United States
Environmental Protection
Agency

Effluent Guidelines Division
WH-552
Washington, DC 20460

EPA 440/1-79/019a
September 1979

Water and Waste Management

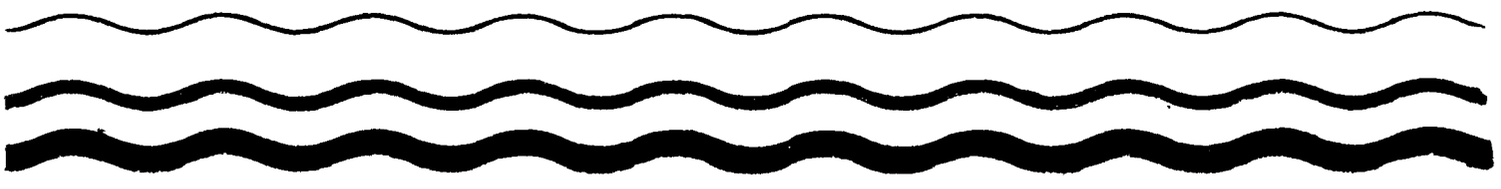
EPA

# Development Document for Effluent Limitations Guidelines and Standards FOR THE

DRAFT

# NONFERROUS METALS MANUFACTURING

## Point Source Category



# DRAFT DEVELOPMENT DOCUMENT

for

# EFFLUENT LIMITATIONS GUIDELINES

and

# NEW SOURCE PERFORMANCE STANDARDS

for the

# MAJOR NONFERROUS METALS SEGMENT

of the

# NONFERROUS METALS MANUFACTURING POINT SOURCE CATEGORY


Douglas M. Costle
Administrator

Swep T. Davis
Deputy Assistant Administrator for
Water Planning and Standards

Robert B. Schaffer
Director, Effluent Guidelines Division

Patricia E. Williams, P.E.
Project Officer, Nonferrous Metals



September 1979

Effluent Guidelines Division
Office of Water and Waste Management
U.S. Environmental Protection Agency
Washington DC 20460



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Region 5, Library (PL-12J)
77 West Jackson Boulevard, 12th Floor
Chicago, IL 60604-3590

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# SECTION I

# CONCLUSIONS

This report presents the results of a study to determine the wastewater characteristics of and treatment and control technologies applicable to the waste streams of nonferrous metal smelters and refineries. To facilitate the study, the industry was divided into subcategories, each of which has similar wastewater characteristics. Cost estimates were prepared for controlling and treating the wastewater to various levels.

EPA made a preliminary assessment that placed all nonferrous metal subcategories into one of two segments. The first segment, covered in this report, includes all subcategories with a large number of plants that discharge wastewater or have high production rates. These subcategories are listed below:

Primary aluminum
Secondary aluminum
Primary columbium and tantalum salts
Primary columbium and tantalum metal
Primary copper smelters
Primary copper refineries
Secondary copper
Primary lead smelters
Primary lead refineries
Secondary lead
Secondary silver from photographic wastes
Secondary silver from non-photographic wastes
Primary tungsten salts (APT)
Primary tungsten metal
Primary zinc
Metallurgical acid plants

The second segment, miscellaneous metals, includes all other nonferrous metals. Results of this study indicate that some plants in the miscellaneous metals segment do discharge wastewater; therefore, the EPA has begun a detailed study of that segment.

The nonferrous metals industry usually treats wastewater to remove metals, suspended solids, and in some cases ammonia and fluorides. Metals and suspended solids frequently occur in high concentrations in raw wastewater. Organic compounds are seldom present in the wastewater at concentrations greater than 1 mg/l. While no plant specifically attempts removal of organic compounds, some amounts of such pollutants may be removed

incidentally by treatment systems designed primarily to remove metals.

The removal of these organic pollutants in the existing wastewater treatment systems varied widely and were found to relate to specific treatment systems.

Treatment techniques are available to reduce potentially toxic compounds in wastewater to very low levels. Some subcategories can eliminate wastewater discharges by recycle and reuse, but reverse osmosis, a fairly expensive process, may be required in some instances to produce water of high enough quality to permit total reuse or recycle. All subcategories can reduce the volume of wastewater discharged by partial recycle and reuse after treatment by lime and settle. The present wastewater regulations generally require the control of some metals, suspended solids, pH, and, in some cases, ammonia, fluorides and oil and grease. Industry frequently controls these pollutants by adjusting the pH with lime followed by settling; steam stripping is used when necessary for ammonia removal.

Many treatment methods were evaluated during this study. Lime and settle is effective for removing suspended solids, metals, fluorides and some organic compounds. Sand filtration will further reduce suspended solids and metals concentrations. Activated alumina will remove additional fluoride and arsenic. Reverse osmosis will remove additional metals and dissolved solids and produces very high quality water that permits 100 percent recycle. Activated carbon removes organics and some metals. Ammonia is effectively removed by steam stripping. Chlorination oxidizes cyanide to carbon dioxide and nitrogen.

## SECTION II

## RECOMMENDATIONS

The Environmental Protection Agency will make recommendations as part of proposed rule making.

# SECTION III

# INTRODUCTION

## PURPOSE AND AUTHORITY

Section 301(b) of the Clean Water Act of 1977 (the Act) (33 U.S.C. 1251 et seq. P.L. 95-217) requires the Environmental Protection Agency (the Agency) to establish effluent limitations for point sources which will result in reasonable further progress toward the goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) of the Act.

On April 8, 1974, the Administrator promulgated effluent limitations and pretreatment standards for point sources within the Nonferrous Metals Manufacturing Point Source Category for the bauxite refining, primary aluminum, and secondary aluminum subcategories; on February 27, 1975 he promulgated regulations governing the primary copper smelting and refining, secondary copper, primary lead, and primary zinc subcategories. Section 301(d) of the Act authorizes the Agency to review and, if necessary, revise effluent limitations within five years of their original promulgation. Pursuant to this authority, and in conformance with a consent decree of the United States District Court for the District of Columbia of June 8, 1976 and modified March 9, 1979, the Agency is required to evaluate the wastewater of nonferrous metal smelters and refineries for the presence of priority pollutants (organic chemicals and heavy metals) as well as other pollutants.

Alternatives for effluent limitations published in this document are based on the alternatives that can be used by EPA to set best available technology economically achievable (BAT). The promulgated limitations must be met by existing point sources within the nonferrous metals manufacturing category no later than July 1, 1984. The best available demonstrated control technology will be the basis for revising the new source performance standards (NSPS). The pretreatment standards for existing and new sources discharging to publicly owned treatment works (POTW), which take effect within one year of promulgation, will also be based on the results of this study and consider the treatability of pollutants by POTW, or their interference with POTW.

Nonferrous metal manufacturers include processors of ore concentrates (primary) and processors of scrap (secondary). The nonferrous metals industry is quite complex and the production process for a specific metal is dictated by the characteristics of raw materials, market conditions, and economics of by-product

recovery, as well as the chemistry of the metals. Some metals, such as primary aluminum, are produced by essentially one process, while others, like copper and zinc, may be produced either pyrometallurgically or electrometallurgically. Additionally, by-products and co-products are important considerations for some industries. Many nonferrous metals are co-products or by-products of the smelting or refining of the base metals (copper, lead, and zinc). For example, all or almost all of the domestic production of arsenic, rhenium, palladium, selenium and tellurium during 1975 was a by-product or co-product of copper. About one-third of all domestic production of silver and gold was a copper by- or co-product. Copper itself is a by-product of lead, zinc, silver and gold. Other metals, such as aluminum and tungsten, are produced without important by-products. The co-product or by-product metals leave the production facilities where they were generated in a variety of forms and states of refinement, i.e. as concentrates, as heterogeneously unrefined materials in the form of slags, drosses, slimes or sludges, or as refined or alloyed metals.

Base-metal residues are interchanged among copper, lead, and zinc processors. Other metal-rich residues are shipped to centralized processing facilities where they are selectively extracted and refined. The production of co or by-product nonferrous metals generally involves relatively small operations.

The industry is divided into subcategories in which all plants within a subcategory have similar production processes and wastewater sources, permitting uniform regulations to be set for all plants within a subcategory. A preliminary assessment by EPA in early 1977 indicated that some 65 different types of metal are produced (counting primary production apart from secondary) at an estimated total of 800 plants. Since many of these metals subcategories are small (1 or 2 plants), and many were believed not to discharge any wastewater, EPA concentrated its efforts on the metals subcategories which have a fairly large number of plants, and discharge wastewater, or those subcategories which produce one of the metals listed in the consent decree and discharge wastewater. The metals not listed below are being covered under a second phase of this project. Certain metals had to be dropped from consideration. (For example, primary nickel was originally believed to be produced by only one plant. Results of an industry survey revealed another plant, and both must be considered for rulemaking). The metals included in the first segment are considered in this report and listed below.

Primary aluminum
Secondary aluminum
Primary columbium and tantalum salts
Primary columbium and tantalum metal
Primary copper smelters
Primary copper refineries
Secondary copper
Primary lead smelters
Primary lead refineries
Secondary lead
Secondary silver from photographic wastes
Secondary silver from non-photographic wastes
Primary tungsten salts (APT)
Primary tungsten metal
Primary zinc
Metallurgical acid plants

All of the plants in the first segment were contacted and requested to complete a detailed data collection portfolio. The responses confirmed that each subcategory listed above contains at least some plants that discharge process wastewater.

All of the plants in the second segment (Table III-1), which includes all the other nonferrous metals, were also contacted as part of this study to determine whether process wastewater is discharged. In some cases, plants do use process water, and those subcategories are now being studied by the Agency.

## METHODS USED IN THE DEVELOPMENT OF ALTERNATIVES FOR EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

The alternatives for effluent limitations and standards of performance contained in this document were developed by analyzing three pools of information: the existing literature on the nonferrous metals industry and other industries, the information submitted by all facilities responding to DCP's, and analysis of wastewater samples collected from 46 plants throughout the nation. Responses to data collection portfolios and analyses of wastewater samples were used to determine current practices within the industry. The practices of other industries were evaluated by reviewing pertinent literature.

The existing literature was studied to obtain information on treatment technologies practiced by the nonferrous metals industry and related industries. A portion of the information sought was related to in-plant controls already in practice, such as recycle. Also, new treatment technologies were considered in this study.

Historical data (both concentration ranges and mass loadings) on pollutant parameters monitored as required by individual state agencies, were available from NPDES (National Pollutant Discharge Elimination System) Discharge Monitoring Reports. Previous development documents were also reviewed to become familiar with production processes, wastewater origins, and treatment technologies used.

The industry was surveyed by mailing a data collection portfolio (DCP) to all companies known or believed to produce nonferrous metals. A listing of the companies comprising the nonferrous metals industry (as classified by standard industrial code numbers) was compiled by consulting trade associations and the U.S. Bureau of Mines. The DCPs sought information about the production processes, yearly production quantity, and wastewater treatment and control technologies. Attention was also placed on non-water quality aspects such as sludge disposal methods, air pollution control technologies, and energy consumption.

Producers of metals in the second segment (Table III-1) were sent abbreviated questionnaires to develop basic information about production of that metal. These producers were asked only (a) what metal they produced and the production quantity; (b) if water was used in the process; (c) if wastewaters were discharged from the process; and (d) what was the volume of wastewater discharged. The results of these surveys are included in Table III-1.

If the questionnaires were not returned, information on production processes, sources of wastewater, and treatment technology at these plants was collected by telephone interview. The information so gathered was validated by sending a copy of the information recorded to the party consulted. The information was assumed to be correct as recorded if no reply was received in 30 days. In total, more than 95% of the industry was contacted either by mail or by telephone.

The information gathered in the data collection portfolios was used to select plants for wastewater sampling. Plants for sampling were selected on the following bases: good wastewater treatment, representative processes and wastewater streams, or other qualities which made it desirable for sampling. Wastewater samples were collected in two phases. The first phase, screen sampling, was to identify which priority pollutants were present in the wastewaters from production of the various metals. This was done at 13 different plants.

The second phase of sampling, verification, was used to determine whether the pollutants identified by screen sampling are present throughout a subcategory, and if so, at what concentrations.

One 72-hour or three 24-hour composite samples were collected and analyzed in accord with the protocol established by the Agency in 1977 (1). Some deviations from the protocol were occasionally necessary. For instance, in some cases, automatic samplers could not be used because the process being sampled was a batch operation. In such cases, a manually composited sample was collected.

In accord with the protocol, tubing blanks were collected in the field by passing approximately one gallon of organic-free water through new tubing just before samples are collected. This procedure was followed for screen sampling. However, during verification, tubing blanks were collected in the laboratory by passing three gallons of organic-free water through segments of tubing in a 72-hour period. This latter procedure parallels the collection of wastewater samples. A representative length of tubing was cut and stored from each roll of tubing before use in the field, thus duplicating sampling conditions between tubing blanks and actual wastewater samples.

## GENERAL DESCRIPTION OF THE NONFERROUS METALS INDUSTRY

The nonferrous metals industry encompasses the primary smelting and refining of nonferrous metals (Standard Industrial Classification (SIC) Number 333) and the secondary smelting and refining of nonferrous metals, (SIC Number 334). The industry does not include the mining and beneficiation of metal ores; rolling, drawing, or extruding metals; or scrap metal collection and preliminary grading.

Industry production figures (2) (Table III-2) show that the aluminum, copper, lead and zinc producers dominate the industry. The history of various parts of the industry can be found in the previous development documents prepared by the Agency for those subcategories (3 through 8).

The nonferrous metals industry can be classified into three broad groups. The first group includes plants that discharge process wastewater directly to navigable waters (direct dischargers). The second group contains plants that discharge process wastewater to publicly owned treatment works (POTW) (indirect dischargers). The third group contains plants that discharge no process wastewater pollutants.

Of 296 plant responses to the detailed industry survey (Table III-3), 86 plants (30 percent) are direct dischargers, while 65 plants (20 percent) are indirect dischargers. Water management techniques of 145 plants (50 percent) that do not discharge process wastewater were examined to determine if the technology could be transferred to other segments of the industry. Figure

III-1 shows the locations of the major nonferrous metals industry plants.

## DESCRIPTION OF METALS SUBCATEGORIES IN THE NONFERROUS METALS INDUSTRY

This section describes the subcategories included in this study. Subcategories for which regulations have been promulgated, and are reviewed in this document, are briefly summarized in terms of raw materials and production processes. More comprehensive descriptions of the production processes can be found in the previous development documents (3 through 8) for these industries.

### Primary Aluminum

Raw Materials. The principal raw materials used in primary aluminum reduction are alumina, petroleum coke, pitch, cryolite, and aluminum fluoride. Alumina is the product of bauxite refining.

Manufacturing Process. Aluminum metal is produced from alumina in electrolytic cells by the Hall-Heroult process (Figure III-2). A potline consists of a row of electrolytic cells (pots). The pots are made of cast iron lined with carbon and contain an electrolyte of cryolite, calcium fluoride, and aluminum fluoride. Alumina is added to the pots periodically and the electrical current causes the reduction of alumina to aluminum metal. Aluminum is removed as it accumulates on the bottom of the pot.

The negatively charged carbon pot lining is called the cathode. The molten aluminum collects in it and becomes the actual cathode or negative pole of the cell. The positive pole, or anode, consists of carbon in the form of petroleum coke and pitch. The anodes are oxidized in the process, producing CO and $CO_2$.

Anodes are of two types: prebaked and Soderberg. Both begin with the preparation of a paste of pitch, coke and other raw materials at an anode paste plant. Paste preparation includes crushing, screening, calcining, grinding and mixing and requires dust control facilities. Pitch handling presents special air pollution problems. If it is handled as a solid, it produces significant amounts of dust. If it is melted by steam, electricity, or heat transferred through a separate medium (i.e., hydrocarbon oils, or glycols), toxic or flammable hydrocarbon vapors must be controlled.

In the Soderberg process, the anode paste is used in the electrolytic cell without further processing. The paste bakes or graphitizes in the heat of the electrolyte bath. Replacement of

the Soderberg anode is continuous: as the anode oxidizes at its tip, paste is added at the top. Two configurations exist in the aluminum industry using the Soderberg process. The HSS system uses horizontal pins to support the anode body while the VSS system uses vertical studs or pins. In the horizontal Soderberg process, adjusting the holding pins is made from the side of the pot while the vertical Soderberg process adjusts the pins on top. Since the paste is added from above, complete hooding of the VSS cell is not possible, and more fumes may be added to the potroom than with other types of anodes.

Prebaked anodes are pressed, baked, and graphitized at an anode bake plant. Prebaked anodes that become too short to be effective are replaced and the spent anode may be recycled.

Anode preparation and baking releases particulates, tars and oils, and hydrocarbons to the air. Paste plant air pollution control usually consists of baghouse removal of dust, sometimes in conjunction with an ESP, although at 4 plants wet methods are employed. Anode bake plant air pollution control may be wet scrubbing or alumina adsorption. Electrostatic precipitators are also used, but have reportedly experienced arcing problems associated with tars and oils. The resulting wastewater contains tars and oils, particulates, sulfur compounds, fuel combustion products, and possibly fluorides.

The potline cells emit gases containing particulates, fluorine compounds, $SO_x$, $CO_x$, tars and oils. Emissions can be collected and treated by wet or dry processes. Activated alumina adsorption is the most common dry process; wet scrubbers and electrostatic precipitators are also used. The alumina dry scrubbers allow recycle of the fluoride back to the cell.

Effective hooding (easier on prebake cells) may eliminate the need for secondary air pollution control, i.e., potroom air scrubbing. The Soderberg configuration may prevent complete hooding of the cell, resulting in emissions to the potroom, although prebake anode pot lines also use secondary scrubbing. All secondary or potroom emission control is by wet systems.

Recycling or disposal of spent anodes and carbon cell-liners also generate wastes. Fluoride from the cryolite and alumina bath in the electrolytic cells adheres to spent prebaked anodes; thus, recycling processes may result in fluorine compounds in the flue gases at the anode bake plant.

Disposal of carbon potliners (cathodes) may include cryolite recovery or, more commonly, disposal on land at the plant. Cathode reprocessing and runoff waters are likely to contain fluorides and cyanides.

Molten aluminum, which collects in the bottom of the electrolytic pots, is tapped and conveyed to holding furnaces for subsequent degassing and alloying. Degassing is performed by injecting chlorine gas (sometimes with nitrogen and carbon dioxide) into the molten metal to remove hydrogen. The addition of gas to the melt also mixes the aluminum to assure that added alloys are distributed evenly in the molten aluminum.

Casting is the final step at most reduction plants. Pigs and sows are cast in conventional molds, while direct chill (DC) casting may be used for other shapes. In DC casting, molten aluminum is poured into a bottomless water-cooled mold, and after surface solidification, slips through the mold and drops down through a series of water sprays into a water filled pit where solidification is completed.

Industry Profile. Figure III-3 shows the location of the 30 primary aluminum reduction plants operating in the United States. Another primary aluminum plant is on a stand-by basis. Because considerable amounts of electrical energy are required to produce aluminum, most primary aluminum plants are located near sources of abundant and inexpensive hydroelectric power, such as the Pacific Northwest and the Tennessee River Valley (TVA).

Of the 30 reduction plants shown in Table III-4, about 70 percent (22 plants) were built in the last 30 years. The average plant age is between 20 and 30 years. From the data summarized in Table III-5, 26 plants (85%) produce less than 200,000 tons per year. Median production is in the 100,000 to 150,000 tons per year range.

Twenty-seven plants are direct dischargers. The other three are at zero discharge. Table III-6 summarizes, by type of discharge, the type of wastewater treatment at primary aluminum plants. The Best Practical Treatment (BPT) is defined in Table III-6, adapted from the previous development document (3). From the table, it can be seen that 18 plants (60 percent) provide BPT or better treatment. Of the remaining 12 plants (40 percent) not providing BPT or better treatment, one-fourth have no treatment.

The vast majority of the 30 plants are in areas of net precipitation (Figure III-4). Thus, the use of solar evaporation ponds may be precluded. Table III-7 shows, by type of discharge, the number of plants using specific chemicals or physical treatment processes to treat wastewater at present. The majority of the plants use lime and sedimentation. A few plants use other types of chemical agents and/or physical processes to treat wastewaters.

Table III-8 indicates the production processes used by aluminum reduction plants.

Secondary Aluminum

The following is a brief summary of the raw materials and processes used in the secondary production of aluminum. Historical highlights and a more detailed and comprehensive description of the processes can be found in the first development document for secondary aluminum (4).

Raw Materials. Nearly all of the raw materials utilized by the secondary aluminum industry are scrap aluminum purchased from scrap dealers or industrial plants. The scrap may be divided into five classifications: new clipping, forgings and other solids; borings and turnings; residues; old casting and sheet; and high iron.

New clippings, forgings, and other solids originate from the aircraft industry, aluminum formers, and manufacturing plants. Borings and turnings come mainly from machining of castings, rods, and forgings. Residues consist of waste dross, skimmings, and slags from operations at primary reduction plants, secondary smelting operations, casting plants, and others. Old casting and sheet come from various sources such as automobile parts, household items and dismantled airplanes. High iron originates from iron scrap and requires special treatment before smelting.

Manufacturing Process. The varied nature of the raw materials used in the secondary aluminum industry requires two distinct operations: presmelting and smelting.

The presmelting process varies with the raw material being handled. Additionally, the degree to which the industry prepares and segregates scrap differs from plant to plant. New clippings and forgings require little preparation other than sorting; however, they are often contaminated with cutting oils. The materials are usually crushed and dried to remove the oils. After drying, the scrap is screened and iron is removed by magnetic separators.

Furnace residues, e.g., dross, slag, and skimmings, have a high impurity content and either wet or dry processes are used to remove these impurities. The dry process consists of crushing, screening, and iron removal by magnetic separation. Baghouses are usually used to control the dust created by this process, but wet scrubbers are sometimes used. The wet process includes washing, screening, drying, and magnetic separation of iron. Fine particles, dissolved salts, and undersize screenings characterize the resultant wastewater.

Scrap sheet and casting preparation is a dry process that can vary from no presmelting treatment to screening and iron removal by magnetic separation. High-iron scrap must undergo presmelting treatment for iron removal ranging from crushing and magnetic separation to iron removal by a sweating furnace. A sweating furnace is a sloped furnace in which molten aluminum flows down the slope, leaving iron and other residuals. The offgases are usually passed through an afterburner before release.

The smelting of secondary aluminum, shown in Figure III-5, consists of six steps: Charging scrap into the furnace, addition of fluxing agents, addition of alloying agents, mixing, demagging or degassing, and skimming. Some plants also process residues to recover a high aluminum fraction for smelting and a low aluminum fraction that is used as a ingot topping by steel manufacturers.

Charging of scrap into the furnace can be a batch process or a continuous process. Each smelting cycle, called a heat, will vary in length depending on the type of process. This process generates fumes and smoke depending on the quality of the scrap used.

The addition of a flux forms a semi-solid barrier on the melt that optimizes oxidation of metal by gas adsorption. The flux also facilitates impurity removal by physical separation. Chloride or fluoride salts of sodium, potassium, calcium, or cryolite are usually used as fluxes. The amount of flux added is proportional to the surface area of the charged scrap.

Alloying agents are added depending on the specified alloy content of the product. Copper, silicon, manganese, magnesium, and zinc may be added as required, usually in scrap form. Minimal fumes are generated in this process.

Mixing the furnace contents is necessary to assure uniform composition of the metal and the fluxing and alloying agents. Mixing may be by injecting nitrogen gas or a mixture of nitrogen and chlorine. Injecting nitrogen gas causes negligible fuming but the nitrogen and chlorine mix does generate fumes.

Magnesium removal (demagging) is achieved by adding chlorine or aluminum fluoride. Volatile aluminum chloride fumes are generated when demagging agents are added, and the extent of their formation is dependent upon residual magnesium in the melt. Air pollution control is required to remove these fumes and wastewater is generated when wet scrubbing is used.

The semi-solid flux or slag, with its associated impurities, is skimmed from the molten aluminum following demagging or degassing. The cooled slag is stored for shipment to a residue

processor, recycled, or discarded. Contamination of runoff water with soluble salts can occur if open storage is used.

The product line(s) of each smelter can be categorized as specification alloy ingots, billets, hot metal, notched bar, shot, and hardeners. Specification alloy ingots, used by foundries for casting, are the most important products of the secondary aluminum industry. Cooling can be done with either contact or noncontact cooling water, and air cooling is also used. Plants employing contact cooling water recycle systems generate intermittent discharges (accompanied with sludge removal). Billets, manufactured for use in the extrusion industry, are cooled with noncontact water that is recycled. Sometimes the molten metal is poured directly into preheated crucibles and then shipped while still in a molten form. No water is used. Notched bar is used in the iron and steel industry as a deoxidant. Notched bar molds may be air or water cooled with either contact or noncontact water. Aluminum shot is also used as a deoxidant in the steel industry. Molten metal is poured into a vibrating feeder, where droplets of molten metal are formed through perforated openings. The droplets are cooled in a quench tank. Water is generally recycled and periodic sludge removal is required.

Industry Profile. A summary of treatment technologies employed by the secondary aluminum industry is given in Table III-9. BPT effluent limitations are based on the production process employed by the secondary aluminum smelter. For those direct dischargers that only produce wastewater by contact cooling of aluminum, the BPT effluent limitation is no discharge of process wastes, as is the case for direct dischargers which employ $AlF_3$ as a demagging agent. BPT for direct dischargers which employ chlorine demagging is pH adjustment and settling. Those direct dischargers which generate process wastewater from dross processing also require a BPT treatment corresponding to pH adjustment and settling.

Of the 63 plants examined, eight (13 percent) are direct dischargers. Of these eight, two provide no treatment. Four plants provide coagulation and solids separation (Level B).

Sixteen (25 percent) of the 63 secondary aluminum facilities examined are indirect dischargers. The existing source pretreatment technologies are as follows: contact cooling water (oil skimming), demagging scrubber wastewater (neutralization) and dross processing wastewater (neutralization). Twelve of the 16 indirect dischargers provide no treatment (see Table III-9). Three of the indirect dischargers treat process wastes by coagulation and solids separation. Thirty-nine secondary aluminum plants (62 percent of those surveyed) do not discharge

process wastewater. All of these plants meet BPT effluent limitations.

A summary of the processes employed by the secondary aluminum industry is presented in Table III-10. Figure III-6 shows that most plants are located in the eastern U.S. and are in urban areas.

The vast majority of the 63 secondary aluminum plants are in areas of net precipitation. This may preclude the use of solar evaporation ponds.

Table III-11 shows, by type of discharge, the number of plants using certain chemicals or physical treatment processes to treat wastewater at present. The majority of the plants do not use any type of treatment process since most plants use dry processes.

The average age of the 63 secondary aluminum smelting plants is 20 to 25 years (Table III-13). This fact reflects the relative youthfulness of this industry. From the summarized data in Table III-12, 42 plants (67 percent) produce under 30,000 tons per year. Median production is in the 5,000 to 10,000 tons-per-year range.

Primary Columbium and Tantalum

While chemists refer to element number 41 as "niobium", in American metallurgy it is known as "columbium", and this name will be used in this report.

Raw Materials. Raw materials for the production of columbium and tantalum salts are ore concentrates and slags. Columbite, tantalite, and pyrochlore are the principal minerals. Columbium and tantalum are commonly found together. Ferrocolumbium ores are also processed. Slags associated with foreign tin production are the major source of these materials. Columbium and tantalum metals are produced by the reduction of purified salts. Some plants produce both columbium and tantalum salts and further refine this material to the metal.

Manufacturing Process. The processes used at a columbium and tantalum production facility depend largely upon the raw material used and the final product of the plant. Three types of plants are found: producers of metals and salts from concentrates and slags; producers of only purified salts from concentrates and slags; and producers of metals from purified salts.

Initial processing of ore concentrates and slags consists of leaching with hydrofluoric acid to solubilize columbium and tantalum salts. In addition, other metal impurities are

solubilized and require removal. Solvent extraction is the most common purification technique, while ion exchange is sometimes used. Frequently, methyl isobutyl ketone (MIBK) is used to preferentially extract columbium and tantalum from solution (Figure III-8). The laden solvent is then stripped of tantalum oxide by deionized water. Following hydrofluoric acid addition, the solvent is stripped again, yielding a columbium-laden stream. The separate solutions are chemically treated to precipitate pure salts of columbium and tantalum. An alternate technique is to recover columbium and tantalum salts directly from the organic solvent as solids. The columbium is further processed by drying and calcining to yield pure $Cb_2O_5$. Tantalum may be precipitated by ammonia addition to produce $Ta_2O_5$, or potassium fluorotantalate may be produced by addition of hydrofluoric acid and potassium fluoride.

A number of methods exist for the reduction of columbium and tantalum salts to metal. Reduction methods include: aluminothermic reduction, sodium reduction, carbon reduction, and electrolysis.

Aluminothermic reduction may be used on purified salts of columbium and tantalum or on ferrocolumbium ores, which require no prior processing. The salt or ore is mixed with aluminum, potassium chlorate, and magnesium. Ignition of this mixture catalyzes an exothermic reaction leading to the reduction of columbium and tantalum while aluminum is oxidized. The reduced metal is separated from the overlying slag after cooling.

Sodium reduction entails charging alternating layers of tantalum salts with layers of sodium under heat and pressure. The layers are capped with sodium chloride during the ensuing exothermic reaction to prevent oxidation of the reduced metal. The metal-containing material is crushed and treated magnetically to remove iron after cooling. The tantalum is further purified by leaching with water and then again with nitric or hydrochloric acid.

A high-purity columbium can be produced by carbon reduction. Reduction of columbium salt is attained by a dry two-stage process. Partial reduction of $Cb_2O_5$ with carbon yields columbium carbide. The columbium carbide and $Cb_2O_5$ react at high temperature yielding pure columbium and carbon dioxide.

Electrolytic reduction of tantalum, using fused-salt techniques, has been commercially used. Commonly, $K_2TaF_7$ is electrolyzed to yield tantalum metal.

Due to the high reactivity of tantalum and columbium, special techniques must be used to further purify and work the metal into the desired form. These processes include: compaction and direct

resistance heating in a vacuum furnace, cold-crucible arc melting, and electron beam melting. Vacuum furnace sintering is used to purify and compact the metal simultaneously. The rate of heating is controlled while the metal undergoes hydrogenation, leaching with nitric acid, and several pressing and sintering steps. Electron beam and arc melting methods, both performed under a vacuum, also serve the purpose of purification and compaction of the metal.

Industry Profile. Most of the plants were built in the 20-year period just after World War II (Table III-14). Data on the age of the remaining two plants were not available. The average plant age is about 20 years. Average plant production is around 450 tons per year range, as shown in Table III-15.

Figure III-9 depicts the geographic locations of the plants comprising the columbium-tantalum subcategory of the nonferrous industry. The plants are scattered, with half the plants located in the New England area and the rest in the Midwest or the West. Comparing this figure to Figures III-4 and III-9 shows that only the plant in Oklahoma is in an area of net evaporation. The other plants are in net precipitation areas.

From Table III-16, it can be seen that all the plants discharge wastewater. This table summarizes the level of treatment achieved by all plants in the columbium-tantalum industry at the present time.

Table III-17 shows, by type of discharge, the number of plants using given chemical or physical treatment processes to treat process wastewater streams at present. As noted, most plants use lime and sedimentation as treatment. Only a limited number of other treatment processes are presently employed. Table III-18 lists the major production processes presently used in the columbium-tantalum industry.

Primary Copper

Raw Materials (Smelting). Although there are about 160 known copper minerals, only about a dozen of these are commercially important. The most important copper ores in the United States are: chalcopyrite, chalcocite, covellite, bornite, cuprite, and malachite. These minerals are either sulfide ores or oxide ores. In Michigan's upper peninsula, however, native copper is a significant ore mineral associated with covellite, a copper sulfide.

Manufacturing Process (Smelting). Primary copper smelters use one of two main process schemes: roasting, smelting, and converting; or simply smelting and converting (Figure III-10).

Smelters that process numerous types of ore concentrates often use roasting as well as smelting, while those that process ore concentrates of uniform consistency may not require the roasting step. Roasting can be done with either a multiple-hearth roaster or a more modern fluid-bed roaster. Roasting reduces the content of sulfur and other impurities in the feed prior to smelting. Smelting may be done with either a reverberatory furnace or an electric furnace. The end product, a molten copper-iron-sulfide material called matte, is sent to a converter, while the slag which contains impurities is skimmed off as waste material for disposal.

In the converting step, air is introduced into the molten bath, and the iron-sulfide component of the matte is oxidized to sulfur dioxide and iron oxide. The sulfur dioxide is carried off in the exhaust air stream and the iron oxide further reacts with silicate, added as a fluxing agent, to form iron-silicate slag. The slag, which contains significant amounts of copper, is recycled to the smelting step. The converter product is called blister copper. Blister copper, containing various impurities, including precious metals, is usually cast into anodes and sent to electrolytic refining for purification. Fire refining, which is a pyrometallurgical method, produces only a small percentage of the refined copper produced in the United States.

Fire refining is done in either a reverberatory or a rotary furnace. Compressed air is introduced beneath the molten copper to oxidize part of the copper to cuprous oxide. The cuprous oxide reacts with sulfur and heavy metals to form sulfur dioxide and metal oxides. Sulfur dioxide escapes to the air exhaust system while metal oxides are collected in the slag that is removed from the furnace by mechanical raking. Cuprous oxide in the molten material is reduced to metallic copper by adding coke or by "poling" after slag removal. In the poling process, green hardwood poles are inserted beneath the molten bath. To prevent reoxidation, the bath is then covered with sand and charcoal to prevent the entry of air. Fire-refined copper is either cast into anodes or other final products.

Large amounts of air pollutants, principally sulfur dioxide and particulate matter, are generated during the smelting process. Particulates are generated in the roasting, smelting, and converting of ore concentrates. In some plants, the off-gases from primary smelting operations pass through a boiler for heat recovery and then pass through a low-velocity flue device to precipitate heavier particles. The smaller fume-sized particulates are usually removed by electrostatic precipitators (ESP); multiclones or baghouses are also used by some plants.

Control of sulfur dioxide offgases usually follows particulate removal. Several schemes exist for recovery of sulfur oxides from off-gases: a single or double contact sulfuric acid plant or dimethylaniline (DMA) system. Further particulate removal from the gas streams is performed before they enter the acid plant by passing the gas streams through an open and/or packed scrubbing tower. The gas is then passed through an electrostatic precipitator to remove remaining particulate matter and $SO_2$ and is dried of moisture before being converted to sulfuric acid. The final gas stream, called tail gas, which contains a high $SO_2$ concentration, is normally passed through a sulfuric acid mist precipitator for additional $SO_2$ recovery. The DMA system uses a three-tray absorbing tower where sulfur oxide chemically combines with the DMA solution. The $SO_2$-laden DMA solution is then passed through a stripper to remove $SO_2$. The concentrated $SO_2$ gas stream is compressed into liquefied $SO_2$ solution as the final product. The depleted DMA solution is recirculated to the first tray of the absorbing tower for reuse.

Raw Materials (Refining). The principal raw material used is the blister copper produced by copper smelters.

Manufacturing Process (Refining). Electrolytic refining, illustrated in Figure III-11, uses many electrolytic baths with a series of cathodes and anodes. The cathodes, called "starter sheets," are thin sheets of electrolytically refined copper. A dilute solution of sulfuric acid and copper sulfate is used as the electrolyte. The electrolytic reaction results in the deposit of copper on the cathode sheet and releases anode impurities that precipitate in the electrolyte. The refined copper cathodes are rinsed, and may be melted, and cast for transport as a final product. Impurities and soluble copper oxides become concentrated in the electrolyte. Spent electrolyte is bled off and replaced with fresh electrolyte to maintain the proper concentrations of copper and impurities. Single- or double-stage liberator cells are used to remove copper from the laden electrolyte by electrolytically depositing copper on a cathode. As the copper concentration of the electrolyte drops to a low level, arsine ($AsH_3$) is evolved at the anode and hooding of the final stage of liberator cells is required to eliminate employee exposure to the toxic gas. The decopperized solution may be recycled, used as a leaching solution, or collected for final disposal.

Insoluble slimes are generated during the electrolytic refining process. These slimes may contain economically significant amounts of copper, selenium, tellurium, lead, silver, and other precious metals. These slimes are usually processed off site, but may be treated on site for by-product recovery. The slime is first screened and washed with sulfuric acid for copper recovery.

The resulting slime cake is sent to a Dore furnace for fusion. The first slag formed in the Dore furnace is skimmed off and sent to a lead smelter for lead recovery. Selenium and tellurium are fluxed into a soda slag when soda ash and sodium nitrate are added. The soda slag is dissolved and filtered and the residue is recycled to the Dore furnace. The tellurium-bearing filtrate is acidified to a pH of about 5.5 to precipitate tellurium oxide ($TeO_2$) which is further reduced, purified as tellurium, and cast. The selenium-bearing filtrate is acidified with sulfuric acid and treated with sulfur to precipitate metallic selenium.

At the Dore furnace, after removal of the soda slag, air is introduced into the metal pool to oxidize any remaining copper and the copper oxide is skimmed off with the newly formed slag. The residual metal (Dore metal) is cast into anodes which may be processed on-site or sold to other refineries for recovery of silver, gold, and other precious metals.

Recovery of precious metals from Dore entails both electrolytic refining and cementation of waste electrolyte evolved from the refining process. The Dore anodes are electrolytically refined in a nitrate solution and silver is produced at the cathodes. The waste electrolyte is subjected to cementation for silver and copper recovery by adding copper to displace soluble silver, and by adding iron to precipitate residual soluble copper. The gold and precious metals bearing slimes produced during the electrolytic refining of silver are melted, cast into anodes and electrolytically refined into gold. Small quantities of particulates are also generated from slime recovery furnaces. Slime recovery furnaces generally employ either electrostatic precipitators or wet scrubbers for air pollution control. Precious metals (platinum, etc.) are produced from the gold electrolyte slime.

Industry Profile. The primary copper industry, consisting of 23 plants depicted in Figure III-12, consists of two distinct operations: smelting and refining. In some cases both operations are found at or near the same site. As a rule, however, smelters are located near copper mines, in the Southwest, and refineries are found near either smelters or maritime centers, e.g., the northeastern seaboard.

Of the plants considered in the primary copper subcategories, Table III-19 shows 23 plants. Table III-19 shows the average age of the plants to be around 40 years. As seen in Table III-20, the average plant production is around 100,000 tons per year.

As shown in Figure III-12 and Table III-21, only 35 percent (eight) of the 23 plants discharge wastewater. Fifteen are at zero discharge of pollutants, and there are no indirect

dischargers. Table III-21 summarizes, by type of discharge, the level of wastewater treatment at plants in the primary copper industry. The present BPT regulation is zero discharge for smelters and refineries in areas of net evaporation. In months of net precipitation, discharge of a volume no more than the net monthly precipitation is allowed. For stand-alone refineries in areas of net precipitation, a discharge is allowed. These regulations are presently being reconsidered. Eight of the 23 plants are direct dischargers, two of which are in areas of net evaporation. Of the eight direct dischargers, three do not presently employ any wastewater treatment, while three are at a level of treatment exceeding chemical coagulation and sedimentation. Table III-22 shows, by type of discharge, the number of plants using a given chemical or physical treatment process to treat process wastewater. Many plants add lime and then settle. An even greater number of plants use solar evaporation ponds, mostly in the Southwest.

Table III-23 summarizes the production processes used at primary copper plants.

Secondary Copper

Raw Materials. Industrial copper-bearing scrap, discarded consumer items, and melting and refining residues are the basic raw materials used by the secondary copper industry. The National Association of Secondary Materials Industries (NASMI) classifies these materials into 44 designations. They can also be grouped into three broad categories: low grade, intermediate grade, and high grade. Low grade scrap consists of highly contaminated waste products, including slags, drosses, skimmings and other industrial residues. Intermediate grade scrap forms the bulk of the materials processed. These are mostly brass or bronze alloys of different composition in a variety of forms and sizes. High grade scrap is basically pure copper.

The wide variety of the raw materials requires several different methods to prepare and process them. The finished products may vary from low quality black copper to high quality electrolytically-refined copper. Additionally, some plants merely warehouse and sell some of these materials after minimum processing, e.g., large railroad journal boxes are cut to crucible size and sold directly to foundries.

Manufacturing Process. As dictated by the type of raw materials and the desired end product, the manufacturing process (as shown in Figure III-13) consists of three distinct operations: pretreatment of scrap, smelting, and refining. Most plants, however, do not go beyond the smelting process.

Pretreatment of scrap--First, the materials are segregated for pretreatment as they arrive at the plant. The composition of each lot is known in most cases. The materials usually are presorted by secondary material dealers or shipped directly by foundries and metal shops. Low grade copper-bearing scrap, in many cases generated in-house, e.g., slag, skimmings, and drosses, is generally broken up with jackhammers and the smaller pieces are fragmented in a ball mill. The milled material is then wet-classified in vibrating tables to recover small copper-rich granules or copper concentrates. Very fine particles of metal, soil, and other impurities are carried away by water to settling basins and eventually removed as sludge when the basins undergo periodic cleaning. The recovered granules may be pelletized, briquetted, or simply mixed with the melt to produce alloys. These concentrates may also be melted, after briquetting, in cupola or blast furnaces to produce black copper. The gangue or depleted slag, which may contain up to five percent copper, is added in small proportions to the heats charged to produce copper-based alloys.

Intermediate grade scrap is used mostly to produce brass and bronze alloys, and the pretreatment processes employed are as varied as the specifications of the raw materials. While some materials require little or no treatment, some may undergo as many as four steps. Most materials require, as a minimum, one of the following: stripping, burning, drying, sweating or sawing. Sweated and sawed materials usually do not require further treatment prior to smelting. Stripped, burned, or dried materials normally undergo shredding followed by magnetic separation. Then the materials, depending on their size, may be briquetted or baled for easy handling.

Other processes not shown in Figure III-13 include classification by manual or mechanical means. Hand-sized homogenous materials are usually separated manually. Air classification may also be done following shredding to remove lightweight contaminants.

High grade materials require only drying and baling or sawing as pretreatment to produce either blister copper or refined copper.

Size reduction processes are used to remove impurities or to improve handling operations. Milling of slags and other large solids is done in ball mills. This is a dry operation that creates moderate amounts of dust. Shredding of bulky materials, done with mechanical shredders or hammer mills, is required to remove iron or light organic contaminants. This is also a dry operation which produces moderate to high amounts of dust. Sawing of huge solids is required to improve handling. Considerable metal dust is produced, but this dust is recovered and briquetted for later use.

Primary contaminant removal processes include stripping, burning, drying, and sweating. Electrical cable and similar items are either stripped or burned to remove insulation, sheathing, or imbedded plastics from copper-bearing materials. Stripping is usually done with automatic machines, but hand stripping is also done. In either case, this process produces significant quantities of solid waste in the form of plastics, paper, or textiles. Sometimes the contaminants are burned away. This method produces emissions that may contain potentially toxic organics along with the combustion products and it is a source of wastewater if wet scrubbing is practiced.

Borings, turnings, and similar industrial wastes are usually contaminated with cutting oils or grease. The contaminants are typically removed by heat-drying in rotary kilns equipped with afterburners to treat the hydrocarbons released by the process. Sulphur oxides and chlorides, if present, are not removed by the afterburner and further air pollution control may be required. Scrap solids with low melting points, such as radiators, journal bearings, and lead-sheathed cables, are sometimes treated in a sweating furnace to remove and recover by-products, e.g., solder, lead, and babbitt. Sweating is done in a sloped furnace where metals of low melting point, such as copper, flow downward and are collected. Sweating may also be done in pots with alloys, in rotary kilns, or in reverberatory furnaces. Wastewater may result from the control of associated air emissions.

Secondary contaminant removal includes classification of copper concentrates from milled slags, air classification to remove lightweight solids, and magnetic separation of iron. These processes produce, respectively, sludge, solid waste and dust, and iron as solid waste. Pelletizing, briquetting and baling are compacting processes required to improve handling of granular-size or bulky materials. Slag granules, turnings, borings, shredded scrap, etc., are usually briquetted. Radiators and other hollow materials are sometimes baled in hydraulic presses.

Smelting Process--The initial smelting step consists of charging low grade scrap into a blast or cupola furnace. While blast furnaces are used to reduce copper oxides and melt the charge, cupola furnaces are generally used only to melt the charge. Both furnaces are charged with coke, metal, slag, and flux. The material is fired with an air blast introduced into the bottom of the furnace. Air pollution equipment is required to control emissions with significant wastewater being generated if wet scrubbers are used. The products of the blast furnace are copper matte and slag, while the product of the cupola furnace is called black copper. Other specialty furnaces, such as crucible or induction furnaces, are sometimes used for special alloy production or precious metal recovery. Although sizeable amounts

of noncontact cooling water are used in induction furnaces, the waste is not contaminated and is usually recycled. Crucible furnaces use no water. Black copper and copper matte are usually processed further in the molten state, but black copper is occasionally cast into molds or shot before further processing. Molds are usually air cooled, while shot is quenched, generating wastewater.

The second smelting step consists of refining, or alloying, premelted low grade materials and/or intermediate and high grade scrap. Black copper may be combined with intermediate and high grade copper to produce either blister copper anodes or fire-refined copper ingots and billets. Intermediate grade scrap, with or without low grade pretreated scrap, is used to produce brass, bronze or other copper-based alloys. Refining or alloying is done in reverberatory or rotary furnaces. Reverberatory furnaces are box-shaped while rotary furnaces are barrel-shaped and rotate either 180 or 360 degrees. The methodology of further refining or alloying varies with the scrap charged, the finished product, equipment available, and individual manufacturer preference. Generally the process begins by charging the mix into the furnace as air or oxygen is introduced into the bottom of the furnace to oxidize impurities. Addition of a flux, usually sodium borate, aids in collecting impurities on the surface of the melt. These impurities are skimmed from the melt and allowed to cool, thus forming what is known as slag. The slag, which contains economically significant quantities of copper and other recoverable metals, is usually reprocessed in-house. Occasionally, however, the slag is sold to other smelters. When the melt has attained the degree of purity required by the product specifications, the metal is cast and cooled. Cooling of castings may be done by air, contact or noncontact cooling water.

In the refining of brass and bronze, metal fluxing agents are added to degasify and alloy the reverberatory or rotary furnace melt. When the melt meets specifications, the brass or bronze is cooled to the proper temperature before casting into ingots. The molds are cooled with water sprays or by partial immersion of the mold in water. These cooling waters are usually recycled, and produce infrequent wastewater discharges during cleaning or sludge removal.

Blister copper may be further fire-refined in-house or cast into anodes for electrolytic refining. If cast into anodes, they are formed in a circular mold-conveying system or conveyor. The anodes may be air cooled, spray cooled, or cooled by noncontact cooling water. Before use, the molds may be coated with a mold release agent such as calcium phosphate. Contact cooling water may be a source of wastewater, but it is usually recycled.

When the melt is to be fire-refined, aeration is continued in the reverberatory or rotary furnace until all the impurities are concentrated in the slag. The slag is removed from the melt, a layer of charcoal or coke is added, and green wood poles are inserted into the melt. The green wood emits gases that deoxidize the melt. The purified copper is cast into various shapes, including billets, cakes, slabs, wire bar, wire rod, and ingot anodes. Wire bars and ingots are cooled and water quenched when solidified. Wastewater discharge usually results from quenching. Other forms are cooled with noncontact or contact cooling water that is recycled.

A few secondary copper facilities practice electrolytic refining. Copper anodes are alternated with refined copper "starter sheets" in the electrolytic cell. Pure copper is deposited on the starter sheets which serve as the cathode in the electrolytic reaction. The starter sheets, with deposited cathode copper, are periodically removed. The electrolyte, a solution of sulfuric acid and copper sulfate, is washed from the cathode copper.

Cathode copper may be melted in either a reverberatory or a shaft furnace. The reverberatory furnace may serve only to melt the copper or may further refine the copper (fire refining using the reverberatory furnace has been discussed previously). The shaft furnace is similar to the cupola furnace discussed earlier. Poling in a small reverberatory holding furnace is used to reduce the melt to pure copper before casting when the shaft furnace is employed. Particulates may be controlled by wet or dry methods. Casting of electrolytically refined copper is essentially the same as for fire-refined copper.

A bleed stream of the electrolyte is used to maintain copper and nickel concentrations at acceptable limits. Recovering the copper values from the bleed stream is essentially the same as the electrolytic refining process except that a lead cathode is used. The spent electrolyte may be concentrated by evaporation to recover nickel sulfate as a by-product. Alternately, scrap iron is added to displace the copper from solution. This is called cementation. Slimes generated during the electrolytic refining process are usually processed off-site for recovery of other metals.

Industry Profile. There are 32 secondary copper processing plants in the United States. The majority of these plants, as shown in Figure III-14, are located in or near major industrial cities where most of the raw materials are generated and collected.

Figure III-14 shows that the secondary copper industry is concentrated around the Great Lakes and the New England states.

The establishment of the industry occurred over a long period of time. As shown in Table III-24, average plant age falls between 30 and 40 years, somewhat older than the average plant age in the primary copper industry. Comparing Table III-25 to Table III-20, it can be seen that the average production of secondary copper plants is only about one-tenth of the average production in the primary copper industry.

Only 22 percent (7 plants) of the 32 plants listed in this subcategory are direct dischargers. Table III-26 summarizes, by type of discharge, the level of wastewater treatment at plants within the secondary copper industry at present. Zero discharge of process wastewater is achieved by 20 plants (Table III-26), which corresponds to best practicable treatment technology. Of the remaining 12 dischargers, only six are without wastewater treatment.

Comparing Figure III-14 to Figure III-4 shows that the majority of the 32 plants are in areas of net precipitation. Table III-27 tabulates, by type of discharge, the number of plants using chemicals or physical wastewater treatment processes. The table shows that few plants treat process wastewater. Lime, caustic, settling, filtration, and evaporation are the methods most often used. Table III-28 shows the production processes used.

Primary Lead

Raw Materials. Galena, cerusite, and anglesite are the principal mineral ores utilized by the primary lead industry. Most of these ores originate in southeast Missouri, but Idaho and Utah also produce significant amounts. Missouri ores have a lead content exceeding 70 percent and a very low impurity content; the combined zinc and copper content of the ores is less than three percent. Fewer refining steps are required at Missouri ores because of the high grade ores. Other domestic lead smelters process domestic and imported ores. The ore concentrates used by these smelters vary in quality but generally contain less lead and more impurities than concentrates from Missouri.

Manufacturing Process. The manufacturing process consists of smelting and refining operations. Typically, both operations are carried out at the same location; however, both smelters and refineries operate independently of each other. A generalized process flow schematic is shown in Figure III-15.

Smelting Process--The initial process consists of blending the ore concentrates with recycle products and fluxes. The blend is moistened and then pelletized using ball drums, and the pellets are fed to a traveling grate furnace or sintering machine. The most common sintering process places a layer of pellets on the

grate and subjects it to an air stream from below (updraft system) while the mixture is ignited by overhead downdraft burners. Another layer of pellets is then laid upon the first layer to burn from the bottom up. In another sintering method, the air flows from above (downdraft system) and the burners are placed below the charge. The charge is completely sintered before reaching the end of the machine and is cooled by an air stream at the end of the process. Sulfur oxides, arsenic, antimony, and cadmium are evolved as gases during this process. A more highly concentrated $SO_x$ stream, emitted during the initial part of the sintering operation, may or may not be sent to a sulfuric acid plant. Particulates are usually removed by a flue and/or baghouse; the collected particulates are mixed with water in a pugmill and then recycled to the sintering machine. Sulfur oxides are not removed by the baghouses. The sinter is then passed through a sinter breaker at the end of the sintering machine where the sinter is broken and sized. Oversize particles are charged to the blast furnace while undersize particles are crushed and water cooled before returning to the sinter feed operation. Sinter breaking produces significant amounts of dust that must be removed by a baghouse or wet scrubber. The collected dust or sludge is recycled to the sinter operation in either case.

The blast furnace is the primary reduction unit of a lead smelter. Blast furnaces are usually rectangular, water cooled, and are charged from the top while air is introduced into the bottom by tuyeres. The charge consists of sinter, flux, coke, and usually includes recycled slag and dust from other operations. Three molten layers are usually formed in the blast furnace. The top layer of the melt is slag containing silicates of iron, calcium, and magnesium along with trace impurities. Significant quantities of lead and zinc may also be present in the slag. Slags with economically recoverable zinc may be processed on-site for zinc recovery. In this process the slag is heated with coal to high temperatures that oxidize zinc to zinc oxide dust particles which are then collected with dust-collecting equipment. The residual slag is granulated and either recycled to the sinter preparation process or discarded. Slag granulation water is usually recycled, but it may be a source of wastewater. A middle layer or matte may be formed in some cases. The matte is composed of copper and iron sulfides along with precious metals. If significant arsenic is present, the matte is referred to as speiss. Matte and speiss are usually sent to copper smelters for recovery of other metals. The bottom layer, lead bullion, is retained and further refined.

Refining Process--The initial step in the refining process is dross decopperizing. This step is usually performed at the smelter. Drossing kettles are generally hemisphere shaped, gas

heated, and externally insulated. The temperature at the dross kettle is maintained slightly above the melting point of lead. Copper is practically insoluble at this temperature and is removed from the melt by skimming. Sulfur is sometimes added to the melt to increase copper removal. Drossing may be performed as a two-stage process, with the bullion going to a second drossing step. The dross, or skimmed slag, is treated in a reverberatory furnace to recover lead. The by-product, copper matte, is sent to a copper smelter.

Antimonial lead (also known as hard lead) is the principal product of the primary lead industry. However, in the production of refined lead, antimony must be removed from the drossed bullion in an oxidation process known as softening. Softening may be done in a reverberatory-type furnace or by an oxidative slagging procedure using a sodium hydroxide and sodium nitrate mixture as an oxidant. In the reverberatory furnace operation, air is introduced through pipes or lances into the melt to oxidize impurities and form a slag which is then skimmed from the melt. This oxidation-skimming step is repeated to remove a second slag. The two slags are treated for recovery of antimony, antimonial lead, and sodium arsenate. Sodium arsenate is usually discarded. A tin slag, generated in this process, is sent to a tin recovery operation.

There are two oxidative slagging techniques for antimony removal from lead bullion: the kettle process and the Harris process. In both processes a sodium hydroxide and sodium nitrate mixture is added to the molten metal and impurities are then removed by skimming. The slag is discarded in the kettle process, but in the Harris process, sodium hydroxide is recovered hydrometallurgically from the slag. Other metals such as arsenic, antimony, and tin may be also recovered.

Final refining of softened lead bullion is undertaken to remove gold, silver and bismuth. Gold and silver are removed by the Parke's process in which zinc is added to the molten bullion to form insoluble zinc-gold and zinc-silver compounds. These compounds are subsequently skimmed and residual zinc is removed from the bullion by vacuum dezincing. Vacuum dezincing is performed in a separate cell which vaporizes and removes zinc from the melt under a vacuum.

The Betterton process is used to remove bismuth from lead. Calcium and magnesium are simultaneously added to molten lead to precipitate $CaMg_2Bi_2$ crystals which float to the surface and are skimmed. Antimony or organic agents are sometimes added to facilitate removal. Residual calcium and magnesium are removed by adding caustic soda to the bullion in a final refining kettle.

A slag containing calcium, magnesium, and other trace impurities is removed from the refined bullion.

Industry Profile. There are seven primary lead plants in the United States, all located west of the Mississippi River, as shown in Figure III-16. Four are smelters and refineries, two are smelters only, and one is exclusively a refinery.

Four plants were built prior to or during World War I and two were built in the last 10 years (Table III-29). From the data in Table III-30, average production is in the 100,000 to 200,000 ton per year range.

Only three of the plants are direct dischargers. Table III-31 summarizes, by type of discharge, the level of wastewater treatment at primary lead plants at present. Only one of the three discharging plants is in an area of net precipitation, as seen by comparing Figure III-16 to Figure III-4.

Table III-32 shows, by type of discharge, the number of plants using given chemicals or physical processes to treat wastewater streams at this time. The table shows that few plants use any treatment processes. Those plants with a treatment process usually use lime, sedimentation and filtration. Table III-33 shows the production processes.

Secondary Lead

Raw Materials. The principal raw materials used in the secondary lead industry are battery storage plates and lead residues. Minor amounts of solder, babbitt, cable coverings, type metal, soft lead, and antimonial lead are also utilized. Discarded batteries are the principal source of raw materials.

The battery-cracking operation may be performed on site or off site by scrap dealers. The battery tops are sawed off and the plates and paste are removed for processing. Spent electrolyte, along with saw cooling water and wash water, constitutes a major source of wastewater at plants where this operation is performed. The battery cases constitute a significant source of solid waste.

Manufacturing Process. A schematic process flow diagram, including various alternate processes that may be used is shown in Figure III-17. Scrap lead from batteries and other lead-base materials is charged to reverberatory or blast furnaces to produce soft or hard lead, respectively. Hard (or antimonial) lead contains significant amounts of antimony. Reverberatory furnace is usually sent to the blast furnace where scrap iron is added as a reducing agent to produce antimonial lead. Soft lead from the reverberatory furnace may be further refined in a remelt

kettle or oxidized in the Barton process to produce lead oxide which is subsequently used to make battery paste. Antimonial lead may be shipped without further processing for later use in the manufacture of battery plates, or it may be further processed on site to make lead alloy by adding arsenic and copper to the remelt kettles.

Emissions from reverberatory and blast furnaces are usually controlled with bag houses although wet scrubbers may be used. Wet scrubbers may also control emissions from remelt kettles. Scrubber water is usually recycled at plants where wet scrubbers are in use. Casting is usually done with noncontact cooling water in closed loop recirculating systems. Sometimes contact cooling may generate a small discharge.

Industry Profile. There are 69 secondary lead-antimony plants in the United States. These plants, as shown in Figure III-18, are predominantly located in or near major urban centers where most of the raw materials are readily available.

Of the 69 secondary lead plants shown in Figure III-18, 21 plants (30 percent) are located west of the Mississippi. The remaining 48 plants are located in two bands east of the Mississippi, around the Great Lakes and in the South.

Table III-34 shows that the average age of secondary lead plants is within a span of 25 to 40 years. Table III-35 shows that the average production of battery cracking plants is in the 10,000 to 15,000 tons per year range. The average size of non battery-cracking plants is 1/3 to 1/4 of the other segment with production of 2500 to 5000 tons per year.

Table III-36 shows that relatively few plants discharge wastewater. Table III-36 summarizes, by type of discharge, the level of wastewater treatment at plants within the secondary lead-antimony industry. In the non-battery cracking segment no process wastewater is discharged.

Comparing Figure III-18 and Figure III-4 reveals that nearly all of the plants east of the Mississippi are located in regions of net precipitation. About half of the plants west of the Mississippi are similarly located. These plant locations may preclude use of solar evaporation ponds.

Table III-37 lists, by type of discharge, the number of plants using chemicals or physical wastewater treatment processes. As noted, the majority of the plants do not use any treatment process. Those plants using treatment processes use lime or ammonia neutralization, sedimentation, filtration and evaporation

ponds most often. As seen in Table III-38, relatively few plants use wet production processes other than battery cracking.

Secondary Silver

Raw Materials. The approximate distribution of sources of secondary silver, except for in-house run-around scrap, is listed below:

Photography: 30 percent
Arts: 20 percent
Electrical: 15 percent
Industrial Alloys: 15 percent
Miscellaneous: 20 percent

The miscellaneous category includes chemicals and ceramics containing silver.

Manufacturing Process (Photographic Wastes). As shown in Figure III-20, silver from photographic film may be recovered by chopping it into small pieces followed by stripping of silver from film. The silver-rich solution is separated from the film by sedimentation, decantation, and filtration. The plastic portion of the film is usually disposed of as solid waste while the solution is mixed with chemicals (e.g., sulfuric acid, alum, caustic soda) to precipitate the silver. The water is decanted and sent to waste treatment and the sludge is thickened, vacuum filtered or centrifuged, and/or dried. The dried cake undergoes roasting and is cast into ingots or Dore plates.

Alternately, the photographic film may be incinerated and the silver-bearing ash undergoes roasting (16). Some refineries buy silver-bearing ash from scrap dealers. A wet scrubber on the incinerator may be a source of wastewater.

Dore plates are electrolytically refined on site or shipped to others. The furnace slag is crushed and classified and the silver concentrate is returned as furnace feed while the tailings are landfilled. If electrolytic refining is practiced, the cell slimes may be further processed for gold and platinum recovery.

Silver-rich solutions from photographic film developing and manufacturing undergo precipitation and purification as described above. There are several alternate methods for concentrating silver from solutions. One method uses precipitation with sulfide compounds or replacement with copper, aluminum, zinc, or iron to produce silver sludges which can be filtered, roasted, and cast as described above. Another method, direct electrolytic refining from high tenor solutions, has also been used to recover

silver that is 99 percent pure. The recovery of silver from photographic wastes is usually done on a toll basis.

Manufacturing Process (Plating and Sterlingware Wastes). Cyanide plating solutions are treated to precipitate silver and oxidize the cyanide. Precipitation is usually accomplished by addition of sodium hypochlorite. After initial settling, cyanide may be oxidized with sodium hypochlorite and lime, and the solution is then resettled and dried. The resulting silver-chloride precipitate is washed and dried for further processing or sold as the final product.

Solid wastes from the sterling industry are melted after separation and reused if the quality is high. Lower quality scrap is melted and cast as silver bullion and sent to an electrolytic refinery.

Manufacturing Process (Electrical Components). The procedures shown in Figure III-21 are typical if electrical component scrap is not suitable for electrolytic refining. The scrap is smelted in a reverberatory furnace to produce lead bullion, copper matte, and slag. The lead bullion is melted in a cupola furnace where litharge and precious metals layers are formed. The litharge layer is sent to a lead refinery and the precious metal layer is cast into anodes for electrolytic refining. The copper matte is crushed, ground, roasted and leached with sulfuric acid. Silver is then precipitated on copper, melted, and cast as refined silver ingots. The reverberatory furnace slag is smelted in a blast furnace to separate the lead and copper portions which are then added to the respective circuits. Blast furnace slag is discarded.

Industry Profile. The high value of silver has always made the recovery of scrap silver attractive. In fact, the secondary silver refined from old scrap in 1974 was 85 percent of the primary production. A projected increase in silver demand during the last quarter of this century of 1.7 percent per year combines with high value to encourage secondary silver production (2). Of the 46 refining plants, Figure III-22 shows that the plants are located in three major areas of the United States: the Gulf Coast states, the Rocky Mountain States and states bordering the Great Lakes and the New England States. Table III-39 shows that half of the 46 plants process photographic wastes and the other half process nonphotographic wastes. Of the plants processing photographic wastes, the average plant age is less than 10 years. Of the plants processing non-photographic wastes, the average plant age falls within a span of 20 to 25 years. Table III-40 shows that average sized plant has a production in the 100,000 to 500,000 troy ounce per year range.

Table III-41 shows that just under half of the photographic waste processing plants and just over half of the non-photographic waste processing plants are direct dischargers. This table summarizes, by type of discharge and subcategory, the level of wastewater treatment at plants within the secondary silver industry at present. Table III-41 shows that about half (22 plants) of the total number of plants are zero dischargers. Of the 24 discharging plants, only nine plants have chemical coagulation and settling of wastewater.

In a comparison of Figure III-22 to Figures III-4, only the plants of the Gulf Coast and some of the plants in the Rocky Mountain area are in an area of net evaporation. All of the other plants are in areas of net precipitation. This may preclude the use of solar evaporation ponds.

Table III-42 numerically relates, by type of discharge, the number of plants employing given chemicals or physical treatment processes to treat a wastewater stream at present. As noted, the majority of the plants do not utilize any treatment processes for metal pollutants other than silver. Those plants which do treat wastewater generally use lime, with some plants also using sedimentation, filtration and evaporation ponds, with some caustic employed for neutralization. Table III-43 shows the production process steps used by secondary silver producers.

Primary Tungsten

Raw Materials. The principal domestic ores used to produce ammonium paratungstate (APT) and tungsten metal powder are ferberite ($FeWO_4$) and scheelite ($CaWO_4$). Both of these ores are mined principally in California and Colorado.

Manufacturing Process. There are several variations in purifying tungsten but, typically, tungstate ($WO_4$) is purified from concentrates and converted to tungstic acid ($H_2WO_4$) by a series of filtration and precipitation reactions. A general process flow diagram is shown in Figure III-23. Usually ground ferberite and scheelite are digested with sodium hydroxide (NaOH) or other sodium salts to form soluble sodium tungstate ($Na_2WO_4$). The waste solids are settled and filtered and either land-filled or sold to other tungsten processors, depending on the tungsten concentration. Calcium chloride ($CaCl_2$) is then added to the solution to precipitate calcium tungstate ($CaWO_4$), and the resulting salt (NaCl) is rinsed from the solids. The precipitate is then leached with hydrochloric acid to convert calcium tungstate to tungstic acid and calcium chloride is rinsed from the solid. The tungstic acid is subsequently dissolved in ammonium hydroxide ($NH_4OH$), forming ammonium tungstate ($NH_4WO_4$). Solids are then removed and the solution is heated to form the

intermediate product known as APT. APT is dried, sifted, and converted to oxides in a nitrogen-hydrogen atmosphere in a furnace. The oxides are subsequently reduced to tungsten metal powder in a high-temperature hydrogen atmosphere. Tungsten powder is subsequently used to produce metal, or combined with carbon or other metals to make carbides or metal alloys, respectively. Monolithic tungsten metal is made by sintering compacted tungsten powder in an inert atmosphere.

In an alternate method, where concentrates high in molybdenum are used, the concentrates are reacted with sodium hydrosulfide (NaHS) to precipitate molybdenum trisulfide ($MoS_3$). The molybdenum can be separated and purified. The tungsten remains in solution and is solvent-extracted with an organic solvent and sodium hydroxide to produce ammonium tungstate. The only difference between this and the former process is the use of the solvent.

In another alternate, scheelite is digested directly with hydrochloric acid to form tungstic acid and calcium chloride. The calcium chloride is subsequently washed from the precipitated and settled tungstic acid. Ammonium hydroxide is mixed with the tungstic acid slurry and dried to form APT.

The acidic wastewater from the rinsing of tungstic acid is a major source of wastewater as well as sludge. Scrubber water used to control fumes from the use of HCl and $NH_3$ is another significant source of wastewater. Producers of tungsten metal from APT, however, do not produce these wastewaters. Hydrogen used during the reduction operations is cleaned with water and this wastewater is discharged.

Industry Profile. In the early 1780's, tungstic acid was first isolated from sheelite and wolframite and, shortly thereafter, tungsten was obtained by both carbon and hydrogen reduction of wolframite ($WO_3$). Hydrogen reduction is still a key step in the production of tungsten powder from which other finished products are derived. From the mid-nineteenth century through the first third of this century, tungsten was used chiefly as an alloying agent in steel. During the last 30 years, however, tungsten uses have increased to include production of carbides and alloys. The 1974 production use breakdown was: 68 percent carbide, 15 percent pure metal, and 15 percent alloy. Another two percent was used to manufacture various metal compounds (2).

There are ten plants in the United States, as shown in Figure III-24, engaged in the manufacture of tungsten products. Four of them process ore concentrates to produce the intermediate product APT, three of these four also reduce APT to tungsten metal, and six plants only process APT to produce tungsten.

Eight of the ten plants are located in states around the Great Lakes. These are areas of net precipitation, which may preclude the use of solar evaporation ponds.

Table III-44 shows the relative ages of the plants in this subcategory. Most plants were built around the time of World War II. From Table III-45, the average size plant has a production in the 1000 to 5000 tons per year range.

Figure III-24 shows that five are direct dischargers while three are indirect dischargers and two are zero dischargers. Table III-46 summarizes, by type of discharge, the level of wastewater treatment at plants within the primary tungsten industry at present. The primary tungsten industry has not yet had BPT regulations promulgated. Of the nine plants which discharge, four of the plants treat wastewater by precipitation and settling.

Table III-47 indicates the frequency of use of production processes in the primary tungsten industry. Table III-48 shows, by type of discharge, the number of plants using chemical or physical processes to treat their wastewater streams. The predominant processes used in this industry include lime, sedimentation and filtration.

Primary Zinc

Raw Materials. More than two-thirds of the zinc concentrate is recovered as a co-product from lead and copper ores; slightly less than one-third originates from zinc ores (2).

Manufacturing Process. There are two zinc production processes: pyrolytic and electrolytic. Both the pyrolytic and electrolytic processes require roasting. Subsequent steps in the pyrolytic process prepare the calcine for retorting, whereas in the electrolytic operations the zinc is leached from the calcine and purified in preparation for electrolysis.

Pyrolytic Zinc Production--After drying and blending, concentrates are roasted to remove sulfur as sulfur dioxide as shown in Figure III-25. Other volatile impurities, such as mercury and some lead and cadmium, may also be removed. The exhaust gas passes through dust collection equipment before entering an acid plant for conversion to sulfuric acid. The waste solids are subsequently treated to recover cadmium.

The roasted concentrate (calcine) is blended with coke, moisture, and sometimes silica sand and then pelletized. The pellets are sintered and crushed prior to feeding to a reduction furnace. Most of the cadmium and lead are removed during sintering and

they report to the dust collection system. This dust is also treated to recover cadmium and lead values.

The zinc contained in the sinter is reduced to zinc oxide or metallic zinc in either a vertical retort furnace or an electrothermic furnace. The charge vessel of the vertical retort furnace is heated externally by gas burners so that fuel combustion products do not mingle with the zinc vapor. The larger electrothermic furnace is heated by passing an electric current through the charge. In both cases, the zinc vapor is condensed and cast into ingots, and the uncondensed zinc and carbon monoxide are passed through a wet scrubber. The exhausted carbon monoxide is used as fuel while zinc is recovered from the scrubber water for reprocessing.

Electrolytic Zinc Production--Roasting of concentrates is required for electrolytic refining as with pyrolytic refining. In the electrolytic process, depicted in Figure III-26, however, magnesium is removed from high-magnesia concentrates by preleaching with weak sulfuric acid to prevent build-up in the electrolyte. Following roasting, the calcine is leached with spent electrolyte ($H_2SO_4$) to dissolve zinc and cadmium. The gangue is separated from the zinc solution by sedimentation and filtration, and these solids are sold to other processors to recover lead and copper.

The zinc solution is further purified in stages by adding zinc dust and sometimes scrap iron to precipitate first copper and other impurities, and then cadmium; pH control is important to selectively precipitate impurities. The pure solution is filtered and cooled and then passed through the electrolytic cells. Cadmium-rich solids are processed on site, while other solids are sent to other processors.

Zinc is deposited on aluminum cathodes during electrolysis. The purified zinc is stripped from the cathode, melted, and cast into various shapes for sale. Strontium carbonate, barium hydroxide, and gum arabic may be added to the electrolyte to help maintain purity of the zinc.

Manufacturing Process (Cadmium Recovery). All U.S. primary zinc refine also recover cadmium. The process is shown in Figure III-27. Cadmium-rich solids obtained from furnace dust collection equipment and from purification of zinc solutions are leached with sulfuric acid to dissolve the cadmium. This solution is treated with zinc dust and other reagents to precipitate cadmium sponge.

The sponge is usually melted under a caustic flux or distilled in a graphite furnace. In some cases, the sponge is dissolved in

sulfuric acid and electrolyzed. The metal is cast into shapes, often balls, suitable for electroplating.

Industry Profile. A distribution of primary zinc plants in the United States is shown in Figure III-28. Primary zinc is produced pyrolytically or electrothermically by two plants and electrolytically by four plants; cadmium is a by-product in every case.

The primary zinc industry is a well-established industry. Table III-49 indicates that the average plant age is about 50 years. Table III-50 shows that the median as well as the average size plant has a production in the 100,000 to 200,000 tons per year range. While the zinc industry is not confined to any particular geographic location, all plants discharge wastewater. Table III-51 summarizes, by type of discharge, the wastewater treatment of plants within the primary zinc industry at present.

Table III-52 numerically relates, by type of discharge, the number of plants using chemical or physical treatment processes to treat wastewater. The majority of the plants use lime, sedimentation and filtration. Evaporation and coagulants, such as polymers and alum, are also used. Table III-53 indicates frequency of use of each production process in the primary zinc industry.

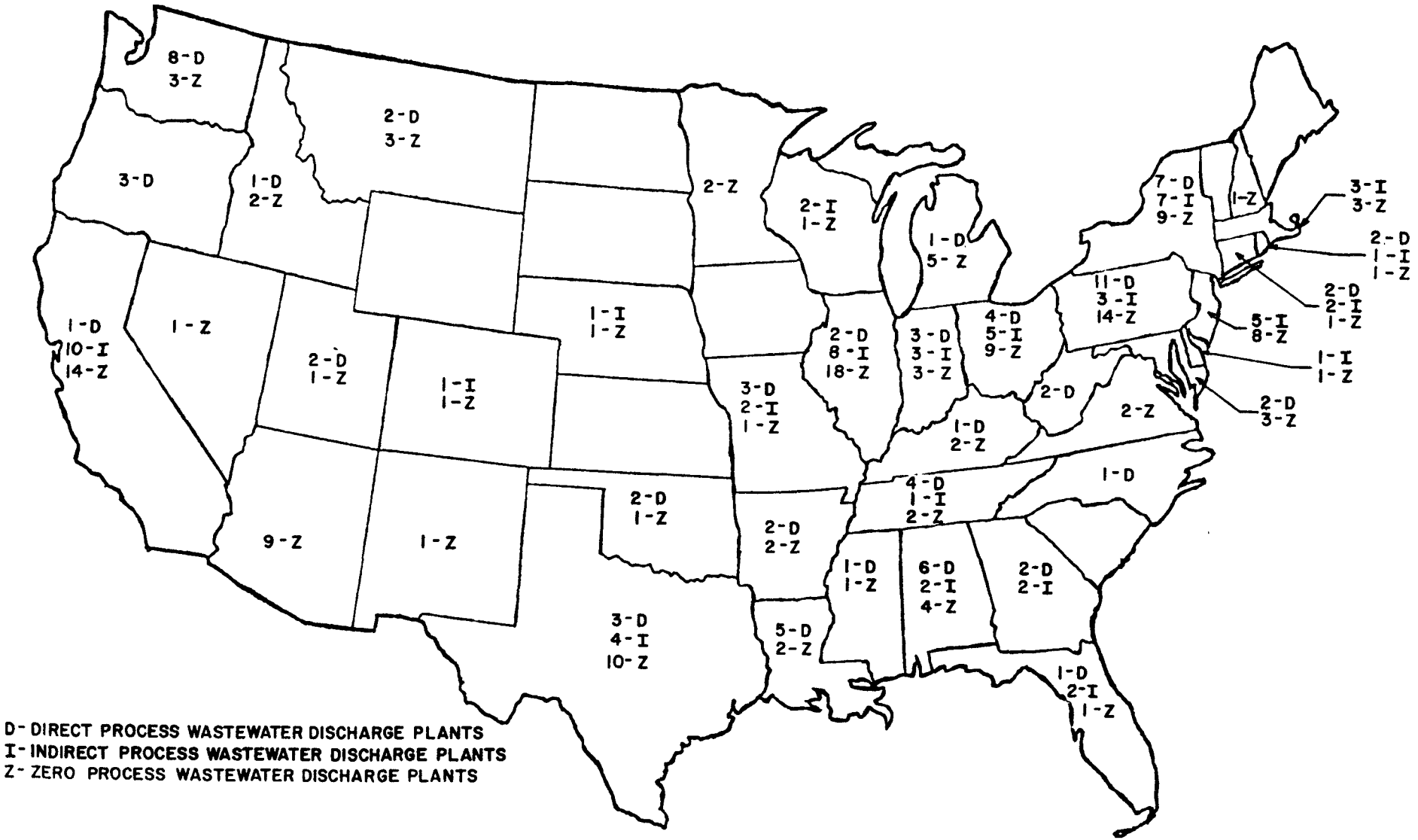


FIGURE III-1. GEOGRAPHIC LOCATIONS OF THE MAJOR NONFERROUS METALS INDUSTRY PLANTS

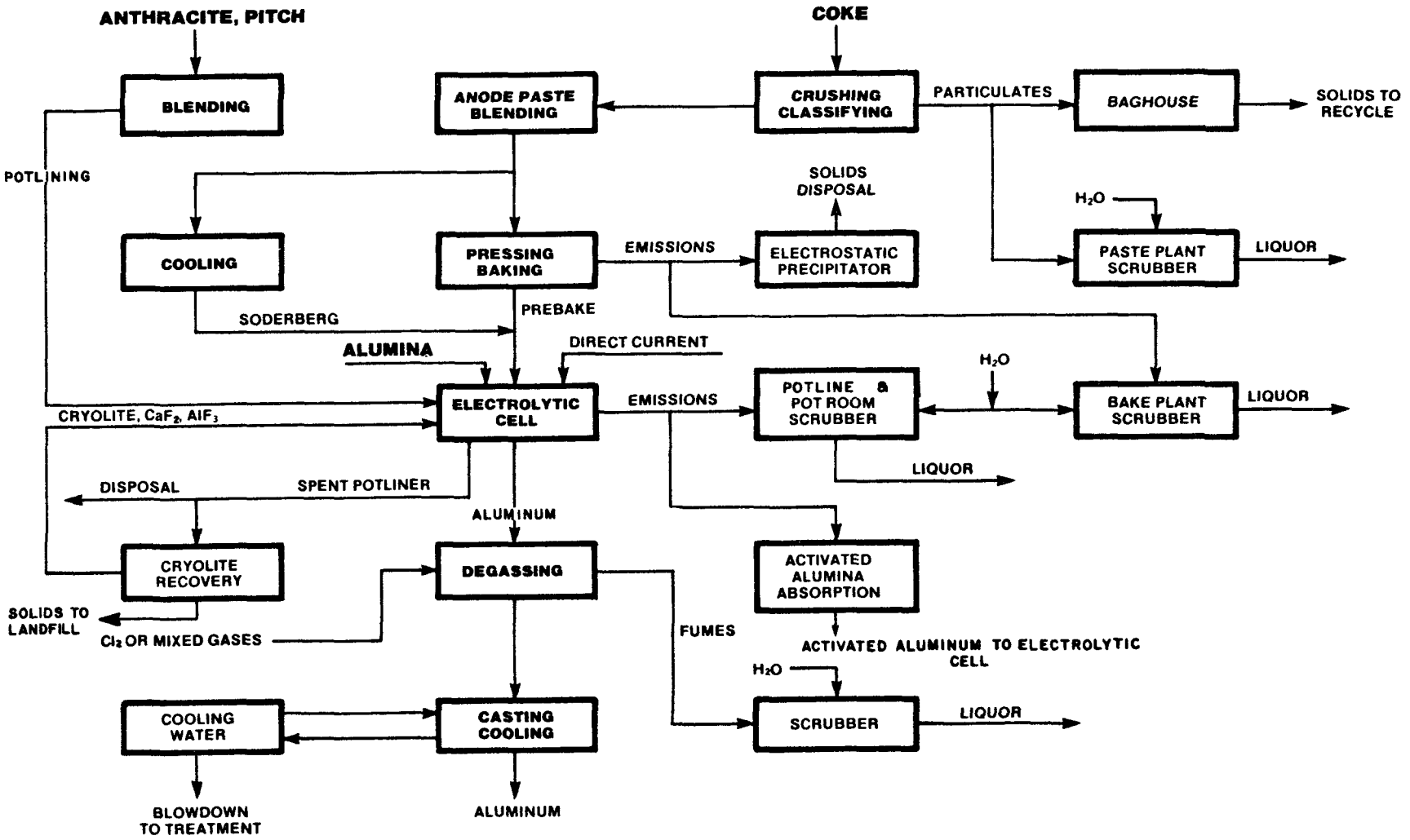


**FIGURE III-2. PRIMARY ALUMINUM REDUCTION PROCESS**

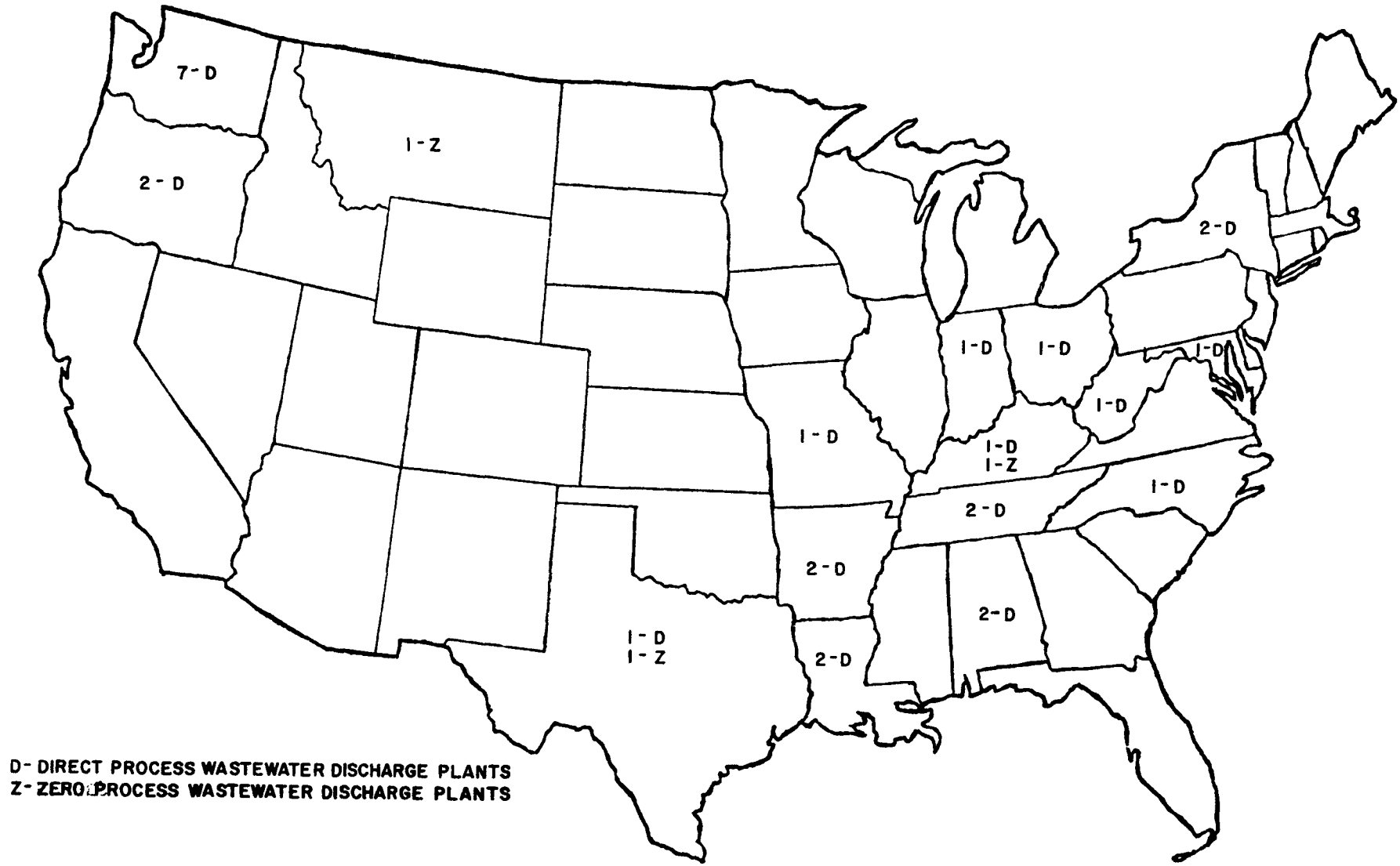


FIGURE III-3. GEOGRAPHIC LOCATIONS OF PRIMARY ALUMINUM REDUCTION PLANTS

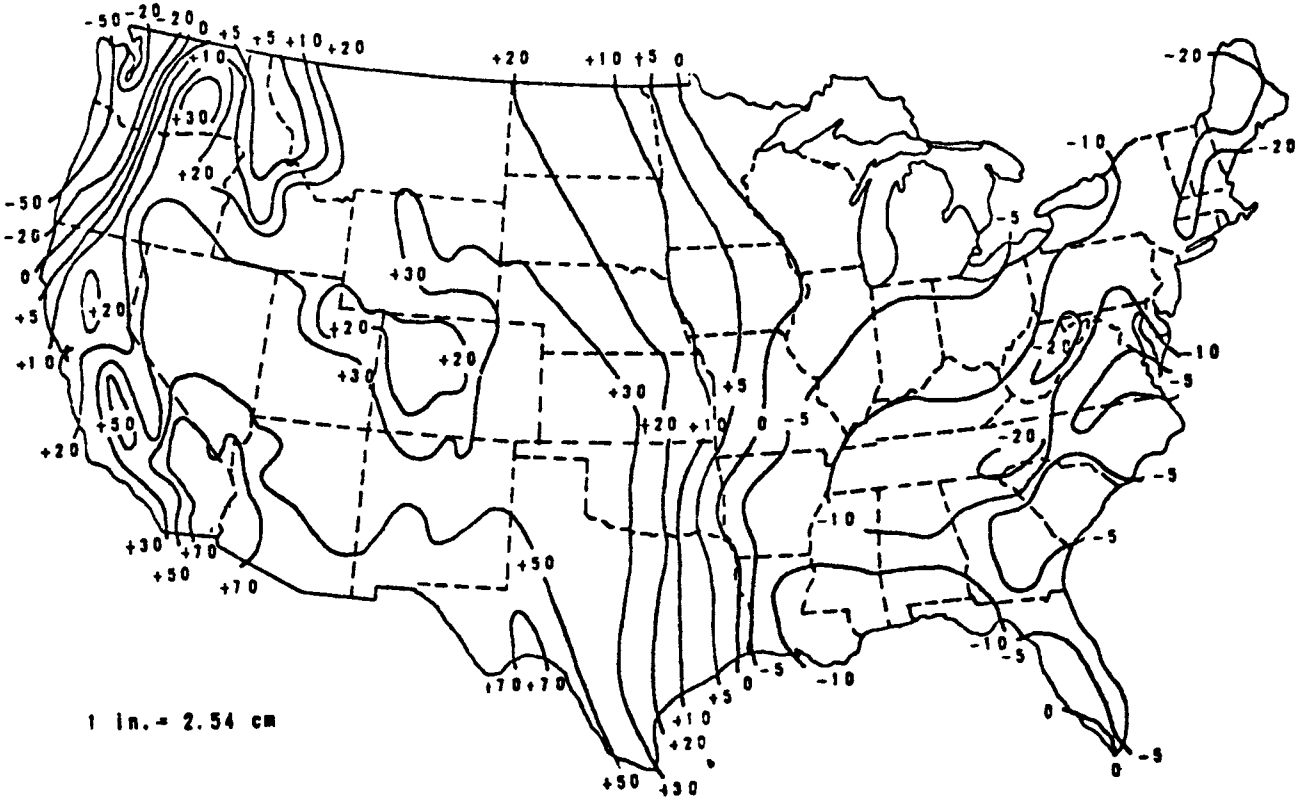


FIGURE III-4. POTENTIAL EVAPOTRANSPIRATION VERSUS MEAN ANNUAL PRECIPITATION (INCHES)

