,000	6,000	6,000	6,000	6,000
Engineering Design and inspection......	6,500	18,000	31,000	44,000	53,000
Incidentals, overhead, fees, contingencies.	15,500	45,000	77,000	110,000	132,500
Land..................		3,000	3,000	6,000	6,000
TOTAL INVESTMENT COST	61,500	162,000	274,000	385,500	462,300
B. OPERATION AND MAINTENANCE COST					
Labor and supervision	11,000	11,000	11,000	11,000	11,000
Energy..............	600	1,000	5,000	6,000	7,000
Chemicals...........	200	1,100	4,000	9,500	12,500
Maintenance.........	6,000	16,000	27,500	38,000	46,000
Taxes and insurance.	2,000	5,000	8,500	12,000	13,800
Residual waste disposal............	1,500	8,500	52,000	108,000	128,500
Monitoring, analysis and reporting.......	7,500	7,500	7,500	7,500	7,500
TOTAL OPERATION AND MAINTENANCE COST	28,800	50,100	115,000	192,500	226,300
C. AMORTIZATION OF INVESTMENT COST	16,632	45,206	76,196	107,897	129,733
TOTAL ANNUAL COST	$ 45,432	$ 95,306	$ 191,196	$ 300,397	$ 356,033

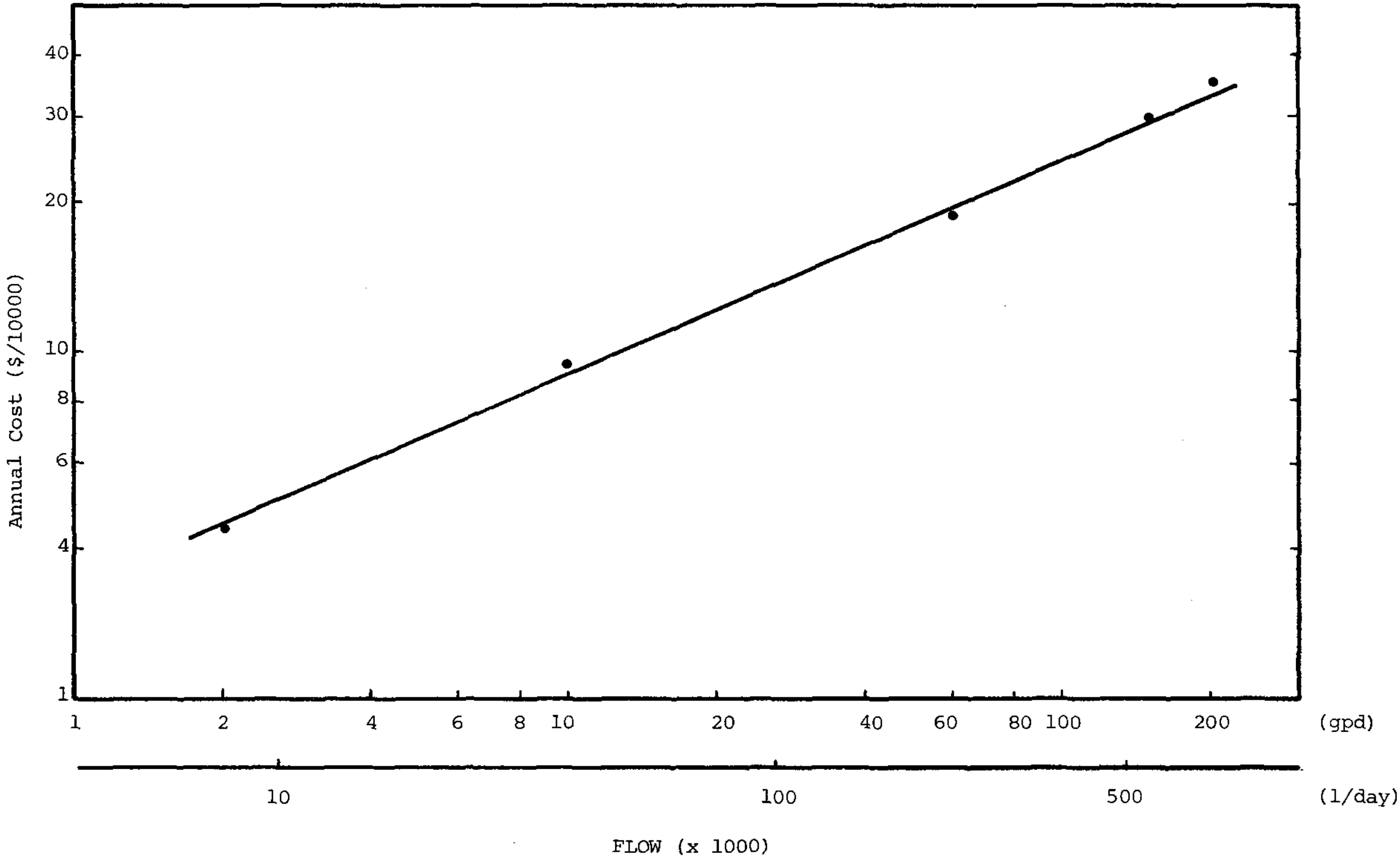

Figure 9-1
Annual Cost vs. Flow for
Option 2 Technology

TABLE 9-3

MODEL PLANT TREATMENT COSTS
OPTION 3

	Fluoride Stream Flow, gpd (l/day)			
	100 (378)	500 (1890)	2,500 (9,460)	6,000 (22,700)
A. INVESTMENT COSTS				
Construction........	$ 3,300	$ 3,300	$ 5,500	$ 10,100
Equipment in place including piping, fittings, electrical work and controls...	40,600	40,600	67,200	121,900
Monitoring equipment in place...........	0	0	0	0
Engineering Design and inspection......	8,800	8,800	14,500	19,800
Incidentals, overhead, fees, contingencies.	8,800	8,800	14,500	26,400
Land................	0	0	0	0
TOTAL INVESTMENT COST	61,500	61,500	101,700	178,200
B. OPERATION AND MAINTENANCE COST				
Labor and supervision	5,000	20,000	20,000	20,000
Energy..............	50	200	350	700
Chemicals...........	200	1,000	5,000	12,000
Maintenance.........	3,100	3,100	5,100	8,900
Taxes and insurance.	1,900	1,900	3,050	5,300
Residual waste disposal............	700	3,500	17,500	42,000
Monitoring, analysis and reporting.......	1,200	1,200	1,200	1,200
TOTAL OPERATION AND MAINTENANCE COST	12,150	30,900	52,200	90,100
C. AMORTIZATION OF INVESTMENT COST	17,500	17,500	28,900	50,700
TOTAL ANNUAL COST	$ 29,650	$ 48,400	$ 81,100	$ 140,800

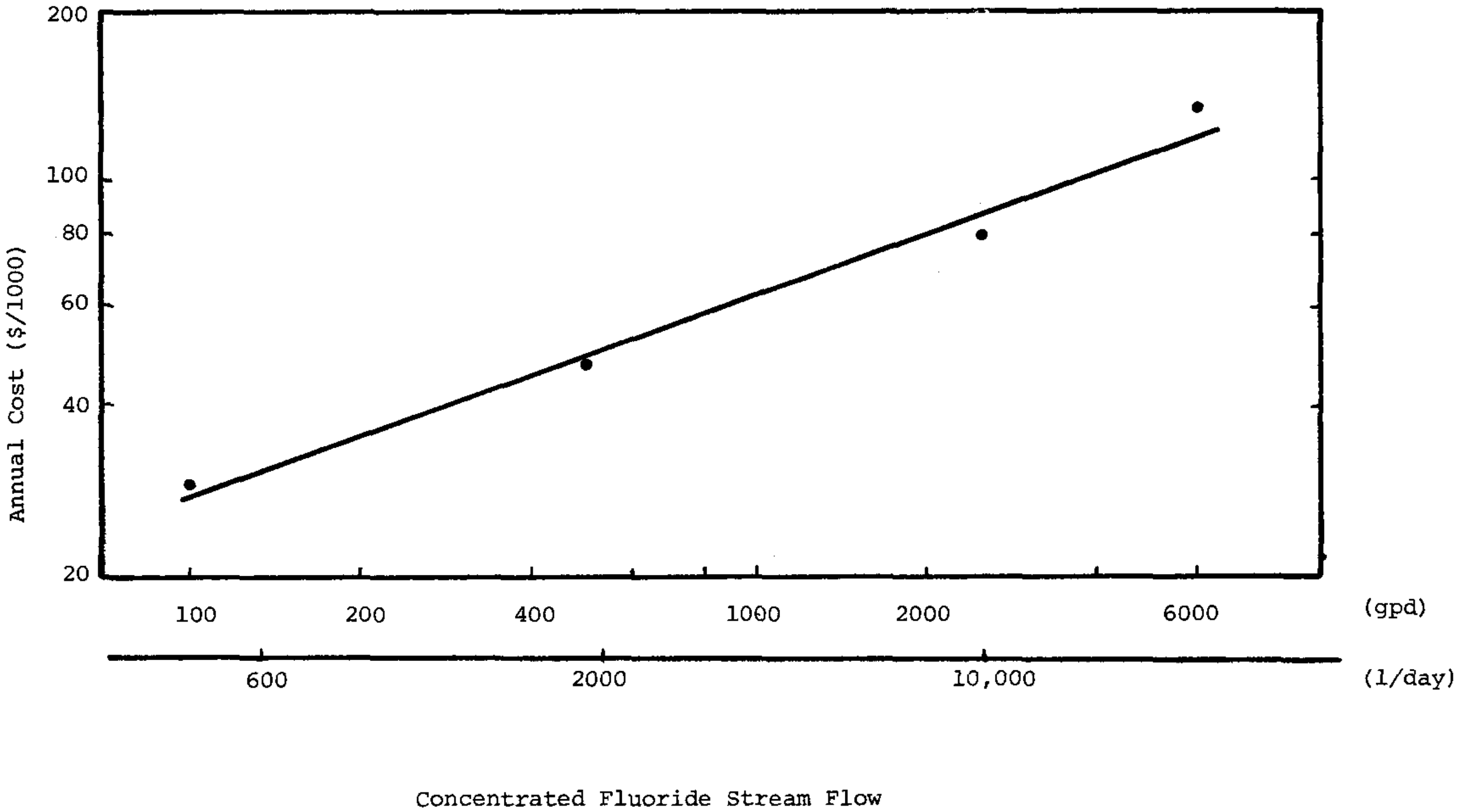

Figure 9-2
Annual Cost vs. Flow for
Option 3 Technology

TABLE 9-4

MODEL PLANT TREATMENT COSTS
OPTION 5, INCREMENTAL COSTS

	Flow, gpd (l/day)				
	2,000 (7,570)	10,000 (37,850)	60,000 (227,000)	150,000 (568,000)	200,000 (757,000)
A. INVESTMENT COSTS					
Construction........	$ 700	$ 800	$ 1,600	$ 3,300	$ 3,800
Equipment in place including piping, fittings, electrical work and controls...	6,700	7,900	16,000	33,000	38,000
Monitoring equipment in place............	-	-	-	-	-
Engineering Design and inspection......	1,500	1,700	3,500	7,200	8,400
Incidentals, overhead, fees, contingencies .	3,700	4,400	8,800	18,200	20,900
Land.................	-	-	-	-	-
TOTAL INVESTMENT COST	$ 12,600	$ 14,800	$ 29,900	$ 61,700	$ 71,100
B. OPERATION AND MAINTENANCE COST					
Labor and supervision	2,000	2,000	3,000	4,000	4.000
Energy..............	300	500	2,500	3,000	3,500
Chemicals...........	-	-	-	-	-
Maintenance.........	1,260	1,480	3,000	6,200	7,100
Taxes and insurance.	380	440	900	1,850	2,130
Residual waste disposal............	-	-	-	-	-
Monitoring, analysis and reporting.......	-	-	-	-	-
TOTAL OPERATION AND MAINTENANCE COST	$ 3,940	$ 4,420	$ 9,400	$ 15,050	$ 16,730
C. AMORTIZATION OF INVESTMENT COST	3,580	4,210	8,500	17,540	20,210
TOTAL ANNUAL COST	$ 7,520	$ 8,630	$ 17,900	$ 32,590	$ 36,940

SECTION 10

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SECTION 11

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34. Webster's Seventh New Collegiate Dictionary, G & C Merriam Co., (1963).

SECTION 12

GLOSSARY

Absorb - To take up matter or radiation.

Act - Federal Water Pollution Control Act.

Activate - To treat the cathode or target of an electron tube in order to create or increase the emission of electrons.

Adjustable Capacitor - A device capable of holding an electrical charge at any one of several discrete values.

Adsorption - The adhesion of an extremely thin layer of molecules (of gas, liquid) to the surface of solids (granular activated carbon for instance) or liquids with which they are in contact.

Aging - Storage of a permanent magnet, capacitor, meter or other device (sometimes with a voltage applied) until the characteristics of the device become essentially constant.

Algicide - Chemicals used to retard the growth of phytoplankton (algae) in bodies of water.

Aluminum Foil - Aluminum in the form of a sheet of thickness not exceeding 0.005 inch.

Anneal - To treat a metal, alloy, or glass by a process of heating and slow cooling in order to remove internal stresses and to make the material less brittle.

Anode - The collector of electrons in an electron tube. Also known as plate; positive electrode.

Anodizing - An electrochemical process of controlled aluminum oxidation producing a hard, transparent oxide up to several mils in thickness.

Assembly or Mechanical Attachment - The fitting together of previously manufactured parts or components into a complete machine, unit of a machine, or structure.

Autotransformer - A power transformer having one continuous winding that is tapped; part of the winding serves as the primary coil and all of it serves as the secondary coil, or vice versa.

Ballast - A circuit element that serves to limit an electric current or to provide a starting voltage, as in certain types of lamps, such as in fluorescent ceiling fixtures.

Binder - A material used to promote cohesion between particles of carbon or graphite to produce solid carbon and graphite rods or pieces.

Biochemical Oxygen Demand (BOD) - (1) The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions. (2) Standard test used in assessing wastewater quality.