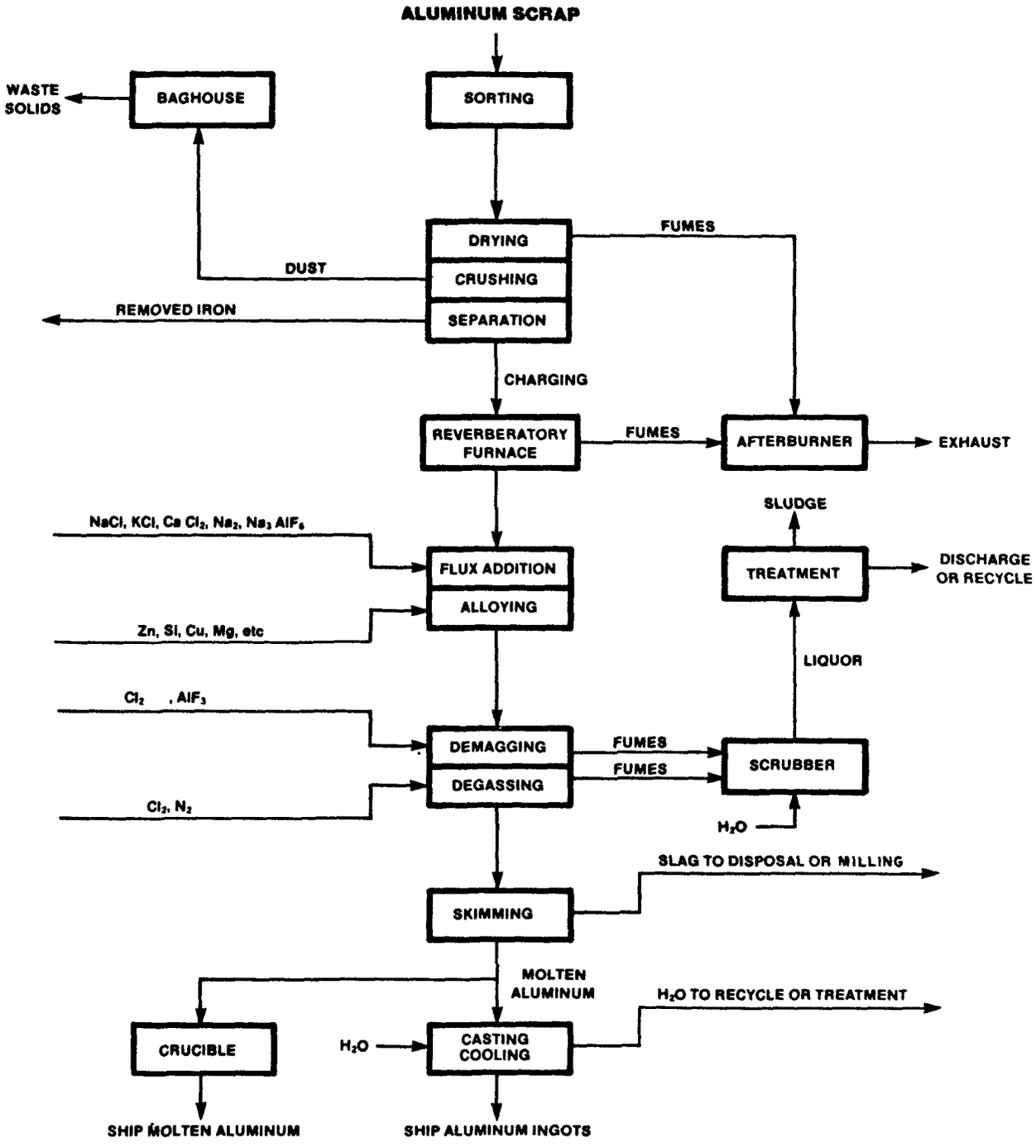


**FIGURE III-5. SECONDARY ALUMINUM SMELTING PROCESS**

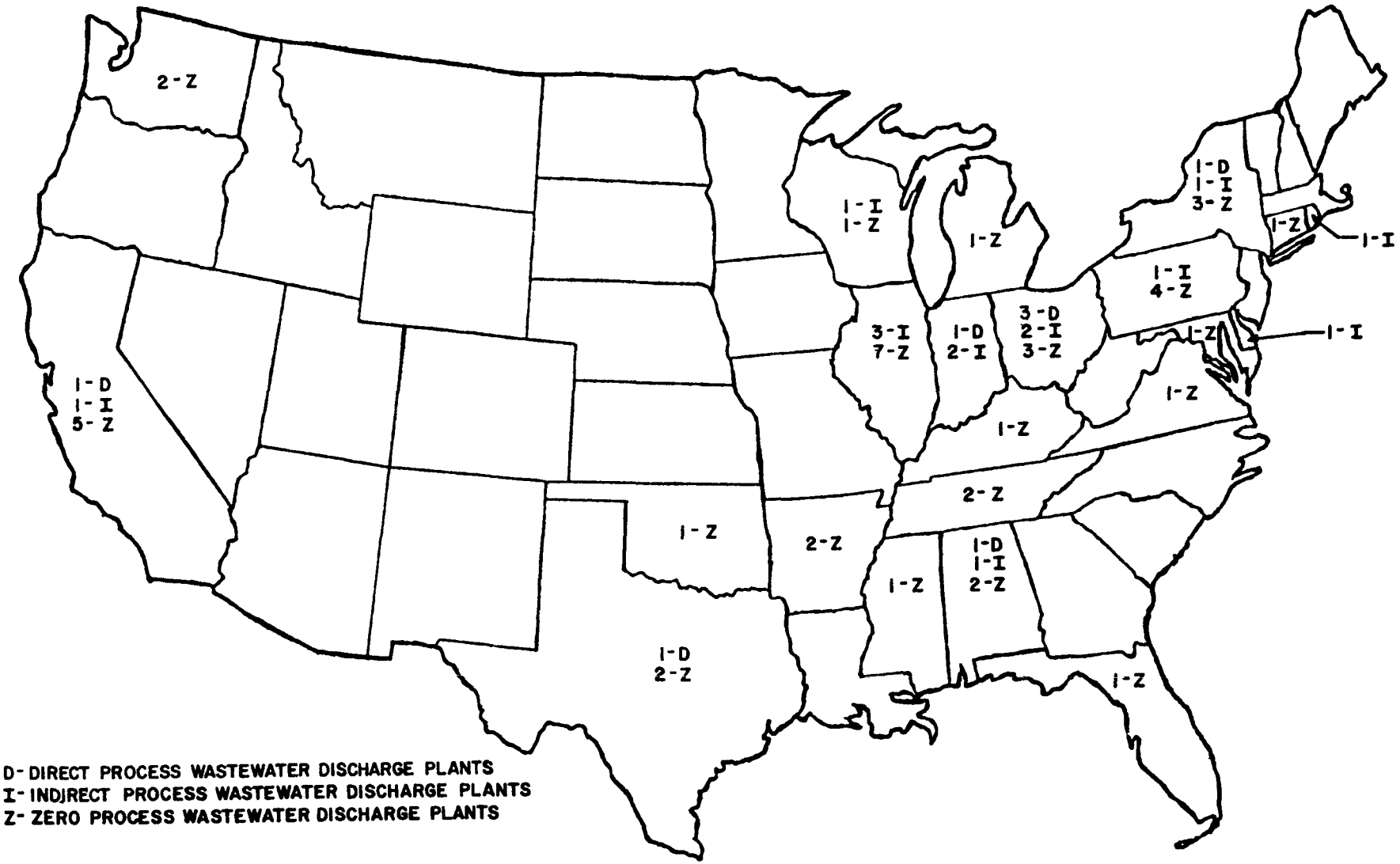


FIGURE III-6. GEOGRAPHIC LOCATIONS OF THE SECONDARY ALUMINUM INDUSTRY SMELTERS & REFINERS

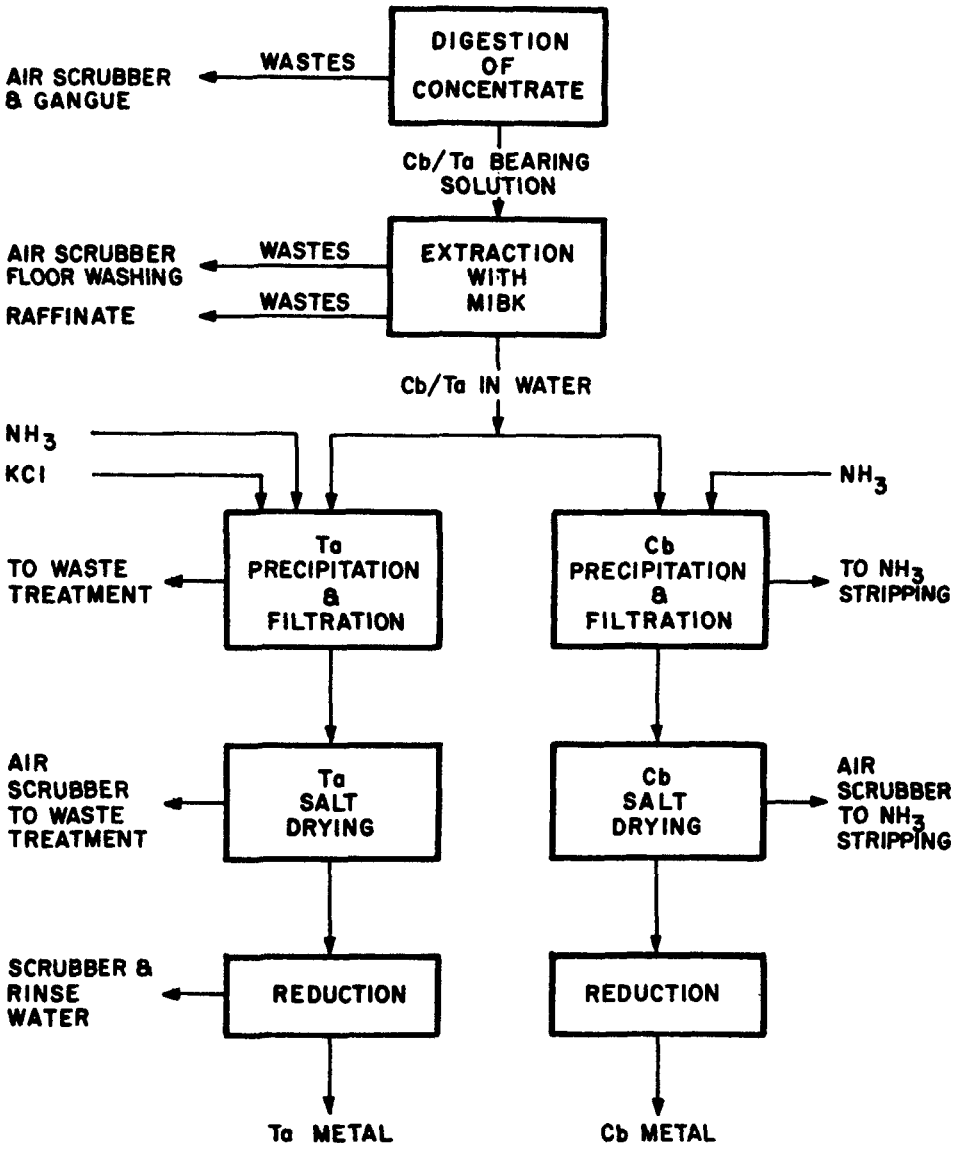


**FIGURE III-8. COLUMBIUM & TANTALUM PRODUCTION PROCESS**

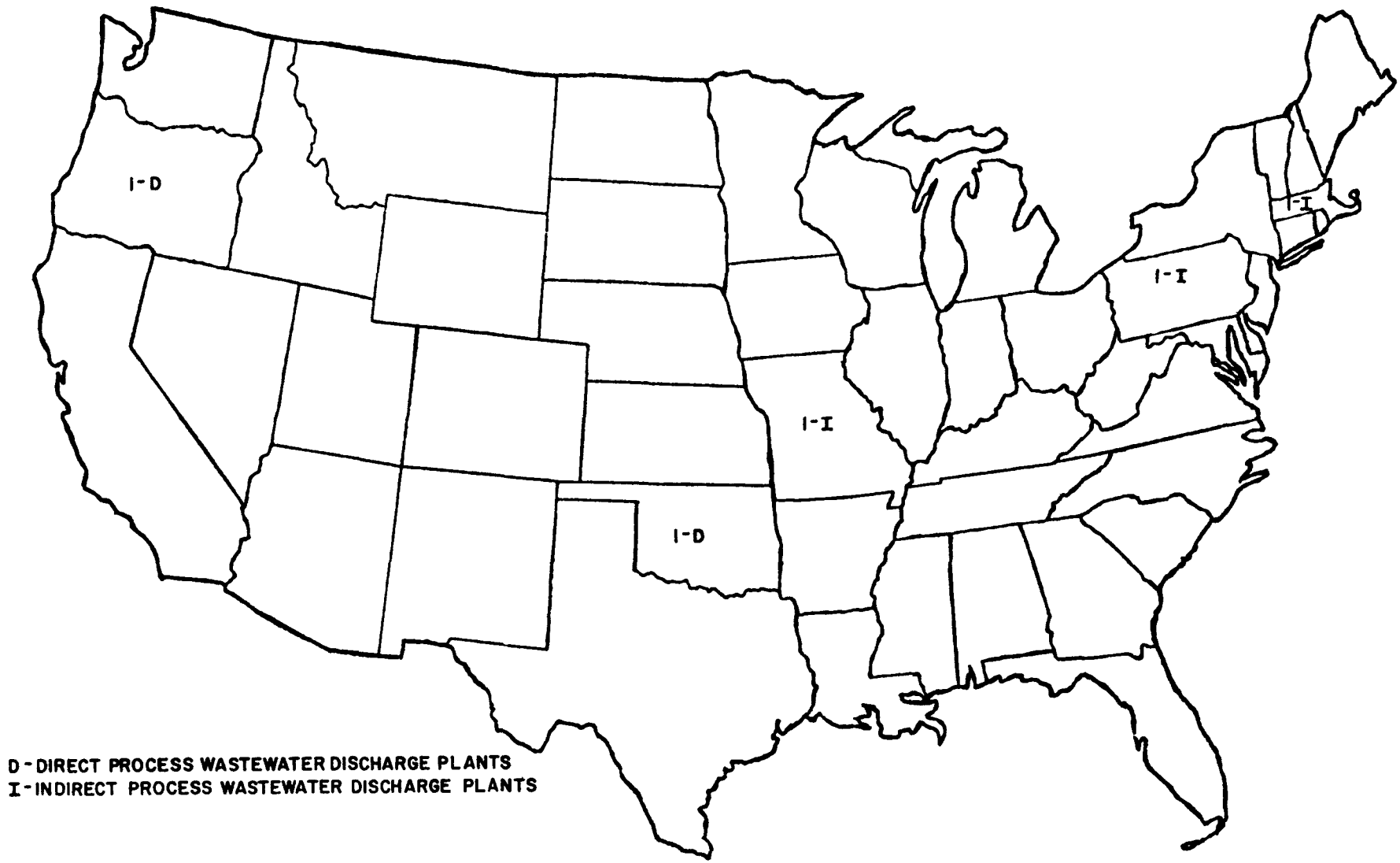


FIGURE III-9. GEOGRAPHIC LOCATIONS OF THE COLUMBIUM AND TANTALUM METAL PRODUCTION PLANTS

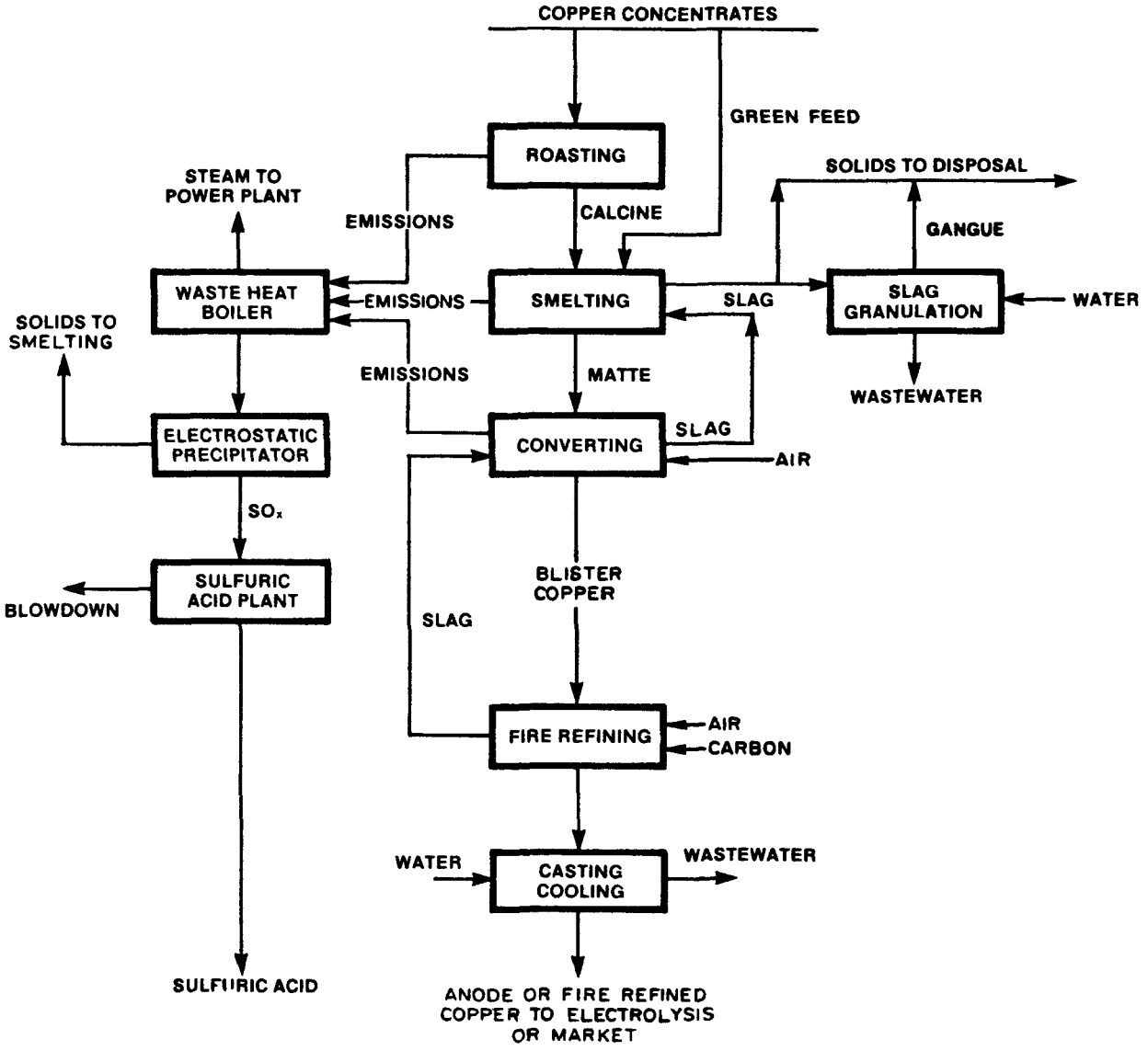


**FIGURE III-10. PRIMARY COPPER SMELTING PROCESS AND FIRE-REFINING PROCESS**

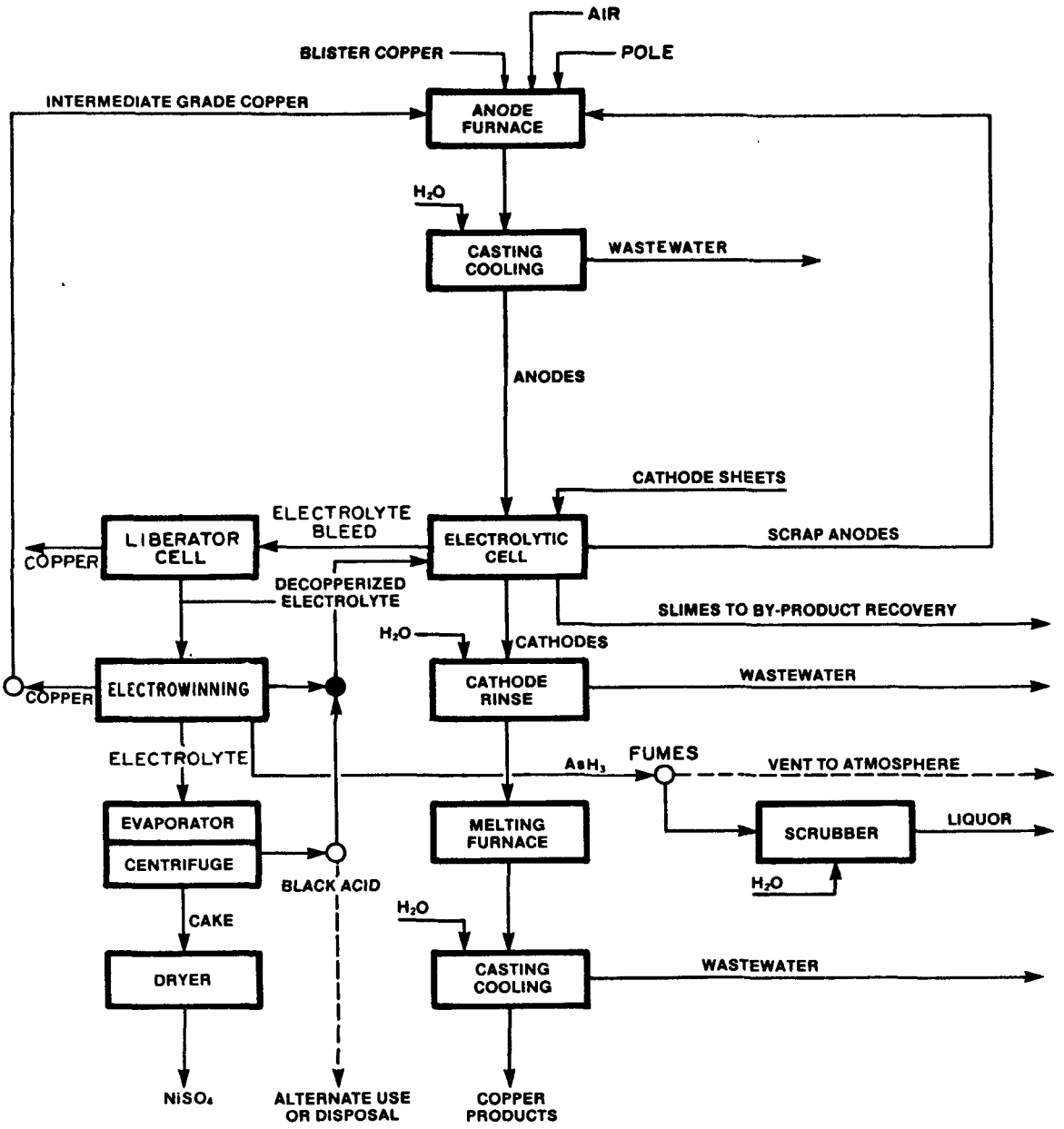


**FIGURE III-11. PRIMARY COPPER ELECTROLYTIC REFINING PROCESS**

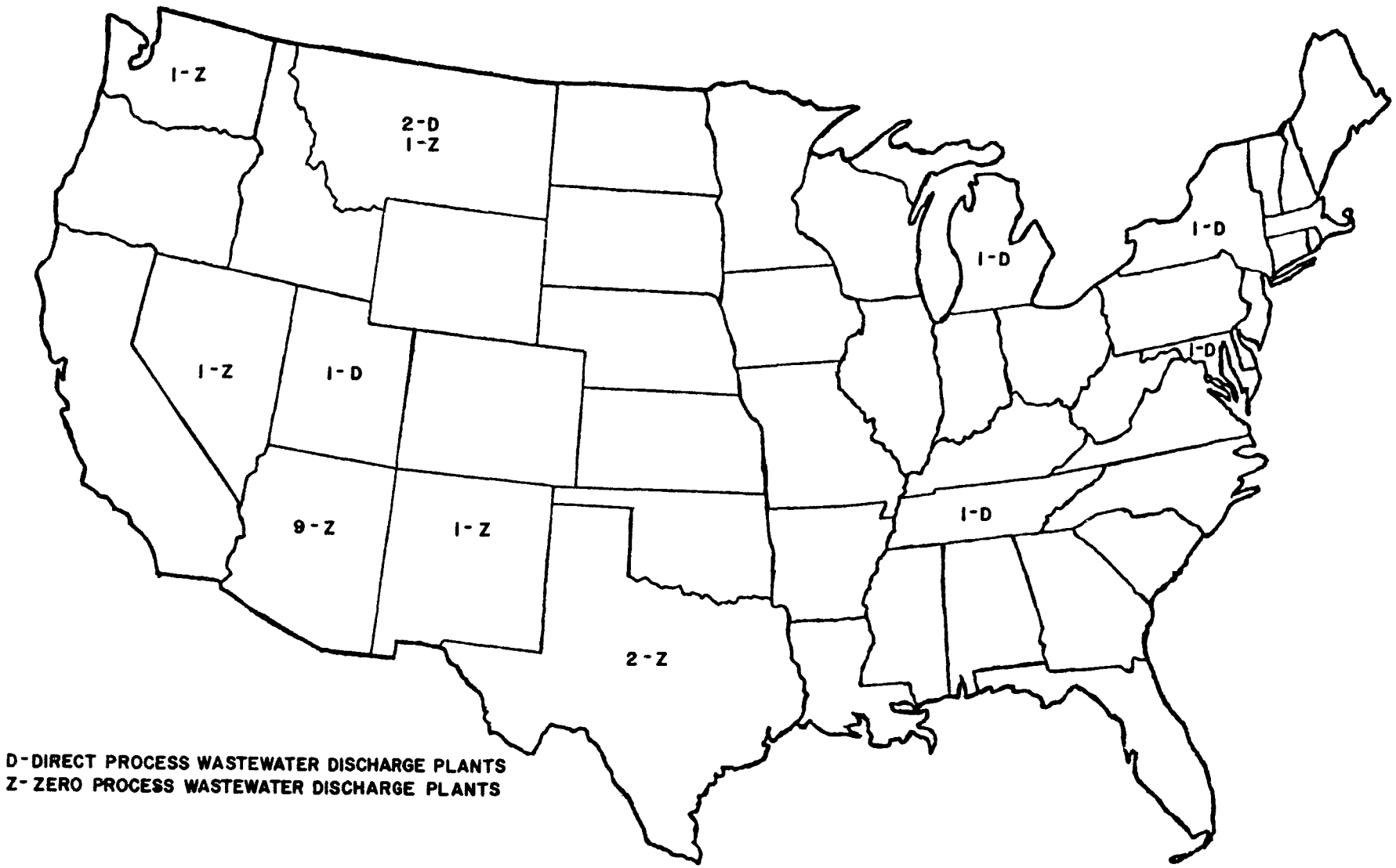


FIGURE III-12. GEOGRAPHIC LOCATIONS OF PRIMARY COPPER SMELTERS AND REFINERS

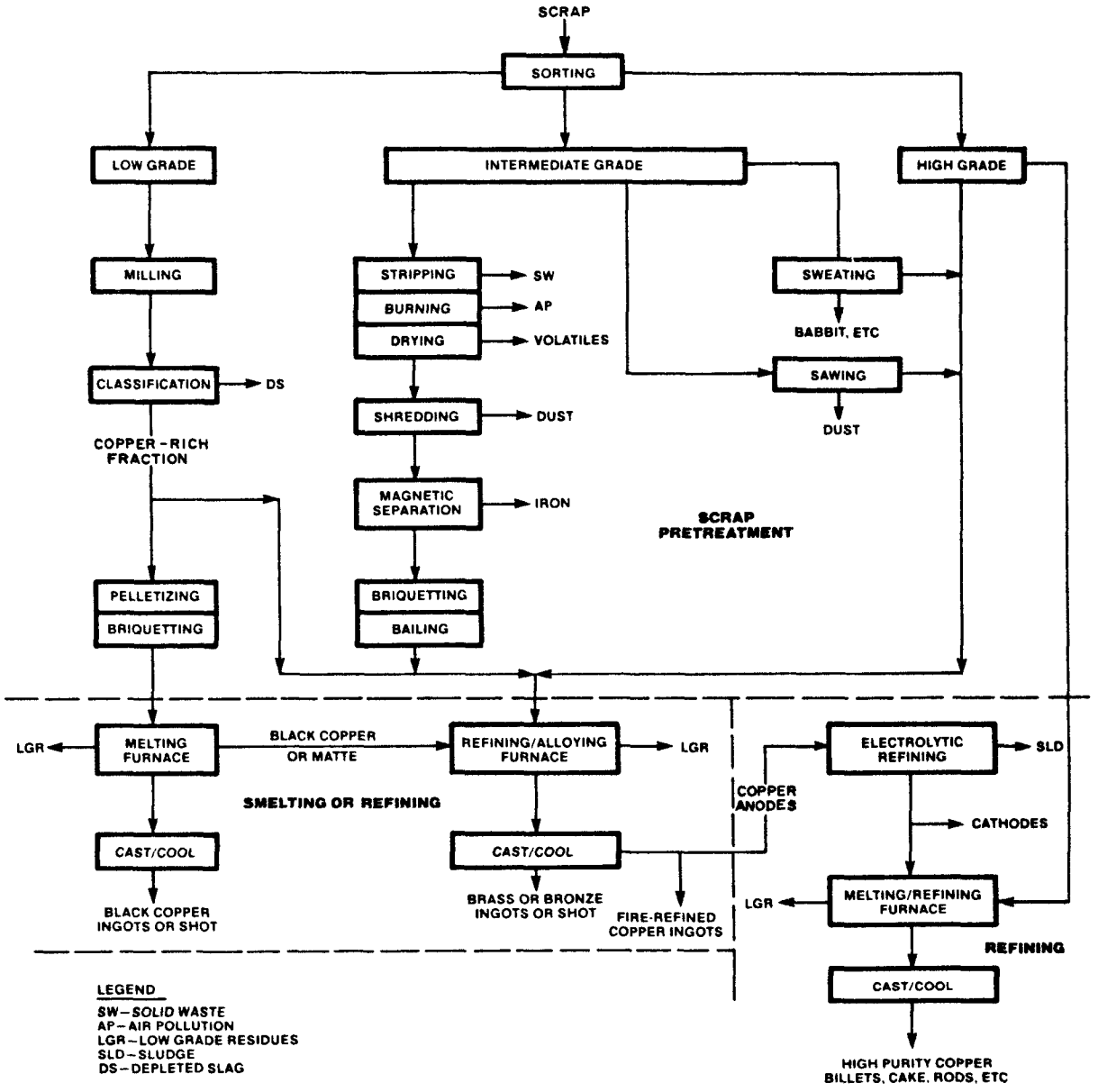


**FIGURE III-13. SECONDARY COPPER PRODUCTION PROCESS**

FIGURE III-14. GEOGRAPHIC LOCATIONS OF THE SECONDARY COPPER INDUSTRY

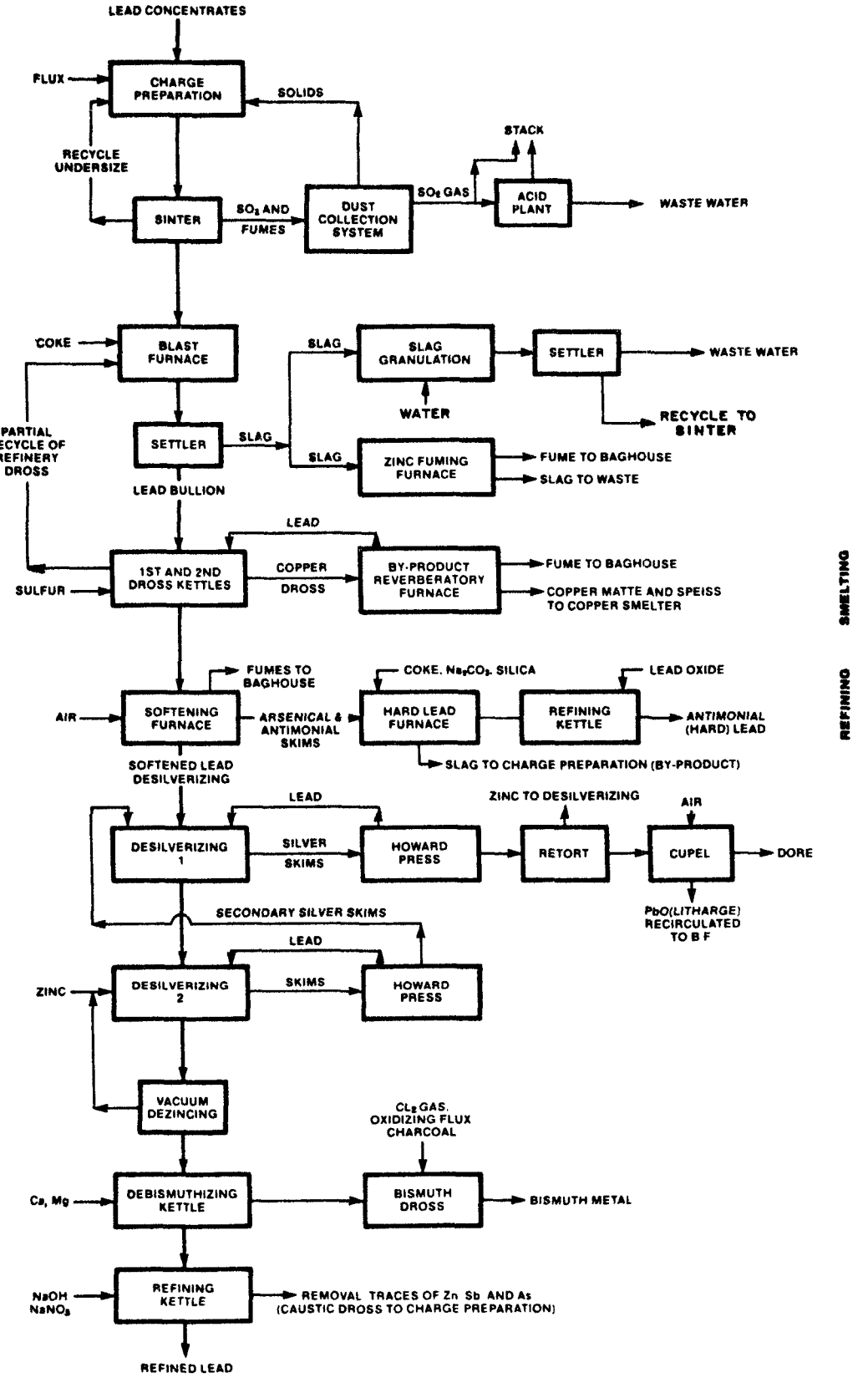


**FIGURE III-15. PRIMARY LEAD MANUFACTURING PROCESS**

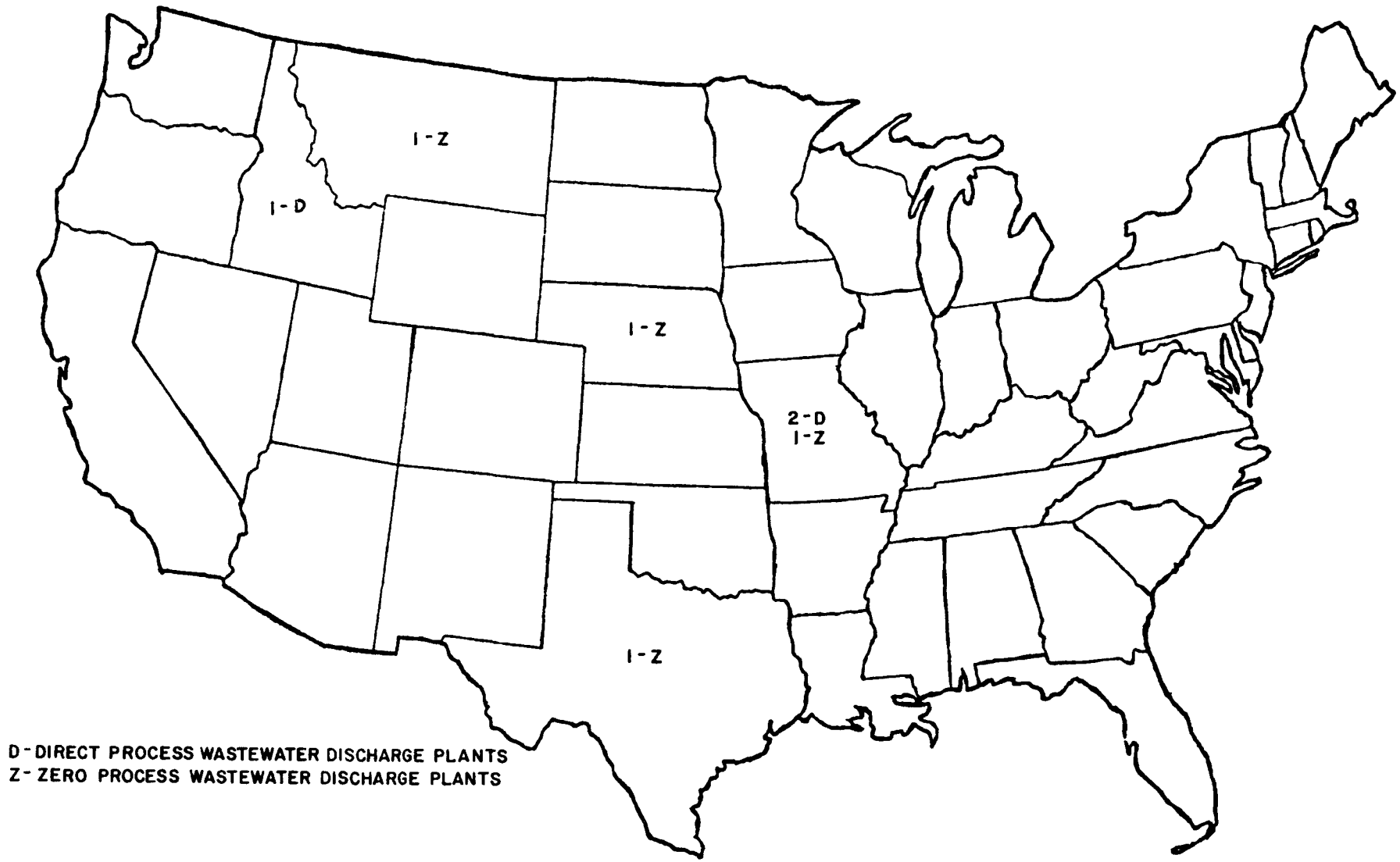


FIGURE III-16. GEOGRAPHIC LOCATIONS OF DOMESTIC PRIMARY LEAD SMELTERS & REFINERIES

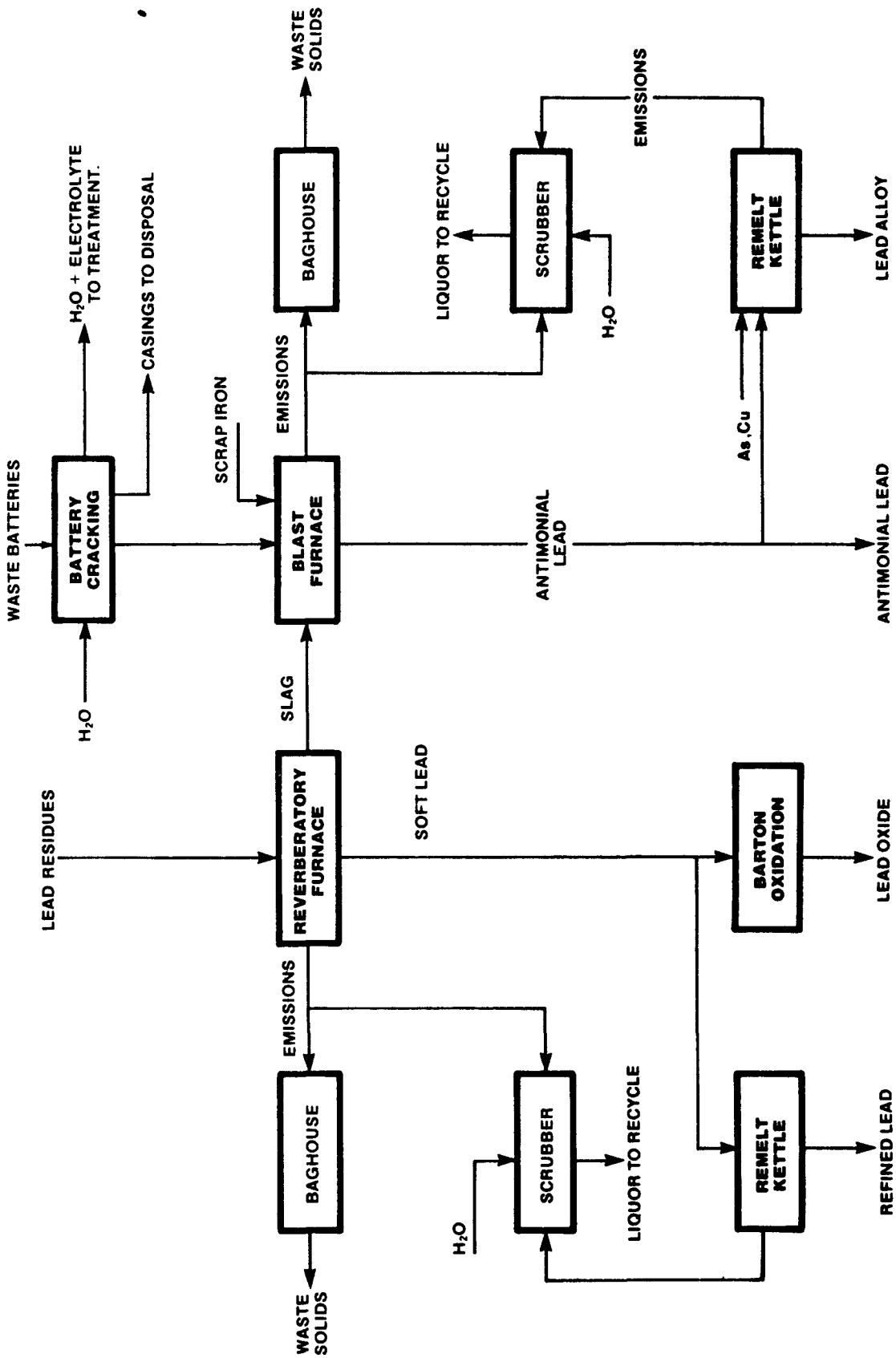


FIGURE III-17. SECONDARY LEAD/ANTIMONY SMELTING PROCESS

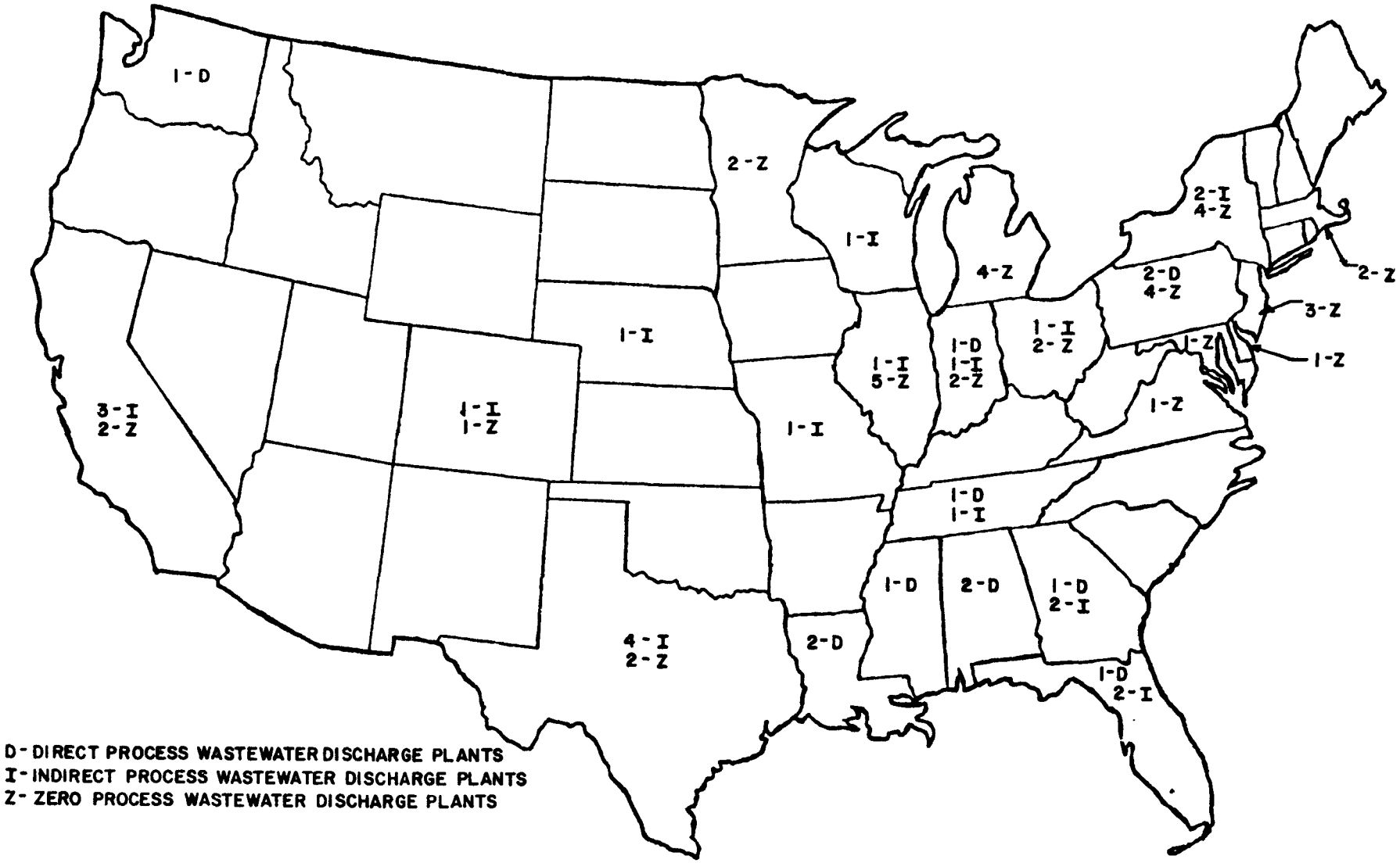


FIGURE III-18. GEOGRAPHIC LOCATIONS OF THE SECONDARY LEAD/ANTIMONY INDUSTRY

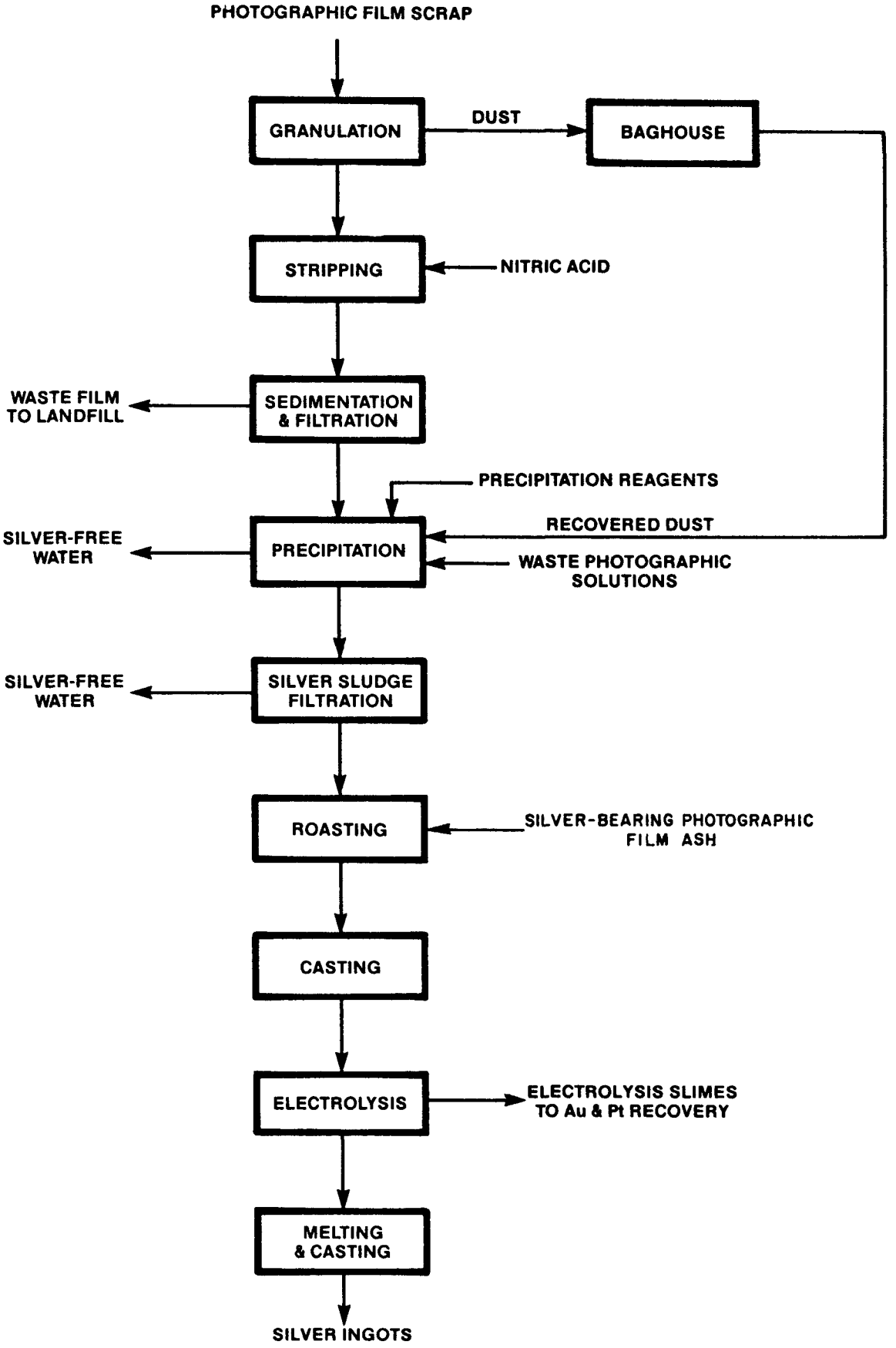


**FIGURE III-20. SILVER REFINING FROM PHOTOGRAPHIC WASTES**

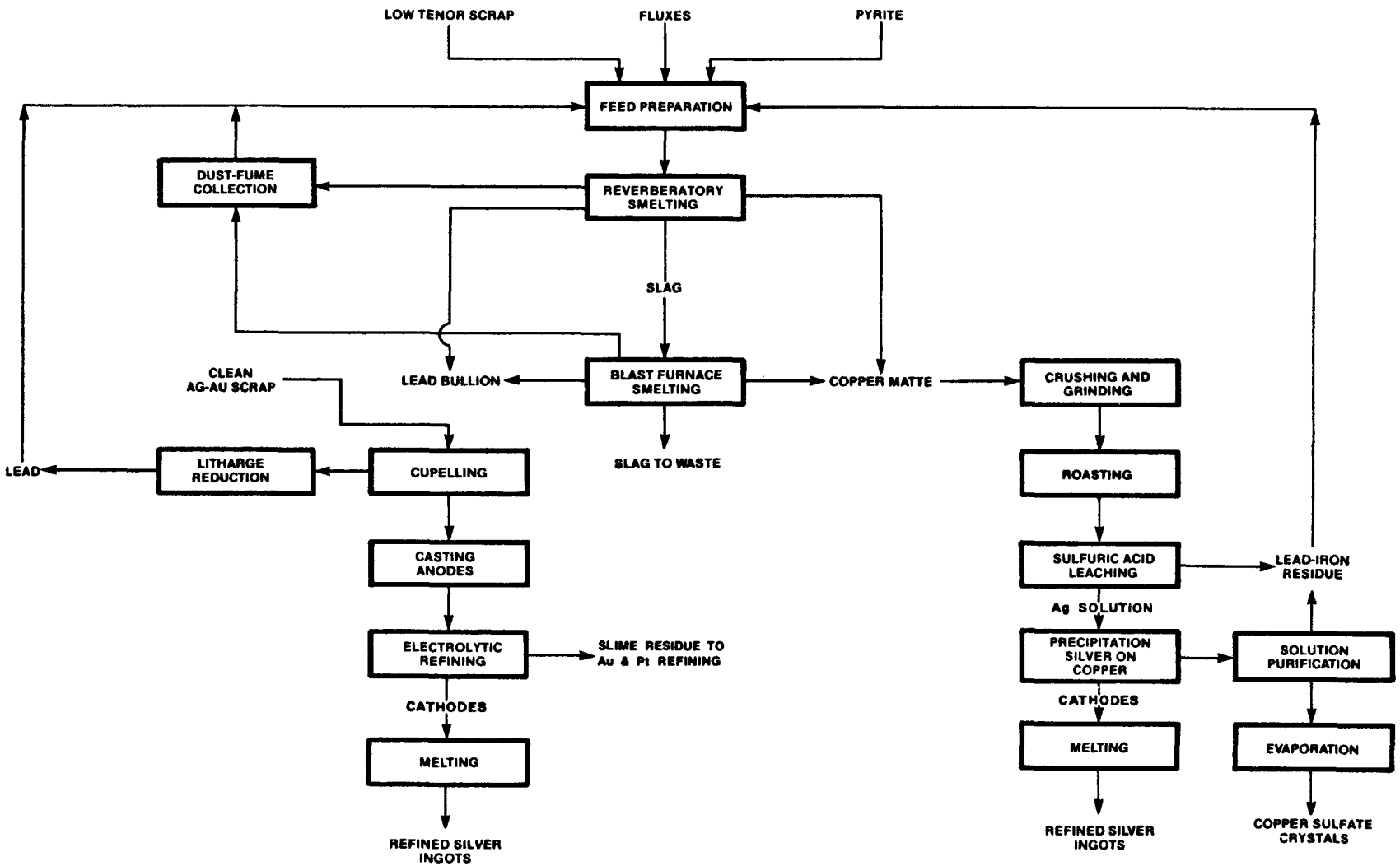


**FIGURE III-21. SECONDARY SILVER PRODUCTION PROCESS FROM NONPHOTOGRAPHIC SCRAP**

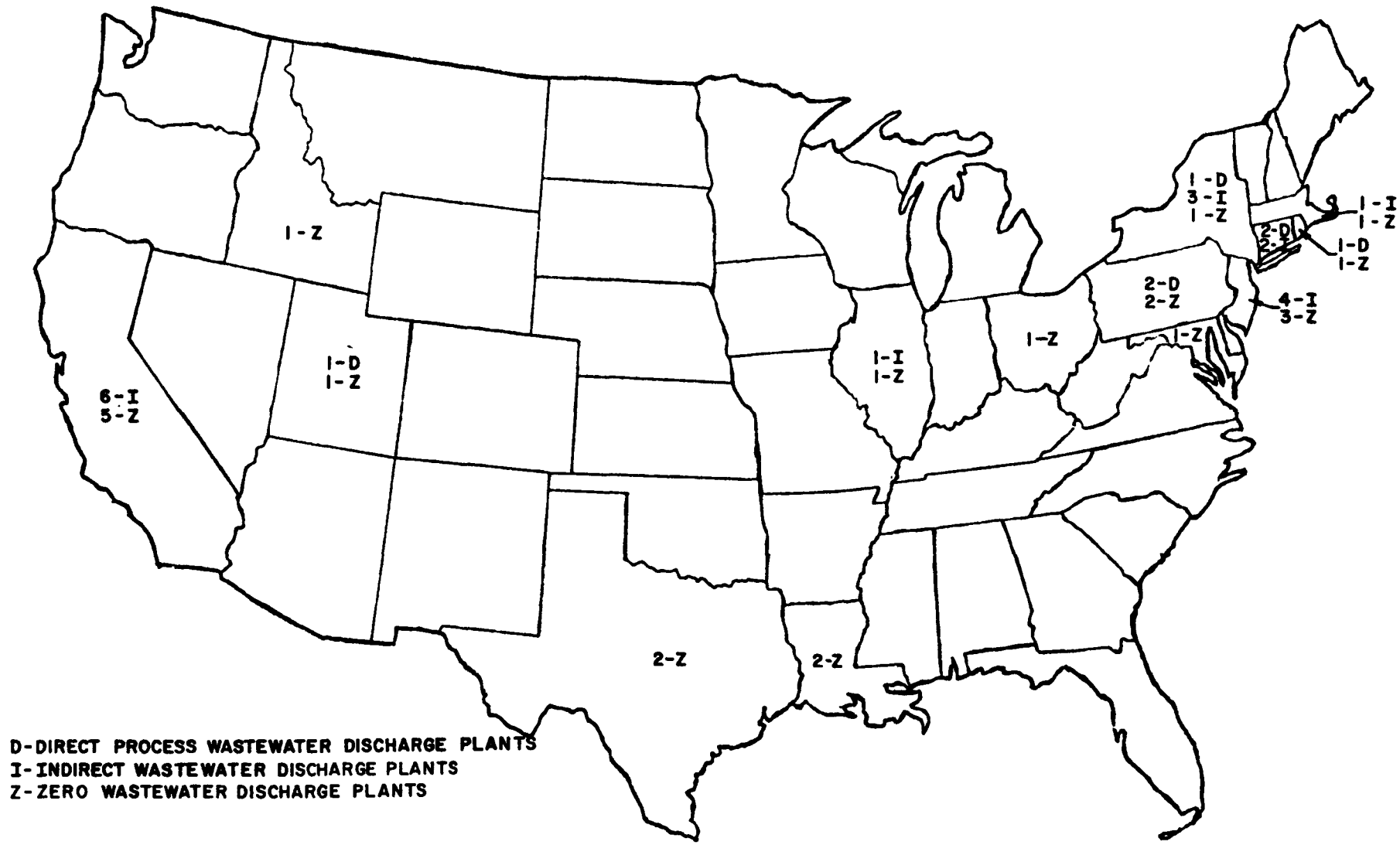


FIGURE III-22. GEOGRAPHIC LOCATIONS OF THE SECONDARY SILVER REFINING INDUSTRY.

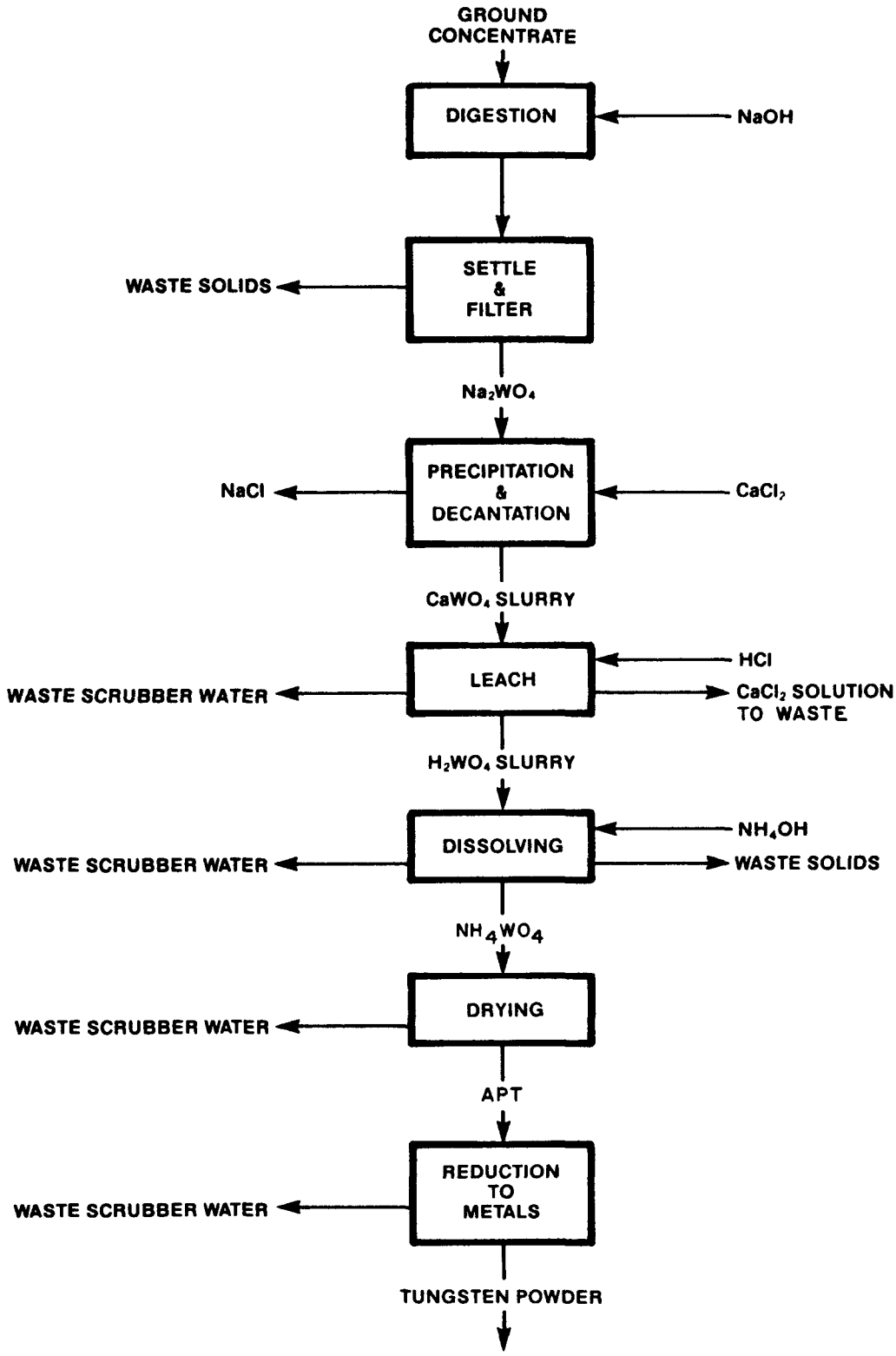


**FIGURE III-23. PRIMARY TUNGSTEN PRODUCTION PROCESS**

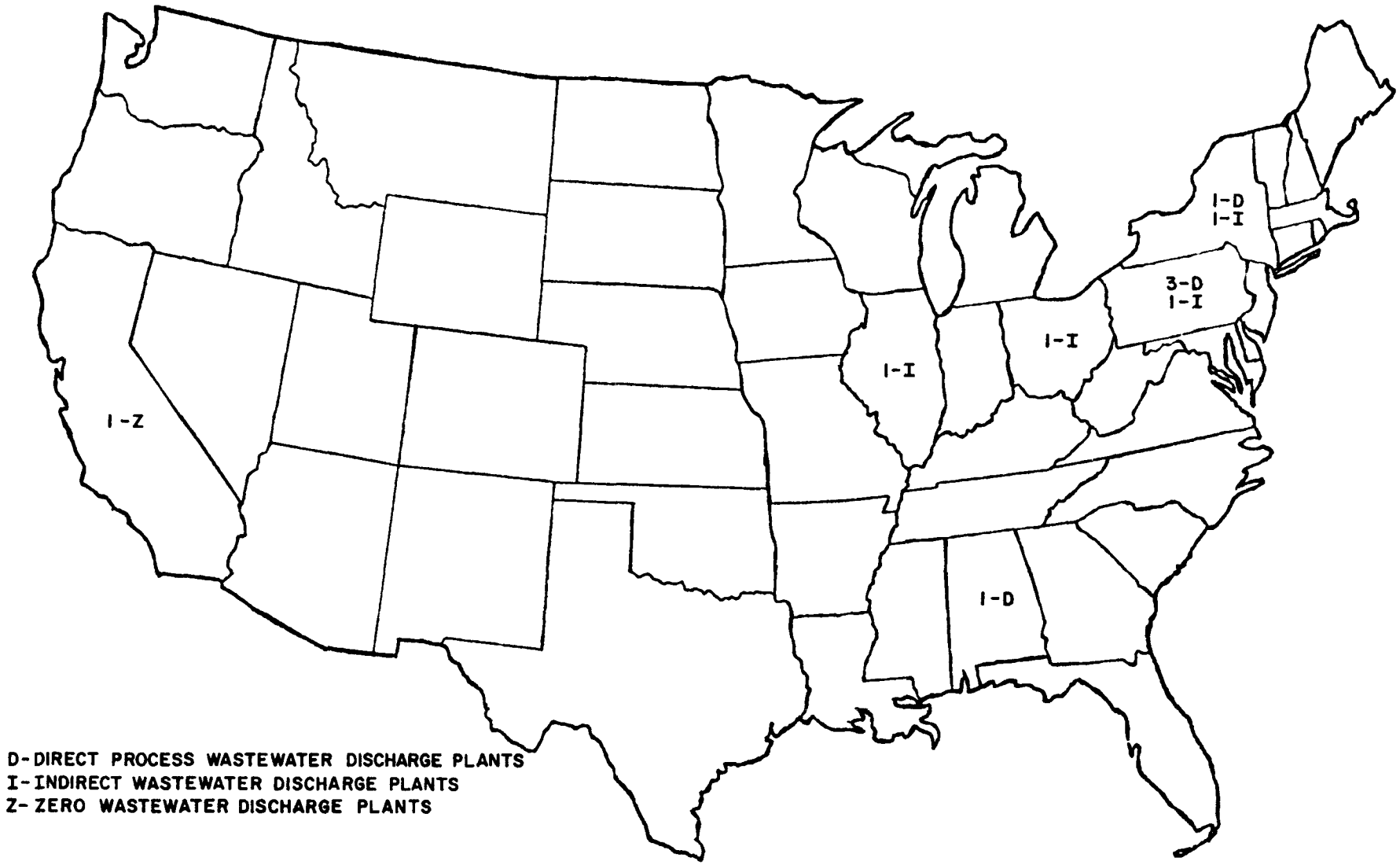


FIGURE III-24. GEOGRAPHIC LOCATIONS OF THE PRIMARY TUNGSTEN INDUSTRY

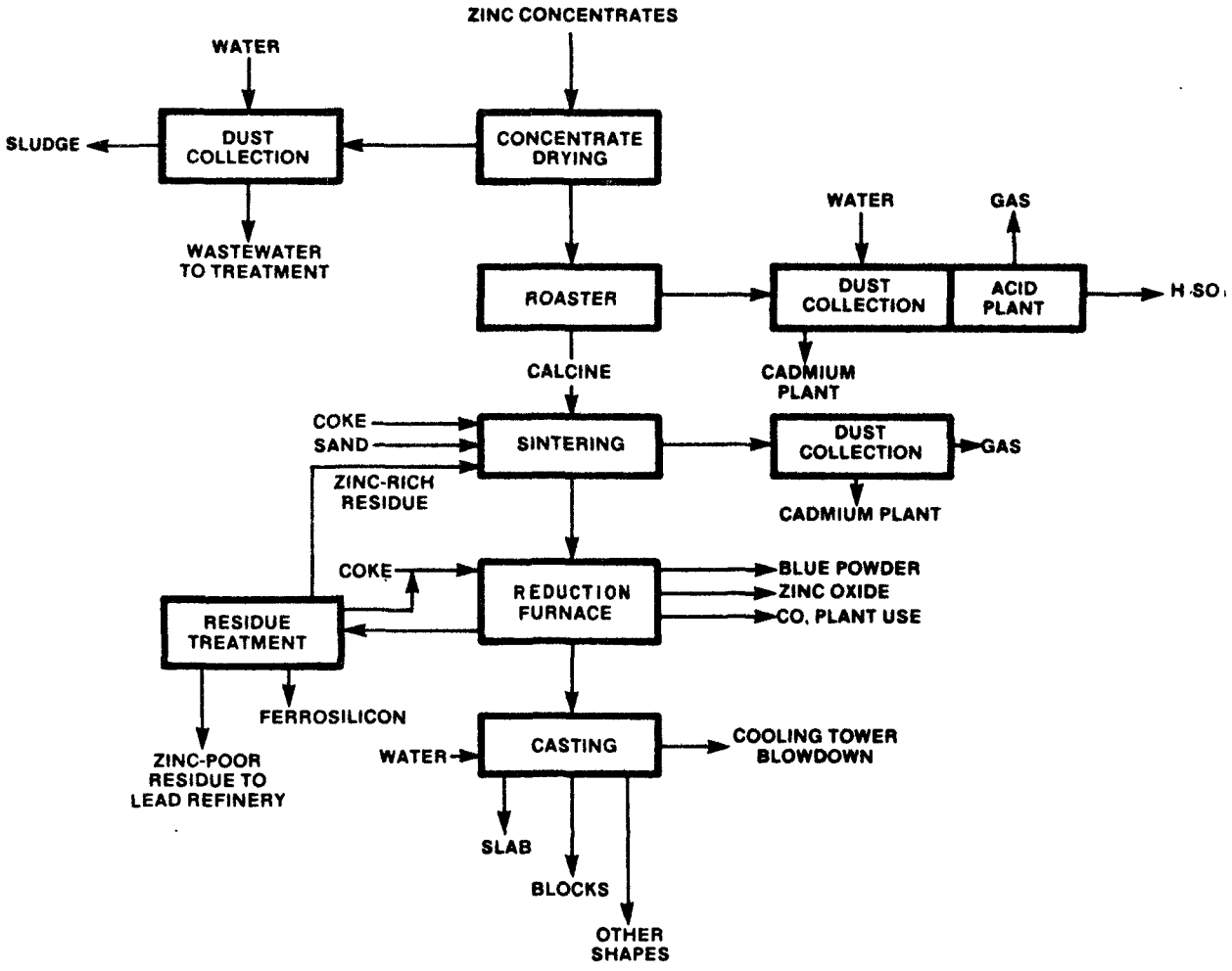


**FIGURE III-25. PYROLYTIC AND ELECTROTHERMIC ZINC PRODUCTION PROCESS**

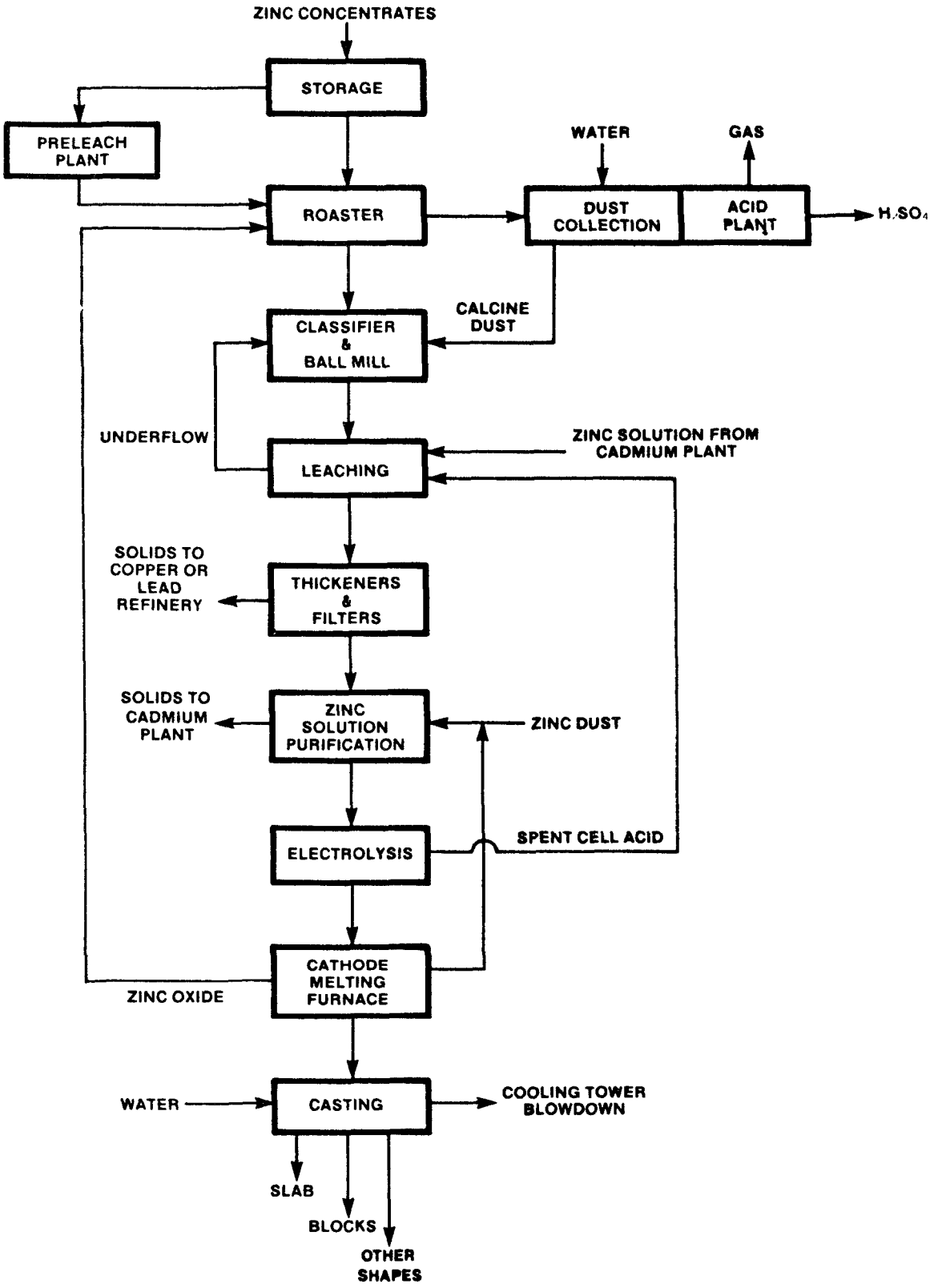


**FIGURE III-26. ELECTROLYTIC ZINC PRODUCTION PROCESS**

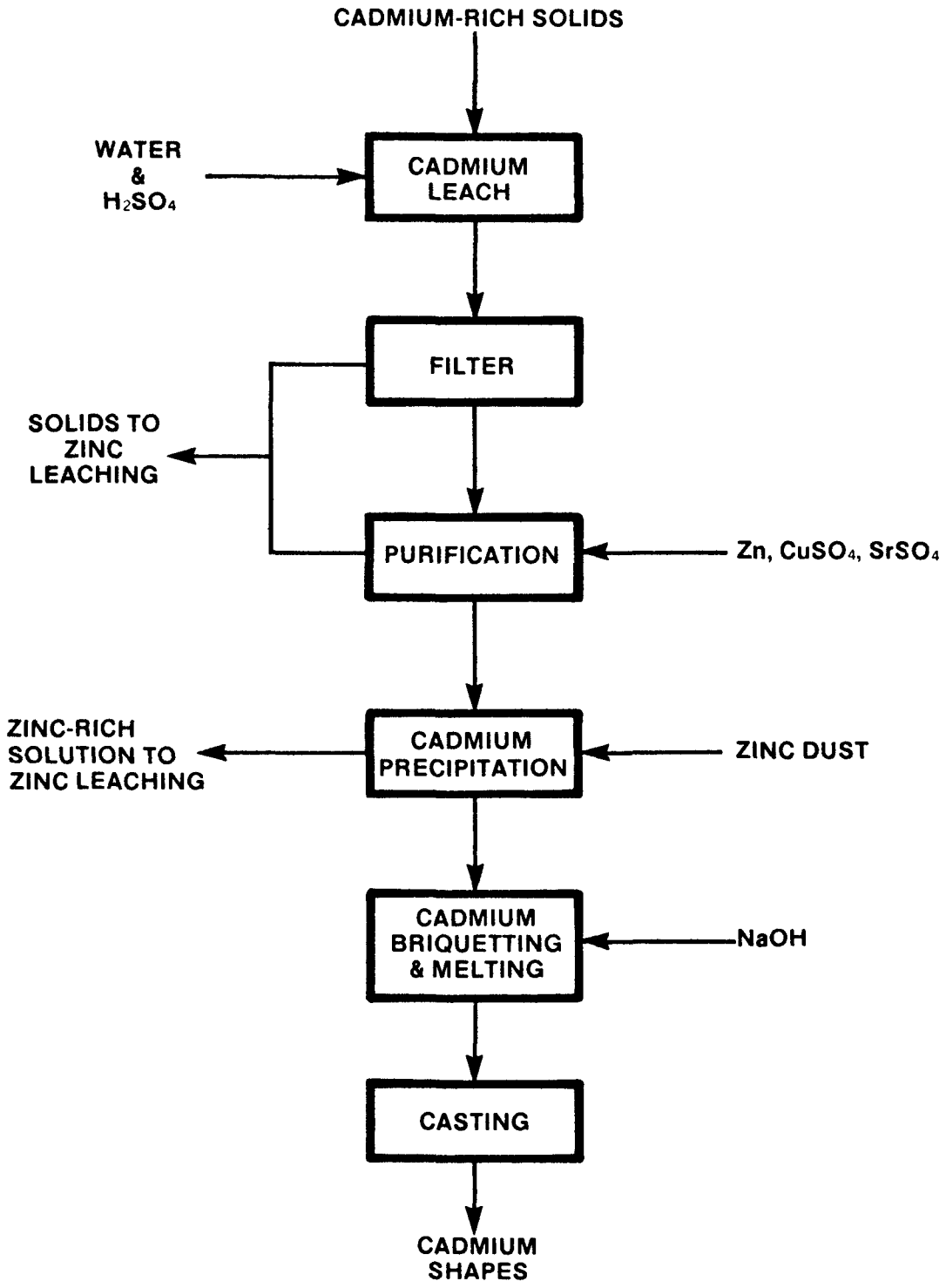


**FIGURE III-27. CADMIUM PRODUCTION PROCESS**

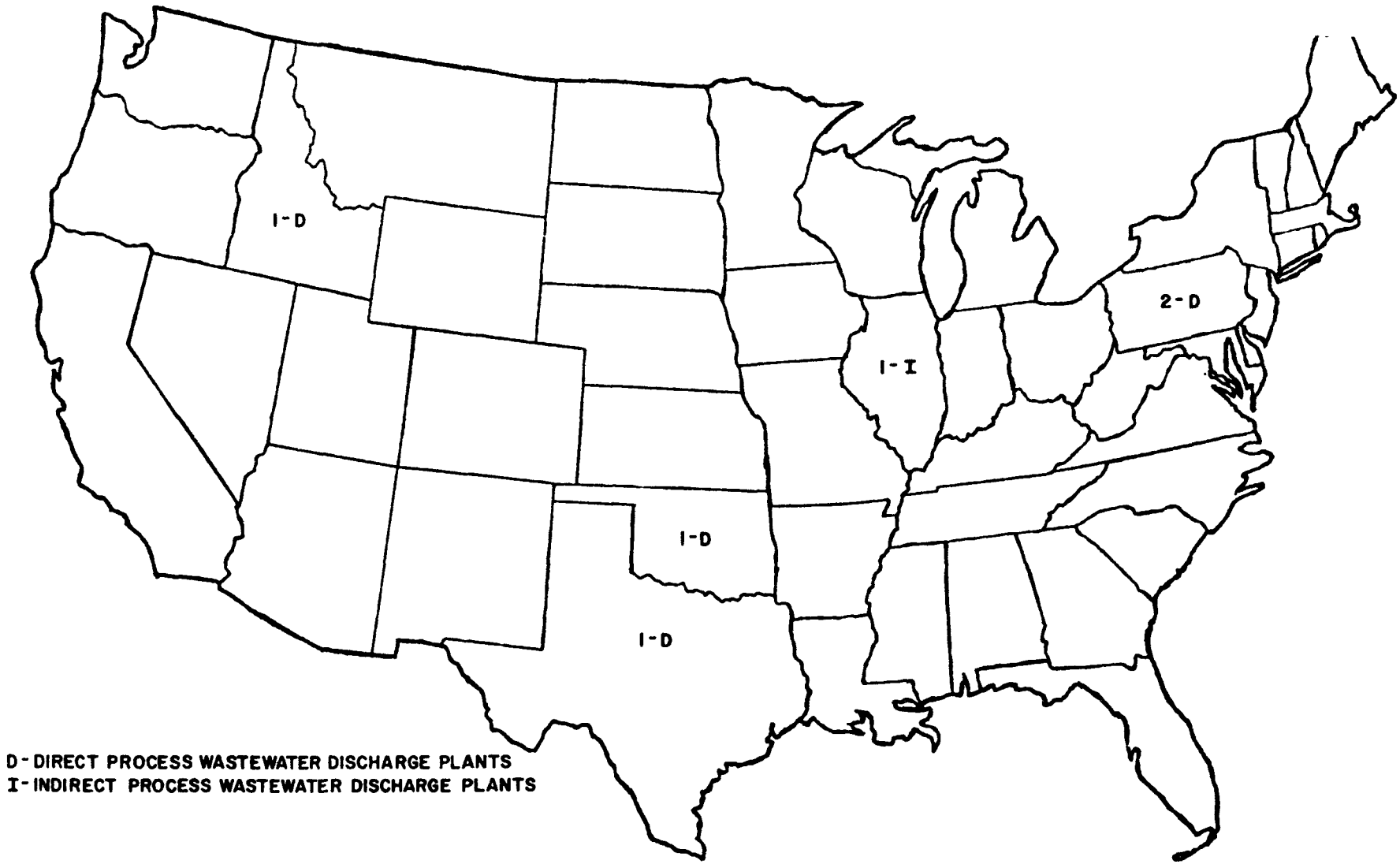


FIGURE III-28. GEOGRAPHIC LOCATIONS OF THE PRIMARY ZINC INDUSTRY

## TABLE III-1

Miscellaneous Nonferrous Metals

| Metal Produced | Primary Production Number of Plants | Number that Discharge | Secondary Production Number of Plants | Number that Discharge |
|---|---|---|---|---|
| Actinium* Group | 4 | None | 2 | None |
| Antimony | 1 | None | 2 | 2 |
| Arsenic | 1 | None | None | None |
| Barium | 1 | None | None | None |
| Beryllium | 2 | 1 | 1 | None |
| Boron | 3 | None | 1 | None |
| Cadmium | + | + | 1 | 1 |
| Cesium | 1 | 1 | None | None |
| Cobalt | 2 | 2 | 2 | 1 |
| Columbium | ++ | ++ | 1 | 1 |
| Gallium | 1 | None | None | None |
| Germanium | 1 | 1 | 1 | 1 |
| Gold | 5 | 2 | 14 | 10 |
| Hafnium | 1 | 1 | None | None |
| Indium | 1 | 1 | 1 | 1 |
| Lanthanum Group** | 2 | 2 | None | None |
| Lithium | 1 | None | None | None |
| Magnesium | 3 | 1 | 3 | 1 |
| Mercury | 2 | None | 2 | None |
| Molybdenum | 4 | 2 | 2 | None |
| Nickel | 2 | 2 | 4 | 2 |
| Platinum Group*** | 1 | 1 | 14 | 10 |
| Rare Earths | 1 | None | None | None |
| Rhenium | 2 | 1 | 1 | 1 |
| Rubidium | 1 | 1 | None | None |
| Sodium | 3 | 3 | None | None |
| Tin | 2 | None | 11 | 7 |
| Titanium | 4 | 3 | 6 | 2 |
| Vanadium | None | None | 1 | None |
| Zinc | + | + | 8 | None |
| Zirconium | 2 | 2 | 1 | None |

---

* Actinium Group: Actinium, Americium, Berkelium, Californium, Curium, Einsteinium, Fermium, Lawrencium, Mendelevium, Neptunium, Nobelium, Plutonium, Protactinium, Thorium and Uranium.

** Lanthanum Group: Cerium, Dysprosium, Erbium, Europium, Gadolinium, Holmium, Lanthanum, Lutetium, Neodymium, Praseodymium, Promethium, Samarium, Terbium, Thulium and Ytterbium.

*** Platinum Group: Irdium, Osmium, Palladium, Platinum, Rhodium and Ruthenium.

\+ Considered with Primary Zinc in this Report.

++ Considered with Columbium/Tantalum in this Report.

TABLE III-2

Nonferrous Metal Production

| Industry | 1973 Production (tons) |
|---|---|
| Primary Aluminum | 4,529,000 |
| Secondary Aluminum | 265,000 |
| Columbium/Tantalum | 5,500 |
| Primary Copper | 1,868,000 |
| Secondary Copper | 486,000 |
| Primary Lead | 687,000 |
| Secondary Lead | 539,000 |
| Secondary Silver | 1,200 |
| Primary Tungsten | 14,000 |
| Primary Zinc | 542,000 |

Based on U.S. Bureau of Mines publications

TABLE III-3
Type of Discharge of Major Nonferrous Metal Manufacturing Plants

| Metal | Primary Production: Number Of Plants | Primary Production: Type of Discharge: Direct | Primary Production: Type of Discharge: Indirect | Primary Production: Type of Discharge: Zero | Secondary Production: Number Of Plants | Secondary Production: Type of Discharge: Direct | Secondary Production: Type of Discharge: Indirect | Secondary Production: Type of Discharge: Zero |
|---|---|---|---|---|---|---|---|---|
| Aluminum | 30 | 27 | 0 | 3 | 63 | 8 | 14 | 41 |
| Columbium/Tantalum | 5 | 3 | 2 | 0 | 1* | 1 | 0 | 0 |
| Copper | 23 | 8 | 0 | 15 | 32 | 7 | 5 | 20 |
| Lead | 7 | 2 | 0 | 5 | 69 | 12 | 21 | 36 |
| Silver | 4 | 2 | 0 | 2 | 46 | 7 | 17 | 22 |
| Tungsten | 10 | 5 | 4 | 1 | 0 | 0 | 0 | 0 |
| Zinc | 6 | 5 | 1 | 0 | NA** | | | |
| Total | 85 | 52 | 7 | 26 | 211 | 34 | 58 | 119 |

Total of Primary and Secondary Plants

| Metal | Number Of Plants | Type of Discharge: Direct | Type of Discharge: Indirect | Type of Discharge: Zero |
|---|---|---|---|---|
| Aluminum | 93 | 36 | 14 | 44 |
| Columbium/Tantalum | 6 | 3 | 3 | 0 |
| Copper | 55 | 15 | 5 | 35 |
| Lead | 76 | 14 | 21 | 41 |
| Silver | 50 | 9 | 17 | 24 |
| Tungsten | 10 | 5 | 4 | 1 |
| Zinc | 6 | 5 | 1 | 0 |
| Total | 296 | 86 | 65 | 145 |

* Tantalum only

** Not applicable, all secondary zinc plants are zero discharge.

TABLE III-4

Initial Operating Years (Range) Summary of Plants in the Primary Aluminum Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1973 0-5 | 1972-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1918 41-60 | 1917-1903 61-75 | Before 1903 75+ | Total |
|---|---|---|---|---|---|---|---|---|---|
| Direct | 0 | 6 | 4 | 8 | 8 | 0 | 1 | 0 | 27 |
| Zero | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 3 |
| Total | 1 | 6 | 4 | 10 | 8 | 0 | 1 | 0 | 30 |

TABLE III-5

Production Ranges for Reduction
Plants of the Primary Aluminum Industry

| Production Ranges for 1976 (tons/Year) | No. of Plants |
|---|---|
| 0- 50,000 | 2 |
| 50,001-100,000 | 9 |
| 100,001-150,000 | 9 |
| 150,001-200,000 | 6 |
| 200,000+ | 3 |
| Not Reported | 1 |
| Total No. of Plants in Survey | 30 |

TABLE III-6

Treatment Level Summary for the
Primary Aluminum Industry+

| Discharge Type | Treatment Level: No Treatment | Less Than BPT | BPT | Above BPT | Total |
|---|---|---|---|---|---|
| Direct | 3 | 9 | 8 | 7 | 27 |
| Indirect | 0 | 0 | 0 | 0 | 0 |
| Zero | 0 | 0 | 0 | 3 | 3 |
| Total | 3 | 9 | 8 | 10 | 30 |

+ Primary Aluminum BPT Regulation Level: Chemical Coagulation and Sedimentation

TABLE III-7
Treatment Processes Utilized by the
Primary Aluminum Industry (30 plants)

| Treatment Processes | Zero Dischargers | Direct Dischargers | Total Industry |
|---|---|---|---|
| Number of Plants | 3 | 27 | 30 |
| Alum | 0 | 1 | 1 |
| Calcium Chloride | 0 | 1 | 1 |
| Caustic | 0 | 6 | 6 |
| Lime | 0 | 10 | 10 |
| Polymer | 0 | 7 | 7 |
| Sodium Aluminate | 0 | 6 | 6 |
| Cooling | 1 | 7 | 8 |
| Evaporate | 2 | 1 | 3 |
| Filter | 0 | 1 | 5 |
| Settle | 0 | 24 | 24 |
| Skim | 0 | 5 | 5 |
| No treatment | 0 | 3 | 3 |

TABLE III-8
Production Processes Utilized by the
Primary Aluminum Reduction Industry (30 plants)

| Production Process | Number of Plants with Process |
|---|---|
| Paste Plant APC++ | 26 |
| Paste Plant CCW** | 1 |
| Bake Plant APC | 21 |
| Cathode Making | 21 |
| Cathode Reprocess (Cryolite Recovery) | 6 |
| Potline APC | 25 |
| Potroom APC | 7 |
| Degassing | 20 |
| Scrap Handling | 13 |
| Casting | 29 |

++ APC - Air Pollution Control
** CCW - Contact Cooling Water

TABLE III-9

Treatment Level Summary for the
Secondary Aluminum Industry

| Discharge Type | No Treatment | Treatment Level+* Level A | Level B | Level C | Total |
|---|---|---|---|---|---|
| Direct | 2 | 2 | 3 | 1 | 8 |
| Indirect | 12 | 1 | 2 | 1 | 16 |
| Zero | 26 | 7 | 0 | 6 | 39 |
| Total | 40 | 10 | 5 | 8 | 63 |

+* The levels of treatment have been defined as:
Level A - Physical separation of solids, cooling or neutralization only.
Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.
Level C - Secondary level processes followed by other treatment processes, including solar evaporation ponds and lagoons.

TABLE III-10

Production Processes Utilized by the
Secondary Aluminum Industry (63 Plants)

| Production Process | Number of Plants With Process |
|---|---|
| Scrap Classification and Drying | 4 |
| Dross Classification | 7 |
| Kiln Air Pollution Control | 25 |
| Demagging: | |
| $Cl_2$ Addition | 19 |
| $AlF_3$ Addition | 10 |
| Casting | 30 |

TABLE III-11

Treatment Processes Utilized by the
Secondary Aluminum Industry (63 Plants)

| Treatment Processes | Direct Dischargers | Indirect Dischargers | Zero Dischargers | Total Industry |
|---|---|---|---|---|
| Number of Plants | 8 | 16 | 39 | 63 |
| Caustic | 2 | 2 | 0 | 4 |
| Lime | 1 | 2 | 0 | 3 |
| Polymer | 1 | 0 | 0 | 1 |
| Sulfide | 0 | 1 | 0 | 1 |
| Cooling | 1 | 1 | 0 | 2 |
| Evaporation | 0 | 0 | 4 | 4 |
| Filtration | 0 | 1 | 0 | 1 |
| Sedimentation | 2 | 3 | 0 | 5 |
| Skimming | 1 | 1 | 0 | 2 |
| No Treatment | 2 | 12 | 26 | 40 |

TABLE III-12

Production Ranges for Smelters and
Refiners of the Secondary Aluminum Industry

| Production Ranges for 1976 (tons/year) | No. of Plants |
|---|---|
| 0 - 2,500 | 6 |
| 2,501 - 5,000 | 3 |
| 5,001 - 10,000 | 17 |
| 10,001 - 20,000 | 13 |
| 20,001 - 30,000 | 3 |
| 30,000 + | 6 |
| No Data | 15 |
| Total No. of Plants in Survey | 63 |

TABLE III-13

Initial Operating Year (Range) Summary of Plants
in the Secondary Aluminum Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1973 0-5 | 1972-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1928 41-50 | 1927-1918 51-60 | 1917-1903 61-75 | Before 1903 75+ | Insuff. Data | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Direct | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 8 |
| Indirect | 0 | 4 | 3 | 4 | 1 | 0 | 1 | 1 | 0 | 0 | 14 |
| Zero | 9 | 4 | 6 | 7 | 3 | 0 | 2 | 1 | 0 | 9 | 41 |
| Total | 9 | 9 | 12 | 12 | 5 | 1 | 3 | 3 | 0 | 9 | 63 |

TABLE III-14

Initial Operating Year (Range) Summary
of Plants in the Columbium/Tantalum Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | Before 1948 30+ | Insuff. Data | Total |
|---|---|---|---|---|---|---|
| Direct++ | 0 | 1 | 1 | 0 | 0 | 2 |
| Indirect | 0 | 1 | 0 | 0 | 2 | 3 |
| | – | – | – | – | – | – |
| Total | 0 | 2 | 1 | 0 | 2 | 5 |

TABLE III-15

Production Ranges for the
Columbium/Tantalum Industry

| Production Ranges for 1976 (tons/year) | No. of Plants |
|---|---|
| Less than 450 | 3 |
| More than 450 | 2 |

TABLE III-16

Treatment Level Summary for the
Columbium/Tantalum Industry

| Discharge Type | Treatment Level* | | | | |
|---|---|---|---|---|---|
| | No Treatment | Level A | Level B | Level C | Total |
| Direct | 0 | 0 | 1 | 2 | 3 |
| Indirect | 0 | 1 | 1 | 0 | 2 |
| Total | 0 | 1 | 2 | 2 | 5 |

* The levels of treatment have been defined as:
  Level A - Physical separation of solids, cooling or neutralization only.
  Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.
  Level C - Secondary level processes followed by other treatment processes, including solar evaporation ponds and lagoons.

TABLE III-17

Treatment Processes Utilized by the Columbium/Tantalum Industry

| Treatment Processes | Direct Dischargers | Indirect Dischargers | Total Industry |
|---|---|---|---|
| Number of Plants | 2 | 3 | 5 |
| Ammonia Stripping | 2 | 0 | 2 |
| Caustic | 1 | 2 | 3 |
| Lime | 3 | 0 | 3 |
| Polymer | 1 | 0 | 1 |
| Cooling | 2 | 1 | 3 |
| Filtration | 1 | 0 | 1 |
| Sedimentation | 3 | 0 | 3 |

TABLE III-18

Production Processes Utilized by the Columbium/Tantalum Industry

| Production Process | Number of Plants With Process |
|---|---|
| Digestion | 3 |
| Extraction | 3 |
| Precipitation | 3 |
| Filtration | 3 |
| Drying Salts | 3 |
| Reduction | 4 |
| Consolidation | 4 |
| Leaching | 2 |

TABLE III-19

Initial Operating Year (Range) Summary of Plants
in the Primary Copper Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1973 0-5 | 1972-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1928 41-50 | 1927-1918 51-60 | 1917-1903 61-75 | 1901-1878 76-100 | Before 1878 100+ | Insuff. Data | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Direct | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 8 |
| Zero | 3 | 0 | 1 | 1 | 1 | 0 | 1 | 3 | 0 | 0 | 5 | 15 |
| Total | 3 | 0 | 3 | 3 | 2 | 0 | 1 | 4 | 1 | 0 | 6 | 23 |

TABLE III-20

**Production Ranges for Smelters and Refiners of the Primary Copper Industry**

| Production Ranges for 1976 (tons/year) | No. of Plants |
|---|---|
| 0 - 50,000 | 5 |
| 50,001 - 100,000 | 6 |
| 100,001 - 150,000 | 3 |
| 150,000 + | 5 |
| No Data | 4 |
| Total No. of Plants in Survey | 23 |

TABLE III-21

Treatment Level Summary for the Primary Copper Industry

| Discharge Type | Treatment Level* | | | | |
|---|---|---|---|---|---|
| | No Treatment | Level A | Level B | Level C | Total |
| Direct | 3 | 1 | 1 | 3 | 8 |
| Zero | 4 | 0 | 1 | 10 | 15 |
| Total | 7 | 1 | 2 | 13 | 23 |

* The levels of treatment have been defined as:

Level A - Physical separation of solids, cooling or neutralization only.

Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.

Level C - Secondary level processes followed by other treatment processes, including solar evaporation ponds and lagoons.

TABLE III-22

Treatment Processes Utilized by the Primary Copper Industry (23 plants)

| Treatment Processes | Direct Dischargers | Zero Dischargers | Total Industry |
|---|---|---|---|
| Number of Plants | 8 | 15 | 23 |
| Ammonia | 0 | 2 | 2 |
| Caustic | 0 | 1 | 1 |
| Lime | 4 | 3 | 7 |
| Polymer | 2 | 1 | 3 |
| Cooling | 3 | 4 | 7 |
| Evaporation | 0 | 8 | 8 |
| Filtration | 2 | 2 | 4 |
| Sedimentation | 2 | 5 | 7 |
| Skimming | 1 | 2 | 3 |
| No Treatment | 4 | 7 | 11 |

TABLE III-23

Production Processes Utilized by the Primary Copper Industry (23 plants)

| Production Process | Number of Plants With Process |
|---|---|
| Roaster | 7 |
| Acid Plant | 11 |
| Smelter | 10 |
| Converter | 10 |
| Fire Refining | 7 |
| Electrolysis | 13 |
| By-Product Metals: | |
| Ag, Se, Au | 2 |
| Ag, Se, Au, Te | 3 |
| Ag, Se, Au, Te, As | 1 |
| Ag, Se, Au, Pt, Pd | 2 |
| Casting | 16 |

TABLE III-24

Initial Operating Year (Range) Summary of Plants
in the Secondary Copper Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1972-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1928 41-50 | 1927-1918 51-60 | 1917-1903 61-75 | Before 1903 75+ | Insuff. Data | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Direct | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 7 |
| Indirect | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 5 |
| Zero | 1 | 4 | 3 | 3 | 2 | 1 | 1 | 0 | 5 | 20 |
| Total | 3 | 5 | 5 | 3 | 5 | 2 | 2 | 0 | 7 | 32 |

TABLE III-25

Production Ranges for Processing Plants
of the Secondary Copper Industry

| Production Ranges for 1976 (tons/year) | No. of Pla |
|---|---|
| 0 - 5,000 | 11 |
| 5,001 - 10,000 | 4 |
| 10,001 - 20,000 | 6 |
| 20,001 - 30,000 | 4 |
| 30,000 + | 4 |
| No Data | 3 |
| Total No. of Plants in Survey | 32 |

TABLE III-26

Treatment Level Summary for the
Secondary Copper Industry

| Discharge Type | Treatment Level* | | | | |
|---|---|---|---|---|---|
| | No Treatment | Level A | Level B | Level C | Total |
| Direct | 3 | 2 | 2 | 0 | 7 |
| Indirect | 3 | 2 | 0 | 0 | 5 |
| Zero | 10 | 3 | 1 | 6 | 20 |
| Total | 16 | 7 | 3 | 6 | 32 |

* The levels of treatment have been defined as:
Level A - Physical separation of solids, cooling or neutralization only.
Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.
Level C - Coagulation and solids removal followed by other treatment processes, including solar evaporation ponds and lagoons.

TABLE III-27

Treatment Processes Utilized by the
Secondary Copper Industry (32 plants)

| Treatment Processes | Direct Dischargers | Indirect Dischargers | Zero Dischargers | Total Industry |
|---|---|---|---|---|
| Number of Plants | 5 | 7 | 20 | 32 |
| Alum | 1 | 0 | 0 | 1 |
| Caustic | 2 | 1 | 1 | 4 |
| Lime | 2 | 0 | 1 | 3 |
| Polymer | 1 | 0 | 1 | 2 |
| Cooling | 3 | 1 | 2 | 6 |
| Evaporation | 0 | 0 | 6 | 6 |
| Filtration | 2 | 0 | 2 | 4 |
| Sedimentation | 2 | 1 | 2 | 5 |
| Skimming | 0 | 1 | 0 | 1 |
| No Treatment | 3 | 3 | 10 | 16 |

TABLE III-28

Production Processes Utilized by the
Secondary Copper Industry (32 plants)

| Production Process | Number of Plants With Process |
|---|---|
| Slag Milling | 8 |
| Slag Granulation | 5 |
| Furnace Scrubber | 26 |
| Electrolysis | 4 |
| Casting | 25 |
| Other Metals | 5 |

TABLE III-29

Initial Operating Year (Range) Summary
of Plants in the Primary Lead Industry by Discharge Type

| Plant Age Range (Years) | | | | | |
|---|---|---|---|---|---|
| 1972-1968 6-10 | 1967-1918 11-60 | 1947-1903 61-75 | 1902-1878 76-100 | Insuff. Data | Total |
| 2 | 0 | 1 | 3 | 1 | 7 |

TABLE III-30

Production Ranges for Smelters and Refiners
of the Primary Lead Industry

| Production Ranges for 1976 (tons/year) | Subcategories | |
|---|---|---|
| | No. of Plants Smelters and Smelter/Refiners | No. of Plants Refiners Only |
| Less than 100,000 | 2 | 0 |
| 100,001 - 200,000 | 1 | 1 |
| More than 200,000 | 3 | 0 |

TABLE III-31

Treatment Level Summary for the
Primary Lead Industry+

| Discharge Type | Treatment Level* | | | |
|---|---|---|---|---|
| | No Treatment | Level A | Level B | Total |
| Direct | 0 | 0 | 3 | 3 |
| Zero | 1 | 1 | 2 | 4 |
| Total | 1 | 1 | 5 | 7 |

* The levels of treatment have been defined as:
Level A - Physical separation of solids, cooling or neutralization only.
Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.

## TABLE III-32

### Treatment Processes Utilized by the Primary Lead Industry (7 plants)

| Treatment Processes | Total Industry |
|---|---|
| Number of Plants | 7 |
| Caustic | 1 |
| Lime | 4 |
| Polymer | 1 |
| Cooling | 2 |
| Evaporation | 6 |
| Sedimentation | 6 |
| No Treatment | 2 |

## TABLE III-33

### Production Processes Utilized by the Primary Lead Industry

| Production Process | Number of Plants with Process |
|---|---|
| Sintering | 6 |
| Sulfuric Acid Plant | 4 |
| Blast Furnace | 5 |
| Slag Granulation | 5 |
| Zinc Fume Scrubber | 2 |
| Dross Kettle | 4 |
| Dross Reverb Furnace | 4 |
| Softening | 2 |
| Hard Lead Refining | 2 |
| Desilverizing | 4 |
| Retort | 4 |
| Cupel | 2 |
| Debismuthizing | 1 |
| Casting | 7 |

TABLE III-34

Initial Operating Year (Range) Summary of Plants in the Secondary Lead Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1973 0-5 | 1972-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1928 41-50 | 1927-1918* 51-60 | 1917-1903 61-75 | Before 1903 76+ | Insuff. Data | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Direct | 0 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 1 | 2 | 12 |
| Indirect | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 2 | 0 | 6 | 21 |
| Zero | 0 | 1 | 6 | 1 | 9 | 3 | 3 | 3 | 0 | 10 | 36 |
| Total | 3 | 5 | 11 | 4 | 11 | 6 | 5 | 5 | 1 | 18 | 69 |

## TABLE III-35

Production Ranges for the Battery Cracking and Non-Battery Cracking Segments of the Secondary Lead Industry

| Production Ranges for 1976 (tons/year) | No. of Plants With Battery Cracking | Production Ranges for 1976 (tons/year) | No. of Plants Without Battery Cracking |
|---|---|---|---|
| 0 - 10,000 | 9 | 0 - 2,500 | 18 |
| 10,001 - 15,000 | 6 | 2,501 - 5,000 | 4 |
| 15,001 - 20,000 | 5 | 5,001 - 10,000 | 3 |
| 20,001 - 30,000 | 4 | 10,001 - 15,000 | 4 |
| 30,000 + | 4 | 15,000 + | 4 |
| Total | 28 | Total | 33 |
| Insufficient Data to Categorize | | | 8 |
| Total No. of Plants in Survey | | | 69 |

## TABLE III-36

Treatment Level Summary for the Secondary Lead Industry

| Discharge Type | Treatment Level* | | | | |
|---|---|---|---|---|---|
| | No Treatment | Level A | Level B | Level C | Total |
| Direct | 0 | 1 | 9 | 5 | 15 |
| Indirect | 1 | 0 | 11 | 0 | 12 |
| Zero | 2 | 0 | 1 | 1 | 42 |
| Total | 3 | 1 | 21 | 6 | 69 |

* The levels of treatment have been defined as:

Level A - Physical separation of solids, cooling or neutralization only.

Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.

Level C - Secondary level processes followed by other treatment processes, including solar evaporation ponds and lagoons.

TABLE III-37

Treatment Processes Utilized by the
Secondary Lead Industry (69 plants)

| Treatment Processes | Direct Dischargers | Indirect Dischargers | Zero Dischargers | Total Industry |
|---|---|---|---|---|
| Number of Plants | 15 | 12 | 42 | 69 |
| Ammonia | 3 | 9 | 0 | 12 |
| Caustic | 2 | 1 | 1 | 4 |
| Lime | 6 | 2 | 3 | 11 |
| Polymer | 2 | 1 | 1 | 4 |
| Cooling | 3 | 5 | 0 | 8 |
| Evaporation | 4 | 4 | 0 | 8 |
| Filtration | 5 | 3 | 4 | 12 |
| Sedimentation | 7 | 11 | 4 | 22 |
| Ion Exchange | 0 | 1 | 0 | 1 |
| Reverse Osmosis | 0 | 0 | 1 | 1 |
| No Treatment | 2* | 3 | 7 | 12 |

* Both have battery cracking

TABLE III-38

Production Processes Utilized by the
Secondary Lead Industry (69 plants)

| Production Process | Number of Plants With Process |
|---|---|
| Battery Cracking | 32 |
| Dross Classification | 2 |
| Furnace Scrubber | 9 |
| Kettle Scrubber | 7 |

TABLE III-39

Initial Operating Year (Range) Summary of Plants
in the Secondary Silver Industry by Subcategory and Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1973 0-5 | 1972-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1928 41-50 | 1927-1918 51-60 | 1917-1903 61-75 | Before 1903 76+ | Insuff. Data | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Direct | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 4 |
| Indirect | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 |
| Zero | 0 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 12 |
| Total | 1 | 7 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 10 | 23 |
| (2) Direct | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Indirect | 3 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 10 |
| Zero | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 10 |
| Total | 5 | 2 | 3 | 2 | 1 | 0 | 1 | 0 | 0 | 7 | 23/46 |

(1) - Subcategory of plants processing photographic wastes

(2) - Subcategory of plants processing non-photographic wastes

TABLE III-40

Production Ranges for the Photographic and Non-photographic Waste Segments of the Secondary Silver Industry

| Production Ranges for 1976 (troy oz./year) | Subcategories: No. of Plants Processing Photographic Wastes | Subcategories: No. of Plants Processing Non-photographic Wastes |
|---|---|---|
| 0 - 50,000 | 4 | 9 |
| 50,001 - 100,000 | 4 | 1 |
| 100,001 - 500,000 | 3 | 1 |
| 500,001 - 1,000,000 | 2 | 3 |
| 1,000,000 + | 4 | 6 |
| | 17 | 20/37 plants |
| Insufficient Data to Categorize | | 9 |
| Total No. of Plants in Survey | | 46 |

TABLE III-41

Treatment Level Summary by Subcategory for the Secondary Silver Industry

| Discharge Type | No Treatment | Treatment Level* Level A | Level B | Level C | Total |
|---|---|---|---|---|---|
| (1) Direct | 2 | 1 | 0 | 1 | 4 |
| Indirect | 2 | 3 | 0 | 2 | 7 |
| Zero | 10 | 1 | 0 | 1 | 12 |
| Total | 14 | 5 | 0 | 4 | 23 |
| (2) Direct | 0 | 1 | 0 | 2 | 3 |
| Indirect | 5 | 1 | 2 | 2 | 10 |
| Zero | 6 | 1 | 2 | 2 | 10 |
| Total | 11 | 3 | 3 | 6 | 23 |
| | | | | TOTAL | 46 |

* The levels of treatment are:
Level A - Physical separation of solids, cooling or neutralization only.
Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.
Level C - Secondary level processes followed by other treatment processes, including solar evaporation ponds and lagoons.

(1) Plants processing photographic wastes

(2) Plants processing non-photographic wastes

TABLE III-42

Treatment Processes Utilized by the
Secondary Silver Industry (46 plants)

| Treatment Processes | Direct Dischargers | Indirect Dischargers | Zero Dischargers | Total Industry |
|---|---|---|---|---|
| Number of Plants | 7 | 17 | 22 | 46 |
| Ammonia | 0 | 1 | 0 | 1 |
| Caustic | 1 | 4 | 2 | 7 |
| Lime | 3 | 4 | 2 | 9 |
| Polymer | 2 | 1 | 1 | 4 |
| Cooling | 1 | 0 | 0 | 1 |
| Evaporation | 1 | 0 | 3 | 4 |
| Filtration | 0 | 2 | 1 | 3 |
| Sedimentation | 2 | 0 | 3 | 5 |

TABLE III-43

Production Processes Utilized by the
Secondary Silver Industry (46 plants)

| Production Process | Number of Plants With Process |
|---|---|
| Leach/Strip Supernatent | 24 |
| Leach/Strip Air Control | 19 |
| Precipitation/Filter Supernatent | 23 |
| Precipitation Air Control | 23 |
| Furnace | 34 |
| Electrolyte | 18 |
| Casting | 12 |

TABLE III-44

Initial Operating Year (Range) Summary of Plants
in the Primary Tungsten Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1973 0-5 | 1972-1968 6-10 | 1967-1958 11-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1928 41-50 | 1927-1918 51-60 | Before 1918 60 + | Insuff. Data | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Direct | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 5 |
| Indirect | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 4 |
| Zero | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | 1 | 1 | 0 | 1 | 2 | 2 | 1 | 0 | 2 | 10 |

TABLE III-45

Production Ranges for
the Primary Tungsten Industry

| Production Ranges for 1976 (tons/year) | Number of Plants |
|---|---|
| 0 - 1,000 | 4 |
| 1,001 - 5,000 | 3 |
| 5,000 + | 2 |
| Insufficient Data | 1 |

TABLE III-46

Treatment Level Summary
for the Primary Tungsten Industry

| Discharge Type | No Treatment | Level A* | Level B* | Total |
|---|---|---|---|---|
| Direct | 3 | 0 | 2 | 5 |
| Indirect | 2 | 1 | 1 | 4 |
| Zero | 0 | 0 | 1 | 1 |
| | 5 | 1 | 4 | 10 |

*The levels of treatment have been defined as:
Level A-Physical separation of solids, cooling or neutralization only.
Level B-Removal of dissolved metals by chemical coagulation and settling or filtration.

TABLE III-47

Production Processes Utilized by the
Primary Tungsten Industry (10 plants)

| Production Process | Number of Plants With Process |
|---|---|
| Fusion of Concentrate | 2 |
| Leaching | 4 |
| Precipitation | 3 |
| Filtration | 2 |
| APT Drying | 6 |
| Reduction | 9 |

TABLE III-48

Treatment Processes Utilized by the
Primary Tungsten Industry (10 plants)

| Treatment Processes | Direct Dischargers | Indirect Dischargers | Zero Dischargers | Total Industry |
|---|---|---|---|---|
| Number of Plants | 6 | 3 | 1 | 10 |
| Ammonia Stripping | 2 | 0 | 1 | 3 |
| Lime | 3 | 1 | 0 | 4 |
| Polymer | 1 | 1 | 0 | 2 |
| Cooling | 1 | 0 | 0 | 1 |
| Evaporation | 0 | 1 | 0 | 1 |
| Sedimentation | 1 | 2 | 0 | 3 |
| No Treatment | 4 | 1 | 1 | 6 |

TABLE III-49

Initial Operating Year (Range) Summary of Plants
in the Primary Zinc Industry by Discharge Type

| Type of Plant Discharge | Plant Age Range (Years) 1978-1958 0-20 | 1957-1948 21-30 | 1947-1938 31-40 | 1937-1928 41-50 | 1928-1918 51-60 | 1917-1903 60-75 | 1902-1878 76-100 | Before 1978 100 + | Insuff. Data | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Direct | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 5 |
| Indirect | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Zero | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 2 | 6 |

TABLE III-50

Production Ranges for the Processing Plants of the Primary Zinc Industry

| Production Ranges for 1976 (tons/year) | No. of Plants |
|---|---|
| Less than 100,000 | 1 |
| 100,001 - 200,000 | 4 |
| More than 200,000 | 1 |
| Total No. of Plants in Survey | 6 |

TABLE III-51

Treatment Level Summary for the Primary Zinc Industry

| Discharge Type | Treatment Level* | | | | |
|---|---|---|---|---|---|
| | No Treatment | Level A | Level B | Level C | Total |
| Direct | 0 | 0 | 4 | 1 | 5 |
| Indirect | 0 | 0 | 1 | 0 | 1 |
| Zero | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 5 | 1 | 6 |

* The levels of treatment have been defined as:
Level A - Physical separation of solids, cooling or neutralization only.
Level B - Removal of dissolved metals by chemical coagulation and settling or filtration.
Level C - Secondary level processes followed by other treatment processes, including solar evaporation ponds and lagoons.

TABLE III-52

Treatment Processes Utilized by the Primary Zinc Industry (6 plants)

| Treatment Processes | Direct Dischargers | Indirect Dischargers | Total Industry |
|---|---|---|---|
| Number of Plants | 5 | 1 | 6 |
| Caustic | 1 | 0 | 1 |
| Lime | 5 | 1 | 6 |
| Polymer | 3 | 1 | 4 |
| Cooling | 5 | 1 | 6 |
| Evaporation | 2 | 0 | 2 |
| Sedimentation | 5 | 1 | 6 |

TABLE III-53

Production Processes Utilized by the Primary Zinc Industry (6 plants)

| Production Process | Number of Plants With Process |
|---|---|
| Preleach | 1 |
| Roaster | 6 |
| Sulfuric Acid | 6 |
| Sinter | 2 |
| Retorts | 2 |
| Leaching | 4 |
| Purification | 4 |
| Electrolysis | 4 |
| Cadmium Plant | 6 |
| Casting | 6 |

# SECTION IV

# INDUSTRY SUBCATEGORIZATION

## BACKGROUND

Subcategorization involves the identification and evaluation of factors that may affect the applicability of uniform and equitable regulations, and may require different limitations for different subcategories.

The nonferrous metals industry has been subcategorized in a number of development documents previously published by the Environmental Protection Agency (3 through 8). BAT and BPT effluent guidelines have been promulgated for the following subcategories:

1. Bauxite refining
2. Primary aluminum
3. Secondary aluminum
4. Primary copper smelting
5. Primary copper refining
6. Secondary copper
7. Primary lead
8. Primary zinc

Since the purpose of this report is to review the existing guidelines and suggest alternative technologies which may serve as the technical basis for BAT regulations, this investigation considered existing and potential subcategories of the nonferrous metals industry. The regulations for bauxite refining were not considered because the BPT limitations require zero discharge of process wastewater pollutants.

Based on the findings detailed in this section, the nonferrous metals industry subcategories and secondary divisions recommended for new or updated regulations are as follows:

Primary aluminum
- (1) potline air scrubbing
- (2) potroom air scrubbing
- (3) contact cooling water
- (4) cryolite recovery
- (5) paste production air scrubbing
- (6) anode bake plant air scrubbing
- (7) cathode making

Secondary aluminum
- (1) contact cooling water
- (2) fume scrubbing

(3) residue milling
Primary columbium-tantalum (ore concentrates, slags or scrap to purified salts)
Primary columbium-tantalum (purified salts to metals (reduction))
Primary copper smelting
Primary copper refining
Secondary copper
(1) metal cooling
(2) slag granulation
(3) slag milling
(4) scrubbers
(5) electrolytic refining
Primary lead smelting
Primary lead refining
Secondary lead-antimony smelting
(1) battery cracking
(2) furnace scrubbers
(a) blast or reverberatory furnaces
(b) kettle furnaces
(3) casting
Secondary silver processing photographic wastes
(1) film silver stripping and precipitation
(2) solution silver recovery
(3) furnace scrubbers
(4) electrolysis
(5) casting
Secondary silver processing non-photographic wastes
(1) leaching/precipitation/filtration
(2) leaching/precipitation/filtration scrubbers
(3) furnace scrubbers
(4) electrolysis
(5) casting
Primary tungsten (ore concentrates to ammonium paratungstate (APT)
Primary tungsten (APT to metallic tungsten)
Primary zinc
(1) Electrolytic
(2) Pyrolytic
Metallurgical acid plants

The preceding subcategorization was based on the combined effect of raw materials, production processes and wastewater characteristics. The raw materials used greatly influence the production process employed and these, in turn, influence the resulting wastewater characteristics.

FACTORS CONSIDERED

The following factors were examined as possible criteria for subcategorizing the nonferrous metals industry:

1. Metal products, co-products, and by-products
2. Product form
3. Raw materials
4. Production process
5. Plant location
6. Plant age
7. Plant size
8. Wastewater volume and characteristics
9. Applicable waste treatment technology
10. Air pollution control methods
11. Meteorological conditions

Metal Products, Co-products, and By-products

The metal products, co-products, and by-products factor is of primary importance in identifying subcategories. Each metal requires its own raw materials and production processes, which affect wastewater volume and characteristics, air pollution control, and waste treatment methodologies. The production of a few metals was found to be inherently allied to the co-production of another metal (i.e., columbium and tantalum). Thus, many co-products are considered in a single subcategory.

In other cases, however, by-product metals were found to be produced in low volume compared with the principal metals, and the by-products' contributions to the overall wastewater volume and characteristics are minimal or virtually impossible to separate from the main product. The following metals fall within this group, and will be covered under the regulations proposed for the principal metal with which they are associated:

1. Primary selenium and tellurium, of primary copper
2. Primary cadmium of primary zinc
3. Primary antimony of primary lead
4. Primary bismuth of primary lead
5. Primary silver of primary copper, lead, and zinc

Product Type

Subcategorization on the basis of the metal product (e.g., copper, lead), includes consideration of the type and form of product produced. For example, some intermediate products, (i.e., anode copper or APT) have entirely different production processes than the processes associated with producing a finished product from the intermediate product. Such differences in products may be sufficient to justify subcategorization since the

different processes associated with producing each product will have different effects on wastewater volume and characteristics.

Raw Materials

In many metal subcategories, the raw materials used (ore concentrates or scrap) determine the process, the reagents used, and the wastewater characteristics. Raw materials are significant in differentiating between primary and secondary producers.

Production Processes

The production processes for each metal are unique and are affected by the raw materials used and the type of end product, while the processes used may affect the volume, characteristics, and treatment of the resulting wastewater.

Plant Location

Most plants in the industry are located near raw materials sources, transportation centers, markets, and sources of inexpensive energy. While large primary copper, lead and zinc producers are mainly found near Midwestern and Western ores and are remote from population centers, plentiful and inexpensive electricity in the Pacific Northwest and Tennessee Valley is important for primary aluminum producers and thus becomes an important locational factor. Secondary producers, on the other hand, are generally located in or near large metropolitan areas. Therefore, primary producers often have more land available for treatment systems than secondary producers who are generally located in cramped urban areas. Plant location may also be significant in that evaporation ponds can be used only in areas where solar evaporation is feasible and where there is sufficient land available for use for this type of waste treatment.

Plant Age

Plants within a given subcategory may have significantly different ages. To remain competitive, plants must be constantly modernized. Modernization of production processes and air pollution abatement equipment produces analogous wastes among all plants producing a given metal, despite the original plant start-up date. Plant age, therefore, is not a factor for subcategorizing.

Plant Size

The size of a plant generally does not affect either the production methods or the wastewater characteristics. The type

of production process is a better basis for subcategorizing. Generally, more water is used at larger plants. However, when water use and discharge are calculated as gallons per unit of production, no real differences can be ascertained relative to size of plant.

Wastewater Volume and Characteristics

The volumes and characteristics of the wastewater generated are directly related to raw materials, production processes, type of air pollution control employed, plant size, and type of operation, and are thus significant in supporting the categorization.

Applicable Waste Treatment Technology

The waste treatment methods in use throughout a given industry vary. Treatment methods are a function of wastewater characteristics and required discharge quality. The treated wastewater may be discharged to a surface stream or to a POTW or may be recycled to the production process. Direct or indirect discharge or recycle may require different levels of treatment. The treatment methods are chosen primarily on wastewater characteristics and thus do not provide an independent basis for subcategorization.

Air Pollution Control Methods

Many facilities use wet scrubbers to control emissions which influence wastewater characteristics. In some cases, the type of air pollution control equipment used provides a basis for individual waste stream limitations, in that if wet air pollution control is used, an allowance may be necessary for that waste stream, while a plant using dry systems should not be given the benefit of that allowance.

Meteorological Conditions

Climate and precipitation may affect treatment technology in that solar evaporation is feasible in arid areas. These factors cannot be used for subcategorization because few plants in a given subcategory are located in areas having similar meteorological conditions; and because plants from different subcategories having identical meteorological conditions often have different waste characteristics.

Wastewater Generation and Use

Subcategorization of nonferrous metals plants on the basis of the entire plant's wastewater generation is not always the most

appropriate approach, because a given plant may have one of several combinations of waste streams. A more useful approach for the purpose of developing effluent limitations is to deal with the wastewater streams themselves. These include: 1) air scrubbing waste streams, 2) contact cooling water, 3) electrolytic wastes, 4) slag granulation wastes, 5) scrap preparation wastes (for example, from wet residue milling in secondary aluminum and from battery cracking in secondary lead), 6) wastewater from hydrometallurgical processes (as in tungsten and columbium-tantalum), and others. Each stream has an associated unit waste loading of pollutants per pound of product produced or scrap processed. Each may also be associated with an appropriate effluent limitation.

## SUBCATEGORY DESCRIPTION AND SELECTION RATIONALE

### Aluminum

Aluminum is produced from both primary and secondary materials in the United States with widely divergent production processes and wastes. Consequently, the industry is divided into primary and secondary aluminum subcategories.

Primary Aluminum. Alumina is the basic raw material and the Hall-Heroult electrolytic reduction process is used at all primary aluminum plants. Both prebake and Soderberg anode potlines may use either dry air pollution control systems or wet scrubbers. Since 1973, many aluminum plants which formerly used wet scrubbers for potline air pollution control have converted to dry scrubbing. All plants with potroom (secondary) air pollution controls use some type of wet system. Wastewater characteristics and volume are dependent on the type of air pollution control method used, i.e., dry or wet scrubbing.

Other processes used at aluminum reduction plants which use water are:

Paste making. Most plants produce all or most of the anode paste used for anodes. Some of these use wet scrubbers to control the fumes and dust from this process.

Anode baking. Prebaked anodes are used in over half the plants. They are reported to be more energy-efficient than Soderberg anodes, as well as being easier to hood effectively for air pollution control. Some of the plants which bake anodes use wet scrubbers to control the offgases.

Refining and degassing. Relatively few primary aluminum plants use wet scrubbers for refining or degassing. Refining or degassing also takes place at aluminum forming plants, and for

that reason, will be considered under the aluminum forming category which is presently under study.

Casting. Contact cooling water is used for cooling the molten aluminum after it is cast. Some plants use direct chill (DC) casting, wherein water is sprayed on the partially solidified ingot and used for complete quenching of the ingot. Some plants use water to cast pigs and sows. Because of the differences between these types of casting, these will be considered separately. The only continuous casting found was rod casting, using Properzi mills, and this will be covered as part of the aluminum forming category.

Cryolite recovery, usually to recover cryolite from worn cathodes, is also used to recover cryolite from potline scrubbing wastewater.

Cathodes or potliners are usually made from purchased carbon blocks, with paste rammed between the blocks to form a solid surface. Only four plants reported any water use associated with cathode making, and all but one had no discharge from this source.

The uniformity of raw materials, products, and process found in the primary aluminum industry support the identification of a single subcategory. A more useful approach for the purpose of developing effluent limitations is to deal with the wastewater streams themselves. These include: potline air scrubbing, potroom air scrubbing, contact cooling water, cryolite recovery, paste plant air scrubbing, anode bake plant air scrubbing and cathode making.

Secondary Aluminum. Aluminum scrap and aluminum-containing dross are the raw materials used by the secondary aluminum industry. Presorted scrap undergoes various treatment steps before smelting which depend on the type or condition of the materials and the desired end products. The smelting steps are common to all plants except for demagging. The typical end-product of secondary aluminum smelters is an aluminum-base alloy suitable for casting engine blocks, structural members, and similar products.

The raw materials used by the secondary aluminum industry may be grouped into solids (clippings and forgings, borings and turnings, and old castings) and residues. Since nearly all smelters use various grades of scrap at one time or another, the type of scrap cannot be used as a basis for subcategorizing.

Some plants do not remove magnesium, while others demag by adding chlorine or aluminum fluoride. These different demagging

practices greatly affect the waste characteristics. Chlorine addition results in volatile metal chlorides which are soluble in water. The metal fluorides formed by adding aluminum fluoride are sparingly volatile and only slightly soluble in water. Wet scrubbing may be practiced with both types of demagging and the resulting scrubber water is usually treated by pH adjustment and settling. Twenty-three plants use chlorine during demagging, but only 13 discharge fume scrubber water from the plant. On the other hand, 12 plants were found to use aluminum fluoride for demagging, but none of them discharged water from fume-control operations.

If molten aluminum is not shipped, the final process step of the secondary aluminum industry is casting. Cooling the final aluminum shapes and forms varies from plant to plant and with the product, and may involve air cooling, and contact or noncontact cooling water. Contact cooling water is generally recycled, so there are only small differences in the magnitude of the waste generated by differing casting practices.

Three process waste streams can be found at secondary aluminum smelters: dross processing, demagging fume scrubbers, and contact cooling water. Since many combinations involving one to three of these streams are found in the industry, setting effluent limitations according to individual waste streams rather than combinations is recommended.

Columbium-Tantalum

Columbium and tantalum metals are produced from the slags of other primary metal industries, from ore concentrates, or tantalum scrap material.

Columbium and tantalum production entails two distinct operations: the production and purification of salts from ore concentrates and slags, and reduction of salts to produce metals. These two operations may or may not be done at the same plant and, consequently, three types of production facilities are found in the industry: 1) plants processing slags or ore concentrates to produce purified salts; 2) plants reducing the purified salts to produce columbium and tantalum metal; and 3) plants producing both salts and metals. A review of sampling data shows that plants processing slag or concentrate and plants processing salts to metals produce significantly different wastewater volume and characteristics. Since these operations frequently occur at different sites, subcategorization is necessary.

While three types of facilities have been identified above, two subcategories can adequately cover the entire industry for the purpose of regulation. These are the columbium and tantalum

salt-purification and the columbium and tantalum metal-reduction subcategories. Plants that both purify salts and reduce metals would be regulated in both subcategories (i.e., their allowable discharge would be the sum of the individual limitations.

The most significant wastewater sources in columbium and tantalum production are the digestion, solvent extraction, and precipitation processes associated with producing salts from concentrates and slags. The processing requires extensive chemical manipulation using acids, ammonia, and organic solvents, all of which appear in the process effluent. Producing columbium and tantalum metal from purified salts contributes wastewater from the leaching operation which follows reduction and from wet air pollution control devices.

Copper

Copper and copper-based alloys are produced from both primary and secondary materials with significantly different processes and process wastes. The industry is, therefore, divided into primary and secondary copper industries. The primary copper industry is also divided into two major types of operations: smelting, including ore smelting to produce unrefined blister copper and fire refining; and electrolytic refining to produce high-purity copper. Smelting and electrolytic refining operations are generally done at separate installations, but some refineries may be located at smelters. Smelters generally process sulfide ores and usually have acid plants. Metallurgical acid plants are a separate subcategory.

Thus, the primary copper industry is divided into two subcategories: smelting and refining.

The subcategorization of the primary copper industry was primarily based on differences in manufacturing process and the wastes generated. Other factors that were considered, but which did not significantly affect subcategorization were plant size and age. Supporting factors for the subcategorization are raw materials and products produced.

Primary Copper Smelting. The basic raw material for the copper smelting industry is copper-ore concentrate. Copper smelters principally produce blister copper, and the manufacturing processes involve smelting and converting. Roasting may also be done before smelting.

While the concentrates serving as raw materials may vary in composition, the same pollutants are usually generated in the processing stages and subcategorizing on this basis is not warranted. Of the 15 primary copper smelters, seven employ

roasting (four with multiple-hearth furnaces, and three with fluid-bed furnaces). Smelting is predominantly done in reverberatory furnaces, although some smelters use electric furnaces and one operates both types of furnaces at adjacent plants. The converting step is essentially similar throughout the industry.

Primary Copper Refining. Fire-refined copper produced by copper smelters is the raw material used in primary copper refining. Electrolytic refining may be done at the smelter but, more typically, it is done at a separate installation. Fire refining is also done at electrolytic refineries to reprocess anode butts or other very high grade copper.

The primary copper refining subcategory should be considered a single subcategory since electrolytic refining is used by all refineries. Because primary copper refineries frequently recover and refine by-product metals (selenium, tellurium, silver, gold, and platinum), primary refining of these metals at copper refineries is included in this subcategory.

Plant location and meteorological conditions, while factors for selecting a waste treatment method, largely do not affect wastewater production. Treating slimes to recover selenium and tellurium produces small and infrequent discharges that have an insignificant effect on the total waste production. Lead slags are shipped to lead refineries, and silver, gold, and platinum are usually recovered by electrolytic methods in small-scale operations.

Secondary Copper. The basic raw materials of the secondary copper industry are copper and copper-based scrap and residues. The scrap is classified into 44 categories which can be grouped into low, intermediate, and high grades depending on the copper content of the scrap. Brass and slags are examples of low-grade scrap; discarded consumer or industrial items such as auto radiators, faucets, turnings, and countless other copper-alloyed scrap make up the intermediate grade; high grade refers to essentially pure copper items which may have non-metallic contaminants.

A variety of processes are available to convert these varied raw materials into salable products. These include: scrap preparation, melting, fire refining or alloying, and electrolytic refining. The procedures may vary somewhat as dictated by different grades of scrap feed or desired end-products. The principal products are brass and bronze alloys and refined copper; black and/or blister copper may also be produced, but these forms are either held in storage for future refining or sold to other refineries. Important by-products, also sold to

other processors, include slags, zinc oxide from the scrubbers, and white metals (babbitt and lead).

The great variety of raw materials, scrap preparation processes, smelting and refining processes, and products produced make this industry difficult to group into discrete categories. Secondary copper plants, in addition, have built-in flexibilities that allow them to change production according to fluctuations in the metal market. A useful approach for the purpose of developing effluent limitations is to deal with the wastewater streams

(1) metal cooling
(2) slag granulation
(3) slag milling
(4) scrubbers
(5) electrolytic refining

Lead

Lead is produced from both primary and secondary materials in the United States. Since the production processes and wastes are dissimilar, the industry is therefore divided into primary and secondary lead subcategories.

Primary Lead. Primary lead production entails smelting and refining of both domestic and foreign ores. The principal raw materials used are ore concentrates. The material handling and pyrometallurgical processes generate air emissions and wastewaters which require control and treatment.

The rationale for considering the primary lead industry as two subcategories is primarily based on production process and raw materials. The primary lead industry is composed of smelters and refineries. Wastes generated during the refining process are small compared to smelting and this is important for the purposes of subcategorizing. The one primary lead refinery not located on site with a smelter should not be included with the smelter subcategory because it does not produce process wastewaters.

Slag-handling practices vary among primary lead plants, with some plants using slag granulation and others using dry processes. Slag granulation does not produce significant waste loads. If the granulation water is recycled, any need for subcategorizing based on slag-handling practices is eliminated. Certain final refining steps, such as bismuth removal, are done by only a few plants. These final refining steps produce little or no waste and, as a result, subcategorizing is not warranted on this basis. Some plants produce sulfuric acid as a by-product of $SO_2$ removal, while other plants do not operate a sulfuric acid plant. Acid plants are a separate subcategory.

Some primary lead facilities process southeastern Missouri ores and others process other domestic and/or foreign ores. The higher grade Missouri ores require fewer processing steps and, theoretically, less waste production than non-Missouri ores. Wastewater quality and quantity, however, does not differ appreciably from the processing of these different materials, and subcategorizing on the basis of raw materials is not justified.

In summary, the primary lead industry should be treated as two subcategories because substantial differences exist with regard to production processes and raw materials. Primary lead refining is considered separate because process wastewater is not produced, and this plant does not generate any process wastewater. All other plants generate process wastewater. A previous development document (6) also mentioned that the one refinery should be excluded from consideration with the other smelters, or smelters and refineries. For the purpose of regulation, smelting or smelting and refining shall be designated the primary lead smelting subcategory.