Biodegradable - The part of organic matter which can be oxidized by bioprocesses, e.g., biodegradable detergents, food wastes, animal manure, etc.

Biological Wastewater Treatment - Forms of wastewater treatment in which bacteria or biochemical action is intensified to stabilize, oxidize, and nitrify the unstable organic matter present. Intermittent sand filters, contact beds, trickling filters, and activated sludge processes are examples.

Breakdown Voltage - Voltage at which a discharge occurs between two electrodes.

Bulb - The glass envelope which incloses an incandescent lamp or an electronic tube.

Busbar - A heavy rigid, metallic conductor, usually uninsulated, used to carry a large current or to make a common connection between several curcuits.

Bushing - An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier (conducting or otherwise), for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

Calcining - To heat to a high temperature without melting or fusing, as to heat unformed ceramic materials in a kiln, or to heat ores, precipitates, concentrates or residues so that hydrates, carbonates or other compounds are decomposed and volatile material is expelled, e.g., to heat limestone to make lime.

Calibration - The determination, checking, or correction of the graduation of any instrument giving quantitative measurements.

Capacitance - The ratio of the charge on one of the plates of a capacitor to the potential difference between the plates.

Capacitor - An electrical circuit element used to store charge temporarily, consisting in general of two conducting materials separated by a dielectric material.

Carbon - A nonmetallic, chiefly tetravalent element found native or as a constituent of coal, petroleum, asphalt, limestone, etc.

Cathode - The primary source of electrons in an electron tube; in directly heated tubes the filament is the cathode, and in indirectly heated tubes a coated metal cathode surrounds a heater.

Cathode Ray Tube - An electron-beam tube in which the beam can be focused to a small cross section on a luminescent screen and varied in position and intensity to produce a visible pattern.

Central Treatment Facility - Treatment plant which co-treats process wastewaters from more than one manufacturing operation or co-treats process wastewaters with noncontact cooling water or with non-process wastewaters (e.g., utility blow-down, miscellaneous runoff, etc.).

Centrifuge - The removal of water in a sludge and water slurry by introducing the water and sludge slurry into a centrifuge. The sludge is driven outward with the water remaining near the center. The dewatered sludge is usually landfilled.

Ceramic - A product made by the baking or firing of a nonmetallic mineral such as tile, cement, plaster, refractories, and brick.

Chemical Coagulation - The destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical.

Chemical Oxidation - The addition of chemical agents to wastewater for the purpose of oxidizing pollutant material, e.g., removal of cyanide.

Chemical Oxygen Demand (COD) - (1) A test based on the fact that all organic compounds, with few exceptions, can be oxidized to carbon dioxide and water by the action of strong oxidizing agents under acid conditions. Organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances. One of the chief limitations is its inability to differentiate between biologically oxidizable and biologically inert organic matter. The major advantage of this test is the short time required for evaluation (2 hours). (2) The amount of oxygen required for the chemical oxidation of organics in a liquid.

Chemical Precipitation - (1) Formation of insoluble materials generated by addition of chemicals to a solution. (2) The process of softening water by the addition of lime and soda ash as the precipitants.

Chlorination - The application of chlorine to water or wastewater generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

Circuit Breaker - Device capable of making, carrying, and breaking currents under normal or abnormal circuit conditions.

Cleaning - The removal of soil and dirt (including grit and grease) from a workpiece using water with or without a detergent or other dispersing agent.

Coil - A number of turns of wire used to introduce inductance into an electric circuit, to produce magnetic flux, or to react mechanically to a changing magnetic flux.

Coil-Core Assembly - A unit made up of the coil windings of a transformer placed over the magnetic core.

Coking - (1) Destructive distillation of coal to make coke. (2) A process for thermally converting the heavy residual bottoms of crude oil entirely to lower-boiling petroleum products and by-product petroleum coke.

Colloids - A finely divided dispersion of one material called the "dispersed phase" (solid) in another material called the "dispersion medium" (liquid). Normally negatively charged.

Composite Wastewater Sample - A combination of individual samples of water or wastewater taken at selected intervals and mixed in proportion to flow or time to minimize the effect of the variability of an individual sample.

Concentric Windings - Transformer windings in which the low-voltage winding is in the form of a cylinder next to the core, and the high-voltage winding, also cylindrical, surrounds the low-voltage winding.

Conductor - A wire, cable, or other body or medium suitable for carrying electric current.

Conduit - Tubing of flexible metal or other material through which insulated electric wires are run.

Contamination - A general term signifying the introduction into water of microorganisms, chemicals, wastes or sewage which renders the water unfit for its intended use.

Contractor Removal - The disposal of oils, spent solutions, or sludge by means of a scavenger service.

Conversion Coating - As metal-surface coating consisting of compound of the base metal.

Cooling Tower - A device used to cool manufacturing process water before returning the water for reuse.

Copper - A common, reddish, chiefly univalent and bivalent metallic element that is ductile and malleable and one of the best conductors of heat and electricity.

Core (Magnetic Core) - A quantity of ferrous material placed in a coil or transformer to provide a better path than air for magnetic flux, thereby increasing the inductance of the coil or increasing the coupling between the windings of a transformer.

Corona Discharge - A discharge of electricity appearing as a bluish-purple glow on the surface of and adjacent to a conductor when the voltage gradient exceeds a certain critical value; caused by ionization of the surrounding air by the high voltage.

Curing - A heating/drying process carried out in an elevated-temperature enclosure.

Current Carrying Capacity - The maximum current that can be continuously carried without causing permanent deterioration of electrical or mechanical properties of a device or conductor.

Dag (Aquadag) - A conductive graphite coating on the inner and outer side walls of some cathode-ray tubes.

Degreasing - The process of removing grease and oil from the surface of the basis material.

Dewatering - A process in which water is removed from sludge.

Dicing - Sawing or otherwise machining a semiconductor wafer into small squares or dice from which transistors and diodes can be fabricated.

Die - A tool or mold used to cut shapes to or form impressions on materials such as metals and ceramics.

Die Cutting (Also Blanking) - Cutting of plastic or metal sheets into shapes by striking with a punch.

Dielectric - A material that is highly resistant to the conductance of electricity; an insulator.

Di-n-octyl-phthalate - A liquid dielectric that is presently being substituted for a PCB dielectric fluid.

Diode (Semiconductor), (Also Crystal Diode, Crystal Rectifier) - A two-electrode semiconductor device that utilizes the rectifying properties of a p-n junction or point contact.

Discrete Device - Individually manufactured transistor, diode, etc.

Dissolved Solids - Theoretically the anhydrous residues of the dissolved constituents in water. Actually the term is defined by the method used in determination. In water and wastewater treatment, the Standard Methods tests are used.

Distribution Transformer - An element of an electric distribution system located near consumers which changes primary distribution voltage to a lower consumer voltage.

Dopant - An impurity element added to semiconductor materials used in crystal diodes and transistors.

Dragout - The solution that adheres to the part or workpiece and is carried past the edge of the tank.

Dry Electrolytic Capacitor - An electrolytic capacitor with a paste rather than liquid electrolyte.

Drying Beds - Areas for dewatering of sludge by evaporation and seepage.

Dry Slug - Usually refers to a plastic-encased sintered tantalum slug type capacitor.

Dry Transformer - Having the core and coils neither impregnated with an insulating fluid nor immersed in an insulating oil.

Effluent - The quantities, rates, and chemical, physical, biological and other constituents of waters which are discharged from point sources.

Electrochemical Machining - Shaping of an anode by the following process: The anode and cathode are placed close together and electrolyte is pumped into the space between them. An electrical potential is applied to the electrodes causing anode metal to be dissolved selectively, producing a shaped anode that complements the shape of the cathode.

Electrolyte - A nonmetallic electrical conductor in which current is carried by the movement of ions.

Electron Beam Lithography - Similar to photolithography - A fine beam of electrons is used to scan a pattern and expose an electron-sensitive resist in the unmasked areas of the object surface.

Electron Discharge Lamp - An electron lamp in which light is produced by passage of an electric current through a metallic vapor or gas.

Electron Gun - An electrode structure that produces and may control, focus, deflect and converge one or more electron beams in an electron tube.

Electron Tube - An electron device in which conduction of electricity is accomplished by electrons moving through a vacuum or gaseous medium within a gas-tight envelope.

Electroplating - The production of a thin coating of one metal on another by electrode position.