Secondary Lead-Antimony. The industry is designated as secondary lead-antimony because antimonial lead is a very common alloy product of secondary lead plants. Waste lead residues, battery storage plates, and various scrap solids comprise the basic raw materials of the secondary lead-antimony industry. These materials undergo various furnace and kettle operations to produce several final products: lead oxide, refined lead, or lead alloys. These products are then used to produce batteries and other products. The principal difference found among plants throughout the industry was whether batteries are cracked on site. In the cracking operation, battery tops are sawed off and the plates and paste removed for processing. Spent electrolyte, saw cooling water and wash water, are major wastewater sources.

Secondary lead-antimony plants are generally located in urban centers where large amounts of land for treatment may not be available. The space requirements of wastewater treatment systems used by the secondary lead-antimony industry, although important, do not affect the subcategorizing because, in general, all the plants have the same problem.

Raw materials are important for the purposes of subcategorizing because of their effects on wastewater production. The principal raw materials are waste batteries. The other lead-antimony raw materials are lead residues and scrap solids. While presmelting treatment of scrap solids and lead residues results in no process wastewater, spent battery electrolyte and battery washing result in significant wastewater generation. There is a constant influx of the electrolyte, which is brought into the plant in the batteries themselves.

Major differences were found between plants which use kettle furnaces with wet scrubbers and those which use blast or reverberatory furnaces. While only two of the seven plants with kettle furnace scrubbers discharged from this source, five of the seven reverb/blast furnace scrubber users discharge water. Additionally, the amount of water used is almost twice as high (per ton of furnace product) for reverb/blast furnace scrubbers as opposed to kettle scrubbers. Based on this difference, the melting operation has been divided into kettle furnace operations and blast or reverberatory operations.

The fourth group under secondary lead is casting. Although eight plants use water for this operation, only three of them discharge.

The operations which produce wastewater are:

a) battery cracking
b) blast or reverberatory furnaces with wet air pollution control
c) kettle furnaces with wet air pollution control
d) casting

Since at the many plants within the secondary lead industry, any or all of these operations may take place, it is appropriate to establish separate effluent limitations for each of these operations.

Secondary Silver

Secondary silver is produced from a variety of sources and by different methods. The secondary silver industry receives scrap silver from a variety of sources, including waste generated by the photographic and silverware industries, industrial alloys, and electrical components. The variability and high commercial value of the raw material usually dictates the necessity for a rather complex and flexible production sequence.

The secondary silver industry is subcategorized into two segments based on raw materials used: processors of silver-rich solutions and photographic film; and processors of solid silver scrap (tableware and jewelry). Hydrometallurgical and pyrometallurgical methods are used to process both types of raw materials; therefore, the basis for subcategorization is not the production process employed but rather the differences in raw waste characteristics resulting from the two types of raw materials.

Hydrometallurgical techniques are used to separate silver from solutions. Silver is precipitated, settled, dried, roasted, and

cast as ingots or Dore plates. Some refineries subsequently produce higher-quality silver by electrolysis. Photographic film is processed in the same way except that the silver is first stripped from the film and solubilized with solvents such as nitric acid and/or organic compounds before precipitation. The waste supernatant high in organics resulting from hydrometallurgical purification must be treated. The wet scrubbers used to control fumes generated in this process also produce wastewater.

Solid-silver scrap refining begins with pyrometallurgical techniques. The high-tenor solid scrap such as sterlingware is melted and reused. Low-tenor scrap (silver-plated items and solders), on the other hand, is smelted in reverberatory and blast furnaces to separate the scrap into lead bullion, copper matte, and slag. The lead bullion is cupelled to form a litharge layer and a silver-rich layer. The litharge layer is returned to the reverberatory furnace while the silver-rich layer is cast into anodes and electrolytically refined. The electrolytic slime often is processed further to recover other precious metals.

The copper matte is ground, roasted, and leached with sulfuric acid to solubilize the silver which is subsequently precipitated onto copper plates. The silver-free solution is treated for copper recovery by evaporation.

The precipitation, sedimentation, and filtration of silver from solutions produce a waste supernatant that must be treated. Wet scrubbers are also used to control the fumes of volatile, odorous, and corrosive chemicals used during hydrometallurgical purification. The solid silver scrap, on the other hand, may be refined without wet air-pollution control devices, but the acid leaching of furnace slag may produce wastewater.

The silver industry is categorized, for the purpose of regulation, into a secondary silver photographic process subcategory and the secondary silver non-photographic process subcategory. Analysis of raw wastewater streams sampled at several representative plants in the industry ascertained a higher concentration of organic priority pollutants in waste streams from the photographic process subcategory than in the non-photographic process subcategory. Differences in the nature of the raw materials and the quality and quantity of the effluent generated justify separating the secondary silver industry into these two subcategories.

The waste streams considered in establishing effluent limitations are:

Photographic

Film silver stripping and precipitation
Solution silver recovery
Furnace scrubbers
Electrolysis
Casting

Non-Photographic

Leaching/precipitation/filtration
Leaching/precipitation/filtration scrubbers
Furnace scrubbers
Electrolysis
Casting

Primary Tungsten

Tungsten is almost exclusively produced from ore concentrates, principally ferberite and scheelite. Processing of tungsten scrap is not considered in this report, nor is the production of tungsten carbides.

Tungsten production entails two distinct operations--ammonium paratungstate (APT) production from ore concentrates, and APT reduction to produce the metal. Principal wastewater sources in producing APT include leaching, washing, and rinsing. The principal metal-production wastewater sources include cooling and air pollution control, mostly by wet scrubbers. These streams are not big contributors of wastewater compared with the wastewater generated in the salt production processes.

These two operations may or may not be done in the same plant and, consequently, three types of production facilities are to be found in the industry: plants processing ore concentrates to produce APT; plants reducing APT to produce tungsten metal; and plants producing both APT and metal.

Sampling at several plants in the industry indicates that the wastewater volume and characteristics produced by APT and metal production are significantly different. Plants processing ore concentrates use a hydrometallurgical process which results in a waste stream that is not generated in the conversion of APT to tungsten metal.

Plant size and operations in the primary tungsten industry are considerably diverse, with the processing sequence being chiefly determined by the desired product. Typically, tungstate is purified from concentrates and converted to tungstic acid by a series of filtration and precipitation reactions. The tungstic

acid is subsequently dissolved in ammonium hydroxide and the solution heated to form the intermediate product known as APT.

APT can either be the final product or it can be processed further to the metal form by conversion to an oxide in a nitrogen-hydrogen atmosphere in an electric furnace. The oxides are subsequently reduced to tungsten metal powder in a high-temperature hydrogen atmosphere.

Two subcategories can adequately cover the entire industry for the purpose of regulation. These subcategories are:

1. Concentrate to APT; and
2. Reducing APT to metal.

Primary Zinc

Zinc is mostly produced from virgin materials. While some secondary zinc plants do exist, all are at zero discharge. Only the primary zinc industry will be considered in this report.

Primary zinc is produced by either electrolytic or pyrolytic processing, both of which require roasting of ore concentrates to remove the sulfur. Other impurities such as cadmium and mercury are at least partially removed from the zinc concentrate by roasting, and cadmium is a by-product at every plant. The offgases from roasting are subjected to conventional $SO_2$ control. The subsequent steps of leaching and electrolysis at the electrolytic plants, or sintering and retorting at the pyrolytic plants, do not produce significant amounts of process wastewaters. The data obtained from sampling wastewater streams at several plants show that little variation in wastewater quality exists between the two types of zinc processors. However, there is a difference between electrolytic and pyrolytic producers in the amount of water used.

The raw materials used, by-products, plant age, raw wastewater characteristics and ancillary operations are all similar at the plants making up the zinc industry. These are thus not a factor for subcategorizing. Since there is a difference in water used and discharged between pyrolytic and electrolytic producers, each type of operation is considered for the purpose of establishing effluent limitations and standards.

Metallurgical Acid Plants

Primary copper, lead and zinc smelters commonly operate by-product sulfuric acid plants. Most of the ores used in these industries are sulfide ores, and the $SO_2$ in the off-gases from the roasting, sintering or smelting operation usually needs to be

removed before they are released to the atmosphere. Although not all plants using sulfide ores operate acid plants, most do. It is expected that all new smelters will have acid plants.

All the acid plants in the nonferrous metals industry were examined for the purpose of subcategorization. Factors considered were: type of acid plant (single or double contact), size of plant, and type of smelter associated with the acid plant (copper, lead or zinc). No significant differences were found between single or double contact acid plants in terms of water use, nor were any significant differences found between copper, lead or zinc acid plants in terms of water use. Based on this analysis, it was determined that for the purpose of subcategorization, all metallurgical acid plants should be considered as a single subcategory. The relatively few DMA plants or plants producing sulfur from off-gases are also included in this subcategory. This subcategory does not cover inorganic chemical acid plants producing sulfuric acid by burning sulfur.

# SECTION V

# WASTE CHARACTERISTICS

The methods used to gather data and report waste characteristics for the nonferrous metals industry, and summaries of those characteristics relative to the subcategories established in Section IV are presented in this section.

Waste characteristics of each subcategory exhibit various process-related and nonprocess-related differences. Process-related factors in waste variability include: raw materials processed, process control measures, and production equipment employed. In some cases, the technology employed by a manufacturer is considered more an art than a science, and process variations have been made according to company experience. Nonprocess-related differences result from addition of wastes other than process waste, such as storm water infiltration, sanitary waste, boiler blowdown, or noncontact cooling water.

## PRIORITY POLLUTANTS

The Clean Water Act of 1977 expanded the spectrum of pollutant parameters for point source discharges to include potentially toxic pollutants. Specifically, 65 classes of compounds originally identified in the Consent Decree in NRDC vs Train, 8 ERC 2120 (D.D.C 1976) are to be considered in establishing effluent limitations.

The 65 classes were selected based on the following criteria:

1. Substances for which there is substantial evidence of carcinogenicity, mutagenicity and/or teratogenicity;

2. Substances structurally similar to the aforementioned compounds or for which there is some evidence of carcinogenicity, mutagenicity, or teratogenicity; and

3. Substances known to have toxic effects on man or aquatic organisms at sufficiently high concentrations and which are present in industrial effluents.

Within the 65 classes, 129 specific elements or compounds were identified for potential regulation as priority pollutants. These include 114 organic compounds, 13 metals, cyanide, and asbestos. A list of all 129 pollutants is provided in Table V-1. Results of field sampling of raw waste and treated effluent for the 129 priority pollutants are also presented in this section.

A discussion of each parameter and its potential impact as a pollutant can be found in Section VI.

Organics

The organic compounds, numbered 1 to 114 in Table V-1, can be subdivided into the following broad classifications:

| | |
|---|---|
| Aliphatics | 36 |
| Aromatics | 59 |
| Pesticides | 19 |

Of these compounds, 33 can be considered volatile, having boiling points less than 150°C, and 69 contain chlorine. The organic priority pollutants pose some unique problems in laboratory analysis and interpretation of the data. They are usually present at much lower concentrations than the metals, some in only fractions of micrograms per liter (µg/l). At these low levels, the organic priority pollutants make only minor contributions to the overall concentration of organics measured by standard BOD, COD, or TOC tests. Elaborate sample collection and handling methods and sophisticated laboratory analytical techniques are necessary for meaningful and reproducible results. The use of blank samples to determine the level of pollutant contamination inherent in sampling and analysis procedures is critical to proper interpretation of the organic priority pollutant data.

Toxic Metals

The 13 priority pollutant metals are:

| | |
|---|---|
| Antimony | (Sb) |
| Arsenic | (As) |
| Beryllium | (Be) |
| Cadmium | (Cd) |
| Chromium | (Cr) |
| Copper | (Cu) |
| Lead | (Pb) |
| Mercury | (Hg) |
| Nickel | (Ni) |
| Selenium | (Se) |
| Silver | (Ag) |
| Thallium | (Tl) |
| Zinc | (Zn) |

The metals are often thought of as a group because of their several common characteristics and behavioral properties, but each has distinctive characteristics that influence its behavior and the effect that it will have on the environment. In addition

to the individual characteristics of a metal acting alone, synergistic or antagonistic effects have been observed between metals that affect toxicity. Metals are not biodegradable and removal mechanisms depend upon physical-chemical processes.

## CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS, CYANIDE AND ASBESTOS

Past studies by the EPA and others have established a list of other pollutant parameters that are useful in characterizing industrial wastewaters. The list includes both conventional and non-conventional pollutants. The conventional pollutants are generally those affected by secondary municipal wastewater treatment. The non-conventional pollutants are not readily affected by municipal treatment schemes.

The conventional pollutants are:

Biochemical Oxygen Demand (BOD)
Chemical Oxygen Demand (COD)
Total Suspended Solids (TSS)
Oil and Grease (O&G)
pH - Acidity and Alkalinity

The non-conventional pollutants are:

Ammonia ($NH_3$)
Fluoride (F)
Total Organic Carbon (TOC)
Total Phenols (4-AAP Method)

These two groups of pollutants will be referred to hereafter as criteria pollutants. Data for cyanide and asbestos, two additional priority pollutants, are presented with the criteria pollutants because they cannot be classified as organics or metals.

Even though the criteria pollutants may be present in nonferrous industry wastewaters, monitoring practices across the industry are, at best, inconsistent. At indirect dischargers, monitoring requirements range from none, the typical case, to very complete programs. The majority of these plants pay for wastewater disposal on the basis of water consumption, and wastewater monitoring is not regularly carried out.

## DATA SOURCES

In order to achieve the best possible characterization of the wastes, all nonferrous metals producers were sent a detailed data collection portfolio requesting information on production

processes, quantity and type of wastewater generated, and on the quality of waste streams in terms of presence or absence of the priority pollutants.

Detailed information was gathered from the completed data collection portfolios and from telephone contacts with plants in the industry. Little factual information was available about the presence of most of the priority pollutants, especially the organics. This lack of data necessitated a field sampling program to provide data to be used to characterize the industry. Samples were analyzed for priority pollutants and criteria pollutants, and the results were tabulated. In addition, some data was obtained from similar sampling programs conducted by other contractors at mine/mill/smelter complexes, and additional sampling data was obtained as a result of EPA regional sampling.

## SAMPLING AND ANALYSIS

Raw waste characteristics for the nonferrous metals industry generally reflect the products and the methods employed to manufacture them. Because there is such a diversity in products, processing, raw materials, and process control, there is a wide range in the characteristics. The variation exists among different streams within each subcategory, as well as among similar streams (such as casting wastewater) in different subcategories. Discharge of nonprocess wastes (sanitary, boiler blowdown, noncontact cooling water, etc.) with process waste streams and other nonprocess-related variables such as raw water quality can contribute to this lack of uniformity.

Processing and raw waste characteristics for each subcategory and the sources of the pollutants specific to each are discussed below.

### Organic Pollutants

Organic priority pollutant data were compiled from the screening and verification phases of this investigation and from sampling programs conducted by other contractors and EPA regions. These pollutants are generally classified for the purpose of laboratory analysis as volatile organics, nonvolatile organics, or cyanide. Nonvolatile organics are further separated as the acid, base/neutral, or pesticide fractions. The results of cyanide analyses are presented with the criteria pollutant data and will not be discussed here.

Blank samples were collected with wastewater samples to determine the level of pollutant contamination inherent in the sampling and testing procedures. Samples to be analyzed for nonvolatile organic priority pollutants were usually composited using an

automatic sampler. Tubing blanks corresponding to these samples were obtained by drawing distilled deionized water through the tubing used in the sampler. During the screening phase, tubing blanks were taken in the field immediately before collecting the first composite sample. During the verification phase, they were collected in the laboratory using a piece of tubing cut from the same roll as that used in the field for sampling. Blanks corresponding to volatile organic samples were obtained in the field during both screening and verification phases.

Samples were taken of intake water during the verification phase. These intake samples were analyzed to determine the levels of organic priority pollutants attributable to intake water. Data for the organic priority pollutants were reviewed both as gross concentrations and net concentrations. Gross concentrations were obtained by subtracting the concentrations found in the analysis blanks from the concentrations present in the wastewater sample. To obtain net concentrations, both blank and intake water concentrations, where available, were subtracted.

The organic priority pollutant data for each of the subcategories of the nonferrous metals industry has been compiled and is presented in tabular form in the following discussions. In one table, the number of times a pollutant was detected within specified concentration ranges is presented. This table is based on gross concentration data which corresponds to either raw or treated wastewater streams. A second table shows the range, mean, and median net concentrations of each organic pollutant detected in the particular subcategory. Once again, raw and treated wastewater data are presented separately. Range, mean, and median concentrations corresponding to the intake water of the plants sampled are shown in a third table. Only the organic priority pollutants that were detected at least once in the subcategory are included in these tables.

Metals and Criteria Pollutants

Data for these pollutant parameters, like the organics, were compiled from the screening and verification phases of this investigation and from similar sampling programs conducted by other contractors. The intake water samples also acted as background blanks for the metals and criteria pollutant parameters. The data are shown in the appropriate tables located in the discussions that follow. The significance of the data will be discussed as it applies to each subcategory.

The metals and criteria pollutants were evaluated by experienced testing laboratories. Techniques described in EPA Standard Methods (70) were employed to analyze for the criteria pollutants. Two methods were used to determine heavy metals

concentrations: flameless atomic adsorption spectrometry (A/A) and inductively coupled argon plasma emission spectrometric analysis (ICAP). The metal concentrations determined by each method were as follows:

| Flameless A/A | ICAP |
|---|---|
| Antimony | Beryllium |
| Arsenic | Cadmium |
| Selenium | Chromium |
| Silver | Copper |
| Thallium | Lead |
| | Nickel |
| | Zinc |

Mercury was analyzed by a special technique -- the manual cold vapor flameless atomic adsorption spectrometry technique.

Samples were also analyzed for asbestos by transmission electron microscopy. Total fiber and chrysotile fiber counts were reported by the testing laboratory. Chrysotile was chosen by the U.S. Environmental Protection Agency (Effluent Guidelines Division) as the screening parameter for asbestos for mining related activities because: (1) its known toxicity when particles are inhaled, (2) its industrial prevalence, (3) its distinguishing selected area electron diffraction (SAED) pattern, and (4) the cumbersome nature of the transmission electron microscopic (TEM) analysis technique limits the identification to one mineral form at the present time due to economics and time constraints.

While the asbestos data vary, the testing laboratory's report (34) indicates that, when the total fiber count (which includes amphibole fibers) is performed in conjunction with a count of chrysotile fibers, a good initial screening parameter is produced. The report recommends re-examining any facility with chrysotile fiber counts greater than $10^8$ fibers/liter because this represents a significant departure from ambient counts of $3 \times 10^6$ fibers/liter in the Great Lakes Basin. The technique used had a threshold of detection of $2.2 \times 10^5$ total fibers/liter.

Only wastewater samples from the plants sampled in the screening phase were analyzed for asbestos. The verification phase wastewater samples were not analyzed for asbestos, mainly because of the difficulty in performing the analysis, the cost involved due to the highly sophisticated apparatus required, and the length of time required to perform each analysis.

## CHARACTERIZATION OF NONFERROUS METAL INDUSTRY WASTEWATER

In the following discussion, wastewater characteristics corresponding to the subcategories in the nonferrous metals industry are presented. The organic priority pollutant data are shown in this section on a subcategory basis, while metals and criteria pollutant data are described for specific wastewater streams.

The final effluent from plants in the nonferrous metals industry typically consists of contributions from both process and nonprocess waste streams. Nonprocess streams that may commingle with process wastes include:

1. Noncontact cooling water
2. Storm water runoff
3. Miscellaneous nonprocess wastes, e.g., sanitary, boiler blowdown, laboratory wastes

Although nonprocess waste streams will not be regulated as part of the nonferrous metals category, their effect on the overall effluent must be considered.

Noncontact cooling water and boiler blowdown frequently contribute significant volumes of wastewater to the final effluent but usually contain negligible concentrations of pollutants. As a result, these streams tend to have a diluting effect when commingled with process wastewater streams. Storm water runoff from nonferrous metals plants may contain pollutants in significant amounts. Waste management techniques such as diking and improved disposal methods for solid wastes result in considerable variability in the characteristics of storm water runoff streams. Laboratory wastes, though considered a nonprocess wastewater stream, may contribute significant amounts of pollutants to the overall effluent. This is particularly true of the organic priority pollutants. Several of these organics are commonly used in laboratory analyses and may enter the wastewater in this stream.

Production processes that are not part of the nonferrous metals industry, such as fabrication and ore concentrating, may also be operated at some plants. Wastewater streams from these processes are usually discharged with metal production streams.

The quantities of raw wastewater are presented in terms of quantity per day ($m^3$/day). The pollutant characteristics of the waters, with the exception of the organic priority pollutants, are presented as concentrations (mg/l). The organic priority pollutant concentrations are presented in µg/l. Quantities of discharge and water use, and criteria pollutant data were acquired from the field sampling program, supplemented by the records of industry treatment plants, Federal and state water

pollution control monitoring reports and the records of publicly owned treatment works (POTWs). Data on organic priority pollutants (other than phenols and cyanide) in effluent discharges were not available from industry records and characterization is based solely on the field sampling program.

In the following tables, the symbol "K" stands for "<", i.e., "K 100" means "< 100". In some of the tables, engineering notation is used. For example, "2.3E6" is the same as "2.3 x $10^6$" or 2,300,000.

Primary Aluminum

The organic priority pollutant data for the primary aluminum industry are presented in Tables V-2, V-3 and V-4.

The concentrations of metal priority pollutants present in waste streams are shown in Table V-5. Results of analysis for criteria pollutants are summarized in Table V-6.

Process wastewater sources in the primary aluminum plants include:

1. Potline air pollution control.
2. Potroom air pollution control.
3. Paste plant air pollution control.
4. Anode bake plant air pollution control.
5. Degassing air pollution control.
6. Cryolite recovery.
7. Contact cooling water.
8. Cathode making

Water use associated with air pollution control varies widely in this industry due to differing in-plant controls and equipment. Both wet and dry methods are currently practiced. Wet air pollution control devices are a major source of wastewater in the industry.

Raw wastewater characteristics of potline air pollution control effluent streams, as shown in Tables V-5 and V-6, are from samples taken at two primary aluminum plants. Typically, waste streams from potline scrubbers or wet electrostatic precipitators contain suspended solids, fluorides and several priority pollutants. Suspended solids result from dust associated with alumina and cryolite addition to the electrolytic cell. Chloride and fluoride salts result from the use of cryolite, a fluoride salt in the cell. Organic pollutants present can be attributed to anode oxidation. In addition, heavy metal impurities in the alumina can be introduced to this waste stream.

As can be seen in Tables V-5 and V-6, potroom air pollution control wastewater streams display characteristics similar to those associated with the potlines, but at reduced concentrations.

Wet air pollution controls on anode bake furnaces generate wastewater in plants utilizing prebaked anodes. Suspended solids, oil and grease, sulfur compounds and fuel combustion products characterize this effluent stream. Fluorides may also be introduced where anode recycle is practiced. A number of organic priority pollutants that have been identified as products of coal-tar distillation are released with anode baking. In plants using prebaked anodes, these organics may be introduced to the bake plant waste stream.

Some aluminum reduction plants degas molten aluminum before casting. Degassing is usually accomplished by bubbling a gas (chlorine, nitrogen, argon, or a combination of these elements) through the melt. When chlorine is used in degassing, wet air pollution controls must be used, and a wastewater stream is produced.

Cryolite recovery is employed by several plants in the processing of spent cathodes or potline scrubbing liquor. As shown in Table V-6, the resultant waste stream is typified by very high levels of cyanide as well as significant amounts of fluoride, suspended solids, and TOC. Although storm water runoff is usually considered a nonprocess waste stream, runoff from cathode storage areas typically contains high concentrations of cyanide and fluoride.

Contact cooling water may be used for casting. The cooling water is frequently recycled but may require a bleed stream to dissipate the buildup of dissolved solids. Heavy metals and oil and grease are usually present in low concentrations.

The data in Tables V-5 and V-6 shows that, when compared to the plant intake water analyses, over half of the raw wastewater parameters are nearly the same or only slightly higher (less than one order of magnitude) than the intake water. Allowing for the intake concentrations, most of the metals at a majority of plants show negligible pickup in the process.

Secondary Aluminum

The organic priority pollutant data are presented in Tables V-7, V-8 and V-9.

The concentrations of metal priority pollutants present in waste streams are shown in Table V-10. Results of analyses for criteria pollutants are summarized in Table V-11.

Sources of process wastewater within the secondary aluminum industry include:

1. Demagging air pollution control.
2. Wet milling of residues.
3. Contact cooling water.

During demagging, chlorine or aluminum fluoride is passed through the melt causing the release of magnesium with heavy fuming. Where wet air pollution controls are utilized, the waste stream will contain significant levels of suspended solids and either chlorides or fluorides, as well as moderate amounts of some heavy metals.

Furnace residues used by the secondary aluminum industry usually require milling and screening. When performed as a wet process, they generate a wastewater stream like the one shown in Table V-10 and V-11. Milling streams contain significant levels of suspended solids (aluminum oxide and hydrated alumina). Drosses also contain aluminum nitride which hydrolyzes in water to yield ammonia, accounting for the high concentrations of ammonia and COD.

Contact cooling water may be used in casting, where it is sprayed onto the ingot molds to solidify the aluminum and allow its ejection from the mold. The production of shot requires rapid quenching of the molten aluminum droplets. The characteristics of raw contact cooling water streams are quite variable, depending on the process employed. Oil and grease and chlorides are usually present along with moderate levels of suspended solids.

In Table V-10, the comparison of the intake water concentrations with those of the wastewater streams indicates that about half of the parameters are present in concentrations markedly less than the concentrations in the wastewater streams. This indicates that large amounts of these parameters are picked up by the water during its use in the processes.

Primary Columbium-Tantalum

The production of columbium and tantalum involves the processing of ore concentrates and slags to obtain columbium and tantalum salts, and the subsequent reduction of those salts into the respective metals. For the purpose of this discussion, wastewater characteristics corresponding to those two processes

will be discussed separately. The effluent of plants that produce columbium and tantalum metals from concentrates and slags consists of waste streams from both manufacturing stages.

The organic priority pollutant data are presented in Tables V-15, V-16 and V-17.

The metals data are presented in Table V-18. Five elements -- antimony, mercury, selenium, silver, and thallium -- all have concentrations in the raw wastewaters that are very nearly the same as in the intake water. The other eight metals are present in substantially larger quantities than in the intake. The processes are mainly responsible for the difference in concentrations.

The criteria pollutant parameter data are presented in Table V-19. As with most of the metals, the waste streams contribute substantial amounts of these parameters, and the concentrations in the intake water do not materially affect the raw wastewater concentrations.

Ore Concentrate to Salt. Process wastewater sources in the production of columbium and tantalum salts from ore concentrates and slags include:

1. Concentrate digestion air pollution control.
2. Gangue solids waste slurry overflow.
3. Raffinate wastewater.
4. Solvent extraction air pollution control.
5. Filtrate from salt precipitation.
6. Precipitate calcining air pollution control.

The first step in the production of salts from concentrates and slags is digestion with hydrofluoric acid. Metals impurities solubilized in the process require removal. Wet scrubber liquor from digestion is strongly acidic, containing suspended solids, fluorides, and some metals. Insoluble gangue materials are removed by filtration. On-site disposal of gangue material is required because it is mildly radioactive. The waste gangue slurry is typically contained in a holding pond. Overflow from these ponds, as shown in Table V-18 and V-19, is very acidic and contains significant levels of metals, fluorides, and suspended solids.

After filtration, the digested solution is generally extracted with an organic solvent such as methyl isobutyl ketone (MIBK). Following the extractions of columbium and tantalum, the raffinate is discharged as a waste stream. As shown in Tables V-18 and V-19, the barren raffinate stream is typically strongly

acidic with high concentrations of organics, fluorides, metals and suspended solids.

After extraction, the laden organic streams are stripped with water to yield purified aqueous solutions of columbium and tantalum. The organic phase is then recycled to extraction. Wet air pollution control equipment associated with this process produces acidic effluent streams containing significant concentrations of fluorides and organic solvents.

Precipitation of pure metal salts from the aqueous phase may be accomplished by ammonia addition to recover columbium or tantalum oxides. The precipitates are then filtered, resulting in a filtrate effluent stream which typically contains very high concentrations of ammonia as well as significant levels of fluoride, various metals, and suspended solids. Ammonia stripping is frequently practiced to recover ammonia from the filtrate prior to discharge. Tantalum may also be recovered as potassium tantalofluoride by precipitation with hydrofluoric acid and potassium chloride or fluoride. The precipitate is filtered, leaving a filtrate effluent stream that may contain high concentrations of potassium, fluorides and chlorides.

Following filtration, the precipitates are usually dried and calcined to yield purified salts. The characteristics of the scrubber waste streams associated with calcination reflect the precipitation process employed. High levels of ammonia are present when ammonia is used as a reagent in the precipitation process.

Salt to Metal. Sources of process wastewater associated with the production of columbium and tantalum metals from their respective salts include:

1. Salt calcination air pollution control.
2. Reduction leachate.
3. Reduction air pollution control.
4. Tantalum sizing.

One of the plants surveyed practices drying, or calcination, of the salt feed stock. Wet scrubbers are required to control air emissions from this process and a wastewater stream results.

Reduction processes vary somewhat in the columbium-tantalum industry. The dominant technique, sodium reduction, uses sodium chloride as a catalyst. Following the reaction, extensive washing with water or acid (nitric or hydrofluoric) is required. Waste streams from reduction operations reflect the processes utilized and the chemical makeup of the original salt. They contain high levels of dissolved solids, including significant

concentrations of fluoride, as well as such compounds as sodium, potassium, chloride, and sulfate. Wet scrubbers are frequently employed to control the reduction process emissions. The resultant discharge is similar to reduction washing streams. The wash water and scrubber water may contain valuable amounts of columbium and tantalum solids. If this is the case, these solids may be recovered by passing the wastewater through a cyclone.

The reduced tantalum metal is sized in water at one of the plants surveyed. Water used for sizing at this facility is not recycled and makes a minor contribution to the total effluent.

Primary Copper

Both smelting and refining are practiced by the primary copper industry. Some plants engage in smelting only, processing concentrates and ores to blister copper. Other plants practice refining only, purifying blister copper received from copper smelters, into refined metal; still others do both. Significant differences in the wastewater characteristics associated with smelting and refining are to be expected. For this reason, effluent streams corresponding to these two processes are discussed separately. Plants engaged in both the smelting and refining of primary copper will have wastewater streams from both operations.

The organic priority pollutant data are shown in Tables V-20, V-21, and V-22.

The field sampling data collected for the priority pollutant metals, phenol and cyanide, and for the criteria parameters are contained in Tables V-23 and V-24. Nearly all the parameters, except thallium and beryllium, are more than two orders of magnitude higher than the concentrations found in the plant intake water. This indicates that, except for these two metals, the process is responsible for high concentrations in the raw wastewater.

Smelting. Process wastewater sources from primary copper smelting include:

1. Acid plant blowdown.
2. Contact cooling.
3. Slag granulation

Most smelters recover sulfur from emissions from smelting, roasting or converting operations either as sulfuric acid or as liquid $SO_2$. Preconditioning of these gases normally utilizes electrostatic precipitators and scrubbing towers which may be operated with a blowdown to prevent the buildup of soluble salts

such as metallic sulfates and chlorides. As shown in Tables V-23 and V-24, acid plant blowdown typically contains very high levels of suspended solids as well as significant concentrations of various metals. In a few instances, wet scrubbing is used to treat smelter and converter offgases without an acid plant. The resultant waste stream can be expected to have very high metals and sulfate levels.

Furnace slag is disposed of by either dumping, a dry process, or granulation. The molten slag may be granulated using high-pressure water jets. Slag granulation wastewater streams are typically high in suspended and dissolved solids and some metals, such as arsenic, lead, zinc and copper. Differences in the impurity of the feed are reflected in the composition of the slag and, to some extent, in the slag granulation wastewater.

The contact casting cooling water used by primary copper smelters is usually recycled with the use of cooling towers or a pond. Blowdown is usually contaminated with solids and small amounts of metals.

Refining. Sources of process wastewater associated with the refining of primary copper include:

1. Waste electrolyte and cathode wash water.
2. Anode wash water.
3. Contact cooling.

Electrolytic refining may result in two principal waste streams: waste electrolyte and cathode and anode wash water. The electrolyte is a dilute solution of sulfuric acid and copper sulfate. Most refineries practice total recycle of the spent electrolyte by treating a bleed stream to control copper and impurity concentrations. Varying degrees of treatment are required due to differences in the purity of the anode copper. Anode impurities, which may include nickel, arsenic, and traces of antimony and bismuth, may be present in the effluent if the spent electrolyte bleed stream is discharged. The rinsing of cathodes after electrolytic refining is usually carried out above the cell and no effluent is generated by this operation. The raw wastewater characteristics of a spent electrolyte stream following electrowinning treatment and a cathode wash stream are shown in Tables V-23 and V-24. They are strongly acidic with high concentrations of suspended solids and several metals.

Contact cooling water is usually recycled, or is reused in another operation. In some cases, a blowdown is discharged. As shown in Tables V-23 and V-24, contact cooling water typically contains only minor amounts of pollutants, except for copper, which may be present in significant concentrations.

Secondary Copper

The organic priority pollutant data are presented in Tables V-25, V-26 and V-27.

The concentrations of metal priority pollutants present in these streams are shown in Table V-28. Results of the analyses of criteria pollutants are summarized in Table V-29.

Process wastewater sources within the secondary copper industry include:

1. Slag milling and classification.
2. Smelting air pollution control.
3. Contact cooling.
4. Electrolyte
5. Slag granulation

When slag is used as a raw material, it is frequently milled and classified prior to smelting. As can be seen in Tables V-28 and V-29, the wastewater generated is typically high in suspended solids, copper, lead, and zinc. Other metals may also be found at significant levels. Since the wastewater streams reflect the composition of the slag being treated, the metal concentrations may vary somewhat.

Most secondary copper smelting operations utilize air pollution control devices. If wet control equipment is used, wastewater may be generated. Smelting air pollution control wastewater is typically acidic and contains significant levels of copper, as well as varying concentrations of other metals. Variation in the composition of this stream is due, in part, to differences in the metallic content of the raw material and the fluxes used.

Only one of the secondary copper plants that practice electrolytic refining discharges process wastewater. The electrolyte, a solution of sulfuric acid and copper sulfate, is usually recycled or sold. When the spent electrolyte is discharged, however, the strongly acidic wastewater contains very high concentrations of copper as well as significant levels of other metals. The characteristics of this stream are shown in Tables V-28 and V-29.

In some plants, the water used in ingot or anode cooling is discharged without recycle. Those contact cooling streams are described in Tables V-28 and V-29, with moderate concentrations of suspended solids and a few metals. Differences in the final product and in the cooling processes utilized will result in minor variations. In cases where contact cooling water is

recycled with a blowdown, the effluent usually contains the same pollutants but at higher concentrations.

Tables V-28 and V-29 show that nearly all of the parameters listed, except antimony and thallium, have raw wastewater concentrations very much greater than the intake concentrations. This indicates that the process is largely responsible for the metals concentrations in the wastewater streams.

Primary Lead

Some primary lead plants engage in smelting only, processing ore concentrates into lead bullion. One plant practices refining only, and still others engage in both smelting and refining. Significant differences in the wastewater characteristics associated with these two processes are to be expected. For this reason, wastewater streams corresponding to smelting and refining are discussed separately. Plants engaged in both the smelting and refining of primary lead will have effluent streams from both operations.

The organic priority pollutant data are shown in Tables V-30 and V-31.

The field sampling data for the priority pollutant metals and the criteria pollutants are presented in Tables V-32 and V-33, respectively. Beryllium, thallium and, to a lesser extent, silver and mercury are present in the raw and treated wastewaters at concentrations nearly the same as those found in the intake. The concentrations in all other parameters listed are much greater than those found in the intake, indicating that large amounts of these parameters are present as a result of the processes.

Smelting. Process wastewater sources in primary lead smelting include:

1. Sintering air pollution control.
2. Acid plant blowdown.
3. Blast furnace air pollution control.
4. Zinc fuming air pollution control.
5. Slag granulation.
6. Dross reverberatory furnace air pollution control.

A major waste stream in primary lead smelting is generated by sintering, which removes sulfur as $SO_2$ and $SO_3$ and also many of the undesirable metallic impurities such as arsenic, antimony and cadmium, in the sinter offgases. The sinter is then sized in preparation for subsequent processing in a blast furnace. The sizing operation produces a considerable amount of dust. Dust

removal and sulfur oxide removal is achieved by air pollution control equipment and conversion to sulfuric acid. Wet emissions control equipment is used at four plants, but only one has a discharge from this source.

Sintering emissions must undergo a series of conditioning treatments before $SO_x$ recovery as sulfuric acid can be accomplished. Process wastewaters described in Tables V-32 and V-33, are typically high in dissolved solids, mostly consisting of sulfates, and metals such as cadmium, lead and zinc. Recycle is commonly practiced, but there may be a blowdown.

The sinter is charged to a blast furnace along with coke and fluxing or slagging additions. Recycled slag, residues, dross, and solids from dust collection equipment may also serve as feed. Blast furnace emission control devices may or may not involve the use of water. Wastewater from wet control equipment is usually recycled with discharge of a blowdown which contains moderate levels of dissolved solids and various metals. A blast furnace scrubber blowdown stream is characterized in Tables V-32 and V-33.

Blast furnace slag is either granulated or processed for zinc recovery in a zinc fuming furnace. Zinc oxide generated in the fuming process is collected as dust particles. One plant has a wastewater associated with the dust collection equipment. After fuming, residual slag is granulated using high-pressure water jets, as is blast furnace slag. Although recycle is practiced, there may be a blowdown.

After slag removal, the lead bullion undergoes drossing to remove copper. Where air pollution control is used, it is usually dry. One plant uses water to cool the gas, but total recycle is achieved. The copper dross is then treated in a reverberatory furnace, where the use of wet air pollution control equipment may result in wastewater.

Refining. Refining lead bullion involves a number of process steps, including softening, hard lead refining, debismuthizing, and refining. Although air pollution control devices are usually required for these operations, dry methods are currently used, except for the use of venturi scrubbers in the hard lead refining process at one plant. This wastewater is reused for slag granulation, resulting in no discharge from this source. In the primary lead industry, metal casting is characteristically accomplished with the use of noncontact cooling water. One plant reported the use of contact cooling water, but there was no discharge from this operation.

Secondary Lead

The principal raw material for the secondary lead industry is scrap batteries. Used batteries are processed or "cracked" to remove the lead before using the lead as a feedstock. One European smelter charges whole batteries to the furnace, however. Some secondary lead plants crack batteries onsite. Other plants purchase battery and other lead-containing scrap that has been processed by scrap dealers; the effluent of these plants consists exclusively of smelting/refining effluent. A description of the wastewater characteristics of secondary lead smelting and refining operations will follow the discussion of the cracking stream.

The organic priority pollutant data are shown in Tables V-34, V-35 and V-36.

The field sampling data for the priority pollutant metals and the criteria pollutants are presented in Tables V-37 and V-38, respectively. The raw wastewater concentrations of all parameters listed except selenium are much greater than those found in the intake water, indicating that these large amounts of parameters are present as a result of the processes.

Battery Cracking. Sources of process wastewater associated with the cracking operation include:

1. Battery acid.
2. Saw cooling.
3. Washdown.

In the cracking operation, the tops of automobile batteries and other lead-acid batteries are sawed off and the contents are dumped. Spent electrolyte (sulfuric acid) drains away. Approximately one-half gallon of acid is produced as waste for each battery cracked. The battery plates and paste are then stored to await smelting. Tables V-37 and V-38 describe battery acid streams sampled in the field study. Battery acid streams are strongly acidic and contain significant levels of suspended solids, as well as several metals including antimony, arsenic, cadmium, lead and zinc. Washdown streams associated with the cracking process frequently make significant contributions to the overall effluent in the secondary lead industry. Representative characteristics of combined battery acid, saw cooling, and washdown streams are shown in Tables V-37 and V-38.

Smelting. Process wastewater sources associated with the smelting and refining of secondary lead include:

1. Blast or reverberatory furnace air pollution control.
2. Kettle air pollution control.
3. Contact cooling.

Following cracking, scrap lead from batteries is smelted along with any other lead-containing scrap. Smelting may involve production of soft lead using reverberatory furnaces and/or hard lead using blast furnaces. Although most plants use dry methods for emission control of these furnaces, some utilize wet methods resulting in wastewater.

Lead is frequently refined further or alloyed with the use of remelt kettles. Air pollution equipment is usually required and wet or dry methods are used. Water is used for air pollution control, but is generally totally recycled. Wastewater characteristics are shown in Tables V-37 and V-38. These streams generally have high concentrations of antimony, cadmium, and nickel.

Metal cooling in the secondary lead industry is usually accomplished using noncontact cooling water, but a few plants use contact cooling water in their casting operations. However, very few plants discharge from this source, since at most plants the water is totally evaporated on the cast product.

Secondary Silver

Silver is recovered from a number of sources including photographic wastes, sterlingware and electrical components. Effluent characteristics are largely dictated by the nature of the raw material used and the processes involved. Significant differences in silver recovery from photographic and non-photographic sources has resulted in subcategorization of the secondary silver industry on this basis, as discussed in Section IV. For this reason, effluent streams associated with the processing of photographic and non-photographic scrap will be described separately. Many plants, however, use both sources of raw material and contributions from each will contribute to the overall effluent.

The organic priority pollutant data are presented in Tables V-39, V-40 and V-41.

The field sampling data for the priority pollutant metals and the criteria pollutants are presented in Tables V-42 and V-43, respectively. All the parameters listed are present in raw and treated wastewater at concentrations much greater than the levels found in the intake water, indicating that these pollutants are a result of the processes employed.

Many secondary silver processors have complete and sophisticated laboratory facilities for testing incoming materials, running pilot tests to determine the treatment recovery process, and conduct quality control analysis.

Photographic. Sources of process wastewater related to the processing of photographic wastes include:

1. Leaching and stripping.
2. Precipitation and filtration.
3. Furnace air pollution control.
4. Electrolysis
5. Contact cooling.

The three major kinds of photographic wastes from which silver is recovered are dry film, sludges, and spent hypo solutions. Photographic film may be chopped into small flakes followed by acid or caustic stripping. Incineration, an alternate method for recovering film silver, will be discussed later. Sludges are also stripped to recover silver but usually require slightly different leaching processes than film. The silver-rich solution is separated for further processing and the waste solids may be landfilled or treated as a wastewater stream. Wastewater from the leaching process and from wet scrubbers associated with leaching will be strongly acidic or caustic, reflecting the kind of leachate used. As can be seen in Tables V-42 and V-43, significant levels of chromium, copper, lead, and zinc are found in this waste stream. A number of organic priority pollutants used in the manufacture of photographic film appear in the leaching wastewater.

After the granulated film or sludge is leached, a variety of chemicals, such as iron, zinc, and soda ash, may be added to precipitate the silver from solution. Processing spent hypo solutions usually begins with such a precipitation step. A series of settling or filtration steps are then used and the silver-free solution is discharged for treatment. A few plants use common wet scrubbers for leaching and precipitation. Wastewater streams associated with precipitation and filtration are similar to leaching waste streams, but may reflect the composition of the chemical additives used.

The filtration cake is roasted to metallic silver and cast. Wet scrubbers are usually used to control furnace emissions.

In some plants, direct incineration of photographic film and sludges is used to recover silver. Scrubbers on these incinerators may generate wastewater streams very high in certain organic priority pollutants.

Two of the sixteen processors of photographic wastes used electrolytic refining after roasting, but neither reported a wastewater associated with the process. Only one plant used contact cooling water for casting silver ingots.

Non-photographic. Process wastewater sources associated with the production of silver from non-photographic scrap include:

1. Leaching and stripping air pollution control.
2. Precipitation and filtration.
3. Furnace air pollution control.
4. Electrolysis
5. Contact cooling.

Non-photographic sources of silver scrap include jewelry, silverware, electrical components, spent catalysts, and silver-bearing solutions. Although processing techniques vary widely, the first step in silver recovery is usually stripping with acid or cyanide solutions. Wet scrubbers are usually used and generate a highly acidic wastewater which may contain significant levels of cyanide (if cyanide is used in the stripping process) as well as other metals. Organic priority pollutants present in leaching waste streams may be attributed to such sources as the decomposition of plastics associated with electrical components.

Chemical additions to the silver-rich solutions cause silver precipitation, typically as silver chloride or nitrate. This is the first step of silver recovery for silver-bearing solutions. Precipitation is usually followed by filtration and the resulting filtrate is discarded as wastewater. These streams are typically acidic and may contain high concentrations of cyanide, as well as significant levels of other metals. Air pollution control is rarely used for precipitation and filtration.

Furnaces melt the cake produced by filtration. Solid scrap may be roasted directly as the first step in processing. In these cases, afterburners may be used to burn combustible material. Wet scrubbers are frequently associated with the furnaces.

Electrolytic refining is used at some plants to further purify the silver. The electrolyte is frequently recycled to the precipitation process described earlier. Spent electrolyte, wash water, and wet scrubber systems may contribute, however, to the final effluent. The wastewater, as shown in Tables V-42 and V-43, contains significant levels of several metals such as cadmium, chromium, copper, lead, nickel and zinc.

Contact cooling water is used by a number of secondary silver plants that process non-photographic wastes.

Primary Tungsten

Tungsten production involves ore processing concentrates to obtain the salt, ammonium paratungstate (APT), and subsequent reduction of APT to metallic tungsten. For the purpose of this

discussion, wastewater characteristics corresponding to these two process stages will be described separately. The effluent of plants that produce metal from ore concentrates will consist of waste streams from both manufacturing stages.

Organic priority pollutant data are presented in Tables V-44, V-45, and V-46.

The field sampling data for the priority pollutant metals and the criteria pollutants are presented in Tables V-47 and V-48, respectively. Only antimony and thallium are present in raw and treated wastewaters at concentrations nearly the same as the levels found in the intake water. The high concentrations of water pollutants relative to the intake indicates that these pollutants are present as a result of the processes employed.

Ore Concentrate to APT. Process wastewater sources from the production of APT from ore concentrates include:

1. Precipitation and filtration.
2. Leaching.
3. APT drying air pollution control.

There are several variations in the production of APT from ore concentrates. Frequently, ground ferberite and scheelite are digested with caustic or other sodium salts to form soluble sodium tungstate in a process known as fusion. Calcium chloride is then added to precipitate calcium tungstate, or synthetic scheelite. The waste solids are settled and filtered and the resultant gangue is landfilled or sold. If molybdenum recovery is feasible, sodium hydrosulfate is used in fusion, precipitating molybdenum trisulfate. From this compound, molybdenum may then be separated and purified. No wastewater streams have been reported to be associated with the fusion process.

Leaching is the next step. In plants that practice fusion, the synthetic scheelite is leached with hydrochloric acid to convert it to tungstic acid. In other plants, scheelite ore concentrates are digested directly with hydrochloric acid. Calcium chloride, and sometimes ferrous chloride, are also precipitated by leaching and must be washed from the tungstic acid after settling or filtration. The filtrate and wastewater streams, as shown in Tables V47 and V-48, reflect the composition of the ore concentrate and the processing steps used prior to leaching. They are typically strongly acidic, very high in chlorides, and may contain significant levels of such metals as arsenic, lead, and zinc as well. Wet scrubbers may also be associated with the leaching process, generating a similar waste stream.

In most cases, the tungstic acid resulting from the leaching process is dissolved in ammonia hydroxide, forming ammonium tungstate. The solids are removed and the solution heated to form APT. Subsequent drying of APT involves the use of wet scrubbers at two plants. The scrubber wastewater contains high concentrations of ammonia and may be stripped to recover the ammonia. One plant converts sodium tungstate directly to ammonium tungstate, using a liquid ion exchange process, and discharges the raffinate following treatment.

APT to Metal. Sources of process wastewater from the production of metallic tungsten from APT include:

1. APT drying air pollution control.
2. APT reduction air pollution control.

Although APT drying is usually associated with the production of APT from ore concentrates, three plants which produce tungsten using APT as a raw material dry the salt before reducing it to metal. The wastewater from the associated wet scrubbers is characteristically high in ammonia. These wastewaters are not stripped for ammonia recovery.

Dried APT is converted to oxides by heating in a nitrogen-hydrogen atmosphere and the oxides are subsequently reduced to tungsten metal powder in a high-temperature hydrogen atmosphere. Wet scrubbers are usually associated with the reduction process. The resultant wastewater contains high concentrations of ammonia.

## Primary Zinc

The organic priority pollutant data are shown in Tables V-49, V-50 and V-51.

The field sampling data for the priority pollutant metals and the criteria pollutants are presented in Tables V-52 and V-53, respectively. Comparing the intake water concentrations with the wastewater streams indicates that all of the parameters are present in markedly larger quantities in the wastewater streams than in the intake water, indicating that large amounts of these elements are picked up by the water during its use in the process.

The following wastewater streams may be associated with the production of primary zinc:

1. Concentrate drying air pollution control.
2. Roasting air pollution control.
3. Acid plant blowdown.
4. Sintering air pollution control.

5. Reduction furnace.
6. Preleaching.
7. Leaching air pollution control.
8. Anode/cathode washing.
9. Contact cooling.

Three primary zinc plants dry the zinc concentrates before they are roasted. Two of these plants use wet scrubbers with a blowdown that contributes to the plant effluent. The sulfur dioxide concentration in this wastewater may be significant.

Roasting at primary zinc plants removes sulfur from the zinc concentrate as sulfur dioxide. Other volatile impurities such as mercury, lead, and cadmium may be partially removed as well. The offgases are sent to an acid plant to recover sulfuric acid. Frequently, the roaster gases are preconditioned using wet air pollution control equipment. As shown in Tables V-52 and V-53, the roasting air pollution control wastewater contains significant concentrations of metals such as lead, arsenic, cadmium, and zinc.

The roasting offgases undergo a series of additional steps at the acid plant before being released to the atmosphere. Impurities such as lead, cadmium, zinc, and mercury are removed by air pollution control devices and appear in the acid plant blowdown. This can be seen in Tables V-52 and V-53, which present the raw waste characteristics of acid plant blowdown. The acid plant blowdown is similar to streams from roaster gas preconditioning, containing high concentrations of a number of metals.

In pyrolytic zinc plants, calcine leaves the roasting furnace and is pelletized and sintered. Dust collection systems associated with the sintering process pick up significant quantities of cadmium and lead. One of the two pyrolytic plants has a wastewater bleed stream associated with sintering air pollution control.

Offgases from the pyrolytic or electrothermic reduction furnace consist principally of metallic zinc vapor and carbon monoxide. By first passing the gases through a condenser, almost all of the zinc vapor is converted to a liquid. One of the pyrolytic plants has a wastewater blowdown from wet scrubbing of the reduction furnace gases. The other uses a baghouse.

One of the four electrolytic zinc reduction plants practices preleaching of ore concentrates with dilute sulfuric acid prior to roasting to remove magnesium and prevent its buildup in the electrolyte. The preleaching waste stream is shown in Tables V-52 and V-53.

Following roasting at electrolytic plants, the calcine is leached with spent electrolyte, a sulfuric acid solution containing residual zinc sulfate, to dissolve zinc and cadmium. Wet scrubbers are used by a few plants to control leaching air emissions and a wastewater may be generated. Zinc dust is then added to the zinc solution to precipitate impurities by displacement; however, no process wastewater streams are associated with purification.

Air pollution devices are typically not required in the electrolytic production operation. Washing of the cathodes and anodes is sometimes practiced, however, which may result in wastewater. The electrolyte itself is usually recycled.

Casting primary zinc usually involves contact cooling water. Air pollution control is sometimes required in casting and one of the six zinc plants utilizes a wet scrubber.

Cadmium by-product recovery is always practiced at primary zinc plants. However, only one plant generates a waste stream associated with cadmium recovery. At this plant, cadmium balls are cast, washed, and rinsed. The rinse water is discharged as an effluent stream.

## POSSIBLE SOURCES OF PRIORITY POLLUTANTS IN THE NONFERROUS METALS INDUSTRY

Information from data collection portfolios and the literature (17, 18, 19) has revealed possible sources of priority pollutants in wastewaters from the nonferrous metals industry. Possible sources of organic priority pollutants are presented below:

1. Plastics
2. Pesticides and algicides
3. Coal or pitch
4. Organic solvents, cleaning compounds
5. Ore flotation compounds
6. Photographic film
7. Heat transfer fluids
8. Metal coatings

Some of these sources may be inherent in the production process, such as pitch used in the aluminum reduction industry. Other sources, such as specific cleaning compounds, may only be used at certain plants.

Possible sources of metal priority pollutants are:

1. Product metal
2. Metal impurities from ore concentrates or scrap

## Plastics

The secondary nonferrous metals industries reclaim metals from materials which may contain plastics, such as copper wire and lead batteries. A number of organic priority pollutants are known to be used in the manufacture of plastics and are listed below (numbers refer to the numerical position in Table V-1):

1. acenaphthene
2. acrolein
3. acrylonitrile
20. 2-chloronaphthalene
29. 1, 1-dichloroethylene
66. bis (2-ethylhexyl) phthalate
67. butylbenzyl phthalate
68. di-n-butyl phthalate
69. di-n-octyl phthalate
70. diethyl phthalate
71. dimethyl phthalate
89. vinyl chloride

## Pesticides and Algicides

Algicides are commonly used in cooling towers and water recycle systems to prevent fouling. One primary aluminum plant reported using pentachlorophenol as an algicide. Runoff may also contain small concentrations of pesticides. The organic priority pollutants possibly used as algicides and pesticides in the nonferrous metals industry are:

1. acenaphthene
6. carbon tetrachloride
8. 1,2,4-trichlorobenzene
9. hexachlorobenzene
15. 1,1,2,2-tetrachloroethane
16. chloroethane
21. 2,4,6-trichlorophenol
23. chloroform
27. 1,4-dichlorobenzene
53. hexachlorocyclopentadiene
55. naphthalene
60. 4,6-dinitro-o-cresol
62. N-nitrosodiphenylamine
64. pentachlorophenol
71. dimethyl phthalate
80. fluorene
90. aldrin
91. dieldrin
92. chlordane
93. 4,4'-DDT
94. 4,4'-DDE
95. 4,4'-DDD
96. alpha-endosulfan
97. beta-endosulfan
98. endosulfan sulfate
99. endrin
100. endrin aldehyde
101. heptachlor
103. alpha-BHC
104. beta-BHC
105. gama-BHC
106. delta-BHC
114. toxaphene

## Coal or Pitch

A number of organic priority pollutants are "coal-tar" compounds, a family of compounds resulting from incomplete distillation of coal. Coal, coke and coal tar (pitch) are used in nonferrous metals pyrolytic or electrothermic processes. Pitch is a major component of carbon anodes and cathodes used in the electrolytic reduction of alumina to aluminum. Anode baking

at primary aluminum plants is believed to release significant quantities of these compound and their presence in wastewater due to scrubbing of air emissions was suspected at eight primary aluminum plants according to the data collection portfolios. Coal tar compounds may also be introduced to the scrubber wastewater of nonferrous metal plants that use electric furnaces with carbonaceous anodes. Coke added to the sintering charge may also be a source of coal tar compounds. The following organic priority pollutants are coal-tar compounds:

1. acenaphthene
34. 2,4-dimethyl phenol
39. fluoranthene
55. naphthalene
72. 1,2-benzanthracene
73. benzo(a) pyrene
74. 3,4-benzofluoranthene
75. 11,12-benzofluoranthene
76. chrysene
77. acenaphthylene
78. anthracene
79. 11,12-benzoperylene
80. fluorene
81. phenanthrene
82. 1,2,5,6-dibenzanthracene
83. indeno (1,2,3,-c,d) pyrene
84. pyrene
87. toluene

Organic Solvents, Cleaning Compounds

Several organic solvents are used in the nonferrous metals industry to chelate metals in solution. Although the solvents (for instance, methyl isobutyl ketone in columbium-tantalum) are not organic priority pollutants, they may be precursors to them. Oil emulsifiers are sometimes added to cooling water circuits and in casting operations. Several priority pollutants are associated with metal cleaning. Some compounds may be associated with metal scrap. Several organic priority pollutants are present in industrial cleaning compounds and may be found in floor washdown streams. Organic priority pollutants that may be used as solvents or cleaning compounds include:

4. benzene
6. carbon tetrachloride
7. chlorobenzene
8. 1,2,4-trichlorobenzene
10. 1,2-dichloroethane
11. 1,1,1-trichloroethane
12. hexachloroethane
13. 1,1-dichloroethane
14. 1,1,2-trichloroethane
15. 1,1,2,2-tetrachloroethane
16. Chloroethane
18. Bis(chloroethyl) ether
20. 2-chloronaphthalene
23. chloroform
25. 1,2-dichlorobenzene
30. 1,2-trans-dichloroethylene
32. 1,2-dichloropropane
38. ethylbenzene
42. bis(2-chloroisopropyl) ester
44. methylene chloride
45. methyl chloride
47. bromoform
54. isophorone
56. nitrobenzene
86. tetrachloroethylene
87. toluene
88. trichloroethylene

Ore Flotation

Certain organic compounds are used to enhance gravity concentration of ores in the primary copper industry and other nonferrous metals mills. Although ore flotation is not part of the nonferrous metals category, ore flotation compounds may be present in the smelter's raw material, especially if it is received in slurry form. 1,2-dichloroethane is reportedly used as a flotation agent.

Photographic Film

Some materials used in the manufacture of photographic film, such as cellulose acetate and various plasticizers, contain organic compounds that have been identified as priority pollutants. This may account for the presence of priority pollutants in the wastewater of secondary silver plants that process photographic film and emulsions. The organic priority pollutants attributable to this source are:

15. 1,1,2,2-tetrachloroethane
20. 2-chloronaphthalene
44. methylene chloride
45. methyl chloride
65. phenol
66. bis(2-ethylhexyl)phthalate
67. butylbenzyl phthalate
68. di-n-butyl phthalate
69. di-n-octyl phthalate
70. diethyl phthalate
71. dimethyl phthalate
89. vinyl chloride

Heat Transfer Fluids

Heat transfer fluids other than water are sometimes used in the nonferrous metals industry. They are used, for example, in pitch handling in the aluminum reduction industry and as electrical insulation fluids in transformers and capacitors. Polychlorinated biphenyls (PCB's), which had frequently been used for these purposes, are now strictly regulated. The manufacture of PCB's has been prohibited and guidelines have been established to control the use and disposal of PCB's in existing transformers and capacitors. Organic priority pollutants that have been used in heat transfer fluids are:

7. chlorobenzene
8. 1,2,4-trichlorobenzene
20. 2-chloronaphthalene
40. 4-chlorophenyl phenyl ether
52. hexachlorobutadiene
107. PCB-1242
108. PCB-1254
109. PCB-1221
110. PCB-1232
111. PCB-1248
112. PCB-1260
113. PCB-1016

Product Metal

At plants which are producing a specific metal, relatively high concentrations of that metal are usually present in the

wastewater. In the primary copper industry, for example, wastewater streams usually contain significant levels of copper.

Metal Impurities from Ore Concentrates

The following subcategories of the nonferrous metals industry use ore concentrates as raw materials:

Primary columbium-tantalum
Primary copper
Primary lead
Primary tungsten
Primary zinc

The metal impurities present in the ore concentrates are usually found in relatively high concentrations in the wastewater of these plants.

TABLE V-1

PRIORITY POLLUTANTS

1. acenaphthene
2. acrolein
3. acrylonitrile
4. benzene
5. benzidine

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6. carbon tetrachloride (tetrachloromethane)
7. chlorobenzene
8. 1,2,4-trichlorobenzene
9. hexachlorobenzene
10. 1,2-dichloroethane

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11. 1,1,1-trichloroethane
12. hexachloroethane
13. 1,1-dichloroethane
14. 1,1,2-trichloroethane
15. 1,1,2,2-tetrachloroethane

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16. chloroethane
17. bis(chloromethyl) ether
18. bis(2-chloroethyl) ether
19. 2-chloroethyl vinyl ether (mixed)
20. 2-chloronaphthalene

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21. 2,4,6-trichlorophenol
22. parachlorometa cresol
23. chloroform (trichloromethane)
24. 2-chlorophenol
25. 1,2-dichlorobenzene

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26. 1,3-dichlorobenzene
27. 1,4-dichlorobenzene
28. 3,3-dichlorobenzidine
29. 1,1-dichloroethylene
30. 1,2-trans-dichloroethylene

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31. 2,4-dichlorophenol
32. 1,2-dichloropropane
33. 1,3-dichloropropylene (1,3,-dichloropropene)
34. 2,4-dimethylphenol
35. 2,4-dinitrotoluene

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36. 2,6-dinitrotoluene
37. 1,2-diphenylhydrazine
38. ethylbenzene
39. fluoranthene
40. 4-chlorophenyl phenyl ether

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41. 4-bromophenyl phenyl ether
42. bis(2-chloroisopropyl) ether
43. bis(2-chloroethoxy) methane
44. methylene chloride (dichloromethane)
45. methyl chloride (chloromethane)

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46. methyl bromide (bromomethane)
47. bromoform (tribromomethane)
48. dichlorobromomethane
49. trichlorofluoromethane
50. dichlorodifluoromethane

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51. chlorodibromomethane
52. hexachlorobutadiene
53. hexachlorocyclopentadiene
54. isophorone
55. naphthalene

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56. nitrobenzene
57. 2-nitrophenol
58. 4-nitrophenol
59. 2,4-dinitrophenol
60. 4,6-dinitro-o-cresol

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61. N-nitrosodimethylamine
62. N-nitrosodiphenylamine
63. N-nitrosodi-n-propylamine
64. pentachlorophenol
65. phenol

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66. bis(2-ethylhexyl) phthalate
67. butyl benzyl phthalate
68. di-n-butyl phthalate
69. di-n-octyl phthalate
70. diethyl phthalate

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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)

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76. chrysene
77. acenaphthylene
78. anthracene
79. 1,12-benzoperylene (benzo(ghi)perylene)
80. fluorene

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81. phenanthrene
82. 1,2,5,6-dibenzanthracene (dibenzo(a,h)anthracene)
83. indeno (1,2,3-cd) pyrene (2,3-o-phenylene pyrene)
84. pyrene
85. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

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86. tetrachloroethylene
87. toluene
88. trichloroethylene
89. vinyl chloride (chloroethylene)
90. aldrin

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91. dieldrin
92. chlordane (technical mixture and metabolites)
93. 4,4'-DDT
94. 4,4'-DDE (p,p'-DDX)
95. 4,4'-DDD (p,p'-TDE)

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96. alpha-endosulfan
97. beta-endosulfan
98. endosulfan sulfate
99. endrin
100. endrin aldehyde

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101. heptachlor
102. heptachlor epoxide
(BHC=hexachlorocyclohexane)
103. alpha-BHC
104. beta-BHC
105. gamma-BHC (lindane)

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106. delta-BHC
(PCB-polychlorinated biphenyls)
107. PCB-1242 (Arochlor 1242)
108. PCB-1254 (Arochlor 1254)
109. PCB-1221 (Arochlor 1221)
110. PCB-1232 (Arochlor 1232)

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111. PCB-1248 (Arochlor 1248)
112. PCB-1260 (Arochlor 1260)
113. PCB-1016 (Arochlor 1016)
114. Toxaphene
115. Antimony

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116. Arsenic
117. Asbestos
118. Beryllium
119. Cadmium
120. Chromium

---

121. Copper
122. Cyanide
123. Lead
124. Mercury
125. Nickel

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126. Selenium
127. Silver
128. Thallium
129. Zinc

TABLE V-2. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Aluminum

| POLLUTANT | RAW WASTE # of Times Analyzed | # of Times Observed (ug/l) * ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 7 | 6 | 1 | | | 9 | 5 | 4 | | |
| 4. benzene | 8 | 7 | 1 | | | 14 | 12 | 2 | | |
| 10. 1,2-dichloroethane | 8 | 8 | | | | 14 | 13 | 1 | | |
| 15. 1,1,2,2-tetrachloroethylene | 8 | 8 | | | | 14 | 14 | | | |
| 23. chloroform | 8 | 8 | | | | 14 | 12 | 1 | 1 | |
| 29. 1,1-dichloroethylene | 8 | 8 | | | | 14 | 13 | | | 1 |
| 35. 2,4-dinitrotoluene | 7 | 7 | | | | 9 | 9 | | | |
| 36. 2,6-dinitrotoluene | 7 | 7 | | | | 9 | 9 | | | |
| 38. ethylbenzene | 8 | 8 | | | | 14 | 13 | 1 | | |
| 39. fluoranthene | 7 | 3 | 1 | 3 | | 9 | 3 | 4 | | |
| 44. methylene chloride | 8 | 7 | 1 | | | 14 | 8 | 2 | 3 | 1 |
| 45. methyl chloride | 8 | 8 | | | | 14 | 14 | | | |
| 54. isophorone | 7 | 7 | | | | 9 | 9 | | | |
| 55. naphthalene | 7 | 6 | 1 | | | 9 | 9 | | | |
| 65. phenol | 6 | 5 | 1 | | | 4 | 4 | | | |
| 66. bis(2-ethylhexyl) phthalate | 7 | 2 | 3 | 2 | | 9 | 7 | 2 | | |
| 67. butyl benzyl phthalate | 7 | 5 | 2 | | | 9 | 9 | | | |
| 68. di-n-butyl phthalate | 7 | 6 | | 1 | | 9 | 6 | 3 | | |
| 69. di-n-octyl phthalate | 7 | 7 | | | | 9 | 8 | 1 | | |
| 70. diethyl phthalate | 7 | 7 | | | | 9 | 9 | | | |
| 71. dimethyl phthalate | 7 | 7 | | | | 9 | 9 | | | |
| 72. 1,2-benzanthracene | 7 | 4 | 2 | 1 | | 9 | 9 | | | |
| 73. benzo(a)pyrene | 7 | 4 | 2 | 1 | | 9 | 8 | 1 | | |
| 74. 3,4-benzofluoranthene | 7 | 6 | | 1 | | 9 | 9 | | | |
| 75. 11,12-benzofluoranthene | 7 | 5 | 1 | 1 | | 9 | 9 | | | |
| 76. chrysene | 7 | 5 | 1 | 1 | | 9 | 9 | | | |

* Gross Concentration - blanks subtracted

TABLE V-2. (Continued) INCIDENCE OF ORGANIC PRIORITY POLUTANTS
Primary Aluminum

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 77. acenaphthylene | 7 | 6 | 1 | | | 9 | 9 | | | |
| 78. anthracene | 7 | 3 | 2 | 2 | | 9 | 7 | 2 | | |
| 79. 1,12-benzoperylene | 7 | 6 | | 1 | | 9 | 9 | | | |
| 80. fluorene | 7 | 6 | 1 | | | 9 | 9 | | | |
| 81. phenanthrene | 7 | 4 | 1 | 2 | | 9 | 7 | 2 | | |
| 82. 1,2,5,6-dibenzanthracene | 7 | 6 | | 1 | | 9 | 9 | | | |
| 83. indeno(1,2,3-cd)pyrene | 7 | 5 | 1 | 1 | | 9 | 9 | | | |
| 84. pyrene | 7 | 3 | 2 | 2 | | 9 | 6 | 3 | | |
| 86. tetrachloroethylene | 8 | 8 | | | | 14 | 13 | 1 | | |
| 87. toluene | 8 | 8 | | | | 14 | 14 | | | |
| 88. trichloroethylene | 8 | 8 | | | | 14 | 13 | | 1 | |
| 90. aldrin | 7 | 7 | | | | 8 | 8 | | | |
| 91. dieldrin | 7 | 7 | | | | 8 | 8 | | | |
| 92. chlordane | 7 | 7 | | | | 8 | 8 | | | |
| 93. 4,4'-DDT | 7 | 7 | | | | 8 | 8 | | | |
| 94. 4,4'-DDE | 7 | 7 | | | | 8 | 8 | | | |
| 97. beta-endosulfan | 7 | 7 | | | | 8 | 8 | | | |
| 100. endrin aldehyde | 7 | 7 | | | | 8 | 8 | | | |
| 101. heptachlor | 7 | 7 | | | | 8 | 8 | | | |
| 102. heptachlor epoxide | 7 | 7 | | | | 8 | 8 | | | |
| 104. beta-BHC | 7 | 7 | | | | 8 | 8 | | | |
| 105. gamma-BHC | 7 | 7 | | | | 8 | 8 | | | |
| 106. delta-BHC | 7 | 7 | | | | 8 | 8 | | | |
| 108. PCB-1254 | 7 | 7 | | | | 8 | 8 | | | |
| 111. PCB-1248 | 7 | 7 | | | | 8 | 8 | | | |

* Gross Concentration - blanks subtracted

TABLE V-3. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Aluminum

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 7 | ND- 50 | 8.4 | | 9 | ND- 13 | 5.0 | |
| 4. benzene | 8 | ND- 6.0 | 0.8 | | 14 | ND- 33 | 4.0 | |
| 10. 1,2-dichloroethane | 8 | ND | | | 14 | ND- 5.5 | 0.4 | |
| 15. 1,1,2,2-tetrachlorethane | 8 | ND | | | 14 | ND- 1.0 | 0.1 | |
| 23. chloroform | 8 | ND- 6.0 | 0.8 | | 14 | ND-320 | 23 | |
| 29. 1,1-dichlorethylene | 8 | ND | | | 14 | ND- 4.1E3 | 290 | |
| 35. 2,4-dinitrotolulene | 7 | ND | | | 9 | ND- 7.0 | 0.9 | |
| 36. 2,6-dinitrotolulene | 7 | ND | | | 9 | ND- 1.0 | 0.1 | |
| 38. ethylbenzene | 8 | ND | | | 14 | ND- 12 | 0.8 | |
| 39. fluoranthene | 7 | ND-320 | 95 | 49 | 9 | ND- 79 | 22 | 11 |
| 44. methylene chloride | 9 | ND- 15 | 3.0 | | 14 | ND- 4.2E3 | 360 | |
| 54. isophorone | 7 | ND- 1.5 | 0.2 | | 9 | ND | | |
| 55. naphthalene | 7 | ND- 20 | 3.0 | | 9 | ND- 1.0 | 0.1 | |
| 65. phenol | 6 | ND- 70 | 12 | | 4 | ND | | |
| 66. bis(2-ethylhexyl)phthalate | 7 | ND-450 | 82 | | 9 | ND-120 | 17 | |
| 67. butyl benzyl phthalate | 7 | ND- 86 | 22 | | 9 | ND- 75 | 9.6 | |
| 68. di-n-butyl phthalate | 7 | ND-120 | 19 | | 9 | ND- 30 | 5.0 | |
| 69. di-n-octyl phthalate | 7 | ND | | | 9 | ND- 13 | 1.8 | |
| 70. diethyl phthalate | 7 | ND- 2.5 | 0.4 | | 9 | ND | | |
| 71. dimethyl phthalate | 7 | ND | | | 9 | ND- 5.0 | 1.0 | |
| 72. 1,2-benzanthracene | 7 | ND-180 | 38 | | 9 | ND- 6.0 | 0.7 | |
| 73. benzo(a)pyrene | 7 | ND-570 | 95 | | 9 | ND- 8.0 | 2.1 | |
| 74. 3,4-benzofluranthene | 7 | ND-260 | 37 | | 9 | ND- 6.0 | 0.7 | |
| 75. 11,12-benzofluoranthene | 7 | ND-210 | 39 | | 9 | ND- 6.0 | 1.1 | |
| 76. chrysene | 7 | ND-230 | 40 | | 9 | ND-140 | 17 | |
| 77. acenaphthylene | 7 | ND- 30 | 5.6 | | 9 | ND- 7.0 | 1.9 | |
| 78. anthracene | 7 | ND-150 | 40 | 8.6 | 9 | ND- 11 | 4.7 | 2.6 |
| 79. 1,12-benzopherylene | 7 | ND-150 | 24 | | 9 | ND- 11 | 0.1 | |
| 80. fluorene | 7 | ND- 50 | 7.4 | | 9 | ND- 1.0 | 0.2 | |
| 81. phenanthrene | 7 | ND-230 | 50 | | 9 | ND- 11 | 44 | |
| 82. 1,2,5,6-dibenzanthracene | 7 | ND-110 | 16 | | 9 | ND | | |

* Net Concentration - source and blanks subtracted
Scientific Notation used, i.e. 4100 = 4.1E3

TABLE V-3. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Aluminum

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 83. indeno(1,2,3-cd)pyrene | 7 | ND-350 | 53 | | 9 | ND- 1.0 | 0.1 | |
| 84. pyrene | 7 | ND-219 | 70 | 39 | 9 | ND- 80 | 20 | 9.0 |
| 86. tetrachloroethylene | 8 | ND | | | 14 | ND- 61.0 | 44 | |
| 87. toluene | 8 | ND- 1.0 | 0.2 | | 14 | ND- 6.8 | 0.5 | |
| 88. trichloroethylene | 8 | ND | | | 14 | ND-120 | 8.5 | |
| 90. aldrin | 7 | ND | | | 8 | ND- 0.1 | | |
| 91. diedrin | 7 | ND | | | 8 | ND- 0.1 | | |
| 92. chlordane | 7 | ND | | | 8 | ND- 0.1 | | |
| 93. 4,4'-DDT | 7 | ND | | | 8 | ND- 0.01 | | |
| 100. endrin aldehyde | 7 | ND | | | 8 | ND- 0.2 | | |
| 101. heptachlor | 7 | ND | | | 8 | ND- 0.2 | | |
| 102. heptachlor epoxide | 7 | ND | | | 8 | ND- 0.2 | | |
| 105. gamma-BHC | 7 | ND- 0.01 | | | 8 | ND- 0.01 | | |
| 106. delta-BHC | 7 | ND | | | 8 | ND- 0.1 | | |
| 108. PCB-1254 | 7 | ND | | | 8 | ND- 0.2 | | |
| 111. PCB-1248 | 7 | ND | | | 8 | ND- 0.4 | | |

* Net Concentration - source and blanks subtracted
Scientific Notation used, i.e. 4100 = 4.1E3

TABLE V-4. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Aluminum

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 1. acenaphthene | 3 | ND- 4.0 | 1.3 | |
| 4. benzene | 6 | ND-80 | 17 | 3.0 |
| 23. chloroform | 6 | ND-39 | 12 | 9.0 |
| 28. 3,3-dichlorobenzidine | 3 | ND- 1.0 | 0.3 | |
| 39. fluoranthene | 3 | ND- 3.0 | 1.3 | 1.0 |
| 44. methylene chloride | 6 | ND-12 | 2.3 | |
| 55. naphthalene | 3 | ND- 2.0 | 0.7 | |
| 66. bis(2-ethylhexyl)phthalate | 3 | 11-33 | 21 | 20 |
| 67. butyl benzyl phthalate | 3 | ND- 9.0 | 3.3 | 1.0 |
| 68. di-n-butyl phthalate | 3 | ND-31 | 10 | |
| 71. dimethyl phthalate | 3 | ND-10 | 3.3 | |
| 72. 1,2-benznathracene | 3 | ND- 2.0 | 0.7 | |
| 73. benzo(a)pyrene | 3 | ND- 2.0 | 0.7 | |
| 75. 11,12-benzofluoranthene | 3 | ND- 3.0 | 0.3 | |
| 76. chrysene | 3 | ND- 8.0 | 3.0 | 1.0 |
| 78. anthracene | 3 | ND-16 | 5.5 | 0.4 |
| 84. pyrene | 3 | ND- 5.0 | 2.0 | 1.0 |
| 86. tetrachloroethylene | 6 | ND- 2.0 | 0.4 | |
| 87. toluene | 6 | ND- 2.0 | 0.6 | |
| 90. aldrin | 3 | ND- 0.03 | | |
| 92. chlordane | 3 | ND- 0.5 | 0.2 | 0.1 |
| 93. 4,4-DDT | 3 | ND- 0.1 | | |
| 94. 4,4-DDE | 3 | ND- 0.1 | | |
| 99. endrin | 3 | ND- 0.2 | 0.1 | |
| 100. endrin aldelhyde | 3 | ND- 0.5 | 0.2 | |
| 101. heptachlor | 3 | ND- 0.1 | | |
| 104. beta-BHC | 3 | ND- 0.5 | 0.2 | |
| 106. delta-BHC | 3 | ND- 0.03 | | |
| 108. PCB-1254 | 3 | ND- 1.7 | 0.7 | 0.4 |
| 111. PCB-1248 | 3 | ND- 1.6 | 0.6 | 0.3 |

TABLE V-5

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Aluminum
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| Plant Intake River Water | A | 19 | - | 30 | <10 | <1.0 | 1.8 | <4.0 | 6.6 | <22 | <2.0 | 42 | <1.0 | <2.0 | <50 | 32 |
| | B | - | - | 100 | <10 | <10 | <20 | <50 | 90 | 300 | 0.10 | 200 | <10 | <20 | <100 | <600 |
| | C | - | - | 100 | <10 | <1.0 | <2.0 | <5.0 | 9.0 | <20 | 0.10 | <5.0 | <10 | <20 | <100 | <60 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Pot Line Air Poll. Cont. (APC) | A | 3.4 | 22 | 450 | <10 | <1.0 | 10 | <4.0 | 26 | <22 | <4.0 | 3.9E3 | <2.0 | <4.0 | <90 | 65 |
| Pot Room Air Poll. Cont. | A | 14 | 86 | 50 | <10 | <1.0 | 2.6 | <4.0 | 18 | <22 | <2.0 | 39 | <1 0 | <2.0 | <1.0 | 55 |
| Pot Line APC; Cryolite Kiln | D | 1.3 | 82 | 770 | 260 | 33 | <200 | 2.2E3 | 77 | 650 | <0.1 | 500 | 450 | <250 | <50 | 540 |
| Paste Plant | A | 0.36 | 2.3 | 30 | <10 | <1.0 | 5.0 | <4.0 | 8.1 | 50 | <2.0 | 140 | <1.0 | <2.0 | <1.0 | 40 |
| Contact Cooling Blowdown | B | 0.22 | 59 | <100 | <10 | <1.0 | <2.0 | 10 | 20 | <20 | <0.10 | <5.0 | <10 | <20 | <100 | <60 |
| Cryolite Recovery; Thickener Underflow | B | 0.057 | 16 | <100 | 610 | 400 | 200 | 600 | 1.0E3 | 5.0E3 | 6.2 | 4.0E3 | 10 | <20 | <100 | 1.0E3 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Pot Line/Room APC; Paste Plant (Lime & Settle) | A | 16 | 100 | 40 | <10 | <1.0 | 6.6 | <4.0 | 6.1 | 59 | <2.0 | 120 | <1.0 | <2.0 | <1.0 | 58 |

TABLE V-5 (Continued)

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Aluminum
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cryolite Recovery (Lime - $CL_2$) | B | 0.37 | 100 | <100 | 50 | 80 | 100 | 200 | 200 | 3.0E3 | 0.1 | 1000 | 10 | 40 | <100 | <600 |
| Cryolite Recovery ($H_2SO_4$ - Mix) | B | 0.32 | 88 | <100 | <10 | <1.0 | 3.0 | 8.0 | 100 | 40 | 0.1 | 40 | <10 | <20 | <100 | <60 |
| Cryolite Recovery; Paste Plant; Anode Cool & Bake Contact Cool; Noncontact Cool (Settle) | D | 1.6 | 100 | 370 | 35 | <8.0 | <80 | <100 | 24 | <260 | 0.2 | 200 | 23 | <100 | <50 | 890 |
| Paste Plant; Bake Plant; Pot Room; Degas; Casting Contact Cool (Lime, NaOH, Settle) | C | 5.8 | - | <100 | <10 | <1.0 | 4.0 | 15.0 | 6.3 | <20 | 0.73 | <5.0 | <10 | <20 | <100 | <60 |
| Pot Line APC; Cryolite Recovery; Degas APC, Anode Paste Plant (Floc-Thicken) + | E | 0.086 | - | <0.5 | 1.3 | 45 | 4 | 100 | 140 | 210 | 21 | 120 | 30 | <2.0 | <1.0 | 56 |
| Casting Contact Cool | E | 9.6 | - | 0.5 | 19 | 1.7 | 2 | 9.3 | 47 | 15 | 1.7 | 40 | 1.5 | 2.0 | 0.5 | 61 |
| Casthouse APC Liquor | E | 0.02 | - | <0.5 | 7.6 | 0.1 | <2.0 | <4.0 | 10 | <10 | 1.9 | 14 | 0.5 | <2.0 | <0.5 | 20 |

Engineering notation used for high concentrations, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-6

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Aluminum
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants* COD | TSS | O & G | NH3 | Nonconventional Pollutants F | TOC | Phenols | Priority Pollutants CN | Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Source Water | E | - | - | - | - | - | - | - | - | <0.001 | <0.01 | - | - |
| Raw Wastewater | | | | | | | | | | | | | |
| Potline Air Poll. Cont. (APC) | A | 3.4 | 22 | - | - | - | - | 2.4 | - | 0.72 | <0.004 | - | - |
| Potroom Air Poll. Cont. | A | 14 | 86 | - | - | - | - | - | - | 0.16 | <0.004 | - | - |
| Potline APC; Cryolite Kiln | D | 1.3 | 82 | 3.40 | 2.3E3 | 3.3 | - | 190 | 150 | 0.13 | 0.024 | 2.5E10 | 5.5E9 |
| Paste Plant | A | 0.36 | 2.3 | - | - | - | - | - | - | 0.10 | <0.004 | - | - |
| Paste Plant | D | 0.15 | 9.5 | - | - | 25 | - | - | - | 0.086 | 0.002 | - | - |
| Contact Cooling Blowdown | B | 0.22 | 59 | 44 | 44 | 4.0 | - | - | 20 | 0.14 | 1.4 | - | - |
| Cryolite Recovery; Thickener Underflow | B | 0.057 | 16 | 27E3 | 54E3 | 5.0 | 120 | 13E3 | 2.0E3 | 0.008 | 130 | - | - |
| Treated Wastewater | | | | | | | | | | | | | |
| Potline/room APC; Paste Plant (Lime + Settle) | A | 16 | 100 | - | - | - | - | - | - | 0.12 | <0.004 | - | - |
| Cryolite Recovery (Lime - $CL_2$) | B | 0.37 | 100 | 810 | 250 | 2.5 | 47 | 950 | 130 | 0.024 | 120 | - | - |
| Cryolite Recovery ($H_2SO_4$ - Mix) | B | 0.32 | 88 | 18 | 220 | 4.0 | 12 | 68 | 16 | 0.0063 | 7.51 | - | - |
| Cryolite Recovery; Paste Plant; Anode Cool + Bake Contact Cool; Noncontact Cool (Settle) | D | 1.6 | 100 | 120 | 80 | 10 | - | 2.4 | 44 | 0.061 | 0.0043 | - | - |

TABLE V-6 (Continued)

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Aluminum
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | NH3 | Non-conventional Pollutants F | TOC | Phenols | Priority Pollutants CN | Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treated Wastewater (Cont.) | | | | | | | | | | | | | |
| Paste Plant; Bake Plant; Pot Room; Degas; Casting Contact Cool (Lime, NaOH, Settle) | C | 5.8 | - | 24 | 18 | 2.5 | - | 8.2 | 8.0 | 0.014 | 0.23 | - | - |
| Pot Line APC; Cryolite Recovery; Degas APC; Anode Paste Plant (Flocculation) | E | 0.086 | - | - | - | - | - | - | - | 0.09 | 82 | - | - |
| + Casting Contact Cool | E | 9.6 | - | 17 | - | - | - | 8.0 | - | 0.005 | 0.54 | - | - |
| Cast House APC Liquor | E | 0.02 | - | - | - | - | - | - | - | <0.001 | 0.14 | - | - |

* Asbestos concentrations are given in fibers/liter.
- Not tested or not detected.

Engineering notation used for high concentrations, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-7. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Aluminum

| POLLUTANT | # of Times Analyzed | RAW WASTE # of Times Observed (ug/l) * ND-10 | 11-100 | 101-1000 | 1000+ | # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000 |
|---|---|---|---|---|---|---|---|---|---|---|
| 4. benzene | 10 | 9 | 1 | | | 11 | 11 | | | |
| 6. carbon tetrachloride | 10 | 9 | 1 | | | 11 | 11 | | | |
| 7. chlorobenzene | 10 | 10 | | | | 11 | 11 | | | |
| 8. 1,2,4-trichlorobenzene | 6 | 6 | | | | 7 | 7 | | | |
| 10. 1,2-dichloroethane | 10 | 10 | | | | 11 | 10 | 1 | | |
| 11. 1,1,1-trichloroethane | 10 | 10 | | | | 11 | 11 | | | |
| 13. 1,1-dichloroethane | 10 | 10 | | | | 11 | 11 | | | |
| 14. 1,1,2-trichloroethane | 10 | 10 | | | | 11 | 10 | 1 | | |
| 15. 1,1,2,2-tetrachloroethane | 10 | 10 | | | | 11 | 11 | | | |
| 23. chloroform | 10 | 4 | 6 | | | 11 | 5 | 4 | 2 | |
| 27. 1,4-dichlorobenzene | 6 | 5 | 1 | | | 7 | 7 | | | |
| 28. 3,3'-dichlorobenzidine | 6 | 6 | | | | 7 | 7 | | | |
| 30. 1,2-trans-dichloroethylene | 10 | 5 | 5 | | | 11 | 9 | 2 | | |
| 38. ethylbenzene | 10 | 10 | | | | 11 | 11 | | | |
| 39. fluoranthene | 6 | 4 | 2 | | | 7 | 7 | | | |
| 44. methylene chloride | 10 | 10 | | | | 11 | 10 | | 1 | |
| 47. bromoform | 10 | 10 | | | | 11 | 10 | 1 | | |
| 48. dichlorobromomethane | 10 | 9 | 1 | | | 11 | 8 | 3 | | |
| 51. chlorodibromomethane | 10 | 10 | | | | 11 | 9 | 2 | | |
| 54. isophorone | 6 | 6 | | | | 7 | 7 | | | |
| 55. napthalene | 6 | 6 | | | | 7 | 7 | | | |
| 66. bis(2-ethylhexyl) phthalate | 6 | 2 | 2 | 1 | 1 | 7 | 1 | 3 | 2 | 1 |
| 67. butyl benzyl phthalate | 6 | 4 | 2 | | | 7 | 7 | | | |
| 68. di-n-butyl phthalate | 6 | 3 | 3 | | | 7 | 4 | 3 | | |
| 69. di-n-octyl phthalate | 6 | 5 | 1 | | | 7 | 6 | | 1 | |

*Gross Concentration - blanks subtracted.

TABLE V-7. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Aluminum

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000 |
|---|---|---|---|---|---|---|---|---|---|---|
| 71. dimethyl phthalate | 6 | 5 | 1 | | | 7 | 7 | | | |
| 73. benzo(a)pyrene | 6 | 5 | 1 | | | 7 | 7 | | | |
| 74. 3,4-benzofluoranthene | 6 | 6 | | | | 7 | 7 | | | |
| 75. 11,12-benzofluoranthene | 6 | 6 | | | | 7 | 7 | | | |
| 76. chrysene | 6 | 5 | | 1 | | 7 | 7 | | | |
| 77. acenaphthylene | 6 | 5 | 1 | | | 7 | 7 | | | |
| 78. anthracene | 6 | 5 | 1 | | | 7 | 7 | | | |
| 79. 1,12-benzoperylene | 6 | 6 | | | | 7 | 7 | | | |
| 81. phenanthrene | 6 | 5 | 1 | | | 7 | 7 | | | |
| 84. pyrene | 6 | 5 | 1 | | | 7 | 7 | | | |
| 86. tetrachloroethylene | 10 | 9 | | 1 | | 11 | 11 | | | |
| 88. trichloroethylene | 10 | 5 | 4 | 1 | | 11 | 11 | | | |
| 92. chlordane | 6 | 6 | | | | 7 | 7 | | | |
| 93. 4,4'-DDT | 6 | 6 | | | | 7 | 7 | | | |
| 94. 4,4'-DDE | 6 | 6 | | | | 7 | 7 | | | |
| 95. 4,4'-DDD | 6 | 6 | | | | 7 | 7 | | | |
| 96. alpha-endosulfan | 6 | 6 | | | | 7 | 7 | | | |
| 99. endrin | 6 | 6 | | | | 7 | 7 | | | |
| 100. endrin aldehyde | 6 | 6 | | | | 7 | 7 | | | |
| 101. heptachlor | 6 | 6 | | | | 7 | 7 | | | |
| 102. heptachlor epoxide | 6 | 6 | | | | 7 | 7 | | | |
| 103. alpha-BHC | 6 | 6 | | | | 7 | 7 | | | |
| 104. beta-BHC | 6 | 6 | | | | 7 | 7 | | | |
| 105. gamma-BHC | 6 | 6 | | | | 7 | 7 | | | |
| 106. delta-BHC | 6 | 6 | | | | 7 | 7 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-8. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Aluminum

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE Range* (ug/l) | RAW WASTE Mean* (ug/l) | RAW WASTE Median* (ug/l) | TREATED WASTE # of Times Analyzed | TREATED WASTE Range* (ug/l) | TREATED WASTE Mean* (ug/l) | TREATED WASTE Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 4. benzene | 10 | ND- 94 | 9.4 | | 11 | ND- 5.0 | 0.7 | |
| 6. carbon tetrachloride | 10 | ND- 10 | 1.0 | | 11 | ND 6.0 | 0.5 | |
| 7. chlorobenzene | 10 | ND | | | 11 | ND- 7.0 | 1.5 | |
| 8. 1,2,4-trichlorobenzene | 6 | ND | | | 7 | ND- 2.0 | 0.3 | |
| 10. 1,2-dichloroethane | 10 | ND- 1.0 | | | 11 | ND- 20 | 2.3 | |
| 11. 1,1,1-trichloroethane | 10 | ND | | | 11 | ND- 5.0 | 0.5 | |
| 13. 1,1-dichloroethane | 10 | ND | | | 11 | ND- 7.0 | 0.6 | |
| 14. 1,1,2-trichloroethane | 10 | ND | | | 11 | ND- 8.5 | 2.3 | |
| 15. 1,1,2,2-tetrachloroethane | 10 | ND | | | 11 | ND- 1.0 | 0.1 | |
| 23. chloroform | 10 | ND- 31 | 3.4 | | 11 | ND- 170 | 32 | |
| 27. 1,4-dichlorobenzene | 6 | ND- 26 | 4.3 | | 7 | ND | | |
| 28. 3,3-dichlorobenzidine | 6 | ND- 2.0 | 0.3 | | 7 | ND | | |
| 30. 1,2-trans-dichloroethylene | 10 | ND- 57 | 19 | 9.5 | 11 | ND- 75 | 9.2 | 1.0 |
| 38. ethylbenzene | 10 | ND | | | 11 | ND- 6.0 | 0.5 | |
| 39. fluorathene | 6 | ND- 12 | 3.8 | | 7 | ND | | |
| 44. methylene chloride | 10 | ND- 93 | 9.3 | | 11 | ND- 200 | 18 | |
| 47. bromoform | 10 | ND | | | 11 | ND- 4.7 | 1.0 | |
| 48. dichlorobromomethane | 10 | ND- 19 | 1.9 | | 11 | ND- 18 | 3.0 | |
| 51. chlorodibromomethane | 10 | ND | | | 11 | ND- 29 | 4.9 | |
| 54. isophorone | 6 | ND- 3.0 | 0.5 | | 7 | ND | | |
| 55. naphthalene | 6 | ND- 1.0 | 0.2 | | 7 | ND- 1.0 | 0.1 | |
| 66. bis(2-ethylhexyl)phthalate | 6 | ND- 2.0E3 | 380 | 46 | 7 | ND- 1.2E3 | 290 | 5.3 |
| 67. butyl benzyl phthalate | 6 | ND- 98 | 19 | | 7 | ND- 2.0 | 0.6 | |
| 68. di-n-butyl phthalate | 6 | ND- 44 | 16 | | 7 | ND- 50 | 13 | |
| 69. di-n-octyl phthalate | 6 | ND- 25 | 4.2 | | 7 | ND- 100 | 15 | |
| 71. dimethyl phthalate | 6 | ND- 56 | 9.5 | | 7 | ND- 3.0 | 0.6 | |
| 73. benzo(a)pyrene | 6 | ND- 12 | 2.0 | | 7 | ND- 1.0 | 0.1 | |
| 74. 3,4-benzofluoranthene | 6 | ND | | | 7 | ND- 2.0 | 0.3 | |
| 75. 11,12-benzofluoranthene | 6 | ND | | | 7 | ND- 2.0 | 0.3 | |
| 76. chrysene | 6 | ND- 190 | 32 | | 7 | ND- 2.5 | 0.4 | |
| 77. acenaphthylene | 6 | ND- 17 | 2.8 | | 7 | ND | | |
| 78. anthracene | 6 | ND- 4.0 | 0.7 | | | | | |

Scientific Notation Used, i.e. 2000 = 2.0E3
*Net Concentration - source and blanks subtracted.

TABLE V-8. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANT
Secondary Aluminum

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE Range* (ug/l) | RAW WASTE Mean* (ug/l) | RAW WASTE Median* (ug/l) | TREATED WASTE # of Times Analyzed | TREATED WASTE Range* (ug/l) | TREATED WASTE Mean* (ug/l) | TREATED WASTE Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 79. 1,12-benzoperylene | 6 | ND | | | 7 | ND- 2.0 | 0.3 | |
| 81. phenanthrene | 6 | ND- 10 | 1.7 | | | | | |
| 84. pyrene | 6 | ND- 24 | 4.5 | | 7 | ND- 1.0 | 0.1 | |
| 86. tetrachloroethylene | 10 | ND- 310 | 32 | | 11 | ND- 4.0 | 0.7 | |
| 88. trichloroethylene | 10 | ND- 530 | 61 | | 11 | ND- 7.0 | 1.0 | |
| 90. aldrin | 6 | ND | | | 7 | ND- 0.1 | | |
| 91. dieldrin | 6 | ND- 0.2 | | | 7 | ND | | |
| 92. chlordane | 6 | ND- 0.3 | 0.1 | | 7 | ND- 0.3 | | |
| 93. 4,4'-DDT | 6 | ND- 0.02 | | | 7 | ND- 0.1 | | |
| 94. 4,4'-DDE | 6 | ND- 0.01 | | | 7 | ND- 0.04 | | |
| 95. 4,4'-DDD | 6 | ND | | | 7 | ND- 0.03 | | |
| 96. alpha endosulfan | 6 | ND | | | 7 | ND- 0.03 | | |
| 99. endrin | 6 | ND- 0.01 | | | 7 | ND- 0.4 | | |
| 100. endrin aldehyde | 6 | ND- 0.4 | 0.1 | | 7 | ND- 0.6 | 0.1 | |
| 101. heptachlor | 6 | ND- 0.4 | 0.1 | | 7 | ND | | |
| 102. heptachlor epoxide | 6 | ND- 0.2 | | | 7 | ND- 0.1 | | |
| 103. alpha-BHC | 6 | ND- 0.1 | | | 7 | ND- 0.2 | | |
| 104. beta-BHC | 6 | ND- 0.4 | | | 7 | ND- 0.1 | | |
| 105. gamma-BHC | 6 | ND- 0.1 | | | 7 | ND- 0.02 | | |
| 108. PCB-1254 | 6 | ND- 0.9 | 0.4 | | 7 | ND- 0.3 | 0.1 | |
| 111. PCB-1248 | 6 | ND- 0.3 | 0.1 | | 7 | ND- 0.3 | | |

*Net Concentration - source and blanks subtracted.

TABLE V-9. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Aluminum

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 4. benzene | 4 | ND-17 | 5.0 | 1.5 |
| 11. 1,1,1-trichloroethane | 4 | ND- 5.0 | 1.3 | |
| 23. chloroform | 4 | 9.0 -38 | 24 | 36 |
| 39. fluoranthene | 4 | ND- 8.0 | 2.0 | |
| 47. bromoform | 4 | ND- 4.0 | 1.0 | |
| 66. bis(2-ethylhexyl)phthalate | 4 | 3.8 -71 | 31 | 25 |
| 68. di-n-butyl phthalate | 4 | ND- 2.0 | 1.3 | 1.5 |
| 69. di-n-octyl phthalate | 4 | ND-11 | 2.8 | |
| 73. benzo(a)pyrene | 4 | ND- 7.0 | 2.3 | 1.0 |
| 76. chrysene | 4 | ND-10 | 2.8 | 0.5 |
| 77. acenaphthylene | 4 | ND- 1.0 | 0.3 | |
| 79. 1,12-benzoperylene | 4 | ND- 5.0 | 1.3 | |
| 80. fluorene | 4 | ND | | |
| 84. pyrene | 4 | ND- 5.0 | 1.3 | |
| 87. toluene | 4 | ND- 3.0 | 0.1 | |
| 92. chlordane | 3 | 0.01- 0.1 | 0.1 | 0.1 |
| 93. 4,4-DDT | 3 | ND- 0.3 | 0.1 | 0.1 |
| 94. 4,4-DDE | 3 | ND- 0.01 | | |
| 96. alpha-endosulfan | 3 | ND- 0.1 | | |
| 101. heptachlor | 3 | 0.06- 0.1 | 0.1 | 0.1 |
| 103. alpha-BHC | 3 | ND- 0.1 | | |
| 104. beta-BHC | 3 | ND- 0.1 | 0.1 | 0.1 |
| 105. gamma-BHC | 3 | ND- 0.01 | | |
| 108. PCB-1254 | 3 | 0.4 - 1.1 | 0.8 | 0.8 |
| 111. PCB-1248 | 3 | 0.1 - 1.0 | 0.7 | 0.7 |

TABLE V-10

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Secondary Aluminum
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| | A | - | - | <100 | <10 | <1.0 | <2.0 | 20 | <6.0 | 20 | 0.4 | <5.0 | <10 | <20 | <100 | 600 |
| Bay Water | B | - | - | <100 | <10 | <1.0 | 2.0 | 9.0 | 20 | <20 | <0.1 | <5.0 | <10 | <20 | <100 | <60 |
| | C | - | - | <100 | <10 | NT | NT | NT | NT | NT | 0.1 | NT | <100 | <20 | <100 | NT |
| City Water | D | - | - | <100 | <10 | <1.0 | 4.0 | 10 | <6.0 | 20 | <0.1 | <5.0 | <10 | <20 | <100 | <60 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Demagging APC | A | 0.1 | 100 | 1.1E3 | 70 | 30 | 90 | 60 | 700 | 1.0E3 | 0.1 | <5.0 | <10 | <20 | <100 | 3.0E3 |
| Demagging APC | E | 0.024 | 100 | 300 | 4.0E3 | 310 | 2.0E3 | 97 | 210 | 2.0E3 | 6.4 | <50 | 200 | <25 | - | 2.0E3 |
| Demagging APC | B | 0.025 | 40 | <100 | <10 | 200 | 500 | <50 | 200 | 2.0E3 | 1.0 | <50 | <10 | <20 | <100 | 3.0E3 |
| Contact Cool (Bosh Tank) | A | 0.005 | 5.0 | <100 | <10 | <1.0 | <2.0 | 30 | 200 | 200 | 6.1 | <5.0 | <10 | <20 | <100 | 700 |
| Contact Cool; Demagging APC | C | 1.8 | 100 | <100 | <10 | 7.0 | 35 | <5.0 | 70 | 65 | 0.2 | <5.0 | <10 | <20 | <100 | 2.0E3 |
| Dross Milling | B | 0.038 | 60 | <100 | <20 | 50 | 400 | 2.0E3 | 10E3 | 8E3 | 0.6 | 1.0E3 | <10 | 70 | 1.0E3 | 8.0E3 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Demagging APC (NaOH + Settle) | D | 0.005 | 100 | <100 | <10 | <7.0 | 120 | 500 | 53 | 410 | 4.8 | 170 | <10 | 20 | <100 | 430 |
| Demagging APC (Soda Ash) | E | 0.024 | 100 | 60 | <2.0 | 170 | 1.0E3 | 76 | 200 | 1.0E3 | 3.5 | <50 | 20 | <25 | - | 10E3 |
| Demagging APC; Dross Milling (NaOH + Settle) | B | 0.022 | 34 | <100 | <10 | 20 | <20 | <50 | <60 | <200 | 0.2 | <200 | <10 | <20 | <100 | <600 |

NT - Insufficient sample, not tested for.

TABLE V-11

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Secondary Aluminum
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants* COD | TSS | O & G | NH3 | Non-conventional Pollutants CL | TOC | Phenols | Priority Pollutants CN | Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | |
| | A | - | - | - | - | - | - | | 37 | - | - | - | - |
| Bay Water | B | - | - | - | - | - | <0.10 | - | - | - | - | - | - |
| | C | - | - | <5.0 | 4.0 | - | - | - | 3.0 | - | - | - | - |
| **Raw Wastewater** | | | | | | | | | | | | | |
| Demagging APC | A | 0.1 | 100 | 14 | 210 | 2.5 | - | 420 | 6 | 0.01 | 0.004 | - | - |
| Demagging APC | E | 0.024 | 100 | 48 | 89 | 98 | <0.10 | 6,000 | 3.0 | 0.025 | <0.001 | 0.75E9 | 58E6 |
| Demagging APC | B | 0.025 | 40 | 50 | 2.1E3 | 7.0 | 0.73 | 3,400 | 9.0 | 0.007 | 0.003 | - | - |
| Contact Cool (Bosh Tank) | A | 0.005 | 5.0 | 180 | 180 | 16 | - | 35 | 28 | 0.007 | 0.005 | - | - |
| Contact Cool; Demagging APC | C | 1.8 | 100 | 14 | 67 | 9.5 | - | - | 7.5 | 0.003 | 0.005 | - | - |
| Dross Milling | B | 0.038 | 60 | 930 | 20E3 | 24 | 240 | - | 220 | 0.011 | 0.011 | - | - |
| **Treated Wastewater** | | | | | | | | | | | | | |
| Demagging APC (NaOH + Settle) | D | 0.005 | 100 | 7.5 | 11 | 5.7 | - | 2,300 | 6.0 | 0.008 | 0.002 | - | - |
| Demagging APC (Soda Ash) | E | 0.024 | 100 | 40 | 1.95E3 | 7.3 | <0.10 | 4,100 | 120 | 0.011 | <0.001 | - | - |
| Demagging APC; Dross Milling (NaOH + Settle) | B | 0.022 | 35 | 54 | 240 | 13 | 16 | 5,500 | 9.0 | 0.02 | 0.004 | - | - |

* Asbestos concentrations are given in fibers/liter.
\- Not tested for or not detected.