Emissive Coating - An oxide coating applied to an electrode to enhance the emission of electrons.

Emulsion Breaking - Decreasing the stability of dispersion of one liquid in another.

End-of-Pipe Treatment - The reduction and/or removal of pollutants by chemical treatment just prior to actual discharge.

Epitaxial Layer - A (thin) semiconductor layer having the same crystaline orientation as the substrate on which it is grown.

Epitaxial Transistor - Transistor with one or more epitaxial layers.

Equalization - The process whereby waste streams from different sources varying in pH, chemical constituents, and flow rates are collected in a common container. The effluent stream from this equalization tank will have a fairly constant flow and pH level, and will contain a homogeneous chemical mixture. This tank will help to prevent unnecessary shock to the waste treatment system.

Etch - To corrode the surface of a metal in order to reveal its composition and structure.

Extrusion - Forcing the carbon-binder-mixture through a die under extreme pressure to produce desireable shapes and characteristics of the piece.

Field-effect Transistors - Transistors made by the metal-oxide-semiconductor (MOS) technique, differing from bipolar ones in that only one kind of charge carrier is active in a single device. Those that employ electrons are called n-MOS transistors; those that employ holes are p-MOS transistors.

Filament - (1) Metallic wire which is heated in an incandescent lamp to produce light by passing an electron current through it. (2) A cathode in a fluorescent lamp that emits electrons when electric current is passed through it.

Filtering Capacitor - A capacitor used in a power-supply filter system to provide a low-reactance path for alternating currents and thereby suppress ripple currents, without affecting direct currents.

Fixed Capacitor - A capacitor having a definite capacitance value that cannot be adjusted.

Float Gauge - A device for measuring the elevation of the surface of a liquid, the actuating element of which is a buoyant float that rests on the surface of the liquid and rises or falls with it. The elevation of the surface is measured by a chain or tape attached to the float.

Floc - A very fine, fluffy mass formed by the aggregation of fine suspended particles.

Flocculation - In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means. In biological wastewater treatment where coagulation is not used, agglomeration may be accomplished biologically.

Flocculator - An apparatus designed for the formation of floc in water or sewage.

Flow-proportioned Sample - A sampled stream whose pollutants are apportioned to contributing streams in proportion to the flow rates of the contributing streams.

Fluorescent Lamp - An electric discharge lamp in which phosphor materials transform ultraviolet radiation from mercury vapor ionization to visible light.

Forming - Application of voltage to an electrolytic capacitor, electrolytic rectifier or semiconductor device to produce a desired permanent change in electrical characteristics as part of the manufacturing process.

Frit Seal - A seal made by fusing together metallic powders with a glass binder for such applications as hermatically sealing ceramic packages for integrated circuits.

Funnel - The rear, funnel-shaped portion of the glass enclosure of a cathode ray tube.

Fuse - Overcurrent protective device with a circuit-opening fusible part that would be heated and severed by overcurrent passage.

Gate - One of the electrodes in a field effect transistor.

Getter - A metal coating inside a lamp which is activated by an electric current to absorb residual water vapor and oxygen.

Glass - A hard, amorphous, inorganic, usually transparent, brittle substance made by fusing silicates, and sometimes borates and phosphates, with certain basic oxides and then rapidly cooling to prevent crystallization.

Glow Lamp - An electronic device, containing at least two electrodes and an inert gas, in which light is produced by a cloud of electrons close to the negative electrode when a voltage is applied between the electrodes.

Grab Sample - A single sample of wastewater taken at an "instant" in time.

Graphite - A soft black lustrous carbon that conducts electricity and is a constituent of coal, petroleum, asphalt, limestone, etc.

Grease - In wastewater, a group of substances including fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oil and certain other nonfatty materials. The type of solvent and method used for extraction should be stated for quantification.

Grease Skimmer - A device for removing grease or scum from the surface of wastewater in a tank.

Green Body - An unbaked carbon rod or piece that is usually soft and quite easily broken.

Grid - An electrode located between the cathode and anode of an electron tube, which has one or more openings through which electrons or ions can pass, and which controls the flow of electrons from cathode to anode.

Grinding - The process of removing stock from a workpiece by the use of abrasive grains held by a rigid or semi-rigid binder.

Hardness - A characteristic of water, imparted by calcium, magnesium, and ion salts such as bicarbonates, carbonates, sulfates, chlorides, and nitrates. These cause curdling of soap, deposition of scale in boilers, damage in some industrial processes and sometimes objectionable taste. Hardness may be determined by a standard laboratory procedure or computed from the amounts of calcium and magnesium as well as iron, aluminum, manganese, barium, strontium, and zinc, and is expressed as equivalent calcium carbonate.

Heavy Metals - A general name given to the ions of metallic elements such as copper, zinc, chromium, and nickel. They are normally removed from wastewater by an insoluble precipitate (usually a metallic hydroxide).

Holding Tank - A reservoir to contain preparation materials so as to be ready for immediate service.

Hybrid Integrated Circuits - A circuit that is part integrated and part discrete.

Impact Extrusion - A cold extrusion process for producing tubular components by striking a slug of the metal, which has been placed in the cavity of the die, with a punch moving at high velocity.

Impregnate - To force a liquid substance into the spaces of a porous solid in order to change its properties.

Incandescent Lamp - An electric lamp producing light in which a metallic filament is heated white-hot in a vacuum by passage of an electric current through it.

Industrial Wastes - The liquid wastes from industrial processes as distinct from domestic or sanitary wastes.

Influent - Water or other liquid, either raw or partly treated, flowing into a reservoir basin or treatment plant.

In-Process Control Technology - The regulation and conservation of chemicals and rinse water at their point of use as opposed to end-of-pipe treatment.

Insulating Paper - A standard material for insulating electrical equipment, usually consisting of bond or kraft paper coated with black or yellow insulating varnish on both sides.

Insulation (Electrical Insulation) - A material having high electrical resistivity and therefore suitable for separating adjacent conductors in an electric circuit or preventing possible future contact between conductors.

Insulator - A nonconducting support for an electric conductor.

Integrated Circuit - Assembly of electronic devices interconnected into circuits.

Interleaved Winding - An arrangement of winding coils around a transformer core in which the coils are wound in the form of a disk, with a group of disks for the low-voltage windings stacked alternately with a group of disks for the high-voltage windings.

Intermittent Filter - A natural or artificial bed of sand or other fine-grained material onto which sewage is intermittently flooded and through which it passes, with time allowed for filtration and the maintenance of aerobic conditions.

Ion Exchange - A reversible chemical reaction between a solid (ion exchanger) and a fluid (usually a water solution) by means of which ions may be interchanged from one substance to another. The superficial physical structure of the solid is not affected.

Ion Exchange Resins - Synthetic resins containing active groups (usually sulfonic, carboxylic, phenol, or substituted amino groups) that give the resin the ability to combine with or exchange ions with a solution.

Ion Implantation - A process of introducing impurities into the near surface regions of solids by directing a beam of ions at the solid.

Junction - A region of transition between two different semiconducting regions in a semiconductor device such as a p-n junction, or between a metal and a semiconductor.

Junction Box - A protective enclosure into which wires or cables are led and connected to form joints.

Knife Switch - Form of switch where moving blade enters stationary contact clips.

Klystron - An evacuated electron-beam tube in which an initial velocity modulation imparted to electrons in the beam results subsequently in density modulation of the beam; used as an amplifier in the microwave region or as an oscillator.

Lagoon - A man-made pond or lake for holding wastewater for the removal of suspended solids. Lagoons are also used as retention ponds after chemical clarification to polish the effluent and to safeguard against upsets in he clarifier; for stabilization of organic matter by biological oxidation; for storage of sludge; and for cooling of water.

Landfill - The disposal of inert, insoluble waste solids by dumping at an approved site and covering with earth.

Lapping - The mechanical abrasion or surface planing of the semiconductor wafer to produce desired surface and wafer thickness.

Lime - Any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite) which is composed almost wholly of calcium carbonates or a mixture of calcium and magnesium carbonates.

Limiting Orifice - A device that limis flow by constriction to a relatively small area. A constant flow can be obtained over a wide range of upstream pressures.

Machining - The process of removing stock from a workpiece by forcing a cutting tool through the workpiece and removing a chip of basis material. Machining operatings such as tuning, milling, drilling, boring, tapping, planing, broaching, sawing and cutoff, shaving, threading, reaming, shaping, slotting, hobbing, filling, and chambering are included in this definition.

Magnaflux Inspection - Trade name for magnetic particle test.

Make-up Water - Total amount of water used by any process/process step.

Mandrel - A metal support serving as a core around which the metals are wound and anealled to form a central hole.

Mask (Shadow Mask) - Thin sheet steel screen with thousands of apertures through which electron beams pass to a color picture tube screen. The color of an image depends on the balance from each of three different electron beams passing through the mask.

Metal Oxide Semiconductor Device - A metal insulator semiconductor structure in which the insulating layer is an oxide of the substrate material; for a silicon substrate, the insulating layer is silicon dioxide (SiO_2).

Mica - A group of aluminum silicate minerals that are characterized by their ability to split into thin, flexible flakes because of their basal cleavage.

Miligrams Per Liter (mg/l) - This is a weight per volume designation used in water and wastewater analysis.

Mixed Media Filtration - A filter which uses two or more filter materials of differing specific gravities selected so as to produce a filter uniformly graded from coarse to fine.

MOS - (See Metal Oxide Semiconductor).

Mount Assembly - Funnel neck ending of picture tube holding electron gun(s).

National Pollutant Discharge Elimination System (NPDES) - The federal mechanism for regulating point source discharge by means of permits.

Neutralization - Chemical addition of either acid or base to a solution such that the pH is adjusted to approximately 7.

Noncontact Cooling Water - Water used for cooling which does not come into direct contact with any raw material, intermediate product, waste product or finished product.

Oil-Filled Capacitor - A capacitor whose conductor and insulating elements are immersed in an insulating fluid that is usually, but not necessarily, oil.

Outfall - The point or location where sewage or drainage discharges from a sewer, drain, or conduit.

Oxide Mask - Oxidized layer of silicon wafer through which "windows" are formed which will allow for dopants to be introduced into the silicon.

Panel - The front, screen portion of the glass enclosure of a cathode ray tube.

PCB (Polychlorinated Biphenyl) - A colorless liquid, used as an insulating fluid in electrical equipment. (The future use of PCB for new transformers was banned by the Toxic Substances Control Act of October 1976).

pH - The negative of the logarithm of the hydrogen ion concentration. Neutral water has a pH value of 7. At pH lower than 7, a solution is acidic. At pH higher than 7, a solution is alkaline.

pH Adjustment - A means of maintaining the optimum pH through the use of chemical additives. Can be manual, automatic, or automatic with flow corrections.

Phase - One of the separate circuits or windings of a polyphase system, machine or other appartus.

Phase Assembly - The coil-core assembly of a single phase of a transformer.

Phosphate Coating - A conversion coating on metal, usually steel, produced by dipping it into a hot aqueous solution of iron, zinc, or manganese phosphate.

Phosphor - Crystalline inorganic compounds that produce light when excited by ultraviolet radiation.

Photolithography - The process by which a microscopic pattern is tranferred from a photomask to a material layer (e.g., SiO_2) in an actual circuit.