Engineering notation used for high concentrations, i.e. 1.3E6 = $1.3 \times 10^6$

TABLE V-15. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Columbium/Tantalum

| POLLUTANT | RAW WASTE # of Times Analyzed | # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 |
|---|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 15 | 14 | 1 | | | 4 | 2 | 2 | |
| 4. benzene | 22 | 20 | 2 | | | 7 | 6 | 1 | |
| 5. benzidine | 15 | 15 | | | | 4 | 4 | | |
| 6. carbon tetrachloride | 22 | 20 | 2 | | | 7 | 5 | 1 | 1 |
| 8. 1,2,4-trichlorobenzene | 15 | 13 | 1 | 1 | | 4 | 2 | 2 | |
| 10. 1,2-dichloroethane | 22 | 16 | 5 | 1 | | 7 | 5 | 2 | |
| 11. 1,1,1-trichloroethane | 22 | 20 | 2 | | | 7 | 7 | | |
| 12. hexachloroethane | 15 | 14 | 1 | | | 4 | 4 | | |
| 14. 1,1,2-trichloroethane | 22 | 20 | 2 | | | 6 | 6 | | |
| 15. 1,1,2,2-tetrachloroethane | 22 | 22 | | | | 7 | 6 | 1 | |
| 20. chloronaphthalene | 15 | 15 | | | | 4 | 4 | | |
| 23. chloroform | 22 | 15 | 6 | 1 | | 7 | 4 | 3 | |
| 29. 1,1-dichloroethylene | 22 | 21 | 1 | | | 7 | 5 | 1 | 1 |
| 30. 1,2-trans-dichloroethylene | 22 | 16 | 3 | 3 | | 7 | 7 | | |
| 35. 2,4-dinitrotolulene | 15 | 15 | | | | 4 | 4 | | |
| 36. 2,6-dinitrotolulene | 15 | 15 | | | | 4 | 4 | | |
| 38. ethylbenzene | 22 | 22 | | | | 7 | 6 | 1 | |
| 39. fluoranthene | 15 | 15 | | | | 4 | 4 | | |
| 44. methylene chloride | 22 | 21 | | | 1 | 7 | 6 | | 1 |
| 47. bromoform | 22 | 21 | 1 | | | 7 | 7 | | |
| 48. dichlorobromomethane | 22 | 21 | 1 | | | 7 | 6 | 1 | |
| 51. chlorodibromomethane | 22 | 19 | 3 | | | 7 | 7 | | |
| 54. isophorone | 15 | 14 | 1 | | | 4 | 4 | | |
| 55. naphthalene | 15 | 14 | 1 | | | 4 | 4 | | |
| 56. nitrobenzene | 15 | 13 | | 2 | | 4 | 4 | | |

*Gross Concentration - blanks subtracted

TABLE V-15. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Columbium/Tantalum

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 64. pentrachlorophenol | 8 | 7 | 1 | | | 2 | 2 | | | |
| 66. bis(2-ethylhexyl) phthalate | 15 | 3 | 4 | 7 | 1 | 4 | 2 | | 2 | |
| 67. butyl benzyl phthalate | 15 | 13 | 2 | | | 4 | 4 | | | |
| 68. di-n-butyl phthalate | 15 | 9 | 5 | | | 4 | 4 | | | |
| 69. di-n-octyl phthalate | 15 | 14 | | 1 | | | 4 | 4 | | |
| 70. diethyl phthalate | 15 | 14 | 1 | | | 4 | 4 | | | |
| 71. dimethyl phthalate | 15 | 13 | 2 | | | 4 | 3 | 1 | | |
| 72. 1,2-benzanthracene | 15 | 15 | | | | 4 | 4 | | | |
| 73. benzo(a)pyrene | 15 | 15 | | | | 4 | 4 | | | |
| 74. 3,4-benzofluoranthene | 15 | 15 | | | | 4 | 4 | | | |
| 75. 11,12-benzofluoranthene | 15 | 15 | | | | 4 | 4 | | | |
| 76. chrysene | 15 | 14 | 1 | | | 4 | 4 | | | |
| 77. acenaphthylene | 15 | 15 | | | | 4 | 4 | | | |
| 78. anthracene | 15 | 15 | | | | 4 | 4 | | | |
| 79. 1,12-benzoperylene | 15 | 15 | | | | 4 | 4 | | | |
| 80. fluorene | 15 | 13 | 2 | | | 4 | 4 | | | |
| 81. phenanthrene | 15 | 15 | | | | 4 | 4 | | | |
| 82. 1,2,5,6-dibenzanthracene | 15 | 15 | | | | 4 | 4 | | | |
| 83. ideno(1,2,3-cd)pyrene | 15 | 15 | | | | 4 | 4 | | | |
| 84. pyrene | 15 | 15 | | | | 4 | 4 | | | |
| 86. tetrachloroethylene | 22 | 21 | 1 | | | 7 | 3 | 2 | 2 | |
| 87. tolulene | 22 | | | | | 7 | 5 | 2 | | |
| 88. trichloroethylene | 22 | 19 | 1 | 2 | | 7 | 4 | 2 | 1 | |
| 90. aldrin | 15 | 15 | | | | 3 | 3 | | | |
| 91. dieldrin | 15 | 15 | | | | 3 | 3 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-15. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANT
Columbium/Tantalum

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 92. chlordane | 15 | 15 | | | | 3 | 3 | | | |
| 93. 4,4'-DDT | 15 | 15 | | | | 3 | 3 | | | |
| 94. 4,4'-DDE | 15 | 15 | | | | 3 | 3 | | | |
| 95. 4,4'-DDD | 15 | 15 | | | | 3 | 3 | | | |
| 96. alpha-endosulfan | 15 | 15 | | | | 3 | 3 | | | |
| 97. beta-endosulfan | 15 | 15 | | | | 3 | 3 | | | |
| 98. endosulfan sulfate | 15 | 15 | | | | 3 | 3 | | | |
| 99. endrin | 15 | 15 | | | | 3 | 3 | | | |
| 100. endrin aldehyde | 15 | 15 | | | | 3 | 3 | | | |
| 101. heptachlor | 15 | 14 | 1 | | | 3 | 3 | | | |
| 102. heptachor epoxide | 15 | 15 | | | | 3 | 3 | | | |
| 103. alpha-BHC | 15 | 15 | | | | 3 | 3 | | | |
| 104. beta-BHC | 15 | 15 | | | | 3 | 3 | | | |
| 105. gamma-BHC | 15 | 15 | | | | 3 | 3 | | | |
| 106. delta-BHC | 15 | 15 | | | | 3 | 3 | | | |
| 108. PCB-1254 | 15 | 14 | 1 | | | 3 | 3 | | | |
| 111. PCB-1248 | 15 | 14 | 1 | | | 3 | 3 | | | |
| 114. toxaphene | 15 | 15 | | | | 3 | 3 | | | |

*Gross Concentration - blanks subtracted

TABLE V-16. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Columbium/Tantalum

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 15 | ND- 17 | 1.1 | | 4 | ND- 16 | 7.4 | 6.9 |
| 4. benzene | 22 | ND- 44 | 4.4 | | 7 | ND- 40 | 6.9 | |
| 6. carbon tetrachloride | 22 | ND- 74 | 5.1 | | 7 | ND-110 | 21 | |
| 7. chlorobenzene | 22 | ND | | | 7 | ND- 65 | 13 | |
| 8. 1,2,4-trichlorobenzene | 15 | ND-260 | 22 | | 4 | ND- 17 | 8.0 | 7.5 |
| 10. 1,2-dichloroethane | 22 | ND-150 | 13 | | 7 | ND- 18 | 5.9 | 3.0 |
| 11. 1,1,1-trichloroethane | 22 | ND- 40 | 2.5 | | 7 | ND | | |
| 12. hexachloroethane | 15 | ND- 23 | 1.5 | | 4 | ND | | |
| 14. 1,1,2-trichloroethane | 22 | ND- 29 | 2.1 | | 7 | ND- 5.0 | | |
| 15. 1,1,2,2-tetrachloroethane | 15 | ND- 6.0 | 0.5 | | 7 | ND- 49 | 7.0 | |
| 20. 2-chloronaphthalene | 15 | ND- 3.0 | 0.3 | | 4 | ND | | |
| 23. chloroform | 22 | ND-140 | 7.8 | | 7 | ND- 47 | 9.0 | |
| 29. 1,1-dichloroethylene | 22 | ND- 22 | 1.4 | | 7 | ND-140 | 21 | |
| 30. 1,2-trans-dichloroethylene | 22 | ND-480 | 49 | | 7 | ND | | |
| 35. 2,4-dinitrotoluene | 15 | ND- 16 | 1.7 | | 4 | ND | | |
| 36. 2,6-dinitrotoluene | 15 | ND- 16 | | | 4 | ND | | |
| 38. ethylbenzene | 22 | ND | | | 7 | ND- 49 | 7.0 | |
| 39. fluoranthene | 15 | ND- 7.2 | 1.1 | | 4 | ND | | |
| 44. methylene chloride | 22 | ND- 88E3 | 4.0E3 | | 7 | ND-600 | 85 | |
| 47. bromoform | 22 | ND- 21 | 1.2 | | 7 | ND | | |
| 48. dichlorobromomethane | 22 | ND- 13 | 0.6 | | 7 | ND- 16 | 2.3 | |
| 51. chlorodibromomethane | 22 | ND- 81 | 5.2 | | 7 | ND- 5.0 | 0.7 | |
| 54. isophorone | 15 | ND- 29 | 2.1 | | 4 | ND | | |
| 55. naphthalene | 15 | ND- 84 | 6.1 | | 4 | ND | | |
| 56. nitrobenzene | 15 | ND-163 | 18 | | 4 | ND | | |
| 64. pentachlorophenol | 8 | ND- 17 | 2.1 | | 2 | ND | | |
| 66. bis(2-ethyhexyl)phthalate | 15 | ND- 1.1E3 | 150 | 22 | 4 | ND- 9.5 | 3.8 | 2.8 |
| 67. butyl benzyl phthalate | 15 | ND- 47 | 6.3 | | 4 | ND | | |
| 68. di-n-butyl phthalate | 15 | ND- 60 | 12 | | 4 | ND- 9.0 | 2.2 | |
| 69. di-n-octyl phthalate | 15 | ND- 95 | 6.6 | | 4 | ND- 2.0 | 0.5 | |

*Net Concentration - source and blanks subtracted.
Scientific Notation Used, i.e. 88,000 = 88E3

TABLE V-16. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Columbium/Tantalum

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 70. diethyl phthalate | 15 | ND- 17 | 1.7 | | 4 | ND- 2.0 | 0.5 | |
| 71. dimethyl phthalate | 15 | ND- 39 | 4.1 | | 4 | ND- 20 | 5.0 | |
| 72. 1,2-benzanthracene | 15 | ND- 1.0 | .1 | | 4 | ND | | |
| 73. benzo(a)pyrene | 15 | ND- 1.0 | .1 | | 4 | ND | | |
| 74. 3,4-benzofluoranthene | 15 | ND | | | 4 | ND- 2.0 | 0.5 | |
| 75. 11,12-benzofluoranthene | 15 | ND | | | 4 | ND- 2.0 | 0.5 | |
| 76. chrysene | 15 | ND- 45 | 3.1 | | 4 | ND | | |
| 77. acenaphthylene | 15 | ND- 2.0 | 0.2 | | 4 | ND- 2.8 | 1.2 | 0.9 |
| 78. anthracene | 15 | ND- 2.0 | 0.3 | | 4 | ND- 12 | 3.8 | 1.5 |
| 79. 1,12-benzoperylene | 15 | ND- 2.0 | 0.2 | | 4 | ND- 1.0 | 0.2 | |
| 80. fluorene | 15 | ND- 20 | 1.3 | | 4 | ND- 69 | 17 | |
| 81. phenanthrene | 15 | ND- 2.0 | 0.3 | | 4 | ND- 12 | 3.8 | 1.5 |
| 82. 1,2,5,6-dibenzanthracene | 15 | ND- 4.0 | 0.3 | | 4 | ND | | |
| 83. indeno(2,3,3-cd)pyrene | 15 | ND- 4.0 | 0.3 | | 4 | ND | | |
| 84. pyrene | 15 | ND- 3.0 | 0.5 | | 4 | ND- 4.9 | 1.4 | 0.4 |
| 86. tetrachloroethylene | 22 | ND- 65 | 3.6 | | 7 | ND-190 | 54 | 10.0 |
| 87. toluene | 22 | ND | | | 7 | ND- 92 | 15 | |
| 88. trichloroethylene | 22 | ND-230 | 21 | | 7 | ND-190 | 32.4 | |
| 90. aldrin | 15 | ND- 4.0 | 0.3 | | 3 | ND- 0.5 | 0.2 | |
| 91. dieldrin | 15 | ND- 0.1 | | | 3 | ND- 0.01 | | |
| 92. chlordane | 15 | ND- 0.8 | 0.1 | | 3 | ND- 1.0 | | |
| 93. 4,4-DDT | 15 | ND- 1.0 | 0.1 | | 3 | ND | | |
| 94. 4,4-DDE | 15 | ND- 0.4 | | | 3 | ND | | |
| 96. alpha-endosulfan | 15 | ND- 0.01 | | | 3 | ND | | |
| 98. endosulfan sulfate | 15 | ND- 0.03 | | | 3 | ND | | |
| 99. endrin | 15 | ND- 5.4 | 0.4 | | 3 | ND- 0.01 | | |
| 100. endrin aldehyde | 15 | ND- 0.2 | | | 3 | ND | | |
| 101. heptachlor | 15 | ND- 0.5 | | | 3 | ND- 0.3 | 0.1 | |
| 102. heptachlor epoxide | 15 | ND- 0.1 | | | 3 | ND | | |
| 103. alpha-BHC | 15 | ND- 0.04 | | | 3 | ND- 0.01 | | |
| 104. beta-BHC | 15 | ND- 4.5 | 0.4 | | 3 | ND- 0.3 | 0.1 | 0.1 |
| 105. gamma-BHC | 15 | ND- 0.03 | | | 3 | ND | | |
| 106. delta-BHC | 15 | ND- 4.0 | 0.3 | | 3 | ND- 0.5 | 0.2 | |
| 108. PCB-1254 | 15 | ND- 52 | 4.1 | | 3 | ND | | |
| 111. PCB-1248 | 15 | ND- 32 | 2.6 | | 3 | ND | | |
| 114. toxaphene | 15 | ND- 0.1 | | | 3 | ND | | |

*Net Concentration - source and blanks subtracted.

TABLE V-17. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Columbium/Tantalum

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 4. benzene | 2 | 2.0 | 2.0 | 2.0 |
| 23. chloroform | 2 | 32 -422 | 227 | 227 |
| 39. fluoranthene | 3 | ND- 4.0 | 1.3 | |
| 48. dichlorobromomethane | 2 | ND- 25 | 13 | 13 |
| 51. chlorodibromomethane | 2 | ND- 8.0 | 4.0 | 4.0 |
| 66. bis(2-ethylhexyl)phthalate | 3 | 9.0-173 | 77 | 49 |
| 67. butyl benzyl phthalate | 3 | ND- 3.0 | 1.0 | |
| 68. di-n-butyl phthalate | 3 | 0.2- 41 | 17 | 11 |
| 69. di-n-octyl phthalate | 3 | 5.0- 14 | 8.3 | 6.0 |
| 71. dimethyl phthalate | 3 | ND- 2.0 | 0.4 | 0.2 |
| 73. benzo(a)pyrene | 3 | ND- 25 | 9.3 | 3.0 |
| 74. 3,4-benzofluoranthene | 3 | ND- 20 | 6.7 | |
| 75. 11,12-benzofluoranthene | 3 | ND- 20 | 6.7 | |
| 76. chrysene | 3 | ND- 3.0 | 0.3 | |
| 78. anthracene | 3 | ND- 12 | 5.7 | 5.0 |
| 80. fluorene | 3 | ND- 46 | 15 | 0.1 |
| 81. phenanthrene | 3 | ND- 12 | 5.7 | 5.0 |
| 84. pyrene | 3 | ND- 1.0 | 0.4 | 0.1 |
| 86. tetrachloroethylene | 2 | ND- 8.0 | 4.0 | 4.0 |
| 88. trichloroethylene | 2 | ND- 9.0 | 4.5 | 4.5 |
| 90. aldrin | 3 | ND- 0.9 | 0.3 | |
| 91. dieldrin | 3 | ND- 5.0 | 1.7 | 0.2 |
| 92. chlordane | 3 | ND- 1.1 | 0.4 | |
| 93. 4,4'-DDT | 3 | ND- 0.1 | 0.1 | 0.1 |
| 94. 4,4'-DDE | 3 | ND- 0.1 | 0.1 | 0.1 |
| 95. 4,4'-DDD | 3 | ND- 0.1 | | |
| 97. beta-endosulfan | 3 | ND- 0.3 | 0.1 | |
| 101. heptachlor | 3 | ND- 0.8 | 0.4 | 0.4 |
| 102. heptachlor epoxide | 3 | ND- 0.2 | 0.1 | 0.1 |
| 103. alpha-BHC | 3 | ND- 0.3 | 0.2 | 0.2 |

TABLE V-17. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Columbium/Tantalum

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 104. beta-BHC | 3 | ND- 0.8 | 0.4 | 0.4 |
| 105. gamma-BHC | 3 | ND- 0.05 | | |
| 106. delta-BHC | 3 | ND- 0.9 | 0.3 | |
| 108. PCB-1254 | 3 | 0.4- 9.4 | 3.4 | 0.4 |
| 111. PCB-1248 | 3 | 0.4- 7.2 | 2.7 | 0.6 |

TABLE V-18

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Columbium/Tantalum
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| City Water | A | - | - | K 100 | K 10 | K 1.0 | K 2.0 | K 5.0 | 30 | K 20 | K 0.1 | K 5.0 | K 10 | K 20 | K 100 | K 60 |
| | B | - | - | K 100 | K 10 | K 1.0 | K 2.0 | K 5.0 | K 6.0 | 20 | 0.1 | K 5.0 | K 10 | K 20 | K 100 | K 60 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Waste Raffinate; Gangue Slurry; Washdown; Salt Ppt. Filtrate; Non-contact Cool; Wet Scrubber Waste | C | 0.33 | + | 10 | 180 | 20 | 8.0 | 3.0E3 | 500 | 3E3 | K 0.1 | 600 | K 10 | K 20 | K 100 | 6.0E3 |
| Stream Eductor $K_2TaF_7$ Dryer; Leaching Wastes; Calciner APC; Powder Wash | B | 0.082 | 32 | K 100 | 50 | 20 | K 20 | 1.0E3 | 200 | 1.0E3 | 1.8 | 1E3 | K 10 | 60 | K 100 | K 600 |
| Gangue Slurry Pond Overflow | B | 0.014 | 5.4 | K 100 | 570 | 500 | 200 | 20E3 | 700 | 10E3 | 0.3 | 10E3 | 20 | 50 | K 100 | 1.0E3 |
| Ammonia Stripper Supernatant Neutral | B | 0.020 | 7.7 | K 100 | 40 | K 100 | 2E3 | K 500 | 800 | K 2E3 | K 0.1 | K 500 | K 10 | 70 | K 100 | K 6.0E3 |
| Raw Wastes - Combined Streams | B | 0.26 | 100 | K 100 | 390 | 90 | 50 | 3E3 | 400 | 3.0E3 | 6.1 | 2E3 | K 10 | 80 | K 100 | K 600 |
| Digester APC; Floor Washdown | D | 0.022 | 21 | 2.9E3 | 3.0 | 180 | 40E3 | 1.0E3 | 50E4 | 90E4 | 63 | 5.0E3 | 2.0 | 1.0E3 | 50 | 1.0E6 |
| Extraction Raffinate | D | 0.023 | 23 | 18E3 | 27E3 | 200 | K 200 | 1.0E6 | 43E3 | 50E6 | 11 | 500 | 45E3 | K 250 | NR | 0.43E6 |

TABLE V-18 (Continued)

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Columbium/Tantalum
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treated Wastewater | | | | | | | | | | | | | | | | |
| Ball Mill & Sizing Wastes (HCL, Centrifuge) | A | 0.0033 | + | 70 | K 10 | K 1.0 | 7.3 | 23 | 15 | 27 | 0.10 | 32 | 10 | K 20 | K 100 | 67 |
| Scrap Degreasing | A | 60E-6 | - | K 100 | 10 | K 10 | K 20 | 150 | 790 | 220 | 4.0 | K 50 | K 10 | 40 | K 100 | K 600 |
| Reduced Ta Leaching Wastes (NaOH, Centrifuge) | A | 0.036 | - | 200 | 10 | K 10 | K 20 | 95 | K 60 | K 10 | 0.2 | K 50 | 10 | 37 | K 100 | K 600 |
| Pickle Rinse Pit | A | 20E-6 | - | K 100 | K 10 | 4.0 | 40 | 100 | 200 | 60 | 0.1 | 70 | K 10 | K 20 | K 100 | 200 |
| Drying Furnace Condensate | A | 0.0086 | - | K 100 | K 10 | K 1.0 | 9.0 | 6.0 | 1E3 | K 2.0 | 0.1 | K 5 | K 10 | K 20 | K 100 | 3.0E3 |
| Cb Filtrate: Salt Drying APC Liquor ($NH_3$ Stripping) + Extraction Raffinate; Ta Filtrate; Digester APC Liquor; Ta Reduction; Foundry & Other Metal Refining Wastes (Lime, Filter) | D | 0.035 | 35 | 4500 | 300 | K 20 | K 200 | K 240 | 1.0E3 | 10E3 | 2.8 | 1.0E3 | 18 | K 250 | 50 | 6.0E3 |
| | D | 0.10 | 100 | 200 | 450 | K 20 | K 200 | K 240 | 110 | 5.0E3 | 0.8 | 500 | 4.5 | K 250 | 50 | 6.0E3 |
| Final Effluent - Combined Streams 38A3, A4, A7, A8 (Lime, Settle) | B | 0.11 | 42 | K 100 | 10 | K 1.0 | 4 | 8 | 10 | 70 | K 0.1 | 60 | K 10 | K 20 | K 100 | K 60 |

+ Insufficient information to determine.
NR Data not received from testing laboratory.

Engineering notation, i.e. $1.3E6 = 1.3 \times 10^6$

TABLE V-19

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Columbium/Tantalum
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants | | | | | Non-conventional Pollutants | | | Priority Pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COD | TSS | O & G | NH3 | Cl | F | TOC | Phenols | CN | Asbestos* Total | Chrys. |
| **Source Water** | | | | | | | | | | | | | | |
| | A | - | - | 8.0 K | 1.0 | - | - | - | - | 2.0 | - | - | - | - |
| | B | - | - | - | - | - K | 0.1 | - | 1.6 | - | - | - | - | - |
| **Raw Wastewater** | | | | | | | | | | | | | | |
| Waste Raffinate; Gangue Slurry; Washdown; Salt ppt. Filtrate; Noncontact Cool; Wet Scrubber Waste | C | 0.33 | + | 140 | 570 | 7.3 | 2.4E3 | 120 | 2.2E3 | 45 | 0.10 | 0.002 | - | - |
| Steam Eductor $K_2TaF_7$ Dryer; Leaching Wastes; Calciner APC; Powder Wash | B | 0.082 | 32 | 200 | 660 | 4.0 | - | 1.1E3 | - | 51 | 0.01 | 0.008 | - | - |
| Digestor APC Liquor; Extraction Raffinate; Floor Washdown | B | 0.096 | 37 | - | - | 5.7 | - | - | - | - | 0.015 | 0.01 | - | - |
| Gangue Slurry Pond Overflow | B | 0.014 | 5.4 | 500 | 440 | 4.3 | - | - | - | 120 | 0.014 | 0.002 | - | - |
| Ammonia Stripper Supernatant | B | 0.02 | 7.7 | 22 | 28E3 | 9.0 | 500 | - | 3.5E3 | 1.0 | 0.0073 | 0.007 | - | - |
| Neutral Raw Wastes - Combined Streams | B | 0.26 | 100 | 400 | 3900 | 5.3 | 380 | - | 3.5E3 | 120 | 0.018 | 0.004 | - | - |
| Digestor APC; Floor Washdown | D | 0.022 | 21 | 2000 | 820 | 9.0 | 64 | - | 13E3 | 236 | 0.018 | 0.003 | 3.5E9 | 0.82E9 |
| Extraction Raffinate | D | 0.023 | 23 | 11E3 | 16E3 | 22 | - | - | - | 1.8E3 | 0.014 | 0.02 | 14E9 | 2.7E9 |

TABLE V-19 (Continued)
SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Columbium/Tantalum
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | NH3 | Cl | Non-conventional Pollutants F | TOC | Phenol | Priority Pollutants CN | Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treated Wastewater | | | | | | | | | | | | | | |
| Ball Mill + Sizing Wastes (NCL, Centrifuge) | A | 0.003 | + | 12 K | 1.0 | 6.0 | 62 | 900 | 13 | 3.0 | 0.0073 | 0.001 | - | - |
| Scrap Degreasing | A | 60E-6 | - | 500 | 1.0E3 | 120 | - | - | - | 220 | - | - | - | - |
| Reduced Ta Leaching Wastes (NaOH, Centrifuge) | A | 0.036 | - | 55 | 98 | 5.3 | 0.17 | 4.6E3 | 5.6E3 | 13 | 0.004 | 0.0013 | - | - |
| Pickle Rinse Pit | A | 20E-6 | - | 110 | 52 | 6.0 | - | 12.0 | 52 | 43 | - | - | - | - |
| Drying Furnace Condensate | A | 0.0086 | - | 6.0 K | 1.0 | - | - | - | 74 | 6.0 | - | - | - | - |
| Cb Filtrate; Salt drying APC Liquor ($NH_3$ Stripping) + Extraction Raffinate Ta Filtrate; Digestor APC Liquor; Ta Reduction; Foundry + other Metal Refining Wastes (Lime, Filter) | D | 0.035 | 35 | 35 | 180 | 5.3 | 24 | - | 21E3 | 12 | 0.02 | 0.003 | 7.2E9 | 0.16E9 |
| | D | 0.10 | 100 | 150 | 89 | 4.0 | 27 | - | 6.0 | 27 | 0.030 | 0.007 | - | - |
| Final Effluent - Combined Streams 38A3, A4, A7, A8 (Lime, Settle) | B | 0.11 | 42 | 44 | 36 | 3.5 | 240 | - | 16 | 9 | 0.012 | 0.0017 | - | - |

+ Insufficient information to determine.
* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.

Engineering notation, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-20. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 4. benzene | 11 | 11 | | | | 5 | 5 | | | |
| 6. carbon tetrachloride | 11 | 8 | 3 | | | 5 | 5 | | | |
| 7. chlorobenzene | 11 | 11 | | | | 5 | 5 | | | |
| 10. 1,2-dichloroethane | 11 | 11 | | | | 5 | 5 | | | |
| 11. 1,1,1-trichloroethane | 11 | 11 | | | | 5 | 4 | 1 | | |
| 14. 1,1,2-trichloroethane | 11 | 11 | | | | 5 | 5 | | | |
| 15. 1,1,2,2-tetrachoroethane | 11 | 8 | 3 | | | 5 | 5 | | | |
| 23. chloroform | 11 | 8 | 3 | | | 5 | 3 | 2 | | |
| 29. 1,2-dichloroethylene | 11 | 11 | | | | 5 | 4 | 1 | | |
| 30. 1,2-trans-dichloroethylene | 11 | 11 | | | | 5 | 5 | | | |
| 34. 2,4-dimethylphenol | 2 | 1 | 1 | | | 2 | 2 | | | |
| 39. fluoranthene | 11 | 11 | | | | 5 | 5 | | | |
| 44. methylene chloride | 11 | 11 | | | | 5 | 5 | | | |
| 48. dichlorobromomethane | 11 | 10 | 1 | | | 5 | 5 | | | |
| 51. chlorodibromomethane | 11 | 10 | 1 | | | 5 | 5 | | | |
| 54. isophorone | 11 | 11 | | | | 5 | 5 | | | |
| 66. bis(2-ethylhexyl) phthalate | 11 | 6 | 5 | | | 5 | | 3 | 1 | 1 |
| 67. butyl benzyl phthalate | 11 | 11 | | | | 5 | 4 | 1 | | |
| 68. di-n-butyl phthalate | 11 | 10 | 1 | | | 5 | 3 | 2 | | |
| 69. di-n-octyl phthalate | 11 | 11 | | | | 5 | 4 | | 1 | |
| 71. dimethyl phthalate | 11 | 11 | | | | 5 | 5 | | | |
| 72. 1,2-benzanthracene | 11 | 11 | | | | 5 | 5 | | | |
| 73. benzo(a)pyrene | 11 | 11 | | | | 5 | 5 | | | |
| 74. 3,4-benzofluoranthene | 11 | 11 | | | | 5 | 5 | | | |
| 75. 11,12-benzofluoranthene | 11 | 11 | | | | 5 | 5 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-20. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 76. chrysene | 11 | 11 | | | | 5 | 5 | | | |
| 77. acenaphthylene | 11 | 11 | | | | 5 | 5 | | | |
| 78. anthracene | 11 | 7 | 4 | | | 5 | 2 | 3 | | |
| 80. fluorene | 11 | 11 | | | | 5 | 5 | | | |
| 81. phenanthrene | 11 | 7 | 4 | | | 5 | 5 | | | |
| 84. pyrene | 11 | 11 | | | | 5 | 5 | | | |
| 86. tetrachloroethylene | 11 | 7 | 4 | | | 5 | 5 | | | |
| 87. toluene | 11 | 11 | | | | 5 | 5 | | | |
| 88. trichloroethylene | 11 | 11 | | | | 5 | 5 | | | |
| 91. dieldrin | 11 | 11 | | | | 5 | 5 | | | |
| 92. chlordane | 11 | 11 | | | | 5 | 5 | | | |
| 93. 4,4'-DDT | 11 | 11 | | | | 5 | 5 | | | |
| 94. 4,4'-DDE | 11 | 11 | | | | 5 | 5 | | | |
| 95. 4,4'-DDD | 11 | 11 | | | | 5 | 5 | | | |
| 96. alpha-endosulfan | 11 | 11 | | | | 5 | 5 | | | |
| 97. beta-endosulfan | 11 | 11 | | | | 5 | 5 | | | |
| 98. endosulfan sulfate | 11 | 11 | | | | 5 | 5 | | | |
| 99. endrin | 11 | 11 | | | | 5 | 5 | | | |
| 100. endrin aldehyde | 11 | 11 | | | | 5 | 5 | | | |
| 101. heptachlor | 11 | 11 | | | | 5 | 5 | | | |
| 102. heptachlor epoxide | 11 | 11 | | | | 5 | 5 | | | |
| 103. alpha-BHC | 11 | 11 | | | | 5 | 5 | | | |
| 104. beta-BHC | 11 | 11 | | | | 5 | 5 | | | |
| 105. gamma-BHC | 11 | 11 | | | | 5 | 5 | | | |
| 108. PCB-1254 | 11 | 11 | | | | 5 | 5 | | | |
| 111. PCB-1248 | 9 | 9 | | | | 3 | 3 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-21. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 4. benzene | 11 | ND- 3.0 | 0.7 | | 5 | ND- 1.0 | 0.4 | |
| 6. carbon tetrachloride | 11 | ND-40 | 8.4 | | 5 | ND | | |
| 7. chlorobenzene | 11 | ND | | | 5 | ND- 6.0 | 1.2 | |
| 10. 1,2-dichloroethane | 11 | ND- 7.0 | 0.6 | | 5 | ND | | |
| 11. 1,1,1-trichloroethane | 11 | ND | | | 5 | ND- 10 | 3.4 | |
| 14. 1,1,2-trichloroethane | 11 | ND- 2.0 | 0.2 | | 5 | ND | | |
| 15. 1,1,2,2-tetrachloroethane | 11 | ND-12 | 1.9 | | 5 | ND- 9.0 | 3.2 | |
| 23. chloroform | 11 | ND-93 | 16 | 5.0 | 5 | ND | | |
| 29. 1,1-dichloroethylene | 11 | ND | | | 5 | ND- 10 | 3.8 | |
| 34. 2,4-dimethylphenol | 2 | ND-14 | 7.0 | 7.0 | 2 | ND | | |
| 39. fluoranthene | 11 | ND- 1.0 | 0.3 | | 5 | ND- 2.0 | 0.4 | |
| 44. methylene chloride | 11 | ND- 6.8 | 0.6 | | 5 | ND | | |
| 48. dichlorobromomethane | 11 | ND-14 | 1.3 | | 5 | ND | | |
| 51. chlorodibromomethane | 11 | ND-13 | 1.2 | | 5 | ND | | |
| 54. isophorone | 11 | ND- 3.0 | 0.3 | | 5 | ND | | |
| 66. bis(2-ethylhexyl)phthalate | 11 | ND-78 | 17 | | 5 | ND-480 | 110 | 17 |
| 67. butyl benzyl phthalate | 11 | ND- 1.0 | 0.1 | | 5 | ND- 48 | 9.6 | |
| 68. di-n-butyl phthalate | 11 | ND-75 | 7.6 | 0.7 | 5 | ND- 73 | 25 | |
| 69, di-n-octyl phthalate | 11 | ND- 3.0 | 0.3 | | 5 | ND-189 | 38 | |
| 72. 1,2-benzanthracene | 11 | ND- 1.0 | 0.1 | | 5 | ND | | |
| 76. chyrsene | 11 | ND | | | 5 | ND- 2.0 | 0.4 | |
| 77. acenaphthylene | 11 | ND- 3.0 | 0.3 | | 5 | ND | | |
| 78. anthracene | 11 | ND-21 | 6.1 | | 5 | ND- 17 | 6.2 | |
| 80. fluorene | 11 | ND- 1.0 | 0.1 | | 5 | ND- 14 | 2.8 | |
| 81. phenanthrene | 11 | ND-21 | 7.1 | 7.0 | 5 | ND- 17 | 3.4 | |
| 84. pyrene | 11 | ND- 1.0 | 0.4 | | 5 | ND | | |
| 86. tetrachloroethylene | 11 | ND-15 | 5.4 | 4.0 | 5 | ND- 3.0 | 1.0 | |
| 87. toluene | 11 | ND- 1.0 | 0.2 | | 5 | ND | | |

*Net Concentration - source and blanks subtracted.

TABLE V-21. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE Range* (ug/l) | RAW WASTE Mean* (ug/l) | RAW WASTE Median* (ug/l) | TREATED WASTE # of Times Analyzed | TREATED WASTE Range* (ug/l) | TREATED WASTE Mean* (ug/l) | TREATED WASTE Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 88. trichloroethylene | 11 | ND- 9.0 | 1.5 | | 5 | ND- 3.0 | 0.6 | |
| 91. dieldrin | 11 | ND- 0.02 | | | 5 | ND | | |
| 92. chlordane | 11 | ND- 0.2 | | | 5 | ND- 0.9 | 0.2 | |
| 93. 4,4'-DDT | 11 | ND- 0.02 | | | 5 | ND- 0.1 | | |
| 94. 4,4'-DDE | 11 | ND- 0.01 | | | 5 | ND- 0.1 | | |
| 96. alpha-endosulfan | 11 | ND | | | 5 | ND- 0.04 | | |
| 97. beta-endosulfan | 11 | ND- 0.01 | | | 5 | ND | | |
| 98. endosulfan sulfate | 11 | ND | | | 5 | ND- 0.2 | 0.1 | |
| 99. endrin | 11 | ND- 0.1 | | | 5 | ND- 0.1 | | |
| 100. endrin aldehyde | 11 | ND- 0.4 | 0.1 | | 5 | ND- 0.4 | 0.1 | |
| 101. heptachlor | 11 | ND- 0.01 | | | 5 | ND- 0.2 | | |
| 102. heptachlor epoxide | 11 | ND- 0.01 | 0.01 | | 5 | ND- 0.1 | | |
| 104. beta-BHC | 11 | ND- 0.01 | | | 5 | ND- 0.2 | 0.1 | |
| 105. gamma-BHC | 11 | ND- 0.04 | | | 5 | ND- 0.01 | | |
| 108. PCB-1254 | 11 | ND- 0.7 | 0.1 | | 5 | ND- 1.5 | 0.5 | |
| 111. PCB-1248 | 9 | ND- 0.6 | 0.1 | | 5 | ND- 1.0 | 0.8 | 1.0 |

*Net Concentration - source and blanks subtracted.

TABLE V-22. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Copper

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 6. carbon tetrachloride | 2 | ND- 59 | 30 | 30 |
| 23. chloroform | 2 | ND- 57 | 29 | 29 |
| 66. bis(2-ethylhexyl)phthalate | 2 | 36.0 -720 | 380 | 380 |
| 67. butyl benzyl phthalate | 2 | ND- 3.0 | 1.5 | 1.5 |
| 68. di-n-butyl phthalate | 2 | ND- 2.0 | 1.0 | 1.0 |
| 69. di-n-octyl phthalate | 2 | ND- 2.0 | 1.0 | 1.0 |
| 71. dimethyl phthalate | 2 | ND- 1.0 | 0.5 | 0.5 |
| 73. benzo(a)pyrene | 2 | 1.0 - 12 | 6.5 | 6.5 |
| 86. tetrachloroethylene | 2 | ND- 2.0 | 1.0 | 1.0 |
| 91. dieldrin | 2 | 0.01 | 0.01 | 0.01 |
| 92. chlordane | 2 | 0.04- 0.1 | | |
| 93. 4,4-DDT | 2 | ND- 0.01 | | |
| 94. 4,4-DDE | 2 | ND- 0.01 | | |
| 95, 4,4-DDD | 2 | ND- 0.01 | | |
| 99. endrin | 2 | ND- 0.01 | | |
| 100. endrin aldehyde | 2 | 0.02- 0.40 | 0.2 | 0.2 |
| 101. heptachlor | 2 | 0.02- 0.03 | | |
| 102. heptachlor epoxide | 2 | 0.01 | 0.01 | 0.01 |
| 103. alpha-BHC | 1 | 0.02 | 0.02 | 0.02 |
| 104. beta-BHC | 2 | 0.01- 0.02 | | |
| 105. gamma-BHC | 1 | 0.03 | 0.03 | 0.03 |
| 108. PCB-1254 | 2 | 0.3 - 0.4 | 0.4 | 0.4 |
| 111. PCB-1248 | 2 | 0.2 - 0.3 | 0.3 | 0.3 |

TABLE V-23
SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Copper
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| | A | - | - | K 100 | K 10 | K 1 | K 2 | K 5 | 60 | K 20 | K 0.1 | K 5.0 | K 10 | K 20 | K 100 | 60 |
| | B | - | - | K 100 | K 10 | K 1 | K 2 | K 5 | 20 | 20 | 0.1 | K 5.0 | K 10 | K 1.0 | K 100 | 60 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Acid Plant - Baghouse | B | 0.10 | + | 27E3 | 3E6 | K 1.0 | 530 | 30 | 83E3 | 1.0E3 | 140 | 90 | 160 | 3.3E3 | 630 | 30E3 |
| Acid Plant - Scrubbers | B | 2.0 | + | 2.4E3 | 0.2E6 | 7.3 | 10E3 | 80 | 0.47E6 | 0.18E6 | 44 | 1.1E3 | 10 | 360 | K 100 | 0.15E6 |
| Acid Plant (w/Sanitary); | C | 2.9 | + | 100 | 10E3 | K 20 | 16 | 25 | 1.2E3 | 1.0E3 | 16 | 1.1E3 | 450 | K 10 | K 100 | 720 |
| Spent Electrolyte; Cathode Wash | C | 2.9 | + | K 100 | 40E3 | K 5 | K 5 | 80 | 11E3 | 1.2E3 | 6.0 | 700 | 1.2E3 | 220 | K 100 | 230 |
| Slag Granulation; Noncontact Cool; Recycled Effluent | C | 9.9 | + | K 100 | 400 | K 5 | K 5 | 50 | 150 | 120 | K 1 | K 20 | 20 | 20 | K 100 | 360 |
| Bosh Cooling Pit | D | 0.22 | + | K 50 | K 2.0 | K 2 | K 5 | K 10 | 1.6E3 | K 20 | K 0.5 | K 20 | 15 | 20 | K 100 | 30 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Casting Contact Cool (Bosh Pit) (Lime - Settle) | A | 0.015 | 100 | 100 | 10 | K 1 | K 2 | 13 | 16.7 | 20 | K 0.1 | K 5.0 | K 10 | K 20 | K 100 | K 60 |
| Contact/Noncontact Cool (w/Slag Launders) | B | 4.2 | + | K 100 | 37 | 2.0 | 24 | 29 | 570 | 180 | 0.06 | 10 | K 10 | K 20 | K 100 | 370 |

NR - Data not received from testing laboratory.
\+ Insufficient information.

Engineering notation, i.e. 1.3E6 = $1.3 \times 10^6$

TABLE V-24
SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Copper
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | NH3 | Cl | Non-conventional Pollutants TOC | Phenols | Priority Pollutants CN | Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | |
| | B | - | | K 5.0 | 1.0 | - | - | - | 3.0 | - | | - | - |
| **Raw Wastewater** | | | | | | | | | | | | | |
| Acid Plant - Baghouse | B | 0.10 | + | 7.9E3 | 12E3 | 7.0 | - | - | 11.0 | 0.020 | K 0.001 | - | - |
| Acid Plant - Scrubbers | B | 2.0 | + | 440 | 4.1E3 | 6.0 | - | - | 6.3 | 0.0047 | K 0.001 | - | - |
| Spent Electrolyte; Cathode Wash | C | 2.9 | + | 100 | 10 | - | - | - | 8.0 | K 0.002 | K 0.02 | - | - |
| Slag Granulation; Noncontact Cool; Recycled Eff | C | 9.9 | + | K 2.0 | 4.0 | - | - | - | K 4.0 | 0.042 | K 0.02 | - | - |
| Bosh Cooling Pit | D | 0.22 | + | K 2.0 | 18 | - | - | - | 7.0 | - | - | - | - |
| **Treated Wastewater** | | | | | | | | | | | | | |
| Casting Contact Cool (Bosh Pit) (Lime - Settle) | A | 0.015 | 100 | 11 | 6.0 | 6.3 | - | 332 | 4.3 | 0.013 | 0.0023 | - | - |
| Contact/Noncontact Cool (w/Slag Launders) | B | 4.2 | + | 5.3 | 2.3 | 6.3 | - | - | 3.7 | 0.0093 | K 0.001 | - | - |

* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.
+ Insufficient information to determine streams.

Engineering notation used, i.e. 1.3E6 = 1.3 x 10 .

TABLE V-25. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 12 | 10 | 2 | | | 13 | 13 | | | |
| 4. benzene | 10 | 9 | 1 | | | 13 | 13 | | | |
| 6. carbon tetrachloride | 10 | 9 | | 1 | | 13 | 12 | 1 | | |
| 9. hexachlorobenzene | 12 | 11 | | | 1 | 13 | 11 | | 2 | |
| 10. 1,2-dichlorobenzene | 10 | 9 | 1 | | | 13 | 13 | | | |
| 14. 1,1,2-trichloroethane | 10 | 10 | | | | 13 | 13 | | | |
| 15. 1,1,2,2-tetrachloroethane | 10 | 10 | | | | 13 | 12 | 1 | | |
| 23. chloroform | 10 | 5 | 2 | 2 | 1 | 13 | 7 | 4 | 2 | |
| 29. 1,1-dichloroethylene | 10 | 8 | 1 | 1 | | 13 | 13 | | | |
| 30. 1,2-trans-dichloroethylene | 10 | 10 | | | | 13 | 12 | 1 | | |
| 38. ethylbenzene | 10 | 10 | | | | 13 | 13 | | | |
| 39. fluoranthene | 12 | 9 | 1 | 1 | 1 | 13 | 12 | 1 | | |
| 44. methylene chloride | 10 | 8 | | 2 | | 13 | 13 | | | |
| 48. dichlorobromomethane | 10 | 10 | | | | 13 | 13 | | | |
| 51. chlorodibromomethane | 10 | 10 | | | | 13 | 13 | | | |
| 55. napthalene | 12 | 9 | 1 | | 2 | 13 | 11 | | 2 | |
| 66. bis(2-ethylhexyl) phthalate | 12 | 3 | 4 | 3 | 2 | 13 | 3 | 9 | 1 | |
| 67. butyl benzyl phthalate | 12 | 11 | 1 | | | 13 | 11 | 2 | | |
| 68. di-n-butyl phthalate | 12 | 7 | 3 | 2 | | 13 | 6 | 6 | 1 | |
| 69. di-n-octyl phthalate | 12 | 11 | 1 | | | 13 | 11 | 1 | 1 | |
| 70. diethyl phthalate | 12 | 10 | 2 | | | 13 | 10 | 3 | | |
| 71. dimethyl phthalate | 12 | 12 | | | | 13 | 9 | 1 | 2 | 1 |
| 73. benzo(a)pyrene | 12 | 12 | | | | 13 | 13 | | | |
| 74. 3,4-benzofluoranthene | 12 | 12 | | | | 13 | 2 | 1 | | |
| 75. 11,12-benzofluoranthene | 12 | 12 | | | | 13 | 2 | 1 | | |

*Gross Concentration - blanks subtracted.

TABLE V-25. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 76. chrysene | 12 | 10 | 1 | | 1 | 13 | 12 | 1 | | |
| 77. acenaphthylene | 12 | 9 | 1 | 2 | | 13 | 13 | | | |
| 78. anthracene | 12 | 10 | 2 | | | 13 | 8 | 4 | 1 | |
| 80. fluorene | 12 | 9 | 3 | | | 13 | 10 | 2 | 1 | |
| 81. phenanthrene | 12 | 9 | 2 | | 1 | 13 | 8 | 4 | 1 | |
| 82. 1,2,5,6-dibenzanthracene | 12 | 12 | | | | 13 | 13 | | | |
| 83. indeno(1,2,3-cd)pyrene | 12 | 12 | | | | 13 | 13 | | | |
| 84. pyrene | 12 | 9 | | 2 | 1 | 13 | 10 | 3 | | |
| 86. tetrachloroethylene | 10 | 8 | 2 | | | 13 | 12 | 1 | | |
| 87. toluene | 10 | 10 | | | | 13 | 12 | 1 | | |
| 88. trichloroethylene | 10 | 9 | 1 | | | 13 | 13 | | | |
| 90. aldrin | 14 | 14 | | | | 13 | 13 | | | |
| 91. dieldrin | 14 | 14 | | | | 13 | 13 | | | |
| 92. chlordane | 14 | 14 | | | | 13 | 13 | | | |
| 93. 4,4'-DDT | 14 | 14 | | | | 13 | 13 | | | |
| 94. 4,4'-DDE | 14 | 14 | | | | 13 | 13 | | | |
| 95. 4,4'-DDD | 14 | 14 | | | | 13 | 13 | | | |
| 96. alpha-endosulfon | 14 | 14 | | | | 13 | 13 | | | |
| 97. beta-endosulfan | 14 | 14 | | | | 13 | 13 | | | |
| 99. endrin | 14 | 14 | | | | 13 | 13 | | | |
| 100. endrin aldehyde | 14 | 14 | | | | 13 | 13 | | | |
| 101. heptachlor | 14 | 14 | | | | 13 | 13 | | | |
| 102. heptachlor epoxide | 14 | 14 | | | | 13 | 13 | | | |
| 103. alpha-BHC | 14 | 14 | | | | 13 | 13 | | | |
| 104. beta-BHC | 14 | 14 | | | | 13 | 13 | | | |
| 105. gamma-BHC | 14 | 14 | | | | 13 | 13 | | | |
| 106. delta-BHC | 14 | 14 | | | | 13 | 13 | | | |
| 108. PCB-1254 | 14 | 14 | | | | 13 | 13 | | | |
| 111. PCB-1248 | 14 | 14 | | | | 13 | 13 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-26. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 12 | ND- 36 | 4.6 | | 13 | ND- 36 | 2.8 | |
| 4. benzene | 10 | ND- 13 | 1.3 | | 13 | ND- 3.0 | .2 | |
| 6. carbon tetrachloride | 10 | ND- 120 | 12 | | 13 | ND- 260 | 20 | |
| 9. hexachlorobenzene | 12 | ND- 5.0E3 | 420 | | 13 | ND- 220 | 30 | |
| 10. 1,2-dichloroethene | 10 | ND- 32 | 3.2 | | 13 | ND- 1.0 | | |
| 15. 1,1,2,2-tetrachloroethane | 10 | ND- 4.0 | 0.4 | | 13 | ND- 14.0 | 2.6 | |
| 23. chloroform | 10 | ND- 1.0E3 | 130 | 7.0 | 13 | ND- 320 | 43 | |
| 29. 1,1-dichloroethylene | 10 | ND- 530 | 57 | | 13 | ND | | |
| 30. 1,2-trans-dichloroethylene | 10 | ND- 5.0 | 0.5 | | 13 | ND | | |
| 38. ethylbenzene | 10 | ND- 4.0 | 0.4 | | 13 | ND- 2.0 | 0.2 | |
| 39. fluoranthene | 12 | ND- 3.0E3 | 280 | 1.0 | 13 | ND- 17 | 3.9 | 2.0 |
| 44. methylene chloride | 10 | ND- 510 | 80 | | 13 | ND | | |
| 48. dichlorobromomethane | 10 | ND | | | 13 | ND- 7.0 | 0.5 | |
| 55. naphthalene | 12 | ND- 5.0E3 | 550 | | 13 | ND- 930 | 87 | |
| 56. nitrobenzene | 12 | ND | | | 13 | ND- 1.0 | | |
| 66. bis(2-ethylhexyl)phthalate | 12 | ND- 7.0E3 | 1.1E3 | 53.0 | 13 | ND- 590 | 84 | 34.0 |
| 67. butyl benzyl phthalate | 12 | ND- 56 | 5.3 | | 13 | ND- 23 | 3.3 | |
| 68. di-n-butyl phthalate | 12 | ND- 390 | 56 | 9.5 | 13 | ND- 110 | 32 | 16.0 |
| 69. di-n-octyl phthalate | 12 | ND- 67 | 5.8 | | 13 | ND- 170 | 15 | |
| 70. diethyl phthalate | 12 | ND- 83 | 11 | | 13 | ND- 82 | 15 | |
| 71. dimethyl phthalate | 12 | ND | | | 13 | ND- 1.3E3 | 210 | 1.0 |
| 73. benzo(a)pyrene | 12 | ND- 1.0 | 0.1 | | 13 | ND- 9.0 | 1.5 | |
| 74. benzofluoranthene | 12 | ND | | | 13 | ND- 12 | | |
| 75. 11,12-benzofluoranthene | 12 | ND | | | 13 | ND- 12 | | |
| 76. chrysene | 12 | ND-10E3 | 840 | | 13 | ND- 8.0 | 0.8 | |
| 77. acenaphthylene | 12 | ND- 120 | 23 | | 13 | ND | | |
| 78. anthracene | 12 | ND- 3.0E3 | 260 | | 13 | ND- 140 | 19 | 5.0 |
| 80. fluorene | 12 | ND- 94 | 14 | | 13 | ND- 100 | 23 | |
| 81. phenanthrene | 12 | ND- 3.0E3 | 255 | | 13 | ND- 140 | 19 | 5.0 |
| 82. 1,2,5,6-dibenzanthracene | 12 | ND | | | 13 | ND- 8.0 | 0.6 | |
| 83. indeno(1,2,3-cd)pyrene | 12 | ND | | | 13 | ND- 8.0 | 0.6 | |

*Net Concentration - source and blanks subtracted.
Scientific Notation Used, i.e. 500 = 5.0E3

TABLE V-26. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Copper

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE Range* (ug/l) | RAW WASTE Mean* (ug/l) | RAW WASTE Median* (ug/l) | TREATED WASTE # of Times Analyzed | TREATED WASTE Range* (ug/l) | TREATED WASTE Mean* (ug/l) | TREATED WASTE Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 84. pyrene | 12 | ND- 7.0E3 | 614 | | 13 | ND- 38 | 7.8 | 3.0 |
| 86. tetrachloroethylene | 10 | ND- 72 | 8.8 | | 13 | ND- 12 | 1.7 | |
| 87. toluene | 10 | ND- 10 | 1.7 | | 13 | ND- 69 | 5.6 | |
| 88. trichloroethylene | 10 | ND- 70 | 7.1 | | 13 | ND- 2.0 | 0.2 | |
| 90. aldrin | 14 | ND- 0.2 | | | 13 | ND | | |
| 91. dieldrin | 14 | ND- 0.03 | | | 13 | ND- 0.2 | | |
| 92. chlordane | 14 | ND- 0.7 | 0.1 | | 13 | ND- 0.5 | 0.1 | |
| 93. 4,4'-DDT | 14 | ND- 0.03 | | | 13 | ND- 0.1 | 0.1 | |
| 94. 4,4'-DDE | 14 | ND- 0.02 | | | 13 | ND- 0.1 | 0.1 | |
| 95. 4,4'-DDD | 14 | ND- 0.1 | | | 13 | ND- 0.04 | | |
| 96. alpha-endosulfan | 14 | ND- 0.3 | | | 13 | ND- 0.6 | 0.1 | |
| 97. beta-endosulfan | 14 | ND- 0.3 | | | 13 | ND- 0.1 | | |
| 99. endrin | 14 | ND- 0.4 | | | 13 | ND- 0.1 | | |
| 100. endrin aldehyde | 14 | ND- 0.3 | | | 13 | ND- 0.4 | 0.1 | |
| 101. heptachlor | 14 | ND- 0.02 | | | 13 | ND- 0.2 | | |
| 102. heptachlor epoxide | 14 | ND | | | 13 | ND- 0.1 | | |
| 103. alpha-BHC | 14 | ND- 0.2 | | | 13 | ND- 0.2 | | |
| 104. beta-BHC | 14 | ND- 0.02 | | | 13 | ND- 0.2 | | |
| 105. gamma-BHC | 14 | ND- 0.04 | | | 13 | ND- 0.1 | | |
| 106. delta-BHC | 14 | ND- 0.2 | | | 13 | ND- 0.01 | | |
| 108. PCB-1254 | 14 | ND- 3.0 | 0.5 | | 13 | ND- 1.7 | 0.2 | |
| 111. PCB-1248 | 14 | ND- 2.0 | 0.5 | | 13 | ND- 2.2 | 0.2 | |
| 114. toxaphene | 14 | ND- 0.4 | | | 13 | ND | | |

*Net Concentration - source and blanks subtracted.
Scientific Notation Used, i.e. 700 = 7E3

TABLE V-27. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Copper

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 4. benzene | 3 | ND- 3.0 | 1.0 | |
| 9. hexachlorobenzene | 3 | ND- 7.0 | 2.3 | |
| 14. 1,1,2-trichloroethane | 3 | ND- 7.0 | 3.3 | |
| 15. 1,1,2,2-tetrachloroethane | 3 | ND- 5.0 | 1.7 | |
| 23. chloroform | 3 | 5.0 - 43 | 20 | 11 |
| 30. 1,2-trans-dichloroethylene | 3 | ND- 3.0 | 1.0 | |
| 48. dichlorobromomethane | 3 | ND- 18 | 6.0 | |
| 51. chlorodibromomethane | 3 | ND- 19 | 6.3 | |
| 55. naphthalene | 3 | ND- 1.0 | 0.3 | |
| 56. nitrobenzene | 3 | ND- 1.0 | 0.3 | |
| 66. bis(2-ethylhexyl)phthalate | 3 | 7.0 -170 | 68 | 31 |
| 68. di-n-butyl phthalate | 3 | 1.0 - 6.0 | 2.7 | |
| 69. di-n-octyl phthalate | 3 | ND- 10 | 3.3 | |
| 70. diethyl phthalate | 3 | ND- 11 | 3.7 | |
| 76. chrysene | 3 | ND- 3.0 | 1.0 | |
| 77. acenaphthylene | 3 | ND- 3.0 | 1.0 | |
| 86. tetrachloroethylene | 3 | 2.0 - 6.0 | 3.7 | 3.0 |
| 88. trichloroethylene | 3 | ND- 3.0 | 1.0 | |
| 90. aldrin | 3 | ND- 0.01 | | |
| 91. dieldrin | 3 | ND- 0.2 | 0.1 | |
| 92. chlordane | 3 | 0.02- 0.2 | 0.1 | |
| 93. 4,4'-DDT | 3 | ND- 0.05 | | |
| 94. 4,4'-DDE | 3 | ND- 0.01 | | |
| 100. endrin | 3 | ND- 0.3 | 0.1 | |
| 101. heptachlor | 3 | 0.03- 0.1 | 0.1 | |

TABLE V-27. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANT
Secondary Copper

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 102. heptachlor epoxide | 3 | ND- 0.04 | | |
| 103. alpha-BHC | 3 | ND- 0.02 | | |
| 104. beta-BHC | 3 | ND- 0.11 | 0.1 | |
| 105. gamma-BHC | 3 | ND- 0.01 | | |
| 106. delta-BHC | 3 | ND- 0.01 | | |
| 108. PCB-1254 | 3 | 0.3 - 1.5 | 0.8 | 0.7 |
| 111. PCB-1248 | 3 | 0.3 - 1.0 | 0.6 | 0.6 |

TABLE V-28
SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Secondary Copper
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| City Water | A | - | - | K 100 | K 10 | K 1.0 | K 2.0 | K 5.0 | 200 | K 20 | 0.1 | 5.0 | K 10 | K 20 | K 100 | K 60 |
| | B | - | - | K 100 | K 10 | K 1.0 | 30 | K 5.0 | K 6.0 | K 20 | K 0.1 | 5.0 | K 10 | K 20 | K 100 | K 60 |
| | C | - | - | K 100 | K 10 | K 1.0 | K 2.0 | 8.0 | 8.0 | K 20 | 0.1 | 5.0 | K 10 | K 20 | K 100 | K 60 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Slag Milling | B | 0.017 | 24 | K 100 | 110 | 100 | 80 | 700 | 40E3 | 10E3 | 0.7 | 3E3 | K 10 | K 20 | K 100 | 40E3 |
| Ball Mill Influent | D | 0.053 | + | 220 | 410 | 160 | 670 | K 240 | 97E3 | 53E3 | 0.53 | 2.0E3 | 270 | K 250 | K 50 | 1.5E6 |
| Contact Cooling | C | 0.015 | 47 | K 100 | K 10 | K 1.0 | 7.0 | 13 | 630 | 2.7E3 | 0.1 | 12 | K 10 | K 20 | K 100 | 3.3E3 |
| Furnace Scrubbers; Acid Tank | A | 0.10 | K 100 | 100 | K 10 | 1.3 | 8.0 | 150 | 15E3 | 467 | 0.17 | 7E3 | K 10 | K 30 | K 100 | 1.5E3 |
| Waste Electrolyte; Electrolyte Refining Area Cleaning Water | E | 0.028 | 100 | 11E3 | 4.2E3 | 30 | 1.2E3 | 2.1E3 | 2.1E6 | 20E3 | 0.53 | 3.1E6 | 220 | 1.6E3 | 53 | 97E3 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Slag Milling; Granulation + Contact/Noncontact Cool (Lime-Settle) | B | 0.017 | 24 | K 100 | 150 | K 1.0 | 2.0E3 | 10 | 20E3 | 4.0E3 | 10 | 300 | K 10 | K 20 | K 100 | 40E3 |
| | B | 0.07 | 100 | K 100 | K 10 | K 1.0 | 10 | K 5.0 | 100 | K 20 | 1.1 | K 5 | K 10 | K 20 | K 100 | 70 |
| Slag Milling | C | 0.017 | 53 | K 100 | 620 | 370 | 47 | 330 | 63E3 | 43E3 | 5.3 | 1600 | 340 | 67 | K 100 | 2.[illegible]E6 |

TABLE V-28 (Continued)
SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Secondary Copper
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Furnace Scrubbers (Lime - NaOH - Polymer - Settle) | A | 0.10 | 100 | K 100 | 10 | K 1 | K 2 | K 5.0 | 50 | K 20 | 0.1 | 10 | K 10 | K 20 | K 100 | 63 |
| Furnace Scrubbers (Settle) | D | 0.019 | + | 670 | 340 | 250 | 7.6E3 | 20E3 | 84E3 | 4.5E6 | 15 | 2,200 | 290 | 460 | K 50 | 0.80E6 |
| Waste Electrolyte; Electrolyte Refining Area Cleaning Water (Settle) | E | 0.028 | 100 | 4.0E3 | 2.0E3 | 30 | 2.3E3 | 2.2E3 | 27E3 | 26E3 | 0.23 | 0.31E6 | 2.3E3 | 250 | 60 | 0.10E6 |

+ Insufficient information to determine.
Engineering notation, i.e. $1.3E6 = 1.3 \times 10^6$

TABLE V-29

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Secondary Copper
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | F | Non-conventional Pollutants TOC | Phenols | Priority Pollutants CN | Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Source Water | | | | | | | | | | | | |
| | A | - | - | K 5.0 | - | - | - | 5.0 | 0.007 | - | - | - |
| Raw Wastewater | | | | | | | | | | | | |
| Slag Milling | B | 0.017 | 24 | 120 | 2400 | - | - | 22 | - | - | - | - |
| Ball Mill Influent | D | 0.053 | + | 900 | 11E3 | 30 | - | 99 | 0.22 | 0.008 | 1.0E11 | 3.3E9 |
| Contact Cooling | C | 0.015 | 47 | 9.7 | 13 | 1.7 | - | 6.0 | 0.0093 | K 0.001 | - | - |
| Furnace Scrubbers; Acid Tank | A | 0.10 | 100 | 36 | 4.0 | 4.7 | - | 43 | 0.0063 | 0.026 | - | - |
| Waste Electrolyte; Electrolyte Refining Area Cleaning Water | E | 0.028 | 100 | 75 | 65 | 3.7 | 0.29 | 30 | 0.080 | 0.004 | 3.3E7 | 16E7 |
| Treated Wastewater | | | | | | | | | | | | |
| Slag Milling; Granulation + Contact/Noncontact Cool (Lime - Settle) | B | 0.017 | 24 | 82 | 23 | 15 | - | 22 | 0.31 | 0.0047 | - | - |
| | B | 0.07 | 100 | 37 K | 1.0 | 9.0 | - | 14 | 0.44 | 0.0033 | - | - |
| Slag Milling | C | 0.017 | 53 | 570 | 3.2E3 | 20 | - | 150 | 0.0087 | 0.055 | - | - |
| Furnace Scrubbers (Lime - NaOH -Polymer - Settle) | A | 0.10 | 100 | 20 | 3.3 | 3.7 | - | 21 | 0.006 | 0.015 | - | - |
| Furnace Scrubbers (Settle) | D | 0.019 | + | 2.E3 | 39E3 | 45 | - | 380 | 1.4 | 0.023 | 0.20E11 | 11E9 |

TABLE V-29 (Continued)

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Secondary Copper
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants | | | | Non-conventional Pollutants | | Priority Pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COD | TSS | O & G | F | TOC | Phenols | CN | Asbestos* Total | Chrys. |
| Waste Electrolyte; Electrolyte Refining Area Cleaning Water (Settle) | E | 0.028 | 100 | 1300 | 200 | 4.3 | 0.43 | 21 | 0.11 | 0.0027 | - | - |



* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.

+ Insufficient information to determine.
Engineering notation, i.e. $1.3E6 = 1.3 \times 10^6$.

TABLE V-30. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Lead

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 44. methylene chloride | 4 | 3 | 1 | | | 1 | | 1 | | |
| 84. pyrene | 3 | 3 | | | | 1 | 1 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-31. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Lead

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 44. methylene chloride | 4 | ND-25 | 7.8 | 3.0 | 1 | 54 | 54 | 54 |
| 84. pyrene | 3 | ND- 7.0 | 2.3 | | 1 | ND | | |

*Net Concentration - source and blanks subtracted.

TABLE V-32

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Lead
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| | A | 1.3 | 100 | 10 | 11 | 1.0 | 1.0 | 5.0 | 93 | 250 | 0.2 | 40 | 5.0 | 1.0 | 5.0 | 250 |
| | B | - | - | 10 | 5.0 | 1.0 | 1.0 | 5.0 | 26 | 14 | 0.2 | 20 | 5.0 | 1.0 | 5.0 | 47 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Acid Plant APC; Granulation Furnace APC; Leaching; Washdown; Noncontact Cool | C | 2.2 | + | K 330 | 93 | 6.7 | 1.3E3 | 30 | 103 | 7.9E3 | 7.5 | 50 | K 13 | K 20 | K 100 | 5.3E3 |
| Acid Plant Cooling Tower Blowdown; Stack APC Water | A | 0.63 | 48 | 10 | 130 | 1.0 | 290 | 15 | 1.7E3 | 38E3 | 0.2 | 200 | 5.0 | 1.0 | 5.0 | 54E3 |
| + Slag Granulation | A | 1.3 | 100 | 10 | 40 | 1.0 | 890 | 21 | 230 | 17E3 | 1.2 | 150 | 13 | 1.0 | 5.0 | 3.4E3 |
| Acid Plant Sump; Blast Furnace Blowdown; Slag & Mat Granulation | B | 1.2 | 82 | 10 | 18 | 1.0 | 44 | 11 | 82 | 1.6E3 | 0.2 | 40 | 5.0 | 1.0 | 5.0 | 1.2E3 |
| Blast Furnace Blowdown | B | - | - | 10 | 5 0 | 1.0 | 40 | 5.0 | 33 | 800 | 0.2 | 50 | 5.0 | 1.0 | 5.0 | 1.1E3 |
| Undefined Process Wastes | B | 0.28 | 18 | 27 | 480 | 1.0 | 15E3 | 28 | 29E3 | 50E3 | 1.8 | 740 | 22 | 40 | 90 | 10E3 |

TABLE V-32 (Continued)

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Lead
Concentrations Observed, ug/l

| Plant Process Streams Treated Wastewater | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acid Plant APC; Cooling Tower Blowdown; Stack APC; Slag Granulation (Lime & Settle) | D | 1.3 | 100 | 10 | 10 | 1.0 | 44 | 5.0 | 34 | 925 | 0.2 | 55 | 6.0 | 1.0 | 5.0 | 2.8E3 |
| Undefined Process Wastes (Settle) | B | 0.28 | 18 | 10 | 50 | 1.0 | 430 | 11 | 47 | 390 | 0.3 | 40 | 20 | 1.0 | 46 | 200 |

+ Insufficient information to determine.

TABLE V-33

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Lead
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | NH3 | Non-conventional Pollutants TOC | Phenols | Priority Pollutants Asbestos* CN | Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | A | 1.3 | 100 | - | - | - | - | - | 0.008 | 0.01 | - | - |
| **Raw Wastewater** | B | - | - | 30 | - | - | 0.4 | - | 0.008 | - | - | - |
| Acid Plant APC; Granulation Furnace APC; Leaching; Washdown; Noncontact Cool | C | 2.2 | + | 3.7 | 26 | - | - | 3.3 | 0.0503 | K 0.02 | - | - |
| Acid Plant Cooling Tower Blowdown; Stack APC Water & Slag | A | 0.63 | 47 | 64 | - | - | 1.3 | - | - | - | - | - |
| Granulation | A | 1.3 | 100 | 220 | - | - | 5.0 | - | - | 0.20 | - | - |
| Acid Plant Sump; Blast Furnace Blowdown; Slag & Mat Granulation | B | 1.2 | 82 | 11 | - | - | 0.4 | - | 0.016 | - | - | - |
| Blast Furnace Blowdown | B | - | - | 18 | - | - | 0.5 | - | 0.009 | - | - | - |
| Undefined Process Wastes | B | 0.28 | 18 | 97 | - | - | 2.8 | - | 0.04 | - | - | - |
| **Treated Wastewater** | | | | | | | | | | | | |
| Acid Plant APC; Cooling Tower Blowdown; Stack APC; Slag Granulation (Lime & Settle) | D | 1.3 | 100 | 28 | - | - | 0.4 | - | - | - | - | - |
| Undefined Process Wastes (Settle) | B | 0.28 | 18 | 47 | - | - | 1.8 | - | 0.02 | K 0.001 | - | - |

* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.
+ Insufficient information to determine.

Engineering notation used, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-34. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
*Secondary Lead*

| POLLUTANT | RAW WASTE # of Times Analyzed | # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 4. benzene | 10 | 10 | | | | 7 | 7 | | | |
| 5. benzidine | 5 | 5 | | | | 4 | 4 | | | |
| 7. chlorobenzene | 10 | 10 | | | | 7 | 7 | | | |
| 10. 1,2-dichloroethane | 10 | 9 | 1 | | | 7 | 7 | | | |
| 14. 1,1,2-trichloroethane | 10 | 10 | | | | 7 | 7 | | | |
| 15. 1,1,2,2-tetrachloroethane | 10 | 10 | | | | 7 | 7 | | | |
| 23. chloroform | 10 | 7 | 3 | | | 7 | 3 | 4 | | |
| 29. 1,1-dichloroethylene | 10 | 9 | 1 | | | 7 | 6 | 1 | | |
| 30. 1,2-trans-dichloroethylene | 10 | 10 | | | | 7 | 6 | 1 | | |
| 38. ethylbenzene | 10 | 10 | | | | 7 | 7 | | | |
| 39. fluoranthene | 5 | 3 | 2 | | | 4 | 4 | | | |
| 47. bromoform | 10 | 9 | 1 | | | 7 | 7 | | | |
| 54. isophorone | 5 | 5 | | | | 4 | 4 | | | |
| 55. naphthalene | 5 | 5 | | | | 3 | 3 | | | |
| 56. nitrobenzene | 5 | 4 | 1 | | | 4 | 4 | | | |
| 66. bis(2-ethylhexyl) phthalate | 5 | | 2 | 3 | | 4 | 1 | 3 | | |
| 67. butyl benzyl phthalate | 5 | 4 | 1 | | | 4 | 4 | | | |
| 68. di-n-butyl phthalate | 5 | 2 | 3 | | | 4 | 3 | 1 | | |
| 69. di-n-octyl phthalate | 5 | 3 | 2 | | | 4 | 4 | | | |
| 71. dimethyl phthalate | 5 | 3 | 2 | | | 4 | 4 | | | |
| 73. benzo(a)pyrene | 5 | 4 | 1 | | | 4 | 4 | | | |
| 74. 3,4-benzofluoranthene | 5 | 5 | | | | 4 | 4 | | | |
| 75. 11,12-benzofluoranthene | 5 | 5 | | | | 4 | 4 | | | |
| 76. chrysene | 5 | 3 | 1 | 2 | | 4 | 4 | | | |
| 77. acenaphthylene | 5 | 4 | 1 | | | 4 | 4 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-34. (Continued) INCIDENCE OF OR PRIORITY POLLUTANT
Secondary Lead

| POLLUTANT | RAW WASTE # of Times Analyzed | # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 78. anthracene | 5 | 4 | 1 | | | 4 | 4 | | | |
| 79. 1,12-benzoperylene | 5 | 5 | | | | 4 | 4 | | | |
| 80. fluorene | 5 | 5 | | | | 4 | 4 | | | |
| 81. phenanthrene | 5 | 4 | 1 | | | 4 | 4 | | | |
| 83. indeno(1,2,3-cd)pyrene | 5 | 5 | | | | 4 | 4 | | | |
| 84. pyrene | 5 | 3 | 2 | | | 4 | 4 | | | |
| 86. tetrachloroethylene | 10 | 10 | | | | 7 | 7 | | | |
| 87. toluene | 10 | 10 | | | | 7 | 7 | | | |
| 88. trichloroethylene | 10 | 10 | | | | 7 | 6 | 1 | | |
| 90. aldrin | 5 | 5 | | | | 4 | 4 | | | |
| 91. dieldrin | 5 | 5 | | | | 4 | 4 | | | |
| 92. chlordane | 5 | 5 | | | | 4 | 4 | | | |
| 93. 4,4'-DDT | 5 | 5 | | | | 4 | 4 | | | |
| 94. 4,4'-DDE | 5 | 5 | | | | 4 | 4 | | | |
| 96. alpha endosulfan | 5 | 5 | | | | 4 | 4 | | | |
| 97. beta endosulfan | 5 | 5 | | | | 4 | 4 | | | |
| 99. endrin | 5 | 5 | | | | 4 | 4 | | | |
| 100. endrin aldehyde | 5 | 5 | | | | 4 | 4 | | | |
| 101. heptachlor | 5 | 5 | | | | 4 | 4 | | | |
| 102. heptachlor epoxide | 5 | 5 | | | | 4 | 4 | | | |
| 103. alpha-BHC | 5 | 5 | | | | 4 | 4 | | | |
| 104. beta-BHC | 5 | 5 | | | | 4 | 4 | | | |
| 105. gamma-BHC | 5 | 5 | | | | 4 | 4 | | | |
| 106. delta-BHC | 5 | 5 | | | | 4 | 4 | | | |
| 108. PCB-1254 | 5 | 5 | | | | 4 | 4 | | | |
| 111. PCB-1248 | 5 | 5 | | | | 4 | 4 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-35. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Lead

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 4. benzene | 10 | ND- 2.0 | 0.2 | | 7 | ND- 7.0 | 1.0 | |
| 5. benzidene | 5 | ND- 6.0 | 1.2 | | 4 | ND | | |
| 7. chlorobenzene | 10 | ND- 5.0 | 0.5 | | 7 | ND | | |
| 10. 1,2-dichloroethane | 10 | ND- 10 | 4.0 | 4.0 | 7 | ND- 2.0 | 0.3 | |
| 14. 1,1,2-trichloroethane | 10 | ND | | | 7 | ND- 7.2 | 1.0 | |
| 15. 1,1,2,2-tetrachloroethane | 10 | ND- 4.0 | 1.0 | | 7 | ND | | |
| 23. chloroform | 10 | ND- 31 | 6.9 | 3.0 | 7 | ND-32 | 4.6 | |
| 29. 1,1-dichloroethylene | 10 | ND- 10 | 3.7 | 2.0 | 7 | ND-17 | 2.4 | |
| 30. 1,2-trans-dichloroethylene | 10 | ND | | | 7 | ND-22 | 3.1 | |
| 38. ethylbenzene | 10 | ND- 1.2 | 0.3 | | 7 | ND- 4.0 | 0.6 | |
| 39. fluoranthene | 5 | ND- 27 | 7.6 | 1.0 | 4 | ND | | |
| 47. bromoform | 10 | ND- 49 | 5.7 | | 7 | ND | | |
| 54. isophorone | 5 | ND- 2.7 | 1.8 | | 4 | ND | | |
| 55. naphthalene | 5 | ND- 4.0 | 0.8 | | 4 | ND- 3.0 | 0.8 | |
| 56. nitrobenzene | 5 | ND- 16 | 3.2 | | 4 | ND | | |
| 66. bis(2-ethylhexyl)phthalate | 5 | ND-580 | 180 | 30 | 4 | ND-22 | 5.5 | 9.5 |
| 67. butyl benzyl phthalate | 5 | ND- 85 | 17 | | 4 | ND- 4.0 | 1.0 | |
| 68. di-n-butyl phthalate | 5 | ND- 27 | 12 | 13 | 4 | ND-35 | 9.5 | 1.5 |
| 69. di-n-octyl phthalate | 5 | ND- 27 | 9.0 | 2.0 | 4 | ND- 2.0 | 0.5 | |
| 71. dimethyl phthalate | 5 | ND- 13 | 2.6 | | 4 | ND | | |
| 73. benzo(a)pyrene | 5 | ND- 10 | 2.0 | | 4 | ND | | |
| 74. 3,4-benzofluoranthene | 5 | ND- 5.3 | 1.6 | | 4 | ND | | |
| 75. 11,12-benzofluoranthene | 5 | ND- 5.3 | 1.6 | | 4 | ND | | |
| 76. chrysene | 5 | ND-540 | 140 | 40 | 4 | ND- 2.0 | 0.5 | |
| 77. acenaphthylene | 5 | ND- 35 | 8.6 | 3.0 | 4 | ND | | |
| 78. anthracene | 5 | ND- 20 | 4.0 | | 4 | ND- 2.0 | 0.5 | |
| 79. 1,12-benzoperylene | 5 | ND | | | 4 | ND- 1.0 | 0.3 | |
| 80. fluorene | 5 | ND- 2.0 | 0.4 | | 4 | ND | | |
| 81. phenanthrene | 5 | ND- 20 | 4.6 | | 4 | ND- 2.0 | 0.5 | |
| 83. indeno(1,2,3-cd)pyrene | 5 | ND- 1.0 | 0.2 | | 4 | ND | | |

*Net Concentration - source and blanks subtracted.

TABLE V-35. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Lead

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 84. pyrene | 5 | ND- 38 | 10 | 1.0 | 4 | ND | | |
| 86. tetrachloroethylene | 10 | ND- 5.0 | 1.1 | | 7 | ND- 3.0 | 0.6 | |
| 87. toluene | 10 | ND | | | 7 | ND- 1.0 | 0.3 | |
| 88. trichloroethylene | 10 | ND- 6.0 | 0.8 | | 7 | ND-28 | 4.7 | 1.0 |
| 90. aldrin | 5 | ND- 0.1 | | | 4 | ND | | |
| 91. dieldrin | 5 | ND- 0.2 | | | 4 | ND- 0.4 | 0.1 | 0.2 |
| 92. chlordane | 5 | ND- 0.2 | 0.2 | 0.2 | 4 | ND-31 | 4.6 | 9.0 |
| 93. 4,4'-DDT | 5 | ND- 0.1 | | | 4 | ND- 0.1 | | |
| 94. 4,4'-DDE | 5 | ND- 0.2 | | | 4 | ND- 0.02 | | |
| 96. alpha-endosulfan | 5 | ND- 0.2 | | | 4 | ND | | |
| 97. beta-endosulfan | 5 | ND | | | 4 | ND- 0.1 | | |
| 99. endrin | 5 | ND- 4.0 | 1.0 | | 4 | ND | | |
| 100. endrin aldehyde | 5 | ND- 0.6 | 0.1 | | 4 | ND | | |
| 101. heptachlor | 5 | ND- 0.3 | 0.1 | 0.1 | 4 | ND- 0.3 | 0.1 | |
| 102. heptachlor epoxide | 5 | ND- 0.2 | 0.1 | 0.1 | 4 | ND- 0.1 | | |
| 103. alpha-BHC | 5 | ND- 0.2 | | | 4 | ND- 0.04 | | |
| 104. beta-BHC | 5 | ND- 0.3 | 0.1 | 0.1 | 4 | ND- 0.3 | 0.1 | |
| 105. gamma-BHC | 5 | ND- 0.1 | | | 4 | ND- 0.02 | | |
| 108. PCB-1254 | 5 | ND- 2.6 | 1.3 | 1.8 | 4 | ND- 1.9 | 1.1 | 1.3 |
| 111. PCB-1248 | 5 | ND- 3.1 | 1.4 | 1.3 | 4 | ND- 1.6 | 0.9 | 1.0 |

*Net Concentration - source and blanks subtracted.

TABLE V-36. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Lead

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 10. 1,2-dichloroethane | 1 | 3.0 | 3.0 | 3.0 |
| 23. chloroform | 1 | 15 | 15 | 15 |
| 30. 1,2-trans-dichloroethylene | 3 | 9.0 | 9.0 | 9.0 |
| 66. bis(2-ethylhexyl)phthalate | 1 | 580 | 580 | 580 |
| 67. butyl benzyl phthalate | 1 | 4.0 | 4.0 | 4.0 |
| 68. di-n-butyl phthalate | 1 | 2.0 | 2.0 | 2.0 |
| 69. di-n-octyl phthalate | 1 | 2.0 | 2.0 | 2.0 |
| 73. benzo(a)pyrene | 1 | 1.0 | 1.0 | 1.0 |
| 88. trichloroethylene | 2 | ND- 6.5 | 3.3 | 3.3 |
| 91. dieldrin | 1 | 0.5 | 0.5 | 0.5 |
| 92. chlordane | 1 | 0.1 | 0.1 | 0.1 |
| 93. 4,4'-DDT | 1 | 0.03 | | |
| 94, 4,4'-DDE | 1 | 0.02 | | |
| 101. heptachlor | 1 | 0.1 | 0.1 | 0.1 |
| 104. beta-BHC | 1 | 0.1 | 0.1 | 0.1 |
| 105. gamma-BHC | 1 | 0.01 | | |
| 106. delta-BHC | 1 | 1.2 | 1.2 | 1.2 |
| 109. PCB-1221 | 1 | 1.1 | 1.1 | 1.1 |

TABLE V-37

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Secondary Lead
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| | A | - | - | <100 | <10 | <1.0 | 30 | <5.0 | 10 | 50 | 0.1 | <5.0 | <10 | <20 | <100 | 100 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Battery Electrolyte | A | .002 | 42 | 95E3 | 8.5E3 | 2.0 | 1.0E3 | 400 | 4.0E3 | 80E3 | 1.4 | 1.0E3 | <10 | 320 | 800 | 5.0E3 |
| Battery Electrolyte | B | 0.018 | 4.5 | 18E3 | NR | NR | 3.0E3 | 430 | 1.8E3 | 92E3 | <0.62 | 980 | NR | NR | NR | 7.6E3 |
| Battery Electrolyte | C | .003 | 80 | 77E3 | 9.1E3 | 3.0 | 3.0E3 | 1.0E3 | 6.0E3 | 40E5 | 10.1 | 2.0E3 | <10 | 160 | 1.0E3 | 10E3 |
| + Saw Washdown | C | .003 | 100 | 83E3 | 16E3 | 6.0 | 1.0E3 | 1.0E3 | 10E3 | 7.0E3 | 13 | 2.0E3 | <10 | 70 | 500 | 20E3 |
| Battery Electrolyte; Saw Washdown; Non-Contact Cool; Runoff | D | 0.030 | 100 | 16E3 | 3.0E3 | 30 | 700 | 640 | 3.0E3 | 7.0E3 | 0.6 | 1.0E3 | <2.0 | <250 | 50 | 3.0E3 |
| " | A | 0.004 | 100 | 45E3 | 6.4E3 | 2.0 | 900 | 300 | 3.0E3 | 8.0E3 | 0.7 | 900 | <10 | 40 | 300 | 4.0E3 |
| "; + Battery Breaking APC; Remote Wastes; Oil & Grease in Oxide Manufacture | B | 0.41 | 99 | 1.1E3 | NR | NR | 120 | 100 | 160 | 12E3 | <0.86 | 180 | NR | NR | NR | 590 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Battery Elect.; Saw Washdown (Lime & Settle) + Noncontact Cool; Runoff ($NH_3$, Lime, Settle) | C | 0.003 | 100 | 52 | <10 | <1.0 | 11 | 55 | 25 | 200 | <0.1 | 12 | <10 | <20 | 100 | 100 |
| " | D | 0.030 | 100 | 2.0E3 | 25 | 2.0 | 410 | 32 | 1.2E3 | 4.2E3 | 0.1 | 520 | 5.0 | <25 | <50 | 1.2E3 |
| "; + Battery Breaking APC; Remote Wastes; Oil & Grease in Oxide Manufacture (Lime, Settle) | A | 0.004 | 100 | 2.0E3 | 2.9E3 | <10 | 400 | 200 | 1.0E3 | 6.0E3 | 0.4 | 600 | <10 | <20 | 200 | 3.0E3 |
| | B | 0.41 | 100 | <1.2E3 | NR | NR | 40 | 100 | 40 | 1270 | <0.4 | 190 | NR | NR | NR | 60 |

NR - Data not received from testing laboratory.

Engineering notation used, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-38

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Secondary Lead
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | NH3 | Non-conventional Pollutants Cl | TOC | Phenols | Priority Pollutants Asbestos* CN | Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Raw Wastewater** | | | | | | | | | | | | | |
| Battery Electrolyte | A | 0.002 | 42 | 380 | 10E3 | 59 | - | - | 330 | 0.007 | 0.006 | - | - |
| Battery Electrolyte | B | 0.018 | 4.5 | - | 0.2 | - | - | - | - | <0.004 | <0.01 | - | - |
| Battery Electrolyte & | C | 0.003 | 80 | 170 | 1.4E3 | 7.0 | - | - | 69 | 0.014 | 0.0043 | - | - |
| + Saw Washdown | C | 0.003 | 100 | 140 | 840 | 6.0 | - | - | 70 | 0.01 | 0.006 | - | - |
| Battery Electrolyte; Saw Washdown; Noncontact Cool; Runoff | D | 0.030 | 100 | 65 | 430 | 40 | 12 | - | 4.0 | 0.0083 | 0.002 | 1.3E11 | 3.8E9 |
| " | A | 0.004 | 100 | 153 | 1.1E3 | 25 | - | 79 | 44 | 0.011 | 0.009 | - | - |
| "; + Battery Breaking APC; Remote Wastes; Oil & Grease in Oxide Manufacture | B | 0.41 | 99 | - | 0.05 | - | - | - | - | <0.004 | <0.01 | - | - |
| **Treated Wastewater** | | | | | | | | | | | | | |
| Battery Elect; Saw Washdown (Lime & Settle) & Noncontact Cool; Runoff ($NH_3$, Lime, Settle) | C | 0.0035 | 100 | 59 | 68 | 4.5 | - | - | 34 | 0.005 | 0.001 | - | - |
| | D | 0.030 | 100 | 28 | 180 | 5.3 | 9.6E3 | - | 13 | 0.021 | 0.002 | - | - |
| " | A | 0.004 | 100 | 32 | 350 | 15 | - | 310 | 19 | 0.009 | 0.002 | - | - |
| "; + Battery Breaking APC; Remote Wastes; Oil & Grease in Oxide Manufacture (Lime, Settle) | B | 0.41 | 100 | - | 0.01 | - | - | - | - | <0.004 | <0.01 | - | - |

* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.
Engineering notation, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-39. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Silver

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 5 | 4 | 1 | | | 5 | 5 | | | |
| 4. benzene | 6 | 2 | 2 | 2 | | 9 | 5 | 4 | | |
| 6. carbon tetrachloride | 6 | 5 | | | 1 | 9 | 4 | 1 | 3 | 1 |
| 7. chlorobenzene | 6 | 6 | | | | 9 | 9 | | | |
| 10. 1,2-dichloroethane | 6 | 3 | 1 | 2 | | 9 | 6 | 1 | 2 | |
| 11. 1,1,1-trichloroethane | 6 | 4 | 2 | | | 9 | 9 | | | |
| 15. 1,1,2,2-tetrachloroethane | 4 | 3 | 1 | | | 8 | 6 | 2 | | |
| 23. chloroform | 6 | 3 | 2 | 1 | | 9 | 3 | 1 | 4 | 1 |
| 29. 1,1-dichloroethylene | 6 | 4 | | 1 | 1 | 9 | 6 | 2 | | 1 |
| 30. 1,2-trans-dichloroethylene | 6 | 6 | | | | 9 | 8 | 1 | | |
| 33. 1,3-dichloropropylene | 6 | 6 | | | | 9 | 9 | | | |
| 38. ethylbenzene | 6 | 3 | 3 | | | 9 | 7 | 2 | | |
| 39. fluoranthene | 5 | 5 | | | | 5 | 4 | | 1 | |
| 44. methylene chloride | 6 | 3 | | 1 | 2 | 9 | 7 | | 2 | |
| 47. bromoform | 6 | 5 | 1 | | | 9 | 8 | 1 | | |
| 48. dichlorobromomethane | 6 | 6 | | | | 9 | 6 | | | 3 |
| 51. chlorodibromomethane | 6 | 5 | 1 | | | 9 | 9 | | | |
| 66. bis(2-ethylhexyl) phthalate | 5 | 1 | 4 | | | 5 | | 4 | 1 | |
| 67. butyl benzyl phthalate | 5 | 4 | 1 | | | 5 | 3 | 2 | | |
| 68. di-n-butyl phthalate | 5 | 1 | 3 | 1 | | 5 | 4 | 1 | | |
| 69. di-n-octyl phthalate | 5 | 2 | 3 | | | 5 | 3 | 2 | | |
| 70. diethyl phthalate | 5 | 4 | 1 | | | 5 | 5 | | | |
| 78. anthracene | 5 | 4 | 1 | | | 5 | 5 | | | |
| 81. phenanthrene | 5 | 4 | 1 | | | 5 | 5 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-39. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Silver

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 84. pyrene | 5 | 4 | | | 1 | 5 | 4 | | 1 | |
| 86. tetrachloroethylene | 6 | 1 | 4 | 1 | | 9 | 5 | 4 | | |
| 87. toluene | 6 | 2 | 4 | | | 9 | 8 | 1 | | |
| 88. trichloroethylene | 6 | 1 | 2 | 3 | | 9 | 6 | 1 | 2 | |
| 90. aldrin | 3 | 3 | | | | 2 | 2 | | | |
| 91. dieldrin | 3 | 3 | | | | 2 | 2 | | | |
| 92. chlordane | 3 | 3 | | | | 2 | 2 | | | |
| 93. 4,4'-DDT | 3 | 3 | | | | 2 | 2 | | | |
| 94. 4,4'-DDE | 3 | 3 | | | | 2 | 2 | | | |
| 95. 4,4'-DDD | 3 | 3 | | | | 2 | 2 | | | |
| 99. endrin | 3 | 3 | | | | 2 | 2 | | | |
| 100. endrin aldehyde | 3 | 3 | | | | 2 | 2 | | | |
| 101. heptachlor | 3 | 3 | | | | 2 | 2 | | | |
| 103. alpha-BHC | 3 | 3 | | | | 2 | 2 | | | |
| 104. beta-BHC | 3 | 3 | | | | 2 | 2 | | | |
| 105. gamma-BHC | 3 | 3 | | | | 2 | 2 | | | |
| 106. delta-BHC | 3 | 3 | | | | 2 | 2 | | | |
| 108. PCB-1254 | 3 | 3 | | | | 2 | 2 | | | |
| 111. PCB-1248 | 3 | 3 | | | | 2 | 2 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-40. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Silver

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 5 | ND- 10 | 2.0 | | 5 | ND | | |
| 4. benzene | 6 | 3.0- 160 | 75 | 66 | 9 | ND- 59 | 14 | |
| 6. carbon tetrachloride | 6 | ND- 2.3E3 | 380 | | 9 | ND- 1.7E3 | 310 | 19 |
| 7. chlorobenzene | 6 | ND- 9.0 | 2.8 | 0.5 | 9 | ND- 4.0 | 0.4 | |
| 10. 1,2-dichloroethane | 6 | ND- 560 | 120 | 21 | 9 | ND- 240 | 48 | 2.0 |
| 11. 1,1,1-trichloroethane | 6 | ND- 22 | 7.3 | | 9 | ND- 5.0 | 0.6 | |
| 15. 1,1,2,2-tetrachloroethane | 4 | ND- 32 | 8.0 | | 8 | ND- 25 | 5.9 | |
| 23. chloroform | 6 | ND- 890 | 160 | 8.5 | 9 | ND- 2.9E3 | 438 | 126 |
| 29. 1,1-dichloroethylene | 6 | ND- 6.1E3 | 1.1E3 | | 9 | ND- 3.4E3 | 390 | |
| 30. 1,2-trans-dichloroethylene | 6 | ND | | | 9 | ND- 44 | 4.9 | |
| 38. ethylbenzene | 6 | ND- 21 | 9.2 | | 9 | ND- 14 | 3.9 | |
| 39. fluoranthene | 5 | ND | | | 5 | ND- 200 | 40 | |
| 44. methylene chloride | 6 | ND- 3.1E3 | 1.0E3 | 170 | 9 | ND- 790 | 160 | |
| 47. bromoform | 6 | ND- 65 | 11 | | 9 | ND- 13 | 1.4 | |
| 51. chlorodibromomethane | 6 | ND- 64 | 11 | | 9 | ND- 2.8E3 | 750 | |
| 55. naphthalene | 5 | ND- 1.0 | 0.2 | | 5 | ND | | |
| 66. bis(2-ethylhexyl)phthalate | 5 | 7.0- 34 | 18 | 11 | 5 | 3.4- 120 | 37 | 17 |
| 67. butyl benzyl phthalate | 5 | ND- 53 | 11 | | 5 | ND- 52 | 18 | 1.0 |
| 68. di-n-butyl phthalate | 5 | ND- 300 | 75 | 15 | 5 | ND- 79 | 19 | 7.0 |
| 69. di-n-octyl phthalate | 5 | ND- 58 | 30 | 33 | 5 | ND- 69 | 16 | |
| 70. diethyl phthalate | 5 | ND- 38 | 7.6 | | 5 | ND | | |
| 78. anthracene | 5 | ND- 4.0 | 0.8 | | 5 | ND | | |
| 81. phenanthrene | 5 | ND- 4.0 | 0.8 | | 5 | ND | | |
| 84. pyrene | 5 | ND- 2.1E3 | 430 | | 5 | ND- 180 | 36 | |
| 86. tetrachloroethylene | 6 | ND- 109 | 43 | 36 | 9 | ND- 35 | 8.3 | |
| 87. toluene | 6 | 3.0- 55 | 21 | 18 | 9 | ND- 19 | 2.7 | |
| 88. trichloroethylene | 6 | ND- 900 | 360 | 230 | 9 | ND- 330 | 51 | |
| 90. aldrin | 3 | ND- 1.1 | 0.4 | | 2 | ND | | |
| 91. dieldrin | 3 | ND- 0.01 | | | 2 | ND- 0.1 | | |

*Net Concentration - source and blanks subtracted.
Scientific Notation Used, i.e. 2300 = 2.3E3

TABLE V-40. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Silver

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE Range* (ug/l) | RAW WASTE Mean* (ug/l) | RAW WASTE Median* (ug/l) | TREATED WASTE # of Times Analyzed | TREATED WASTE Range* (ug/l) | TREATED WASTE Mean* (ug/l) | TREATED WASTE Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 92. chlordane | 3 | ND- 0.1 | | | 2 | ND- 0.1 | 0.1 | 0.1 |
| 93. 4,4'-DDT | 3 | ND- 0.01 | | | 2 | 0.02- 0.03 | | |
| 94. 4,4'-DDE | 3 | ND- 0.01 | | | 2 | ND- 0.01 | | |
| 95. 4,4'-DDD | 3 | ND- 0.1 | | | 2 | ND- 0.01 | | |
| 99. endrin | 3 | ND- 2.0 | 0.7 | | 2 | ND- 0.2 | 0.1 | 0.1 |
| 100. endrin aldehyde | 3 | ND | | | 2 | ND- 0.5 | 0.2 | 0.2 |
| 101. heptachlor | 3 | ND- 0.02 | | | 2 | 0.01- 0.04 | | |
| 103. alpha-BHC | 3 | ND | | | 2 | ND- 0.1 | | |
| 104. beta-BHC | 3 | ND- 0.02 | | | 2 | 0.01- 0.04 | | |
| 105. gamma-BHC | 3 | ND | | | 2 | ND- 0.03 | | |
| 106. delta-BHC | 3 | ND- 1.1 | 0.4 | | 2 | ND | | |
| 108. PCB-1254 | 3 | ND- 0.7 | 0.2 | | 2 | 0.2 - 2.6 | 1.4 | 1.4 |
| 111. PCB-1248 | 3 | ND- 0.5 | 0.2 | | 2 | 0.3 - 1.9 | 1.1 | 1.1 |

*Net Concentration - source and blanks subtracted.

TABLE V-41. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Secondary Silver

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 23. chloroform | 2 | 10.0 -21 | 16 | 16 |
| 66. bis(2-ethylhexyl)phthalate | 2 | 4.0 -16.0 | 10 | 10 |
| 67. butyl benzyl phthalate | 2 | ND- 1.0 | 0.5 | 0.5 |
| 68. di-n-butyl phthalate | 2 | 1.0 - 2.0 | 1.5 | 1.5 |
| 69. di-n-octyl phthalate | 2 | ND- 1.0 | 0.5 | 0.5 |
| 86. tetrachloroethylene | 2 | 2.0 -11.0 | 6.5 | 6.5 |
| 87. toulene | 2 | ND- 1.0 | 0.5 | 0.5 |
| 91. dieldrin | 2 | 0.01- 0.1 | | |
| 92. chlordane | 2 | 0.02- 0.04 | | |
| 93. 4,4'-DDT | 2 | 0.01- 0.02 | | |
| 94, 4,4'-DDE | 2 | ND- 0.01 | | |
| 99. endrin | 2 | ND- 0.02 | | |
| 100. endrin aldehyde | 2 | ND- 0.5 | 0.2 | 0.2 |
| 101. hpetachlor | 2 | 0.02- 0.1 | | |
| 102. heptachlor epoxide | 2 | ND- 0.01 | | |
| 104. beta-BHC | 2 | 0.02- 0.1 | | |
| 105. gamma-BHC | 2 | ND- 0.01 | | |
| 108. PCB-1254 | 2 | 0.5 - 0.8 | 0.7 | 0.7 |
| 111. PCB-1248 | 2 | 0.4 - 0.7 | 0.5 | 0.5 |

TABLE V-42

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Secondary Silver
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| | A | - | - | K 100 | K 10 | 1.0 | 2.0 | 5.0 | 200 | K 20 | K 0.1 | K 5.0 | K 10 | K 20 | K 100 | K 60 |
| Tap in Lab | B | - | - | K 100 | K 10 | K 1.0 | K 2.0 | K 5.0 | 40 | K 20 | 0.2 | K 5.0 | K 10 | K 20 | K 100 | K 60 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Metal Depleted Soln; Spent Electrolyte; Washdown | A | 0.91E-3 | + | K 100 | 50 | K 1.0 | 1.0E3 | 2.0E3 | 70E3 | 4E3 | K 0.1 | 30E3 | K 10 | 430 | K 100 | 20E3 |
| Spent Plant Liquor; Contact Cool; APC after Filter | B | 0.0026 | 100 | K 100 | 50 | 20 | 80E3 | 20E3 | 60E3 | 50E3 | 0.1 | 0.8E6 | K 10 | 4.7E3 | 100 | 2.0E6 |
| Ag Slurry Supernatant; APC Filtrate; Complexing Agents & Polymers | C | 0.70E-3 | 25 | 0.12E6 | 2E3 | K 20 | 370 | 0.10E6 | 30E3 | 9.0E3 | 17 | K 500 | 900 | K 250 | 400 | 20E3 |
| Film Waste Influent | C | .0021 | 76 | 700 | 200 | K 20 | 5.0E3 | 9.0E3 | 2.0E3 | 2.0E3 | 3.2 | 1.0E3 | 600 | K 250 | 650 | 4.0E3 |
| Sludge Tank Influent | C | 0.69E-3 | 24 | 1.5E3 | 2E3 | K 20 | 650 | 7.0E3 | 720 | 6.0E3 | 0.8 | 2.0E3 | 250 | K 250 | 200 | 10E3 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Metal Depleted Soln; Spent Electrolyte; Washdown (NaOH, Settle) | A | 0.75E-3 | + | 1.5E3 | 1.3E3 | K 10 | 2.0E3 | 8.0E3 | 0.30E6 | 20E3 | 0.1 | 60E3 | K 10 | 7E3 | K 100 | 30E3 |
| Spent Plant Liquor; Contact Cool; APC after Filter (Lime, $FeCl_2$, $AlCl_x$, Settle) | B | 0.0026 | 100 | K 100 | K 10 | 10 | 100 | K 50 | 600 | K 200 | 0.1 | K 50 | K 10 | K 20 | 100 | 1.0E3 |

TABLE V-42 (Continued)

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Secondary Silver
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neutralization Tank Effluent (NaOH or Acid, Polymer, Settle, Filter) | C | 0.0028 | 100 | 450 | 700 | <20 | 3.0E3 | 8.0E3 | 1.0E3 | 3.0E3 | 1.6 | 4.0E3 | 400 | <250 | 640 | 5.0E3 |
| Filtered Spent Hypo Soln (Filter) | D | 0.12E-3 | 100 | 100 | <30 | <10 | 6.0E3 | 300 | 1.0E3 | 500 | 1.0 | 400 | <40 | 9.2E3 | 200 | 0.20E6 |

+ Insufficient information to determine.
Plants A and B are in the non-photographic waste processing subcategory. All other streams are in the photographic subcategory.
Engineering notation, i.e. $1.3E6 = 1.3 \times 10^6$.

TABLE V-43

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Secondary Silver
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants | | | | Non-conventional Pollutants | | | | Priority Pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COD | TSS | O & G | NH3 | Cl | F | TOC | Phenols | CN | Asbestos* Total | Chrys. |
| Source Water | A | - | - | K 5.0 | 14 | - | - | 1.3 | - | 7.0 | - | - | - | - |
| Tap in lab. | B | - | - | K 5.0 | K 1.0 | - | - | 41 | - | 5.0 | - | - | - | - |
| **Raw Wastewater** | | | | | | | | | | | | | | |
| Metal Depleted Soln; Spent Electrolyte; Washdown | A | 0.91E-3 | + | 3.0E3 | 120 | 17 | 1500 | - | 1.2 | 440 | 0.02 | 0.05 | - | - |
| Spent Plant Liquor; Contact Cool; APC after filter | B | 0.0026 | 100 | 230 | 110 | 8.0 | 12.0 | 32E3 | - | 24 | 0.04 | 0.001 | - | - |
| Ag slurry supernatant; APC filtrate; Complexing Agents & Polymers | C | 0.70E-3 | 25 | 10E3 | 3.7E3 | 110 | - | - | - | 4.0E3 | 0.20 | 6.0 | 8.4E9 | 2.5E9 |
| Film Waste Influent | C | 0.0021 | 76 | 15E3 | 480 | 132 | - | - | - | 13E3 | 26 | 1.4 | 0.38E9 | 0.11E9 |
| Sludge Tank Influent | C | 0.69E-3 | 24 | 6.5E3 | 160 | 20 | - | - | - | 2.4E3 | 62 | 0.31 | 0.55E9 | 91E6 |
| **Treated Wastewater** | | | | | | | | | | | | | | |
| Metal Depleted Soln; Spent Electrolyte; Washdown (NaOH, Settle) | A | 0.75E-3 | + | 231 | 3.1E3 | 32 | 2.4E3 | - | 2.4 | 97 | 0.02 | 0.05 | - | - |
| Spent Plant Liquor; Contact Cool; APC after Filter (Lime, $FeCl_2$, $AlCl_x$, Settle) | B | 0.0026 | 100 | K 5.0 | 10 | 10 | 0.6 | 670 | - | K 1.0 | 0.01 | 0.001 | - | - |

TABLE V-43 (Continued)

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Secondary Silver
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants | | | Non-conventional Pollutants | | | | | Priority Pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COD | TSS | O & G | NH3 | Cl | F | TOC | Phenols | CN | Asbestos* Total | Chrys. |
| Neutralization Tank Effluent (NaOH or Acid, Polymer, Settle, Filter) | C | 0.0028 | 100 | 30E3 | 120 | 67 | - | - | - | 14E3 | 25 | 1.5 | - | - |
| Filtered Spent Hypo Soln (Filter) | D | 0.12E-3 | 100 | 41E3 | 92 | 3.0 | 5.6E3 | 730 | - | 3.1E3 | - | <0.025 | - | - |

+ Insufficient information to determine.
* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.
Plants A and B are in the non-photographic waste processing subcategory. All other streams are in the photographic subcategory.
Engineering notation, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-44. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Tungsten

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 5 | 4 | | 1 | | 2 | 2 | | | |
| 4. benzene | 9 | 9 | | | | 4 | 3 | 1 | | |
| 7. chlorobenzene | 9 | 9 | | | | 4 | 4 | | | |
| 8. 1,2,4-trichlorobenzene | 5 | 5 | | | | 2 | 2 | | | |
| 9. hexachlorobenzene | 5 | 5 | | | | 2 | 2 | | | |
| 10. 1,2-dichloroethane | 9 | 9 | | | | 4 | 2 | 2 | | |
| 11. 1,1,1-trichloroethane | 9 | 8 | 1 | | | 4 | 4 | | | |
| 14. 1,1,2-trichloroethane | 9 | 9 | | | | 4 | 4 | | | |
| 15. 1,1,2,2-tetrachloroethane | 9 | 8 | 1 | | | 4 | 4 | | | |
| 23. chloroform | 9 | 7 | 1 | | 1 | 4 | 2 | 1 | 1 | |
| 29. 1,1-dichloroethylene | 9 | 7 | 2 | | | 4 | 2 | 2 | | |
| 30. 1,2-trans-dichloroethylene | 9 | 9 | | | | 4 | 4 | | | |
| 38. ethylbenzene | 9 | 9 | | | | 4 | 4 | | | |
| 39. fluoranthene | 5 | 5 | | | | 2 | 2 | | | |
| 47. bromoform | 9 | 7 | 2 | | | 4 | 4 | | | |
| 48. dichlorobromomethane | 9 | 9 | | | | 4 | 3 | 1 | | |
| 51. chlorodibromomethane | 9 | 8 | 1 | | | 4 | 4 | | | |
| 54. isophorone | 5 | 5 | | | | 2 | 2 | | | |
| 55. naphthalene | 5 | 4 | | 1 | | 2 | 1 | 1 | | |
| 56. nitrobenzene | 5 | 5 | | | | 2 | 2 | | | |
| 66. bis(2-ethylhexyl) phthalate | 5 | 1 | 3 | 1 | | 2 | | 1 | 1 | |
| 67. butyl benzyl phthalate | 5 | 5 | | | | 2 | 2 | | | |
| 68. di-n-butyl phthalate | 5 | 3 | 2 | | | 2 | | 2 | | |
| 69, di-n-octyl phthalate | 5 | 4 | 1 | | | 2 | 1 | 1 | | |
| 70. diethyl phthalate | 5 | 5 | | | | 2 | 1 | 1 | | |

*Gross Concentration - blanks subtracted.

TABLE V-44. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Tungsten

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 71. dimethyl phthalate | 5 | 5 | | | | 2 | 1 | | 1 | |
| 73. benzo(a)pyrene | 5 | 5 | | | | 2 | 2 | | | |
| 76. chrysene | 5 | 4 | | 1 | | 2 | 2 | | | |
| 77. acenaphthylene | 5 | 4 | | 1 | | 2 | 2 | | | |
| 78. anthracene | 5 | 4 | | 1 | | 2 | 2 | | | |
| 79. 1,12-benzoperylene | 5 | 5 | | | | 2 | 2 | | | |
| 80. fluorene | 5 | 4 | 1 | | | 2 | 2 | | | |
| 81. phenanthrene | 5 | 4 | | 1 | | 2 | 2 | | | |
| 84. pyrene | 5 | 5 | | | | 2 | 1 | 1 | | |
| 86. tetrachloroethylene | 9 | 4 | 5 | | | 4 | 3 | 1 | | |
| 87. toluene | 9 | 7 | 2 | | | 4 | 4 | | | |
| 88. trichloroethylene | 9 | 7 | 2 | | | 4 | 1 | 3 | | |
| 89. vinyl chloride | 9 | 9 | | | | 4 | 4 | | | |
| 90. aldrin | 5 | 5 | | | | 2 | 2 | | | |
| 91. dieldrin | 5 | 5 | | | | 2 | 2 | | | |
| 92. chlordane | 5 | 5 | | | | 2 | 2 | | | |
| 93. 4,4'-DDT | 5 | 5 | | | | 2 | 2 | | | |
| 95. 4,4'-DDD | 5 | 5 | | | | 2 | 2 | | | |
| 96. alpha-endosulfan | 5 | 4 | 1 | | | 2 | 2 | | | |
| 97. beta-endosulvan | 5 | 4 | 1 | | | 2 | 2 | | | |
| 99. endrin | 5 | 5 | | | | 2 | 2 | | | |
| 100. endrin aldehyde | 5 | 5 | | | | 2 | 2 | | | |
| 101. heptachlor | 5 | 5 | | | | 2 | 2 | | | |
| 102. heptachlor epoxide | 5 | 5 | | | | 2 | 2 | | | |
| 103. alpha-BHC | 5 | 5 | | | | 2 | 2 | | | |
| 104. beta-BHC | 5 | 5 | | | | 2 | 2 | | | |
| 105. gamma-BHC | 5 | 5 | | | | 2 | 2 | | | |
| 108. PCB-1254 | 5 | 5 | | | | 2 | 2 | | | |
| 111. PCB-1248 | 5 | 5 | | | | 2 | 2 | | | |

*Gross Concentration - blanks subtracted.

TABLE V-45. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Tungsten

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE Range* (ug/l) | RAW WASTE Mean* (ug/l) | RAW WASTE Median* (ug/l) | TREATED WASTE # of Times Analyzed | TREATED WASTE Range* (ug/l) | TREATED WASTE Mean* (ug/l) | TREATED WASTE Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 5 | ND- 100 | 21 | | 2 | ND | | |
| 4. benzene | 9 | ND- 3.0 | 0.7 | | 4 | ND- 17 | 8.0 | 7.5 |
| 7. chlorobenzene | 9 | ND | | | 4 | ND- 1.0 | | |
| 8. 1,2,4-trichlorobenzene | 5 | ND | | | 2 | 4.0- 5.5 | 4.8 | 4.8 |
| 10. 1,2-dichloroethane | 9 | ND- 8.0 | 2.1 | | 4 | ND- 29 | 11 | 7.5 |
| 11. 1,1,1-trichloroethane | 9 | ND- 10 | 1.1 | | 4 | ND | | |
| 15. 1,1,2,2-tetrachloroethane | 9 | ND- 35 | 5.2 | | 4 | ND- 9.0 | 5.0 | 5.3 |
| 23. chloroform | 9 | ND- 1.8E3 | 210 | | 4 | ND-870 | 230 | 29 |
| 29. 1,1-dichloroethylene | 9 | ND- 19 | 4.3 | | 4 | ND- 29 | 12 | 10 |
| 30. 1,2-trans-dichloroethylene | 9 | ND- 2.0 | 0.2 | | 4 | ND- 2.0 | 0.5 | |
| 38. ethylbenzene | 9 | ND- 11 | 2.2 | | 4 | ND- 1.0 | 0.3 | |
| 39. fluoranthene | 5 | ND- 1.0 | 0.2 | | 2 | ND- 1.0 | 0.5 | 0.5 |
| 47. bromoform | 9 | ND- 48 | 9.3 | | 4 | ND | | |
| 48. dichlorobromomethane | 9 | ND | | | 4 | ND- 12 | 6.0 | 6.0 |
| 51. chlorodibromomethane | 9 | ND- 38 | 4.2 | | 4 | ND | | |
| 54. isophorone | 5 | ND | | | 2 | ND- 6.0 | 3.0 | 3.0 |
| 55. naphthalene | 5 | ND- 1.1E3 | 220 | | 2 | ND- 32 | 16 | 16 |
| 56. nitrobenzene | 5 | ND | | | 2 | ND- 5.5 | 2.8 | 2.8 |
| 66. bis(2-ethylhexyl)phthalate | 5 | ND- 880 | 180 | 10.0 | 2 | 32.0-730 | 380 | 380 |
| 68. di-n-butyl phthalate | 5 | ND- 23 | | | 2 | 22.0- 66 | 44 | 44 |
| 69. di-n-octyl phthalate | 5 | ND- 1.0 | 0.2 | | 2 | ND- 43 | 22 | 22 |
| 70. diethyl phthalate | 5 | ND | | | 2 | ND- 16 | 8.0 | 8.0 |
| 71. dimethyl phthalate | 5 | ND | | | 2 | ND-230 | 120 | 120 |
| 73. benzo(a)pyrene | 5 | ND- 1.0 | 0.2 | | 2 | ND- 1.0 | 0.5 | 0.5 |
| 76. chrysene | 5 | ND- 240 | 48 | | 2 | ND | | |
| 77. acenaphthylene | 5 | ND- 110 | 23 | | 2 | ND | | |
| 78. anthracene | 5 | ND- 150 | 30 | | 2 | ND- 8.0 | 4.0 | 4.0 |

*Net Concentration - source and blanks subtracted.
Scientific Notation Used, i.e. 1800 = 1.8E3

TABLE V-45. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Tungsten

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 80. fluorene | 5 | ND- 55 | 11 | | 2 | ND | | |
| 81. phenanthrene | 5 | ND | | | 2 | ND- 8.0 | 4.0 | 4.0 |
| 84. pyrene | 5 | ND | | | 2 | ND- 15 | 7.5 | 7.5 |
| 86. tetrachloroethylene | 9 | ND- 69 | 20 | | 4 | 3.0- 20 | 9.3 | 7.0 |
| 87. toluene | 9 | ND- 45 | 11 | 3.0 | 4 | ND- 1.0 | 0.3 | |
| 88. trichloroethylene | 9 | ND- 19 | 2.9 | | 4 | ND- 88 | 41 | 38 |
| 90. aldrin | 5 | ND- 7.0 | 1.4 | | 2 | ND | | |
| 91. dieldrin | 5 | ND- 0.1 | 0.1 | | 2 | ND | | |
| 92. chlordone | 5 | ND- 1.2 | 0.2 | | 2 | ND- 0.5 | 0.3 | 0.3 |
| 93. 4,4'-DDT | 5 | ND- 0.1 | | | 2 | ND | | |
| 95. 4,4'-DDD | 5 | ND | | | 2 | ND- 0.2 | 0.1 | 0.1 |
| 96. alpha-endosulfan | 5 | ND- 15 | 3.2 | 0.1 | 2 | ND- 0.6 | 0.3 | 0.3 |
| 97. beta-endosulfan | 5 | ND- 15 | 3.1 | | 2 | ND- 0.2 | 0.1 | 0.1 |
| 99. endrin | 5 | ND- 0.8 | 0.2 | | 2 | ND | | |
| 100. endrin aldehyde | 5 | ND- 0.9 | 0.3 | 0.2 | 2 | ND | | |
| 101. heptachlor | 5 | ND- 0.2 | 0.1 | | 2 | ND | | |
| 102. heptachlor epoxide | 5 | ND- 0.2 | 0.1 | | 2 | ND | | |
| 103. alpha-BHC | 5 | ND- 0.6 | 0.1 | | 2 | ND | | |
| 104. beta-BHC | 5 | ND- 0.2 | 0.1 | | 2 | ND | | |
| 105. gamma-BHC | 5 | ND- 0.2 | 0.1 | | 2 | ND- 0.1 | | |
| 108. PCB-1254 | 5 | ND- 5.4 | 1.4 | 0.4 | 2 | ND- 1.9 | 1.0 | 1.0 |
| 111. PCB-1248 | 5 | ND- 1.0 | 0.3 | 0.2 | 2 | ND- 2.4 | 1.2 | 1.2 |

*Net Concentration - source and blanks subtracted.

TABLE V-46. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Tungsten

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 4. benzene | 2 | ND- 8.0 | 4.0 | 4.0 |
| 7. chlorobenzene | 2 | ND- 8.0 | 4.0 | 4.0 |
| 15. 1,1,2,2-tetrachloroethane | 2 | ND- 5.0 | 2.5 | 2.5 |
| 23. chloroform | 2 | 5.0 - 75 | 40 | 40 |
| 39. fluoranthene | 2 | ND- 47 | 24 | 24 |
| 55. naphthalene | 2 | ND- 1.0 | 0.5 | 0.5 |
| 66. bis(2-ethylhexyl)phthalate | 2 | 58.0 - 60 | 59 | 59 |
| 67. butyl benzyl phthalate | 2 | ND- 17 | 8.5 | 8.5 |
| 68. di-n-butyl phthalate | 2 | 11.0 -140 | 75 | 75 |
| 69. di-n-octyl phthalate | 2 | ND- 37 | 19 | 19 |
| 73. benzo(a)pyrene | 2 | ND- 1.0 | 0.5 | 0.5 |
| 76. chrysene | 2 | ND- 8.0 | 4.0 | 4.0 |
| 78. anthracene | 2 | ND- 16 | 8.0 | 8.0 |
| 79. 1,12-benzoperylene | 2 | ND- 2.0 | 1.0 | 1.0 |
| 80. fluorene | 2 | ND- 5.0 | 2.5 | 2.5 |
| 81. phenanthrene | 2 | ND- 16 | 8.0 | 8.0 |
| 82. 1,2,5,6-dibenzanthracene | 2 | ND- 4.0 | 2.0 | 2.0 |
| 83. indeno(1,2,3-cd)pyrene | 2 | ND- 4.0 | 2.0 | 2.0 |
| 84. pyrene | 2 | 1.0 - 46 | 24 | 24 |
| 86. tetrachloroethylene | 2 | 2.0 - 4.0 | 3.0 | 3.0 |
| 88. trichloroethylene | 2 | ND- 43 | 22 | 22 |
| 90. aldrin | 2 | ND- 0.02 | | |
| 91. dieldrin | 2 | ND- 0.04 | | |
| 92. chlordan | 2 | - 0.2 | 0.2 | 0.2 |
| 93. 4,4-DDT | 2 | 0.02- 0.04 | | |
| 94. 4,4-DDE | 2 | 0.01- 0.02 | | |
| 95. 4,4-DDD | 2 | ND- 0.02 | | |

TABLE V-46. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Tungsten

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 96. alpha-endosulfan | 2 | ND- 0.02 | | |
| 101. heptachlor | 2 | 0.06- 0.07 | 0.1 | 0.1 |
| 102. heptachlor epoxide | 2 | ND- 0.04 | | |
| 104. beta-BHC | 2 | 0.06- 0.07 | 0.1 | 0.1 |
| 105. gamma-BHC | 2 | ND- 0.01 | | |
| 106. delta-BHC | 2 | ND- 0.02 | | |
| 108. PCB-1254 | 2 | 0.07- 1.7 | 1.2 | 1.2 |
| 111. PCB-1248 | 2 | 0.6 - 1.5 | 1.1 | 1.1 |

TABLE V-47

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Tungsten
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| | A | - | - | K 100 | K 10 | K 1.0 | K 2.0 | K 5.0 | K 10 | K 20 | K 0.1 | K 5.0 | K 10 | K 20 | K 100 | 100 |
| | B | - | - | K 100 | K 10 | K 1.0 | 8.0 | K 5.0 | 10 | K 20 | K 0.1 | K 5.0 | K 10 | 20 | K 100 | 80 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Ion Exchange Raffinate | A | 0.12 | + | 100 | 220 | K 10 | K 20 | K 50 | 100 | K 200 | 0.3 | K 50 | K 10 | 100 | K 100 | K 600 |
| Tungstic Acid ppt. Supernatant & Rinsewater | A | 0.0059 | + | 100 | 130 | K 10 | 30 | 100 | 200 | K 200 | 0.5 | K 50 | K 10 | 20 | K 100 | 1.0E3 |
| Tungstic Acid ppt. Rinsewater | B | 0.034 | 100 | K 100 | 7.2E3 | 30 | 200 | 2.0E3 | 5.0E3 | 20E3 | 1.1 | 1.0E3 | 30 | 290 | 700 | 2.0E3 |
| Tungstic & Dilute HCL Acid Washes; Furnace APC | C | 0.36 | 52 | 800 | 20 | K 2.0 | K 20 | 44 | 120 | 240 | 3.0 | 92 | 1.0E3 | 86 | 200 | 250 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Tungstic Acid Rinsewater (Lime & Settle) | B | 0.034 | 100 | K 100 | 80 | K 10 | 80 | K 50 | 70 | K 200 | NT | 100 | K 10 | 30 | 900 | K 600 |

TABLE V-47 (Continued)

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Tungsten
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tungstic & Dilute HCL Acid Washes; Furnace APC (Lime, Polymer, Acid, Settle) + Cooling Tower Blowdown; Graphite Lubricant; Wire Wash; $H_2$ recycle and Acidic Wash Soln from Doping Operation (+ Soda Ash) | C | 0.36 | 52 | K 2 | K 2 | K 2 | K 20 | K 24 | 150 | 220 | 0.2 | 110 | 90 | K 25 | 220 | 240 |
| | C | 0.68 | 100 | K 2.0 | 18 | K 2.0 | K 20 | 430 | 64 | 140 | 0.63 | K 50 | 10 | K 25 | NR | 83 |

NR Data not received from testing laboratory.

\+ Insufficient information to determine.

Engineering notation used, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-48

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Tungsten
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants | | | | Non-conventional Pollutants | | | Priority Pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COD | TSS | O & G | NH3 | Cl | TOC | Phenols | CN | Asbestos* Total | Chrys. |
| **Raw Wastewater** | | | | | | | | | | | | | |
| Ion Exchange Raffinate | A | 0.12 | + | 130 | 43 | 7.0 | 950 | - | 28 | 0.039 | 0.002 | - | - |
| Tungstic Acid Ppt Supernatant and Rinsewater | A | 0.0059 | + | 22 | 19 | 2.0 | - | 17E3 | 4.0 | 0.029 | K 0.001 | - | - |
| Tungstic Acid Ppt Rinsewater | B | 0.034 | 100 | 320 | 210 | 6.3 | 3.9 | 26E3 | 6.0 | 0.089 | 0.013 | - | - |
| Tungstic & Dilute HCL Acid Washes; Furnace APC | C | 0.36 | 52 | 880 | 6.7E3 | 17 | 1.6E3 | - | 270 | 0.038 | 0.14 | 6.0E9 | 1.1E9 |
| **Treated Wastewater** | | | | | | | | | | | | | |
| Tungstic Acid Rinsewater (Lime & Settle) | B | 0.034 | 100 | 53 | 150 | 4.6 | 5.2 | 19E3 | 10 | 0.91 | 0.0037 | - | - |

TABLE V-48 (Continued)

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Tungsten
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | $NH_3$ | Non-conventional Pollutants CL | TOC | Phenols | Priority Pollutants CN | Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tungstic & Dilute HCL Acid Washes; Furnace APC (Lime, Polymer, Acid, Settle) + Cooling Tower Blowdown; Graphite Lubricant; Wire Wash; $H_2$ recycle and acidic wash soln from doping operation (+ Soda Ash) | C | 0.36 | 52 | 240 | 370 | 11 | 1.1E3 | - | 61 | 0.01 | 0.37 | - | - |
| | C | 0.68 | 100 | 100 | 91 | 10.3 | 310 | - | 33 | 0.011 | 0.11 | - | - |

* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.
+ Insufficient information to determine.

Engineering notation, i.e. 1.3E6 = $1.3 \times 10^6$.

TABLE V-49. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Zinc

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. acenaphthene | 9 | 9 | | | | 11 | 11 | | | |
| 4. benzene | 9 | 8 | 1 | | | 11 | 11 | | | |
| 8. 1,2,4-trichlorobenzene | 9 | 9 | | | | 11 | 10 | 1 | | |
| 9. hexachlorobenzene | 9 | 8 | | 1 | | 11 | 11 | | | |
| 10. 1,2-dichloroethane | 9 | 8 | 1 | | | 11 | 11 | | | |
| 13. 1,1-dichloroethane | 9 | 8 | | 1 | | 11 | 11 | | | |
| 19. 2-chloroethyl vinyl ether | 9 | 9 | | | | 11 | 11 | | | |
| 20. 2-chloronaphthalene | 9 | 9 | | | | 11 | 11 | | | |
| 21. 2,4,6-trichlorophenol | 9 | 9 | | | | 11 | 11 | | | |
| 23. chloroform | 9 | 6 | 2 | 1 | | 11 | 10 | 1 | | |
| 28. 3,3-dichlorobenzidine | 9 | 9 | | | | 11 | 11 | | | |
| 29. 1,1-dichloroethylene | 9 | 8 | 1 | | | 11 | 11 | | | |
| 38. ethylbenzene | 9 | 9 | | | | 11 | 11 | | | |
| 39. fluroanthene | 9 | 8 | 1 | | | 11 | 11 | | | |
| 44. methylene chloride | 9 | 5 | | 3 | 1 | 11 | 11 | | | |
| 47. bromoform | 9 | 9 | | | | 11 | 10 | 1 | | |
| 48. dichlorobromomethane | 9 | 9 | | | | 11 | 11 | | | |
| 49. trichlorofluoromethane | 9 | 8 | | 1 | | 11 | 11 | | | |
| 54. isophorone | 9 | 8 | 1 | | | 11 | 11 | | | |
| 55. naphthalene | 9 | 9 | | | | 11 | 11 | | | |
| 56. nitrobenzene | 9 | 9 | | | | 11 | 11 | | | |
| 64. pentachlorophenol | 9 | 9 | | | | 11 | 11 | | | |
| 66. bis(2-ethylhexyl) phthalate | 9 | 3 | 5 | 1 | | 11 | 7 | 3 | 1 | |
| 67. butyl benzyl phthalate | 9 | 8 | 1 | | | 11 | 11 | | | |
| 68. di-n-butyl phthalate | 9 | 8 | 1 | | | 11 | 10 | 1 | | |

*Gross Concentration - blanks subtracted.

TABLE V-49. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Zinc

| POLLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ | TREATED WASTE # of Times Analyzed | TREATED WASTE # of Times Observed (ug/l)* ND-10 | 11-100 | 101-1000 | 1000+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 69. di-n-octyl phthalate | 9 | 9 | | | | 11 | 11 | | | |
| 70. diethyl phthalate | 9 | 8 | 1 | | | 11 | 11 | | | |
| 71. dimethyl phthalate | 9 | 8 | 1 | | | 11 | 11 | | | |
| 72. 1,2-benzanthracene | 9 | 9 | | | | 11 | 11 | | | |
| 73. benzo(a)pyrene | 9 | 9 | | | | 11 | 11 | | | |
| 76. chrysene | 9 | 8 | 1 | | | 11 | 11 | | | |
| 77. acenaphthalene | 9 | 8 | 1 | | | 11 | 11 | | | |
| 78. anthracene | 9 | 9 | | | | 11 | 11 | | | |
| 80. fluorene | 9 | 8 | 1 | | | 11 | 11 | | | |
| 81. phenanthrene | 9 | 9 | | | | 11 | 11 | | | |
| 84. pyrene | 9 | 7 | 2 | | | 11 | 11 | | | |
| 86. tetrachloroethylene | 9 | 9 | | | | 11 | 10 | 1 | | |
| 87. toluene | 9 | 8 | 1 | | | 11 | 11 | | | |
| 88. trichloroethylene | 9 | 8 | | 1 | | 11 | 10 | 1 | | |
| 91. dieldrin | 9 | 9 | | | | 11 | 11 | | | |
| 92. chlordane | 9 | 9 | | | | 11 | 11 | | | |
| 93. 4,4'-DDT | 9 | 9 | | | | 11 | 11 | | | |
| 94. 4,4'-DDE | 9 | 9 | | | | 11 | 11 | | | |
| 95. 4,4'-DDD | 9 | 9 | | | | 11 | 11 | | | |
| 97. beta-endosulfan | 9 | 9 | | | | 11 | 11 | | | |
| 99. endrin | 9 | 9 | | | | 11 | 11 | | | |
| 100. endrin aldehyde | 9 | 9 | | | | 11 | 11 | | | |
| 101. heptachlor | 9 | 9 | | | | 11 | 11 | | | |
| 102. heptachlor epoxide | 9 | 9 | | | | 11 | 11 | | | |
| 103. alpha-BHC | 9 | 9 | | | | 11 | 11 | | | |
| 104. beta-BHC | 9 | 9 | | | | 11 | 11 | | | |
| 105. gamma-BHC | 9 | 9 | | | | 11 | 11 | | | |
| 108. PCB-1254 | 9 | 9 | | | | 11 | 10 | 1 | | |
| 111. PCB-1248 | 9 | 9 | | | | 11 | 11 | | | |

*Gross Concentration - blank subtracted.

TABLE V-50. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Zinc

| POLLUTANT | RAW WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) | TREATED WASTE # of Times Analyzed | Range* (ug/l) | Mean* (ug/l) | Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 4. benzene | 9 | ND- 24 | 2.7 | | 11 | ND- 3.0 | 0.4 | |
| 8. 1,2,4-trichlorobenzene | 9 | ND | | | 11 | ND- 47 | 4.3 | |
| 9. hexachlorobenzene | 9 | ND-100 | 11 | | 11 | ND | | |
| 10. 1,2-dichlorethane | 9 | ND- 22 | 2.9 | | 11 | ND | | |
| 13. 1,1-dichlorethane | 9 | ND-180 | 20 | | 11 | ND | | |
| 23. chloroform | 9 | ND- 71 | 16 | 53 | 11 | ND- 54 | 5.4 | |
| 28. 3,3-dichlorobenzidine | 9 | ND | | | 11 | ND- 2.0 | 0.2 | |
| 29. 1,1-dichlorethylene | 9 | ND- 23 | 2.6 | | 11 | ND | | |
| 38. ethylbenzene | 9 | ND- 2.0 | 0.2 | | 11 | ND- 6.0 | 0.5 | |
| 39. fluoranthene | 9 | ND- 15 | 1.7 | | 11 | ND | | |
| 44. methylene chloride | 9 | ND- 2.6E3 | 350 | | 11 | ND- 7.0 | 0.8 | |
| 47. bromoform | 9 | ND | | | 11 | ND- 44 | 4.0 | |
| 49. trichlorofluoromethane | 9 | ND-101 | 12 | | 11 | ND | | |
| 54. isophorone | 9 | ND- 18 | 2.0 | | 11 | ND | | |
| 55. naphthalene | 9 | ND | | | 11 | ND- 6.0 | 0.5 | |
| 64. pentachlorophenol | 9 | ND- 8.0 | 0.9 | | 11 | ND | | |
| 66. bis(2-ethylhexyl)phthalate | 9 | ND- 98 | 28 | 15 | 11 | ND-170 | 22 | 14 |
| 67. butyl benzyl phthalate | 9 | ND- 30 | 3.3 | | 11 | ND- 0.1 | | |
| 68. di-n-butyl phthalate | 9 | ND- 26 | 3.6 | 5.0 | 11 | ND- 12 | 1.6 | 4.0 |
| 69. di-n-octyl phthalate | 9 | ND | | | 11 | ND- 1.0 | 0.1 | |
| 70. diethyl phthalate | 9 | ND- 18 | 2.7 | | 11 | ND- 0.9 | 0.1 | |
| 71. dimethyl phthalate | 9 | ND- 22 | 2.4 | | 11 | ND | 0.1 | |
| 76. chrysene | 9 | ND- 11 | 2.2 | | 11 | ND- 0.7 | | |
| 77. acenaphthylene | 9 | ND- 18 | 2.0 | | 11 | ND- 8.0 | 0.7 | |
| 78. anthracene | 9 | ND- 0.4 | | | 11 | ND- 9.0 | 1.6 | 7.0 |
| 80. fluorene | 9 | ND- 14 | 1.6 | | 11 | ND- 3.0 | 0.3 | |
| 81. phenanthrene | 9 | ND | | | 11 | ND- 9.0 | 1.4 | |
| 84. pyrene | 9 | ND- 15 | 3.2 | | 11 | ND- 8.0 | 0.9 | |
| 86. tetrachlorethylene | 9 | ND- 8.0 | 0.9 | | 11 | ND- 22 | 2.6 | |
| 87. toluene | 9 | ND- 54 | 7.5 | 7.0 | 11 | ND- 5.3 | 0.8 | 3.0 |
| 88. trichloroethylene | 9 | ND-160 | 19 | 7.2 | 11 | ND- 19 | 2.0 | |

* Net Concentration - source and blanks subtracted
Scientific Notation Used, i.e. 2600 = 2.6E3

TABLE V-50. (Continued) INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Zinc

| POLLUTANT | RAW WASTE # of Times Analyzed | RAW WASTE Range* (ug/l) | RAW WASTE Mean* (ug/l) | RAW WASTE Median* (ug/l) | TREATED WASTE # of Times Analyzed | TREATED WASTE Range* (ug/l) | TREATED WASTE Mean* (ug/l) | TREATED WASTE Median* (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 91. dieldrin | 9 | ND | | | 11 | ND-0.03 | | |
| 92. chlordane | 9 | ND | | | 11 | ND-1.6 | 0.2 | |
| 93. 4,4'-DDT | 9 | ND | | | 11 | ND-0.4 | 0.03 | |
| 94. 4,4'-DDE | 9 | ND | | | 11 | ND-0.2 | 0.01 | |
| 101. heptachlor | 9 | ND | | | 11 | ND-0.7 | 0.1 | |
| 102. heptachlor epoxide | 9 | ND | | | 11 | ND-0.7 | 0.1 | |
| 103. alpha-BHC | 9 | ND | | | 11 | ND-0.7 | 0.1 | |
| 104. beta-BHC | 9 | ND | | | 11 | ND-0.03 | | |
| 108. PCB-1254 | 9 | ND | | | 11 | ND-9.8 | 0.9 | |
| 111. PCB-1248 | 9 | ND | | | 11 | ND-7.0 | 0.6 | |



* Net Concentration - source and blanks subtracted

TABLE V-51. INCIDENCE OF ORGANIC PRIORITY POLLUTANTS
Primary Zinc

| POLLUTANT | # of Times Analyzed | BACKGROUND WATER Range (ug/l) | Mean (ug/l) | Median (ug/l) |
|---|---|---|---|---|
| 15. 1,1,2,2-tetrachloroethane | 2 | ND-3.0 | 1.5 | 1.5 |
| 23. chlorform | 2 | ND-4.0 | 2.0 | 2.0 |
| 39. fluoranthene | 2 | ND-5.4 | 2.7 | 2.7 |
| 40. 4-chlorophenyl phenyl ether | 2 | ND-2.4 | 1.3 | 1.2 |
| 44. methylene chloride | 2 | ND-1.3 | 0.6 | 0.6 |
| 47. bromoform | 2 | ND-5.3 | 2.6 | 2.6 |
| 48. dichlorobromomethane | 2 | ND-9.3 | 4.6 | 4.6 |
| 51. chlorodibromomethane | 2 | ND-7.7 | 3.8 | 3.8 |
| 62. n-nitrosodiphenylamine | 2 | ND-4.6 | 2.3 | 2.3 |
| 66. bis(2-ethylhexyl)phthalate | 2 | 5.0-8.6 | 6.8 | 6.8 |
| 68. di-n-butyl phthalate | 2 | ND-1.0 | 0.5 | 0.5 |
| 72. 1,2-benzathracene | 2 | ND-2.4 | 1.2 | 1.2 |
| 73. benzo(a)pyrene | 2 | ND-1.0 | 0.5 | 0.5 |
| 78. anthracene | 2 | ND-0.1 | | |
| 84. pyrene | 2 | ND-4.0 | 2.0 | 2.0 |
| 86. tetrachloroethylene | 2 | ND-4.0 | 2.0 | 2.0 |
| 87. toluene | 2 | ND-2.7 | 1.4 | 1.4 |
| 88. trichloroethylene | 2 | ND-1.0 | 0.5 | 0.5 |
| 93. 4,4'-DDT | 2 | ND-0.01 | | |
| 95. 4,4'-DDD | 2 | ND-0.01 | | |
| 97. beta-endosulfan | 2 | ND-0.01 | | |
| 101. heptachlor | 2 | ND-0.03 | | |
| 102. heptachlor epoxide | 2 | ND-0.02 | | |
| 104. beta-BHC | 2 | ND-0.03 | | |
| 108. PCB-1254 | 2 | ND-0.8 | 0.4 | 0.4 |
| 111. PCB-1248 | 2 | ND-0.5 | 0.2 | 0.2 |

TABLE V-52

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Zinc
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | | | | |
| Tap Water | A | - | - | K 100 | K 10 | 1.0 | 20 | 5.0 | 7.0 | 50 | K 0.1 | 5.0 | K 10 | K 20 | K 100 | 900 |
| **Raw Wastewater** | | | | | | | | | | | | | | | | |
| Acid Plant APC Bleed & Preleaching Filtrate | B | 0.065 | 5.9 | 2.1E3 | 3E3 K | 8.0 | 44E3 | 69 | 26E3 | 18E3 K | 4 | 1.0E3 | 1.2E3 | 740 | 360 | 1.7E6 |
| Boiler Blowdown | C | 0.43 | 100 | 67 | 12 | 7.0 | 5.0E3 | 610 | 560 | 3.0E3 | 6.9 | 4.3E3 | 270 K | 25 | - | 1.0E5 |
| Roaster | D | 0.28 | + | 50 | 280 K | 20 | 1.9E3 | 60 | 1.9E3 | 5.7E3 | 52 | 180 | 450 | 90 | K 20 | 0.22E6 |
| Roaster; Reduction; Contact/Noncontact Cool; Neutral Acid Plant APC | E | 0.42 | 100 | K 2.0 | 3 | K 2.0 | 350 K | 24 | 37 | 280 | 2.9 | K 50 | 24 | K 25 | NR | 8.7E3 |
| **Treated Wastewater** | | | | | | | | | | | | | | | | |
| Leachate; Purification; Electrolytic Wastes; Contact/Noncontact Cooling (Settle) + Acid Plant APC Bleed (Lime, Polymer, Settle) | B | 0.57 | 52 | 2.0E3 | 920 | 32 | 8400 | 1.7E3 | 7.3E3 | 16E3 | 130 | 2.4E3 | 18 | 200 K | 120 | 2.0E6 |
| | B | 1.1 | 100 | 800 | 10 | 3.0 | 36 | 160 | 53 | 250 | 2.0 | 620 | 40 | 16 | K 50 | 1.2E3 |
| Roaster; Reduction; Contact/Noncontact Cool; Neutral Acid Plant APC (Settle) | E | 0.42 | 100 | 2.7 | 2.3 K | 2.0 | 630 K | 24 | 18 K | 60 | 0.5 | K 50 | 26.7 | K 25 | NR | 7.7E3 |

TABLE V-52 (Continued)

SUMMARY OF ANALYTICAL RESULTS - PRIORITY POLLUTANT METALS SAMPLING PROGRAM
Primary Zinc
Concentrations Observed, ug/l

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Ag | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acid Plant APC Bleed; Preleaching Filtrate; Boiler Blowdown (Lime, Settle) | C | 0.43 | 100 | 51 | 4.8E3 | <2.0 | 110 | 350 | 54 | 150 | 0.2 | <50 | 101 | <32 | 3.5 | 2.0E3 |
| Rolling Mill Effluent (Skim) | A | 0.024 | 4.7 | <100 | <10 | <1.0 | 4.7 | <5.0 | 16 | <20 | 0.05 | <5.0 | <10 | <20 | <100 | 400 |
| Drying Kiln APC; Acid Plant APC; Runoff; Groundwater (Lime, Settle) | A | 0.48 | 95 | <100 | <10 | <1.0 | 68 | <5.0 | 19 | 47 | 3.0 | <5.0 | <10 | <20 | <100 | 3.9E3 |

NR Data not received from testing laboratory.
\+ Insufficient information to determine.

Engineering notation, i.e. 1.3E6 = 1.3 x $10^6$.

TABLE V-53

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Zinc
Concentrations Observed, mg/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants COD | TSS | O & G | NH3 | Non-conventional Pollutants F | TOC | Phenols | CN | Priority Pollutants Asbestos* Total | Chrys. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source Water** | | | | | | | | | | | | | |
| Tap Water | A | - | - | - | - | 4.0 | - | 1.3 | - | - | - | - | - |
| **Raw Wastewater** | | | | | | | | | | | | | |
| Acid Plant APC Bleed + Preleaching Filtrate | B | 0.065 | 5.9 | - | - | - | - | - | - | K 0.002 | K 0.002 | - | - |
| Boiler Blowdown | C | 0.43 | 100 | 59 | 15 | 14 | - | - | 9.33 | 4.3E-3 | 3.3E-3 | 0.43E8 | 1.03E7 |
| Roaster | D | 0.28 | + | - | - | - | - | - | - | K 0.01 | K 0.01 | - | - |
| Roaster; Reduction; Contact/Noncontact Cool; Neutral Acid Plant APC | E | 0.42 | 100 | 20 | 13 | 10 | - | - | 7.3 | 0.025 | 0.38 | 32E6 | K 0.55E6 |
| **Treated Wastewater** | | | | | | | | | | | | | |
| Leachate; Purification; Electrolytic Wastes; Contact/Noncontact Cooling (Settle) + Acid Plant APC Bleed (Lime, Polymer, Settle) | B | 0.57 | 52 | - | - | - | - | - | - | K 0.002 | K 0.002 | - | - |
| | B | 1.1 | 100 | - | - | - | - | - | - | K 0.002 | K 0.002 | - | - |
| Roaster; Reduction; Contact/Noncontact Cool; Neutral Acid Plant APC (Settle) | E | 0.42 | 100 | 17 | K 1.0 | 7.3 | - | - | 8.3 | 8.7E-3 | 0.008 | - | - |

TABLE V-53 (Continued)

SUMMARY OF ANALYTICAL RESULTS - CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS SAMPLING PROGRAM
Primary Zinc
Concentrations Observed, ug/l (unless noted)

| Plant Process Streams | Plant | Stream Flow, MGD | % of Total Flow | Conventional Pollutants | | | | Non-conventional Pollutants | | | Priority Pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COD | TSS | O & G | NH3 | F | TOC | Phenols | CN | Asbestos* Total | Chrys. |
| Acid Plant APC Bleed; Preleaching Filtrate; Boiler Blowdown (Lime, Settle) | C | 0.43 | 100 | 17 | 9.3 | 13 | - | - | 8.3 | 0.009 | 6.7E-3 | - | - |
| Rolling Mill Effluent (Skim) | A | 0.024 | 4.7 | 34 | 12 | 24 | 0.24 | - | 11 | 5.3E-3 | 1.3E-3 | - | - |
| Drying Kiln APC; Acid Plant APC; Runoff; Groundwater (Lime, Settle) | A | 0.48 | 95 | 24 | 51 | 4.0 | 13 | - | 3.0 | 0.002 | 0.001 | - | - |

* Asbestos concentrations are given in fibers/liter.
- Not tested for or not detected.
+ Insufficient information to determine.

Engineering notation, i.e. 1.3E6 = $1.3 \times 10^6$.

# SECTION VI

# SELECTION OF POLLUTANT PARAMETERS

The wastewater parameters to be considered in establishing effluent limitations guidelines and standards of performance are presented in this section. They are grouped into two separate classes: criteria and priority pollutants. The priority pollutants are further classified into five groups, based on their evaluated significance in nonferrous metals industry wastewaters.

## CRITERIA FOR SELECTION OF POLLUTANT PARAMETERS

### Priority Pollutants

Using the field sampling data presented in Section V, each of the 129 priority pollutants was evaluated in terms of its significance in each subcategory of the nonferrous metals industry. Responses to data collection portfolios and information collected in a literature review were also taken into consideration. The priority pollutants for each subcategory were grouped as one of the following:

1. Significant (selected for potential regulation)
2. Site specific
3. Marginally significant
4. Insignificant
5. Not detected

The priority pollutants were classified as significant if all the following criteria were satisfied for the subcategory being considered:

1. The priority pollutant was frequently present in wastewater above a threshold concentration or it was found in one particular wastewater stream at concentrations an order of magnitude higher than the threshold level. The threshold concentration for each priority pollutant is indicated in Table VI-1. The rationale for selecting these thresholds is discussed later in this section.

2. Samples of similar waste streams taken at different plants contained similar concentrations of the pollutant. That is, the pollutant was present throughout a subcategory.

If pollutants were found above the threshold concentration at only one plant in a subcategory, it is considered as site specific.

In a few instances, priority pollutants were designated as marginally significant due to unusual circumstances which will be described in the subcategory discussions later in this section.

If a pollutant was not found above the threshold concentration, but was detected at least once, it is classified as insignificant.

Priority pollutants that were never detected are, of course, classified as not detected. No acid fraction compound was detected.

Table VI-2 summarizes the heavy metal limits set on the concentrations in water for various conditions. The threshold levels given in Table VI-1 were chosen based on the treatability limits and a minimum limit that would satisfy the conditions set for a majority of the water uses given in Table VI-2.

Two pollutants that have not been previously discussed are asbestos and cyanide. They are priority pollutants, but are not organic or metallic.

Asbestos is a generic name describing several fibrous, hydrated silicate minerals. Chrysotile is the particular mineral selected for this study. It has been suggested (28) that values over $10^8$ fibers/l should be reexamined because this represents a significant departure from ambient concentrations. A threshold value of $10^8$ fibers/l of chrysotile will be the limit used to determine significance in the nonferrous metals industry. A value of 100 µg/l was chosen for cyanide because that is the approximate quantitative detection limit.

Criteria Pollutants

The conventional pollutants (BOD, COD, TSS, oil and grease and pH) and the non-conventional pollutants (fluoride, TOC, $NH_3$ and phenols), unlike the organic priority pollutants, have been used extensively for characterizing all types of wastewater.

The conventional pollutants TSS and pH have been selected as pollutant parameters. The monitoring of TSS is useful in this industry because it indicates the efficiency of treatment methods used to remove metals from the wastewater. Another conventional pollutant, pH, was also selected as a pollutant parameter. It serves as a simple, reliable indicator of the acidity or alkalinity of the wastewater.

Fluoride, $NH_3$ and phenols, non-conventional pollutants, were also selected as pollutant parameters for some of the subcategories. Fluoride compounds are used in the production of primary aluminum

and columbium-tantalum and are present at significant concentrations in the raw wastewater of these industries. This was confirmed by the sampling data. Phenols were designated as a pollutant parameter in the primary aluminum, secondary copper, and secondary silver subcategories because they were found in wastewater of these industries in excess of 250 µg/l. In the secondary aluminum, columbium-tantalum, and tungsten industries, $NH_3$ is used in the process or formed during a process step. In other subcategories, it has been used for neutralization of the wastewater. Monitoring of $NH_3$ may be necessary.

BOD, COD, TOC, and oil and grease were not selected as pollutant parameters. BOD in wastewater is measured with a biological test. High concentrations of metals, a characteristic of wastewater in the nonferrous metals industry, may inhibit biological activity, and may render the test ineffective for this industry. The monitoring of COD and TOC is of limited value in this industry. These tests measure concentrations of organics, but may not be a reliable indicator of the presence of specific organic priority pollutants in this industry. Typically, low values of oil and grease were detected in the wastewater. This is to be expected, however, as none is used in production processes. On-site forming operations present at several of the plants contributed significant levels of oil and grease to the overall plant effluent, but these forming operations are the subject of other studies.

## POLLUTANT PARAMETERS

A summary of the significance of the priority and criteria pollutants in the nonferrous industry is given in Table VI-3. Priority pollutants are listed with the level of significance to which each has been assigned for each subcategory, based upon an evaluation of the waste characteristics data given in Section V. The significance of criteria pollutants as pollutant parameters is for each subcategory is also presented.

## BACKGROUND INFORMATION ON SELECTED POLLUTANT PARAMETERS

Using the data from the sampling program and the other sources of information described in Section V, each of the 129 priority pollutants was evaluated in terms of its significance in the nonferrous metals industry by subcategory. The following discussions represent information on uses of the pollutants, possible sources of the pollutant in the environment, and some information on the toxicity or carcinogenicity of the parameters. Only those priority pollutants classified as significant in at least one subcategory in the nonferrous metals industry are considered in this discussion. Criteria pollutants were suggested as parameters where appropriate. Several literature

sources (17-19, 29) were used to compile background information for the organic priority pollutants. Other references are cited in the discussion.

## Priority Pollutant Parameters

Acenaphthene. Acenapthene belongs to a class of organic compounds identified by structure as polynuclear aromatics (PNA). It is a coal tar residue solid (at ambient temperature) · produced during high temperature carbonization or coking of coal. Acenaphthene is also used as a dye intermediate, insecticide, fungicide, and in the manufacture of some plastics. Research indicates that some polynuclear aromatics have highly carcinogenic properties.

Benzene. Benzene is an aromatic organic produced principally from coal tar and petroleum. It serves as a degreasing and cleaning agent and is commonly used as a general solvent. Benzene acts as an intermediate in the synthesis of medicines, dyes, and other organic compounds and is used in the manufacture of varnishes, lacquers, and other products. Studies indicate that benzene is toxic to aquatic organisms.

1,2,4-Trichlorobenzene. The compound 1,2,4-trichlorobenzene is a halogenated aromatic. It is used as a capacitor dielectric (in mixtures), dye carrier, heat transfer fluid, degreaser, lubricant, and as an intermediate in herbicide manufacture. Research indicates that chlorinated benzenes are resistant to chemical and physical degradation and tend to accumulate in fatty tissues.

1,2-Dichloroethane. 1,2-dichloroethane is a halogenated aliphatic used in the production of tetraethyl lead and vinyl chloride, as an industrial solvent, and as an intermediate in the production of other organochlorine compounds. Some chlorinated ethanes have been found in drinking waters, natural waters, aquatic organisms and foodstuffs. Research indicates that they may have mutagenic and carcinogenic properties.

1,1-Dichloroethylene. This is a halogenated aliphatic used as an internal plasticizer in fibers and plastics manufacturing. Polymers with high 1,1-dichloroethylene content (such as Saran) are widely used in food packaging. The heat-seal characteristics of Saran-type coatings make them useful in the manufacture of nonflammable synthetic fiber. 1,1-dichloroethylene polymers have also been used extensively as interior coatings for marine tanks, railroad cars and fuel storage tanks, and for coating of steel pipes and structures. Dichloroethylenes are highly volatile and do not decay rapidly. Research indicates that dichloroethylenes may have mutagenic and carcinogenic properties.

1,2-Trans-Dichloroethylene. This is a halogenated aliphatic Fluoranthene. Fluoranthene is a polynuclear aromatic (PNA) produced as a residue during the pyrolysis or combustion of coal and petroleum. It is also found in coal tar, pitch, asphalt, and creosote and occurs as a by-product during the carbonization or coking of coal. Some polynuclear aromatics have been found to have highly carcinogenic properties.

Methylene Chloride. Methylene chloride, a halogenated aliphatic, is commonly used as an industrial solvent. It is also found in metal degreasers and cleaning fluids, paints, and insecticides. Research has shown that some chlorinated ethanes have mutagenic properties.

Dichlorobromomethane. This compound is a halogenated aliphatic. Research has shown that halomethanes have carcinogenic properties, and exposure to this compound may have adverse effects on human health.

Phthalate Esters. Phthalate esters are used mainly as plasticizers in plastic compositions. Their other uses are in gasoline additives, synthetic lubricants, pesticides, cosmetics, fragrances and insect repellents.

The phthalate ester plasticizers, which can be present in concentrations up to 60 percent of the total weight of the plastic, are only loosely linked to the plastic polymers and are easily extracted. Phthalate esters are believed to enter the environment via vaporization during use or through plastic waste disposal. They are known to be widely distributed in the environment, having been found in soil, water, air, fish tissue, and human tissue.

The phthalate esters which were found in the wastewaters generated in the nonferrous metals industry are:

Bis (2-ethylhexyl) phthalate
Butylbenzylphthalate
Di-n-butyl phthalate
Di-n-octyl phthalate
Diethyl phthalate
Dimethyl phthalate

Benzo(a)pyrene. Benzo(a)pyrene is a polynuclear aromatic found in coal tar, cigarette smoke, and in the atmosphere as a product of incomplete combustion. It is a derivative of 1,2-benzanthracene. Benzo(a)pyrene is believed to be carcinogenic.

Chrysene. Chrysene is a polynuclear aromatic present in coal tar. It is formed during the distillation of coal and, to a

lesser degree, during the distillation and pyrolysis of a number of fats and oils. Research indicates that some polynuclear aromatics are highly carcinogenic.

Fluorene. Fluorene, a polynuclear aromatic, is found in coal tar, coal tar pitch, asphalt and creosote and is formed during the pyrolysis and combustion of fossil fuels. It is used in the manufacture of resins, insecticides and dyes. Research indicates that some polynuclear aromatics are highly carcinogenic.

Pyrene. Pyrene is a polynuclear aromatic that occurs in coal tar and is formed during the pyrolysis of fossil fuels. Research indicates that some polynuclear aromatics are highly carcinogenic.

Trichloroethylene. Trichloroethylene, a halogenated unsaturated aliphatic, is used primarily as a degreasing solvent in metal industries. It had minor applications as a dry cleaning solvent and as an extractive solvent for decaffeinating coffee, but was replaced in both of these uses by perchloroethylene and methylene chloride, respectively.

Its volatilization during production and use is the major source of environmental levels of this compound. Trichloroethylene has been detected in ambient air, in food, and in human tissue in µg/l (ppb) quantities. Its detection in rivers, municipal water supplies, and the sea and aquatic organisms indicates that trichloroethylene is widely distributed in the aquatic environment at the µg/l level or lower.

Polychlorinated Biphenyls. Polychlorinated biphenyls (PCBs) have been used as hydraulic oils, as heat transfer fluids, and as dielectrics in capacitors and transformers. They have also been used in brake linings, asphalt paving compositions, printing inks and die castings. PCBs have been detected in most species monitored throughout the world and are believed to be carcinogenic. PCBs are stored in fatty tissues and it has been documented that fish and other organisms accumulate the substances in amounts as high as 75,000 times the levels to which they are exposed. The high degree of persistence of PCBs suggests that they will persist in the environment for decades and perhaps even centuries. The manufacture of PCBs has been essentially prohibited in this country and regulations have been established to control the use and disposal of PCBs currently in existence.

The following PCBs have been detected in wastewaters from the nonferrous metals industry:

PCB-1254

Antimony. Antimony is a naturally occurring silver-white element that makes up between 0.00002 and 0.00005 percent of the earth's crust. Environmental concentrations of antimony are reported at 0.33 µg/l in seawater of 35 parts per thousand salinity and at 1.1 µg/l in freshwater streams. Antimony and its compounds are used in the manufacturing of alloys, as flame retardants, pigments, and catalysts, as well as for medicinal and veterinary uses.

Antimony forms salts with a +3 and +5 valence which are soluble in water. Sulfide and oxide salts are largely insoluble. Antimony has been found to be toxic. Doses as low as 100 mg have been fatal. The symptoms are similar to those of arsenic poisoning. Since 1949, antimony potassium tartrate has been given intravenously for the treatment of schistosomiasis but it has been known to produce severe electrocardiographic abnormalities, skin eruptions, and even pneumonia (30).

The compounds of antimony are toxic, and are classed as acutely, moderately, or chronically severe. According to this categorization, moderate toxicity includes injury to internal organs, and severe toxicity includes seriously debilitating effects or death (31). It has been reported that antimony has caused the deaths of an adult and a child. Antimony metal, fed to rats, allowed normal growth but resulted in consistent injury to the heart. Antimony added to the food of rabbits caused a progressive increase in both the hemoglobin and in the total red cells, and when fed to cats was accompanied by a decrease in white cells (30).

It has been reported (32) that antimony can be concentrated by certain forms of marine life to over 300 times its concentration in the surrounding waters.

Arsenic. Arsenic is a naturally occurring element often referred to as a metal, although chemically classified as a metalloid. Environmental concentrations of arsenic have been reported at 0.0005 percent in the earth's crust and 3 µg/l in seawater. Analyses of 1,577 surface water samples in the U.S. showed arsenic present in 87 samples, with concentrations ranging from 5 to 336 µg/l, and a mean level of 64 µg/l (33). Arsenic and its compounds are used in the manufacturing of glass, cloth, electrical semiconductors, as fungicides, wood preservatives, and growth stimulants for plants and animals, and in veterinary applications.

Although arsenic compounds are constantly taken into the body as a constituent of food, there is no evidence that it is an

essential element in human nutrition (30). Normal human blood contains 0.2 to 1.0 mg/l of arsenic. Arsenic is very toxic to humans. Ingestion of small amounts usually results in severe poisoning and larger doses have proven fatal (30). Arsenic also accumulates in the body so that small doses may become fatal in time. Slow excretion is the basis for the cumulative toxic effect.

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

Dissolved cadmium was found in less than 3 percent of 1,577 U.S. surface water samples with a mean concentration of slightly under 10 µg/l. Most fresh waters contain less than 1 µg/l cadmium and analyses of seawater indicate an average concentration of about 0.15 µg/l (33). The chloride, nitrate, and sulfate salts of cadmium are highly soluble in water.

Cadmium poisoning of humans has resulted from the consumption of foods or liquids prepared and left in cadmium-plated containers. Consumption of cadmium salts causes cramps, nausea, vomiting, and diarrhea. Oral ingestion has been reported as the source of a number of deaths (38). Once cadmium enters the body, it tends to remain, concentrating in the liver, kidneys, pancreas, and thyroid (39). The major sources in the human diet appear to be grains and seafoods.

Chromium. Chromium salts are used extensively in the metal finishing industry as electroplating and passivating agents, and as mordants in the textile industry. They also are used in cooling waters, in the leather tanning industry, in manufacturing catalysts, in pigments and primer paints, and in fungicides and wood preservatives. In the analysis of 1,577 surface water samples collected at 130 sampling points in the U.S., chromium was found in 386 samples ranging from 1 to 112 µg/l; the mean concentration was 9.7 µg/l (33). Trivalent chromium is recognized as an essential trace element for animals and humans. Hexavalent chromium is suspected to be carcinogenic.

Of the trivalent chromic salts, the chloride, nitrate, and sulfate are readily soluble in water. Of the hexavalent chromate salts, sodium, potassium, and ammonium chromates are soluble. When administered orally, chromium salts are not retained in the body but are rapidly eliminated. Although the salts of trivalent chromium are not considered to be physiologically harmful (40), there is evidence that large doses of chromates lead to corrosive effects in the intestinal tract and to nephritis (38). The taste threshold for the most sensitive person is about 1.5 mg/l.

Copper. Copper is a soft heavy metal that is ubiquitous in its distribution in rocks and minerals of the earth's crust. In nature, copper occurs usually as sulfides and oxides and occasionally as metallic copper. Weathering and solution of these natural copper minerals result in background levels of copper in natural surface waters in concentrations generally well below 20 µg/l. Higher concentrations of copper originate from human sources. These sources include corrosion of brass and copper pipe by acidic waters, industrial effluents and runoff, sewage treatment plant effluents, and the use of copper compounds as aquatic algicides. Potential industrial copper pollution sources number in the tens of thousands in the U.S. However, the major industrial sources include the smelting and refining industries, copper wire mills, coal burning industries, and electroplating industries. Copper may enter natural waters either directly from these sources or by atmospheric fallout of air pollutants produced by these industries.

A study of natural surface waters in the U.S. revealed copper concentrations ranging from less than 10 µg/l to 280 µg/l, with a mean value for U.S. waters of 15 µg/l. Values from 0.6 µg/l to 4.3 µg/l have been reported in seawater (33). The chloride, nitrate, and sulfate of divalent copper are highly soluble in water.

Copper is found in traces in all plant and animal life, and it is believed to be essential for nutrition. The physiological function of copper appears to be involved in the metabolism of iron, because the utilization of iron by the blood-forming organs does not occur properly in the absence of copper (30, 41).

Copper is not considered to be a cumulative systemic poison, like lead or mercury. Most of the copper ingested is excreted by the body and little is retained. Even so, copper has been suspected as a cause of haemachromatosis, a rare liver disease among middle-aged men (42). Chronic copper poisoning among human beings, however, has never been proved, even among people in copper industries who have absorbed enough copper for their skin and hair to be colored green (43, 44, 45, 30). There is no evidence that poisoning of humans has ever occurred as a result

of consumption of copper in water. It would appear that copper in concentrations high enough to be dangerous to human beings renders water disagreeable to taste; consequently, copper is probably not a hazard in domestic supplies. However, copper in water may be disadvantageous or detrimental for certain industrial uses. While in trace amounts, copper may be beneficial or even essential for the growth of living organisms, in excessive quantities it has been found toxic to a wide variety of aquatic forms, from bacteria to fish (44, 45).

The limiting factor in domestic water supplies is taste. Threshold concentrations for taste have been generally reported in the range of 1.0-2.0 mg/l of copper, while as much as 5-7.5 mg/l makes the water completely undrinkable (44, 45).

Cyanide. Cyanide compounds are almost universally present where life and industry are found. Besides being very important in a number of manufacturing processes, they are found in many plants and animals as metabolic intermediates that generally are not stored for long periods of time. Cyanides occur in the effluents from gas works and coke ovens, from the scrubbing of gases at steel plants, from metal cleaning and electroplating processes, and from chemical industries.

When toxicities are expressed in terms of the cyanide ion, it must be realized that most of the cyanide in water is in the form of HCN. It is apparent that HCN rather than the cyanide ion is the major toxic species. In natural streams, cyanides deteriorate or are decomposed by bacterial action, so that excessive concentrations may be expected to diminish with time. In 1962, the USPHS Drinking Water Standards set a recommended limit of 0.01 mg/l. The toxicity of cyanides is a function of pH, temperature, and dissolved oxygen. According to Klein (48), the odor threshold for hydrogen cyanide in water is 0.001 mg/l.

The CN ion, except for a small portion exhaled, is changed rapidly to the relatively non-toxic sulfur complex (SCN, thiocyanate) in the liver, and is eliminated irregularly and slowly in the urine. There is no evidence that the CN ion is stored in the body. Small doses of CN, incapable in themselves of causing intoxication, can be disposed of indefinitely in the body, since the natural detoxifying mechanisms are practically inexhaustible, although slow.

Cyanide has been shown to be poisonous to humans, and small amounts can have adverse effects.

Trout and other aquatic organisms are extremely sensitive to cyanide. Certain metals, such as nickel, may complex with

cyanide to reduce lethality especially at higher pH values, but zinc and cadmium cyanide complexes are exceedingly toxic.

When fish are poisoned by cyanide, the gills become considerably brighter in color than those of normal fish, owing to the inhibition by cyanide of the oxidase responsible for oxygen transfer from the blood to the tissues.

Lead. Lead is a naturally occurring metal that makes up 0.002 percent of the earth's crust. The reported concentration of lead in seawater of 35 parts per thousand salinity is 0.03 µg/l, while available data indicate that the mean natural lead content of the world's lakes and rivers ranges from 1 to 10 µg/l. Analyses of over 1,500 stream samples from 1962 to 1967 found lead in 19.3 percent of the samples, with concentrations ranging from 2 to 140 µg/l, and a mean value of 23 µg/l (33).

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

Certain lead salts, such as the acetate and chloride, are readily soluble, while the sulfate is only slightly soluble. Foreign to the human body, lead is a cumulative poison which tends to be deposited in bones. The intake that can be regarded as safe for everyone cannot be stated definitely, because the sensitivity of individuals to lead differs considerably.

Lead is not among the metals considered essential to the nutrition of animals or human beings (30). Lead poisoning usually results from the cumulative toxic effects of lead after continuous consumption over a long period of time, rather than from occasional small doses. Immunity to lead cannot be acquired, and sensitivity to lead seems to increase with exposure (49).

Mercury. Mercury, a silver-white metal that is a liquid at room temperature, can exist in three oxidation states: elemental, mercurous, and mercuric; it can be part of both inorganic and organic compounds. The elemental form of mercury is rather inert chemically. The mercuric salts of acetate, chlorate and cyanide are highly soluble in water.

A major use of mercury has been as a cathode in the electrolytic preparation of chlorine and caustic soda; this accounted for 33 percent of total demand in the U.S. in 1968. Electrical apparatus (lamps, arc rectifiers, and mercury battery cells) accounted for 27 percent, and industrial and control instruments (switches, thermometers, and barometers), and general laboratory

applications accounted for 14 percent of demand. Use of mercury in antifouling and mildew-proofing paints and mercury formulations used to control fungal diseases of seeds, bulbs, plants, and vegetation were other major utilizations; however, mercury is no longer registered by the EPA for use in antifouling paints or for the control of fungal diseases of bulbs. The remainder was used for dental amalgams, catalysts, pulp and paper manufacture, pharmaceuticals, and metallurgy and mining.

Mercury and mercuric salts are considered to be highly toxic to humans (50, 36, 30). They are readily absorbed by the gastro-intestinal tract, and have been fatal.

Nickel. Nickel is a silver-white ductile metal commonly occurring in natural waters in the +2 valence state in concentrations ranging from a few micrograms per liter to more than 100 µg/l. Nickel seldom is found in groundwater, and, if present, probably exists in colloidal form. It seldom exists in nature in the elemental form.

Approximately 0.01 percent of the earth's crust is nickel, and it is ranked 24th in order of abundance of the elements. By far the greatest proportion of nickel in the earth's crust comes from igneous rocks. Some common minerals containing nickel include pentlandite and ullmannite. Certain secondary silicate minerals contain nickel, which also substitutes for magnesium in various primary minerals (e.g. olivine, hypersthene, hornblende, biotite).

In a study of 130 surface water sampling stations throughout the U.S., nickel appeared in 16.2 percent of 1,577 samples collected between 1962 and 1967, with a mean concentration of 10 µg/l and a range of 1 to 130 µg/l. In drinking water samples taken throughout the U.S., nickel was detected in only 4.6 percent of the samples, with a mean concentration of 34.2 µg/l and a range of 1 to 490 µg/l.

Nickel as a pure metal is not a water pollution problem because it is not affected by, or soluble in, water. Many nickel salts, however, are highly soluble in water and, since they are used in metal-plating works, they may be discharged to surface or ground waters. The toxicity of nickel to man is believed to be low, though there are no data available to substantiate this (50). Systematic poisoning of human beings by nickel or nickel salts is almost unknown (30). Nickel has been found, however, to be toxic to plants at low concentrations. (28). Research indicates that the presence of nickel salts in aquatic environments may pose serious hazards to freshwater and marine organisms.

Selenium. Selenium is an essential nutrient with concentrations ranging from 0.1 to 100 µg/l in potable water and averaging 0.09 µg/l in the major oceans. In most natural waters, selenium levels are low (less than 1 µg/l), but in areas with seleniferous soils, water levels up to 300 µg/l have been reported (33). Selenium occurs in some soils as basic ferric selenite, as calcium selenite, as elemental selenium, and in organic compounds derived from decayed plant tissue. Although selenium is found in some natural waters, food appears to be the most likely source for human ingestion (54, 55 56).

Proof of human injury by selenium is scanty and definite symptoms of selenium poisoning have not been identified, but it is widely believed that selenium is highly toxic to man (50, 57, 56, 58). It has been stated that the symptoms of selenium poisoning are similar to those of arsenic poisoning (59). Mild chronic selenium poisoning has been observed in humans living in areas where the soil and crops are rich in selenium. In addition, there have been cases of selenosis at industrial establishments that use or produce selenium compounds.

Selenium in trace amounts appears to be essential for the nutrition of animals, including man, although very little is known about the mechanism of its action (60). Arsenic and selenium are apparently antagonistic in their toxicity, tending to counteract each other. Selenium salts are rapidly and efficiently absorbed from the gastro-intestinal tract and excreted largely through the urine. Retention is highest in the liver and kidneys (30, 37).

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

There is abundant literature on the bactericidal power of silver (30). Silver toxicity to microorganisms is so high that at dosage rates sufficient to sterilize water, silver is not a toxicant nor an irritant, and it does not interfere with the water's palatability. A large part of ingested silver would pass through the intestinal tract without assimilation (30).

Water quality criteria for silver have been set, not because of the danger of silver in natural sources of water supply, but to prevent its intentional addition to water, in excessive amounts, for disinfection. If silver is ingested by humans, a condition known as argyria may result, causing a permanent gray discoloration of skin, eyes and mucous membranes (61, 62, 63).

Thallium. Pure thallium is a bluish-white, soft, inelastic, heavy metal that constitutes about 0.003 percent of the earth's crust. It oxidizes readily in air to thallium oxide. Analyses of U.S. river water during 1958 and 1959 detected no thallium.

Industrial uses of thallium include the manufacture of alloys, electronic devices, dyes and pigments in fireworks and special optical glass. Many thallium-containing catalysts have been patented for industrial organic reactions. Its salts are used as poisons for rats and other rodents (36) and as ant bait.

Thallium is a cumulative poison, four times as toxic as arsenious oxide, and it affects the sympathetic nervous system, causes muscular pains, endocrine disturbances, and loss of hair (64). It does not occur normally in animal tissues, but when taken into animal bodies, it is cumulative (30). Thallium salts, for the most part, are highly soluble in water.

Zinc. Zinc is a naturally occurring element that makes up approximately 0.02 percent of the earth's crust. It is used in various alloys, as a protective coating for other metals, in galvanizing steel, and as a reducing agent. Zinc was detected in 1,207 of 1,577 surface water samples collected at 130 sampling locations throughout the U.S. between 1962 and 1967. The maximum observed concentration was 1,183 µg/l and the mean value was 64 µg/l. Levels of zinc in natural seawater approximate 5 µg/l (33).

Many zinc salts are highly soluble in water. The taste threshold for zinc occurs at about 5 mg/l. Zinc has no known adverse physiological effects upon man except at high concentrations. In fact, zinc is an essential and beneficial element in human nutrition (30, 38). Unlike the aberrant syndromes for most of the essential trace elements, there has been no primary disorder of zinc metabolism described for humans.

From an acute toxicity point of view, invertebrate marine animals seem to be the most sensitive organisms tested. Zinc has caused growth retardation in sea urchins and fatalities to bryozoan larvae and barnacles.

## Criteria Pollutant Parameters

Total Suspended Solids (TSS). The solid materials or residues found suspended in water may be either organic or inorganic, or both. Commonly found inorganic materials are sand, silt, and clay. The organic fraction may include such materials as grease, oil, tar, or animal or vegetable waste products. Solids discharged with the wastes of civilization contain varying amounts of inert materials, slowly biodegradable materials, and

rapidly decomposable substances. Finely-divided solids may remain suspended in water for a relatively long period of time before settling to the bed of the stream or lake.

Solids in suspension are aesthetically displeasing because of the turbidity they impart to the water. The increased turbidity, or reduced light penetration, impairs the photosynthetic activity of aquatic plants, thus promoting and maintaining the noxious conditions due to depletion of dissolved oxygen. This results in the death of fish and fish food organisms. Suspended solids also reduce the recreational value of the water (9).

Disregarding any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries and by clogging gills and respiratory passages of various aquatic fauna.

Suspended solids in water interfere with many industrial processes, cause foaming in boilers, and incrustations on equipment exposed to such water, especially as the temperature rises. They are undesirable in process water used in the textile industry, in laundries, in dyeing, and in cooling systems.

When suspended solids settle to form sludge deposits on the stream or lake bed, they are often damaging to life in the water. Blanketing of the stream or lake bed can destroy the living spaces of benthic organisms. When of an organic nature, solids may use a portion or all of the dissolved oxygen available in the area.

Ammonia ($NH_3$). Ammonia occurs in surface and ground waters as a result of the decomposition of nitrogenous organic matter. It is one of the constituents of the complex nitrogen cycle. It may also result from the discharge of industrial wastes from chemical or gas plants, refrigeration plants, scouring and cleaning operations where "ammonia water" is used, the processing of meat and poultry products, rendering operations, leather tanning plants, and the manufacture of certain organic and inorganic chemicals. Ammonia may be indicative of pollution and it increases the chlorine demand for drinking water treatment. The WHO European Drinking Water Standards set a recommended limit of 0.5 mg/l as $NH_3$.

Ammonia exists in its non-ionized form only at higher pH levels and is most toxic in this state. The lower the pH, the more ionized ammonia is formed, and its toxicity decreases. The toxicity of a given concentration of ammonium compounds on fish has been found to increase by 200 percent or more between pH 7.4 and 8.0. Ammonia, in the presence of dissolved oxygen, is converted to nitrate ion ($NO_3^-$) by nitrifying bacteria. Nitrite

ion ($NO_2^-$), an intermediate product between ammonia and nitrate ion, sometimes occurs in quantity when depressed oxygen conditions permit. Ammonia can exist in several other chemical combinations including ammonium chloride and other salts.

Nitrates and nitrites are considered to be among the objectionable components of mineralized waters. Excess nitrates cause irritation of the gastrointestinal tract, causing diarrhea and diuresis. Methemoglobinemia, a condition characterized by cyanosis and which can result in infant and animal deaths, can be caused by high nitrate concentrations in waters used for feeding. Possible carcinogenic properties of nitrites and nitrate derivatives have caused a considerable amount of concern recently. Nitrites can combine with other chemicals to form nitrosamines, potent cancer-causing agents. A recent study at MIT indicates that nitrates by themselves can cause cancer in laboratory animals (68). Evidence exists that ammonia exerts a toxic effect on all aquatic life depending on pH, dissolved oxygen level, and the total ammonia concentration in the water. Low ammonia concentrations have been reported to be acutely toxic in various species of fish. Suffocation results from the decreased ability of the hemoglobin to combine with oxygen in the presence of ammonia. Very low ammonia concentrations have caused a noticeable drop in the oxygen content of the blood of fish. Algae, which thrive on high nitrate concentrations, appear to be harmed or inhibited when the nitrogen is in the form of ammonia. A significant oxygen demand can result from the microbial oxidation of ammonia. Approximately 4.5 grams of oxygen are required for every gram of ammonia that is oxidized. Ammonia can add to eutrophication problems by supplying nitrogen to aquatic life. Ammonia is a major reagent in some processes and appears in high concentrations in the plant effluent (9).

pH - Acidity and Alkalinity. Although not a specific pollutant, pH is related to the acidity or alkalinity of a wastewater stream. It is not a linear or direct measure of either; however, it may properly be used as a surrogate to control both excess acidity and excess alkalinity in water. The term pH is used to describe the hydrogen ion-hydroxyl ion balance in water. Technically, pH is the negative logarithm of the hydrogen ion concentration. A pH of 7 indicates neutrality or a balance between free hydrogen and free hydroxyl ions. A pH above 7 indicate that the solution is alkaline, while a pH below 7 indicates that the solution is acid.

Knowledge of the pH of water or wastewater is useful in determining necessary measures for corrosion control, pollution control, and disinfection. Waters with a pH below 6.0 are corrosive to water 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. The hydrogen ion concentrations can affect the taste of the water; at a low pH, water tastes sour.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Even moderate changes from acceptable criteria limits of pH are deleterious to some species. The harmful effect on aquatic life of many materials is increased by changes in the water pH. For example, metallocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. Similarly, the toxicity of ammonia is a function of pH. The bactericidal effect of chlorine in most cases is less as the pH increases, and it is economically advantageous to keep the pH close to 7 (9).

Fluoride ($F^-$). Fluorine is the most reactive of the nonmetals and is never found free in nature. It is a constituent of fluorite or fluorspar, calcium fluoride, and sodium aluminum fluoride (cryolite). Due to their origins, fluorides in high concentrations are not a common constituent of natural surface waters; however, they may occur in hazardous concentrations in ground waters.

Fluoride can be found in plating rinses and in glass etching rinse waters. Fluorides are also used as a flux in the manufacture of steel, for making aluminum, for preserving wood and mucilages, as a disinfectant, and in insecticides.

Fluorides in sufficient quantities are toxic and can be lethal to humans. Fluoride may also cause endemic cumulative fluorosis and skeletal effects. There is abundant literature describing the advantages of fluoride in drinking water to aid in the reduction of dental decay, especially among children. However, slightly higher concentrations may cause mottled enamel in children.

Fluorides may be harmful in certain industries, particularly those involved in the production of food, beverages, pharmaceuticals, and medicines. Fluorides found in irrigation waters in high concentrations have caused damage to certain plants exposed to these waters. Chronic fluoride poisoning of livestock has been observed. Fluoride from waters apparently does not accumulate in soft tissue to a significant degree; it is transferred to a very small extent into the milk and to a somewhat greater degree into eggs. Data for fresh water indicate that fluorides are toxic to fish.

High fluoride levels result from the use of fluoride compounds in columbium-tantalum and primary aluminum production processes.

Total Phenols (Phenolics). Total phenols as measured by the 4-AAP method are defined as hydroxy derivatives of benzene and its condensed nuclei. It is unlikely that harmful concentrations of phenolics will be consumed in drinking water since such concentrations are much higher than taste would allow. Threshold concentrations for taste and odor for phenols are less than 1 mg/l (20). The literature has listed many sources of phenolic pollutants including gas works (production), wood distillation, oil refineries, sheep and cattle dip, chemical plants, photographic developers, explosives, insecticides, foundry operations, Orlon manufacture, and stocking factories, among several others.

Many phenolic compounds are more toxic than pure phenol: their toxicity varies with the combinations and general nature of total wastes. The effect of combinations of different phenolic compounds is cumulative.

Phenols and phenolic compounds are both acutely and chronically toxic to fish and other aquatic animals. Also, chlorophenols produce an unpleasant taste in fish flesh that destroys their recreational and commercial value.

It is necessary to limit phenolic compounds in raw water used for drinking water supplies, as conventional treatment methods used by water supply facilities do not remove phenols. The ingestion of concentrated solutions of phenols will result in severe pain, renal irritation, shock and possibly death.

Phenols also reduce the utility of water for certain industrial uses, notably food and beverage processing, where it creates unpleasant tastes and odors in the product.

## JUSTIFICATION FOR THE SELECTION OF PRIORITY POLLUTANT PARAMETERS

The following section briefly describes the rationale used to select priority pollutant parameters for the various subcategories of the nonferrous metals industry. Wastewater characteristics presented and described in Section V were the principal basis for pollutant parameter selection. Data corresponding to similar wastewater streams was analyzed to observe trends and establish possible sources of the pollutants. Background information regarding the properties and possible sources of pollutants was also considered. A summary of this material was presented previously in this section. Another source of information was the data collection portfolios described in Section I. Part of the portfolio asked that the

plants identify each of the 129 priority pollutants as known present, suspected present, suspected absent, or known absent in the effluent. The responses for each pollutant were tallied for the different subcategories and will be presented in the discussions which follow.

Primary Aluminum

The pollutant parameters selected for the primary aluminum industry are:

| Significant | Site Specific | Marginally Significant |
|---|---|---|
| Acenaphthene | 1,2-benzanthracene | Antimony |
| Fluoranthene | Copper | Cadmium |
| Methylene chloride | Nickel | |
| Benzo(a) pyrene | Selenium | |
| Chrysene | Silver | |
| Pyrene | Beryllium | |
| Arsenic | | |
| Chromium | | |
| Cyanide | | |
| Lead | | |
| Mercury | | |
| Zinc | | |
| Fluoride | | |
| TSS | | |
| Phenolics | | |
| pH | | |

Organics. Analyses for the presence of acenaphthene were performed on samples from four plants. It was found at two plants in concentrations greater than 10 µg/l. A known residue of coal and petroleum pyrolysis, this compound appears to be generated by the baking of coal tar pitch in anode bake plants or in the cell at plants using Soderberg anodes.

Fluoranthene appeared consistently in samples from three plant. Three streams contained fluoranthene at concentrations greater than 100 µg/l. Fluoranthene appears to be generated principally in streams involving the baking of anodes, but is also present in cryolite recovery and paste plant wastewater streams. This compound is also known to be produced during the pyrolysis and combustion of coal and petroleum.

Benzo(a) pyrene was detected at concentrations equal to or exceeding 10 µg/l in wastewater streams of two plants. The concentration in one potline scrubber wastewater was greater than

500 µg/l. Benzo(a)pyrene is known to be present in coal tar and may be produced by anode baking operations. Benzo(a) pyrene has been found in Soderberg potroom air samples.

Chrysene is also known to occur in coal tar and is formed during the distillation of coal. It was detected at more than 100 µg/l at two plants. It is suspected of being associated with anode baking operations.

Pyrene is known to be produced with the heating of fossil fuels. At three plants, pyrene was found at more than 10 µg/l. One potline air pollution control stream contained a concentration of more than 200 µg/l of this compound. Once again, the source of pyrene is suspected to be anode baking operations.

1,2-Benzanthracene occurred in samples from only one plant and therefore is considered site specific. This compound is known to be present in coal tar and pitch and may be introduced by anode baking. Methylene chloride was detected at all four plants, twice at values greater than 100 µg/l. It is a commonly used solvent, but the actual source in this industry cannot be determined from the data. Since methylene chloride was used to prepare sample bottles, its presence may be an artifact of sampling.

In the data collection portfolios, 27 plants which discharge wastewater were asked to specify the presence or absence of the priority pollutants in their effluent. Responses for the organic compounds selected as pollutant parameters are summarized below. Although most of the plants indicated that these compounds were believed to be absent, several reported that they believed the pollutant parameters to be present in their wastewater.

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Acenaphthene | - | 4 | 20 | 3 |
| Fluoranthene | - | 6 | 19 | 2 |
| Methylene chloride | - | - | 26 | 1 |
| 1,2-benzanthracene | - | 8 | 19 | - |
| Benzo(a) pyrene | - | 8 | 19 | - |
| Chrysene | - | 7 | 20 | - |
| Pyrene | - | 8 | 19 | - |

Metals. The majority of the aluminum plants stated that the metals selected as significant were believed absent in their waste streams. The responses for the metals are summarized below.

| | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | - | 2 | 21 | 4 |
| Arsenic | 3 | 3 | 17 | 4 |
| Cadmium | 5 | 2 | 16 | 4 |
| Chromium | 6 | 3 | 16 | 2 |
| Copper | 7 | 5 | 14 | 1 |
| Lead | 1 | 5 | 19 | 2 |
| Mercury | 1 | 3 | 21 | 2 |
| Nickel | 1 | 3 | 23 | - |
| Selenium | 1 | 1 | 22 | 3 |
| Silver | 1 | 3 | 22 | 1 |
| Zinc | 8 | 3 | 16 | - |

All of the priority pollutant metals were detected in waste streams in the field sampling program. From the data and information in Section V, arsenic, chromium, lead, mercury, and zinc occur industry-wide at concentrations several orders of magnitude greater than the significance thresholds previously discussed. Streams with cryolite recovery contribute these metals in larger amounts than any other process stream. They also remained in the effluent in higher concentrations than in other streams.

The metals beryllium, copper, nickel, selenium, and silver were also detected at high concentrations, but only at one or two plants sampled. The concentrations were generally three to five orders of magnitude larger than the threshold limits. Cryolite recovery wastewater was present in the streams sampled. These metals were termed site specific because, while in high concentrations, the metals did not appear to be present on an industry-wide basis.

In the case of antimony and cadmium, the intake water concentrations play a greater role. Industry-wide, the amount by which the metals are greater than the threshold concentration, after accounting for the background levels, is very small, always less than one order of magnitude greater than the threshold. Removal of the selected metals should remove the trace amounts of the metals labeled marginally significant.

Other Priority Pollutants. Cyanide has also been selected as a pollutant parameter. Its presence appears to be related to cryolite recovery. Cyanide complexes have been found in spent cathode leachate.

Secondary Aluminum

The pollutant parameters selected for the secondary aluminum industry are the following:

| Significant | Site Specific |
|---|---|
| Dichlorobromomethane | Benzene |
| Di-n-butyl phthalate | 1,2-trans-dichloroethylene |
| Cadmium | Bis(2-ethylhexyl) phthalate |
| Chromium | Butylbenzyl phthalate |
| Copper | Di-n-octyl phthalate |
| Lead | Dimethyl phthalate |
| Zinc | Antimony |
| Ammonia | Arsenic |
| TSS | Beryllium |
| pH | Mercury |
| | Nickel |
| | Selenium |
| | Thallium |

Organics. Dichlorobromomethane was detected in excess of 10 µg/l at two of the five plants sampled in this study. In both cases, it occurs in waste streams from chlorine demagging air pollution control.

Di-n-butyl phthalate appears to be significant in the secondary aluminum industry, having been detected in excess of 10 µg/l at all of the five plants sampled. The compound was present in a variety of waste streams in concentrations as high as 50 µg/l. The levels of di-n-butyl phthalate in the intake and blank samples were negligible. This compound is used mainly as a plasticizer in plastics compositions, though it is also found in gasoline additives and lubricants. The specific source of di-n-butyl phthalate in the secondary aluminum industry is not known.

Benzene, a common solvent, is considered to be site specific because it was detected at only one plant sampled at levels greater than 10 µg/l. The demagging air pollution control waste stream was found to contain more than 100 µg/l of benzene at this plant.

Another organic solvent, 1,2-trans-dichloroethylene, was detected in excess of 10 µg/l at only one secondary aluminum plant. It was detected, however, in several wastewater streams at approximately 50 µg/l. For these reasons, 1,2-trans-dichloroethylene has been designated as site specific.

A number of phthalate compounds were detected in the dross milling sample from one of the five plants sampled. These compounds are designated as site specific because they were present in significant levels, but only at that plant. Bis(2-

ethylhexyl) phthalate was detected in the dross milling stream at approximately 2,000 µg/l and in the demagging stream at approximately 200 µg/l. These streams were combined for treatment and the treated waste stream contained more than 1,200 µg/l. Butylbenzyl phthalate concentrations in the dross milling stream were reported to be almost 100 µg/l. Di-n-octyl phthalate was also detected in this stream though at slightly lower concentrations. The raw data for this compound was 36 µg/l, but this value was reduced to 15 µg/l after subtracting the intake concentration. Di-n-octyl phthalate was also found at another plant, but it was detected during only one of the three days of sampling. The dross milling stream also contained concentrations of dimethyl phthalate in excess of 50 µg/l. Phthalates are mainly used as plasticizers in plastic compounds though they may also be present in gasoline additives and synthetic lubricants. The source of these compounds at this particular plant is not known.

The secondary aluminum plants which discharge wastewater were asked to specify the presence or absence of the priority pollutants in their effluent. All of the plants indicated that they believed the organic priority pollutants were absent. The only exception was the compound hexachloroethane, which two of the plants believed to be present in their effluent. This compound was not found in any sample taken in this industry.

Metals. The majority of plants believed most metals to be absent in their effluent. The responses for the metals are summarized below.

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | - | - | 19 | - |
| Arsenic | - | 1 | 21 | - |
| Beryllium | 1 | - | 21 | - |
| Cadmium | 5 | 1 | 17 | - |
| Chromium | 11 | 5 | 7 | - |
| Copper | 1 | - | 20 | 1 |
| Lead | 7 | 6 | 10 | - |
| Mercury | 2 | 2 | 17 | 1 |
| Nickel | 5 | 2 | 15 | - |
| Selenium | - | - | 20 | 1 |
| Thallium | - | - | 20 | 1 |
| Zinc | 9 | 6 | 8 | - |

In field sampling, all of the priority pollutant metals were detected. From the data and information in Section V, it was determined that cadmium, chromium, copper, lead, and zinc occurred industry-wide at concentration levels several orders of

magnitude greater than the thresholds. The data indicates that waste streams related to dross milling, and to a lesser extent demagging wet air pollution controls, contain the highest levels. They also remained in the effluent in higher concentrations than in the other streams. Subtraction of intake concentrations had no effect on reducing the significance level in which these metals were placed.

All of the remaining metals except for silver were detected at moderate concentrations in only one or two streams in the plants surveyed. Nearly all of the intake concentrations are less than the threshold levels previously selected. Intake concentrations did eliminate the seemingly high concentrations of some metals in a few waste streams, allowing the metals to be called site specific. While dross milling and demagging air pollution control appear to contribute significant levels of three metals, after deducting the intake concentrations, it appears that generally only very small concentrations of the site specific metals are added to the waste streams by the processes employed in the secondary aluminum industry. Since zinc, cadmium, and lead are in the greatest concentration, treatment for removal of these metals should remove all other heavy metals to acceptable levels.

Primary Columbium-Tantalum

The pollutant parameters selected for the columbium/ tantalum industry are the following:

| Significant | Site Specific |
|---|---|
| 1,2,4-trichlorobenzene | 1,2-trans-dichloroethylene |
| 1,2-dichloroethane | Methylene chloride |
| Bis(2-ethylhexyl) phthalate | Nitrobenzene |
| Tetrachloroethylene | Butyl-benzyl phthalate |
| PCB-1254 | Di-n-butyl phthalate |
| PCB-1248 | Di-n-octyl phthalate |
| Cadmium | Trichloroethylene |
| Chromium | Antimony |
| Copper | Arsenic |
| Lead | Beryllium |
| Mercury | Silver |
| Nickel | |
| Zinc | |
| TSS | |
| Ammonia | |
| pH | |
| Fluoride | |

Organics. 1,2,4-trichlorobenzene was detected at two of the four columbium-tantalum plants sampled, once at more than 200 µg/l. This compound was found only in streams containing gangue slurry effluents. The original source of 1,2,4-trichlorobenzene in the columbium-tantalum industry cannot be positively identified, but it is reportedly used as a capacitor dielectric, heat transfer fluid, degreaser, and lubricant.

1,2-dichloroethane was detected at low levels at all plants sampled. The highest concentrations (up to approximately 150 µg/l) appeared in streams containing digester scrubber and floor washdowns. 1,2-dichloroethane is used as an industrial solvent.

Bis(2-ethylhexyl) phthalate was detected at all of the plants sampled. Although high concentrations of this compound appeared in the intake water of some of these plants, effluent concentrations were uniformly higher than in the intake. Bis(2-ethylhexyl) phthalate concentrations at three of the plants exceeded 100 µg/l and one stream contained 1,100 µg/l. This compound does not appear to be limited to particular wastewater streams. It is used primarily as a plasticizer in plastic compositions, though some use in gasoline additives and synthetic lubricants is also reported.

Tetrachloroethylene was selected as a pollutant parameter because it was detected at two of the four plants sampled in this industry, twice at concentrations exceeding 100 µg/l. One of the known uses of tetrachloroethylene is as a solvent for metal degreasing. The data suggest washdowns as a possible source of this compound.

PCB-1254 and PCB-1248 were detected at all but one of the four plants sampled. The two compounds were frequently found to be present at net concentrations in excess of 1 µg/l even after subtracting blank and intake water values. In one wastewater stream, more than 50 µg/l of PCB-1254 and 30 µg/l of PCB-1248 were present. PCBs have been used as dielectrics in transformers and capacitors, as hydraulic oils, and as heat transfer fluids.

1,2-trans-dichloroethylene is designated as site specific. During one of the three days of sampling at one plant, it was detected at concentrations greater than 200 µg/l in a number of streams. 1,2-trans-dichloroethylene is used as a general solvent.

Methylene chloride, another industrial solvent, was found at a very high level, approximately 88,000 µg/l, in a digester scrubber/floor washdown stream. Methylene chloride was not detected at any other plant sampled.

Nitrobenzene, another site specific parameter, was found in gangue slurry wastewater at one plant at concentrations exceeding 150 µg/l. Nitrobenzene is used in the manufacture of aniline and as a dye intermediate, but its source in the columbium-tantalum industry is not known.

Three phthalates have been selected as site specific. Butylbenzyl phthalate and di-n-octyl phthalate were detected in tantalum metal leaching wastewater at one plant, at approximately 50 µg/l of each compound. Di-n-butyl phthalate was detected in several streams of another plant. Two streams contained di-n-butyl phthalate at approximately 50 µg/l. Phthalates are used primarily as plasticizers in plastic compositions though they may also be present in gasoline additives and synthetic lubricants. The sources of these phthalates at the particular plants have not been identified.

Trichloroethylene was detected at more than 200 µg/l in a digester scrubber/floor washdown stream at one plant sampled. During one of the three days of sampling, 20 µg/l of the compound was detected at a second plant in a waste stream which also was composed of washdown and other wastewater. Trichloroethylene, a degreasing solvent, appears to be present in effluent from some plants, but it was not judged to occur industry-wide.

In the data collection portfolios, all of the columbium-tantalum plants responding to the question concerning the presence or absence of the priority pollutants in their wastewater indicated that the organic priority pollutants were known or believed to be absent from their wastewater.

Metals. The majority of metals were believed absent by the plants. The responses for the metals are summarized below.

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | 1 | - | 2 | 1 |
| Arsenic | 1 | - | 2 | 1 |
| Beryllium | - | - | 3 | 1 |
| Cadmium | - | - | 2 | 2 |
| Chromium | 1 | 1 | 1 | 1 |
| Copper | - | 1 | 2 | 1 |
| Lead | - | - | 2 | 2 |
| Mercury | - | 1 | 1 | 2 |
| Nickel | 1 | 1 | 1 | 1 |
| Silver | - | - | 2 | 2 |
| Zinc | - | - | 3 | 1 |

All of the priority pollutant metals were detected in field sampling. The data in Section V show that cadmium, chromium, copper, lead, mercury, nickel, and zinc occur industry-wide at concentrations several orders of magnitude greater than the significance thresholds previously discussed. The effect of the intake on reducing the concentrations of the significant metals is negligible and can be ignored. The data in Table V-14 indicate that the waste streams related to floor washdown and digester air pollution control contain the highest levels of these metals. While a large percentage of each metal appears to be removed by existing treatment, the treated wastewaters still contain the metals in amounts greater than the threshold concentrations.

Antimony, arsenic, beryllium, and silver were detected in all of the waste streams, but only in one or two plants at levels substantially greater than the threshold limits. Allowing for the intake concentrations eliminates the significance of the metal in several of the waste streams. As with the significant metals, floor washdown and digester air pollution control streams contain the highest concentrations. Extraction raffinate streams also contain large concentrations of the site specific metals.

For all the site specific metals, after accounting for intake concentrations the residual concentrations are generally still very much greater than the threshold. Treatment for removal of the metals of highest concentration (zinc, cadmium and lead) should remove the other heavy metals to acceptable levels.

Primary Copper

The pollutant parameters selected for the primary copper industry are the following:

| Significant | Site Specific |
|---|---|
| Arsenic | Antimony |
| Chromium | Cadmium |
| Copper | Thallium |
| Lead | Zinc |
| Mercury | |
| Nickel | |
| Selenium | |
| Silver | |
| TSS | |
| pH | |

Organics. No organic priority pollutants were included as pollutant parameters in this industry. Samples collected from primary copper plants did not indicate that these organic

compounds were present in the wastewater at significant concentrations. These findings support the opinion of the industry itself. All of the primary copper plants believed that the organic priority pollutants were absent from their wastewater.

Metals. The majority of the primary copper plants either knew the priority pollutant metals to be present or believed them to be absent. The responses for the metals are summarized below.

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | 6 | 3 | 2 | - |
| Arsenic | 7 | 2 | 1 | 1 |
| Cadmium | 7 | 1 | 3 | - |
| Chromium | 5 | 2 | 4 | - |
| Copper | 10 | 1 | - | - |
| Lead | 8 | - | 3 | - |
| Mercury | 4 | 1 | 5 | 1 |
| Nickel | 8 | 2 | 1 | - |
| Selenium | 5 | 2 | 3 | 1 |
| Silver | 6 | 2 | 3 | - |
| Thallium | - | 1 | 9 | - |
| Zinc | 9 | 1 | 1 | - |

All of the priority pollutant metals were detected in field sampling. The data in Section V show that all the priority pollutant metals, except antimony, cadmium, thallium and zinc, occur industry-wide at concentrations several times greater than the significance thresholds previously discussed. As in previous subcategories, the intake water concentrations are lower than the threshold levels. The highest metals concentrations are associated with the acid plant blowdown.

Antimony, cadmium, thallium, and zinc were detected in all of the waste streams, but only in one plant at levels substantially greater than the threshold limits. All these metals are also at the highest levels in the acid plant streams. Allowing for intake concentrations of these metals reduces their significance in several of the waste streams.

For the site specific metals, after accounting for concentrations, the concentrations are still very much greater than the threshold. However, cadmium and zinc are likely to be removed by treatment methods used to remove significant pollutants such as copper, lead and nickel.

Secondary Copper

The following were designated as pollutant parameters for the secondary copper industry:

| Significant | Site Specific | Marginally Significant |
|---|---|---|
| Fluoranthene | Naphthalene | Hexachlorobenzene |
| Bis(2-ethylhexyl) phthalate | Di-n-octyl phthalate | Chrysene |
| Di-n-butyl phthalate | Dimethyl phthalate | |
| Diethyl phthalate | Acenaphthylene | |
| Fluorene | Antimony | |
| Pyrene | Beryllium | |
| PCB-1254 | | |
| PCB-1248 | | |
| Arsenic | | |
| Cadmium | | |
| Chromium | | |
| Copper | | |
| Lead | | |
| Mercury | | |
| Nickel | | |
| Selenium | | |
| Silver | | |
| Zinc | | |
| pH | | |
| Phenolics | | |
| TSS | | |

Organics. The sampling data show some general characteristics that should be noted. While a few wastewater streams sampled contained very high concentrations of a number of organics, (i.e. hundreds or thousands of µg/l, these high concentrations were not always confirmed by results from samples taken at similar waste streams at other plants. In addition, the levels of organics detected in this industry showed a tendency to vary during successive days of sampling.

Fluoranthene was detected at concentrations greater than 10 µg/l at three of the five plants sampled. The highest concentration, approximately 3,000 µg/l, was detected in a treated furnace scrubber wastewater stream during one day of sampling. Fluoranthene also occurred in a waste electrolyte/floor washdown at concentrations as high as 250 µg/l and at lower levels in a number of other streams. Fluoranthene is a polynuclear aromatic known to be produced during the pyrolysis or combustion of coal and petroleum. This is a possible explanation of its presence in the furnace scrubber stream.

Three phthalates have been designated as significant pollutant parameters. Bis(2-ethylhexyl) phthalate was detected in wastewater at all the secondary copper plants sampled. Concentrations of bis(2-ethylhexyl) phthalate in these streams were relatively high, ranging from 10 to 7,000 µg/l. Di-n-butyl phthalate was also detected at all five plants, but at somewhat lower concentrations. Three of the streams contained maximum concentrations of more than 100 µg/l. Diethyl phthalate was detected at two plants. A waste electrolyte/floor washdown stream and a slag milling stream each had average concentrations of approximately 50 µg/l. Phthalates are used mainly as plasticizers in plastic compositions, though uses in gasoline additives and synthetic lubricants have also been reported.

Fluorene was detected at three plants. Concentrations of approximately 50 µg/l occurred in some streams associated with slag milling and waste electrolyte/floor washdown operations. Fluorene is a polynuclear aromatic found in coal tar and coal tar pitch. Its specific origins in this industry have not been identified.

Pyrene, another polynuclear aromatic found in coal tar, was present in wastewater at three plants. The highest concentration, approximately 7,000 µg/l, was detected in treated furnace scrubber wastewater during one day of sampling. Similar waste streams from other plants did not contain significant concentrations of pyrene, however. A waste electrolyte/floor washdown stream at one plants contained more than 100 µg/l of pyrene and approximately 20 µg/l was found in a slag milling wastewater stream.

The polychlorinated biphenyls, PCB-1254 and PCB-1248, were present in the wastewater of three plants. The maximum net concentrations of these compounds detected in the sampling program were approximately 3 µg/l and 2 µg/l, respectively. The PCBs were found in a variety of wastewater streams and their origin in this industry cannot be traced on the basis of the sampling data. PCBs have been used as dielectrics in transformers and capacitors, as hydraulic oils, and as heat transfer fluids.

Four organic priority pollutants have been designated as site specific. Two polynuclear aromatics, naphthalene and acenaphthylene, were detected in the waste electrolyte/floor washdown stream at one plant. The average concentration of naphthalene in this stream exceeded 2,000 µg/l. Acenapthylene concentrations were lower, usually about 100 µg/l. Naphthalene is the major constituent of coal tar and is also used as an intermediate in the production of solvents and lubricants. Acenapthylene is also

present in coal tar and is produced in the pyrolysis or combustion of fossil fuels.

Di-n-octyl phthalate appears to be introduced by a contact and noncontact cooling water stream at net concentrations of 175 µg/l at one plant. The slag milling wastewater stream at another plant contained dimethyl phthalate in concentrations as high as 1000 µg/l. Phthalates are known to be used as plasticizers and may also be used in gasoline additives and synthetic lubricants. The specific origins of these compounds in this industry have not been identified.

Two organic priority pollutants have been classified as marginally significant. Although high concentrations of these compounds were detected, they were not found to be present frequently or consistently in wastewater. Hexachlorobenzene was detected in wastewater at two plants. The compound was present at concentrations of approximately 5,000 µg/l in a furnace scrubber stream during one day of sampling, but was not detected the following day. The slag milling stream at a second plant contained hexachlorobenzene at approximately 200 and 150 µg/l during two consecutive days, but was not detected on the third. Both wastewater streams were sampled after some wastewater treatment. Chrysene concentrations in the furnace scrubber stream mentioned above were approximately 10,000 µg/l the first day but were not detected during the second day. Chrysene was detected in a waste electrolyte/floor washdown stream during only one of three days sampling. On this day, however, a concentration of more than 56 µg/l of this compound was found.

In the data collection portfolios, the secondary copper plants that discharge wastewater were asked to specify the presence or absence of the priority pollutants in their wastewater. In every case the plants believed that the organic priority pollutants were absent.

Metals. The data collection portfolio responses of the secondary copper plants asked to specify the possible presence or absence of the priority pollutant metals varied. The majority of the plants either knew the metals to be present or believed them to be absent. The responses for the metals are summarized below.

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | 2 | 1 | 7 | - |
| Arsenic | 1 | - | 8 | 1 |
| Beryllium | 1 | - | 9 | - |
| Cadmium | 3 | - | 7 | - |
| Chromium | 2 | 1 | 7 | - |
| Copper | 7 | 1 | 2 | - |
| Lead | 6 | 1 | 3 | - |
| Mercury | 2 | 1 | 6 | 1 |
| Nickel | 4 | 1 | 5 | - |
| Selenium | - | - | 9 | 1 |
| Silver | 1 | 1 | 8 | - |
| Zinc | 7 | 1 | 1 | - |

At the five plants in the field sampling program, all of the priority pollutant metals were detected. The data in Section V show that all of the metals except antimony, beryllium, and thallium occur industry-wide at concentration levels much greater than the significance thresholds previously discussed. The effect of the intake water on reducing the concentrations of the significant metals is negligible. Thus, most of the metals are present as a direct result of the production processes. The waste streams containing the waste electrolyte and refining area cleaning water contained the highest levels of all metals. The treated waste streams still contain the metals in amounts greater than the threshold concentrations.

Antimony and beryllium were detected in all of the waste streams, but only in one or two waste streams at levels substantially greater than the threshold limits. Both of these metals are also found in the greatest concentrations in the waste electrolyte streams. Allowing for intake water concentrations of these metals eliminates the significance in several of the waste streams.

For all the metals, after accounting for intake concentrations, the net concentrations are generally still very much greater than the threshold values. Since lead, copper, and zinc are in such high concentrations, treatment for removal of these metals should also remove the other heavy metals to acceptable levels.

Primary Lead

The pollutant parameters selected for the primary lead industry are the following:

| Significant | Site Specific | Marginally Significant |
|---|---|---|
| Cadmium | Antimony | Arsenic |
| Copper | Beryllium | Mercury |
| Lead | Nickel | Selenium |
| Zinc | Ammonia | Silver |
| TSS | | |
| pH | | |

Organics. No organic priority pollutants were included as pollutant parameters in this industry. Samples collected from three primary lead plants did not indicate that these compounds were present in the wastewater at significant concentrations. All of the primary lead plants which discharge wastewater indicated in data collection portfolios that they knew or believed the organic priority pollutants to be absent from their effluent.

Metals. The data collection portfolio responses of the primary lead plants asked to specify the possible presence or absence of the priority pollutant metals were varied. However, a majority of the plants stated that most of the metals were either known to be present or believed absent. The responses for the metals is summarized below.

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | 3 | - | 2 | - |
| Arsenic | 3 | 1 | 1 | - |
| Beryllium | - | - | 4 | 1 |
| Cadmium | 5 | - | - | - |
| Copper | 5 | - | - | - |
| Lead | 5 | - | - | - |
| Mercury | 1 | - | 2 | 2 |
| Nickel | 2 | 2 | 1 | - |
| Selenium | 1 | 1 | 2 | 1 |
| Silver | 2 | 2 | 1 | - |
| Zinc | 5 | - | - | - |

All of the above metals were detected in waste streams. The data in Section V show that cadmium, copper, lead, and zinc occur industry-wide at concentration levels much greater than the threshold limits. As in previous subcategories, the intake water concentrations of these metals are lower than the threshold levels. Thus, most of the significant metals is contributed by the production processes. Table V-34 reveals that the waste streams related to the acid plant and slag granulation processes contained the highest levels of these metals. While a large

percentage of the metal appears to be removed by the existing treatment methods, the treated waste streams still contain the metals in amounts greater than the threshold concentrations.

Antimony, beryllium, and nickel were detected in all of the waste streams, but only at one plant at levels substantially greater than the threshold limits. These site specific metals were higher in the acid plant and slag granulation waste streams at the one plant. Allowing for intake water concentrations of these metals eliminates their significance.

For all the metals previously mentioned, after accounting for intake concentrations the net concentrations are generally still very much greater than the threshold values. The marginally significant metals--arsenic, mercury, selenium, and silver--were all detected in the wastewaters, but at levels only slightly above the threshold limits. Treatment for removal of the high concentration metals --zinc, cadmium and lead--should remove the marginally significant metals to acceptable levels.

Secondary Lead

The pollutant parameters selected for the secondary lead industry are the following:

| Significant | Site Specific | Marginally Significant |
|---|---|---|
| Bis(2-ethylhexyl) phthalate | Butylbenzyl phthalate | Thallium |
| Di-n-butyl phthalate | Mercury | |
| Di-n-octyl phthalate | | |
| Chrysene | | |
| PCB-1254 | | |
| PCB-1248 | | |
| Antimony | | |
| Arsenic | | |
| Cadmium | | |
| Chromium | | |
| Copper | | |
| Lead | | |
| Nickel | | |
| Silver | | |
| Zinc | | |
| TSS | | |
| Ammonia | | |
| pH | | |

Organics. In field sampling, wastewater samples from three plants were analyzed for organic priority pollutants. Three phthalates were selected as significant pollutant parameters.

Bis(2-ethylhexyl) phthalate was detected at every plant. After accounting for blank and intake concentrations, levels of bis(2-ethylhexyl) phthalate as high as 300 µg/l and 500 µg/l were found in two of the waste streams, as well as at several lower values. Di-n-butyl phthalate occurred at two plants at concentrations ranging between 10 and 50 µg/l. Di-n-octyl phthalate was also found in wastewater streams at two plants, although concentrations never exceeded 30 µg/l. Phthalates are used mainly as plasticizers in plastic compositions, though they may also be present in gasoline additives and synthetic lubricants. The phthalates do not appear to be associated with one particular stream in this industry and their source cannot be identified on the basis of this sampling data.

Chrysene was detected at every plant sampled. Concentrations as high as 100 µg/l and 500 µg/l were found in two of the wastewater streams. Chrysene is a polynuclear aromatic formed during the distillation of coal and, to a lesser degree, during the distillation and pyrolysis of a number of fats and oils. The source of chrysene in this industry cannot be identified on the basis of the sampling data. It was detected in a number of different wastewater streams.

PCB-1254 and PCB-1248 were detected in wastewater streams at two plants. The compounds were present in all streams sampled at these plants in concentrations ranging from approximately 1 to 5 µg/l. PCBs have been used as dielectrics in transformers and capacitors, as hydraulic oils, and as heat transfer fluids.

Butylbenzyl phthalate was classified as site specific because it was found at concentrations exceeding 10 µg/l at only one plant sampled. In a combined raw wastewater stream, however, it was detected at 85 µg/l. The origin of butylbenzyl phthalate in this industry is not known. Like other phthalates, it is used primarily as a plasticizer, though it also can be used as a gasoline additive and synthetic lubricant.

In the data collection portfolios, plants which discharge wastewater were asked to specify the presence or absence of the priority pollutants in their wastewater. All of the plants indicated that they knew or believed the organic priority pollutants to be absent.

Metals. The data collection portfolio responses of the secondary lead industry plants asked to specify the possible presence or absence of the priority pollutant metals were varied and inconclusive. The majority of the plants believed most of the metals to be absent from their waste stream. The responses for the metals are summarized below.

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | 13 | 5 | 4 | - |
| Arsenic | 9 | 7 | 6 | - |
| Cadmium | 7 | 6 | 6 | 3 |
| Chromium | 3 | 5 | 10 | 4 |
| Copper | 12 | 2 | 7 | 1 |
| Lead | 17 | 4 | - | - |
| Mercury | 2 | 4 | 13 | 3 |
| Nickel | 6 | 4 | 11 | 1 |
| Silver | 2 | 3 | 17 | - |
| Thallium | 1 | - | 18 | 3 |
| Zinc | 10 | 6 | 6 | - |

At the four plants sampled, all of the priority pollutant metals were detected in waste streams. The data in Section V show that all the metals except beryllium and selenium (considered insignificant), and mercury and thallium, occur industry-wide at concentration levels several orders of magnitude greater than the significance thresholds previously discussed. The intake water concentrations of these metals are lower than the threshold levels, as has been the case in every other subcategory. Their effect on the gross concentration of the significant metals is negligible. Thus, the intake water can be ignored as a factor in any analysis. The highest concentrations of these metals are found in the battery electrolyte waste streams. While the metals appear to be removed somewhat by existing treatment methods, the treated waste streams still contain the metals in amounts greater than the threshold concentrations.

Mercury was detected in all of the waste streams, but only in battery electrolyte waste streams at levels substantially greater than the threshold. The intake water concentration allowance eliminates the significance of the metal in several of the waste streams and plants. Existing treatment systems appear capable of partially removing this metal from the waste streams.

Thallium was also detected in all of the waste streams but at levels only slightly greater than the threshold level at all of the plants sampled. Allowing for the intake concentration in the wastewater streams indicates that only very small amounts of the material must be removed to reach the threshold. Existing treatment methods are capable of removing some of the thallium present. For all of the other significant metals, the net concentrations are generally still very much greater than the threshold levels after treatment. Treatment for removal of zinc, lead and copper should remove the other heavy metals to acceptable levels.

Secondary Silver

The following were selected as pollutant parameters for the secondary silver industry:

| Significant | Site Specific |
|---|---|
| (Photographic and Non-photographic) | |
| Benzene | Carbon Tetrachloride |
| Bis(2-ethylhexyl) phthalate | Fluoranthene |
| Butylbenzyl phthalate | Dichlorobromomethane |
| Di-n-octyl phthalate | Di-n-butyl phthalate |
| Tetrachloroethylene | Mercury |
| PCB-1254 | Thallium |
| PCB-1248 | Trichloroethylene |
| Antimony | |
| Arsenic | |
| Cadmium | |
| Chromium | |
| Copper | |
| Cyanide | |
| Lead | |
| Nickel | |
| Selenium | |
| Silver | |
| Zinc | |
| TSS | |
| Ammonia | |
| pH | |
| Phenolics | |
| (Photographic Only) | |
| 1,2-dichloroethane | |
| 1,1-dichloroethylene | |
| Methylene chloride | |

Organics. Benzene was detected at two of the four secondary silver plants sampled in this study. One plant processed photographic wastes, while another reclaimed silver from non-photographic material. Raw wastewater concentrations in excess of 100 µg/l were found in two streams. Benzene is a common solvent which may be used as a degreasing and cleaning agent. The sources of this compound in the secondary silver industry are not known.

Three phthalates have been selected as significant. Bis(2-ethylhexyl) phthalate was detected in every stream sampled.

Concentrations in these streams ranged from 7 µg/l to 124 µg/l. Butylbenzyl phthalate was found above 10 µg/l in the wastewater at two plants. One plant processed photographic wastes while another used non-photographic material. Concentrations were as high as 60 µg/l. Di-n-octyl phthalate was detected at all plants sampled in this study, although concentrations at one plant were less than 10 µg/l. Streams at the other three plants contained concentrations ranging from 10 µg/l to 70 µg/l. Phthalates are primarily used as plasticizers in plastic composition, though they are also found in gasoline additives and lubricants. One possible source of phthalates in this industry is their presence in photographic wastes introduced as raw materials. The phthalates mentioned above, however, were found to exist in plants that process non-photographic materials as well as those using photographic waste.

Tetrachloroethylene was detected at concentrations exceeding 50 µg/l at two plants. One plant processed photographic wastes, while the other reclaimed silver from non-photographic materials. Tetrachloroethylene is known to be used as a solvent in metal degreasing. Its origins in the secondary silver industry, however, cannot be clearly identified on the basis of this data.

The polychlorinated biphenyls, PCB-1254 and PCB-1248, were found to be present in wastewaters of two plants after accounting for concentrations of the compound in blank and intake water samples. Maximum net concentrations of PCB-1254 and PCB-1248 were 2.3 µg/l and 1.7 µg/l, respectively. The compounds have been used as dielectrics in transformers and capacitors, as hydraulic oils, and as heat transfer fluids. Their source in the secondary silver industry is not known.

Several organic priority pollutants were found to be significant only for the secondary silver plants that process photographic wastes. One such compound, 1,2-dichloroethane, was detected at both photographic secondary silver plants sampled in this study. Concentrations of 1,2-dichloroethane at these plants frequently exceeded 100 µg/l. This compound is a common industrial solvent, but its specific use in this industry cannot be identified on the basis of this sampling program.

Another pollutant parameter, 1,1-dichloroethylene, was also detected only at the two plants that recover silver from photographic wastes. Several streams contained concentrations greater than 100 µg/l. More than 6,000 µg/l of this compound was detected in a raw wastewater stream associated with film sludge processing. 1,1-dichloroethylene is used as an internal plasticizer in fibers and plastics manufacturing.

Methylene chloride was detected at only one photographic secondary silver plant. Concentrations at this plant were found to be very high. Two of the three raw wastewater streams contained approximately 3,000 µg/l of methylene chloride. This compound was not designated as site specific because another plant indicated in the data collection portfolio that methylene chloride was believed to be present in its wastewater.

A number of organic priority pollutants were identified as site specific because they occurred at significant levels in the wastewater of only one plant. Carbon tetrachloride, a site specific parameter, was detected at concentrations as high as 2,000 µg/l, in wastewater streams of a plant processing non-photographic wastes. Carbon tetrachloride is commonly used as an all-purpose solvent and chemical intermediate.

Dichlorobromomethane was found to be present in the treated wastewater of one plant processing non-photographic wastes. Concentrations ranged between 1,500 and 2,800 µg/l. The industrial uses of dichlorobromomethane are not known and the origin of this compound in secondary silver processing wastewater cannot be determined.

Another designated as site specific compound is di-n-butyl phthalate. While di-n-butyl phthalate was detected at two plants, only at one non-photographic plant was it found in excess of 15 µg/l. Here the compound was found at 80 µg/l and 300 µg/l. Phthalates are used mainly as plasticizers in plastics, though they also occur in gasoline additives and synthetic lubricants.

Trichloroethylene was detected only at one secondary silver plant, a processor of photographic wastes. Most of the streams sampled at this plant contained more than 100 µg/l, and concentrations as high as 900 µg/l were detected. Trichloroethylene is used primarily as a degreasing solvent in metal industries. Its source in the secondary silver industry has not been identified.

In the data collection portfolios, the secondary silver plants which discharge wastewater were asked to specify the presence or absence of the priority pollutants in their effluent. Although most of the plants indicated that the organic compounds were known or believed to be absent, one plant, a processor of photographic wastes, reported that it believed methylene chloride to be present. The organic priority pollutants listed below were not selected as pollutant parameters on the basis of the sampling data but were identified by this plant as being known or believed present:

Methyl chloride
Phenol
Diethyl phthalate
Dimethyl phthalate
Vinyl chloride

Metals. The data collection portfolio responses of the secondary silver plants asked to specify the possible presence or absence of the priority pollutant metals were varied and inconclusive. The majority of the plants stated that they knew most of the metals were present in their waste streams or believed them to be absent. The responses for the metals are summarized below:

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | 3 | 2 | 7 | 1 |
| Arsenic | 2 | 1 | 9 | 1 |
| Cadmium | 5 | 3 | 4 | 1 |
| Chromium | 5 | 2 | 4 | 2 |
| Copper | 9 | 1 | 1 | 2 |
| Lead | 6 | 2 | 2 | 3 |
| Mercury | 2 | 1 | 8 | 2 |
| Nickel | 8 | - | 3 | 2 |
| Selenium | 2 | - | 9 | 2 |
| Silver | 11 | 1 | 1 | - |
| Thallium | - | - | 9 | 4 |
| Zinc | 9 | 1 | 1 | 2 |

All of the priority pollutant metals were detected in the sampling program. The data in Section V show that all the metals except mercury, thallium, and beryllium occur industry-wide at concentrations several orders of magnitude greater than the significance thresholds previously discussed. The intake concentrations of these metals are lower than the threshold levels and several orders of magnitude less than the actual waste stream concentrations. The highest metals concentrations were found in the waste streams from air pollution control devices and silver slurry supernatant. While existing treatment schemes appear to remove a large percentage of each metal, the treated waste streams still contain the metals in amounts greater than the threshold concentrations.

Mercury and thallium were detected in all the waste streams, but only in one or two waste streams at levels substantially greater than the threshold limits. Allowing for the intake concentrations of these metals eliminates the significance of these in several of the waste streams and plants. As with the other metals, both mercury and thallium are contained in the

highest concentrations in the waste streams from silver slurry supernatant and air pollution control devices.

While the site specific metals are not present in as high a concentration as significant ones, the net concentrations in the treated effluents are still greater than the threshold limits. Since zinc, chromium, lead, and cadmium are present in the greatest concentrations, treatment for removal of these metals should remove all the other heavy metals to acceptable levels.

Other Priority Pollutants. Cyanide was designated as a pollutant parameter because it was found in concentrations several orders of magnitude greater than the threshold limits. It was present predominately in the film waste influent stream as well as in silver slurry supernatant and air pollution control device streams. This trend appears to be applicable to nearly all of the metals and the criteria parameters. The existing treatment methods used in the secondary silver industry are not very effective in removing cyanide.

Primary Tungsten

The following pollutant parameters were selected for the primary tungsten industry:

| Significant | Site Specific | Marginally Significant |
|---|---|---|
| Tetrachloroethylene | Acenaphthene | Cadmium |
| Chromium | Naphthalene | Mercury |
| Copper | Bis(2-ethylhexyl) phthalate | Nickel |
| Lead | Di-n-butyl phthalate | Zinc |
| Silver | D n-octyl phthalate | |
| TSS | Dimethyl phthalate | |
| Ammonia | Chrysene | |
| pH | Acenaphthylene | |
| | Vinyl chloride | |
| | Arsenic | |
| | Selenium | |
| | Thallium | |

Organics. Tetrachloroethylene, the only organic priority pollutant designated as significant, was detected at concentrations ranging between 20 µg/l and 70 µg/l in the wastewater of two of the three plants sampled. The presence of tetrachloroethylene did not appear to be specific to a particular waste stream and its origin in this industry has not been determined.

Several organics were identified as site specific. Of these, a number were detected in the ion exchange raffinate which is discharged as a wastewater stream at one of the plants sampled. Acenaphthene, naphthalene, and acenaphthylene were each found in the raffinate stream at concentrations of 100 µg/l or greater. These three compounds are polynuclear aromatics and have similar chemical structures. Another compound, vinyl chloride, was also detected in this stream in excess of 150 µg/l during one day of sampling. Vinyl chloride is used in a number of plastics. The occurrence of these organic priority pollutants in the raffinate waste stream can probably be attributed to the organic solvent used in the ion exchange process.

Several phthalates were designated as site specific. Bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, and di-n-octyl phthalate were detected at one plant in a stream containing tungstic acid rinsewater. Concentrations in this stream varied between 700 µg/l and 900 µg/l. Di-n-butyl and di-n-octyl phthalate were present at lower concentrations, averaging 50 µg/l and 20 µg/l, respectively, after accounting for blank and intake values. Dimethyl phthalate was detected at 230 µg/l at one plant. The compound occurred in a combined wastewater stream and the specific source of dimethyl phthalate cannot be identified.

Chrysene was also detected at only one tungsten plant and is therefore designated as site specific. A stream consisting of tungstic acid rinsewater contained 240 µg/l of chrysene. Chrysene is a polynuclear aromatic formed during the distillation of coal and, to a lesser extent, during the distillation and pyrolysis of a number of fats and oils.

In the data collection portfolios, the tungsten plants which discharge wastewater were asked to specify the presence or absence of priority pollutants in their wastewater. In all cases, the plants indicated that the organic priority pollutants were believed to be absent.

Metals. The data collection portfolio responses of the plants asked to specify the possible presence or absence of the priority pollutant metals were varied. Nearly all of the plants stated that they either knew the metals to be present or they believed the metals to be absent. The responses for the metals are summarized below:

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Arsenic | 3 | - | 3 | - |
| Cadmium | 3 | - | 3 | - |
| Chromium | 4 | - | 2 | - |
| Copper | 4 | 1 | 1 | - |
| Lead | 3 | - | 3 | - |
| Mercury | 4 | - | 2 | - |
| Nickel | 3 | 1 | 2 | - |
| Selenium | - | - | 6 | - |
| Silver | 4 | - | 2 | - |
| Thallium | - | - | 6 | - |
| Zinc | 4 | - | 2 | - |

In the field sampling program, all of the priority pollutant metals were detected in the waste streams. The data in Section V show that chromium, copper, lead, and silver occur industry-wide at concentrations several orders of magnitude greater than the significance thresholds previously established. The intake concentrations of these metals are lower than the threshold levels and are also a couple of orders of magnitude smaller than the gross concentrations of these four metals. Their effect on reducing the gross concentrations of the significant metals is negligible. The data in Table V-49 shows that the highest concentrations of these metals are found in the tungstic acid rinsewater stream. While a large percentage of each metal appears to be removed by existing treatment schemes (lime and settle), the treated waste streams still contain the metals in amounts greater than the threshold values.

Arsenic, selenium, and thallium were also detected in all waste streams, but only in one or two waste streams at levels much greater than the threshold limit. These metals are also found in the highest concentrations in waste streams associated with tungstic acid and dilute hydrochloric acid washes and rinses. Allowing for the intake water concentrations of these metals eliminates their significance in several of the waste streams and plants. This leaves them in the site specific category. Treatment schemes used by the plants generally appear able to remove the metals down to levels near but not below the threshold limits of each metal.

Cadmium, mercury, nickel, and zinc were also detected in all waste streams, but at levels less than an order of magnitude greater than the threshold limit. Allowing for the intake water concentrations indicates that treatment schemes would only have to remove small amounts of each metal to reach the threshold limit. Lead, chromium, and copper are in the highest

concentrations, and treatment for removal of these metals should remove the other heavy metals to acceptable levels.

Other Priority Pollutants. Cyanide is considered to be site specific because it was found in concentrations several orders of magnitude greater than the threshold limits in only two waste streams. Cyanide was found to predominate in waste streams consisting of tungstic acid precipitate rinse water.

Primary Zinc

The following pollutant parameters were selected for the primary zinc industry:

| Significant | Site Specific |
|---|---|
| Methylene chloride | Hexachlorobenzene |
| Bis(2-ethylhexyl) phthalate | 1,1-dichloroethane |
| Arsenic | Trichlorofluoromethane |
| Cadmium | PCB-1254 |
| Chromium | PCB-1248 |
| Copper | Antimony |
| Lead | Cyanide |
| Mercury | Thallium |
| Nickel | Ammonia |
| Selenium | |
| Silver | |
| Zinc | |
| TSS | |
| pH | |

Organics. Methylene chloride was designated as a pollutant parameter because significant net concentrations of the compound were detected at three of the five plants sampled. Concentrations of methylene chloride in the raw wastewater at these plants exceeded 100 µg/l after accounting for blanks. One treated wastewater stream exceeded 2,000 µg/l. This compound was also detected at a fourth plant, but at concentrations less than those found in the blank samples. Methylene chloride is used as an industrial solvent and is also found in metal degreasers and cleaning fluids, paints, and insecticides. It was found to be present in a number of wastewater streams and its origins in this industry cannot be traced.

Bis(2-ethylhexyl) phthalate was detected at more than 10 µg/l at four plants. Most of the net concentrations were relatively low and none exceeded 100 µg/l. Phthalates are used mainly as plasticizers, but are also found in gasoline additives and synthetic lubricants.

Several organic priority pollutants were found to be site specific. 1,1-dichloroethane was detected at one plant. It was found present in a roasting wastewater stream at 180 µg/l. Three similar roasting/acid plant streams did not contain this compound at detectable levels. 1,1-dichloroethane is used as an intermediate in vinyl chloride manufacture, and as an all purpose solvent. Its source in this industry is not known.

Trichlorofluoromethane was detected in a combined wastewater stream at one plant. This stream contained concentrations of approximately 100 µg/l. This compound is a Freon used in aerosols and as a refrigerant. Its origin in the primary zinc industry has not been determined.

PCB-1254 and PCB-1248 were designated as site specific pollutant parameters because they were detected at one plant. During one of the three sampling days, net concentrations of these pollutants exceeded 9 and 7 µg/l, respectively. PCBs have been used as dielectrics in transformers and capacitors, as hydraulic oils, and as heat transfer fluids. The presence of these compounds in the effluent stream can probably be attributed to one of these sources.

In the data collection portfolios, all five primary zinc plants responding to the question of the presence or absence of the priority pollutants in their effluents indicated that they did not believe any of the organic priority pollutants to be present in their wastewater.

Metals. The responses of the zinc plants asked to specify the possible presence or absence of the priority pollutant metals were varied. Nearly all of the plants stated that they either knew the metals to be present or believed them to be absent. The responses for the metals are summarized below:

| Pollutant | Known Present | Believed Present | Believed Absent | Known Absent |
|---|---|---|---|---|
| Antimony | - | 2 | 3 | - |
| Arsenic | 3 | 2 | - | - |
| Cadmium | 5 | - | - | - |
| Chromium | 1 | 1 | 2 | 1 |
| Copper | 3 | - | 1 | 1 |
| Lead | 4 | - | - | 1 |
| Mercury | 4 | - | - | 1 |
| Nickel | 1 | 1 | 3 | - |
| Selenium | 3 | 1 | 1 | - |
| Silver | 1 | 2 | 2 | - |
| Thallium | 2 | 1 | 2 | - |
| Zinc | 4 | - | - | - |

In the sampling program, all of the priority pollutant metals were detected in the waste streams. The data in Section V show that all of the metals except for antimony, thallium, and beryllium occur industry-wide at concentrations up to a couple of orders of magnitude greater than the significance thresholds previously discussed. The intake water concentrations of these metals are lower than the threshold levels and are also a couple of orders of magnitude smaller than the gross concentrations of the metals classed as being significant. Thus, their effect on the gross concentrations in the wastewater streams is negligible. The data in Table V-54 show that the highest concentrations of these metals are found in the acid plant waste stream. While a large percentage of each metal appears to be removed by the existing treatment schemes (lime and settle), the treated waste streams still contain the metals in amounts greater than the threshold concentrations.

Antimony and thallium were also detected in all waste streams, but seldom at levels much greater than the threshold limits. These metals are also found in the highest concentrations in acid plant waste streams. Allowing for the intake water concentrations of these metals eliminates their significance in several of the waste streams and plants. This leaves them in the site specific category. Treatment schemes presently in use were generally not very effective in removing these two metals. For all the metals, after accounting for intake concentrations, the net concentrations are generally still very much greater than the threshold. Treatment for removal of zinc, cadmium and lead, the metals in highest concentration, should remove the other heavy metals to acceptable levels.