Photomask - A film or glass negative that has many high-resolution images, used in the production of semiconductor devices and integrated circuits.

Photon - A quantum of electromagnetic energy.

Photoresist - A light-sensitive coating that is applied to a substrate or board, exposed, and developed prior to chemical etching; the exposed areas serve as a mask for selective etching.

Picture Tube - A cathode ray tube used in television receivers to produce an image by varying the electron beam intensity as the beam scans a fluorescent screen.

Plate - (1) Preferably called the anode. The principal electrode to which the electron stream is attracted in an electron tube. (2) One of the conductive electrodes in a capacitor.

Polar Capacitor - An electrolytic capacitor having an oxide film on only one foil or electrode which forms the anode or positive terminal.

Pole Type Transformer - A transformer suitable for mounting on a pole or similar structure.

Poling - A step in the production of ceramic piezoelectric bodies which orients the oxes of the crystallites in the preferred direction.

Polishing - The process of removing stock from a workpiece by the action of loose or loosely held abrasive grains carried to the workpiece by a flexible support. Usually, the amount of stock removed in a polishing operation is only incidental to achieving a desired surface finish or appearance.

Pollutant - The term "pollutant" means dredged spoil,, solid wastes, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal and agricultural waste discharged into water.

Pollutant Parameters - Those constituents of wastewater determined to be detrimental and, therefore, requiring control.

Pollution Load - A measure of the unit mass of a wastewater in terms of its solids or oxygen-demanding characteristics, or in terms of harm to receiving waters.

Polyelectrolytes - Synthetic or natural polymers containing ionic constituents, used as a coagulant or a coagulant aid in water and wastewater treatment.

Power Regulators - Transformers used to maintain constant output current for changes in temperature output load, line current, and time.

Power Transformer - Transformer used at a generating station to step up the initial voltage to high levels for transmission.

Prechlorination - (1) Chlorination of water prior to filtration. (2) Chlorination of sewage prior to treatment.

Precipitate - The discrete particles of material settled from a liquid solution.

Pressure Filtration - The process of solid/liquid phase separation effected by passing the more permeable liquid phase through a mesh which is impenetrable to the solid phase.

Pretreatment - Any wastewater treatment process used to reduce pollution load partially before the wastewater is introduced into a main sewer system or delivered to a treatment plant for substantial reduction of the pollution load.

Primary Feeder Circuit (Substation) Transformers - These transformers (at substations) are used to reduce the voltage from the subtransmission level to the primary feeder level.

Primary Treatment - A process to remove substantially all floating and settleable solids in wastewater and partially to reduce the concentration of suspended solids.

Primary Winding - Winding on the supply (i.e. input) side of a transformer.

Priority Pollutant - The 129 specific pollutants established by the EPA from the 65 pollutants and classes of pollutants as outlined in the consent decree of June 8, 1976.

Process Wastewater - Any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw materials, intermediate product, finished product, by-product, or waste product.

Process Water - Water prior to its direct contact use in a process or operation. (This water may be any combination of a raw water, service water, or either process wastewater or treatment facility effluent to be recycled or reused.)

Pyrolysis - The breaking apart of complex molecules into simpler units by the use of heat, as in the pyrolysis of heavy oil to make gasoline.

Quenching - Shock cooling by immersion of liquid or molten material in a cooling medium (liquid or gas). Used in metallurgy, plastics forming, and petroleum refining.

Raceway - A channel used to hold and protect wires, cables or busbars.

Rapid Sandfilter - A filter for the purification of water where water which has been previously treated, usually by coagulation and sedimentation, is passed through a filtering medium consisting of a layer of sand or prepared anthracite coal or other suitable material, usually from 24 to 30 inches thick and resting on a supporting bed of gravel or a porous medium such as carborundum. The filtrate is removed by a drain system. The filter is cleaned periodically by reversing the flow of the water through the filtering medium. Sometimes supplemented by mechanical or air agitation during backwashing to remove mud and other impurities.

Raw Wastewater - Plant water prior to any treatment or use.

Rectifier - (1) A device for converting alternating current into direct current. (2) A nonlinear circuit component that, ideally, allows current to flow in one direction unimpeded but allows no current to flow in the other direction.

Recycled Water - Process wastewater or treatment facility effluent which is recirculated to the same process.

Resistor - A device designed to provide a definite amount of resistance, used in circuits to limit current flow or to provide a voltage drop.

Retention Time - The time allowed for solids to collect in a settling tank. Theoretically retention time is equal to the volume of the tank divided by the flow rate. The actual retention time is determined by the purpose of the tank. Also, the design residence time in a tank or reaction vessel which allows a chemical reaction to go to completion, such as the reduction of hexavalent chromium or the destruction of cyanide.

Reused Water - Process wastewater or treatment facility effluent which is further used in a different manufacturing process.

Rinse - Water for removal of dragout by dipping, spraying, fogging etc.

Sanitary Sewer - A sewer that carriers liquid and water wastes from residences, commercial buildings, industrial plants, and institutions together with ground, storm, and surface waters that are not admitted intentionally.

Sanitary Water - The supply of water used for sewage transport and the continuation of such effluents to disposal.

Secondary Settling Tank - A tank through which effluent from some prior treatment process flows for the purpose of removing settleable solids.

Secondary Wastewater Treatment - The treatment of wastewater by biological methods after primary treatment by sedimentation.

Secondary Winding - Winding on the load (i.e. output) side of a transformer.

Sedimentation - Settling of matter suspended in water by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material.

Semiconductor - A solid crystalline material whose electrical conductivity is intermediate between that of a metal and an insulator.