Other Priority Pollutants. Cyanide was detected in all waste streams, but in only one or two streams at levels much greater than the threshold limit. Cyanide levels are highest in waste streams associated with the acid plant air pollution control and contact cooling.

TABLE VI-2

SUMMARY OF GUIDELINES FOR SELECTION OF SIGNIFICANCE LIMITS FOR THE PRIORITY POLLUTANT METALS

Concentrations, ug/l, unless noted.

| Pollutant Metals | EPA[20] Domestic MCL | Limits[21,22] Equip. Detect. | Treat-ability Limit | Second Plant Eff. | Typical Eff. In Literature | Summary State Stds.[23] Domestic Water | Irriga-tion | Recrea-tion | Act. Sludge Limit[24] | Marine Life[20] | Fresh Water Life[20] | Agri-culture[25] | Toxic Limits mg/l[26] | Lethal Limits mg/l[26] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sb | 2 | 0.8-2.0 | 200 | - | - | - | - | - | - | 200 | - | - | - | - |
| As[8] | 50 | 0.6-7.5 | - | 0.4-10 | - | 10-50 | 10-1000 | 10-1000 | 100 | 50 | - | 1000 | 7-67 | 133-400 |
| Be | 3 | 0.4 | | - | - | - | - | - | - | 1500 | - | 100 | - | - |
| Cd[9] | 10 | 0.3 | 10 | 2-79 | 1-60 | 5-300 | 5-50 | 5-50 | 1000 | 10 | 4[30][6] | 10 | 4 | - |
| Cr[9] | 50 | 0.3 | 30-75 | 3-246 | 13-680 | 50 | 50 | 20-50 | 1000-10,000 | 10 | 50 | 100 | 270 | - |
| Cu | 1000[1] | 0.1 | 150-250 | 10-352 | 10-650 | 10-1000 | 20-1000 | 20-1000 | 400-1000 | 50 | - | 100 | 330-670 | - |
| Pb[10] | 50 | 2.0 | 2-10 | 7-80 | 1 -500 | 40-100 | 40-100 | 40-100 | 100 | 50 | 30 | 5000 | 0.5-0.8 | - |
| Hg[9] | 2.0 | 0.2 | 1-10 | 0.2-2.9 | 0.1-10 | 0.5-5 | 0.5-5 | 0.5-5 | 100-5000 | 0.1 | 0.2 | - | - | 200-40 |
| Ni | 3 | 0.4 | 50-90 | 12-1240 | 30-720 | - | 1.0 | 1.0 | 1000-2500 | 100 | - | 200 | (Low)[7] | - |

TABLE VI-2 (continued)

SUMMARY OF GUIDELINES FOR SELECTION OF SIGNIFICANCE
LIMITS FOR THE PRIORITY POLLUTANT METALS

Concentrations, ug/l, unless noted.

| Pollutant Metals | EPA[20] Domestic MCL | Limits[21,22] Equip. Detect. | Treat-ability Limit | Second Plant Eff. | Typical Eff. In Literature | Summary State Stds.[23] Domestic Water | Irriga-tion | Recrea-tion | Act. Sludge Limit[24] | Marine Life[20] | Fresh Water Life[20] | Agri-culture[25] | Toxic Limits mg/l[26] | Lethal Limits mg/l[26] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Se | 10 | 0.6-5.0 | 20 | 1.6 | - | 5-10 | 5-1000 | 5-100 | - | 10 | - | 20 | 0.5-3.0 | 5-20 |
| Ag | 50 | 0.015-0.050 | 5-15 | 2-10 | - | 1-50 | 1-50 | 1-50 | 5000 | 5.0 | - | - | 11 | - |
| Tl | 3 | 0.3 | - | - | - | - | - | - | - | 100 | - | - | - | 800 |
| Zn | 5000[1] | 16.0 | 250-500 | 13-1039 | 0-2410 | 10-5000 | 500-5000 | 500-5000 | 80-10000 | 100 | - | 2000 | 1000 | - |

1. Value is not an MCL (maximum contaminant level) but a recommended limiting concentration.
2. No values found for those pollutant metals whenever dash occurs.
3. MCL's not established for Be and Ni at this time.

6. 4 ug/l if the water is soft; 30 ug/l if the water is hard.
7. Not very toxic except in extremely high concentrations.
8. The inorganic forms of arsenic are most toxic.
9. Dietary relationships exist from cadmium, chromium (avg. intake: 70 ug/l) and mercury (avg. intake: 7-30 ug/l).
10. The World Health Organization in the reference cited in note 9 above recommends a limit on lead of 0.025 mg/l (25 ug/l) in water due to the increased presence of lead in the air.
11. Silver is held indefinitely; pathological changes in some vital organs have been found to occur at Q 0.4 mg/l (Q 400 ug/l).

TABLE VI-3

LEVELS OF SIGNIFICANCE

| | PARAMETER | SUBCATEGORY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Priority Pollutants | 1° Al | 2° Al | Cb/ Ta | 1° Cu | 2° Cu | 1° Pb | 2° Pb | 2° Ag | 1° W | 1° Zn |
| 1. | acenaphthene | 1 | | 4 | | 4 | | | 4 | 2 | |
| 2. | acrolein | | | | | | | | | | |
| 3. | acrylonitrile | | | | | | | | | | |
| 4. | benzene | 4 | 2 | 4 | 4 | 4 | | 4 | 1 | 4 | 4 |
| 5. | benzidine | | | | | | | | | | |
| 6. | carbon tetrachloride (tetrachloromethane) | | 4 | 4 | 4 | 4 | | | 2 | | |
| 7. | chlorobenzene | | 4 | 4 | 4 | | | 4 | 4 | 4 | |
| 8. | 1,2,4-trichlorobenzene | | 4 | 1 | | | | | | | |
| 9. | hexachlorobenzene | | | | | 3 | | | | 4 | 2 |
| 10. | 1,2-dichloroethane | 4 | 4 | 1 | 4 | 4 | | 4 | 1* | 4 | 4 |
| 11. | 1,1,1-trichloroethane | | | 4 | 4 | | | 4 | 4 | | |
| 12. | hexachloroethane | | | | | | | | | | |
| 13. | 1,1-dichloroethane | | 4 | | | | | | | | 2 |
| 14. | 1,1,2-trichloroethane | | 4 | 4 | 4 | | | 4 | | 4 | |
| 15. | 1,1,2,2-tetrachloroethane | | | | | | | | 4 | 4 | |
| 16. | chloroethane | | | | | | | | | | |
| 17. | bis(chloromethyl) ether | | | | | | | | | | |
| 18. | bis(2-chloroethyl) ether | | | | | | | | | | |
| 19. | 2-chloroethyl vinyl ether (mixed) | | | | | | | | | | |
| 20. | 2-chloronaphthalene | | | 4 | | | | | | | |
| 21. | 2,4,6-trichlorophenol | | | | | | | | | | 4 |
| 22. | parachlorometa cresol | | | | | | | | 4 | | |
| 23. | chloroform (trichloro-methane) | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 24. | 2-chlorophenol | | | | | | | | | | |
| 25. | 1,2-dichlorobenzene | | | | | | | | | | |
| 26. | 1,3-dichlorobenzene | | | | | | | | | | |
| 27. | 1,4-dichlorobenzene | | 4 | | | | | | | | |
| 28. | 3,3'-dichlorobenzidine | | 4 | | | | | | | | 4 |
| 29. | 1,1-dichloroethylene | 4 | 4 | 4 | 4 | 4 | | 4 | 1* | | 4 |
| 30. | 1,2-trans-dichloroethylene | | 2 | 2 | 4 | 4 | | 4 | 4 | 4 | |

TABLE VI-3 (Continued)

LEVELS OF SIGNIFICANCE

| PARAMETER | SUBCATEGORY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Priority Pollutants | 1° Al | 2° Al | Cb/ Ta | 1° Cu | 2° Cu | 1° Pb | 2° Pb | 2° Ag | 1° W | 1° Zn |
| 31. 2,4-dichlorophenol | | | | | | | | | | |
| 32. 1,2-dichloropropane | | | | | | | | | | |
| 33. 1,3-dichloropropylene (1,3,-dichloropropene) | | | | | | | | 4 | | |
| 34. 2,4-dimethylphenol | | | | 4 | | | | | | |
| 35. 2,4-dinitrotoluene | | | | | | | | | | |
| 36. 2,6-dinitrotoluene | | | | | | | | | | |
| 37. 1,2-diphenylhydrazine | | | | | | | | | | |
| 38. ethylbenzene | 4 | 4 | 4 | | | | 4 | 4 | 4 | 4 |
| 39. fluoranthene | 1 | 4 | 4 | 4 | 1 | | 4 | 2 | 4 | 4 |
| 40. 4-chlorophenyl phenyl ether | | | | | | | | | | |
| 41. 4-bromophenyl phenyl ether | | | | | | | | | | |
| 42. bis(2-chloroisopropyl) ether | | | | | | | | | | |
| 43. bis(2-chloroethoxy) methane | | | | | | | | | | |
| 44. methylene chloride (dichloromethane) | 1 | 4 | 2 | 4 | 4 | 4 | 4 | 1* | 4 | 1 |
| 45. methyl chloride (chloromethane) | 4 | | | | | | | | | |
| 46. methyl bromide (bromomethane) | | | | | | | | | | |
| 47. bromoform (tribromomethane) | | | 4 | | | | 4 | 4 | | |
| 48. dichlorobromomethane | | 1 | 4 | 4 | 4 | | | 2 | 4 | 4 |
| 49. trichlorofluoromethane | | | | | | | | | | 2 |
| 50. dichlorodifluoromethane | | | | | | | | | | |
| 51. chlorodibromomethane | | 4 | 4 | | | | | | | |
| 52. hexachlorobutadiene | | | | | | | | | | |
| 53. hexachlorocyclopentadiene | | | | | | | | | | |
| 54. isophorone | 4 | 4 | 4 | 4 | | | 4 | | | 4 |
| 55. naphthalene | 4 | 4 | 4 | | 2 | | 4 | | 2 | 4 |
| 56. nitrobenzene | | | 2 | | | | 4 | | 4 | |
| 57. 2-nitrophenol | | | | | | | | | 4 | |
| 58. 4-nitrophenol | | | | | | | | | | |
| 59. 2,4-dinitrophenol | | | | | | | | | | |
| 60. 4,6-dinitro-o-cresol | | | | | | | | | | |

TABLE VI-3 (Continued)

LEVELS OF SIGNIFICANCE

| PARAMETER | SUBCATEGORY | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Priority Pollutants | 1° Al | 2° Al | | Cb/ Ta | 1° Cu | 2° Cu | 1° Pb | 2° Pb | 2° Ag | 1° W | 1° Zn |
| 61. N-nitrosodimethylamine | | | | | | | | | | | |
| 62. N-nitrosodiphenylamine | | | | | | | | | | | |
| 63. N-nitrosodi-n-propylamine | | | | | | | | | | | |
| 64. pentachlorophenol | | | | 4 | | | | | | | 4 |
| 65. phenol | 4 | | | | | | | | | | |
| 66. bis(2-ethylhexyl) phthalate | 4 | 2 | | 1 | 4 | 1 | | 1 | 1 | 2 | 1 |
| 67. butyl benzyl phthalate | 4 | 2 | | 2 | 4 | 4 | | 2 | 1 | | 4 |
| 68. di-n-butyl phthalate | 4 | 1 | | 2 | 4 | 1 | | 1 | 2 | 2 | 4 |
| 69. di-n-octyl phthalate | 4 | 2 | | 2 | 4 | 2 | | 1 | 1 | 2 | 4 |
| 70. diethyl phthalate | 4 | | | 4 | | 1 | | 4 | 4 | 4 | 4 |
| 71. dimethyl phthalate | 4 | 2 | | 4 | 4 | 2 | | 4 | | 2 | 4 |
| 72. 1,2-benzanthracene (benzo(a)anthracene) | 2 | | | 4 | 4 | | | | | | 4 |
| 73. benzo(a)pyrene (3,4-benzopyrene) | 1 | 4 | | 4 | 4 | 4 | | 4 | | 4 | |
| 74. 3,4-benzofluoranthene (benzo(b)fluoranthene) | 4 | | | 4 | | | | | | | |
| 75. 11,12-benzofluoranthene (benzo(k)fluoranthene) | 4 | | | | | | | | | | |
| 76. chrysene | 1 | 4 | | 4 | 4 | 3 | | 1 | | 2 | 4 |
| 77. acenaphthylene | 4 | 4 | | 4 | | 2 | | 4 | | 2 | 4 |
| 78. anthracene | 4 | | | | | 4 | | 4 | | | |
| 79. 1,12-benzoperylene (benzo(ghi)perylene) | 4 | 4 | | 4 | | | | 4 | | 4 | |
| 80. fluorene | 4 | | | 4 | 4 | 1 | | 4 | | 4 | |
| 81. phenanthrene | | | | | | 4 | | 4 | | 4 | |
| 82. 1,2,5,6-dibenzanthracene (dibenzo(a,h)anthracene) | 4 | | | | | | | | | | |
| 83. indeno (1,2,3-cd) pyrene (2,3-o-phenylene pyrene) | 4 | | | | | | | | | | |
| 84. pyrene | 1 | 4 | | 4 | 4 | 1 | 4 | 4 | 4 | 4 | 4 |
| 85. 2,3,7,8-tetrachlorodi-benzo-p-dioxin (TCDD) | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |

TABLE VI-3 (Continued)

LEVELS OF SIGNIFICANCE

| PARAMETER | SUBCATEGORY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Priority Pollutants | 1° Al | 2° Al | Cb/ Ta | 1° Cu | 2° Cu | 1° Pb | 2° Pb | 2° Ag | 1° W | 1° Zn |
| 86. tetrachloroethylene | 4 | 4 | 1 | 4 | 4 | | 4 | 1 | 1 | 4 |
| 87. toluene | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 88. trichloroethylene | 4 | 4 | 2 | | 4 | | 4 | 2* | 4 | 4 |
| 89. vinyl chloride (chloroethylene) | | | | | | | | | 2 | |
| 90. aldrin | 4 | 4 | 4 | | 4 | | 4 | 4 | 4 | |
| 91. dieldrin | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 92. chlordane (technical mixture and metabolites) | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 93. 4,4'-DDT | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 94. 4,4-DDE (p,p'-DDX) | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 95. 4,4'-DDD (p,p'-TDE) | | | 4 | 4 | 4 | | | 4 | 4 | |
| 96. alpha-endosulfan | | 4 | 4 | 4 | 4 | | 4 | | 4 | |
| 97. beta-endosulfan | 4 | | 4 | 4 | 4 | | 4 | | 4 | 4 |
| 98. endosulfan sulfate | | | 4 | 4 | 4 | | 4 | 4 | 4 | |
| 99. endrin | | 4 | 4 | 4 | | | | | | |
| 100. endrin aldehyde | | | 4 | 4 | 4 | | | 4 | 4 | |
| 101. heptachlor | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 102. heptachlor epoxide (BHC=hexachlorocyclohexane) | 4 | 4 | 4 | 4 | 4 | | 4 | | 4 | |
| 103. alpha-BHC | | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | |
| 104. beta-BHC | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 105. gamma-BHC (lindane) | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 |
| 106. delta-BHC | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | | |
| (PCB-polychlorinated biphenyls) | | | | | | | | | | |
| 107. PCB-1242 (Arochlor 1242) | | | | | | | | | | |
| 108. PCB-1254 (Arochlor 1254) | 4 | 4 | 1 | 4 | 1 | | 1 | 1 | 4 | 2 |
| 109. PCB-1221 (Arochlor 1221) | | | | | | | 4 | | | |
| 110. PCB-1232 (Arochlor 1232) | | | | | | | | | | |
| 111. PCB-1248 (Arochlor 1248) | 4 | 4 | 1 | 4 | 1 | | 1 | 1 | 4 | 2 |
| 112. PCB-1260 (Arochlor 1260) | | | | | | | 4 | | | |
| 113. PCB-1016 (Arochlor 1016) | | | | | | | | | | |
| 114. Toxaphene | | | | | 4 | | | | | |
| 115. Antimony | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 4 | 2 |

TABLE VI-3 (Continued)

LEVELS OF SIGNIFICANCE

| PARAMETER | SUBCATEGORY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Priority Pollutants | 1° Al | 2° Al | Cb/ Ta | 1° Cu | 2° Cu | 1° Pb | 2° Pb | 2° Ag | 1° W | 1° Zn |
| 116. Arsenic | 1 | 2 | 2 | 1 | 1 | 3 | 1 | 1 | 2 | 1 |
| 117. Asbestos | + | + | + | + | + | + | + | + | + | + |
| 118. Beryllium | 4 | 2 | 2 | 4 | 2 | 2 | 4 | 4 | 4 | 4 |
| 119. Cadmium | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 1 |
| 120. Chromium | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 |
| 121. Copper | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 122. Cyanide | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 2 | 2 |
| 123. Lead | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 124. Mercury | 1 | 2 | 1 | 1 | 1 | 3 | 2 | 2 | 3 | 1 |
| 125. Nickel | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 3 | 1 |
| 126. Selenium | 2 | 2 | 4 | 1 | 1 | 3 | 4 | 1 | 2 | 1 |
| 127. Silver | 2 | 4 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| 128. Thallium | 4 | 2 | 4 | 2 | 4 | 4 | 3 | 2 | 2 | 2 |
| 129. Zinc | f | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 1 |

TABLE VI-3 (Continued)

LEVELS OF SIGNIFICANCE

| PARAMETER | SUBCATEGORY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Conventional Pollutants | 1° Al | 2° Al | Cb/ Ta | 1° Cu | 2° Cu | 1° Pb | 2° Pb | 2° Ag | 1° W | 1° Zn |
| Biochemical Oxygen Demand | NOT SELECTED | | | | | | | | | |
| Chemical Oxygen Demand | NOT SELECTED | | | | | | | | | |
| Total Suspended Solids | SELECTED AS POLLUTANT PARAMETER | | | | | | | | | |
| Oil and Grease | NOT SELECTED | | | | | | | | | |
| pH - Acidity and Alkalinity | SELECTED AS POLLUTANT PARAMETER | | | | | | | | | |
| Non-Conventional Pollutants | | | | | | | | | | |
| Fluoride | PP | NS | PP | NS | NS | NS | NS | NS | NS | NS |
| Ammonia | | PP | PP | | | | PP | PP | PP | |
| Total Organic Carbon | NOT SELECTED | | | | | | | | | |
| Total Phenols (4AAP-method) | PP | NS | NS | NS | PP | NS | NS | PP | NS | NS |

NS Not Selected
PP Selected as Pollutant Parameter
* Associated only with photographic wastes
** Insufficient data available
\+ Data from one plant in each subcategory indicates that asbestos is an insignificant pollutant

Numbers presented in the table correspond to the following significance levels:

1. Significant
2. Site specific
3. Marginally significant
4. Insignificant

Blanks indicate that the compound was never detected in the analyses.

# SECTION VII

# CONTROL AND TREATMENT TECHNOLOGY

The control and treatment technologies that are currently being used, or have anticipated application, for reducing or eliminating the discharge of pollutants in process wastewaters in the nonferrous metals industry are discussed in this section.

In the context of this report, the term "control technology" refers to any practice applied in order to reduce a given wastewater flow for one or more of the following purposes: 1) to concentrate pollutants for greater removal efficiencies, 2) to reduce the volume of wastewater which must be handled, and 3) to reduce or eliminate a wastewater discharge through either conversion to a dry process or wastewater recycle or reuse. "Treatment technology" refers to any practice applied to a wastewater to reduce the concentration of pollutants or a specific pollutant in the wastewater before discharge, recycle, or reuse in another process.

The control and treatment technologies in use, or which can be used, are first discussed generally and then in relation to each subcategory and its associated wastewaters.

## CURRENT CONTROL PRACTICES

Several control technologies are available in the nonferrous metals industry, all of which can be helpful in reducing pollutant discharge either by reducing the pollutant concentration or the wastewater volume. By optimizing control technology use, plants can significantly or totally reduce their treatment requirements. Controls presently in use industry-wide are discussed first and those with more limited applications or possible future use are then discussed.

### Conservation and Reuse

Recycle. Recycle of process water is currently practiced where it is desirable due to water costs or shortage, where it is advantageous in terms of reducing treatment costs, or where it is necessary to meet permit conditions. Recycle, as compared to once through use of process water, is becoming a more frequent practice.

Two types of recycle are possible, recycle with a blowdown and total recycle. Total recycle of process water may not always be possible because of dissolved solids. The recycled stream is often cooled by evaporation, which concentrates any dissolved

solids in the wastewater. The dissolved solids (i.e., sulfates and chlorides) may precipitate, forming scale if the solubility limits of the dissolved solids are exceeded. A bleed stream may be necessary to prevent problems (pipe plugging, or scaling, etc.) that would be caused by the precipitation of dissolved solids. While the volume of bleed required is a function of the amount of dissolved solids in the wastewater, five percent blowdown is a common value. Some plants operate at less than two percent blowdown. Increased blowdown of cooling water may be required unless adequate cooling devices (cooling towers or ponds) are used to reduce the temperature. Another alternative is the use of non-contact heat exchangers, which eliminate concentration by evaporation and minimize scaling problems. A copper refinery on the East Coast is using this method to achieve zero discharge.

Recycle offers economic as well as environmental advantages. Water consumption is reduced and wastewater handling facilities (pumps, pipes, clarifiers, etc.) can be sized for smaller flows. By concentrating the pollutants in a much smaller volume (the blowdown) greater removal efficiencies can be attained by any applied treatment technologies. Recycle may require some treatment of water prior to its reuse. This may entail only sedimentation or cooling.

Three variations of recycle or reuse are used in the nonferrous metals industry: 1) a wastewater is recycled within a given process; 2) a wastewater is combined with others and the combined wastewater is recycled to the processes from which it originated; and 3) reuse of a wastewater in different processes.

Evaporation. Evaporation is a control technology which offers the possibility of total wastewater elimination with only the remaining solids requiring disposal. Evaporation can be natural or artificial.

Natural evaporation in wastewater impoundments located in arid regions is a technique practiced at many operations to reduce discharges to zero or nearly zero. Its successful employment depends on favorable climatic conditions (net evaporation) and on the availability of land. Land requirements can be significant in areas where the net evaporation value is small and a large surface area of water must be exposed. In some instances where impoundment is not practical for the plant's total wastewater discharge, impoundment of smaller, highly contaminated wastewaters from specific processes may afford significant advantages.

Two methods of artificial evaporation are practiced in the nonferrous metals industry: 1) application of cooling water in

such a way that total evaporation of the cooling water occurs and 2) reusing a wastewater in another process in which evaporation occurs. Total evaporative cooling may require longer conveyors for additional air cooling to assure that the ingots have cooled sufficiently to be handled and may not be applicable to plants with limited space. Evaporative consumption by cooling hot gases for preconditioning and the use of wastewater in fluid bed roasters offer two means of eliminating wastewater flow through consumptive reuse in a different process.

Dry Air Pollution Control Devices. Dry air pollution control devices allow the elimination of a wastewater (scrubbing wastewater) with high pollution potential. However, occasionally wet devices may be necessary to control certain gaseous pollutants.

Dry air pollution control devices and methods include cyclones, dry electrostatic precipitators, fabric filters (baghouses), adsorption of fluorides on dry activated alumina and afterburners. These devices remove particulate matter, the first three by entrapment and the afterburners by combustion. Afterburner use is limited to emissions consisting of mostly combustible particles. Characteristics of the particulate-laden gas which affect the design and use of a device are gas density, temperature, viscosity, flammability, corrosiveness, toxicity, humidity, and dew point. Particle size, shape, density, resistivity, concentration, and physiochemical properties are particulate characteristics which affect the design and use of a device.

Proper application of a dry control device can result in particulate removal efficiencies greater than 99 percent by weight for fabric filters, electrostatic precipitators and afterburners, and up to 95 percent for cyclones.

The important difference between wet and dry devices is that wet devices control gaseous pollutants as well as particulates. Common wet air pollution control devices are venturi scrubbers, packed tower scrubbers and wet electrostatic precipitators. Collection efficiencies depend on the solubility of the contaminant in the scrubbing liquid. (71). Depending on the contaminant removed, collection efficiencies are usually around 99 percent for particles and gases.

Wet devices may be chosen over dry devices because of any of the following factors: 1) the particulate size is predominantly under 20 microns, 2) flammable particles or gases are to be treated at minimal combustion risk, 3) both vapors and particles are to be removed from the carrier medium, and 4) the gases are corrosive and may damage dry air pollution control devices (71).

Dry Slag Processing. Slag from pyrometallurgical processes is a solid waste that must be disposed of or reused. Slag can be disposed of by slag granulation or slag dumping. Slag granulation involves the use of a high-velocity water jet to produce a finely divided and evenly sized rock, which can be used as concrete agglomerate or for road surfacing. Slag dumping is the dumping and subsequent solidification of slag, composed almost entirely of insolubles, which can be crushed and sized for such applications as road surfacing. Slag can be reprocessed if the metal content is high enough to be economically recovered. Wet or dry milling, and recovery of metal by melting can be used to process slag with recoverable amounts of metal. Of course, in all slag reuse processes, ultimate disposal of the reprocessed slag must be considered.

Although slag dumping eliminates the wastewater associated with slag granulation, two additional factors must be dealt with. Large volumes of dust are generated during crushing operations and dust control systems may be necessary. Also, slag dumping may not be acceptable to slag processors, since salts are not removed from the slag by dry processing.

Process Variations. Process variations which eliminate or reduce a wastewater or pollutant concentration in a wastewater may be considered as controls. While the possibility of such variations exists throughout the nonferrous metals industry, a detailed discussion is best made on a subcategory basis. Therefore, the topic is briefly discussed here and will be further discussed by individual subcategories later in this chapter.

Waste Stream Segregation. The segregation of process wastewaters is a valuable control technology and may reduce treatment costs. Individual process wastewaters may exhibit very different chemical characteristics and by separating these wastewaters the proper method of treatment or disposal may be applied to each wastewater. Consider two wastewaters, one high in fluorides, ammonia, and other dissolved solids; the other, a contact cooling water. Significant advantages exist in segregating these two wastewaters. If ammonia stripping was performed on the combined wastewaters, the cost of steam or air stripping would be higher than necessary. Also, if fluoride removal by lime precipitation was practiced, reduced removals would result from combining the wastewaters due to dilution of the fluoride concentration. In addition, recycle of the cooling water would be made difficult by mixing the relatively pure cooling water with the high dissolved solids stream. There are many other examples in the nonferrous metals industry where segregation affords advantages, such as separating acid plant blowdown and contact cooling water.

Rainfall runoff is not considered a process wastewater unless mixed with process wastes. However, its segregation from process streams can eliminate hydraulic overloading of sewers and treatment facilities. Some plants located lower than the surrounding terrain have built flood control dams at higher elevations in order to minimize the passage of storm water runoff onto plant property. The use of curbing is an excellent control practice for minimizing the commingling of runoff with process wastewaters. Lining retention ponds should also be practiced to minimize infiltration of spring water during periods of local flooding and exfiltration of the wastewaters to a nearby aquifer.

Contact Cooling Water Reduction. Contact cooling of molten metal is widely used. Control of contact cooling water can be achieved by recycle, total evaporation, air cooling, or conversion to noncontact cooling.

Recycle and total evaporation were discussed in previous sections. Air cooling of molten metal has limited potential. Air cooling is not generally employed in the production of high tonnage metal for several reasons. The casting line might be inordinately long (or large), requiring a large number of molds to allow for the slower cooling of the metal. Maintenance might be higher because of the longer conveyor, the added heat load on equipment and lubricants, and the need for added blowers. Air cooling without these process appurtenances might greatly reduce the rate of finished metal production from levels now possible with water cooling. Also, air cooling cannot be used in direct chill casting operations. Its applicability, except in low tonnage operations, is doubtful.

While noncontact cooling water can replace contact cooling water in some applications, industry-wide conversion to noncontact cooling may not be possible. Plants that already have contact cooling in place would require extensive retrofitting. Also, certain molten metals require contact cooling to produce desired surface characteristics. Some plants produce a metal shot by allowing molten metal to flow through a screen into a tank of water, immediately quenching the metal and producing a spherical shot product. Shot could probably not be produced without contact cooling water.

Although all the technologies discussed are being used by many plants within the nonferrous metals industry, many other plants do not apply appropriate control technologies. Some plants already built can not easily implement some of the previously discussed controls, such as air cooling, because flexibility may not be readily available in the process and/or costs to implement changes may be high. Recycle and reuse, however, are widely applicable control technologies.

Total recycle may become more wide-spread in the future if methods for removal of dissolved solids such as reverse osmosis and ion exchange become more common and inexpensive.

Lessening the need for wet scrubbing systems, or reducing the volume of scrubber water required, is an area where advances are possible. Processes could be modified such that the volume or severity of air emissions can be limited, thereby minimizing the volume of water used for air pollution control. For example, furnaces can be designed to minimize the volume of emissions. Using inert gases, instead of chlorine, for degassing in the aluminum industry is an example of how the severity of air emissions can be limited.

## CURRENT TREATMENT PRACTICES

Several methods of pollutant removal are now in place in the nonferrous metals industry. Their use and application for a subcategory or wastewater is dependent on many factors, including wastewater characteristics, expense relative to similar technologies, plant layout and space availability, and individual company preferences. Methods which are being used industry-wide are discussed first and those with more limited applications or possible future uses are then discussed.

### Physical-Chemical Methods

Precipitation. The removal of materials from solution by the addition of chemicals which form insoluble (or sparingly soluble) compounds with them is common practice in both hydrometallurgical processes and wastewater treatment. This precipitation technology includes coagulation, flocculation, and clarification. It is especially useful in the removal of metals and fluorides from wastewater.

To be successful, precipitation depends primarily upon two factors:

1. Sufficient excess of the added ion to drive the reaction toward complete precipitation of the solute.
2. Removal of the resulting solid phase from the wastewater.

If the first requirement is not met, only a portion of the pollutant(s) will be removed from solution, and desired concentrations may not be achieved. Failure to remove the precipitates formed prior to discharge is likely to lead to redissolution, since ionic equilibrium in the receiving stream will not, in general, be the same as in the treated waste. Effective sedimentation or filtration is thus a vital component of a precipitation treatment system and frequently limits the

overall removal efficiency. In practice, sedimentation is usually done in settling ponds or clarifiers.

Lime, caustic, soda ash, and calcium chloride are the most commonly used precipitants in the industry. Lime, caustic, and soda ash create alkaline conditions conducive to the formation of insoluble carbonates or hydroxides of the pollutant cations and their removal, together with adsorbed suspended solids, upon flocculation and clarification. Calcium chloride removes fluoride by precipitation as calcium fluoride.

Lime for chemical precipitation has gained widespread use because of its ease of handling, economy, and treatment effectiveness for a great variety of dissolved materials. In the nonferrous metals industry, lime is used for fluoride precipitation as calcium fluoride and hydroxide precipitation of metals.

The treatment conditions, dosages, and final pH must be optimized for any given wastewater, but, in general, attaining a pH of at least 9 is sufficient to ensure removal of heavy metals. To attain desired levels of control for some heavy metals, however, it is necessary to attain a pH of 10 to 12.

Pourbaix (72) has compiled "Potential pH Diagrams" and solubility curves for many elements, based on theoretical considerations. Curves based on Pourbaix's results are shown in Figure VII-1 for the soluble metals silver, cadmium, copper, iron, nickel, lead, tellurium, and zinc. These are equilibrium curves for pure compounds in simple systems, and may not be extrapolated directly to the complex systems of nonferrous wastewaters. Many factors, such as the effects of widely differing solubility products, mixed-metal hydroxide complexing, and metal chelation render the values of Figure VII-1 of only limited value when assessing attainable concentrations from a treatment system. Among the metals effectively removed in alkaline solution are: arsenic, cadmium, copper, trivalent chromium, iron, manganese, nickel, lead, antimony, and zinc.

Lime precipitation is widely used for the control of fluoride as well as for the removal of heavy metals. High lime dosages contribute excess calcium ion to the solution, resulting in precipitation of calcium fluoride. The elevated pH produced by the lime enhances the precipitation effectiveness by shifting the equilibrium towards the presence of free fluoride ion, which may then be precipitated as calcium fluoride. Published sources (3, 73, 74, 75, 76) indicate that lime is effective in removing fluoride to less than 20 mg/l.

Shown in Tables VII-1 and VII-2 are sampling results showing the effect of lime precipitation on various parameters in wastewaters

from the columbium-tantalum and tungsten industries. These tables are based on results of 3 24-hour composite samples. Table VII-3 lists removall efficiencies of several pollutants by lime precipitation. These removals are illustrative and greater removals can be attained.

Removal efficiencies of organic priority pollutants which were selected as pollutant parameters in Chapter VI are listed in Table VII-4.

Coagulation and Flocculation. Suspended solids removal by precipitation reactions can be aided through the use of coagulation and flocculation. Coagulation is the reduction of electrical repulsive forces on a particle's surface. Flocculation is the agglomeration of particles, through adsorption or molecular bridging and is induced by particle contact.

Mechanical stirring is the most frequently used flocculating method. Polymers are often used as flocculant aids. Widely used coagulants are aluminum salts ($Al_2(SO_4)_3 \cdot 14H_2O$, $AlCl_3$), iron salts ($FeCl_3$, $Fe_2(SO_4)_3$, $FeSO_4 \cdot 7H_2O$) and lime. Coagulants and flocculants are added to the water to be treated under controlled conditions of concentration, pH, mixing time, and temperature. They upset the stability of the colloidal suspension by charge neutralization and flocculation of suspended solids, thus increasing the effective diameter of these solids and increasing their subsequent settling rate.

The effectiveness and performance of individual coagulation-flocculation systems may vary somewhat with respect to suspended solids removal, incidental removal of soluble components by adsorptive phenomena, and operating characteristics and costs. Specific system performance must be analyzed and optimized with respect to mechanical mixing time, coagulant or flocculant dosage, settling time, thermal and wind-induced mixing, and other factors.

pH Adjustment. Adjustment of pH is a chemical treatment frequently practiced by industry. The addition of either acidic or alkaline constituents to a wastewater for pH adjustment generally influences the behavior of both suspended and dissolved components. The pH of acid wastewaters may be adjusted by addition of a variety of basic reagents, including lime, limestone, sodium hydroxide, soda ash, ammonium hydroxide, and others, to raise the pH to any desired level. Lime is most often used because it is inexpensive and easy to apply.

Ammonia neutralization is frequently used in hydrometallurgical processes, where ammonia offers an advantage in being volatile

and therefore easily removed from the final product, allowing the recovery of nearly pure oxides. In waste treatment, however, its use or presence is a disadvantage, because of its toxicity and oxygen demand during microbial oxidation to nitrites and nitrates in the receiving waters. Additionally, ammonia neutralization does not effectively remove metals when used for waste treatment.

Excessively basic wastewaters may be neutralized by addition of an acid, commonly sulfuric, although hydrochloric and nitric acid and carbon dioxide are also used. Since many metals form insoluble hydroxides in basic solutions, sedimentation of the alkaline wastewater prior to neutralization prevents the resolubilization of the metals and may simplify subsequent waste treatment requirements.

All wastewaters should be essentially neutral prior to discharge. Generally, the wastewater will be sufficiently uniform to allow adequate pH control based only on the wastewater flow rate, with only periodic adjustments based on effluent pH. Automated systems which monitor and continuously adjust the concentration of reagent added to the wastewater are currently available and in use. One bauxite refining plant mixing very acidic and alkaline wastes and using automated controls reported no deviations from the pH range of 6 to 9 in over a year.

Ammonia Stripping. Ammonia which is introduced as a process reagent may be removed from process wastewaters by stripping with air or steam. Air stripping is generally accomplished in a packed or lattice tower and involves blowing air through a packed bed or lattice, over which the ammonia-laden stream flows. Usually, the wastewater is heated prior to delivery to the tower, and air is used at ambient temperature. The evaporation of water and the volatilization of ammonia generally produces a drop in both temperature and pH, which ultimately limit the removal of ammonia that may be achieved in a single air stripping tower. High removals are generally achievable and are favored by:

1. High pH values, which shift the equilibrium from ammonium toward free ammonia;
2. High temperature, which decreases the solubility of ammonia in aqueous solutions;
3. Intimate and extended contact between the wastewater to be stripped and the stripping gas.

Of these factors, pH and temperature are generally more cost effective to optimize than increasing contact time by an increase in contact tank volume or recirculation ratio. With air stripping, the temperature will, to some extent, be controlled by the climatic conditions; the pH of the wastewater can be adjusted to assure optimum stripping. As a result, the major drawback of

air stripping is the low efficiency in cold weather and the possibility of freezing within the tower. Because lime may cause scaling problems and the types of towers used in air stripping are not easily cleaned, caustic soda is generally employed to raise the feed pH.

Steam stripping offers better ammonia removal (99 percent or better) (9) than air stripping for the high ammonia concentrations found in some wastewaters of the nonferrous metals industry. Tray towers are used, and the pH is adjusted to 12 or more with lime. Simple tray designs (such as disk and doughnut trays) are used in steam stripping because of the presence of appreciable suspended solids and the scaling produced by lime. These allow easy cleaning of the tower, at the expense of somewhat lower steam/water contact efficiency, necessitating the use of more trays for the same removal efficiency.

Extremely high initial ammonia concentrations in wastewaters allow recovery of significant quantities of reagent ammonia by steam stripping, which partially offsets the capital and energy costs of the technology.

Strippers are widely used in industry for the removal of a variety of materials, including hydrogen sulfide and volatile organics as well as ammonia, from aqueous streams. The basic techniques have been applied both in process and in wastewater treatment applications and are well understood. The use of steam strippers with and without pH adjustment is standard practice for the removal of hydrogen sulfide and ammonia in the petroleum refining industry and has been studied extensively in this context (84, 85, 86). Air stripping has been applied to municipal (87) and industrial wastewater treatment and is recognized as an effective technique of broad applicability (88). Both air and steam stripping have been successfully applied to wastewater treatment, either within the nonferrous metals industry or to similar wastes in closely related industries.

Physical Separation Methods

Filtration. Filtration is the separation of suspended solids from water by using a permeable material. Filtration by various means (sand, dual- and multi-media, pressure, and cloth filters) is generally used as a polishing step to further reduce suspended solids after sedimentation. Vacuum filtration is commonly used to dewater clarifier sludges. Table VII-5 lists organic priority pollutant removal efficiencies by multi-media filtration.

Sedimentation. Removal of solids from water by gravity is widely used in wastewater treatment. In sedimentation ponds, relatively low solids loads are removed, necessitating only occasional

dredging to maintain adequate settling volume. Such ponds may serve a variety of purposes in addition to removal of suspended solids, including cooling. As basins for a variety of chemical treatments, they can provide sufficient retention time for completion of reactions, for pH control, for chemical precipitation, and for the removal of precipitates.

Settling ponds are frequently used in multiples. The purpose of this scheme is to further reduce suspended solids loadings in the sequential ponds and to allow the use of precipitation or pH control before discharge or recycle.

A more space-efficient method of removing suspended solids from wastewater is the use of clarifiers, which are essentially large tanks with directing baffles and phase segregating systems. The design of these devices provides for concentration and removal of suspended and settleable solids as a semi-solid sludge in one effluent stream and a clarified liquid in the other. Through proper design and application, the clarified waters may have extremely low solids content. Clarifiers may range in design from simple units to more complex systems involving sludge blanket pulsing or sludge recycle to improve settling and increase the density of the sludge. Since settling of suspended solids depends mostly on the surface area of the clarifier or pond, settling can be improved by inserting trays or tubes in the settling basin, which has the effect of converting a clarifier into many shallow settling basins. Since the tubes are inclined from 45 to 60 degrees from the horizontal, settled solids that collect on the tubes will slide down while the wastewater flows upward. Thus, the tubes are self-cleaning. Settled solids from clarifiers are removed periodically or continuously for either disposal or recovery of various concentrated metals. Thickeners are often used to increase the solids concentration in the clarifier underflow.

Clarifiers have a number of distinct advantages over settling ponds:

1. Less land space is required. On a volumetric capacity basis these devices are much more efficient for settling than ponds.
2. Influences of rainfall are reduced compared to ponds. If desired, the clarifiers can be covered.
3. Since the external structure of clarifiers consists of concrete or steel (in the form of tanks), infiltration and rainfall runoff influences do not exist.
4. Clarifiers can generally be placed adjacent to a production plant, making recycle easier.

Clarifiers also suffer some disadvantages compared to ponds:

1. They have mechanical parts, and thus require more maintenance.
2. Their storage capacity for either clarified water or settled solids is limited.
3. The internal sweeps and agitators in clarifiers require energy for operation.

Centrifugation. Centrifugation, which may be considered as a form of forced or assisted settling, may be feasible in specific treatment applications. The presence in a wastewater of abrasive components or significant fine particles (less than 5 microns) tends to limit centrifugation as a solids removal option.

Other Applicable Treatment Technologies

There are a number of treatment technologies which are used infrequently or not at all in the nonferrous metals industry, but which are applicable to treating the types of wastewaters present in the industry. Their limited application may be due to a number of factors, including higher costs, operational complexity, and the availability of more accepted techniques. However, these technologies often afford much greater pollutant reduction than can be achieved with more conventional technologies and therefore, should be considered.

Sulfide Precipitation. The use of sulfide ion as a precipitant for removal of heavy metals accomplishes more complete removal than the use of hydroxide for that purpose. Arsenic, cadmium, cobalt, chromium, copper, iron, mercury, manganese, nickel, lead, and zinc have been reported to be removed by sulfide precipitation (89, 90, 91, 92). Figure VII-2 illustrates theoretical solubilities of several metal sulfides as a function of pH. By comparing Figures VII-1 and VII-2 it can be seen that the theoretical solubilities of metal hydroxides are much greater than those of the sulfides.

Sodium sulfide, calcium sulfide, sodium bisulfide, and barium sulfide are commonly used reagents for sulfide precipitation of metals (90). The steps involved in a typical sulfide precipitation facility are:

1. pH adjustment and sulfide reagent addition - the wastewater pH is raised by alkali addition and the sulfide reagent is flash mixed with the wastewater,
2. Precipitation - metal sulfide forming reactions occur followed by agglomeration,
3. Clarification - the treated wastewaters are passed through a quiescent zone allowing the precipitate to settle out, and
4. Final effluent filtration and pH adjustment - the treated overflow from clarification is filtered to remove any unsettled

solids and the stream pH is adjusted to meet discharge regulations (90).

Two problems associated with sulfide precipitation are the possible formation of hydrogen sulfide gas and the production of an oxidizable metal sulfide sludge. Formation of hydrogen sulfide gas during sulfide precipitation can be avoided by three methods. First, by raising the pH of the wastewater to 8.0 or above, hydrogen sulfide will disassociate into $HS^-$ and $H^+$. Secondly, when the reactions between the sulfide reagent and the dissolved metals are completed, the pH will rise sharply. Therefore, pH monitoring to control sulfide dosage rate can prevent excess sulfide being added to the wastewater. This method was used at two pilot plants (93). Thirdly, when the precipitation reactions are complete, the solution undergoes a sharp negative electric potential change. This change in potential can be measured by an oxidation/reduction potentiometer. The response of the potentiometer can be made to control the rate of sulfide reagent addition. This method was used at a smelter in Japan (94) and at a pilot plant (95).

Metal sulfide sludge can oxidize if exposed to air, allowing the metallic portion of the sludge to dissolve into the aqueous phase from which it may reenter the environment. Possible safe disposal methods of metal sulfide sludge are: 1) maintaining the sludge in an oxygen free environment (96), 2) chemical treatment or fixation (73, 97), or 3) recycling the sludge to a smelter for metals recovery (94, 98).

While little cost information is available concerning sulfide precipitation, those differences from hydroxide precipitation which will probably increase costs are: 1) a separate reaction tank and associated equipment for sulfide addition, 2) hoods on the reaction tank and flocculator/ clarifier for hydrogen sulfide control, 3) special instrumentation to control excess sulfide addition, and 4) higher chemical costs (90). Those differences which will probably lower costs are: 1) smaller sludge handling equipment due to the lower operating pH of the system which results in less carbonate and sulfate precipitates, and 2) less alkali needed since the operating pH is lower (90).

Sulfide precipitation is effective for removal of heavy metals, especially as a polishing treatment following lime and settle treatment. Separation of the sulfide precipitates from solutions is not always easy, and filtration may be required. Sulfide precipitation is more complicated than hydroxide precipitation. It would be most applicable to small volume, highly polluted wastewaters, such as those from acid plants or from refinery by-product recovery.

EPA is studying full scale sulfide precipitation treatment at a Swedish copper smelter. Preliminary results are shown below. The plant, treating combined process wastes and rainfall run-off, uses a $Na_2S$ solution and after the sulfide reaction is completed, clarifies and filters the wastewater. Following filtration, the wastes are mixed with lime prior to discharge.

| Pollutant | Influent (mg/l) | Sulfide Effluent (mg/l) | Lime Effluent (mg/l) |
|---|---|---|---|
| As | 208 | 52.0 | 28 |
| Cu | 3.6 | 0.3 | 0.5 |
| Pb | 45.0 | 0.9 | 1.1 |
| Cd | 6.8 | 0.13 | 0.12 |
| Zn | 45.0 | 22.0 | 21.0 |
| Fe | 15. | 12 | 11 |
| Hg | 2.5 | 0.06 | 0.08 |
| pH (units) | 2.6 | 4.2 | 11.3 |
| Flow ($m^3$/hr) | 125 | | |
| (gal/min) | 550 | | |

Ultrafiltration and Reverse Osmosis. Ultrafiltration and reverse osmosis are similar processes in which pressure is used to force water through membranes which do not allow passage of contaminants. They differ in the size of contaminants passed and in the pressures required. Ultrafiltration generally retains particulates and materials with a molecular weight greater than 500, while reverse osmosis membranes generally pass only materials with a molecular weight below 100 (although sodium chloride, with a molecular weight below 100, is retained, allowing application to desalinization). Pressures used in ultrafiltration generally range from 50 to 100 psi, while reverse osmosis is run at pressures ranging from 400 to 1,800 psi.

Ultrafiltration has been applied on a significant commercial scale for oil removal from emulsions, yielding a highly purified water effluent and an oil residue sufficiently concentrated to allow reuse, reclamation, or combustion. The equipment is readily available, and present day membranes are tolerant of a broad pH range.

Reverse osmosis is conceptually similar to ultrafiltration. The process of osmosis involves the passage of a liquid through a semipermeable membrane, from a dilute to a more concentrated solution. Reverse osmosis is an operation in which pressure is applied to the more concentrated solution, forcing the permeate to diffuse through the membrane into the more dilute solution. This filtering action produces a concentrate and a permeate on opposite sides of the membrane.

Reverse osmosis divides a liquid waste into two fractions, a pure one suitable for reuse or recycle, and a residue containing all of the pollutants originally present, but in a more concentrated form. A typical value for the volume of the concentrated reject brine stream is 15 percent of the original wastewater volume (99, 100, 101). Evaporation and land filling of the resulting concentrate, total impoundment, and land spreading are a few possible methods of disposing the concentrated fraction.

Reverse osmosis cannot tolerate variations of input conditions and therefore requires, in general, considerable pretreatment of the wastewater. The pH, temperature, and suspended solids levels must be modified before reverse osmosis is used. Membrane life and efficiency are both adversely affected by inadequate treatment of waters prior to membrane contact.

Figure VII-3 illustrates a typical reverse osmosis system. Table VII-6 records selected metal removal efficiencies by reverse osmosis, Table VII-7 records organic removal efficiencies, and Table VII-8 characterizes the three most common membrane types: hollow fiber, spiral wound, and tubular.

Deep Well Disposal. Disposal of wastes, especially oil field brines and chemical wastes, in deep wells is practiced as an alternative to treatment as restrictions on discharging wastes to navigable waters become tighter. A primary copper refinery is disposing of its wastewater with deep well disposal. Such wells can be costly, especially when several are needed and depths are one or two thousand meters. Geologic conditions must be suitable, and in many parts of the country, deep wells are not practical. Confined sand strata below the level from which drinking water is obtained, especially those already naturally saline, are among the most suitable candidates for deep well disposal. However, care must be taken in using deep well disposal to avoid groundwater contamination.

Oxidation. A number of the wastewater constituents resulting from industrial processes may be removed or rendered less harmful by oxidation. Among these are cyanide, sulfide, phenols, ammonia, and a variety of materials presenting high COD levels. The simplest approach to this treatment process is aeration of the wastewater. This may occur naturally as a result of the aeration induced by pumping or on a pond surface, and artificially in a spray pond. More elaborate oxidation by controlled introduction of strong oxidants, such as chlorine or ozone, achieves more complete and rapid results but at greater costs.

Cyanide ($CN^-$) is oxidized to cyanate ($CNO^-$) and, ultimately, to $CO_2$ and $N_2$. This can be accomplished by rapid chlorination at

alkaline pH (about 10.5). The probable reaction with excess chlorine and caustic soda used for neutralization has been expressed as:

$$2NaCN + 5Cl_2 + 12NaOH = N_2 + 2Na_2O_3 + 10NaCl + 6H_2O$$

A pH of 10 to 11 is necessary. This reaction may be performed on either a batch or continuous process. If metal cyanide complexes are present, extended chlorination for several hours may be necessary. If organics are present in the wastewater, halogenated organics may be formed by chlorination (104, 105, 106).

Ammonia may be converted in wastewaters through oxidation to nitrate by aeration--or, more rapidly, by ozonation--or use of chemical oxidants.

Ozone is a powerful oxidant with a wide range of uses, including disinfection, and as an aid in the removal of organics, color, odor, iron, and manganese. It is attractive since only oxygen is added to the water through its use. Ozone would be effective as an oxidant where chlorine toxicity problems might exist. Ozone is reported to be an economical alternative for destruction of phenols in industrial wastewaters (107) and industrial applications are considered practical (107, 108, 109).

Activated Carbon. Activated carbon is a sorptive material characterized by high surface area within its internal pore system. Pores generally range from 0.001 to 0.01 micrometer, and surface areas of up to 202 $m^2/g$ (300,000 $ft^2/oz$) are considered normal. Although pollutant removal by activated carbon is usually associated with adsorption, five mechanisms of removal by activated carbon have been noted: 1) true adsorption, 2) precipitation, 3) ion exchange, 4) reduction to metal or oxidation to insoluble forms, and 5) filtration or entrapment (110). One or all of these mechanisms may be responsible for removing a pollutant.

In contrast to alumina, silica gel, and other adsorbents, activated carbon exhibits a relatively low affinity for water. Compounds which are readily removed by activated carbon include aromatics, phenolics, chlorinated hydrocarbons, surfactants, organic acids, high molecular weight alcohols, and amines. Current applications of this material also involve the removal of color, taste, and odor components in water. Table VII-9 lists organic priority pollutant removal efficiencies. Activated carbon has been reported to remove ammonia, cyanide, phenols, and fluorides above 90 percent (78, 191).

Activated carbon has also been shown to remove a variety of inorganic salts. Table VII-10 lists several metals and their respective potentials for removal. Since removal of metals is variable and dependent on waste stream characteristics, exact removal of a metal by activated carbon cannot be determined (90, 110, 79).

When the pollutant removal capability of the carbon has been exhausted it must be reactivated or disposed. Reactivation is accomplished by heating in a furnace and volatilizing the entrapped organics. Approximately 10% makeup carbon will be necessary due to losses in handling during reactivation. For different carbon exhaustion rates the wastewater flow at which regenerative columns becomes more economical than throw-away carbon varies. For example, for an exhaustion rate of 5,500 pounds of carbon per million gallons, regenerative carbon becomes more economical than throw-away carbon at a flow of 115,000 gallons per day, but for an exhaustion rate of 12,400 pounds of carbon per million gallons the breakeven flow is 51,000 gallons per day. Disposal of exhausted carbon in landfills may result in leaching of organic and metal pollutants to groundwaters (113, 114, 115).

Granular activated carbon may be more applicable than powdered activated carbon for treating nonferrous wastewaters. The use of powdered activated carbon is most commonly associated with activated sludge systems (113, 114), where continual mixing of the wastewater allows the powdered activated carbon to contact the wastewater for a much longer time than can be achieved with the lime and settle treatment schemes used throughout the nonferrous metals industry. Also, powdered activated carbon is more difficult to regenerate than granular activated carbon due to problems in handling the slurry which results from the powdered activated carbon addition and possible volatilization of a large percentage of powdered activated carbon during thermal regeneration (115,194).

Activated Alumina. Activated alumina has been used for the removal of fluorides (74, 77, 116, 117, 118, 119, 120) and arsenic (121, 122). Adsorption is the mode of pollutant removal usually associated with activated alumina, however, all five mechanisms mentioned under activated carbon most likely occur.

The ability of the alumina to effectively remove a pollutant is dependent on the wastewater characteristics. High concentrations of alkalinity or chloride and high pH reduce activated alumina's removal capacity. The alkalinity-causing and chloride anions compete with fluoride ions for removal sites on the alumina.

While fluoride can be removed as calcium fluoride to less than 20 mg/l by precipitation, levels lower than 1 mg/l of fluoride are achievable with activated alumina (77, 111). An initial concentration of 8-30 mg/l of fluoride can be reduced by 85-99+ percent (78, 80, 82, 118). However, some complex forms of fluoride are not removed by activated alumina (117). Caustic, sulfuric acid, hydrochloric acid, and alum can be used for activated alumina regeneration. Influent arsenic concentrations of 0.3 - 10 mg/l can be reduced by 85-99+ percent (121, 122).

Solidification. Conversion of a wastewater or sludge to a solid is one treatment to eliminate the discharge of pollutants. Some silicates are known to form solids; one of the best known is portland cement. There are also some proprietary compounds, the chemical nature of which is undisclosed, which are used to convert liquid and slurries to a solid form. One such system is reputed to convert a solution or slurry to a solid in a period of from 24 to 72 hours, after which the waste can be landfilled (123). This system reportedly reacts with polyvalent metal ions to produce stable, insoluble, inorganic compounds. Monovalent cations, many organic compounds, many anions, water, and colloidal or high molecular weight materials may not enter into the reaction, but are physically entrapped in the solid matrix. Only limited data on the fixation achieved by this system are available. The results of one simple leach test are presented for illustration (5). In this test, 25 g of a fixed waste from a coppery refinery by-products bleed stream (selenium and tellurium recovery operation) were leached by recirculating 250 ml of water (pH 7.3) over the waste contained in a Buchner funnel for 4 days (96 hrs.). Analyses of the solution at the end of this period indicated the following removals from the fixed waste:

Ions Leached, ug/g material

| pH | As | Cd | Cu | Fe | Pb | Se | Te | Zr |
|---|---|---|---|---|---|---|---|---|
| 10.3 | 0.08 | 0.015 | 1.1 | 1.05 | 0.75 | 0.33 | 0.60 | 1.6 |

Since costs for this fixation treatment are estimated to run between $0.005 and $0.025/l ($0.02 and $0.10/gal), it is not one to be applied indiscriminately to large volume wastewaters. It would be applicable to low volume, highly polluted wastewaters, such as those from copper refinery by-products recovery operations, where the waste stream may involve only a few thousand liters per day. Prior reduction of the volume to be

treated, by reverse osmosis, ion exchange, or evaporation, may be a useful adjunct to fixation as a solid.

Ion Exchange. Ion exchange is basically a process for removal of various ionic species in or on fixed surfaces. During the process, ions in the matrix are exchanged for soluble ionic species. Cationic, anionic, and chelating ion exchangers are available and may be either solids or liquid. Solid ion exchangers are generally available in granular, membrane, and bead forms (ion exchange resins) and may be employed in upflow or downflow beds or columns, in agitated baskets, or in cocurrent or countercurrent flow modes. Liquid ion exchangers are usually employed in equipment similar to that employed in solvent extraction operations (pulsed columns, mixed settlers, rotating disc columns, etc.) In practice, solid resins are probably more likely candidates for end-of-pipe wastewater treatment, while either liquid or solid ion exchangers may be utilized for internal process streams.

Ion exchangers' behavior and performance are usually dependent upon pH, temperature, and concentration. The highest removal efficiencies are generally observed for polyvalent ions. In ion exchange, some pretreatment or preconditioning of wastes to reduce suspended solid concentrations, which may clog ion exchange resins, and other parameters, which may be removed in preference to a pollutant whose removal is desired, is likely to be necessary.

Table VII-11 summarizes the range of conditions and variety of purposes for which various ion exchange resins are employed. The disadvantages of ion exchange in treatment of industrial wastewater are the relatively high operating and maintenance costs, somewhat limited resin exchange capacity, and insufficient specificity -- especially in cationic exchange resins--for some applications. Although it is suitable for complete deionization of water, ion exchange is generally limited in this application, by economics and resin exchange capacity, to the treatment of water containing 500 mg/l or less of total dissolved solids.

For recovery of specific ions or group of ions (e.g., divalent heavy metal cations, or metal anions such as molybdate, vanadate, and chromate), ion exchange is applicable to a broad range of solutions. This use is typified by the recovery of uranium from ore leaching solutions using strongly basic anion exchange resin. Additional examples are the commercial reclamation of chromate plating and anodizing solutions, and the recovery of copper and zinc from rayon production wastewaters (124). Chrome plating and anodizing wastes have been purified and reclaimed by ion exchange on a commercial scale, yielding economic as well as environmental benefits. In tests, chromate solution containing levels in

excess of 10 mg/l chromate, treated by ion exchange at practical resin loading values over a large number of loading cycles, consistently produced an effluent containing no more than 0.03 mg/l of chromate. Concentrations of arsenic, barium, cadmium, chromium, copper, cyanide, lead, iron, manganese, mercury, selenium, silver, and zinc can be reduced by 95 percent (125).

Ammonia removal can be performed with the natural inorganic zeolite, clinoptilolite. Clinoptilolite, a cation exchanger, sorbs ammonium ions in preference to calcium, magnesium, and sodium (126). Regeneration can be performed in a closed loop system with the ammonia being removed by an air stripping unit. Caustic and sodium chloride are the most common regenerants, with the sodium displacing the ammonium ions.

High concentrations of ions other than those to be removed may interfere with removal. Calcium ions, for example, are generally collected along with the divalent heavy metal cations of copper, zinc, lead, etc. High calcium concentrations, therefore, may make ion exchange removal of divalent heavy metal ions impractical by causing rapid loading of resins and necessitating unmanageably large resin inventories and/or very frequent regeneration steps. Less difficulty of this type is experienced with anion exchange. Available resins have fairly high selectivity against the common anions, such as chloride and sulfate. Anions adsorbed along with uranium include vanadate, molybdate, ferric sulfate anionic complexes, chlorate, cobalticyanide, and polythionate anions.

Ion exchange resin beds may be fouled by particulates, precipitation within the beds, oil and greases, and biological growth. Pretreatment of water, as discussed earlier, is therefore commonly required for successful operation. Generally, feed water needs to be treated by coagulation and filtration for removal of iron, manganese, carbon dioxide, hydrogen sulfide, bacteria, algae, and hardness. Since there is some latitude in selection of the ions that are exchanged for the contaminants that are removed, post-treatment may or may not be required.

## CONTROL AND TREATMENT TECHNOLOGIES BY SUBCATEGORY

The foregoing control and treatment technologies are discussed in this section as they apply to the individual subcategories. This section will discuss the processes in each subcategory and the possible wastewaters and related control and treatment technologies. Tables summarizing existing control and treatment technologies for individual wastewater streams are included. Data from these tables will be referred to for clarification and emphasis.

Primary Aluminum

The processes to be considered are:

1. Anode paste preparation
2. Anode baking.
3. Reduction (potline and potroom scrubbing).
4. Degassing.
5. Metal cooling.
6. Cryolite recovery.

Anode and Cathode Preparation. Preparing anode paste requires crushing, screening, calcining, grinding and mixing of coke and pitch and is inherently a dusty operation requiring extensive particulate control. As shown in Table VII-12, 22 plants preparing paste use dry air pollution control devices while only four use wet air pollution control devices. Three do not use any emission control. Paste plant water use and discharge levels are, in gallons/ton paste, as follows.

| Plant | Use | Discharge |
|---|---|---|
| 13 | 683 | 683 |
| 14 | 632 | 632 |
| 26 | 140 | 53 |
| 29 | 171 | 171 |

Anode bake plant air emissions are reportedly more difficult to control by dry methods. Supposedly, dry electrostatic precipitators may not control gaseous fluorides and baghouses may be susceptible to blinding caused by tars and oils emitted during the baking process. Fluidized alumina beds, a dry system, avoid the previously mentioned problems. Dry systems are used by eleven out of the 21 plants which control anode baking emissions. Three plants which use fluidized bed alumina systems for emissions control reported using water, although none discharged from this source.

Wastewater from wet air pollution control of bake plant emissions must be treated for fluorides (where anode stubs are recycled), tars, oils, and particulates. If care is taken in the removal of fused cryolite from the anode stubs before reprocessing, fluoride emissions from the anode bake plant would be greatly minimized, and hence fluoride concentrations in the bake plant scrubber water would be minimized. Typical treatment of this wastewater consists of addition of an alkali and sedimentation for suspended solids and fluoride removal. Nine plants reported the use of water in bake plant air pollution control devices. The water use and discharge levels for these operations are, in gallons/ton baked anodes, as follows:

| Plant | Use | Discharge |
|---|---|---|
| 1 | 33 | 0 |
| 2 | 292 | 0 |
| 3 | 94 | 0 |
| 5 | 9791 | 9791 |
| 5 | 6524 | 6524 |
| 13 | 4693 | 0 |
| 14 | 6009 | 10 |
| 24 | 92 | 0 |
| 25 | 404 | 264 |

Four plants reported using water to make potliners. Only one plant (#29) discharged from this source, at a rate of 2 gal/ton aluminum.

Reduction (Potline and Potroom Scrubbing). Wet and dry emission control devices are used for potline air emissions. Dry scrubbing of potline gas involves removal of pollutants contained in the gases from the electrolytic cells (potlines) by dry alumina. The pollutants are sorbed by the alumina, with particulate collection performed by baghouses. The system is used for gases collected immediately above the cell having relatively high concentrations of pollutants.

The outstanding features of the system include the sorption of emitted gases on alumina, the subsequent return of the alumina and sorbed fluorine compounds to the pots to produce aluminum, and the generally high levels of removal efficiency for both gaseous fluorine compounds and particulates (e.g., greater than 99 percent). This process uses no water.

A typical dry scrubbing process includes hoods and ducts to collect and deliver the gases from the pots to air pollution control units, usually a cyclone type device to separate coarse particulates; a reactor section in which the gases are contacted with the alumina, and a fabric filter, from which the gases are released to the atmosphere.

When dry scrubbing is properly operated with efficient hooding, atmospheric emissions limits may be satisfied without the use of water. Thus, the dry scrubbing process is of major significance to water pollution control at primary aluminum plants.

Although many plants have converted from wet to dry scrubbing since 1973, 12 plants still practice wet air pollution control for potline emissions. All plants using secondary emission control (i.e., potroom scrubbing) use some form of wet scrubber. Water from wet scrubbers can be treated in various ways to remove impurities, so that the water can be recycled. In the case of

primary potline and secondary potroom wet scrubbers, the fluoride dissolved in the water can be precipitated and settled. This treatment reduces the suspended solids content at the same time.

In general, the method used to remove the fluoride from the wastewater is precipitation either as cryolite or as calcium fluoride. In the first case, sodium aluminate (or caustic soda and hydrated alumina) is added. In the second case, a lime slurry (or calcium chloride) is used. After precipitation, thickening of the slurry is accomplished in clarifiers or thickeners. The treatment of wet scrubber liquor to recover cryolite is a significant practice, because a sufficient quantity of fluoride is removed to permit recycle of the treated liquor to the scrubbers. The process also recovers the fluoride in a form which can be returned to the aluminum cell bath. The value of the recovered cryolite represents a credit to partially offset the cost of the treatment process. Sulfates are present, thus preventing total recycle of the scrubber liquor.

High suspended solids concentrations are reduced by the fluoride precipitation. Fluoride removals below levels achievable by precipitation can be achieved by activated alumina and activated carbon. High cyanide concentrations in potline and potroom scrubbers can be treated by breakpoint chlorination, as one plant already does, or by ozone oxidation. For potline emissions the reported anode type and water use and discharge, in gallons/ton aluminum, are as follows:

| Plant | Anode Type | Use | Discharge |
|---|---|---|---|
| 2 | PB | 29071 | 4845 |
| 3 | PB | 335 | 0 |
| 21 | PB | 821 | 110 |
| 23 | PB | 8086 | 56 |
| 9 | VSS | 5475 | 0 |
| 19 | VSS | 6845 | 6845 |
| 20 | VSS | 14194 | 14194 |
| 26 | HSS | 1655 | 0 |
| 28 | HSS | 156,839 | 381 |
| 30 | HSS | 11975 | 0 |
| 31 | HSS | 1263 | 219 |
| 29 | HSS + PB | 3600 | 0 |

(PB=prebaked, VSS=vertical stud Soderberg, and HSS=horizontal stud Soderberg).

For potroom emissions control devices, the anode type and reported water use and discharge levels, in gallons/ton aluminum, are as follows:

| Plant | Anode Type | Use | Discharge |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 12 | PB | 37542 | 37542 |
| 13 | PB | 3600 | 2100 |
| 14 | PB | 3802 | 83 |
| 24 | PB | 23464 | 538 |
| 9 | VSS | 2669 | 0 |
| 19 | VSS | 48667 | 48667 |
| 20 | VSS | 55967 | 53128 |

No HSS plants reported the use of potroom controls.

Degassing. There are a number of variations in degassing procedures that function as process control techniques to eliminate the use of water for wet scrubbing of degassing emissions. The necessity for degassing varies with product specifications. Products which must be especially high in purity and free of pin holes caused by gas bubbles require degassing.

Alternative degassing operations are:

1. Chlorine degassing with wet scrubbing of gases.
2. Degassing with mixtures of chlorine and other gases.
3. Degassing with inert (nitrogen or argon) gases.
4. Filtration of the molten metal, using special materials and conditions.

Wet scrubbing may be necessary due to the characteristics of the gas and the possible formation of hydrochloric acid and its resulting damage to dry air pollution control systems. Environmental control efforts have resulted in the development, and successful use, of gas mixtures such as chlorine plus an inert gas, or chlorine, carbon monoxide, and nitrogen. In the case of mixed gases, gas burners or controlled combustion gas generators are used to produce a gas of carefully controlled composition.

A degree of uncertainty exists with regard to the basic reactions in the degassing process. The degassing process may depend to a degree on the chemical reaction of chlorine with hydrogen, followed by evolution of hydrogen chloride gas bubbles. It may also depend on the formation of gas bubble nuclei and interfaces, which furnish the basis for the simple physical evolution of the hydrogen from its dissolved state in the metal.

All of the above listed degassing alternatives are in commercial use on a regular basis and have been for sufficient time to be considered established practice in one or more producing plants. There is no known evidence that the degassing alternatives are completely applicable to every plant. Applicability of a specific process to a specific plant must be determined on an

individual basis. The reported water use and discharge levels for degassing scrubbers, in gallons/ton degassed aluminum, are;

| Plant | Use | Discharge |
|---|---|---|
| 14 | 701 | 596 |
| 19 | 730 | 730 |
| 26 | 445 | 408 |

Contact Cooling. Control of wastewater from direct contact cooling can be achieved by means of a cooling tower, with recycle of the water. A bleed stream will be necessary to prevent the buildup of dissolved and suspended solids, and oil and grease. The water use and discharge levels for casting operations are shown below, in gallons/ton aluminum cast:

DC Casting

| Plant | Use | Discharge |
|---|---|---|
| 1 | 7604 | 7604 |
| 2 | 0 | 0 |
| 2 | 2920 | 2920 |
| 3 | Var. | 0 |
| 4 | 608 | 107 |
| 5 | 14497 | 14224 |
| 6 | 33182 | 796 |
| 7 | 28064 | 1947 |
| 9 | 2477 | 0 |
| 10 | 34219 | 0 |
| 11 | 4936 | 3949 |
| 13 | 11250 | 729 |
| 15 | 267 | 8 |
| 15 | 8184 | 105 |
| 17 | 5840 | 117 |
| 20 | 4964 | 4964 |
| 22 | 13140 | 30 |
| 23 | 6822 | 341 |
| 25 | 1560 | 1560 |
| 26 | 3006 | 3006 |
| 27 | 61 | 61 |
| 29 | 4380 | 2071 |
| 29 | 7300 | 3445 |
| 30 | 1700 | 698 |
| 31 | 2898 | 2898 |
| 31 | 12587 | 12587 |

Sow & Pig Casting

| Plant | Use | Discharge |
|---|---|---|

| | | |
|---|---|---|
| 5 | 0 | 0 |
| 15 | 0 | 0 |
| 15 | 0 | 0 |
| 18 | 0 | 0 |
| 20 | 219 | 219 |
| 23 | 0 | 0 |
| 23 | 0 | 0 |
| 24 | 0 | 0 |
| 25 | 0 | 0 |
| 29 | 0 | 0 |
| 31 | 0 | 0 |

Mixed Casting

| Plant | Use | Discharge |
|---|---|---|
| 3 | 0 | 0 |
| 6 | 92,318 | 1947 |
| 8 | 2978 | 666 |
| 12 | 3066 | 3066 |
| 14 | 4683 | 4449 |
| 18 | 4737 | 4737 |
| 21 | 608 | 15 |
| 25 | 0 | 0 |
| 28 | 0 | 0 |
| 19 | 6529 | 0 |

Properzi Casting

| Plant | Use | Discharge |
|---|---|---|
| 3 | ? | 0 |
| 9 | 0 | 0 |
| 15 | 7276 | 73 |
| 18 | 0 | 0 |
| 22 | 31,536 | 0 |

Cryolite Recovery. In addition to recovering cryolite from potline scrubber water, cryolite can be recovered from spent cathodes by a leaching operation. Cryolite is precipitated and the resulting waste stream must be treated for cyanide destruction by chlorination or ozonation, for suspended solids by settling and flocculation, and for metals by lime precipitation.

The water use and discharge levels reported for cathode reprocessing, in gal/ton of aluminum produced at the plants from which the spent cathodes came, are as follows:

| Plant | Use | Discharge |
|---|---|---|

| | | |
|---|---|---|
| 23 | 101 | 101 |
| 24 | 33 | 0 |
| 26 | 388 | 97 |
| 28 | 190 | 0 |
| 31 | 365 | 62 |

Secondary Aluminum

The processes to be considered are:

1. Dross processing.
2. Smelting and demagging.
3. Molten metal cooling.

Dross Processing. Dry and wet dross processing (milling) methods are practiced in secondary aluminum. Table VII-13 shows that of the 63 plants surveyed, 20 report dross processing, of which 4 use water and 16 use a dry method.

The dry method of dross processing consists of impact mills, grinders, and screening operations to recover the metallic aluminum values from the nonmetallics. The dust from these operations is vented to baghouses. The baghouse dust and the nonmetallic fines from screening constitute the solid waste from the operation. These are disposed of at the plant site on the ground. Dry processing has the disadvantage of not removing the fluxing salts from the dross, thus impregnating runoff and ground water if the solids are stored on the surface. While an attempt may be made to control dissolved salts by containing runoff in drainage ditches, some contamination of surface and subsurface waters is unavoidable considering present solid waste disposal practices. Those practicing dry dross processing in areas where land for solid waste disposal is limited use the services of industrial waste disposal contractors.

Of the four plants that practice wet dross processing, two have instituted total recycle, one recycles with a blowdown, and one attains zero discharge by solar evaporation. Certain industry personnel claim that wet milling of primary aluminum residues and secondary aluminum slags with a countercurrent flow process is the only way to reduce or possibly eliminate salt impregnation of runoff and ground water from discarded solid waste. By using a countercurrent milling and washing approach, two advantages could be realized. The final recovered metal would be washed with clean water providing a low salt feed to the melting furnaces. The wastewater, with the insolubles removed, would be of a concentration suitable for economical salt recovery by evaporation and crystallization. Heat for evaporation could be supplied by the waste heat from the furnaces. The process would

have to contend with the ultimate disposal of dirt, trace metals, and insoluble salts not removed from the dross during milling. Such salt recovery installations are operating in England and Switzerland, and the salts recovered assist in paying for the operation, since they are reusable as fluxing salts in the secondary aluminum industry (4).

Smelting and Demagging. Smelting can be performed with or without demagging thus creating different pollution controls for each method. When smelting is performed without demagging, baghouses or other dry devices can be used to treat emissions, as is demonstrated by the fact that only 3 of the 22 plants that do not demag have wet air pollution control systems. Demagging complicates emissions control due to the possible formation of hydrochloric acid in the smelting emissions if chlorine is used.

Demagging can be performed with chlorine or aluminum fluoride. Although emissions from demagging with fluoride are generally controlled with dry processes, chlorine is still used for demagging at the majority of plants that demag. Aluminum fluoride is more expensive than chlorine and is not regarded as effective as chlorine in removing magnesium. Also, the furnace refractory lining life is shorter when aluminum fluoride is used since residues resulting from aluminum fluoride demagging are more corrosive than chlorine demagging residues.

If chlorine is used for demagging, wet scrubbing is usually necessary due to the corrosiveness of the offgases. However, methods have been developed for reduction and/or removal of fumes without a major use of water either in the process or in fume control.

The Alcoa Process* is described as a fumeless demagging process. It recovers molten magnesium chloride. The unit is installed between the holding furnace and the casting machine and removes magnesium continuously as the metal flows through. The operation uses no flux salts. Little data is available regarding its effectiveness, but two passes through the unit may be necessary to meet magnesium specifications in the aluminum product.

The Derham process* includes equipment and techniques for magnesium removal, with chlorine, from secondary aluminum melts, with a minimum of fume generation and without major use of water in either the process or in fume control. The principal concept is the entrapment of magnesium chloride, the reaction product of magnesium removal, in a liquid flux cover with the flux being subsequently used in the melting operations. The Derham process may not be able to meet stringent air pollution regulations

*The use of trade names does not constitute endorsement or recommendation for use.

without the use of a very fine or coated baghouse or a wet scrubber.

The Carborundum metal pump system* is another dry method for chlorine demagging. However, little information is available concerning this process and questions remain regarding its effectiveness in controlling air pollution.

The water from chlorine demagging fume scrubbing operations, is highly acidic, due to the hydrolysis of aluminum chloride and magnesium chloride which forms hydrochloric acid. Existing treatment practices are listed in Table VII-13; pH adjustment to 6.0-7.0 will precipitate most of the aluminum and magnesium as hydroxides. Coprecipitation of heavy metal hydroxides also occurs. The effectiveness of pH adjustment is diminished for aluminum removal if too much alkali is added, since dissolution of aluminum hydroxide occurs at about pH 9.

The reported water use and discharge levels for plants using chlorine demagging are as follows, in gal/ton aluminum:

| Plant | Use | Discharge |
|---|---|---|
| 1 | 65 | 65 |
| 2 | 289 | 289 |
| 3 | 54 | 54 |
| 4 | 490 | 0 |
| 5 | 184 | 184 |
| 6 | 65 | 65 |
| 7 | 70 | 70 |
| 8 | 137 | 137 |
| 9 | 781 | 781 |
| 10 | 550 | 550 |

Metal Cooling. The major pollutants in wastewater generated during the cooling of molten ingots are oil and grease and suspended and dissolved solids. Oil and grease, used to lubricate mold conveyor systems, is washed from equipment as the ingots are sprayed with water. The production of deoxidizer shot differs from ingot cooling, in that the molten aluminum flows through the mesh of a screen and forms a spherical shot product before quenching in the cooling tank.

The amount of wastewater discharged from metal cooling can be reduced by recycle and using cooling towers or ponds. Discharge of contact cooling water could be eliminated by adopting either total evaporation through regulated flow or air cooling. However, the latter two alternatives are not suited to smelters producing deoxidizer shot.

Fifteen of the plants surveyed are practicing total recycle. Flash cooling on hot ingots may be a viable disposal method. While oil and grease accumulation would appear to be unavoidable in a recirculation system, removal by skimming is facilitated at higher concentrations of oil and grease. Use of greases that melt at higher temperatures and are less prone to erosion has been suggested as a means of controlling this pollution problem.

Six plants are using total or near total consumption to reduce contact cooling flows and seven plants report that the molten aluminum is cooled without wastewater being discharged. Twenty-eight plants report no treatment of contact cooling water before recycle or discharge. However, one plant does treat its contact cooling water with caustic and polymer addition for suspended solids and various dissolved solids removal, as well as oil removal (by skimming) and sedimentation.

Columbium-Tantalum.

This industry is composed of five plants, three in the ore to salt subcategory, and four in the salt to metal subcategory. The processes to be discussed for only the ore to salt subcategory are:

1. Digestion.
2. Solvent extraction.
3. Precipitation and filtration.

The processes to be considered for the metal subcategory are:

1. Salt drying.
2. Reduction.
3. Consolidation.

The potential sources of wastewaters from this subcategory are summarized in Table VII-14.

Digestion. All three plants use hydrofluoric acid to leach the columbium/ tantalum ore concentrates with the leachate going to solvent extraction. Two plants report a gangue slurry of unreacted ore that must be treated. Wet scrubbers are in place at all three plants, two with recycle and a bleed stream, and one with once through water usage. Wet scrubbers are necessary due to the acidic nature of the emissions and the presence of gaseous fluoride. Existing treatments are shown in Table VII-14. The scrubber liquor and the gangue slurry are high in suspended solids, fluoride, acidity and metals and require alkali addition for suspended solids, fluoride, and metals reduction and pH adjustment. Additional fluoride removal technologies, such as activated alumina and reverse osmosis, may be necessary, as well

as filtration for additional suspended solids removal. Also, additional heavy metal removal techniques such as reverse osmosis or ion exchange may be necessary since initial concentrations are extremely high.

Solvent Extraction. After methyl isobutylketone extraction the barren raffinate must be treated. One plant recycles a portion to the leaching process to utilize the highly acidic nature of this wastewater. The raffinate has characteristics similar to the gangue slurry and treatment techniques would be similar. Waste characteristics and subsequent treatment would also be similar for wet scrubbers used over the solvent extraction process.

Precipitation and Filtration. The metal values in the pregnant extraction solutions are precipitated to recover metal salts by oxide precipitation with ammonia or by potassium chloride precipitation of potassium fluorotantalate. The barren solutions must be subsequently treated. A wastewater similar to those previously produced in the digestion and solvent extraction processes results from potassium chloride precipitation and the attendant treatment is also similar. However, the ammonia laden streams from ammonia precipitation require treatment for high levels of this pollutant. All three plants practice steam stripping.

Salt Drying. Four of the five plants surveyed practice salt drying or calcining prior to further processing. Wet scrubbers are necessary since gaseous fluoride may still be present, and ammonia gas will be present when ammonia-precipitated salts are being dried, possibly making steam stripping or ion exchange necessary. Three plants practice recycle with a bleed stream and one plant discharges the scrubber liquor without recycle.

Reduction. Four plants practice reduction. Leaching after sodium reduction, a common practice for the tantalum production, is a major source of wastewater. After completion of the reduction reaction, and cooling of the products, tantalum is obtained as small particles in a matrix of potassium and sodium salts. The salts are removed by successive leaches in water and acid to produce a pure metal powder. The resultant leachate is laden with fluorides and dissolved solids. Fluoride treatment technologies, including lime precipitation and activated alumina, must be applied to this wastewater.

Only one plant reports reducing columbium oxide. This plant reduces the columbium salt aluminothermically with no air pollution control systems employed or other wastewaters reported.

Consolidation. Three plants practice consolidation. Two use electron beam furnaces for purification and consolidation and use only noncontact cooling water for the furnace. The other plant uses water for tantalum sizing. The sizing stream contains ammonia to prevent solubilization of the tantalum. Treatment for the sizing stream consists of hydrochloric acid neutralization and centrifugation.

Additional Comments. Opportunities in this industry for reuse of process wastewater or for major reductions in water discharge may be limited. Currently there is no alternative to the practice of dissolving columbium and tantalum ores with hydrofluoric acid. (This inevitably leads to the solubilization of many other ore constituents which limits the extent to which barren solutions remaining after extraction of columbium and tantalum may be reused.) Similar constraints apply to wastewaters resulting from precipitation of metal salts and from reduction wastes, since contamination must be avoided at every step in the process. Segregation of wastewaters in this subcategory is important if treatment costs are to be minimized and pollutant removals are to be maximized.

The reported discharge levels from the ore-to-salt operations, in gal/lb of precipitation capacity, are as follows:

| Plant | Discharge |
|---|---|
| A | 13.2 |
| B | 7.8 |
| E | 22.7 |

The discharge levels from salt-to-metal operations, in gal/lb of reduction capacity, are as follows.

| Plant | Discharge |
|---|---|
| A | 19.44 |
| B | 11.70 |
| C | 3.74 |
| D | 17.42 |

Primary Copper

Smelting and refining are the subcategories of the primary copper industry. Copper acid plants are discussed with other metallurgical acid plants. The specific operations are:

1. Roasting, smelting, and converting (including acid plants)
2. Slag granulation.
3. Fire refining

4. Electrolytic refining
5. Metal cooling.

Roasting, Smelting, and Converting. All of these operations require some degree of air pollution control. The type of air pollution control is dependent on the nature of the emissions produced and whether or not an acid plant is employed. Relatively high amounts of sulfur dioxide will be emitted from all of these operations, especially roasting and converting. Gases from roasting and converting operations, except at one plant without an acid plant, are sent to an acid plant directly or after preliminary conditioning or particulate removal. Some plants send emissions from smelting to an acid plant. Smelting emissions can be controlled with wet or dry methods, although dry electrostatic precipitators are most frequently used.

Slag Granulation. Reverberatory furnace slag from smelting is usually loaded into rail cars or pots and transported to the slag waste area. Two disposal methods are used, slag dumping or slag granulation. Slag dumping, of course, eliminates a wastewater and is practiced at most plants.

The main criteria for the recycle of granulating water is temperature. Plants that practice slag granulation can recycle this wastewater if sufficient retention time can be provided to assure adequate cooling. If pond area or capacity is not available, a cooling tower or heat exchanger is a practical approach. Slag granulation water could also be used for ore concentrating. Existing treatment for slag granulation wastewater can be seen in Table VII-15.

Electrolytic Refining. Spent electrolyte is an effluent which has commercial value. $NiSO_4$, $CuSO_4$, and black acid are all recoverable by-products from this effluent. At some refineries, the spent acid is returned to the electrolytic cells for reuse.

Gold, selenium, silver, and tellurium are recoverable by-products of slimes which form in electrolytic cells. Wastewater is discharged from the recovery of these by-products at only one plant and is treated with lime, polymer, and ferric salts addition and sedimentation.

When the cathodes and the spent anodes are removed from the electrolytic cell, adhering acid is rinsed off. The general practice at primary copper refineries is to use all of this water as electrolyte make-up. Total recycle of this washwater is practiced at five plants.

Metal Cooling. Smelters and refineries use large volumes of water for contact cooling. In contact cooling, intermediate and

finished products are both sprayed and quenched with water to solidify the item to produce required surface characteristics.

When blister copper is cast into cakes, surface characteristics are not critical, and the casting is usually sprayed with water, most of which is consumed through evaporation, and then allowed to air cool. Fire refined copper castings are subjected to direct cooling with water as is copper shot. Most smelter produce an intermediate product, anode copper, which is subsequently used in the electrolytic production of cathode copper. As the copper is poured into an anode mold contained on a casting wheel, direct contact water is used as both a spray and for complete immersion in a bosh tank. When cathode copper is cast into shapes such as cakes and wire bars, direct contact cooling is used to achieve both cooling and the required surface characteristics. Some refineries sell their cathodes "as is", without melting and casting.

Temperature is an important operating parameter for cooling water in that at a lower temperature, less water is needed to cool a given amount of metal. If effective cooling means are supplied (cooling ponds or towers), blowdown requirements attributable to temperature will be minimized. Waste cooling water is handled in many ways throughout the industry as can be seen in Table VII-15.

Reported water use, blowdown and discharge from refineries are as follows, in gal/ton refined copper:

| Plant | Use | Blowdown | Discharge |
|---|---|---|---|
| 1 | ? | 0 | 0 |
| 2 | 2036 | 2036 | 2036 |
| 3 | 9333 | 0 | 0 |
| 4 | ? | 145 | 0 |
| 5 | 2336 | 2336 | 0 |
| 6 | 4869 | 39 | 39 |
| 7 | 362 | 362 | 362 |
| 8 | 4508 | 115 | 0 |
| 9 | 261 | ? | 0 |
| 10 | 2634 | 222 | 162 |

Secondary Copper

The processes to be considered are:

1. Slag milling
2. Slag granulation
3. Pyrometallurgical processing
4. Electrolytic refining
5. Molten metal cooling.

Slag Milling. Copper-rich slags undergo recovery of their copper content by either wet or dry processing. Dry processing is accomplished by collecting the molten slag in an inverted cone-shaped thick metal pot, about one meter or larger in diameter. The slag is cooled in the pot without the use of water and is transported in the pot to a slag storage pile, where it is dumped. Slag from this pile is further processed to reclaim the copper values, either by remelting in the smelter or by selling it to another secondary copper smelter for reclaiming.

In some cases the slag is wet milled rather than being remelted. Of the plants that do practice wet slag milling, six of eight plants surveyed practice total recycle as can be seen in Table VII-16. Sedimentation is necessary for suspended solids reduction before recycle. Some plants practice additional treatment, such as screening or filtration.

Slag Granulation. Copper-poor slags are either dumped or wet granulated. Although slag dumping is possible, granulated slags may be easier to dispose of as fill or railroad ballast than the large chunks formed in slag pots. Five of the plants surveyed practice slag granulation, although none discharge any wastewater. Four plants practice total recycle of the slag granulation wastewater and one disposes of this wastewater in an evaporation pond.

Pyrometallurgical Processing. In the smelting operation, many types of furnaces are used in the secondary copper industry, such as cupola, convertor, rotary, electric, blast, and reverberatory furnaces. Air pollution control devices for these furnaces vary widely.

The wastewater from wet scrubbing devices contains suspended solids and heavy metals. Existing treatments for scrubbing liquor are shown in Table VII-16.

Electrolytic Refining. Electrolyte is normally totally recycled by circulating it through thickeners and filters to remove the solids (slimes). Depending on the quality of the anodes and the impurities from the scrap metal that are carried through the fire refining, soluble metal concentrations build up in the electrolyte which cannot be removed as slimes. When this occurs, a bleed stream of the electrolyte is required. Such waste electrolyte normally is treated to remove the copper content first by high-voltage deposition and finally by cementation with iron. Cementation with iron involves the precipitation of copper ions by displacement with iron, which has a higher oxidation potential than copper. The resulting solution may then be lime precipitated and filtered before discharge. Some electrolytic refineries have a ready market for the contaminated electrolyte.

Cathode rinse water is used as electrolyte makeup or is totally recycled.

Metal Cooling. Contact cooling, air cooling, and noncontact cooling are used throughout the industry as shown on Table VII-16. Anodes and rough brass or bronze ingots are generally spray-cooled to rapidly solidify the casting, and the casting is then quenched in a tank of water. Smooth brass or bronze ingots must be slowly cooled in the mold under a layer of charcoal to produce the smooth surface required by certain customers. Ingot mold lines are quite long for the production of smooth ingots. The ingots are air cooled in the mold during the first portion of the conveyor travel, then the bottom of the ingot mold is submerged in water during the second portion of the conveyor travel, and finally the solidified ingot is dumped into a quench tank. Part of the charcoal burns during the ingot's travel period on the conveyor. The unburned charcoal and ash go into the quench water. These residues settle as a sludge and are periodically cleaned out of the quenching tanks and subsequent settling tanks or ponds. The water may or may not be recycled with cooling and treatment. Treatment is necessary for oil and grease, suspended solids, and some heavy metals. Lime precipitation can be used for treatment.

Air cooling is employed only by some producers and may not be applicable to all producers since very long or large conveyors would be necessary.

Primary Lead

The processes to be considered are:

1. Sintering.
2. Other pyrometallurgical processes.
3. Slag granulation.
4. Metal cooling.

Sintering. Sintering removes sulfur as $SO_2$ and $SO_3$, as well as other impurities such as arsenic, antimony, and cadmium. Of the seven plants surveyed, four plants have sinter scrubbers, as shown in Table VII-17. This waste stream is high in heavy metals, suspended solids, and other dissolved solids, including arsenic. Existing treatments are shown in Table VII-17.

Other Pyrometallurgical Processes. The other pyrometallurgical processes performed in primary lead plants are: blast furnace smelting, dezincing, drossing, dross processing, softening, hard lead refining, desilverizing, debismuthizing, retort and cupel furnace processing, and refining. Virtually every application of these processes in the primary lead industry employs baghouses

for air pollution control. The few exceptions can be seen by referring to Table VII-17.

Slag Granulation. Five plants practice slag or speiss granulation with three plants discharging wastewater from this process. One plant attains total recycle with sedimentation as the only treatment. The plants which discharge use at least lime precipitation.

Metal Cooling. None of the plants surveyed report any discharge of contact cooling water. Two of the seven plants that cast lead ingots use noncontact cooling water. One plant does use contact cooling water but it is applied such that total evaporation occurs.

The discharge levels reported from primary lead smelters are, in gal/ton of blast furnace capacity:

| Plant | Discharge |
|---|---|
| A | 309 |
| B | 0 |
| C | 0 |
| D | 0 |
| E | 1098 |
| F | 1227 |

The one refinery is at zero discharge.

Secondary Lead

The processes to be considered are:

1. Battery cracking.
2. Pyrometallurgical processing.
3. Metal cooling.

Battery Cracking. Wastewater results from battery cracking from these sources:

1. Waste electrolyte from the battery.
2. Saw cooling water.
3. Washdown.

The combined wastewater from these sources has the characteristics of the battery electrolyte, with concentrations of pollutants dependent upon dilution from the other water sources. Characteristics of a battery cracking wastewater are low pH and high suspended and dissolved solids, heavy metals, and arsenic concentrations. Adjustment of pH with lime and resultant

removal of suspended solids and heavy metals is a necessary treatment for this wastewater. Activated alumina can be used for greater arsenic reduction than that achieved by lime precipitation. Many types of treatment for the battery cracking wastewater exist throughout the industry, as is shown in Table VII-18.

The reported blowdown and discharge from battery cracking operations are shown below, in gal/ton lead cracking produced in the operation. Also shown is the calculated battery electrolyte, also in gal/ton lead. The electrolyte represents the difference between the water used and the blowdown from the cracking operation. In some cases, plants reported the tonnage of batteries cracked. This tonnage was assumed to be whole batteries, and multiplied by 0.45 to arrive at the contained lead weight.

| Plant | Electrolyte | Blowdown | Discharge |
|---|---|---|---|
| 1 | 33 | 33 | 33 |
| 2 | 35 | 59 | 59 |
| 3 | 93 | 186 | 186 |
| 4 | 145 | 291 | 291 |
| 5 | 100 | 200 | 0 |
| 6 | 92 | 92 | 0 |
| 7 | 60 | 90 | 90 |
| 8 | 107 | 161 | 0 |
| 9 | 68 | 102 | 102 |
| 10 | 225 | 238 | 238 |
| 11 | 228 | 255 | 255 |
| 12 | 146 | 153 | 153 |
| 13 | 29 | 34 | 0 |
| 14 | 37 | 37 | 37 |
| 15 | 52 | 69 | 69 |
| 16 | 71 | 88 | 88 |
| 17 | 31 | 260 | 168 |
| 18 | 51 | 251 | 251 |
| 19 | 0 | 395 | 395 |
| 20 | 118 | 1116 | 1116 |
| 21 | 212 | 217 | 217 |
| 22 | 10 | 19 | 19 |
| 23 | 231 | 1225 | 1225 |
| 24 | 11 | 69 | 0 |
| 25 | 63 | 169 | 0 |
| 26 | 101 | 144 | 0 |
| 27 | 129 | 388 | 388 |
| 28 | 281 | 476 | 0 |
| 29 | 94 | 106 | 130 |
| 30 | 44 | 76 | 76 |
| 31 | 86 | 191 | 191 |

| | | | |
|---|---|---|---|
| 32 | 73 | 73 | 73 |

Pyrometallurgical Processing. Pyrometallurgical processing refers to metal processing by either blast, reverberatory, or kettle furnaces. Several plants use wet scrubbers to control possible acidic sulfur dioxide emissions. The water use and discharge figures reported from plants using wet emissions control systems are as follows, in gal/ton of furnace or kettle capacity:

Kettles

| Plant | Use | Discharge |
|---|---|---|
| 3 | 1456 | 0 |
| 4 | 2407 | 0 |
| 5 | 1123 | 0 |
| 10 | 83 | 0 |
| 19 | 398 | 16 |
| 21 | 737 | 0 |
| 24 | 2253 | 188 |

Reverbs & Blast Furnaces

| Plant | Furnace Type | Use | Discharge |
|---|---|---|---|
| 17 | Blast | 5174 | 347 |
| 23 | Blast | 5373 | 875 |
| 9 | Blast & Reverb | 155 | 0 |
| 17 | Reverb | 1868 | 313 |
| 20 | Reverb | 626 | 626 |
| 1 | Reverb | 6739 | 156 |
| 33 | Reverb | 780 | 0 |

Other Furnaces

| Plant | Use | Discharge |
|---|---|---|
| 25 | 58,656 | 0 |
| 28 | 246 | 0 |

Metal Cooling. As can be seen in Table VII-18, noncontact cooling water is used in the majority of plants. Where contact cooling is used total recycle, recycle with bleed, total evaporation, or discharge without recycle is practiced. Water use and discharge quantities reported by secondary lead plants for casting are as follows, in gallons per ton lead cast:

| Plant | Use | Discharge |
|---|---|---|

| | | |
|---|---|---|
| 6 | 16 | 0 |
| 7 | 26 | 0 |
| 9 | 5 | 0 |
| 25 | 62 | 0 |
| 27 | 15 | 2 |
| 32 | 42 | 42 |
| 34 | 1123 | 0 |
| 35 | 189 | 189 |

Secondary Silver.

Two subcategories are to be considered within the secondary silver industry: plants that recover secondary silver from photographic wastes; and plants that recover secondary silver from non-photographic wastes. Although the silver sources are different, the recovery processes are similar, and both subcategories will be discussed together in this section. The processes to be considered are:

1. Leaching and film stripping.
2. Precipitation and filtration.
3. Pyrometallurgical processing.
4. Electrolytic refining.
5. Metal cooling.

Leaching and Film Stripping. The greatest source of recovered silver from photographic sources is the stripping of silver from photographic film. There will usually be no wastewaters from this process since the flow associated with this process is impregnated with silver. However, wet air pollution control devices are used at some plants to control air emissions. Recycle is possible and is practiced in all three plants with wet scrubbers as can be seen in Table VII-19. Complex treatment schemes are employed at two of the plants. The other evaporates the wastewater in a smelting furnace.

Non-photographic leaching streams can be impregnated with either silver or impurities, depending on the process employed. In those cases where impurities are leached, treatment of this wastewater, high in heavy metals and suspended solids and low in pH, is necessary. pH adjustment and precipitation of the heavy metals and suspended solids removal are practiced throughout the industry. Wet scrubbers are also necessary on this acidic process. Waste characteristics of the scrubber liquor are similar to the leaching waste and must be treated accordingly. Existing treatments are shown in Table VII-20.

Precipitation and Filtration. The depleted silver solutions must be discarded after precipitation; this waste is common to both subcategories. High heavy metal concentrations (especially in

nonphotographic leaching wastes), suspended solids, and possibly ammonia require treatment. Several methods of treatment and control of this waste stream are being practiced. Blowdown from wet air pollution control devices is treated similarly to the precipitation and filtration wastes.

Pyrometallurgical Processes. Furnaces for melting, drying, and incinerating are employed in the secondary silver industry. Given this wide variability in furnace applications, the characteristics of the emissions from these furnaces, and the type of air pollution control employed, may also vary. Thus, certain plants may require wet scrubbers to clean emissions from their furnances while other plants may be able to use dry air pollution control devices.

Electrolytic Refining. Although electrolytic refining is practiced, discharges from this source are not common. Contractor hauling, artificial evaporation, and total recycle of electrolyte are practiced. Spent electrolyte is sent to precipitation in two plants.

Metal Cooling. Since the volume of silver cast is small, little if any contact cooling water is required. A flow of 1,000 gpd is the only significant discharge of contact cooling water in secondary silver and it is treated by lime, caustic, and polymer addition and sedimentation. Several other plants have contact cooling water flows of less than 100 gpd and others use air cooling.

The water use and discharge levels reported for the various secondary silver operations are as follows, in gallons per troy ounce:

Wet Film Stripping and Recovery

| Plant | Use | Discharge |
|---|---|---|
| 1 | .462 | 0 |
| 2 | .044 | .044 |
| 3 | 18.863 | .156 |
| 4 | ? | 0 |

Photographic Solution Silver Recovery

| Plant | Use | Discharge |
|---|---|---|
| 2 | 25.4 | 25.4 |
| 5 | .3 | .6 |
| 6 | 4.9 | 4.9 |

Non-Photographic Leaching-Precipitation-Filtration

| Plant | Use | Discharge |
|---|---|---|
| 7 | 26.0 | 26.0 |
| 8 | 195.28 | 195.28 |
| 8 | 3.56 | 3.56 |
| 9 | 1.14 | .67 |
| 10 | .31 | .31 |
| 11 | .12 | 0 |
| 11 | .17 | 0 |
| 11 | .11 | 0 |
| 12 | .31 | .31 |
| 13 | .17 | .17 |
| 14 | .08 | .08 |
| 14 | .43 | .43 |
| 15 | .42 | .42 |

Leaching-Precipitation-Filtration Scrubbers

| Plant | Use | Discharge |
|---|---|---|
| 7 | 166.4 | .87 |
| 8 | 7074.2 | 17.19 |
| 10 | 10.7 | .10 |
| 11 | 19.7 | 0 |
| 11 | 320.6 | 0 |
| 3 | .009 | .009 |
| 14 | 173.3 | 60.67 |
| 15 | 26.0 | 26.0 |
| 16 | 77.7 | 0 |
| 17 | 7.5 | 2.6 |

Furnace Scrubbers

| Plant | Use | Discharge |
|---|---|---|
| 18 | 4.5 | 0 |
| 7 | ? | .7 |
| 5 | 1.0 | 0 |
| 10 | 2.1 | 0 |
| 11 | 7.8 | 0 |
| 16 | 131.5 | 0 |

Electrolytic Refining

| Plant | Blowdown | Discharge |
|---|---|---|
| 18 | .059 | 0 |

| | | |
|---|---|---|
| 2 | 0 | 0 |
| 8 | 0 | 0 |
| 9 | 0 | 0 |
| 11 | .111 | 0 |
| 19 | .520 | .008 |
| 20 | .390 | .390 |
| 21 | 0 | 0 |
| 13 | .017 | .017 |
| 14 | .035 | .035 |
| 15 | .104 | .104 |
| 22 | .008 | .008 |
| 16 | .007 | 0 |
| 23 | 0 | 0 |
| 17 | 0 | 0 |

Casting. Nine plants do not use any water. The others are:

| Plant | Use | Discharge |
|---|---|---|
| 8 | .029 | .029 |
| 9 | .011 | .011 |
| 11* | 7.826 | 0 |
| 13 | .083 | .083 |
| 14* | .143 | .143 |
| 24 | .005 | .005 |
| 16 | .122 | 0 |

*includes scrubber

Primary Tungsten

The processes to be considered are:

1. Fusion of concentrates.
2. Leaching.
3. Precipitation and filtration.
4. APT drying.
5. Reduction.

Fusion of Concentrates. As shown in Table VII-21 no tungsten plants discharge wastewater from this process. Dry air pollution control devices, if any, are used to control emissions from this process.

Leaching. Leaching wastewater cannot be eliminated since water is necessary to the process and the pollutant levels present in this wastewater prohibit recycle with the treatment technologies in current use in the tungsten industry.. Therefore, adequate treatment is necessary to eliminate the potential of pollution from this wastewater. Two of the three plants which discharge

leaching wastes use lime and polymer addition, and sedimentation to treat this waste. The other plant discharges its leaching wastes with no treatment. Leaching is performed at a fourth plant but all of the resulting leachate is sent to a precipitation process.

Precipitation and Filtration. Sodium tungstate solutions are generally precipitated with calcium chloride and filtered to recover calcium tungstate or are reacted with ammonia solutions and filtered to recover crude ammonia tungstate. The barren solutions from these processes must be treated. The characteristics of these wastes are similar to the leaching wastes except the pH may not be acidic. Recycle of this waste stream may not be possible because dissolved solids are very high. Ammonia stripping is practiced by one plant on the wastewater produced by ammonia tungstate formation. Two plants have eliminated a barren ammonium solution by evaporating the entire solution to recover the ammonium tungstate.

APT Drying. APT drying is usually performed before further processing. Wet air pollution control devices are used at several plants and may be necessary to prevent ammonia emissions to the atmosphere. No plant currently treats this stream for ammonia removal. Treatment applied to this wastewater can be seen in Table VII-21.

Reduction. When tungstic oxide is reduced to pure tungsten by heating in a hydrogen atmosphere, water vapor is produced, and the emissions are usually controlled by a wet scrubber. Total recycle of this wastewater is practiced at two plants.

Water use and discharge levels reported from APT production operations are shown below, in gallons/pound of APT:

| Plant | Use | Discharge |
|---|---|---|
| 1 | 12.2 | 11.5 |
| 2 | 11.4 | 11.4 |
| 3 | 7.1 | 6.1 |
| 4 | 12.7 | 12.7 |

Water use and discharge levels reported from metal production operations are shown below, in gallons/pound tungsten metal:

| Plant | Use | Discharge |
|---|---|---|
| 2 | 37.9 | 37.9 |
| 3 | 6.15 | .86 |
| 5 | 1.04 | 1.04 |
| 6 | 14.98 | 0 |

| | | |
|---|---|---|
| 7 | 2.59 | 2.59 |

Primary Zinc

The processes to be considered are:

1. Roasting
2. Sintering and zinc reduction.
3. Leaching.
4. Electrolytic refining.
5. Cadmium production.
6. Metal cooling.

Roasting. Since all zinc plants process ores high in sulfur (30-32%), roasters and acid plants are utilized at all the plants. Preconditioning of the emissions from roasting is performed with wet scrubbers at every plant. From Table VII-22 it can be seen that pH adjustment with caustic or lime is practiced at every plant to precipitate metals and reduce suspended solids concentrations.

Sintering and Zinc Reduction. Two plants produce zinc pyrometallurgically rather than hydrometallurgically as at the other plants. Pyrometallurgical zinc is produced by sintering and reduction. Sintering does not require wet scrubbers since most of the sulfur is removed during roasting. The reduction furnaces, however, may require the use of wet scrubbers if the carbon monoxide content in the emissions are captured for use. One plant treats the bleed stream from the wet scrubber with polymer addition and sedimentation for suspended solids removal.

Leaching. Leaching is used to produce zinc hydrometallurgically. This operation may require wet scrubbers to control acidic emissions since sulfuric acid is used to leach the zinc from the roasted ore concentrates. Controls and treatments for this wastewater are summarized in Table VII-22.

Electrolytic Refining. Air pollution control devices for refining are not utilized by the electrolytic zinc plants. Electrolyte is not discharged at any plant, but is recycled after passing through a series of electrowinning cells. After refining, the electrolytically deposited zinc may be washed. Two plants discharge this washwater; one plant treats this waste with lime and polymer addition, sedimentation, and filtration and the other plant discharges the washwater to an evaporation pond.

Cadmium Production. The only wastewater associated with the recovery of cadmium is washwater of the cadmium balls and mold cooling water. Two plants do not discharge this wastewater, one by total recycle. Of the plants that discharge this wastewater,

two of the plants use lime and polymer addition, and sedimentation, and another plant settles and discharges the washwater.

Metal Cooling. Two plants do not produce any wastewater from this operation. Total evaporation is employed at another plant to avoid discharge. One plant uses an air cooling system.

The process wastewater discharged, apart from acid plant and roaster scrubber wastewater, is as follows, in gal/ton of zinc capacity:

Electrolytic

| Plant | Discharge |
|---|---|
| A | 341 |
| B | 1521 |
| C | 2816 |
| D | 0 |

Pyrolytic

| Plant | Discharge |
|---|---|
| E | 80 |
| F | 547 |

Metallurgical Acid Plants

Acid plants are used in a variety of subcategories - primary copper, lead and zinc. These metals are usually produced from sulfide ores, and in the production sequence, sulfur is released (as $SO_x$) in a pyrometallurgical process, either roasting, sintering or converting.

After the hot gases have been subjected to primary particulate control, the gases are usually treated with an open scrubbing tower and a packed scrubbing tower (or one scrubber performing both operations of preconditioning and scrubbing), and a mist precipitator (for final particulate and $SO_3$ removal). Due to a buildup in salts, a blowdown may be necessary. This wastewater is highly acidic and is contaminated with metals.

In areas of net evaporation, this wastewater is usually impounded and evaporated. Other control measures are reuse and minimization of the amount of blowdown. Using the acid plant blowdown for cooling hot gases from other processes, feeding the blowdown into fluid bed roasters, or using the blowdown for ore concentrating are three possible reuse schemes. One plant

reports that it uses its blowdown for concentrating after sedimentation. The amount of acid plant blowdown can be minimized by using highly efficient primary particulate control devices. This would minimize the particulate load carried to acid plant scrubbers, thus minimizing required blowdown.

Lime precipitation is used at three lead plants for acid plant wastewaters.

Preconditioning of the emissions from roasting is performed with wet scrubbers at every zinc plant. From Table VII-22 it can be seen that pH adjustment with caustic or lime is practiced at every plant to precipitate metals and reduce suspended solids concentrations.