Settleable Solids - (1) That matter in wastewater which will not stay in suspension during a preselected settling period, such as one hour, but either settles to the bottom or floats to the top. (2) In the Imhoff cone test, the volume of matter that settles to the bottom of the cone in one hour.

Sewer - A pipe or conduit, generally closed, but normally not flowing full, for carrying sewage and other waste liquids.

Silvering - The deposition of thin films of silver on glass, etc. carried by one of several possible processes.

Skimming Tank - A tank so designed that floating matter will rise and remain on the surface of the wastewater until removed, while the liquid discharges continuously under walls or scum boards.

Sludge - The solids (and accompanying water and organic matter) which are separated from sewage or industrial wastewater.

Sludge Cake - The material resulting from air drying or dewatering sludge (usually forkable or spadable).

Sludge Disposal - The final disposal of solid wastes.

Sludge Thickening - The increase in solids concentration of sludge in a sedimentation or digestion tank.

Snubber - Shock absorber.

Soldering - The process of joining metals by flowing a thin (capillary thickness) layer of nonferrous filler metal into the space between them. Bonding results from the intimate contact produced by the dissolution of a small amount of base metal in the molten filler metal, without fusion of the base metal.

Solvent - A liquid capable of dissolving or dispersing one or more other substances.

Solvent Degreasing - The removal of oils and grease from a workpiece using organic solvents or solvent vapors.

Sputtering - A process to deposit a thin layer of metal on a solid surface in a vacuum. Ions bombard a cathode which emits the metal atoms.

Stacked Capacitor - Device containing multiple layers of dielectric and conducting materials and designed to store electrical charge.

Stamping - Almost any press operations including blanking, shearing, hot or cold forming, drawing, blending, or coining.

Steel - An iron-based alloy, malleable under proper conditions, containing up to about 2% carbon.

Step-Down Transformers - (Substation) - A transformer in which the AC voltages of the secondary windings are lower than those applied to the primary windings.

Step-Up Transformer - Transformer in which the energy transfer is from a low-voltage primary (input) winding to a high-voltage secondary (output) winding or windings.

Studs - Metal pins in glass of picture tube onto which shadow mask is hung.

Substation - Complete assemblage of plant, equipment, and the necessary buildings at a place where electrical energy is received (from one or more power-stations) for conversion (e.g. from AC to DC by means of rectifiers, rotary converters), for stepping-up or down by means of transformers, or for control (e.g. by means of switch-gear, etc.).

Subtransmission (Substation) Transformers - At the end of a transmission line, the voltage is reduced to the subtransmission level (at substations) by subtransmission transformers.

Suspended Solids - (1) Solids that are either floating or in suspension in water, wastewater, or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater" and referred to as non-filterable residue.

Tantalum - A lustrous, platinum-gray ductile metal used in making dental and surgical tools, penpoints, and electronic equipment.

Tantalum Foil - A thin sheet of tantalum, usually less than 0.006 inch thick.

Terminal - A screw, soldering lug, or other point to which electric connections can be made.

Testing - A procedure in which the performance of a product is measured under various conditions.

Thermoplastic Resin - A plastic that solidifies when first heated under pressure, and which cannot be remelted or remolded without destroying its original characteristics; examples are epoxides, melamines, phenolics and ureas.

Transformer - A device used to transfer electric energy, usually that of an alternating current, from one circuit to another; especially, a pair of multiply-wound, inductively coupled wire coils that effect such a transfer with a change in voltage, current, phases, or other electric characteristics.

Transistor - An active component of an electronic circuit consisting of a small block of semiconducting material to which at least three electrical contacts are made; used as an amplifier, detector, or switch.

Trickling Filter - A filter consisting of an artificial bed of coarse material, such as broken stone, clinkers, slats, or brush over which sewage is distributed and applied in drops, films, or spray, from troughs, drippers, moving distributors or fixed nozzles and through which it trickles to the underdrain giving opportunity for the formation of zoogleal slimes which clarify the oxidized sewage.

Trimmer Capacitors - These are relatively small variable capacitors used in parallel with larger variable or fixed capacitors to permit exact adjustment of the capacitance of the parallel combination.

Vacuum Filter - A filter consisting of a cylindrical drum mounted on horizontal axis, covered with a filter cloth revolving with a partial submergence in liquid. A vacuum is maintained under the cloth for the larger part of a revolution to extract moisture and the cake is scraped off continuously.

Vacuum Metalizing - The process of coating a workpiece with metal by flash heating metal vapor in a high-vacuum chamber containing the workpiece. The vapor condenses on all exposed surfaces.

Vacuum Tube - An electron tube vacuated to such a degree that its electrical characteristics are essentially unaffected by the presence of residual gas or vapor.

Variable Capacitor - A device whose capacitance can be varied continuously by moving one set of metal plates with respect to another.

Voltage Breakdown - The voltage necessary to cause insulation failure.

Voltage Regulator - Like a transformer, it corrects changes in current to provide continuous, constant current flow.

Welding - The process of joining two or more pieces of material by applying heat, pressure or both, with or without filler material, to produce a localized union through fusion or recrystallization across the interface.

Wet Air Scrubber - Air pollution control device which uses a liquid or vapor to absorb contaminants and which produces a wastewater stream.

Wet Capacitor - (See oil-filled capacitor).

Wet Slug Capacitor - Refers to a sintered tantalum capacitor where the anode is placed in a metal can, filled with an electrolyte and then sealed.

Wet Tantalum Capacitor - A polar capacitor the cathode of which is a liquid electrolyte (a highly ionized acid or salt solution).

Wet Transformer - Having the core and coils immersed in an insulating oil.

Yoke - A set of coils placed over the neck of a magnetically deflected cathode-ray tube to deflect the electron beam horizontally and vertically when suitable currents are passed through the coils.

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