Reported blowdown rates from metallurgical acid plants are as follows, in gal/ton acid:

| Plant | Type | Metal | Blowdown |
|---|---|---|---|
| 1 | SC | Cu | 355 |
| 2 | SC | Cu | 291 |
| 3 | SC | Cu | 1009 |
| 4 | SC | Cu | 0 |
| 5 | SC | Cu | 1812 |
| 6 | SC | Pb | 535 |
| 7 | SC | Pb | 1496 |
| 8 | SC | Pb | 1262 |
| 9 | SC | Zn | 547 |
| 10 | SC | Zn | 1312 |
| 11 | SC | Zn | 485 |
| 12 | SC | Zn | 1006 |
| 13 | SC | Zn | 645 |
| 14 | DC | Cu | 502 |
| 15 | DC | Cu | 332 |
| 16 | DC | Cu | 352 |
| 17 | DC | Cu | 80 |
| 18 | DC | Cu | 3798 |
| 19 | DC | Cu | 179 |
| 20 | DC | Pb | 179 |
| 21 | DC | Zn | 514 |

(SC=Single Contact, DC=Double Contact Acid Plant)

(Cu=Copper, Pb=Lead and Zn=Zinc)

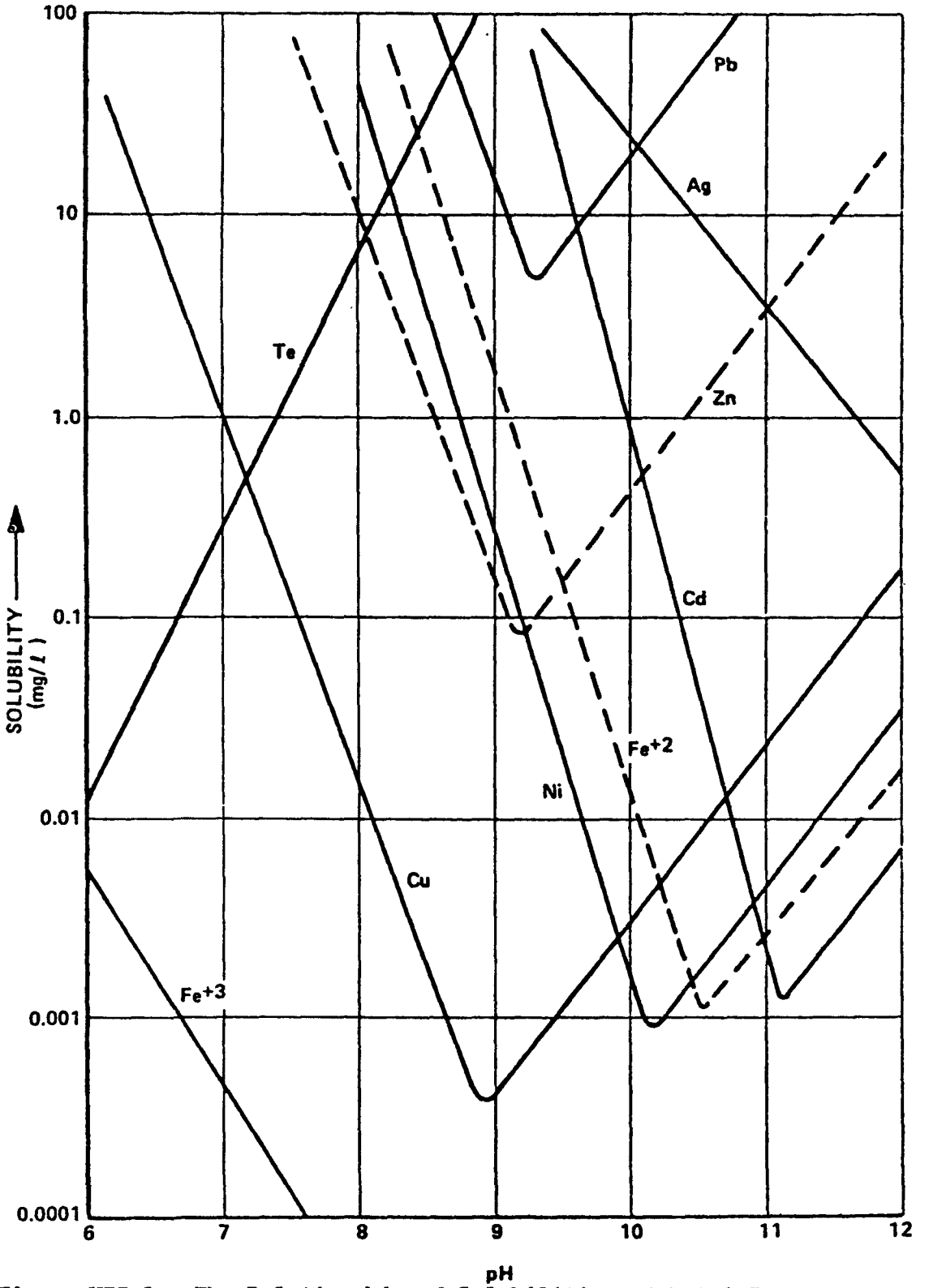



Figure VII-1. The Relationship of Solubilities of Metal Ions as a Function of pH

Source: Reference: 9

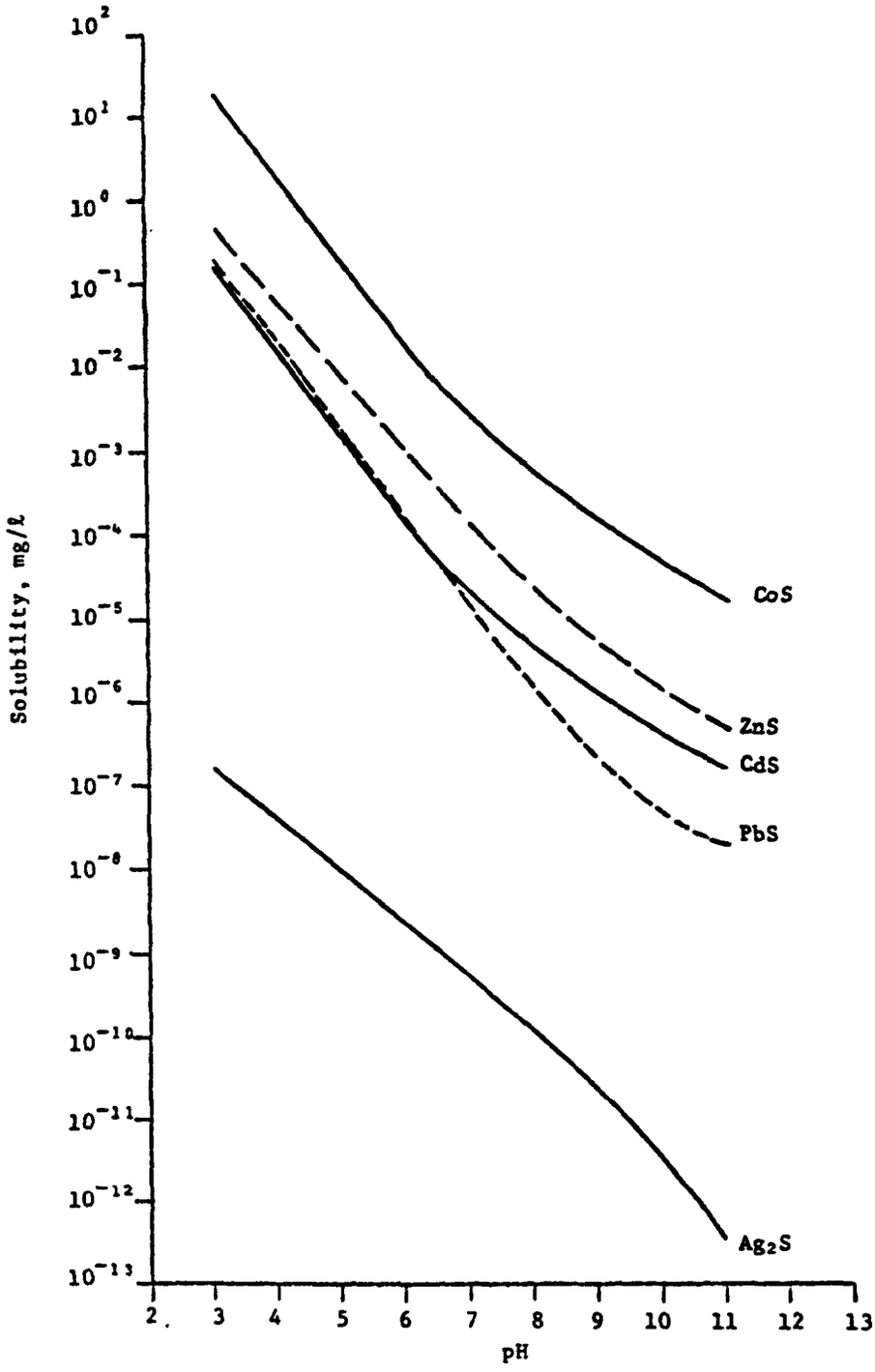



Figure VII-2. Theoretical solubilities of metal sulfides as a function of pH.

Reference : 89

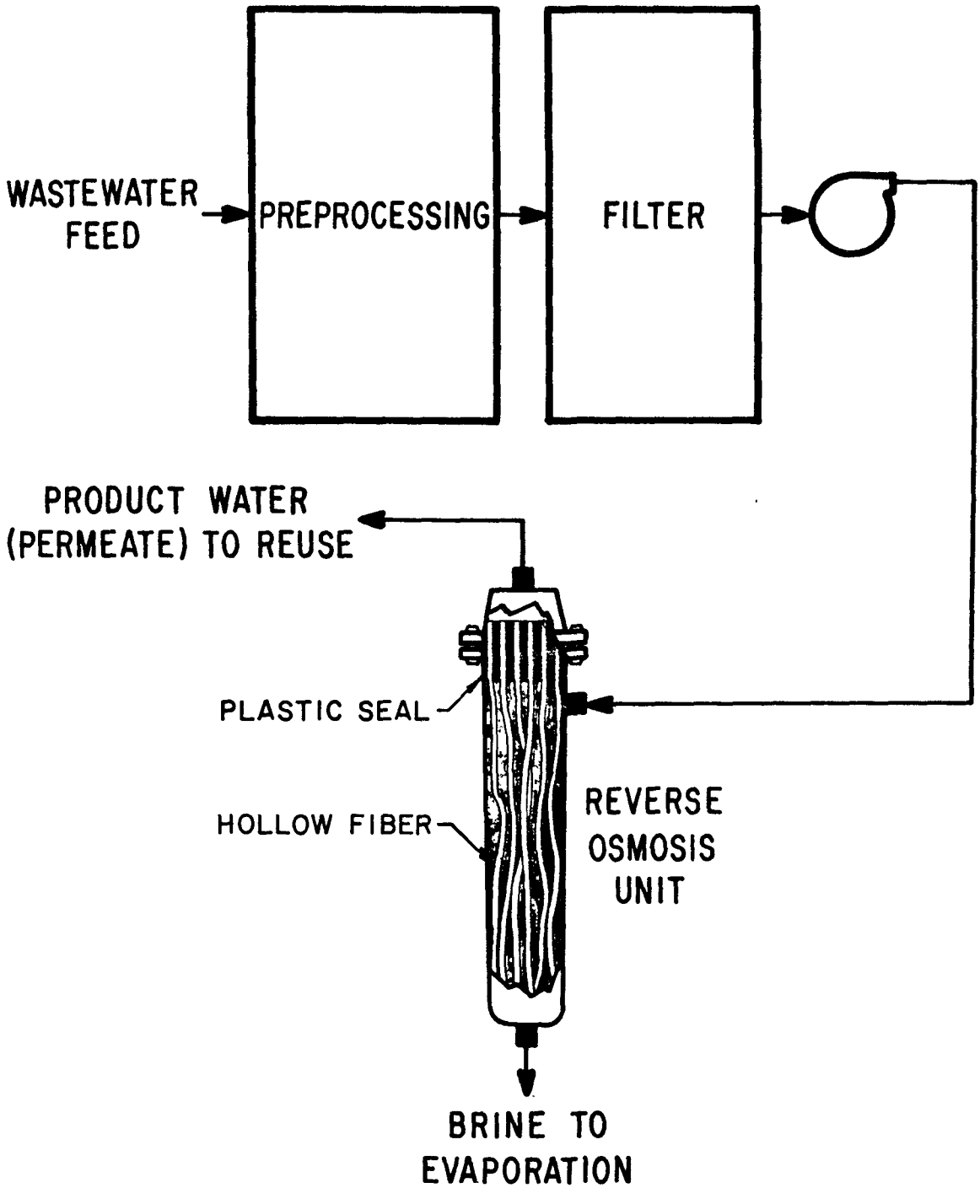



FIGURE VII-3: REVERSE OSMOSIS SYSTEM

TABLE VII-1

Concentrations of Various Parameters of a Columbium/Tantalum
Raw Waste Stream Before and After Lime Addition and Sedimentation

| Parameter | Influent (mg/l) | Effluent (mg/l) | Percent Removal % |
|---|---|---|---|
| pH | 10 | 11.5 | |
| COD | 16 | 8 | 50 |
| TSS | 900 | 10 | 99 |
| Fluoride | 4.5 | 2.5 | 45 |
| Aluminum | 9 | 0.2 | 97 |
| Calcium | 550 | 230 | 57 |
| Copper | 110 | 0.7 | 99 |
| Cadmium | 0.025 | 0.002 | 99 |
| Iron | 120 | 0.3 | 99+ |
| Lead | 50 | 0.3 | 99 |
| Manganese | 17 | 0.2 | 99 |
| Nickel | 60 | 0.5 | 99 |
| Zinc | 27 | 0.2 | 99 |

TABLE VII-2

Concentrations of Various Parameters of a Tungsten
Raw Waste Stream Before and After Lime Addition and Sedimentation

| Parameter | Influent (mg/l) | Effluent (mg/l) | Percent Removal (%) |
|---|---|---|---|
| pH | 0.5 | 7-9 | |
| COD | 300 | 53 | 84 |
| TSS | 200 | 150 | 28 |
| Chloride | 25E3 | 19E3 | 26 |
| Arsenic | 7 | 0.08 | 99 |
| Aluminum | 3 | 0.5 | 83 |
| Cadmium | 0.2 | 0.08 | 60 |
| Copper | 5 | 0.07 | 99 |
| Chromium | 2 | 0.05 | 97 |
| Iron | 50 | 2 | 96 |
| Lead | 20 | 0.2 | 99 |
| Nickel | 1 | 0.1 | 90 |
| Zinc | 2 | 0.6 | 70 |

Scientific Notation Used, i.e. 19,000 = 19E3

TABLE VII-3

Percent Removal of Selected Pollutants by Lime Precipitation

| Pollutant | Influent Concentration (mg/l) | Removal (%) |
|---|---|---|
| COD | 350 - 1500 | 75 - 85 |
| | 100 - 350 | 65 - 75 |
| | 25 - 100 | 50 - 65 |
| TSS | 150 - 5,000 | 90 - 99 |
| | 60 - 150 | 75 - 90 |
| | 30 - 60 | 60 - 75 |
| | 15 - 30 | 30 - 60 |
| Fluoride | 200 - 3,000 | 90 - 99 |
| | 40 - 200 | 75 - 90 |
| | 20 - 40 | 60 - 75 |
| Sb | 1 - 100 | 95 - 99+ |
| As | 0.5 - 100 | 95 - 99 |
| | 0.2 - 0.5 | 85 - 95 |
| Cd | 0.1 - 100 | 95 - 99 |
| Cr | 1.0 - 5,000 | 95 - 99+ |
| Cu | 3.0 - 500 | 95 - 99+ |
| | 0.3 - 3 | 85 - 95 |
| Pb | 4.0 - 100 | 95 - 99+ |
| | 1.0 - 4 | 85 - 95 |
| | 0.3 - 1 | 70 - 85 |
| Hg | 0.003 - 0.1 | 95 - 99+ |
| Ni | 3.0 - 1,000 | 95 - 99+ |
| | 0.7 - 3 | 80 - 95 |
| | 0.2 - 0.7 | 60 - 80 |
| Ag | 0.01 - 2 | 70 - 99+ |
| Zn | 10 - 2,000 | 95 - 99+ |
| | 2 - 10 | 70 - 95 |

Source: Sampling data and References 77, 78, 79, 80, 81, 82, 83

TABLE VII-4

Percent Removal of Organic
Priority Pollutants by Lime Precipitation

| | Organic Priority Pollutant | Influent Range (ug/l) | Average Removal (%) | Similar Compounds* |
|---|---|---|---|---|
| 1. | acenaphthene | 4-570 | 80 | 39, 73, 76, 84 |
| 4. | benzene | 15 | 80 | |
| 8. | 1,2,4-trichlorobenzene | 1580 | 90 | |
| 10. | 1,2-dichloroethane | 2- 23 | 91 | |
| 29. | 1,1-dichloroethylene | 1-224 | 76 | 10, 23, 44, 86 |
| 39. | fluoranthene | 4-320 | 82 | |
| 44. | methylene chloride | 191-224 | 99 | |
| 48. | dichlorobromomethane | 1-224 | 76 | 10, 23, 44, 86 |
| 66. | bis(2-ethylhexyl) phthalate | 31 | 32 | |
| 67. | butyl benzyl phthalate | 14- 31 | 60 | 66, 68 |
| 68. | di-n-butyl phthalate | 14 | 89 | |
| 69. | di-n-octyl phthalate | 14- 31 | 60 | 66, 68 |
| 70. | diethyl phthalate | 14- 31 | 60 | 66, 88 |
| 73. | benzo(a)pyrene | 570 | 93 | |
| 76. | chrysene | 230-545 | 94 | |
| 80. | fluorene | 4-570 | 80 | 39, 73, 76, 84 |
| 84. | pyrene | 220 | 56 | |
| 86. | tetrachloroethylene | 5- 12 | 50 | |
| 108. | PCB-1254 | 1- 3 | 41 | |
| 111. | PCB-1248 | 1- 2 | 39 | |

*For pollutants for which removal data was not available, the percent removal recorded in the second column was based on an average percent removal of the molecularly similar compounds listed in the third column by priority pollutant number (see Table V-1).

Source: Sampling data, and references 17 and 111

TABLE VII-5

Percent Removal of Organic
Priority Pollutants by Multimedia Filtration

| | Organic Priority Pollutant | Influent Range (ug/l) | Average Removal (%) | Similar Compounds* |
|---|---|---|---|---|
| 1. | acenaphthene | 0.08- 0.2 | 32 | 39, 84 |
| 4. | benzene | Tr- 15 | 53 | |
| 8. | 1,2,4,-trichlorobenzene | 29 - 154 | 62 | |
| 10. | 1,2-dichloroethane | 46 -1020 | 59 | 23, 44 |
| 29. | 1,1-dichloroethylene | 46 -1020 | 59 | 23, 44 |
| 39. | fluoranthene | 0.08 | 38 | |
| 44. | methylene chloride | 46 | 20 | |
| 48. | dichlorobromomethane | 46 -1020 | 59 | 23, 44 |
| 66. | bis(2-ethylhexyl) phthalate | Tr - 760 | 54 | |
| 67. | butyl benzyl phthalate | Tr - 760 | 54 | 66 |
| 68. | di-n-butyl phthalate | Tr - 760 | 54 | 66 |
| 69. | di-n-octyl phthalate | Tr - 760 | 54 | 66 |
| 70. | diethyl phthalate | Tr - 760 | 54 | 66 |
| 73. | benzo(a)pyrene | 0.08- 0.2 | 32 | 39, 84 |
| 76. | chrysene | 0.08- 0.2 | 32 | 39, 84 |
| 80. | fluorene | 0.08- 0.2 | 32 | 39, 84 |
| 84. | pyrene | 0.10- 0.2 | 25 | |
| 86. | tetrachloroethylene | 0.8 - 6.7 | 62 | |
| 108. | PCB-1254 | 50 | 80 | PCB (in general) |
| 111. | PCB-1248 | 50 | 80 | PCB (in general) |

*For pollutants for which removal data was not available, the percent removal recorded in the second column was based on an average percent removal of the molecularly similar compounds listed in the third column by priority pollutant number (see Table V-1).

Reference 17

TABLE VII-6

Percent Removals of Various Pollutants by Reverse Osmosis

| Pollutant | Influent Range (mg/l) | Average Removal (%) | Reference |
|---|---|---|---|
| Aluminum | 2 - 150 | 96-99 | 110, 182 |
| Cadmium | 0.02- 0.06 | 98 | 110 |
| Chloride | 12 -1080 | 74-91 | 103, 182 |
| Chromium (Vl) | 0.1 - 50 | 91-99 | 182 |
| Copper | 1 - 100 | 82-96 | 182 |
| Cyanide | 0.8 - 78 | 79-83 | 182 |
| Iron | 0.2 - 94 | 95-98 | 182 |
| Lead | 0.02- 0.03 | 99+ | 110 |
| Magnesium | 11 - 265 | 62-64 | 182 |
| Nickel | 0.7 - 0.8 | 99 | 110 |
| Zinc | 0.02- 0.1 | 97 | 110 |

TABLE VII-7

Percent Removal of Organic
Priority Pollutants by Reverse Osmosis*

| Organic Priority Pollutant | Removal (%) |
|---|---|
| 39. fluoranthene | 99.9+ |
| 66. bis(2-ethylhexyl) phthalate | 99.9+ |
| 67. butyl benzyl phthalate | 99.9+ |
| 68. di-n-butyl phthalate | 99.9+ |
| 69. di-n-octyl phthalate | 99.9+ |
| 70. diethyl phthalate | 99.9+ |
| 73. benzo(a)pyrene | 99.9+ |
| 76. chrysene | 99.9+ |
| 84. pyrene | 99.9+ |
| 108. PCB-1254 | 99.9+ |
| 111. PCB-1248 | |

*Based on nearly 100 percent removal of compounds with molecular weight greater than 200.

Reference 102

TABLE VII-8

Commercially Available Membrane Systems

| Type | Allowable pH range | Maximum operating pressure kg/sq cm | Approximate cost,* $/liter/day | Susceptibility to plugging by suspended solids | Space requirement |
|---|---|---|---|---|---|
| Hollow Fiber + (Polyamide Membrane) | 4 to 12 | 29 (400 psig) | $0.084 ($0.32/gal/day) | very high | very low |
| Spiral Wound (Cellulose Acetate Membrane) | 2.5 to 7 | 58 (800 psig) | $0.084 ($0.32/gal/day) | high | very low |
| Tubular (Generally Cellulose Acetate Membrane) | 2.5 to 7 | 109 | $0.26 - 0.53 ($1 to 2/gal/day) | low | moderate |

* Cost of membrane element alone, without pump, controls, piping, instrumentation, etc.

+ A high-pressure, hollow-fiber module (duPont B-10)$_2$ has recently become commercially available. It is capable of operating at 58 kg/cm$^2$ (800 psi) and uses the same membrane (polyamide) as the lower pressure module (duPont B-9).

Reference 103, 92

TABLE VII-9

Percent Removal of Organic
Priority Pollutants by Carbon Adsorption

| | Organic Priority Pollutant | Influent Range (ug/l) | Average Removal (%) | Similar Compounds* |
|---|---|---|---|---|
| 1. | acenaphthene | 0.1 | 99 | PAH+, 84 |
| 4. | benzene | Tr - 2 | 93 | |
| 8. | 1,2,4-trichlorobenzene | 94 | 99 | |
| 10. | 1,2-dichloroethane | 0.1- 8 | 95 | |
| 29. | 1,1-dichloroethylene | Tr -130 | 73 | 10, 23, 44, 48, 86 |
| 39. | fluoranthene | 0.1 | 99 | PAH, 84 |
| 44. | methylene chloride | 47 | 43 | |
| 48. | dichlorobromomethane | 12 - 47 | 73 | |
| 66. | bis(2-ethylhexyl)phthalate | Tr -400 | 36 | |
| 67. | butyl benzyl phthalate | Tr -400 | 36 | 66 |
| 68. | di-n-butyl phthalate | Tr -400 | 36 | 66 |
| 69. | di-n-octyl phthalate | Tr -400 | 36 | 66 |
| 70. | diethyl phthalate | Tr -400 | 36 | 66 |
| 73. | benzo(a)pyrene | 0.1 | 99 | PAH, 84 |
| 76. | chrysene | 0.1 | 99 | PAH, 84 |
| 80. | fluorene | 0.1 | 99 | PAH, 84 |
| 84. | pyrene | 0.1 | 99 | PAH |
| 86. | tetrachloroethylene | Tr - 0.06 | 88 | |
| 108. | PCB-1254 | 10 -100 | 95 | PCB ++ |
| 111. | PCB-1248 | 10 -100 | 95 | PCB |

*For pollutants for which removal data was not available, the percent removal recorded in the second column was based on an average percent removal of the molecularly similar compounds listed in the third column by priority pollutant number (see Table V-1).

+Polynuclear aromatic hydrocarbon (in general)
++ PCB (in general)

Reference 17, 111, 112, 192, 193.

TABLE VII-10

Removal Potential for Metals by Activated Carbon

| Influent Range (mg/l) | | High (Q 90% removed) | Reference |
|---|---|---|---|
| 0.001 | - 0.5 | Ag | 186, 187 |
| 0.96 | - 2.6 | As | 122 |
| 0.10 | | Be | 186 |
| 0.001 | - 5.0 | Cd | 79, 80, 185, 186 |
| 0.05 | - 5.0 | Cr (Vl) | 78, 79, 185, 186, 187 |
| 0.7 | -113 | Cu | 78, 79, 186 |
| 0.012 | - 0.087 | Hg | 78, 186 |
| 0.002* | - 5.0 | Ni | 79, 185, 186 |
| 0.002* | - 5.0 | Zn | 79, 185, 186 |
| | | **Good** (80-90% removed) | |
| 0.002* | - 5.0 | Pb | 79, 185, 186 |
| | | **Low** (Q 80% removed) | |
| 0.002* | - 2.0 | Sb | 185, 186 |
| 0.009 | - 0.5 | Se | 185, 186, 187 |
| 0.5 | - 0.6 | Tl | 186 |

*Organic complexing agent added to attain greater removal efficiencies for the lower range of the influent values (185).

TABLE VII-11
Properties of Ion Exchangers for Metallurgical Applications

| Desired Characteristic | Generally Recommended Application: Cation Exchangers: Inorganic: Zeo-Dur | Inorganic: Decalso | Organic: Sulfonated Coal: Zeo-Karb | Organic: Sulfonated Resins: Permutit Q | Organic: Carboxylic Resin: Permutit H-70 | Anion Exchangers: Weakly Basic: Granular: De-Acidite | Weakly Basic: Bead: Permutit W | Strongly Basic: Granular: Permutit A | Strongly Basic: Bead: Permutit S |
|---|---|---|---|---|---|---|---|---|---|
| **Chemical Stability To:** | | | | | | | | | |
| Acids | | | X | X | x | x | X | X | X |
| Alkalies | | | | X | X | X | X | X | X |
| Oxidation | | | | X | X | | X | | X |
| Temperature | | | | X | X | | X | | X |
| Organic Solvents | X | X | | X | | | X | | X |
| **Physical Stability for:** | | | | | | | | | |
| Removal of weak acids | | | | | | | | X | X |
| Removal of strong acids | | | | | | X | X | X | |
| High regeneration efficiency | | | X | | X | X | | | |
| High capacity | | X | | X | X | X | | X | X |
| High porosity | | X | X | | | X | | | |
| Hydrogen exchange at low pH | | | X | X | | | | | |
| Salt splitting | | | | | | | | X | X |
| pH range (operating) | 6.2 to 8.7 | 6.9 to 7.9 | 0 to 11 | 0 to 13 | 3.5 to 12 | 0 to 12 | 0 to 13.9 | 0 to 13.9 | 0 to 13.9 |

Reference 58

TABLE VII-12

PRIMARY ALUMINUM: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | ANODE PASTE PRODUCTION | | | ANODE PASTE BAKING | | | POTLINE | | | POTROOM | | | REFINING DEGASSING | | | METAL COOLING | | | CRYOLITE RECOVERY | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | | | | | | | | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 29 | | | 21 | | | 30 | | | 30 | | | 20 | | | 29 | | | 7 | | |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| **POTENTIAL SOURCE OF WASTEWATER** | | | | | | | | | | | | | | | | | | | | | |
| Wet | | 4 | | | 8 | | | 9 | 2 | | 6 | 1 | | 4 | | | 23 | 3 | | 5 | |
| Dry | | 19 | 3 | | 10 | 1 | | 14 | 1 | | | | | 1 | | | | | | | |
| No air pollution control | | 3 | | | 1 | 1 | | 4 | | | 21 | 2 | | 2 | 1 | | | | | | |
| No wastewater produced + | | | | | | | | | | | | | | 11 | 1 | | 3 | | | 2 | |
| **Control of Wastewater** | | | | | | | | | | | | | | | | | | | | | |
| Total recycle | | | | | | | | 1 | | | | | | | | | 1 | | | | 1 |
| Recycle with blowdown | | | | | 1 | | | 3 | 1 | | 2 | | | 2 | | | 12 | 1 | | | |
| No recycle | | 5 | | | 3 | | | 5 | 1 | | 6 | | | 2 | | | 10 | 2 | | 3 | |
| **Treatment** | | | | | | | | | | | | | | | | | | | | | |
| No Treatment | | 2 | | | | | | | | | 2 | | | 2 | | | 10 | | | | |
| Natural Evaporation | | | | | | | | 1 | 1 | | 1 | | | | | | | 1 | | | |
| Spray Irrigation | | | | | | | | | | | | | | | | | | 1 | | | |
| Settle | | 1 | | | | | | | | | 1 | | | | | | 8 | | | | |
| Settle, skim | | | | | | | | | | | | | | | | | 2 | | | | |
| Chlorination | | | | | | | | | | | | | | | | | 1 | | | | |
| Polymer settle | | | | | | | | | | | 1 | | | | | | | | | | |
| Alum., filter | | | | | | | | | | | | | | | | | 1 | | | | |
| Lime, settle | | 1 | | | 1 | | | | | | | | | | | | | | | | |
| $Na_2Al_2O_3$, settle | | | | | | | | 1 | | | | | | | | | | | | | |
| Undefined cryolite recovery | | | | | | | | 2 | | | | | | | | | | | | 1 | |
| $CO_2$, settle | | | | | | | | 1 | | | 1 | | | | | | | | | | |
| Lime, settle, skim | | | | | | | | 1 | | | | | | 1 | | | 1 | | | | |
| Acid neutralization, settle, skim | | | | | | | | | | | | | | | | | 1 | | | | |
| Lime, polymer, settle | | | | | | | | 3 | | | | | | | | | | | | | |
| Lime, caustic, settle | | | | | 1 | | | | | | | | | | | | | | | | |
| Caustic, polymer, settle | | | | | 1 | | | | | | | | | | | | | | | | |

TABLE VII-12 (Cont'd)

PRIMARY ALUMINUM: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | ANODE PASTE PRODUCTION | | | ANODE PASTE BAKING | | | POTLINE | | | POTROOM | | | REFINING DEGASSING | | | METAL COOLING | | | CRYOLITE RECOVERY | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | | | | | | | | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 29 | | | 21 | | | 30 | | | 30 | | | 20 | | | 29 | | | 7 | | |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| $Na_2AlO_2$, settle | | | | | | | 1 | | | | | | | | | | | | | | |
| $Cl_2$, $Na_2AlO_2$, settle | | | | | | | | | | 1 | | | | | | | | | | | |
| $CaCl_2$, caustic, settle | | | | | | | | | | 1 | | | | | | | | | | | |
| $CaCl_2$, caustic, settle, skim | | 1 | | | 1 | | | | | | | | | | | | | | | | |
| $CaCl_2$, KCl, NaCl, settle | | | | | | | | | | | | | 1 | | | | | | | | |
| Caustic, $Na_2AlO_3$, polymers, settle | | | | | | | | | | | | | | | | | | | 1 | | |
| Caustic, $Na_2AlO_3$, $CO_2$, settle | | | | | | | | | | | | | | | | | | | 1 | | |
| Caustic, $Na_2AlO_3$, NaF, $CO_2$, $Cl_2$, Lime, settle | | | | | | | | | | | | | | | | | | | 1 | | |

Number of Plants Surveyed = 30

* I = Indirect D = Direct Z = Zero

+ Data Collection Portfolio Response Incomplete, further classification not possible.

TABLE VII-13

SECONDARY ALUMINUM: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | DROSS PROCESSING | | | SMELTING | | | DEMAGGING | | | METAL COOLING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 20 | | | 44 | | | 34 | | | 63 | | |
| TYPE OF DISCHARGE * | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| POTENTIAL SOURCE OF WASTEWATER | | | | | | | | | | | | |
| Wet | | 1 | 3 | | 2 | | 8 | 1 | 9 | 14 | 5 | 16 |
| Dry | 6 | 3 | 7 | 8 | 1 | 15 | 3 | | 4 | 3 | 3 | 22 |
| No Air Pollution Control | | | | 4 | 2 | 5 | 2 | | 4 | | | |
| No Wastewater Produced + | | | | 2 | 1 | 4 | 1 | 1 | 1 | | | |
| Control of Wastewater | | | | | | | | | | | | |
| Total Recycle | | | 2 | | | | | | 4 | 2 | 1 | 11 |
| Recycle with blowdown | | | 1 | | 1 | | 2 | | | 4 | 1 | |
| No Recycle | | 1 | | | 1 | | 6 | 1 | 5 | 9 | 3 | 2 |
| Total Evaporation | | | | | | | | | | | | 3 |
| TREATMENT | | | | | | | | | | | | |
| No Treatment | | 1 | | | 1 | | 4 | | 1 | 13 | 1 | 9 |
| Natural Evaporation | | | 1 | | | | | | 5 | | 2 | 4 |
| Settle | | | 2 | | | | | | 1 | | 1 | 3 |
| Caustic | | | | | 1 | | 1 | | 1 | | | |
| $Na_2CO_3$, settle | | | | | | | 2 | 1 | 1 | | | |
| Caustic, $NaS_2$, skim | | | | | | 1 | | | 1 | | | |
| Caustic, polymer, skim, settle | | | | | | | | | | | 1 | |

Total Number of Plants Surveyed = 63

* I = Indirect D = Direct Z = Zero

+ Data Collection Portfolio Response incompletely, further classification not possible.

TABLE VII-14
COLUMBIUM/TANTALUM: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | DIGESTION | | | DIGESTION | | | SOLVENT EXTRACTION | | | SALT DRYING | | | REDUCTION | | | REDUCTION | | | SOLVENT EXTRACTION | | | PRECIPITATION & FILTRATION + | | | CONSOLIDATION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WATER | GANGUE SLURRY | | | AIR POLLUTION CONTROL | | | | | | | | | | | | LEACHING | | | WASTE RAFFINATE | | | SUPERNATANT | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 3 | | | 3 | | | 3 | | | 4 | | | 2 | | | 3 | | | 3 | | | 3 | | | 4 | | |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| **POTENTIAL SOURCE OF WASTEWATER** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wet | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 3 | | | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | |
| Dry | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| **Control of Wastewater** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Recycle With Blowdown | | | | | 1 | | | 1 | | 1 | 2 | | | | | | | | 1 | | | | | | | | |
| No Recycle | 1 | 2 | | 1 | 1 | | 1 | 1 | | | 1 | | | 2 | | 1 | 2 | | | 2 | | 1 | 2 | | 1 | 3 | |
| **Treatment** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Caustic | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | | | 1 | | | | | | | | |
| Caustic, centrifuge | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| Acid Neutralization, centrifuge | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| Lime, settle | | 2 | | | 2 | | | | | | 3 | | | | | | 2 | | | 2 | | | | | | | |
| Lime, settle, filter | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | |
| Steam Stripping, Lime, Settle | | | | | | | | | | | | | | | | | | | | | | | 3 | | | | |
| Lime, Acid Neutrization, Polymer, Caustic, Settle | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |

Number of Plants Surveyed = 5
* I = Indirect D = Direct Z = Zero

+ Since more than one waste steam may result at a plant from precipitation and filtration, the number of waste streams recorded will not equal the number of plants that perform precipitation and filtration operations.

TABLE VII-15

PRIMARY COPPER: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | ROASTING | | | SULFURIC ACID PRODUCTION | | | SMELTING | | | CONVERTOR | | | FIRE REFINING | | | SLAG GRANULATION | | | ELECTROLYTIC | | | REFINING | | | METAL COOLING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | | | | | | | | | | ELECTROLYTE | | | WASHWATER | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 6 | | | 11 | | | 12 | | | 12 | | | 7 | | | 3 | | | 13 | | | 13 | | | 16 | | |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| POTENTIAL SOURCE OF WASTEWATER | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wet | 2 | 4 | | 2 | 9 | | | 2 | | 1 | 4 | | | | | 2 | 1 | | 5 | 1 | | 5 | 1 | | 6 | 10 | |
| Dry | | | | | | | 1 | 3 | | | 3 | | 2 | 1 | | | | | | | | | | | | | |
| No Air Pollution Control | | | | | | | | | | 1 | | | 2 | 2 | | | | | | | | | | | | | |
| No Wastewater Produced + | | | | | | | 2 | 3 | | | | | | | | | | | 2 | 5 | | 2 | 5 | | | | |
| Emissions Directly to Acid Plant | 2 | 4 | | | | | 1 | | | 2 | 1 | | | | | | | | | | | | | | | | |
| CONTROL OF WASTEWATER | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Recycle | | 1 | | 1 | 2 | | | 1 | | | 2 | | | | | | 1 | | 1 | 1 | | 4 | 1 | | | 3 | |
| Recycle With Blowdown | | | | 1 | 4 | | | | | | | | | | | 1 | | | 1 | | | 1 | | | 2 | 3 | |
| No Recycle | | | | | 2 | | | 1 | | 1 | 1 | | | | | 1 | | | 3 | | | | | | 4 | 3 | |
| Total Evaporation | | | | | 1 | | | | | | 1 | | | | | | | | | | | | | | | 1 | |
| TREATMENT | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| No Treatment | | | | | | | | | | | 1 | | | | | | | | 1 | 1 | | 5 | 1 | | 2 | 2 | |
| Sold | | | | | | | | | | | | | | | | | | | 2 | | | | | | | | |
| Deep Well Disposal | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| Natural Evaporation | | | | | 5 | | | 1 | | | 1 | | | | | | | | 1 | | | | | | | 4 | |
| Settle | | 1 | | | 2 | | | 1 | | | 1 | | | | | | 1 | | | | | | | | 1 | 2 | |
| Lime, filter | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| Lime, settle | | | | 1 | 1 | | | | | 1 | | | | | | 1 | | | | | | | | | 2 | | |
| Lime, Polymer, Ferric Salts, Settle | | | | 1 | | | | | | | | | | | | 1 | | | 1 | | | | | | | | |

Number of Plants Surveyed = 23

* I = Indirect D = Direct Z = Zero

+ Data Collection Portfolio response incomplete, further classification not possible.

TABLE VII-16

SECONDARY COPPER: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | SLAG MILLING | | | SLAG GRANULATION | | | PYROMETALURIGAL PROCESSING | | | ELECTROLYTIC REFINING | | | | | | METAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | | | | | | | AIR POLLUTION | | | ELECTROLYTE | | | WASHWATER | | | COOLING | | |
| NUMBER OF PLANTS WITH OPERATION | 8 | | | 5 | | | 26 | | | 5 | | | 5 | | | 31 | | |
| TYPE OF DISCHARGE * | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| **POTENTIAL SOURCE OF WASTEWATER** | | | | | | | | | | | | | | | | | | |
| Wet | 1 | 1 | 5 | | | 5 | 1 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 2 | 4 | 5 | 13 |
| Dry | | | | | | | 4 | | 9 | | | | | | | 1 | 1 | 7 |
| No Wastewater Produced + | | | | | | | | 2 | 4 | | | | | | | | | |
| **CONTROL OF WASTEWATER** | | | | | | | | | | | | | | | | | | |
| Total Recycle | | 1 | 5 | | | 4 | | 1 | 3 | | | | | | 1 | | 1 | 9 |
| Recycle With Blowdown | | | | | | | | 1 | | | 1 | 1 | | | | | 2 | |
| No Recycle | 1 | | | | | 1 | 1 | 1 | | 1 | 1 | 1 | | | | 4 | 3 | |
| **TREATMENT** | | | | | | | | | | | | | | | | | | |
| No Treatment | | | 1 | | | | | 2 | | | | | | | 1 | 3 | 3 | 3 |
| Contractor Hauling | | | | | | | | | | | 2 | 2 | | | | | | |
| Filter | | | 1 | | | | | | | | | | | | | | | |
| Screening | | | | | | 1 | | | | | | | | | | | | 1 |
| Grit Removal | | 1 | | | | | | | | | | | | | | | | |
| Natural Evaporation | | | | | | 1 | | | | | | | | | | | | |
| Settle | 1 | | 2 | | | 2 | | | 2 | | | | | | | | 2 | 4 |
| Neutralization | | | | | | | 1 | | | | | | | | | 1 | | |
| Caustic, settle | | | | | | | | | 1 | | | | | | | | | |
| Lime, settle | | | | | | | | | | | | | | | | | | 1 |
| Acid Neutralization, Lime, settle | | | | | | | | | | | | | | | | | 1 | |
| Settle, screen, filter | | | | | | 1 | | | | | | | | | | | | |
| Lime, caustic, iron salts, Polymer settle, filter | | | | | | | | 1 | | | | | | | | | | |
| Lime, caustic, iron salts, Polymer settle, filter | | | | | | | | 1 | | | | | | | | | | |
| Acid Neutralization, settle, filter, screen | | | 1 | | | | | | | | | | | | | | | |
| Cementation | | | | | | | | | | | 1 | | | | | | | |

Number of plants surveyed = 32, one plant mills slag only.

* I = Indirect D = Direct Z = Zero

\+ Data Collection Portfolio response incomplete, further classification not possible.

TABLE VII-17

PRIMARY LEAD: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | SINTERING | | SULFURIC ACID PRODUCTION | | BLAST FURNACE | | ZINC FUME | | DROSS KETTLE | | DROSS REVERB | | SOFTENING | | HARD LEAD REFINE | | DESILVERIZING | | RETORT | | CUPEL | | DEBISMUTHIZING | | REFINING | | SLAG GRANULATION | | METAL COOLING | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 4 | | 3 | | 5 | | 2 | | 5 | | 4 | | 2 | | 2 | | 5 | | 4 | | 2 | | 1 | | 5 | | 3 | | 7 | |
| TYPE OF DISCHARGE* | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z | D | Z |
| POTENTIAL SOURCE OF WASTEWATER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wet | 2 | 2 | 3 | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | | | | | | | | | | | | 2 | 1 | | 1 |
| Dry | | | | | 1 | 2 | | | 1 | 2 | 1 | 1 | | | | | | | 2 | 2 | 1 | | 1 | | | | | | 6 | |
| No Air Pollution Control | | | | | | | | | 1 | | | | | | | | 5 | | | | | | | | 2 | 3 | | | | |
| No Wastewater produced + | | | | | | | | | | | | | 1 | | 1 | | | | | | 1 | | | | | | | | | |
| CONTROL OF WASTEWATER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Recycle | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | 1 | | | | | | | | | | | | | | | | | 1 | | |
| Recycle With Blowdown | 1 | 1 | 2 | | 1 | | | | | | | 1 | | | | | | | | | | | | | | | 2 | | | |
| No Recycle Total Evaporation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| TREATMENT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Settle | | 2 | | | | 1 | | 1 | | 1 | | 1 | | | | | | | | | | | | | | | | 1 | | |
| Lime, settle | 1 | | 1 | 1 | 1 | | | | | | 1 | | | | | | | | | | | | | | | | 1 | | | |
| Lime, caustic, polymer, cooling tower, settle, filter | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | |

Number of Plants Surveyed = 7

* I = Indirect D = Direct Z = Zero

\+ Data Collection Portfolio response incomplete, further classification not possible.

TABLE VII-18

SECONDARY LEAD: CONTROL AND TREATMENT TECHNOLOGIES

| SUBCATEGORY | WITH BATTERY CRACKING | | | | | | | | | WITHOUT BATTERY CRACKING | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OPERATION | BATTERY CRACKING | | | PYROMETALLURGICAL PROCESSING | | | METAL COOLING | | | PYROMETALLURGICAL PROCESSING | METAL COOLING |
| POTENTIAL SOURCE OF WASTEWATER | WASTE ELECTROLYTE AND WASHWATER | | | AIR POLLUTION CONTROL | | | | | | AIR POLLUTION CONTROL | |
| NUMBER OF PLANTS WITH OPERATION | 32 | | | 32 | | | 32 | | | 36 | 36 |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | Z | Z |
| **POTENTIAL SOURCE OF WASTEWATER** | | | | | | | | | | | |
| Wet | 15 | 12 | 4 | 7 | 3 | 3 | 3 | 3 | | | 8 |
| Dry | | | | 4 | 4 | 3 | 11 | 4 | 2 | 15 | 15 |
| No air pollution control | | | | | | | | | | 7 | |
| No wastewater produced + | | | | 5 | 1 | | 2 | 1 | 4 | 14 | 11 |
| **CONTROL OF WASTEWATER** | | | | | | | | | | | |
| Total Recycle | | | 1 | 1 | 3 | 2 | | | | | |
| Recycle with blowdown | | | | 4 | | 1 | | 2 | | | 3 |
| No recycle | 15 | 12 | 2 | 2 | | | 2 | | | | 3 |
| Total Evaporation | | | | | | | 1 | 1 | | | 2 |
| **TREATMENT** | | | | | | | | | | | |
| No treatment | 1 | | | 3 | 3 | 2 | 2 | 2 | | | 5 |
| Contractor hauling | | | 1 | | | 1 | | | | | |
| Filter | | | | | | | | | | | 1 |
| Natural evaporation | | | 5 | | | | | | | | |
| Settle | | 1 | | | | | | | | | |
| Ammonia | 2 | | | | | | | | | | |
| Ammonia, filter | 1 | | | 1 | | | | | | | |
| Ammonia, settle | 4 | | | | | | | | | | |
| Lime, settle | 2 | 2 | | | | | | | | | |
| Caustic, settle | | | | 1 | | | | | | | |
| Neutralization, settle | 1 | 1 | | | | | | | | | |
| Caustic, settle, sold | | | 1 | | | | | | | | |

TABLE VII-18 (Cont'd)

SECONDARY LEAD: CONTROL AND TREATMENT TECHNOLOGIES

| SUBCATEGORY | WITH BATTERY CRACKING | | | | | | | WITHOUT BATTERY CRACKING | |
|---|---|---|---|---|---|---|---|---|---|
| OPERATION | BATTERY CRACKING | | | PYROMETALLURGICAL PROCESSING | | | METAL COOLING | PYROMETALLURGICAL PROCESSING | METAL COOLING |
| POTENTIAL SOURCE OF WASTEWATER | WASTE ELECTROLYTE AND WASHWATER | | | AIR POLLUTION CONTROL | | | | AIR POLLUTION CONTROL | |
| NUMBER OF PLANTS WITH OPERATION | 32 | | | 32 | | | 30 | 36 | 36 |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I D Z | Z | Z |
| Lime, caustic | | 1 | | | | | | | |
| Lime, settle, filter | | 1 | | | | | | | |
| Ammonia, settle, cooling tower, ion exchange | 1 | | | | | | | | |
| Ammonia, settle, filter | 2 | 4 | | 2 | | | | | |
| Lime, polymer, settele | | 2 | | | | | | | |
| Ammonia, polymer, settle | 1 | | | | | | | | |

Total Number of plants surveyed: With battery cracking = 30; without battery cracking = 36

* I = Indirect D = Direct Z = Zero

+ Data collection portfolio response incomplete, further classification not possible.

TABLE VII-19

SECONDARY SILVER (PHOTOGRAPHIC): EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | LEACHING & STRIPPING | | | PRECIPITATION & FILTRATION | | | PYROMETALLURICAL PROCESSING | | | LEACHING & STRIPPING | | | PRECIPITATION & FILTRATION | | | ELECTROLYTIC REFINING | | | | | | METAL COOLING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | WASHWATER | | | SUPERNATANT | | | ELECTROLYTE | | | WASHWATER | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 7 | | | 12 | | | 15 | | | 8 | | | 12 | | | 5 | | | 5 | | | 7 | | |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| **POTENTIAL SOURCE OF WASTEWATER** | | | | | | | | | | | | | | | | | | | | | | | | |
| Wet | 2 | | 1 | 2 | | 2 | 2 | | 4 | 2 | | | 6 | 2 | 4 | | | | | | 2 | | | 1 | |
| Dry | | | | | | | 1 | 1 | 4 | | | | | | | | | | | | | | | |
| No air pollution control | | 1 | 3 | 4 | 1 | 3 | 1 | 1 | | | | | | | | | | | | | | | | |
| No wastewater produced + | | | | | | | | | 1 | | 1 | 5 | | | | 1 | 2 | 2 | 1 | | 2 | 1 | | 5 |
| **CONTROL OF WASTEWATER** | | | | | | | | | | | | | | | | | | | | | | | | |
| Total recycle | 1 | | | | | | 1 | | 1 | | | | | | | | | | | | | | | |
| Recycle with bleed | 1 | | 1 | 1 | | 2 | 1 | | 3 | | | | | | | | | | | | | | | |
| No recycle | | | | 1 | | | | | | | | | | | | | | | | | 2 | | | 1 |
| **TREATMENT** | | | | | | | | | | | | | | | | | | | | | | | | |
| No treatment | | | | | | | 1 | | 1 | | | | 3 | | | | | | | | | | | |
| Contractor hauling | | | | | | 1 | | | 1 | | | | | | 2 | | | | | | | | | |
| Artificial evaporation | | | 1 | | | 1 | | | 2 | | | | | | 2 | | | | | | 2 | | | 1 |
| Neutralization | | | | | | | | | | | | | 1 | 1 | | | | | | | | | | |
| Activated Sludge | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| $H_2O_2$, caustic, acid neutralization, polymer, | 1 | | | 1 | | | | | | 1 | | | 1 | | | | | | | | | | | |
| Caustic, peroxysulfuric acid, flocculant, settle filter | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | | | | | | | | |

Number of Plants surveyed = 23

* I = Indirect D = Direct Z = Zero

\+ Data collection portfolio response incomplete, further classification no possible.

TABLE VII-20

SECONDARY SILVER (NON-PHOTOGRAPHIC): EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | LEACHING & STRIPPING | | | PRECIPITATION & FILTRATION | | | PYROMETALLURICAL & PROCESSING | | | LEACHING & STRIPPING | | | PRECIPITATION & FILTRATION | | | ELECTROLYTIC REFINING | | | | | | INGOT COOLING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | LEACHATE | | | SUPERNATANT | | | ELECTROLYTE | | | WASHWATER | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 12 | | | 11 | | | 19 | | | 12 | | | 11 | | | 13 | | | 13 | | | 15 | | |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| POTENTIAL SOURCE OF WASTEWATER | | | | | | | | | | | | | | | | | | | | | | | | |
| Wet | 4 | 2 | 3 | 3 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 1 | 8 | 1 | 2 | 1 | | 2 | 2 | 1 | 2 | 3 | | 1 |
| Dry | 1 | | | | | 1 | 5 | 1 | 3 | | | | | | | | | | | | | | | |
| No air pollution control | 1 | | 1 | 4 | | 1 | 1 | | | | | | | | | | | | | | | | | |
| No wastewater produced + | | | | | | | | | | 3 | 1 | 3 | | | | 6 | 1 | 3 | 5 | | 3 | 2 | 3 | 6 |
| CONTROL OF WASTEWATER | | | | | | | | | | | | | | | | | | | | | | | | |
| Total recycle | | | 1 | | | | | 1 | 2 | | | | | | | | | 1 | 1 | | | | | |
| Recycle with bleed | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 4 | | | | | | | | | | | | | | | |
| No recycle | 1 | | | 1 | | | | | | | | | | | | 1 | | 1 | 1 | 1 | 2 | 3 | | 1 |
| TREATMENT | | | | | | | | | | | | | | | | | | | | | | | | |
| No treatment | | 1 | 1 | | 1 | | | 1 | 1 | | | | 1 | 1 | | 1 | | | 1 | | | | | |
| Contractor hauling | | | 1 | | | | | | 2 | | | 1 | 2 | | | | | 1 | | | | | | 1 |
| Artificial evaporation | | | 1 | | | 1 | | | 2 | | | | | | 1 | | | | | | 2 | | | |
| Caustic | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| Lime, settle | 1 | | | 1 | | | | | | 2 | | | 1 | | 1 | | | | | | | 1 | | |
| Ammonia, settle | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| Caustic, settle filter | 1 | | | 1 | | | | | | | | | 1 | | | | | | | | | | | |

TABLE VII-20 (Cont'd)

SECONDARY SILVER (NON-PHOTOGRAPHIC): EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | LEACHING & STRIPPING | | | PRECIPITATION & FILTRATION | | | PYROMETALLURICAL & PROCESSING | | | LEACHING & STRIPPING | | | PRECIPITATION & FILTRATION | | | ELECTROLYTIC REFINING | | | | | | INGOT COOLING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | LEACHATE | | | SUPERNATANT | | | ELECTROLYTE | | | WASHWATER | | | | | |
| NUMBER OF PLANTS WITH OPERATION | 12 | | | 11 | | | 19 | | | 12 | | | 11 | | | 13 | | | 13 | | | 15 | | |
| TYPE OF DISCHARGE* | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| Cementation, caustic settle | | | | | | | | | | | | | 1 | | | | | | | | | 1 | | |
| NaCl, ammonia, settle | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| Lime, caustic, polymer settle | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| Lime, polymer, iron salts, settle | | 1 | | | | | | 1 | | | 1 | | | | | | | | | 1 | | | | |
| Lime, caustic, ammonia grit removal, settle cooling tower | | | | | | | | | 1 | | | | | | | | | 1 | | | | | | |
| Caustic, peroxysulfic acid, flocculant, settle, filter | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | | | | | | | | |

Number of Plants surveyed = 23

* I = Indirect D = Direct Z = Zero

\+ Data collection portfolio response incomplete, further classification not possible.

TABLE VII-21

TUNGSTEN: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | FUSION | | | LEACHING | | | APT DRYING | | | REDUCTION | | | LEACHING | | | PRECIPITATION & FILTRATION + | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCE OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | | | | | LEACHATE | | | SUPERNATANT | | |
| NUMBER OF PLANTS WITH OPERATION | 2 | | | 4 | | | 7 | | | 7 | | | 4 | | | 4 | | |
| TYPE OF DISCHARGE * | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z | I | D | Z |
| POTENTIAL SOURCE OF WASTEWATER | | | | | | | | | | | | | | | | | | |
| Wet | | | | 1 | 1 | | 1 | 2 | | 2 | 3 | 1 | 1 | 2 | | 1 | 2 | 1 |
| Dry | | 1 | | | 1 | | 1 | | 1 | | | | | | | | | |
| No Air pollution control | | | | | | | 1 | 1 | | | | | | | | | | |
| No wastewater produced ++ | | 1 | | | 1 | | | | | 1 | | | | | 1 | | | |
| CONTROL OF WASTEWATER | | | | | | | | | | | | | | | | | | |
| Total Recycle | | | | | | | | | | 1 | 1 | | | | | | | |
| Recycle with bleed | | | | | | | | | | | 1 | 1 | | | | | | |
| No Recycle | | | | 1 | 1 | | 1 | 2 | | 1 | 1 | | 1 | 2 | | 1 | 4 | 2 |
| TREATMENT | | | | | | | | | | | | | | | | | | |
| No Treatment | | | | | | | 1 | 1 | | 2 | 2 | 1 | | 1 | | | | |
| Artificial evaporation | | | | | | | | | | | | | | | | | | |
| Natural evaporation | | | | | | | | | | | | | | | | | | 1 |
| Ammonia stripping natural evaporation | | | | | | | | 2 | 1 | | | | | | | | | 1 |
| Lime, settle | | | | | 1 | | | | | | | | | 2 | | | | |
| Lime, polymer, settle | | | | | | | | 1 | | | 1 | | | 1 | | 1 | 2 | |
| Lime, polymer, settle, acid neutralization | | | | 1 | | | | | | | | | 1 | | | | | |

Number of plants surveyed = 10

* I = Indirect  D = Direct  Z = Zero

\+ Recorded on a wastestream, rather than a plant basis, since each plant may have more than one precipitation and filtration stream

++ Data Collection Portfolio Response incomplete, further classification not possible.

TABLE VII-22

PRIMARY ZINC: EXISTING CONTROL AND TREATMENT TECHNOLOGIES

| OPERATION | ROASTING & SULFURIC ACID PRODUCTION | | SINTERING | | ZINC REDUCTION | | LEACHING | | ELECTROLYTIC REFINING | | | | CADMIUM PRODUCTION | | METAL COOLING | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTENTIAL SOURCES OF WASTEWATER | AIR POLLUTION CONTROL | | | | | | | | ELECTROLYTE | | WASHWATER | | WASHWATER | | | |
| NUMBER OF PLANTS WITH WASTEWATER | 6 | | 2 | | 2 | | 4 | | 4 | | 3 | | 5 | | 6 | |
| TYPE OF DISCHARGE * | I | D | I | D | I | D | I | D | I | D | I | D | I | D | I | D |
| POTENTIAL SOURCES OF WASTEWATER | | | | | | | | | | | | | | | | |
| Wet | 1 | 5 | | 2 | | 1 | | 3 | | | 1 | 2 | | 4 | | 5 |
| Dry | | | | | | 1 | 1 | | | | | | 1 | | 1 | |
| No wastewater produced + | | | | | | | | | 1 | 3 | | | | | | |
| CONTROL OF WASTEWATER | | | | | | | | | | | | | | | | |
| Total Recycle | | | | | | | | 1 | | | | | | 1 | | |
| Recycle with blowdown | 1 | 3 | | | | 1 | | 2 | | | 1 | | | | | |
| No Recycle | | 1 | | 1 | | | | | | | | 2 | | 3 | | 2 |
| Total evaporation | | | | | | | | | | | | | | | | 1 |
| TREATMENT | | | | | | | | | | | | | | | | |
| No treatment | | | | | | | | 1 | | | | | | 1 | | |
| Natural evaporation | | | | | | | | | | | | 1 | | | | |
| Settle | | | | | | | | | | | | | | 1 | | 1 |
| Polymer, settle | | | | 1 | | 1 | | 1 | | | | | | | | |
| Caustic, settle | | 1 | | | | | | | | | | | | | | |
| Lime, polymer, settle | 1 | 4 | | | | | | | | | | | | | | |
| Lime, polymer, iron salts, settle, acid neutralization | | 1 | | | | | | | | | | | | 1 | | |

Number of plants surveyed = 6

* I = Indirect D = Direct Z = Zero

\+ Data collection portfolio response incomplete, further classification not possible.

# SECTION VIII

## COST, ENERGY, AND NON-WATER QUALITY ASPECTS

This section presents an analysis of cost estimates and associated energy and non-water quality impacts of various alternative technologies. Selected in-plant controls are discussed herein, and the costs are included under the technology costs. The determination of which costs and benefits are acceptable for BPT will be made by the EPA prior to proposing regulations.

The treatment alternatives for direct and indirect dischargers are considered together, rather than separately, because the majority of POTWs (Publicly Owned Treatment Works) are unable to remove the heavy metals found in this industry's wastewater. In many cases, an industrial source can discharge to a municipal sewer by paying a service charge and providing some form of pretreatment. Pretreatment is required for any pollutant that "interferes with, passes through, or otherwise is incompatible" with a POTW. Many POTWs are secondary biological systems which do not effectively treat heavy metals to low levels. POTWs, like other discharge sources, have limitations on the levels of pollutant they discharge. As a result, municipalities have developed sewer ordinances limiting the discharge level to the POTW of pollutants that POTWs can not remove. A survey of these ordinances revealed that many municipalities limit the levels of heavy metals being discharged to the POTW (23). A summary of the limits set in sewer ordinances are tabulated below.

| Pollutant | Minimum Limit (mg/l) | Mode (mg/l) | Maximum Limit (mg/l) | Number of Municipalities |
|---|---|---|---|---|
| As | 0.01 | 0.05 | 3 | 35 |
| Cd | 0.002 | 0.1;2 | 15 | 58 |
| Cr | 0.1 | 5 | 25 | 49 |
| Cu | 0.06 | 1;3 | 18 | 66 |
| Pb | 0.05 | 0.1 | 5 | 49 |
| Hg | 0.0005 | 0.005 | 5 | 30 |
| Ni | 0.1 | 1 | 15 | 57 |
| Se | 0.01 | 0.02 | 5 | 24 |
| Ag | 0.03 | 0.1 | 5 | 35 |
| Zn | 0.2 | 5 | 50 | 64 |

Therefore, nonferrous metals plants that discharge to POTWs must, in many cases, remove heavy metals to levels comparable to direct dischargers. For this reason, the treatment alternatives for indirect and direct dischargers are developed without distinguishing between the two.

The basis used to develop costs for treatment technologies is presented first, followed by the estimated costs and benefits for the alternatives applicable to each subcategory. Energy and other non-water quality aspects are also presented.

Existing plants and new sources are discussed separately with existing plants being covered first.

EXISTING SOURCES

In-Plant Control Measures

The in-plant control measures that exist in or are available to plants in the nonferrous metals industry are discussed in Section VII. The incorporation of in-plant controls into the processes of an existing source can be a cost-effective means of reducing pollutant and hydraulic loadings and thereby the cost of treatment facilities. Recycle of various process streams is the most common in-plant control suggested for BAT. The assumptions used to develop the costs of recycling wastewater are presented under the "Investment Cost Basis" portion of this section. A description of the recycled streams is provided in the "Plant Costs" portion of this section. The costs of the recommended in-plant controls are included for each treatment scheme in the summation curves of annual costs.

Alternative Technologies and Basis of Cost Estimates

The results of detailed cost analyses of various treatment technologies for existing sources are described below. Summation curves have been used to present the annual costs. Costs for each subcategory are presented separately. In some subcategories the individual wastewaters combine in ways that require a unique set of treatment alternatives. In other cases treatment schemes are essentially the same for more than one subcategory. In these cases, the same annual cost curves for a given alternative are presented under the discussion of more than one subcategory.

Investment Cost Basis and Technology Description

Investment costs include equipment and installation costs of treatment components and monitoring equipment plus allowances for contingencies and engineering. For technologies currently in use, i.e. chemical precipitation, vacuum filtration, filtration,

pH adjustment, chlorine oxidation, activated alumina, activated carbon, steam stripping, reverse osmosis, sedimentation, holding tanks, cooling towers, and evaporation, specific cost curves were developed from current bids, the literature and other sources (74, 99, 100, 127 through 159). The cost information was equalized by updating all the costs to the 4th quarter of 1976. The national average EPA-Standard Treatment Plant (STP) index and/or EPA-Large City Advanced Treatment (LCAT) index were used to update the costs for preliminary engineering estimates. The EPA-LCAT index was chosen because its component mix is indicative of the treatment processes presented herein. The EPA-STP index was chosen because it was the index used by a majority of the references from which costs were obtained. These cost values are averages for the nation and, under specific regional market conditions, could vary as much as 40%. The factors (160) in Figure VIII-1 can be used to obtain the capital cost for a particular location.

Total installed costs are broken into equipment and construction fractions as follows: (160)

| Process | Equipment | Construction |
|---|---|---|
| Chemical Precipitation | 20 | 80 |
| Vacuum Filtration | 35 | 65 |
| Multi-Media Filtration | 20 | 80 |
| pH Adjustment | 35 | 65 |
| Chlorine Oxidation | 35 | 65 |
| Activated Alumina | 50 | 50 |
| Activated Carbon | 50 | 50 |
| Steam Stripping | 35 | 65 |
| Reverse Osmosis | 50 | 50 |
| Holding Tank | 50 | 50 |
| Sedimentation | 10 | 90 |
| Cooling Tower | 35 | 65 |
| Evaporation Lagoon | 10 | 90 |

A contingency allowance of 15% of the installed cost was used to cover unexpected costs due to local plant conditions and differences between actual systems and those used for the cost estimates. No allowance was made for plant shutdown during construction. The need for a shutdown is dependent on the layout of each plant. Engineering costs were estimated by using a percentage of the installed cost plus contingencies. The percentage used was to the nearest 0.5% from curve A in Consulting Engineering (ASCE MOP #45), which is a plot of percent engineering costs versus construction costs.

Investment costs were developed for each level of treatment and were then amortized for incorporation into the annual cost

summation curves. The summation curves present the cost of each alternative as a plot of annual cost ($/yr) versus plant flow (mgd). This approach allows the reader to determine the cost of any size plant.

The alternatives for treatment include one or more of the following unit operations or processes in various combinations:

Chemical Precipitation. Lime is used to precipitate metals and the process includes sedimentation and thickening of the sludge plus sludge dewatering by vacuum filtration. Investment costs for chemical precipitation were developed assuming lime as the precipitant and including sedimentation, gravity thickening and vacuum filtration. Lime was selected because of its comparatively low cost coupled with its proven effectiveness in the industry. While it is recognized that caustic, iron salts, and sulfides may be more appropriate in some applications, costs for these precipitants and their feed systems are comparable to lime relative to the overall costs of a chemical precipitation system.

Specific cases were developed for chemical precipitation relating investment cost to lime dosage and sludge production. The cases are as follows:

| Case | Lime (mg/l) | Sludge (lb/mil gal) |
|---|---|---|
| 1 | 16,000 | 500,000 |
| 2 | 7,300 | 250,000 |
| 3 | 2,500 | 100,000 |
| 4 | 1,100 | 50,000 |
| 5 | 580 | 25,000 |
| 6 | 285 | 10,000 |
| 7 | 50 | 1,500 |

Units were sized for these cases based on an overflow rate of 40.75 $m^3/day\text{-}m^2$ (1000 $gpd/ft^2$) for sedimentation and an application rate of 122 $kg/day\text{-}m^2$ (25 $lb/ft^2/day$) for gravity thickening (161).

The investment costs for vacuum filtration were developed in terms of the amount of sludge to be dewatered. The filter area was calculated using a dry solids loading rate of 19.53 $kg/m^2/hr$ (4 $lb/ft^2/hr$) and an operating period of 10 hrs/day (143). The quantity of solids requiring dewatering is dependent on the treatment alternative and the specific lime dosage and sludge production cases, as previously described, used with each alternative.

Multi-Media Filtration. A granular media filter bed is used to remove fine particulates. The filter bed consists of graded layers of gravel, coarse anthracite coal, and fine sand. Normally the filter backwash is pumped to the secondary sedimentation tank. However, when filtration is used without chemical precipitation, the backwash is pumped directly to a vacuum filter.

The hydraulic loading rate used was 163 l/min-m$^2$ (4 gpm/ft$^2$) (143). Specific cases were developed for filtration as follows:

| Case | TSS Removed (mg/l) |
|---|---|
| 1 | 100 |
| 2 | 50 |
| 3 | 15 |
| 4 | 5 |

The solids carried over to the filter from chemical precipitation have a direct influence on the solids being recycled in the backwash to the secondary clarifier and therefore add to the sludge volume applied to the vacuum filter.

Neutralization or pH Adjustment. $H_2SO_4$ (66°Be') and/or NaOH (50% liquid) are utilized to obtain desired pH values at various points in any given alternative sequence. The investment costs include a mixing tank and chemical handling systems for both acid and alkaline solutions, which also include storage tanks.

Chlorine Oxidation. Chlorine gas is used to oxidize or break down undesirable pollutants that may interfere with other processes or remain in an effluent. Specifically, chlorine oxidation is used for cyanide and ammonia destruction.

The investment costs include chlorine storage and feed systems, and a chlorine contact tank with a detention time of 30 minutes. The costs also include a feed system for adjustment to alkaline pH prior to chlorine addition.

Activated Alumina. Contact columns containing alumina are used to remove arsenic and fluoride. The backwash and spent regenerant are both recycled to the chemical precipitation unit for removal of the concentrated pollutant.

The investment costs are based on a system using activated alumina in contacting columns. A surface loading rate of 122 l/min-m$^2$ (3 gpm/ft$^2$) was assumed with an alumina adsorption capacity of 0.5% by weight for fluoride and arsenic (80).

Activated Carbon. Granular activated carbon in downward flowing contacting columns is used to adsorb colloids and large molecular pollutants. An exhaustion rate of .18 kg/m³ (1500 lb/mil gal) was assumed for all subcategories except secondary silver. A .66 kg/m³ (5500 lb/mil gal) and 1.49 kg/m³ (12,400 lb/mil gal) exhaustion rate was assumed for secondary silver, non-photographic and photographic, respectively. On-site multiple-hearth furnace regeneration was assumed for plants treating wastewater flows greater than 1287, 435, and 193 m³/day (.34, .115, and .051 mgd) for exhaustion rates of .18, .66, and 1.49 kg/m³ (1500, 5500, and 12,400 lb/mil gal) respectively. For plants smaller than those given for each exhaustion rate, it was assumed that the spent carbon would be discarded. Many factors influence the investment cost for activated carbon systems; namely, exhaustion rate, carbon type (manufacturer & raw material), contact type (upward, downward - packed, expanded) and regeneration method.

Steam Stripping. A stripping tower and steam are used to remove ammonia from the wastewater. The investment costs include a stripping tower, a boiler, and a blower. A surface loading rate of 81.5 l/min-m² (2 gpm/ft²) was assumed along with a steam requirement of 1 pound of steam per gallon of wastewater treated.

Reverse Osmosis. To remove selected ions from the wastewater streams, prefiltration cartridges are used along with membranes. The resulting brines are further concentrated into a disposable sludge by multiple-effect evaporators.

The investment costs include prefiltration cartridges, membranes, membrane housing, pumps, and mechanical evaporation of the brine. Costs were based on a recovery of 85% of the flow through the reverse osmosis unit and a 98% reduction in the brine flow through the mechanical evaporator.

Holding Tank and Cooling Tower. These two items will be discussed together as they are incorporated into the various treatment schemes to provide cooling of contact cooling water prior to recycle.

By reviewing the information supplied in the data collection portfolios it was found that 85% of the plants that recycle contact cooling water following treatment through cooling towers have flows greater than 303 m³/day (80,000 gpd). It was also found that 60% of the plants that recycle contact cooling water following sedimentation or no treatment have flow rates less than 303 m³/day (80,000 gpd). For those plants that recycle contact cooling water with no reported treatment, 86% had contact cooling water flows less than 303 m³/day (80,000 gpd). It was therefore assumed that plants having contact cooling water flows less than

303 $m^3$/day (80,000 gpd) would provide recycle following a day's retention time in a holding tank and that plants having contact cooling water flows greater than 303 $m^3$/day (80,000 gpd) would provide recycle following treatment in a cooling tower.

The investment costs for a holding tank include tanks, pumps, and 1,000 ft of piping with the tanks sized to store a day's flow. The investment costs for a cooling tower assume the use of a mechanical (induced) draft tower and include the tower, pumps, 305 meters (1,000 ft) of piping, fans and packing. The sizing of the tower is based on a range of 13.9°C (25°F), an approach of 5.6°C (10°F), and a wet bulb temperature of 21.11°C (70°F) (162).

Sedimentation. Primary sedimentation is utilized to remove suspended solids from the wastewater stream prior to recycle. The investment costs include a primary sedimentation tank, solids removal mechanism, and 305 meters (1,000 ft) of piping. The costs were based on a hydraulic loading rate of 32.6 $m^3$/day-$m^2$ (800 gpd/$ft^2$) (161).

Evaporation. A lagoon is used for solar evaporation of wastewater in regions of net evaporation. The investment costs include excavation and dikes, land costs, asphalt or plastic liner, pumps and pipes. The sizing of the lagoons was based on the net effective annual evaporation rate. This value was determined for each plant.

Monitoring. The costs are based on collecting samples of the influent and effluent streams of the treatment plant. The sampling schedule is for 24-hour composite samples to be taken once per week. Continuous monitoring of the pH and flow is also provided for the influent and effluent of all treatment plants.

The equipment items include two flow meters, two primary and one backup refrigerated samplers, two pH meters, refrigerated sample storage containers, and a refrigerator. The costs are based on equipment manufacturers' price lists (157, 158, 159).

The above treatment operations and processes, alone or in combination, have been arranged in alternatives which may be BAT level technologies. Removal of metallic priority pollutants by chemical precipitation has been widely demonstrated in this industry. Consequently, treated concentrations can be determined with a high degree of accuracy. Removing metals to lower levels by activated alumina and reverse osmosis has had limited use in the industry. The effectiveness of activated carbon in removing the organic priority pollutants has not been demonstrated in the nonferrous metals industry. Reports are available, however, that discuss the degree of adsorbability of activated carbon for the individual priority pollutant organics (102, 111, 163, 112, 17).

Based upon these reports, conservative estimates have been made for removals by carbon and its exhaustion rates under different operating conditions.

Land Costs

Land requirements (129) are presented in Figure VIII-2 for individual technologies. The technologies are: chemical precipitation, primary sedimentation, filtration, activated alumina, activated carbon, steam stripping, oxidation by chlorine, cooling tower, pH adjustment, reverse osmosis, holding tanks, and vacuum filtration. The total land requirement can be determined from Figure VIII-2 by summing the individual requirements of each technology for any given alternative.

Land costs are not provided, as costs are highly site specific and could vary by several magnitudes. Land costs for evaporation lagoons, however, were taken to be $1,000/acre, as lagoons would be utilized in rural areas where $1,000/acre would be a reasonable cost for land. Land requirements for evaporation lagoons are presented in Figure VIII-3 (98).

Annual Costs

Capital. Capital costs were amortized at an interest rate of 7.75% over a 20-year period, i.e. cost of capital being 10% of the investment per annum. Consequently, the capital investment cost can be determined from the capital cost curve by multiplying any annual capital cost value by ten. Since the current money market is unstable, the annual capital costs may need adjustment for higher interest rates. The following table presents factors to convert the amortized cost of capital expenditures shown in the annual cost summation curves to the amortized capital cost at a variety of other interest rates. These factors are based on a payback period of 20 years.

| Interest Rate | Capital Recovery Factor | Multiplication Factor |
|---|---|---|
| 7.75 | .09996 | 1.0 |
| 8 | .10185 | 1.02 |
| 8.5 | .10567 | 1.06 |
| 9 | .10955 | 1.10 |
| 9.5 | .11348 | 1.13 |
| 10 | .11746 | 1.17 |
| 10.5 | .12149 | 1.21 |
| 11 | .12558 | 1.26 |
| 11.5 | .12970 | 1.3 |
| 12 | .13388 | 1.34 |
| 12.5 | .13810 | 1.38 |
| 13 | .14235 | 1.42 |
| 13.5 | .14665 | 1.47 |
| 14 | .15099 | 1.51 |

Depreciation. Estimated lives of the components of each alternative were established and related to the investment costs to determine the estimated design life of each alternative (131). The estimated lives for each component are as follows:

| Technology | Useful Life (yrs.) |
|---|---|
| Chemical Precipitation | 25 |
| Vacuum Filtration | 15 |
| Filtration | 15 |
| pH Adjustment | 15 |
| Chlorine Oxidation | 15 |
| Activated Alumina | 15 |
| Activated Carbon | 15 |
| Steam Stripper | 15 |
| Reverse Osmosis | 20 |
| Holding Tank | 20 |
| Sedimentation | 25 |
| Cooling Tower | 15 |
| Evaporation Lagoon | 25 |

The life of any alternative was determined by calculating a cost weighted average (dividing the sum of the products of cost and useful life for each process by the sum of the costs). This can be expressed as:

$$\text{Years} = \frac{(\$ \times \text{Years})}{\$} = \frac{(\$C.P \times Yr\ C.P.) + (\$VF \times Yr\ VF) + (\$F \times YrF) + \ldots}{\$C.P. + \$VF + \$F + \$\ldots}$$

The installed cost plus contingencies were depreciated on a straight line basis for the calculated life of each alternative.

Operation and Maintenance Labor. Estimates of the annual man-hours required to operate and maintain the various systems were developed from the literature (129, 164). A productive work value of 6.5 hr/man/day, or 1,500 hr/yr/man was assumed (164). A rate of $15/hr was used as the total cost for wages, benefits, and overhead expenses. Supervisory, administrative, clerical, and laboratory man-hours were developed and are included in the O&M labor costs. Figure VIII-4 shows how the wage rates will vary with location throughout the U.S. The factors (165) shown can be multiplied by the assumed rate of $15/hr to obtain the wage rate at that location.

Maintenance Materials. The annual costs of materials and parts needed to maintain each process were developed from the literature and equipment manufacturers. (129, 131, 100, 99, 138, 139, 140, 141).

Chemicals. To determine the chemical cost for chemical precipitation, lime was chosen as the precipitant. The annual use for a given installation was determined by the cases described under Chemical Precipitation which correspond to the wastewater characteristics.

Sulfuric acid (66°Be') and sodium hydroxide (50% liquid) were assumed to be used for pH adjustment. A dosage of 0.5 pounds of acid or caustic per 1,000 gallons of flow was used as a conservative assumption.

For chlorine oxidation of cyanide a dosage of 800 mg/l of chlorine was assumed, while 3,000 mg/l of chlorine was assumed as the dosage for oxidation of ammonia.

Activated alumina chemical usage includes sulfuric acid (66° Be') and sodium hydroxide (50% liquid) for regeneration, and replacement of activated alumina. For regeneration, four bed volumes of 1% NaOH and one bed volume of .05N $H_2SO_4$ are needed every two days. An attrition rate of 10% per year for activated alumina was assumed.

The activated carbon process incurs chemical costs for the replacement of carbon. For small plants that find it more economical to discard the carbon after exhaustion, the entire carbon inventory is replaced according to the exhaustion rate. For those plants that utilize on-site regeneration, it was assumed that 8% of the carbon is lost during each regeneration and must be replaced.

The chemical costs for reverse osmosis include the membrane cleaning chemicals. These costs were taken from literature (139,

145, 149). The costs of chemicals (166) were assumed to be as follows:

| Chemical | Cost ($/ton) |
|---|---|
| Lime (CaO) | 30 |
| $SO_2$ | 180 |
| Activated Alumina | 340 |
| Activated Carbon | 1000 |
| NaOH (50% liquid) | 160 |
| $H_2SO_4$ (66° Be') | 47 |

Energy and Power. Operating time for all equipment of all the treatment alternatives, with the exception of vacuum filtration, was assumed to be 24 hrs/day and 300 days/yr. Vacuum filters were sized to operate 10 hrs/day, 300 days/yr.

Annual electrical energy consumption values for each component were developed utilizing technical literature (167, 168, 169, 170, 146) and equipment manufacturers' specifications (145). In developing the costs, all electric motors were assumed to have an efficiency of 88% (171) and the cost of electricity was assumed to be 3.3¢/kwh. This cost value is an average value for the entire U.S. taken from the industry data collection portfolio responses.

Fuel oil and natural gas costs were developed from the data collection portfolio responses and applicable technical literature (134). National average costs were determined to be 24¢/therm for fuel oil and 18¢/therm for natural gas.

Vacuum filtration energy consumption varies with filter area. The area, or size of the filter, is dependent on the amount of sludge to be dewatered which is a function of the chemical precipitation and filtration cases, and of the flow rate being evaluated. Consequently, energy consumption is dependent on these criteria also.

Energy consumption for activated carbon is dependent on the flow and whether the exhausted carbon is regenerated or discarded. The remaining technologies' consumption is based solely on flow.

Sludge Disposal. Sludge disposal costs cover hauling dewatered sludge, exhausted activated carbon, and concentrated reverse osmosis brine, when applicable, to an approved sanitary landfill. The hauling costs were obtained from literature (172, 173), and plotted as tons/yr of dry sludge hauled vs. $/dry ton. A round trip hauling distance of 10 miles was assumed. (See Figure VIII-5).

Sludge disposal costs are related to the cases developed for chemical precipitation and filtration. Recycle of spent activated alumina regenerant to the chemical precipitation unit increases the amount of sludge.

Costs to dispose of spent activated carbon are based on hauling to a landfill. It was assumed that the carbon would be dewatered to 50% solids, i.e., containing its own weight in water.

Monitoring. Monitoring costs include outside laboratory analytical charges and time for reporting results to regulatory agencies. The costs associated with collecting and delivering samples are included under operation and maintenance labor.

Sampling frequency was assumed to be once per week of both the influent and effluent. Criteria pollutants are analyzed once per week and priority pollutants are analyzed once per month.

Laboratory cost estimates were based on current (Jan. - June, 1978) commercial laboratory price lists (174, 175, 176, 177, 178, 179, 180). Reporting costs were based on $15/hr and allowed 2 hr/week for compiling data plus 8 hr/month for preparing reports.

Plant Costs

In the nonferrous metals industry, each subcategory possesses a set of wastewater streams that must be treated to remove pollutants or for recycle. Most plants differs from each other in the combination of streams and/or the flow rate. Wastewater characteristics play an important role in determining treatment alternatives and these characteristics are primarily dependent on the combination of streams existing at each plant. Therefore, the various subcategories in the nonferrous metals industry are discussed separately in order to present the wastewaters, the combinations of wastewaters, the rate of flow, and the treatment alternatives.

To determine a specific plant's costs, first calculate the process wastewater flow in gal/day. The rate used for contact cooling water should be 5% of the plant's use, or the amount discharged, whichever is less. Rainfall runoff was not considered as a process wastewater, nor was noncontact cooling water. The annual costs can then be read easily from the appropriate curves.

For example, assume a primary aluminum plant has the following discharged flows:

| | Actual Flow | Flow for Costing |
|---|---|---|
| Anode bake plant | 10,000 | 10,000 |

| | | |
|---|---|---|
| Potline scrubber | 60,000 | 60,000 |
| Casting (use=discharge) | 140,000 | 7,000 |
| Noncontact cooling | 100,000 | 0 |
| | | 77,000 |

This plant would be included in Combination 3. Going to the appropriate cost curves, the incremental annual costs would be as follows:

| | |
|---|---|
| Alternative 1 | $150,000 |
| Alternative 2 | 210,000 |
| Alternative 3 | 320,000 |
| Alternative 4 | 250,000 |

and the total annualized costs would be as follows:

| | |
|---|---|
| Alternative 1 | $150,000 |
| Alternative 2 | 360,000 |
| Alternative 3 | 680,000 |
| Alternative 4 | 610,000 |

The treatment alternatives assume 95% recycle of contact cooling water, after a cooling tower or a holding tank, which are included in the costs. All other process wastewater presently discharged is assumed to be treated by each alternative. For example, it was assumed that the hypothetical plant above would treat all its present effluent through each alternative, i.e., 77,000 gpd would be treated by reverse osmosis in Alternative 3.

Obviously, where recycle is employed it is less expensive to treat the recycled wastewater only to the extent necessary to prevent plugging, fouling, or other problems. The hypothetical plant above could recycle 50% of its flow after chemical precipitation, and 50% of the remainder after filtration, leaving only about 20,000 gpd to be treated by reverse osmosis. This would result in annual savings of about $250,000.

Determination of the Benefits of Treatment

The wastewater concentrations for each waste stream given in the tables below were determined from sampling data presented in Section V. The effluent quality from each treatment alternative was determined from information presented in Sections V and VII.

For each subcategory's waste streams, the water use and discharge levels (in gallons per production normalizing unit) for each plant were calculated, as shown in Section VII. BAT flow rates were selected for each. In all cases, wastewater flow and production data obtained from the data collection portfolio responses, NPDES Discharge Monitoring Reports, and the sample

collection program were considered in determining the appropriate BAT flow rate.

Primary Aluminum. Four groups of wastewaters exist in this subcategory. These streams are:

1. Paste, bake plant, and cathode making wastewater
2. Air pollution control wastewater
3. Contact cooling water
4. Cathode reprocessing wastewater with cryolite recovery

These four streams are found in eight different combinations throughout the subcategory. The first five combinations were chosen for the cost analysis, because they cover most of the subcategory. The combinations are tabulated below. The costs of treatment for plants in combination 6 are represented by the costs given for combination 5. Combinations 7 and 8 are represented by combination 3.

| COMBINATION | PASTE PLANT | SCRUBBERS | CONTACT COOLING WATER | CRYOLITE RECOVERY |
|---|---|---|---|---|
| 1 | x | | x | |
| 2 | | | x | |
| 3 | x | x | x | |
| 4 | | x | x | |
| 5 | x | x | x | x |
| 6 | | x | x | x |
| 7 | x | x | | |
| 8 | | x | | |

Three levels of treatment were developed for combinations 1 and 2, and four levels of treatment were developed for combinations 3, 4, and 5. The alternatives are described below and schematically presented in Figure VIII-6.

Level 1. For combinations 1 and 2 -- 95% of the contact cooling water is recycled through a cooling tower, and a five percent blowdown is combined with the other stream for combination 1 and treated by chlorine oxidation, lime precipitation, and filtration followed by recycle. For combinations 3, 4, and 5 -- 95% of the contact cooling water is recycled through a cooling tower, and a five percent blowdown is combined with the other streams for treatment by chlorine oxidation and lime precipitation, followed by recycle.

Level 2. For combinations 1 and 2 -- reverse osmosis is added to level 1 and the effluent is completely recycled. For combinations 3, 4, and 5 -- filtration and activated alumina are added

to level 1, followed by recycle. For combination 3, costs may tend to be conservative for those plants which practice recycle of reduction scrubber wastewater following lime precipitation.

Level 3. For combinations 1 and 2 -- activated carbon is added to level 1, followed by recycle. For combinations 3, 4, and 5 -- reverse osmosis is added to level 2 with the effluent being completely recycled.

Level 4. For combinations 3, 4, and 5 -- activated carbon is added to level 2, followed by recycle.

The cost versus pollution reduction summary includes a summation curve for each level of treatment of each combination, accompanied by a table showing the effluent quality (77 to 83, 110, 118 121, 122, 125, 147 and 181 to 190) achieved for the significant pollutants at each level of treatment. The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables VIII-1 to 6.

| COMBINATION | FIGURES VIII- |
|---|---|
| 1 | 7 - 9 |
| 2 | 10 - 12 |
| 3 | 13 - 16 |
| 4 | 17 - 20 |
| 5 | 13 - 16 |

Secondary Aluminum. Three wastewaters exist in this subcategory. The streams are:

1. Dross milling wastewater
2. Demagging scrubber wastewater
3. Contact cooling water

These three streams are found in five different combinations throughout the subcategory. The first three combinations have been chosen for the cost analysis. The combinations are tabulated below. Combination 4 is represented by combination 1, and combination 5 is represented by combination 2.

| COMBINATION | DROSS MILLING | SCRUBBER | CONTACT COOLING |
|---|---|---|---|
| 1 | x | x | |
| 2 | | x | x |
| 3 | | | x |
| 4 | x | | |
| 5 | | x | |

Four levels of treatment were developed for combinations 1 and 2, and three levels of treatment were developed for combination 3. The treatment alternatives are described below and schematically presented in Figure VIII-21.

Level 1. For combination 1--settling of the dross milling effluent and treating the supernatant by steam stripping, followed by combining the effluent with the scrubber wastewater for treatment by lime precipitation followed by recycle. For the remaining combinations, the combined streams are treated by lime precipitation followed by recycle.

Level 2. Gravity filtration is added to the components of level 1, followed by recycle.

Level 3. Reverse osmosis and complete recycle of the effluent is added to the components of level 2 for combinations 1 and 2. Activated carbon is added to level 2 for combination 3 followed by recycle.

Level 4. Activated carbon is added to level 2 for combinations 1 and 2 followed by recycle.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables VIII-7 to 10.

| COMBINATION | FIGURES VIII- |
|---|---|
| 1 | 22 - 25 |
| 2 | 26 - 29 |
| 3 | 30 - 32 |

Columbium-Tantalum. For costing purposes, the columbium-tantalum industry has been divided into two groups. The groups are defined as: ore to salt or metal; and salt to metal.

Ore to Salt/Metal

Three plants exist in this group and there are two combinations. Each combination consists of the following wastewaters:

1. Digestion air pollution control wastewater
2. Extraction raffinate and gangue washwater
3. Precipitation supernatant
4. Salt drying air pollution control wastewater
5. Reduction air pollution control and leachate

Combination 1 represents those plants which practice steam stripping of ammonia-laden streams and at least lime precipitation of the overall combined wastes. Four levels of treatment are presented. The alternatives are described below and schematically presented in Figure VIII-33.

Level 1. Oxidation of the precipitation supernatant and salt drying wastewater by chlorination and filtration followed by recycle, as appropriate.

Level 2. Activated alumina is added to level 1, followed by recycle, if necessary.

Level 3. Reverse osmosis and complete recycle of the effluent are added to level 2.

Level 4. Activated carbon is added to level 2, followed by recycle, if appropriate.

Combination 2 consists of a plant that does not treat its ammonia-laden streams. Five levels of treatment are presented. The alternatives are described below and schematically presented in Figure VIII-33.

Level 1. Steam stripping and oxidation by chlorine are used to treat the precipation supernatant and salt drying effluent, followed by recycle, if necessary.

Level 2. The combined wastewaters are treated by lime precipitation and filtration, followed by recycle if necessary.

Level 3. Activated alumina is added to the components described for level 2, followed by recycle if necessary.

Level 4. Reverse osmosis and complete recycle of the effluent are added to level 3.

Level 5. Activated carbon is added to the components specified for level 3, followed by recycle.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Table VIII-11.

| COMBINATION | FIGURES VIII- |
|---|---|
| 1 | 34 - 37 |
| 2 | 38 - 42 |

Salt to Metal

Two plants exist in this group. One plant performs tantalum reduction with wastewaters from reduction air pollution control and leaching. The other plant discharges wastewater from air pollution control of columbium salt drying after lime treatment and sedimentation. Treatment costs and removal summaries are based on the former plant. It is anticipated that the raw waste characteristics of the salt drying scrubber stream will be no worse than those of the tantalum reduction streams, thus the cost and removal estimates for the columbium plant may be conservative.

The plant considered in this combination discharges wastewater from the reduction process without lime treatment of the wastewater. Tantalum recovery is practiced, but substantial concentrations of fluoride are discharged. As a result, three levels of treatment are presented. The alternatives are described below and schematically presented in Figure VIII-43.

Level 1. Treatment is provided by lime precipitation and filtration, followed by recycle if necessary.

Level 2. Treatment of the combined streams from level 1 is by activated alumina, followed by recycle, if necessary.

Level 3. Activated carbon is added to level 2, and the effluent may be recycled.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Table VIII-12.

| COMBINATION | FIGURES VIII- |
|---|---|
| 1 | 44 - 46 |

Primary Copper. The wastewaters are:

1. Acid plant blowdown and related air pollution control wastewater
2. Slag granulation wastewater
3. Contact cooling water

Four combinations of these streams exist in this group. The combinations are shown in the following tabulation:

| COMBINATION | ACID PLANT | SLAG | CONTACT COOLING | ELECTROLYTE |
|---|---|---|---|---|
| 1 | | | x | |
| 2 | x | x | x | x |
| 3 | | x | x | |
| 4 | x | x | x | |

Combinations 1 and 2 represent the group, with combinations 3 and 4 being included in combination 2.

Three levels of treatment were developed for combination 1. The alternatives are described below and schematically presented in Figure VIII-47:

Level 1. Recycle of the contact cooling water after cooling, and treatment of a five percent blowdown is provided by lime precipitation followed by recycle.

Level 2. Filtration is added to level 1 prior to recycle.

Level 3. Activated carbon is added to level 2 prior to recycle.

Three levels of treatment are presented for combination 2. The alternatives are described below and presented schematically in Figure VIII-51.

Level 1. Recycle of contact cooling water is provided combining a five percent blowdown with the other streams prior to treatment by lime precipitation and recycle.

Level 2. Filtration is added to level 1 prior to recycle.

Level 3. Activated carbon is added to level 2 prior to recycle.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables 13 and 28.

| COMBINATION | FIGURES VIII- |
|---|---|
| 1 | 48 - 50 |
| 2 | 51 - 53 |

A fourth level of treatment at primary copper plants can be added to or used in place of any of the above alternatives provided the plant is located in an area of net evaporation, namely evaporation lagoons. The costs for lagoons in areas of 10, 20, and 30 inches net effective evaporation per year are presented in Figures VIII-58, 59, and 60 respectively.

Secondary Copper. Four wastewater streams exist in this subcategory. The streams are:

1. Slag milling and granulation
2. Scrubber wastewater
3. Electrolyte
4. Contact cooling water

These streams exist in five combinations in the subcategory. These combinations are:

| COMBINATION | SLAG MILLING | SCRUBBER | ELECTROLYTE | CONTACT COOLING |
|---|---|---|---|---|
| 1 | x | | | x |
| 2 | | | | x |
| 3 | | x | | x |
| 4 | | x | | |
| 5 | | x | x | x |

Three levels of treatment were developed for each combination. The treatment alternatives are described below and schematically presented in Figure VIII-61.

Level 1. For Combination 1--the supernatant from primary settling of the slag milling water is combined with the contact cooling water for treatment by lime precipitation prior to recycle. For Combination 2--the contact cooling water is treated by lime precipitation prior to recycle. For Combination 3--the contact cooling and scrubber water are treated by lime precipitation prior to recycle. For Combination 4--the scrubber water is treated by lime precipitation prior to recycle. For Combination 5--the contact cooling water is recyled through a holding tank and a five percent blowdown is combined with the other streams for treatment by lime precipitation prior to recycle.

Level 2. Gravity filtration is added to level 1 for each combination, followed by recycle.

Level 3. For Combination 1 and 2--the effluent from level 2 is pumped to a holding tank for recycle. For Combination 3, 4, and 5--activated carbon is added to level 2, followed by recycle.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables VIII-14 to 18.

| COMBINATION | FIGURES VIII- | TABLE VIII- |
|---|---|---|
| 1 | 62 - 64 | 15 |
| 2 | 65 - 67 | 16 |
| 3 | 65, 66, 68 | 17 |
| 4 | 65, 66, 68 | 18 |
| 5 | 69 - 71 | 19 |

Primary Lead. There are only three primary lead plants that discharge any wastewater. All three plants have at least lime precipitation in place. Therefore, the stream to be treated is the effluent from the existing treatment. Three levels of treatment are presented as add on to existing treatment. These alternatives are described below and schematically presented in Figure VIII-72.

Level 1. Filtration is added to the existing treatment, followed by recycle.
Level 2. Activated carbon added to level 1, followed by recycle.
Level 3. Reverse osmosis and complete recycle are added to level 2.

The cost curves are presented in Figures VIII-73 to 75, while the summary of the associated pollution reduction is presented in Tables VIII-19 and 28.

Secondary Lead. There are three sources of wastewater which form three combinations in the group. The combinations are presented in the following tabulation:

| COMBINATION | BATTERY ACID & SAW WATER | CONTACT COOLING | CONTACT COOLING AND/OR SCRUBBER |
|---|---|---|---|
| 1 | x | | |
| 2 | x | | x |
| 3 | x | x | |

Combinations 2 and 3 will be considered as one combination.

Four levels of treatment are presented for these combinations. The alternatives are described below and schematically presented in Figure VIII-76.

Level 1. The combined wastewaters are treated by lime precipitation and filtration prior to recycle.
Level 2. Activated alumina is added to level 1, followed by recycle.
Level 3. Reverse osmosis and complete recycle are added to level 2.

Level 4. Activated carbon is added to level 2, followed by recycle.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables VIII-20 and 21.

| COMBINATION | FIGURES VIII- |
|---|---|
| 1 | 77 - 80 |
| 2 | 81 - 84 |

Secondary Silver. This industry has been divided into two subcategories. These subcategories are:

Photographic

In this group there are five wastewater streams. The wastewaters are:

1. Precipitation supernatant
2. Solution treating supernatant
3. Furnace air pollution control wastewater
4. Electrolysis wastewater
5. Contact cooling water

Four levels of treatment are presented for all combinations. The alternatives are described below and schematically presented in Figure VIII-85.

Level 1. The precipitation supernatant is treated by steam stripping, followed by recycle if applicable.

Level 2. The combined effluent is treated by lime precipitation prior to recycle.

Level 3. Filtration is added to level 2, followed by recycle.

Level 4. Activated carbon is added to level 3, followed by recycle.

The cost curves are presented in Figures VIII-86 to 89, while the summary of the associated pollution reduction is presented in Table VIII-22.

Non-Photographic

The streams present in this group are the same as those found in the photographic group except that the first stream is leaching,

precipitation and filtration supernatant, and the second is air pollution control wastewater from precipitation and leaching.

Three levels of treatment are presented for these combinations. The alternatives are described below and schematically presented in Figure VIII-90.

Level 1. The leaching, precipitation and filtration supernatant is treated by steam stripping, followed by recycle.

Level 2. The combined streams are treated by lime precipitation and filtration prior to recycle.

Level 3. Activated carbon is added to level 2, followed by recycle.

The cost curves are presented in Figures VIII-91 to 93, while the summary of the associated pollution reduction is presented in Table VIII-23.

Primary Tungsten. This industry is divided into two groups based on plant configuration. These are:

Ore to Salt/Metal

In this group there are three plants that discharge wastewater. All three plants have the equivalent of lime precipitation in place. Substantial concentrations of ammonia may exist, however, in the treated effluent. This situation required the development of two combinations. Combination 1 includes those plants that do not have excessive ammonia in their discharge. Three levels of treatment have been developed for this combination. The alternatives are described below and presented schematically in Figure VIII-94.

Level 1. The combined effluent is treated by filtration, followed by recycle if appropriate.

Level 2. Reverse osmosis with complete recycle is added to level 1.

Level 3. Activated carbon is added to level 1, followed by recycle if appropriate.

The cost curves are presented in Figures VIII-95 to 97, while the summary of the associated pollution reduction is presented in Table VIII-24.

Combination 2 includes those plants that have significant ammonia concentrations in their combined effluent. Four levels of

treatment are presented. The alternatives are described below and schematically presented in Figure VIII-94.

Level 1. The combined effluent is treated by steam stripping, followed by recycle if appropriate.

Level 2. Filtration is added to level 1, followed by recycle.

Level 3. Reverse osmosis and complete recycle are added to level 2.

Level 4. Activated carbon is added to level 2, followed by recycle.

The cost curves are presented in Figures VIII-98 to 101, while the summaries of the associated pollution reduction are presented in Tables VIII-26 and 27.

Salt to metal

Two levels of treatment are presented. The alternatives are described below and presented schematically in Figure VIII-102.

Level 1. The combined wastewaters are treated by steam stripping and filtration prior to recycle.

Level 2. Activated carbon is added to level 1, followed by recycle.

The cost curves are presented in Figures VIII-103 to 104, while the summary of the associated pollution reduction is presented in Table VIII-25.

Primary Zinc. All the plants in this subcategory have at least the equivalent of lime precipitation in place. As a result, the effluent stream from the existing treatment is the only discharge stream.

Three levels of treatment were developed to add to the existing treatment. These alternatives are described below and are schematically presented in Figure VIII-105.

Level 1. Filtration and activated alumina are added to the existing treatment, followed by recycle.

Level 2. Reverse osmosis and complete recycle are added to level 1.

Level 3. Activated carbon is added to level 1, followed by recycle.

The cost curves are presented in Figures VIII-106 to 108, while the summary of the associated pollution reduction is presented in Table VIII-28.

Metallurgical Acid Plants. It was assumed that blowdown from metallurgical acid plants would be treated in conjunction with the other process wastewater at the plant. Therefore, the costs of treatment are included in the costs of treatment for Primary Copper, Lead and Zinc. The associated pollution reduction is presented in Table VIII-28.

## NEW SOURCES

New sources, as opposed to existing sources, are defined in the Act as "any source, the construction of which is commenced after publication of proposed regulations prescribing a standard of performance." The new source cost information presented in this section includes only end-of-pipe treatment and control and does not include in-plant control measures, as these costs will be incorporated in the production plant construction costs. A cost comparison was made on the use of dry air pollution controls versus wet air pollution controls and it was found that the initial investment was higher for dry systems but the annual costs were higher for wet systems.

### In-Plant Control Measures

New sources are expected to employ in-plant controls extensively to reduce the quantity of pollutants discharged, and possibly eliminate some wastewaters found in existing sources. In-plant control measures, as presented in Section VII, can greatly affect the type and size, and subsequently the cost, of end-of-pipe treatment alternatives.

### Treatment and Control Technologies

The technologies developed to meet new source standards are the same as those developed for existing sources. A description of each technology and the assumptions used to develop costs are presented in the "Existing Sources" portion of this section. As with existing sources, new source costs will be presented by discussing each subcategory separately including a description of the wastewaters, the various combinations of the streams, and the recommended treatment alternatives. The ratio of mass of pollutants to mass of product was determined by evaluating the methods that existing plants have used to reduce or eliminate wastewater flow.

Primary Aluminum. By use of in-plant controls and utilizing dry scrubbing methods, new sources will have two wastewater streams. These streams are:

1. Contact cooling water
2. Cathode reprocessing with cryolite recovery

The following combinations could exist:

| COMBINATION | CONTACT COOLING | CRYOLITE |
|---|---|---|
| 1 | x | x |
| 2 | x | |

Four levels of treatment were developed for combination 1 and three levels for combination 2. The alternatives are described below and schematically presented in Figure VII-109. The alternatives for combination 2 are the same as for combination 2 for existing sources, and are described there.

Level 1. For Combination 1--recycle of the contact cooling water and combining a five percent blowdown with the other stream for treatment by chlorine oxidation and lime precipitation, followed by recycle.

Level 2. For Combination 1--filtration and activated alumina are added to level 1, followed by recycle.

Level 3. For Combination 1--reverse osmosis and complete recycle are added to level 2.

Level 4. For Combination 1--activated carbon is added to level 2, followed by recycle.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables VIII

| COMBINATION | FIGURES VIII- | TABLE VIII- |
|---|---|---|
| 1 | 110 - 113 | 29 |
| 2 | 10 - 12 | 5 |

Secondary Aluminum. New sources in this subcategory will have two possible wastewaters. These streams are:

1. Slag milling wastewater
2. Scrubber wastewater

The following combinations of these streams could exist:

| COMBINATION | MILLING | SCRUBBERS |
|---|---|---|
| 1 | x | x |
| 2 | | x |
| 3 | x | |

The following levels of treatment are presented for each combination with a schematic presentation provided in Figure VIII-117.

Level 1. For Combination 1--the slag milling water is completely recycled after primary settling. The scrubber water is treated by lime precipitation, followed by recycle.

For Combination 2--the scrubber effluent is treated by lime precipitation prior to recycle.

For Combination 3--the slag milling water is totally recycled after primary settling.

Level 2. For Combinations 1 and 2--filtration is added to level 1, followed by recycle.

Level 3. For Combinatons 1 and 2--reverse osmosis and complete recycle are added to level 2.

Level 4. For Combinations 1 and 2--activated carbon is added to level 2, followed by recycle.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables VIII

| COMBINATION | FIGURES VIII- | TABLE VIII- |
|---|---|---|
| 1 | 118 - 121 | 31 |
| 2 | 122 - 125 | 32 |
| 3 | 126 | |

Columbium-Tantalum. The columbium-tantalum industry has been divided into groups based on plant configuration. These groups are: ore to salt/metal, and salt to metal.

Ore to salt/metal

New sources in this group will have streams similar to those in existing sources. Five levels of treatment have been developed. The alternatives are described below and schematically presented in Figure VIII-127.

Level 1. Steam stripping and oxidation by chlorine are provided for treatment of the precipitation supernatant and the salt drying scrubber effluent, prior to recycle.

Level 2. The combined streams are treated by lime precipitation and filtration, followed by recycle.

Level 3. Activated alumina is added to level 2, followed by recycle.

Level 4. Reverse osmosis and complete recycle are added to level 3.

Level 5. Activated carbon added to level 3, followed by recycle.

The cost curves are presented in Figures VIII-128 to 132, while the summary of the associated pollution reduction is presented in Table VIII-33.

Salt to Metal

New plants will have wastewaters from the reduction scrubber and leachate processes. Five levels of treatment are presented. The alternatives are described below and presented schematically in Figure VIII-133.

Level 1. The combined streams are treated by lime precipitation, followed by recycle.

Level 2. Filtration is added to level 1, followed by recycle.

Level 3. Activated alumina is added to level 2.

Level 4. Reverse osmosis and complete recycle are added to level 3.

Level 5. Activated carbon is added to level 3, followed by recycle.

The cost curves are presented in Figures VIII-134 to 138, while the summary of the associated pollution reduction is presented in Table VIII-34.

Primary Copper. The primary copper industry has been segregated into two groups based on plant configuration. They are as follows:

Smelting and Refining

New sources belonging to this group will have two possible wastewaters: air pollution control wastewater and contact cooling water. Four levels of treatment have been developed. The alternatives are described below and schematically presented in Figure VIII-139.

Level 1. The supernatant from primary settling of the air pollution control wastewater is combined with the contact cooling water for treatment by lime precipitation and filtration prior to recycle.

Level 2. Activated alumina is added to level 1, followed by recycle.

Level 3. Reverse osmosis and complete recycle are added to level 2.

Level 4. Activated carbon is added to level 2, followed by recycle.

The cost curves are presented in Figures VIII-140 to 143, while the summary of the associated pollution reduction is presented in Table VIII-35.

Refining

New sources in this group will have only contact cooling water as a wastewater. Four levels of treatment are presented. The alternatives are described below and schematically presented in Figure VIII-144.

Level 1. Recycle of the contact cooling water and treatment of a five percent blowdown by lime precipitation and filtration prior to recycle.

Level 2. Activated alumina is added to level 1, followed by recycle.

Level 3. Reverse osmosis and complete recycle are added to level 2.

Level 4. Activated carbon is added to level 2, followed by recycle.

The cost curves are presented in Figures VIII-145 to 148, while the summary of the associated pollution reduction is presented in Table VIII-36.

An additional level of treatment can be added on to or used in place of the alternatives given for both subcategories for any

plant located in an area of net evaporation. For such plants, the alternative is an evaporation lagoon. The cost for a lagoon located in an area of 20 inches net effective evaporation per year is presented in Figure VIII-59.

Secondary Copper. New sources in this subcategory will have two possible wastewater sources. They are contact cooling water and slag milling wastewater. Two possible combinations can exist and are shown in the following tabulation.

| COMBINATION | CONTACT COOLING | MILLING |
|---|---|---|
| 1 | x | x |
| 2 | x | |

Alternatives for combinations 1 and 2 are the same as for combinations 1 and 2, respectively, for existing sources. The alternatives are schematically presented in Figure VIII-87.

The cost curves are presented in Figures VIII-62 to 67, while the summaries of the associated pollution reduction are presented in Tables VIII-14 and 15.

Primary Lead. New sources in this subcategory will have one waste stream: blowdown from the acid plant. Two conditions may exist for this subcategory: areas of net precipitation and areas of net evaporation.

For all plants, three levels of treatment are presented. The alternatives are described below and are presented schematically in Figure VIII-157.

Level 1. Lime precipitation and filtration, prior to recycle.

Level 2. Activated carbon is added to level 1, followed by recycle.

Level 3. Reverse osmosis and complete recycle are added to level 2.

Another level of alternative treatment for new sources built in an area of net evaporation is evaporation lagoons.

The cost curves are presented in Figures VIII-158 to 160, while the summary of the associated pollution reduction is presented in Table VIII-39. The costs for a lagoon located in an area of 20 inches net effective evaporation per year is presented in Figure VIII-59.

Secondary Lead. New sources in this group may have the following wastewaters in the following combinations:

| COMBINATION | BATTERY ACID AND SAW WATER | SCRUBBER WATER |
|---|---|---|
| 1 | x | |
| 2 | x | x |

Alternatives for combinations 1 and 2 are the same as for combinations 1 and 2, respectively, for existing sources. The alternatives are schematically presented in Figure VIII-76.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in Tables VIII

| COMBINATION | FIGURES VIII- | TABLE VIII- |
|---|---|---|
| 1 | 77 - 80 | 20 |
| 2 | 81 - 84 | 21 |

Secondary Silver. This industry has been divided into two subcategories. These subcategories are:

Photographic

New sources in this group will have three possible wastewaters; precipitation/filtration supernatant, stripping air pollution control, and furnace air pollution control. These alternatives are the same as for existing sources and are schematically presented in Figure VIII-85.

The cost curves are presented in Figures VIII-86 to 89, while the summary of the associated pollution reduction is presented in Table VIII-22.

Non-Photographic

New sources in this group will have the same wastewaters as the photographic group. alternatives are the same as for existing sources and are schematically presented in Figure VIII-90.

The cost curves are presented in Figures VIII-91 to 93, while the summary of the associated pollution reduction is presented in Table VIII-23.

Primary Tungsten. This industry has been segregated into two groups based on plant configuration. The groups are:

Ore to Salt/Metal

New sources in this group will have the same wastewaters as the existing sources. Two possible combinations could result, one being those plants which do not have significant concentrations of ammonia in their wastewater and the other being those plants that do.

Three levels of treatment are presented for combination 1. The alternatives are:

Level 1. The combined streams are treated by lime precipitation and filtration, followed by recycle.

Level 2. Reverse osmosis and complete recycle are added to level 1.

Level 3. Activated carbon is added to level 1, followed by recycle.

Four levels of treatment are presented for combination 2. The alternatives are:

Level 1. The high ammonia streams are treated by steam stripping, prior to recycle.

Level 2. Chemical precipitation and filtration are added to level 1, followed by recycle.

Level 3. Reverse osmosis and complete recycle are added to level 2.

Level 4. Activated carbon is added to level 2, followed by recycle.

The alternatives for both combinations are schematically presented in Figure VIII-179.

The cost curves are presented in the figures listed below. The summaries of the associated pollution reduction are shown in the tables.

| COMBINATION | FIGURES VIII- | TABLE VIII- |
|---|---|---|
| 1 | 180 - 182 | 44 |
| 2 | 183 - 186 | 45 |

Salt to Metal

New sources in this group will have the same wastewaters as the existing sources. Four levels of treatment have been developed. The alternatives are described below and schematically presented in Figure VIII-187.

Level 1. Steam stripping is provided for treatment of high ammonia streams, prior to recycle.

Level 2. Lime precipitation is used to treat the combined streams, followed by recycle.

Level 3. Filtration is added to level 2, followed by recycle.

Level 4. Activated carbon is added to level 3, followed by recycle.

The cost curves are presented in Figures VIII-188 to 191, while the summary of the associated pollution reduction is presented in Table VIII-46.

Primary Zinc. New sources in this subcategory will have wastewater from two sources: blowdown from the acid plant and wastewater from air pollution control of the leaching operation. These two streams can be combined and treated by four levels of treatment. The alternatives are described below and schematically presented in Figure VIII-192.

Level 1. Lime precipitation is used for treatment of the combined streams prior to recycle.

Level 2. Filtration is added to level 1, followed by recycle.

Level 3. Reverse osmosis and complete recycle are added to level 2.

Level 4. Activated carbon is added to level 2, followed by recycle.

The cost curves are presented in Figures VIII-193 to 196, while the summary of the associated pollution reduction is presented in Table VIII-47.

ENERGY ASPECTS

An investigation was made to determine the added energy requirement for a plant caused by the installation of a wastewater treatment system. The energy consumption reported in the data collection portfolios was tabulated and the median total plant energy consumption was calculated and is reported as Btu's/year for each industry group. For each group, the median

sized plant was determined, based on flow rate. The most complex set of treatment alternatives for each group, and corresponding energy requirement for each level of treatment was determined. These requirements are expressed as the maximum percent increase in energy requirements caused by the installation of a wastewater treatment system. This investigation is summarized in Table VIII-48. By reviewing this table, it can be seen that the added energy requirement is less than 1% of the total plant energy requirement for a majority of the alternatives. Those alternatives that require an increase greater than 1% include reverse osmosis in the treatment sequence.

## NON-WATER QUALITY ASPECTS

### Sludge

Sludge disposal is a problem in this industry. As shown in previous sections, the waste streams being discharged contain large quantities of heavy metals; the most common method of removing the metals is by lime precipitation. Consequently, large volumes of heavy metal-laden sludge are generated that must be disposed of. Table VIII-49 summarizes the methods currently in use, along with their frequency of occurrence, for treating and disposing of sludges.

The technologies that directly generate sludge are:

1. Chemical precipitation
2. Multi-media filtration
3. Primary sedimentation
4. Reverse osmosis

Sludge is also indirectly generated by the recycling of the spent activated alumina regenerant, containing fluoride or arsenic, to the chemical precipitation unit.

The sludge resulting from the four technologies listed above will vary in characteristics depending on the subcategory and combination of streams being treated. However, in most cases, the majority of the sludge produced is a result of chemical precipitation. This sludge will, in general, contain large quantities of calcium salts, due to the use of lime, and large quantities of precipitated metals. The sludge indirectly generated from activated alumina will contain large quantities of fluoride or arsenic. The estimated characteristics of the sludge generated by the sets of alternatives presented for BAT are given in Table VIII-50.

A major concern in the disposal of sludges is the contamination of soils, plants, and animals by the heavy metals contained in

sludge. The leaching of heavy metals from sludge and subsequent movement through soils is enhanced by acidic conditions. Sludges treated with lime prior to disposal possess high pH values and exhibit little loss of metals (110). Since the largest amount of sludge that results from the alternatives presented previously is generated by lime precipitation, it is not that the metals will be readily leached from the sludge. Disposal of sludges in a lined sanitary landfill will further reduce the possibility of heavy metals contamination of soil, plants and animals.

Other methods of treating and disposing of sludge are available. Table VIII-49 shows that one method currently being used at a number of plants is reuse or recycle, usually to recover metals. Table VIII-50 shows that the metal concentrations in some sludges may be substantial. Consequently, it may be cost effective for some plants to recover the metal fraction of their sludges prior to disposal.

Hazardous Wastes

EPA recently proposed hazardous waste guidelines and regulations (December 18, 1978, 43 FR 58946-59027). These proposals covered:

1) criteria for identifying and listing hazardous waste, identification methods, and a hazardous waste list;
2) standards applicable to generators of such waste for recordkeeping, labelling, containerizing, and using a transport manifest;
3) performance standards for hazardous waste management facilities.

The proposed regulations create a "cradle-to-grave" management control system for hazardous waste. Solid waste which is not subject to the hazardous waste regulations will be subject to the requirements of Subtitle D of the Resource Conservation and Recovery Act of 1976, under which open dumping is prohibited and environmentally acceptable practices are required.

A hazardous waste is a waste which is toxic, ignitable, corrosive, or reactive, or which is listed in 40 CFR 250.14. A toxic waste is defined as one, which after undergoing an acetic acid extraction, has more than the following contaminant levels in the extract. The contaminants and extract levels of most concern to the nonferrous metals industry are:

| Contaminant | Extract Level (mg/l) |
|---|---|
| Arsenic | 0.50 |
| Barium | 10.00 |
| Cadmium | 0.10 |
| Chromium | 0.50 |
| Lead | 0.50 |
| Mercury | 0.02 |
| Selenium | 0.10 |
| Silver | 0.50 |

The specific hazardous wastes from the nonferrous metals industry listed in 40 CFR 250.14 are the following, by SIC code:

| | |
|---|---|
| 3331 | Primary copper smelting and refining electric furnace slag, converter dust, acid plant sludge, and reverberatory dust |
| 3332 | Primary lead blast furnace dust |
| 3332 | Primary lead lagoon dredging from smelter |
| 3333 | Zinc acid plant blowdown lime treatment: gypsum cake (acid cooling tower and neutral cooling tower) |
| 3333 | Zinc production: oxide furnace residue and acid plant sludge |
| 3333 | Zinc anode sludge |
| 3339 | Primary antimony-electrolytic sludge |
| 3339 | Primary tungsten-digestion residues |
| 3339 | Primary lead sinter dust scrubbing sludge |
| 3339 | Primary antimony-pyrometallurgical blast furnace slag |
| 3341 | Secondary lead, scrubber sludge from $SO_2$ emission control, soft lead production |
| 3341 | Secondary lead-white metal production furnace dust |
| 3341 | Secondary copper-pyrometallurgical blast furnace slag |
| 3341 | Secondary copper-electrolytic refining wastewater treatment sludge |
| 3341 | Secondary aluminum dross smelting-high salt slag plant residue |

Spent potliners (or cathodes) from primary aluminum reduction, and other nonferrous metals industry wastes, were added to this list in a proposal published August 22, 1979 in the Federal Register.

Air Pollution

Various forms of both wet and dry air pollution control methods are utilized throughout the industry. Replacement of wet systems

by dry systems will reduce the pollutant loading discharged by a plant. The alternatives for BAT presented in this section assume that those plants presently using wet air pollution control systems would not change to dry systems since it may be more cost effective to treat and recycle the wastewater from the wet system than to replace it with a dry system. For those plants where it is not more cost effective, the cost estimates presented are conservative estimates. It was assumed that new sources would install dry systems instead of wet systems when it has been established that dry systems could sufficiently control the air quality of a given process operation.

At this time there are no other known non-water quality aspects in terms of soil infiltration, air pollution, noise or radiation that may result from the application of the treatment alternatives presented.

FIGURE VIII-1. GEOGRAPHICALLY DISTRIBUTED CAPITAL COST FACTORS

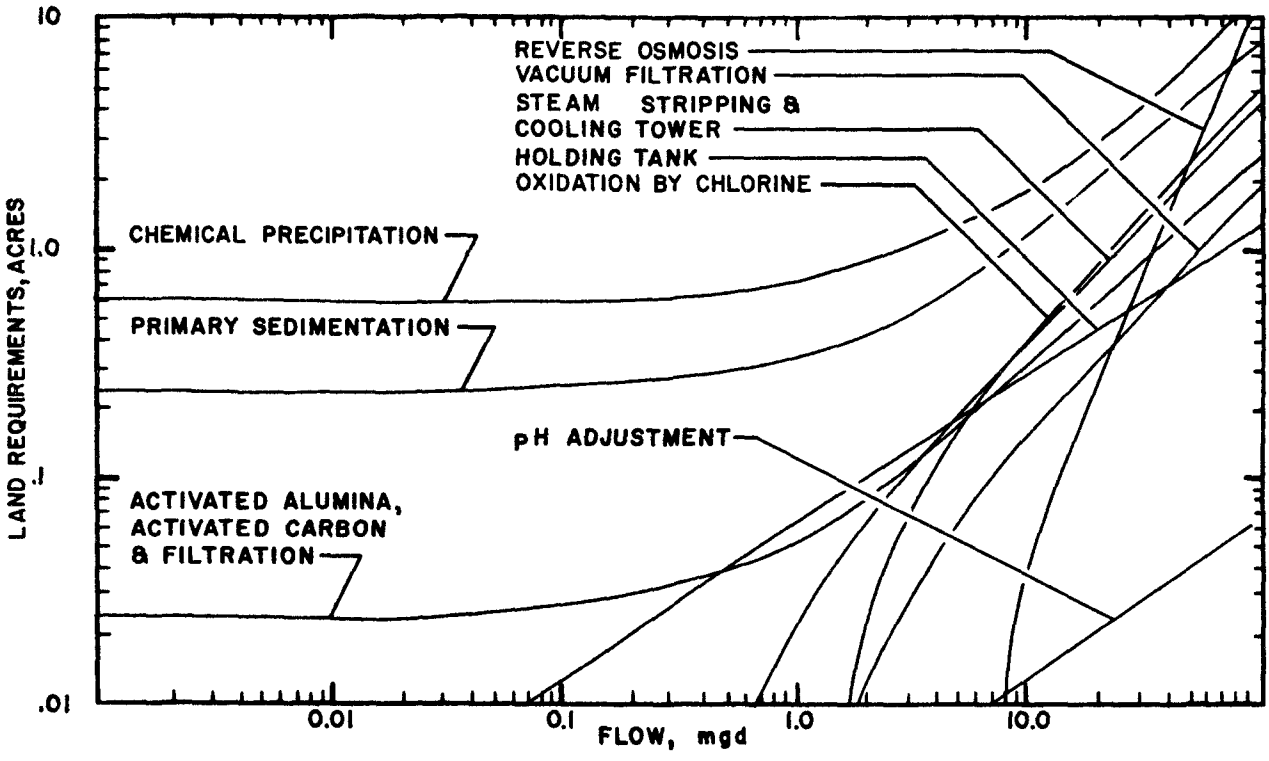



FIGURE VIII-2. LAND REQUIREMENTS

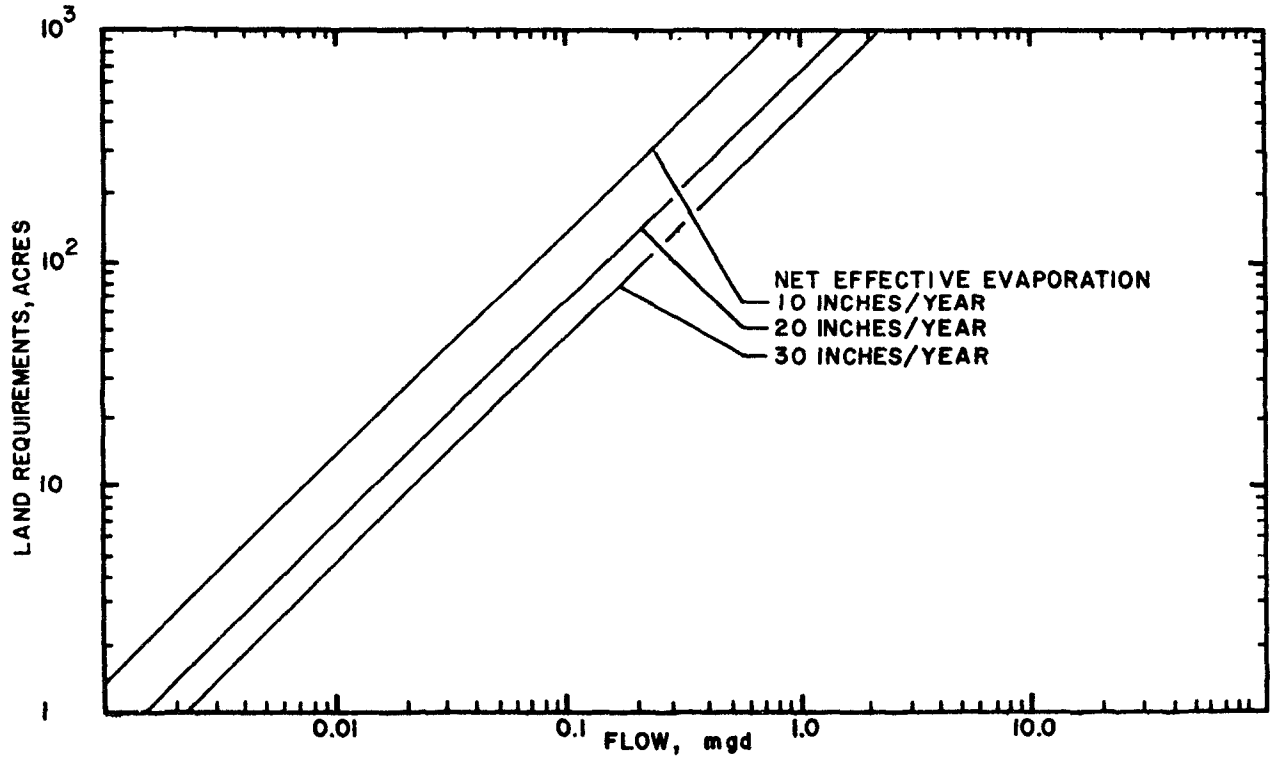



FIGURE VIII-3. EVAPORATION LAGOON LAND REQUIREMENTS

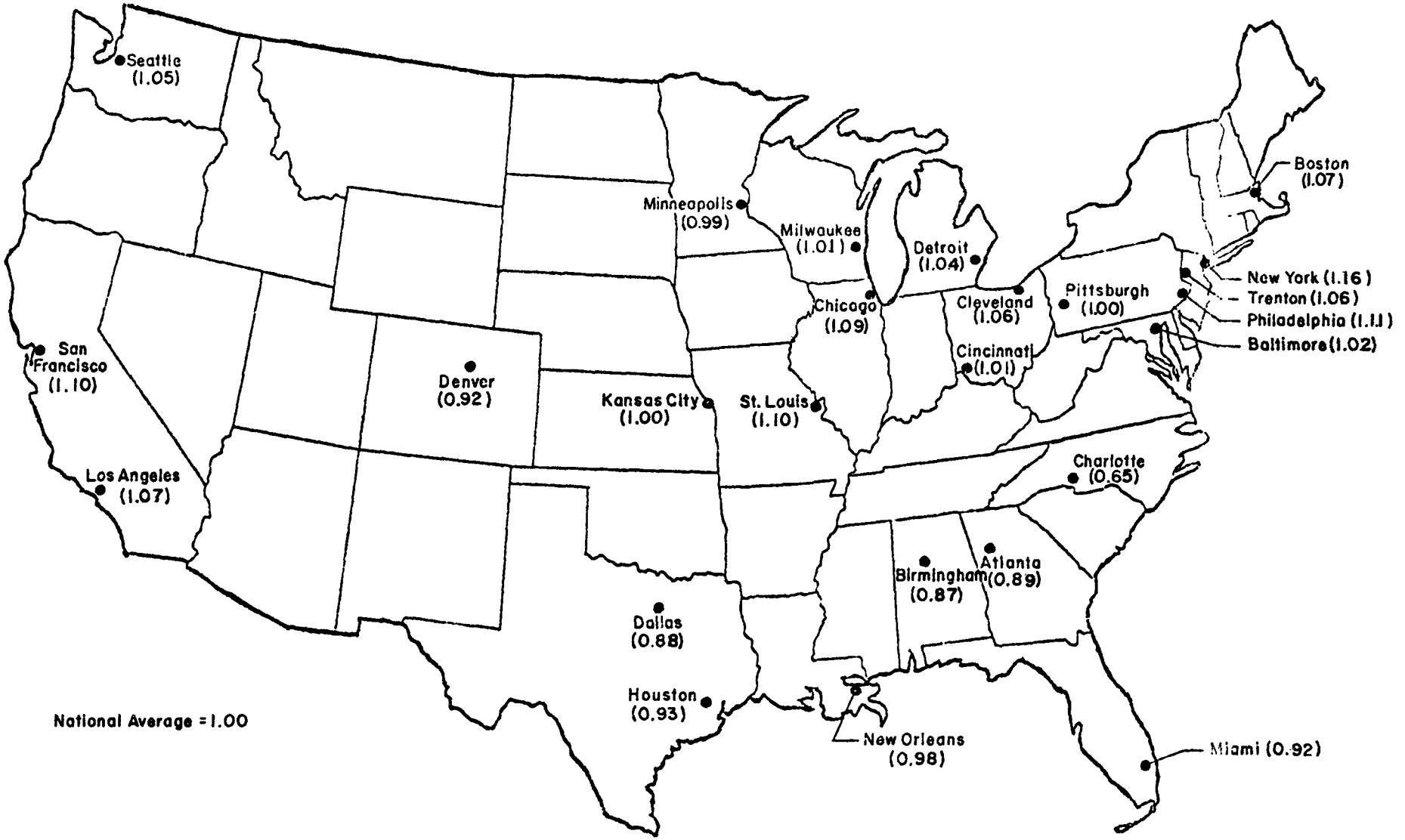



FIGURE VIII-4. GEOGRAPHICALLY DISTRIBUTED WAGE RATE FACTORS

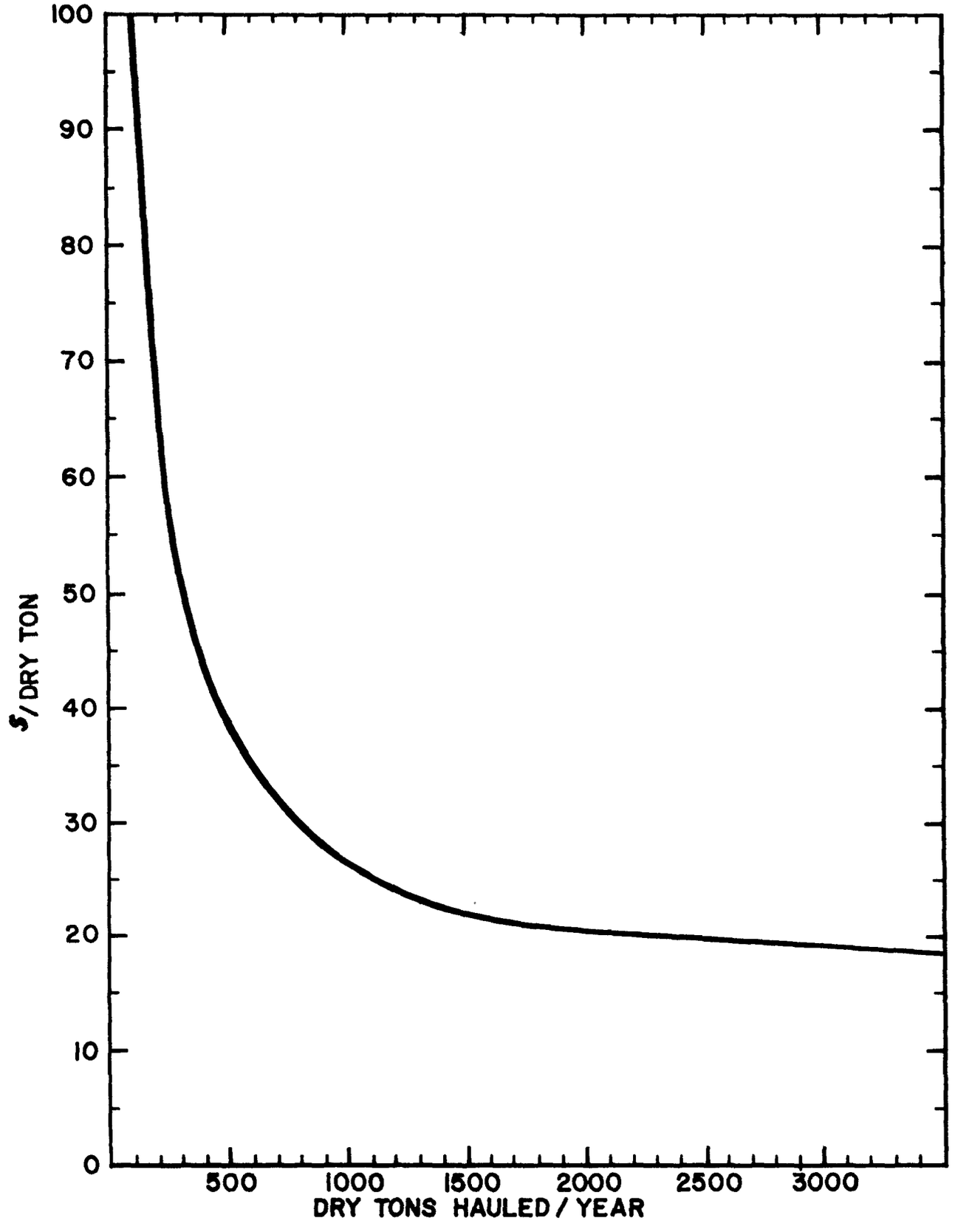
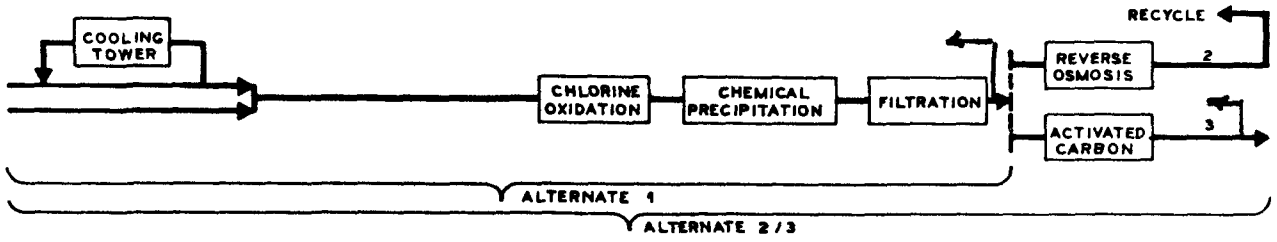
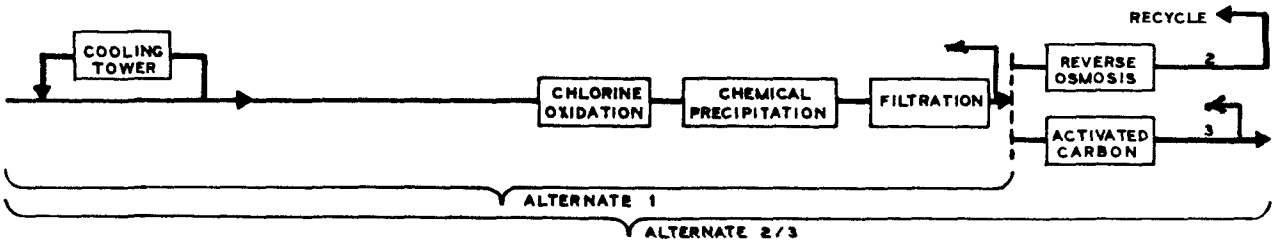


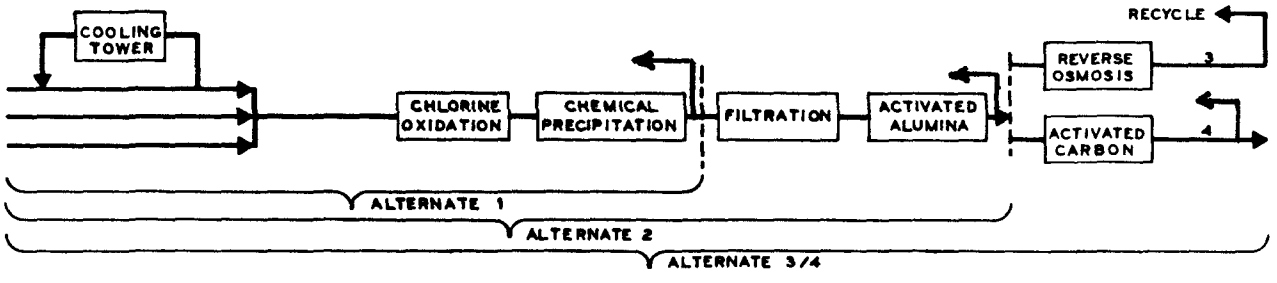

FIGURE VIII-5. SLUDGE HAULING COSTS
10 MILE ROUND TRIP



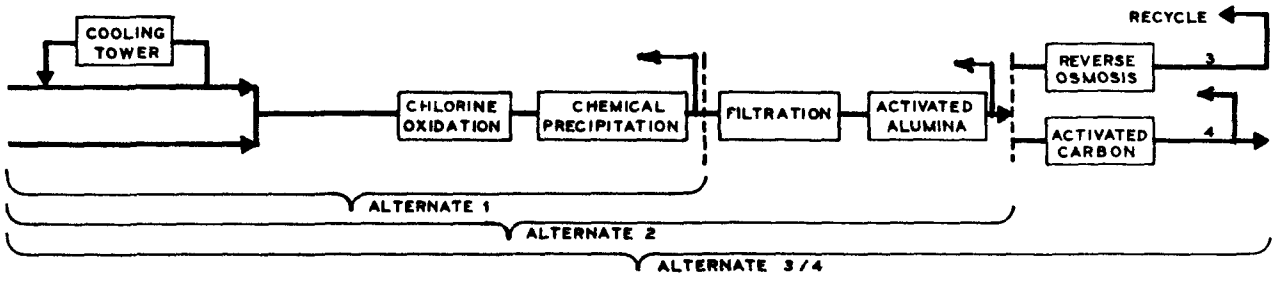

COMBINATION 1
(CONTACT COOLING, PASTE PLANT,



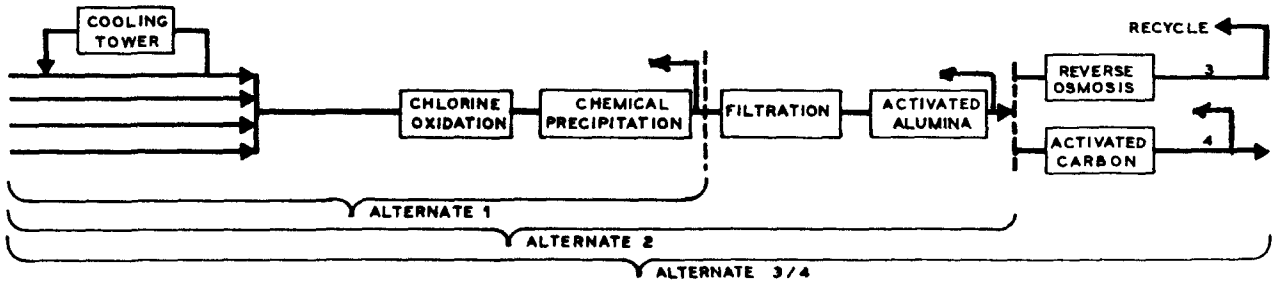

COMBINATION 2
(CONTACT COOLING)




COMBINATION 3
(CONTACT COOLING, REDUCTION SCRUBBER, PASTE PLANT)




COMBINATION 4
(CONTACT COOLING, REDUCTION SCRUBBER)




COMBINATION 5
(CONTACT COOLING, REDUCTION SCRUBBER, PASTE PLANT, CRYOLITE RECOVERY)

FIGURE VIII-6. PRIMARY ALUMINUM TREATMENT SCHEMES

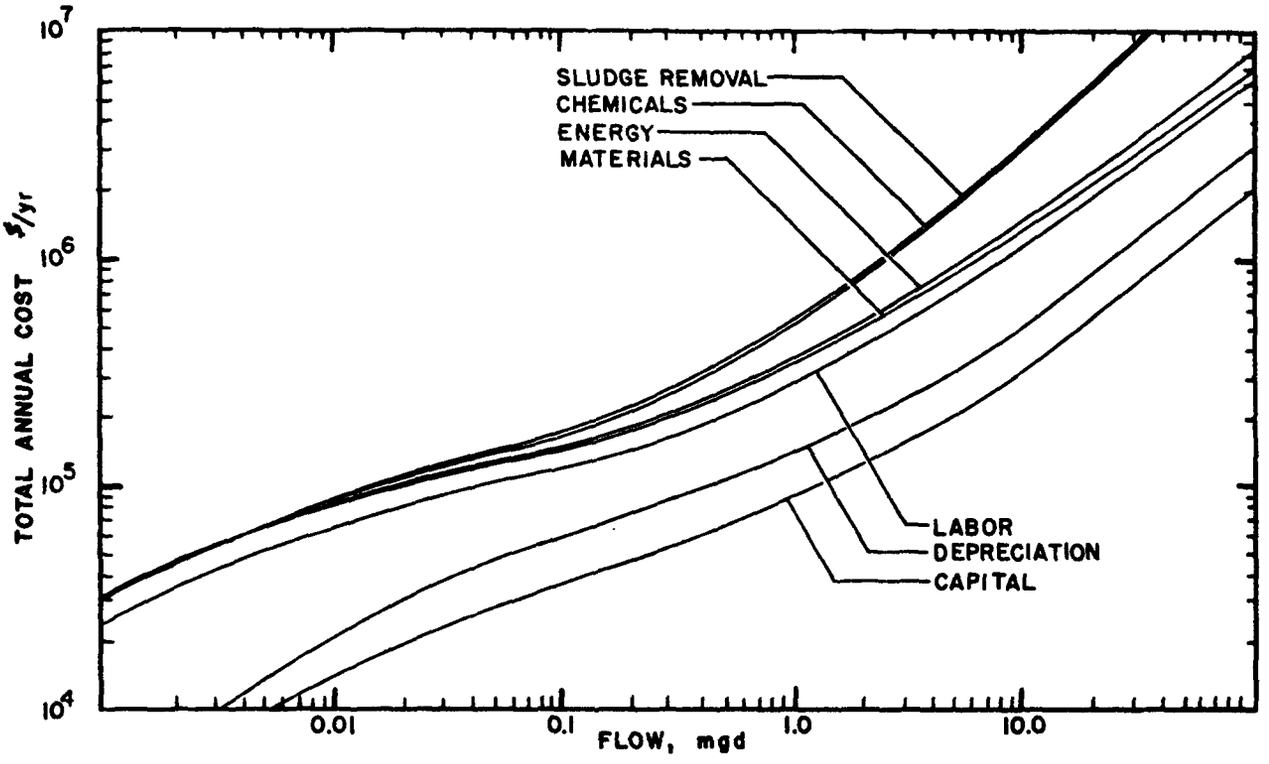



FIGURE VIII-7. PRIMARY ALUMINUM COMB. 1, ALT. 1

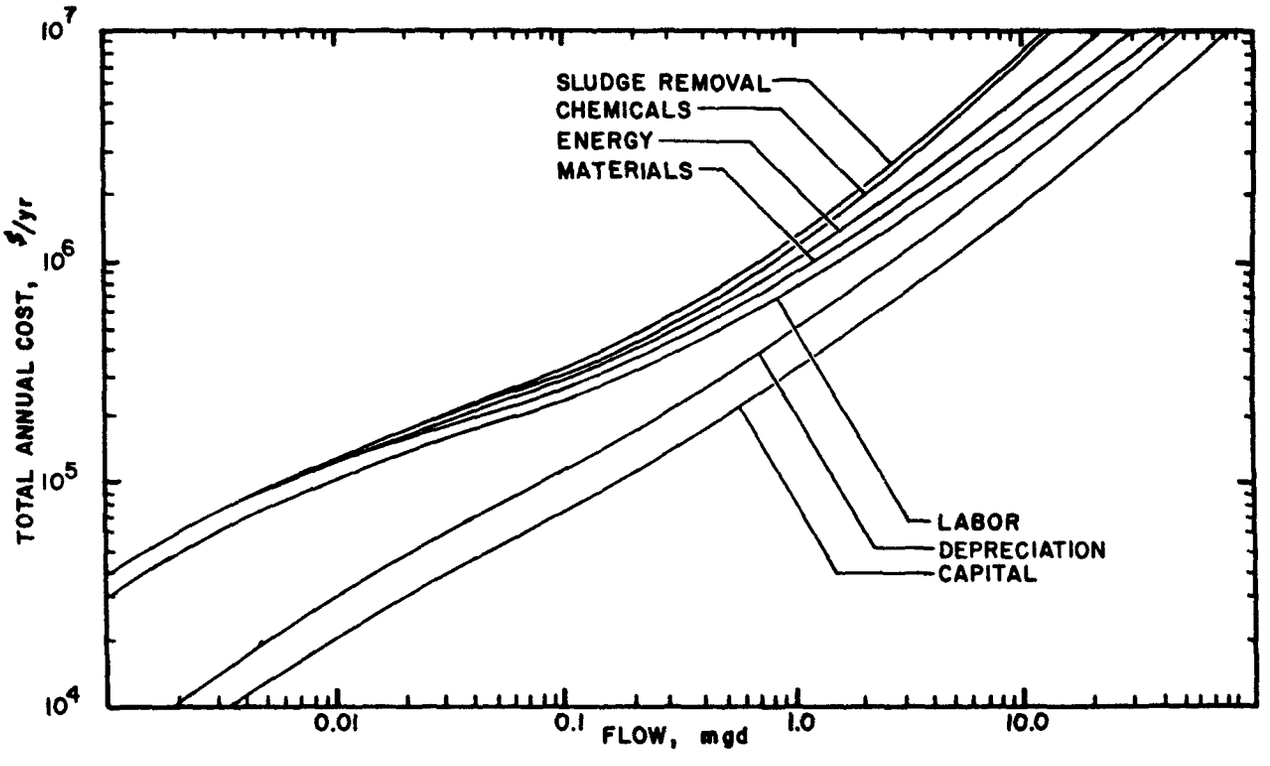



FIGURE VIII-8. PRIMARY ALUMINUM COMB. 1, ALT. 2

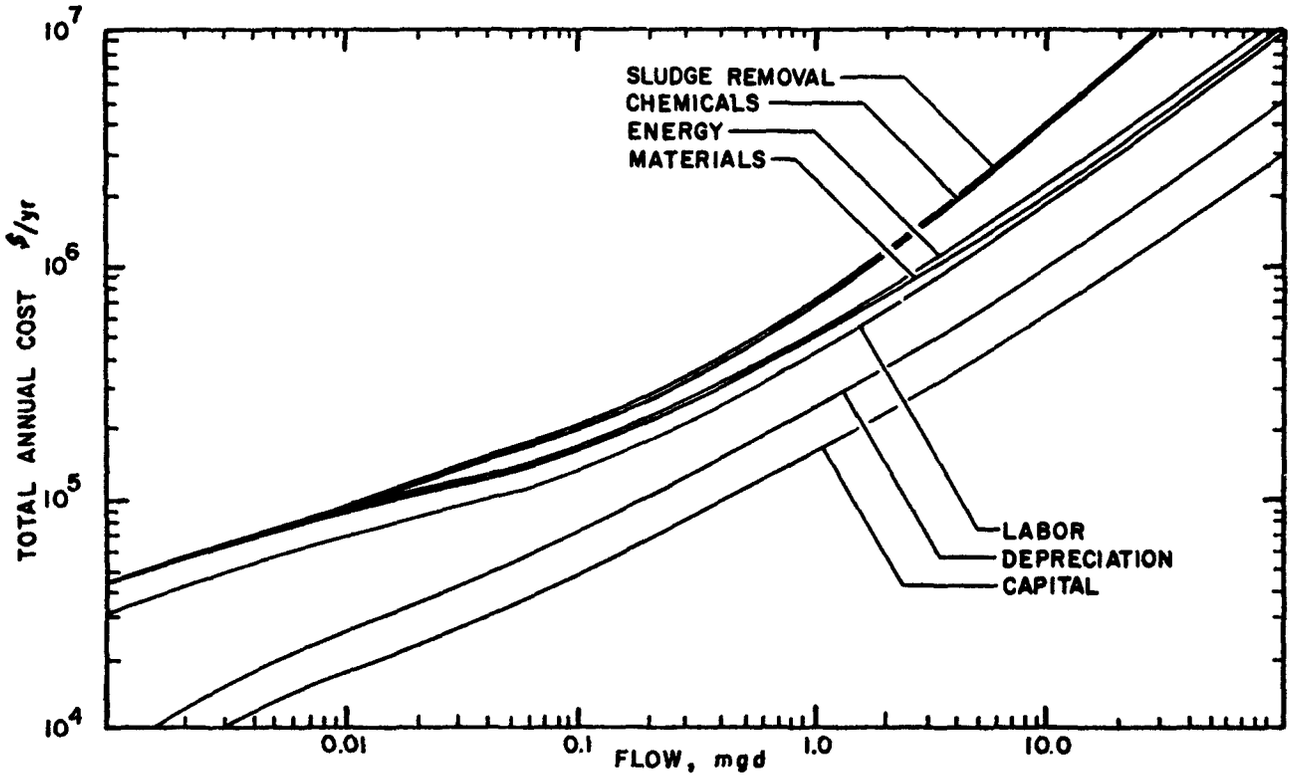



FIGURE VIII-9. PRIMARY ALUMINUM COMB. 1, ALT. 3

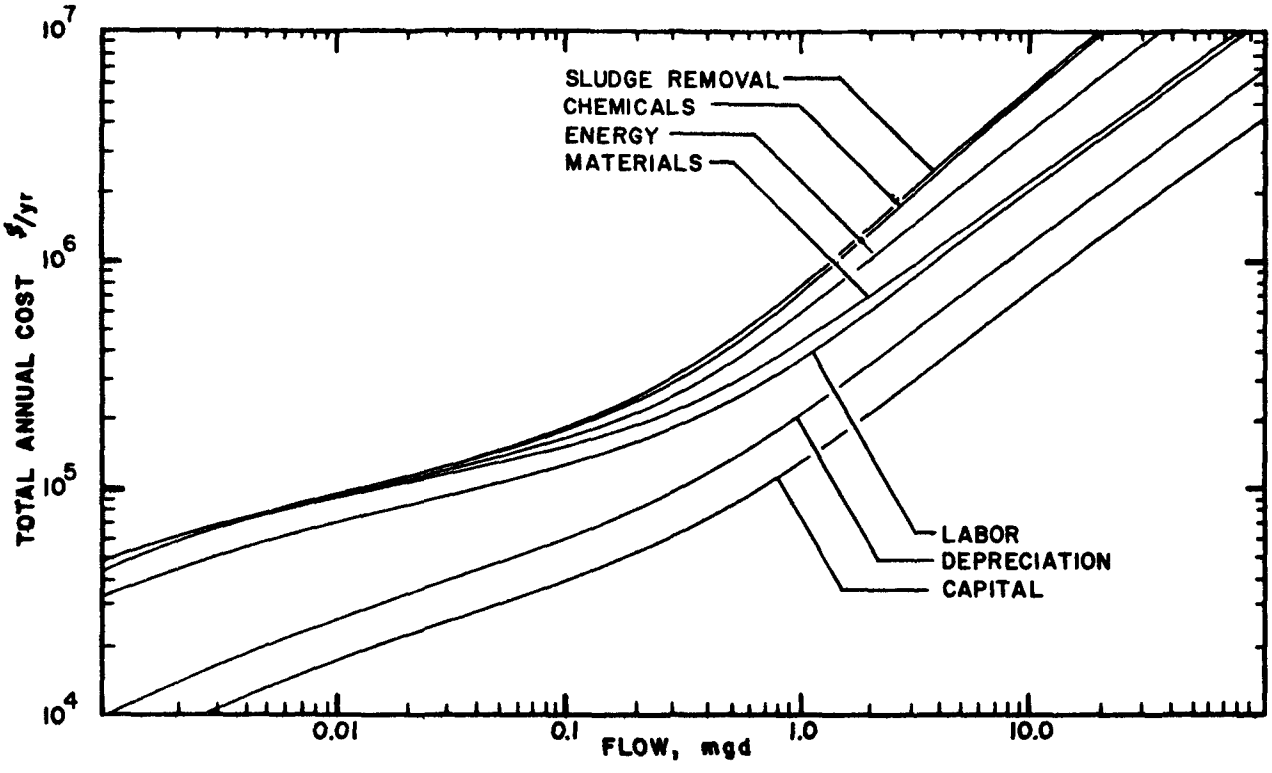



FIGURE VIII-10. PRIMARY ALUMINUM COMB. 2, ALT. 1

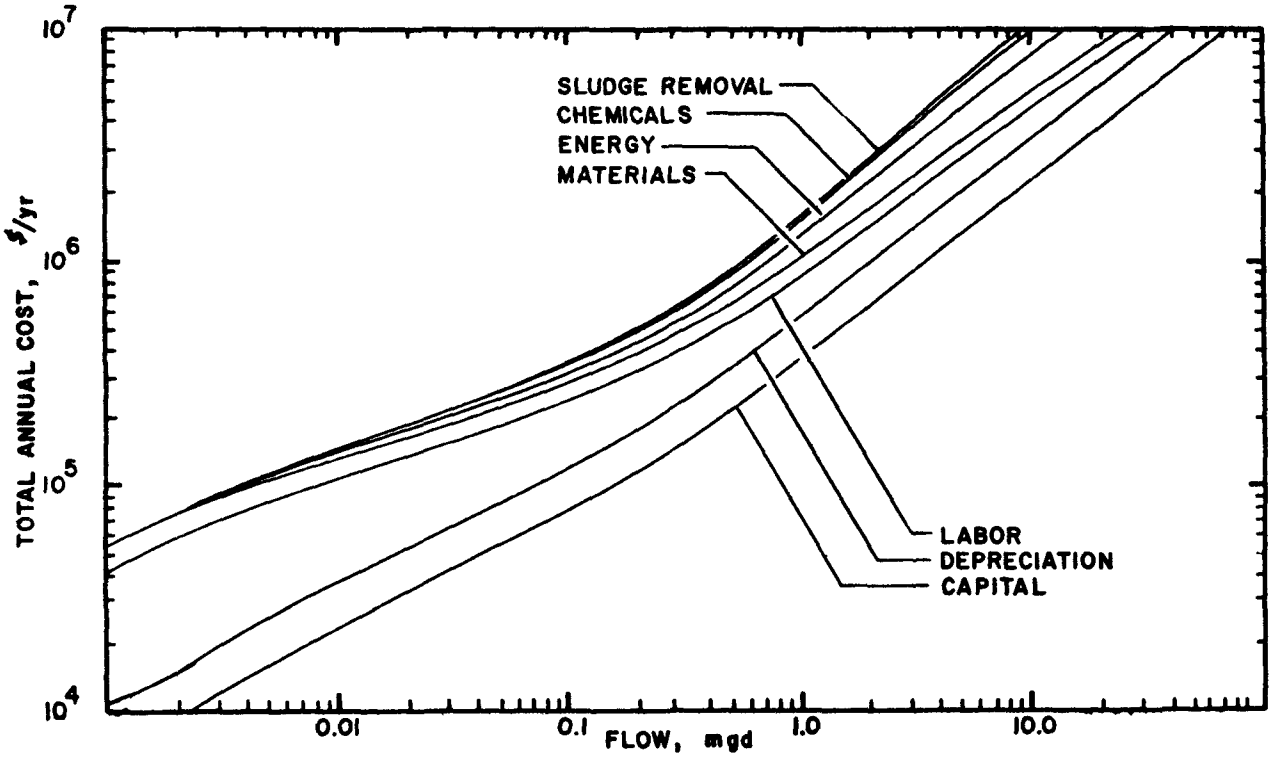



FIGURE VIII-11. PRIMARY ALUMINUM COMB. 2, ALT. 2

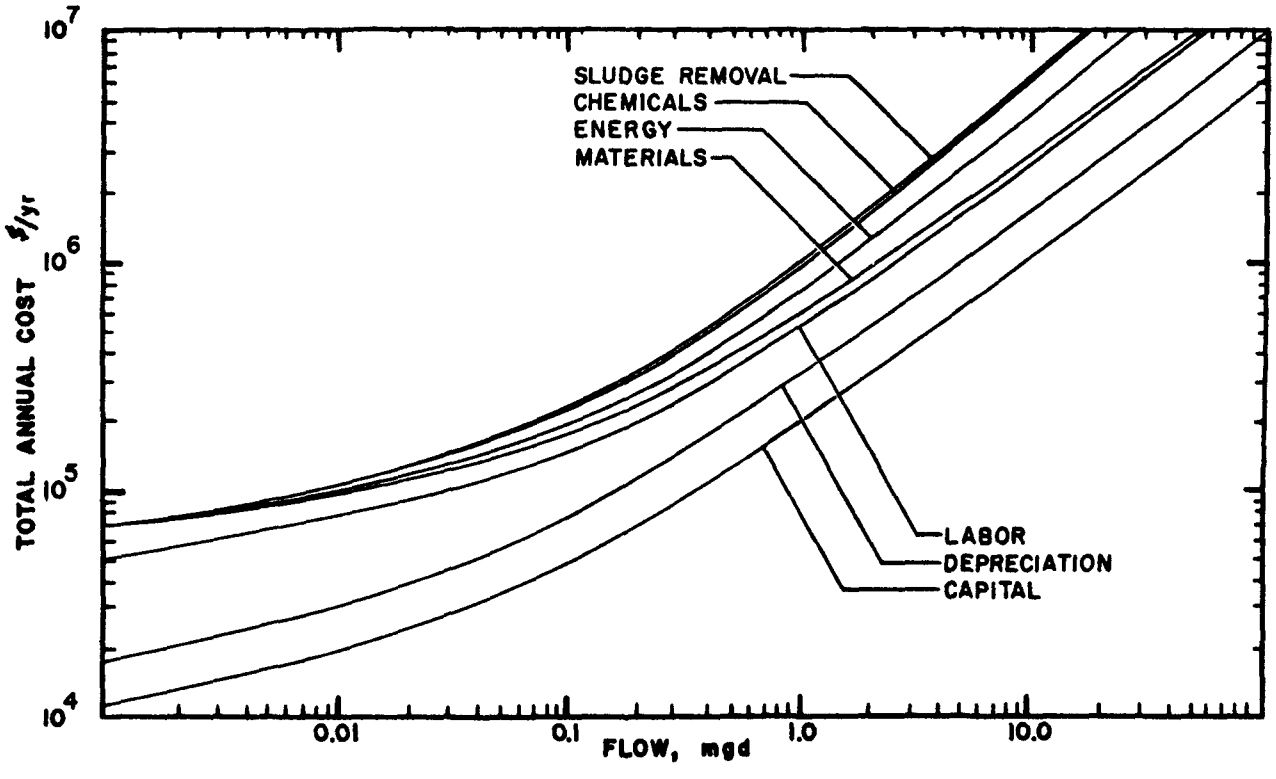



FIGURE VIII-12. PRIMARY ALUMINUM COMB.2, ALT. 3

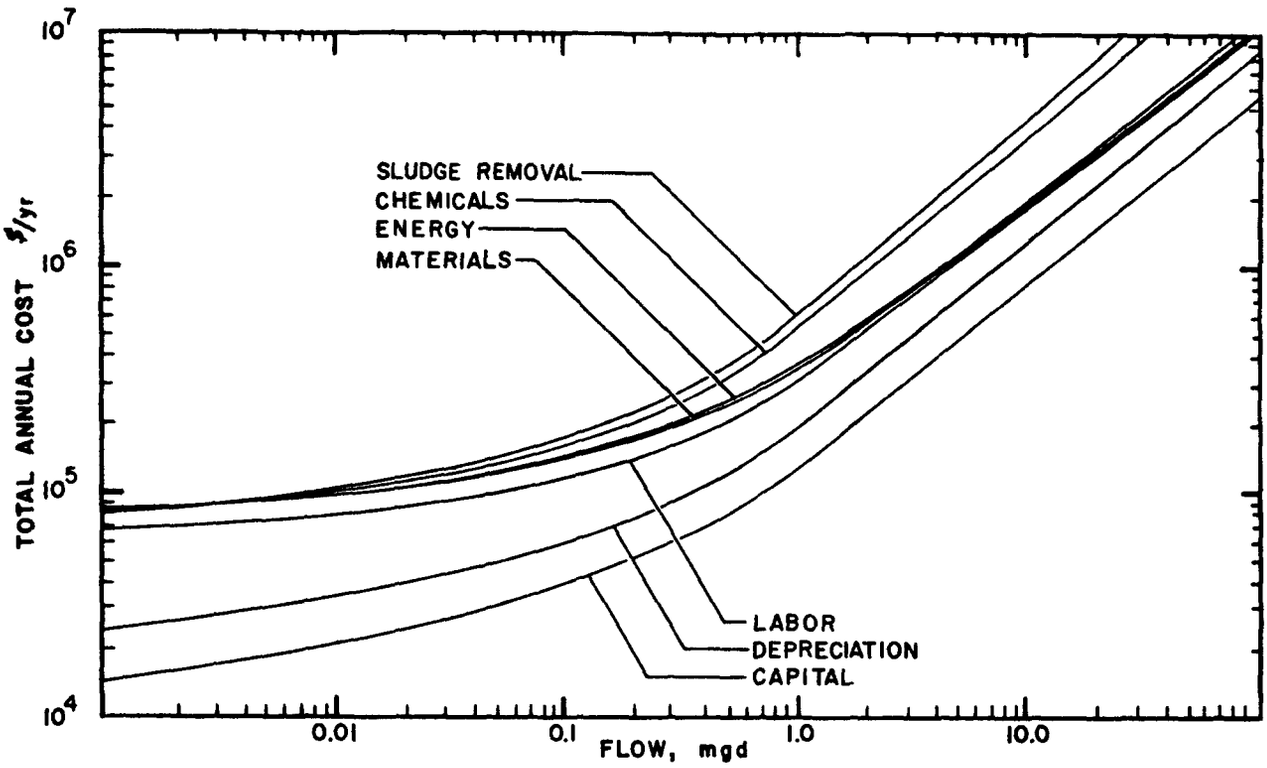



FIGURE VIII-13. PRIMARY ALUMINUM COMB. 3 & 5 , ALT. 1

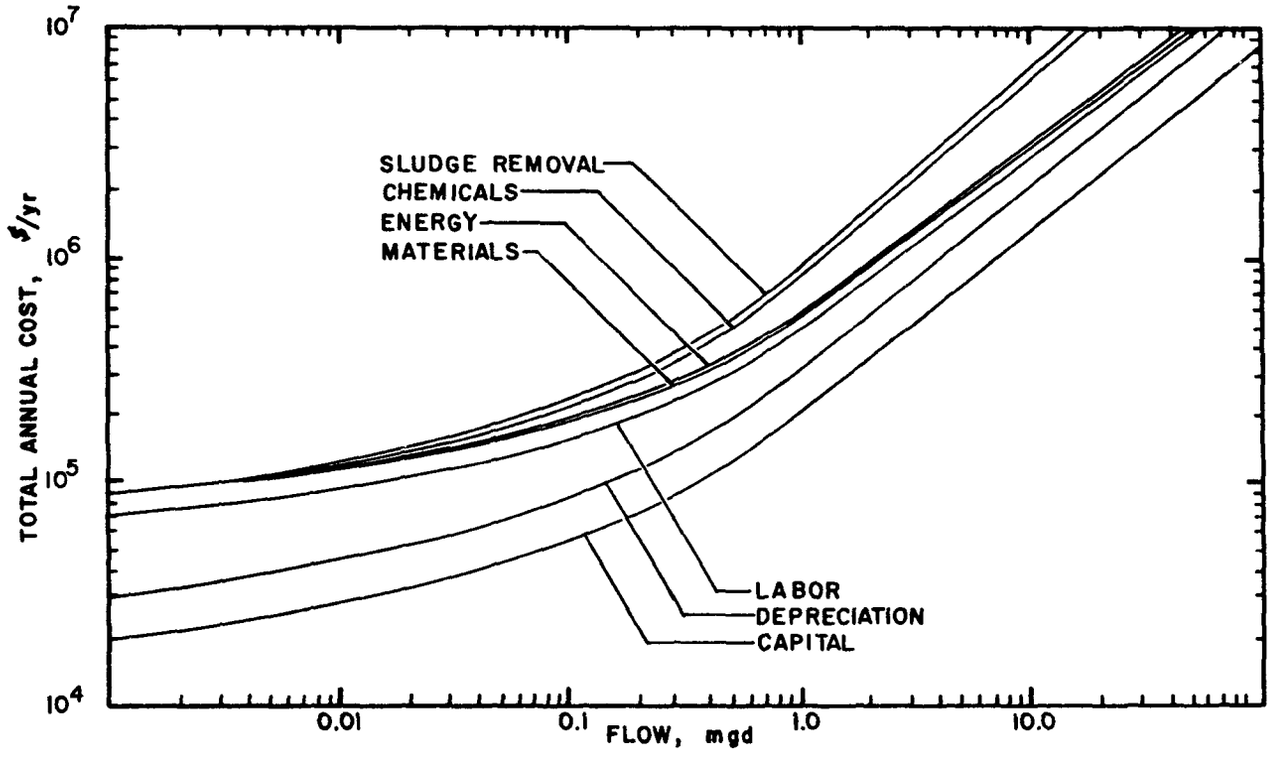



FIGURE VIII-14. PRIMARY ALUMINUM COMB. 3 & 5, ALT. 2

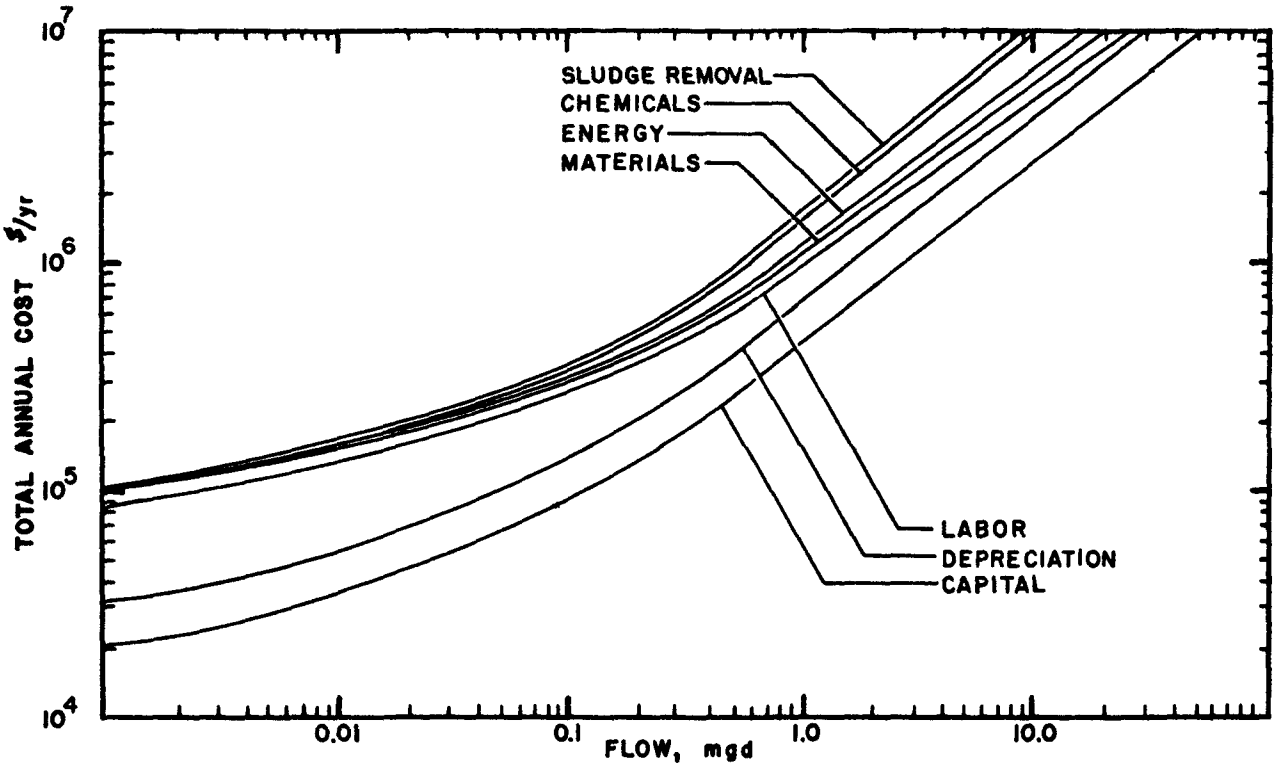



FIGURE VIII-15. PRIMARY ALUMINUM COMB. 3 & 5, ALT. 3

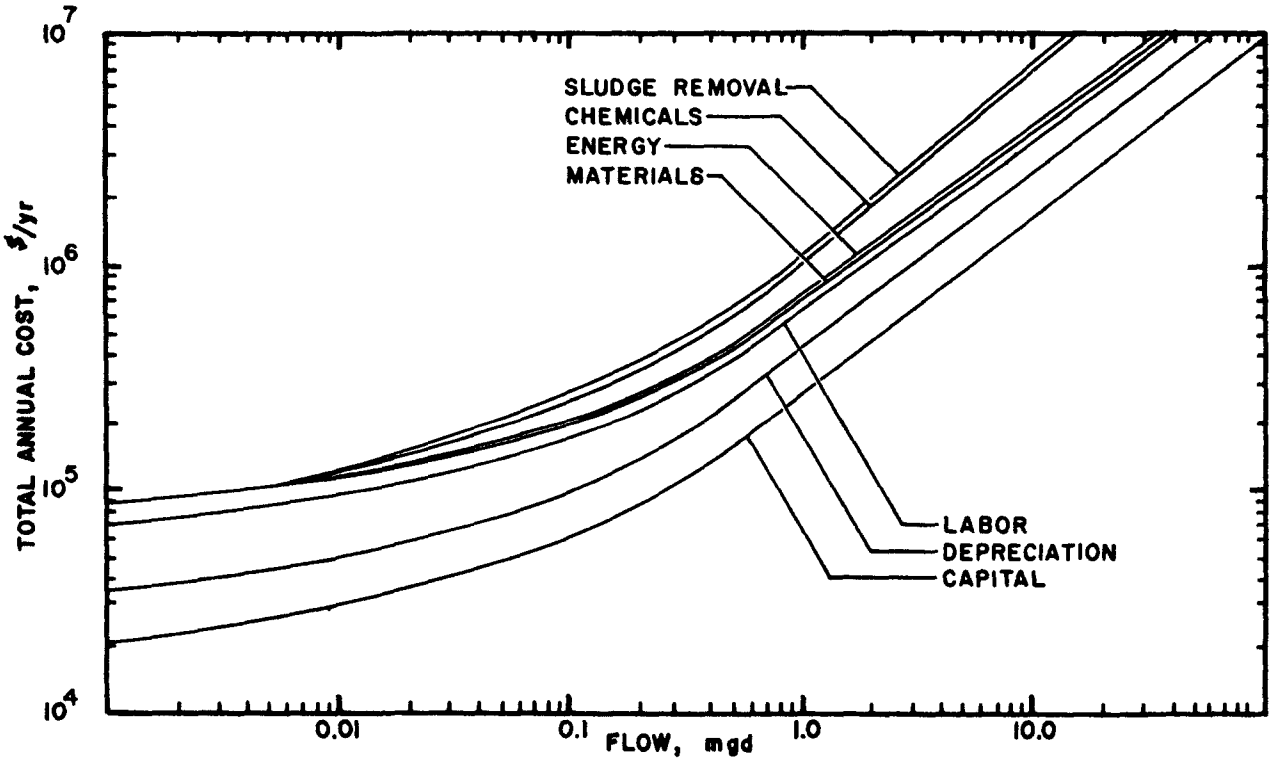



FIGURE VIII-16. PRIMARY ALUMINUM COMB. 3&5 , ALT. 4

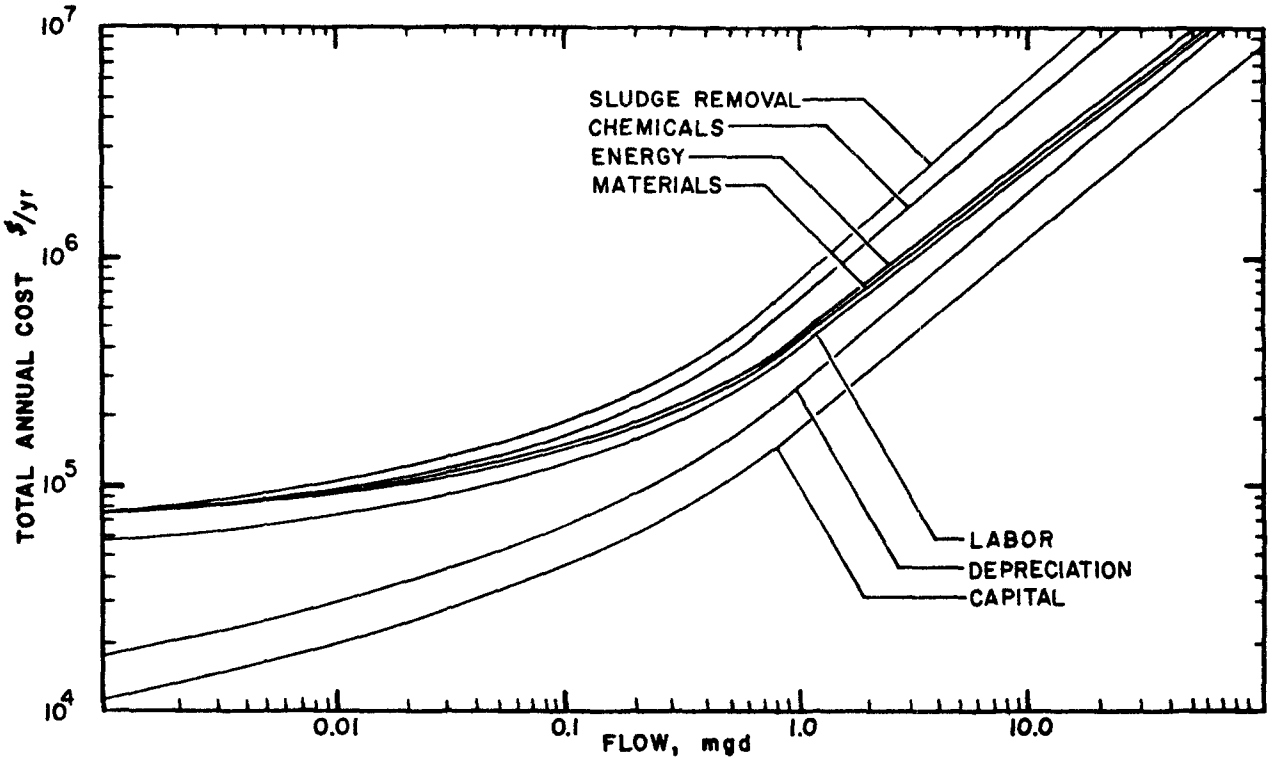



FIGURE VIII-17. PRIMARY ALUMINUM COMB. 4 , ALT. 1

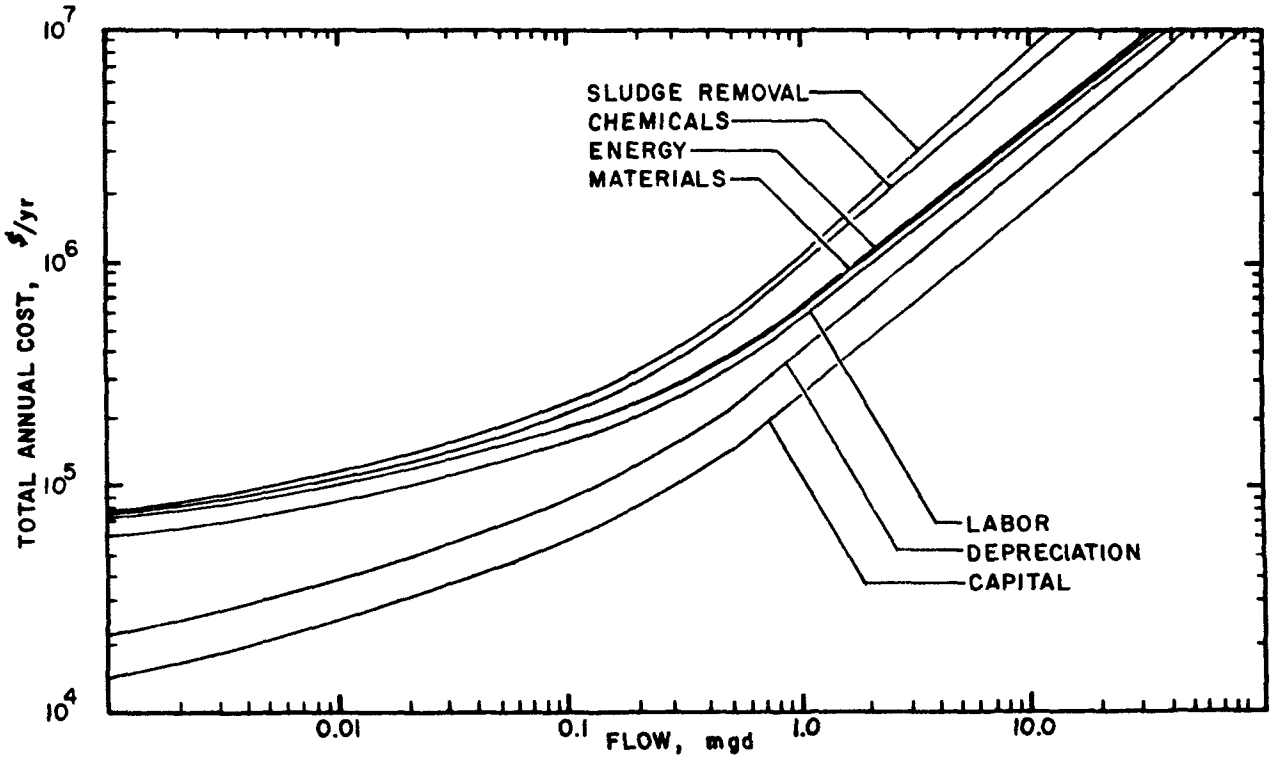



FIGURE VIII-18. PRIMARY ALUMINUM COMB. 4 , ALT. 2

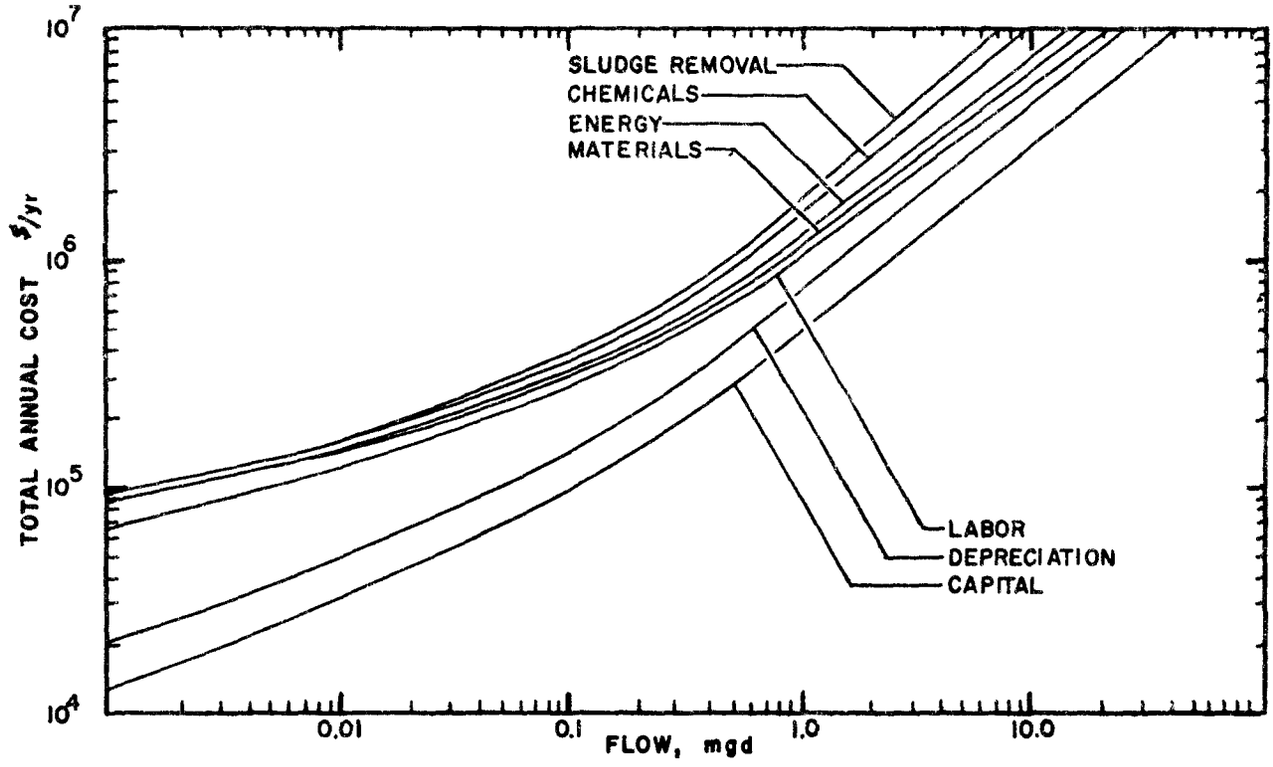



FIGURE VIII-19. PRIMARY ALUMINUM COMB. 4 , ALT. 3

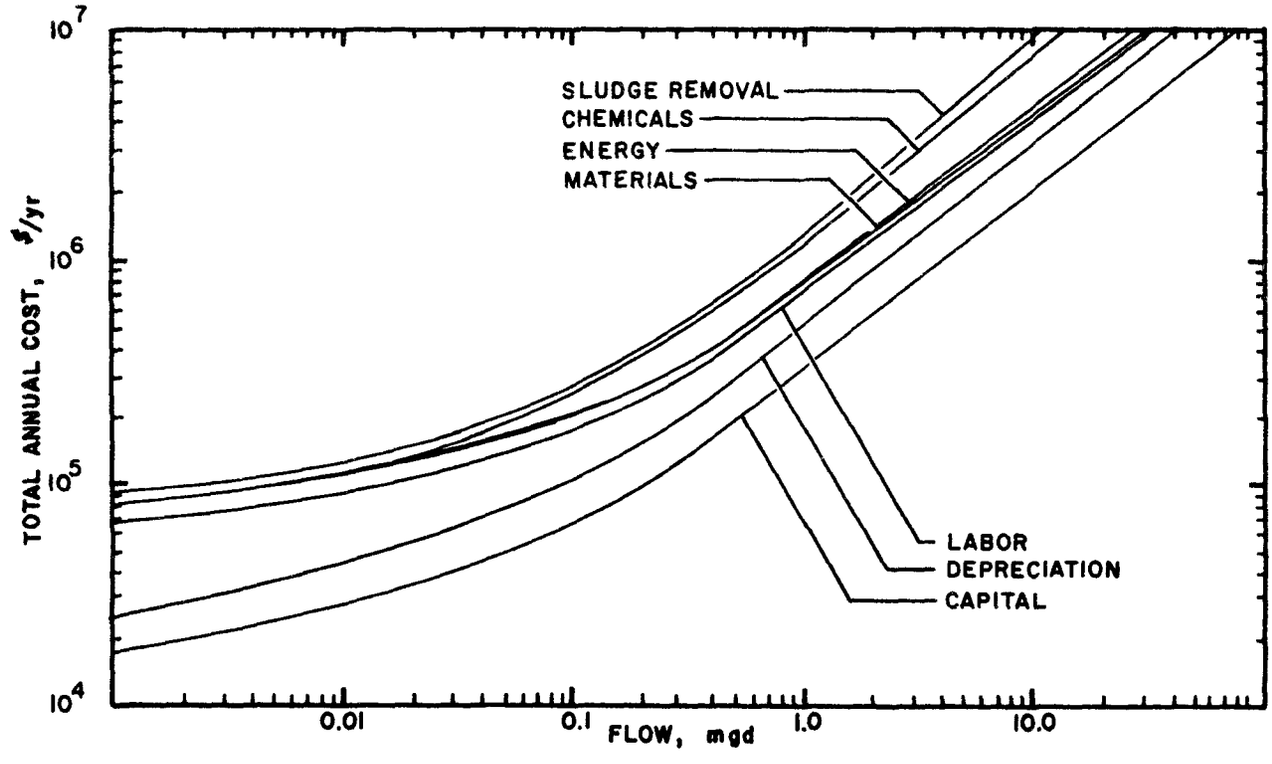
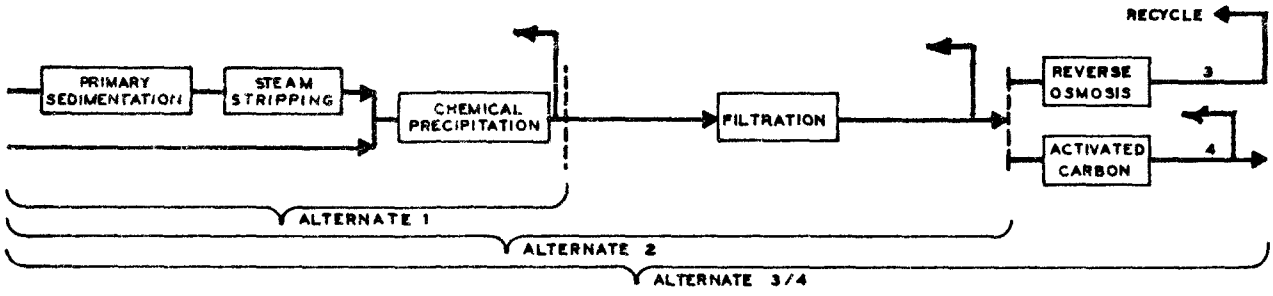
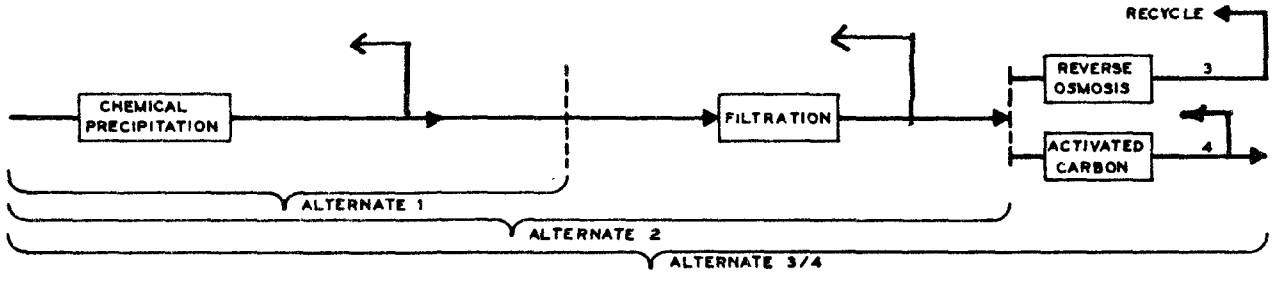


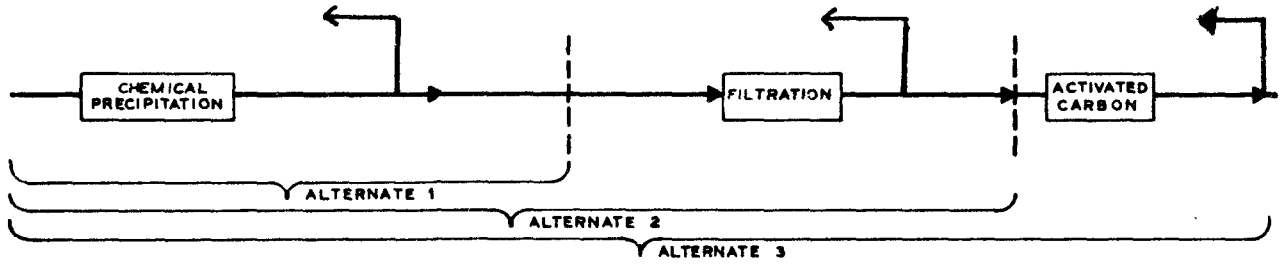

FIGURE VIII-20. PRIMARY ALUMINUM COMB. 4, ALT. 4




COMBINATION 1
(DROSS MILLING, FUME SCRUBBER)




COMBINATION 2
(CONTACT COOLING, FUME SCRUBBER)




COMBINATION 3
(CONTACT COOLING)

FIGURE VIII-21. SECONDARY ALUMINUM TREATMENT SCHEMES

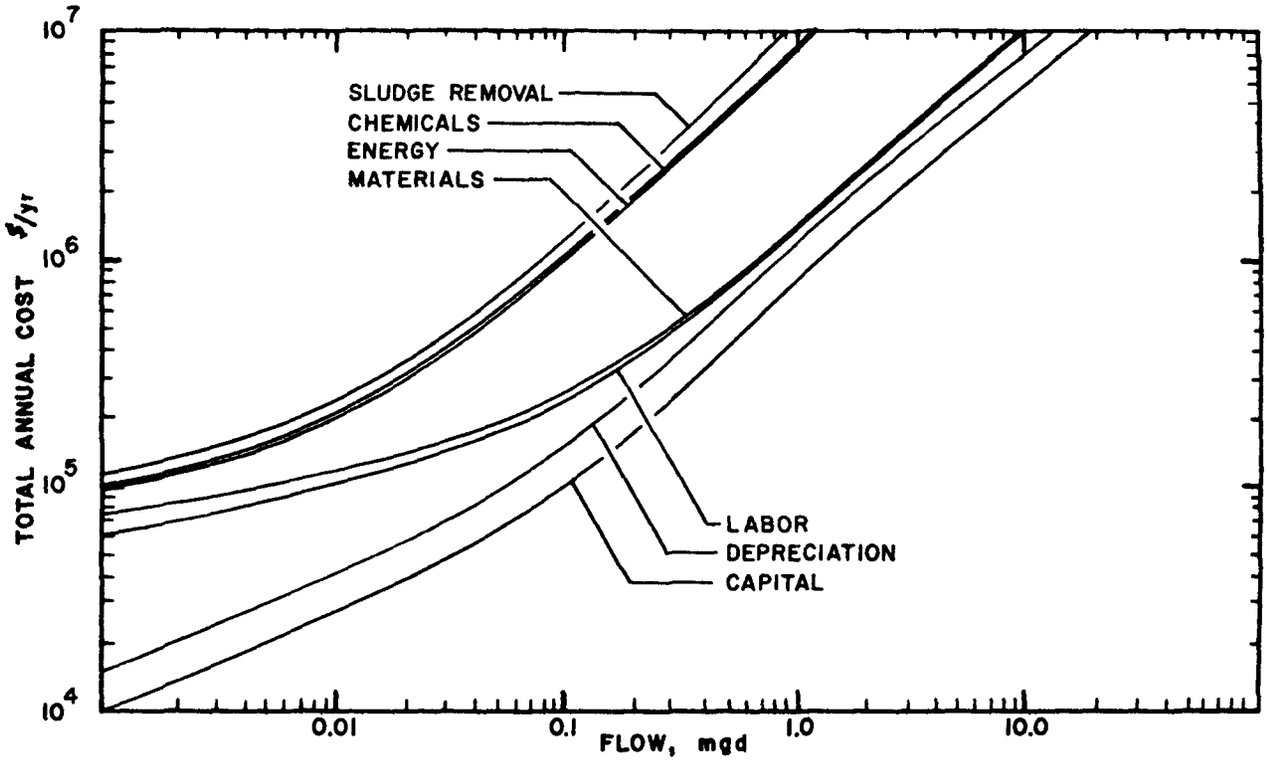



FIGURE VIII-22. SECONDARY ALUMINUM COMB. 1, ALT. 1

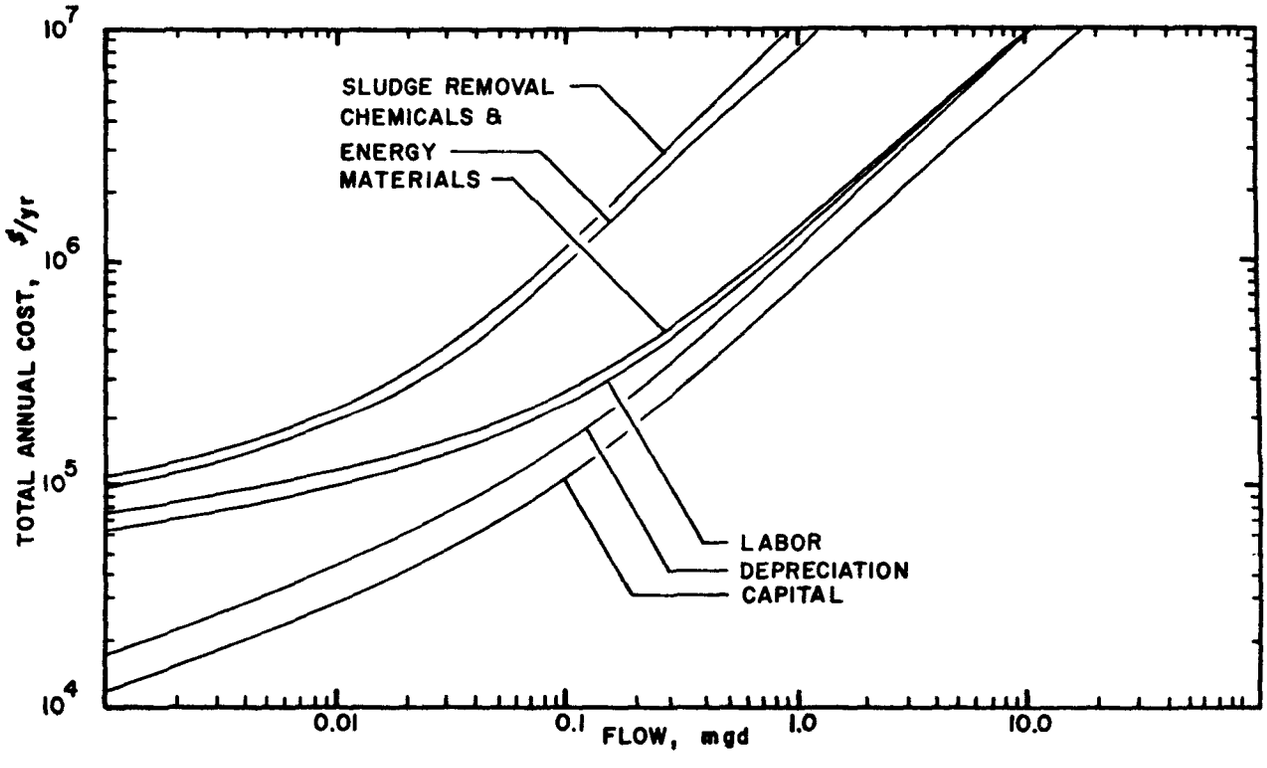



FIGURE VIII-23. SECONDARY ALUMINUM COMB. 1, ALT. 2

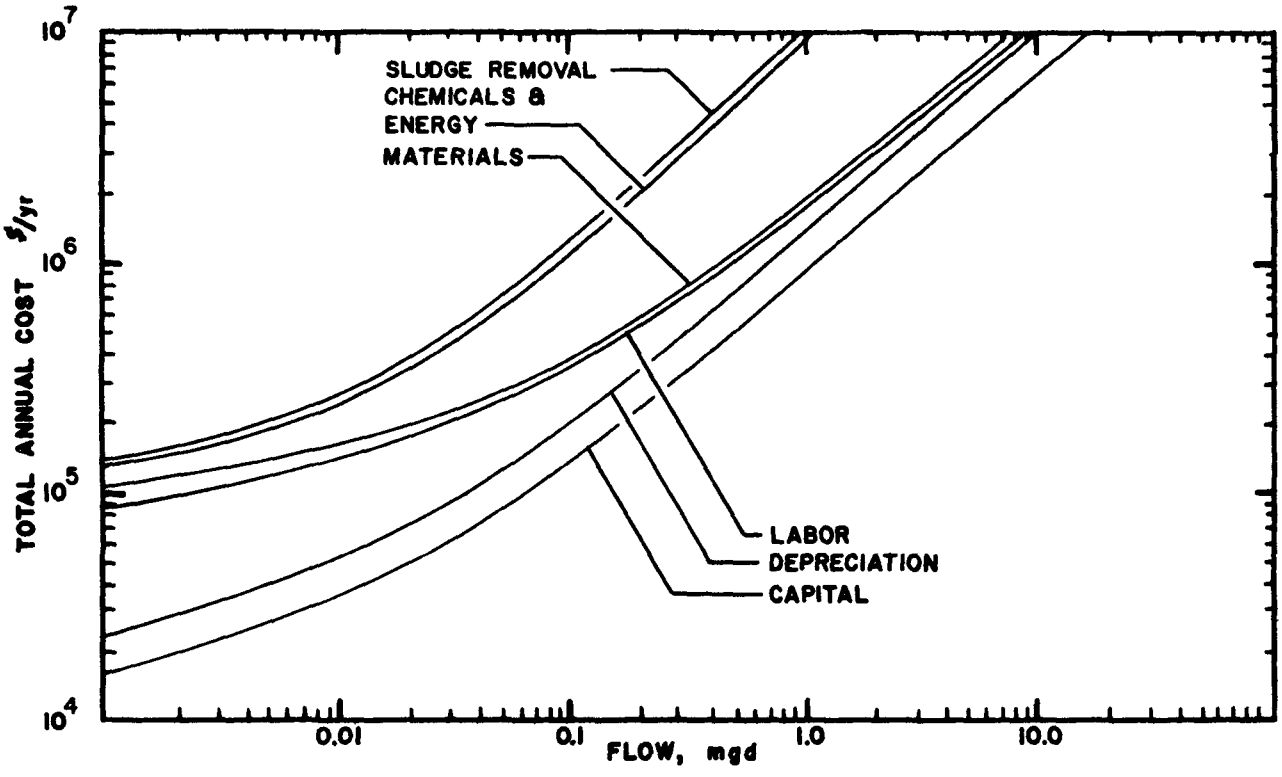



FIGURE VIII-24. SECONDARY ALUMINUM COMB. I, ALT. 3

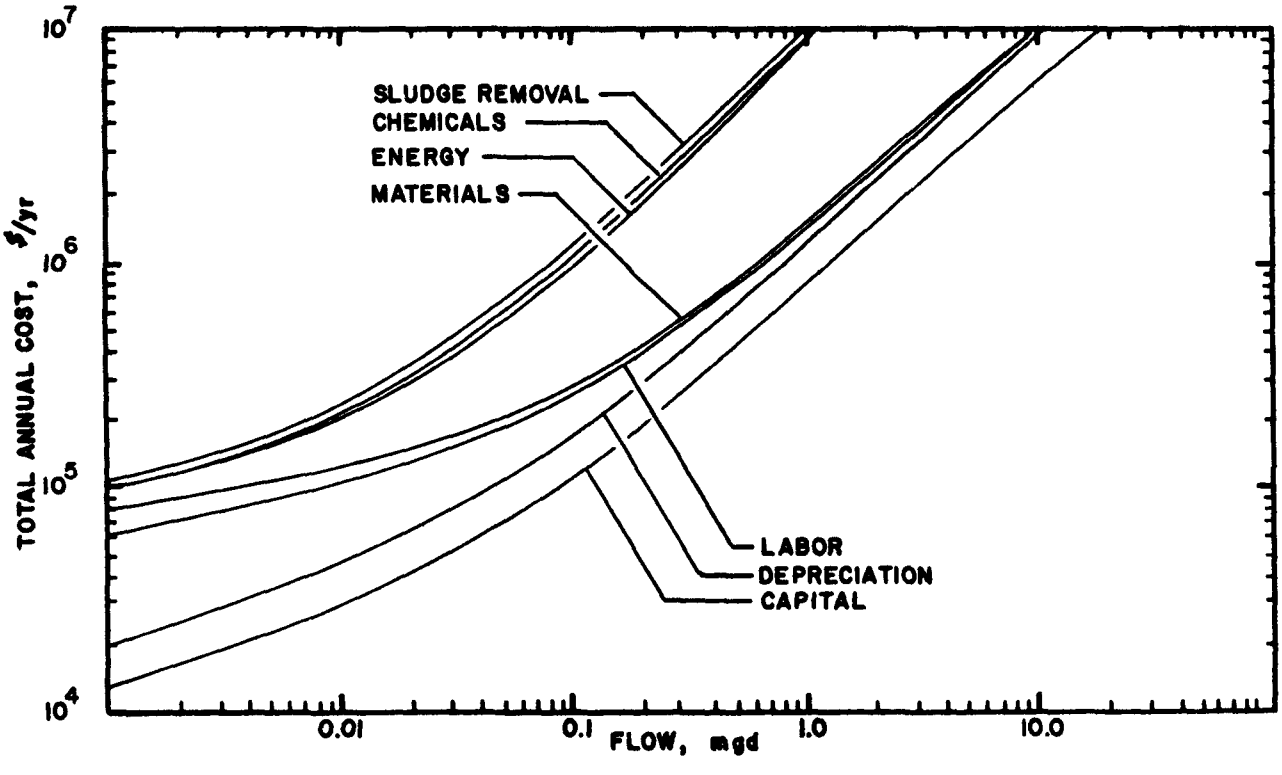



FIGURE VIII-25. SECONDARY ALUMINUM COMB.I, ALT. 4

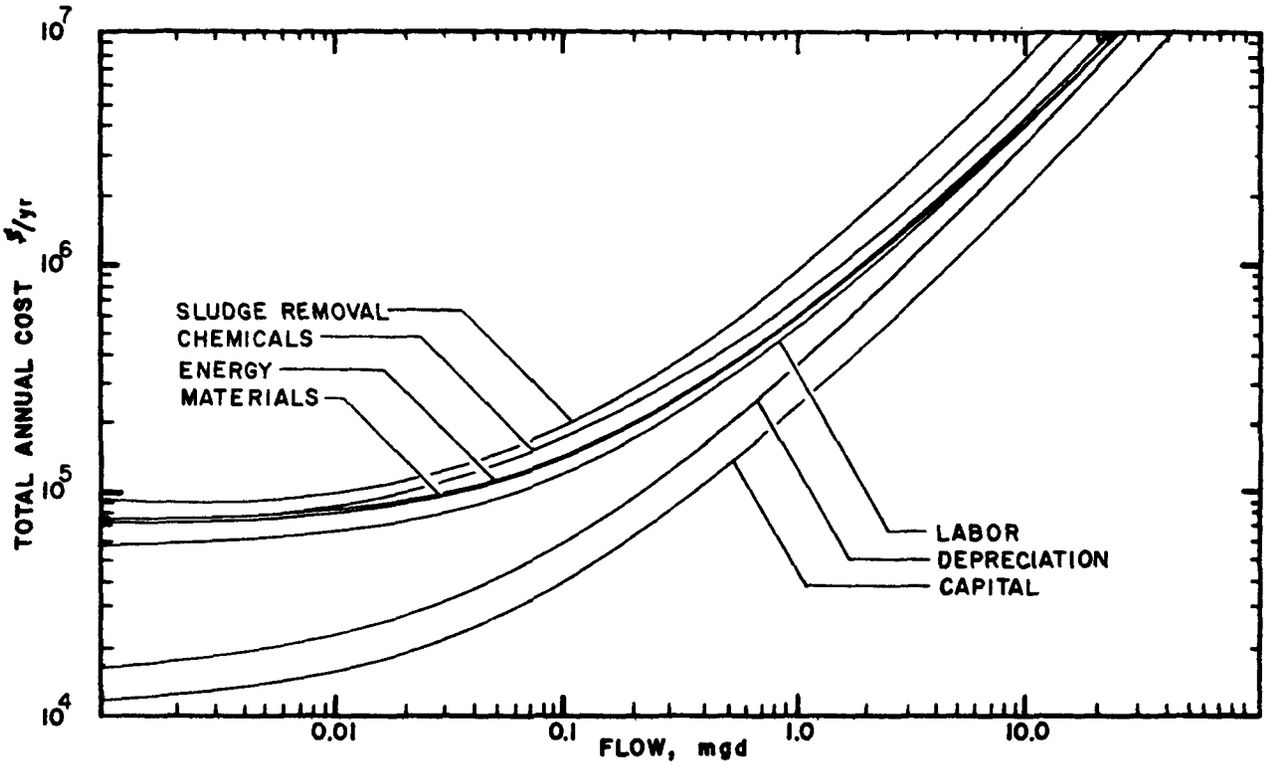



FIGURE VIII-26. SECONDARY ALUMINUM COMB. 2, ALT. 1

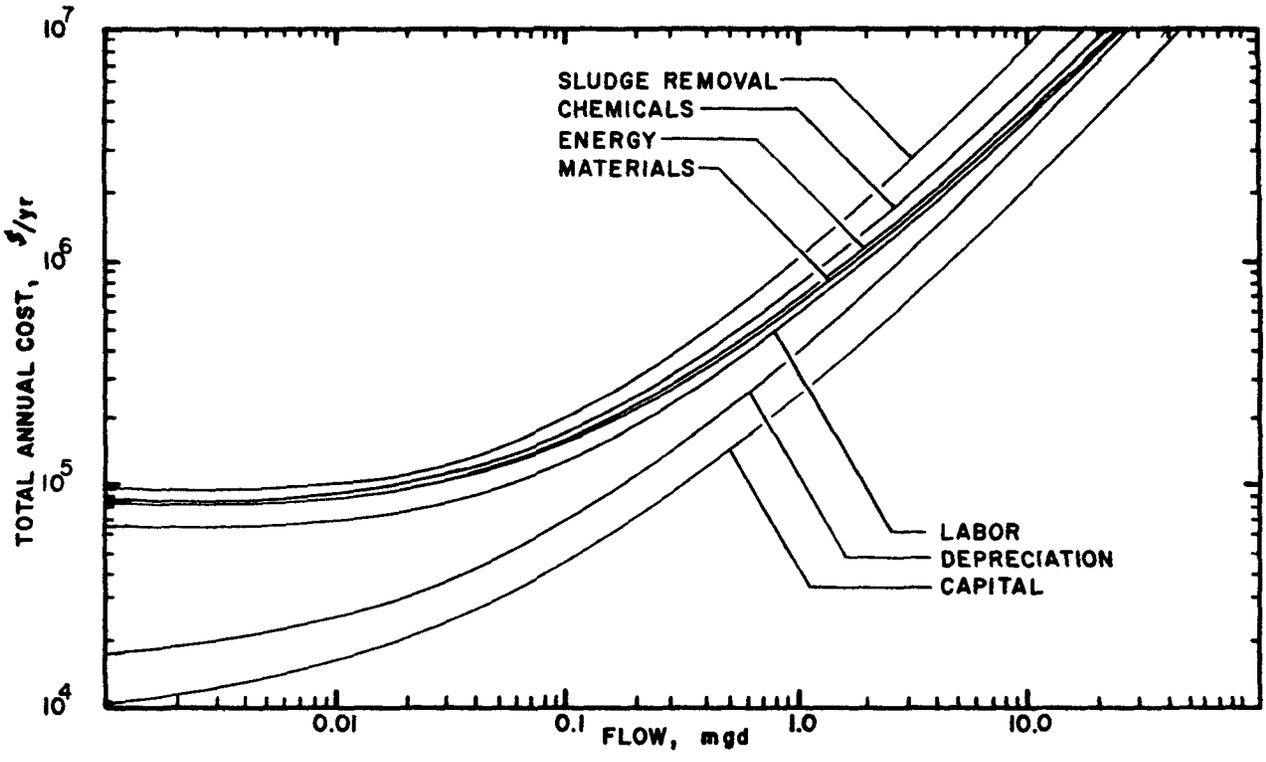



FIGURE VIII-27. SECONDARY ALUMINUM COMB. 2, ALT. 2

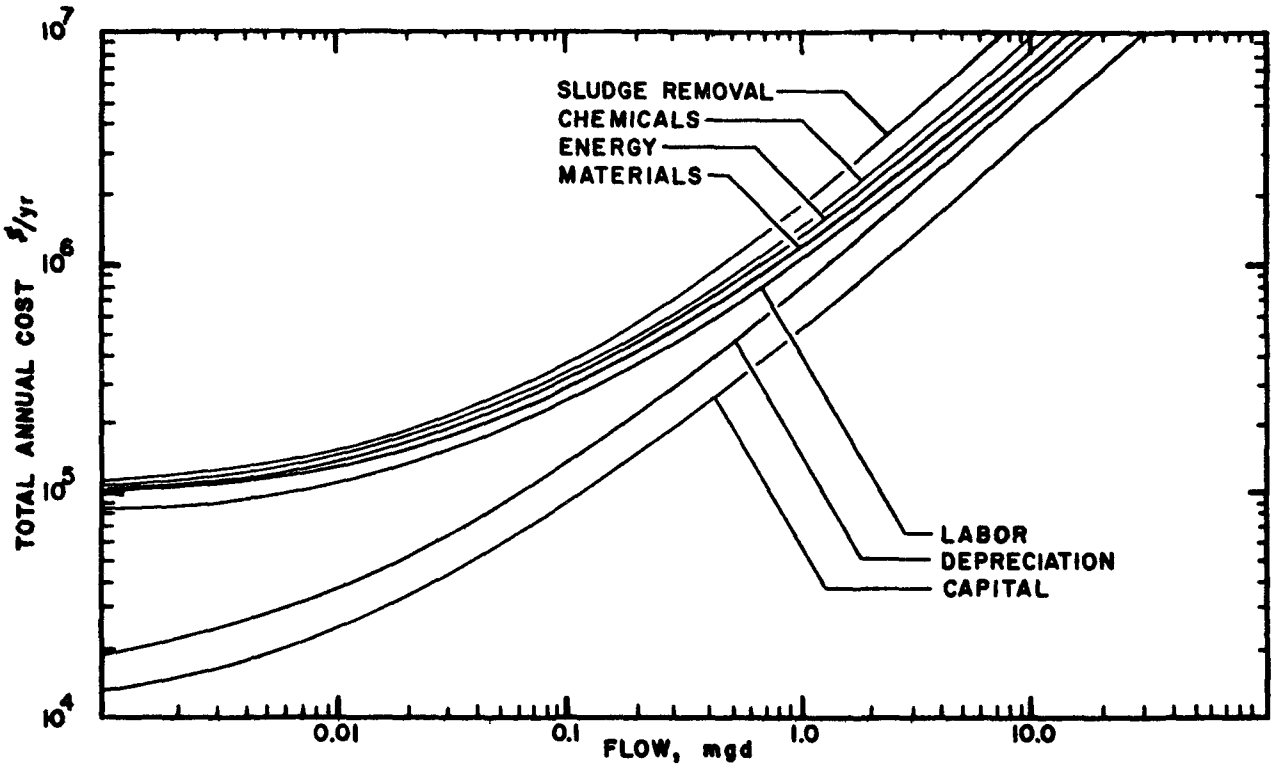



FIGURE VIII-28. SECONDARY ALUMINUM COMB. 2 , ALT. 3

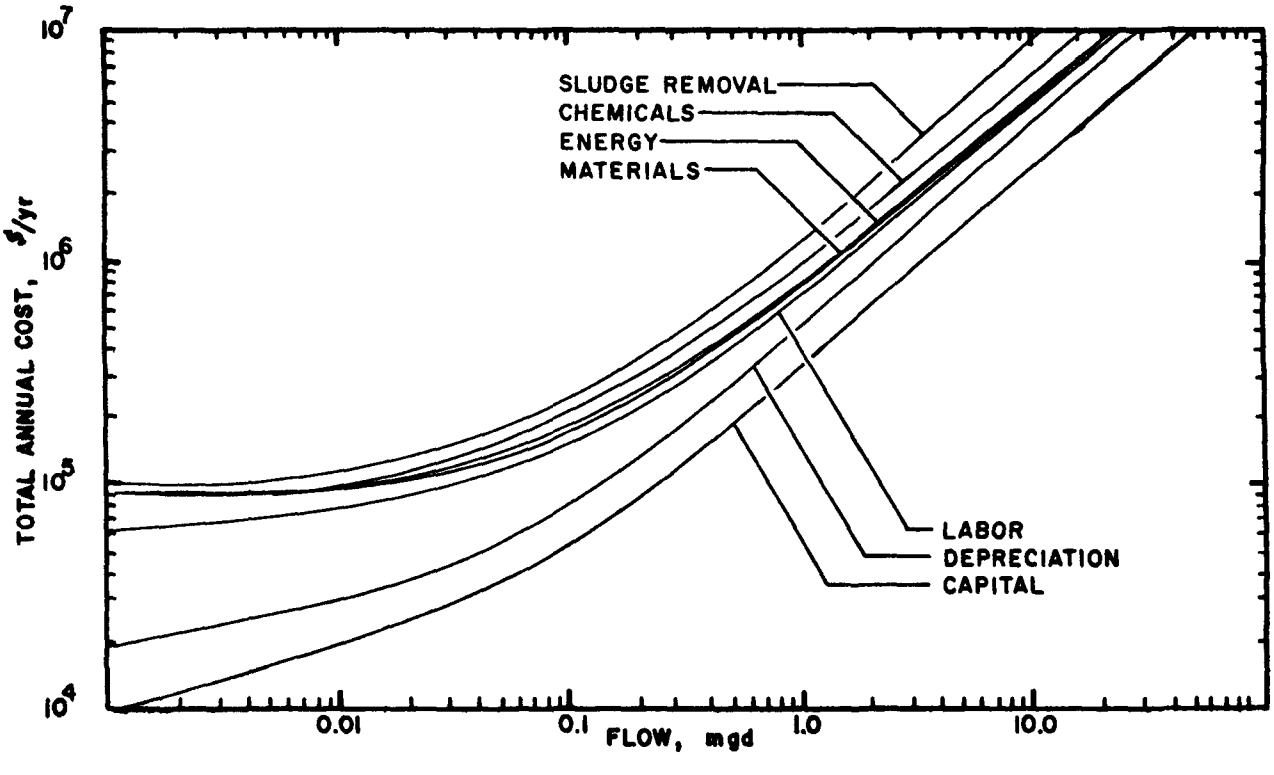



FIGURE VIII-29. SECONDARY ALUMINUM COMB. 2 , ALT. 4

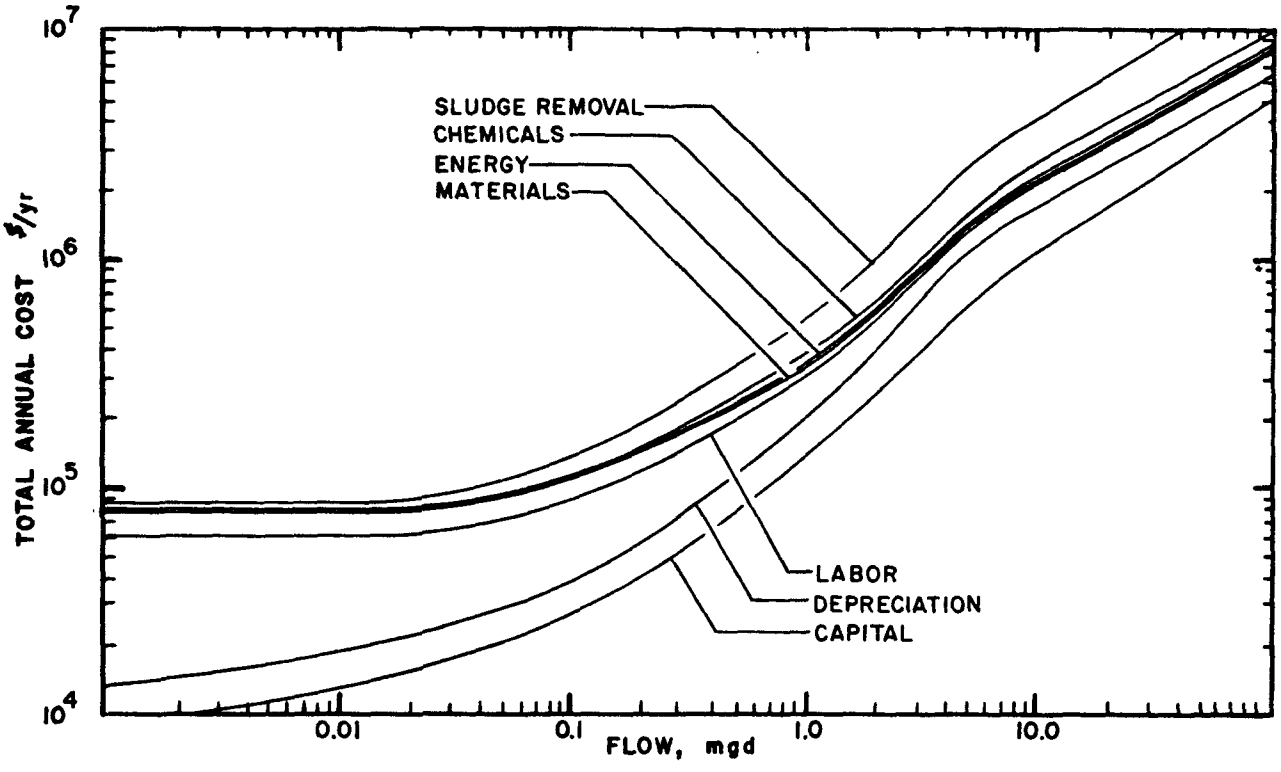



FIGURE VIII-30, SECONDARY ALUMINUM COMB. 3 , ALT. 1

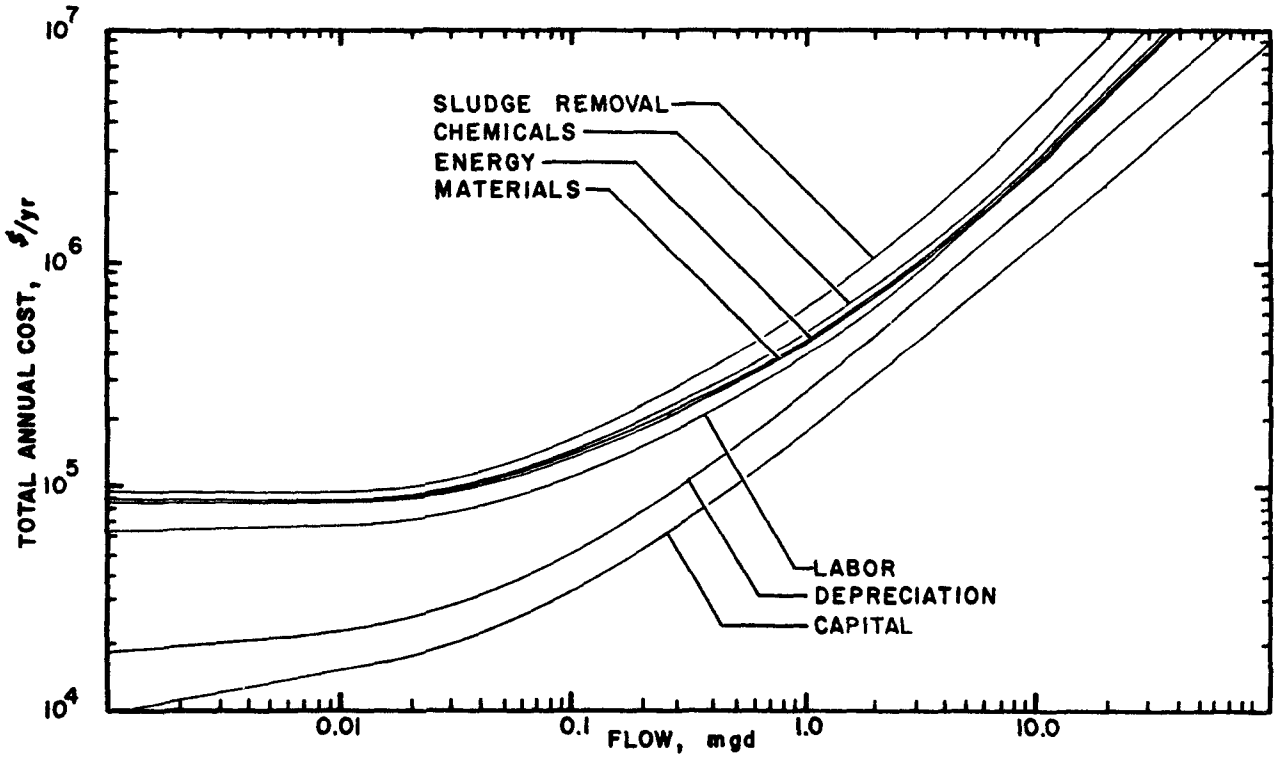



FIGURE VIII-31. SECONDARY ALUMINUM COMB. 3 , ALT. 2

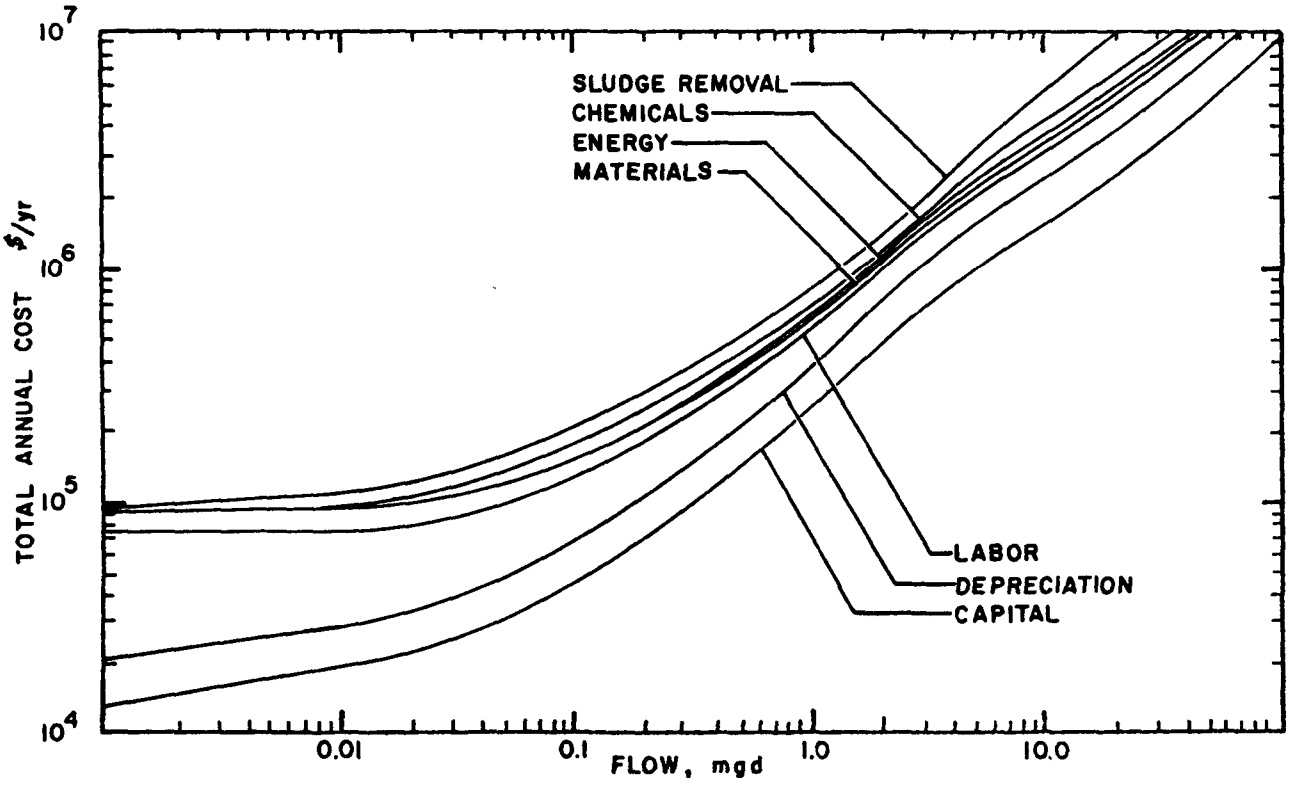
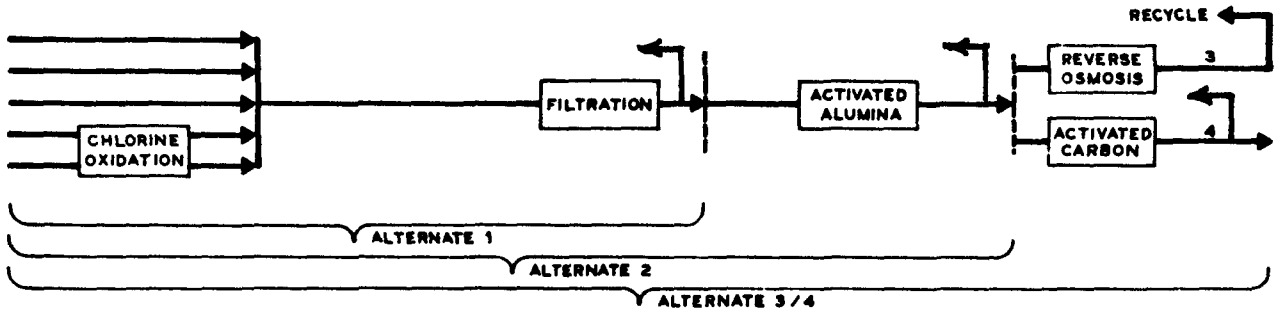
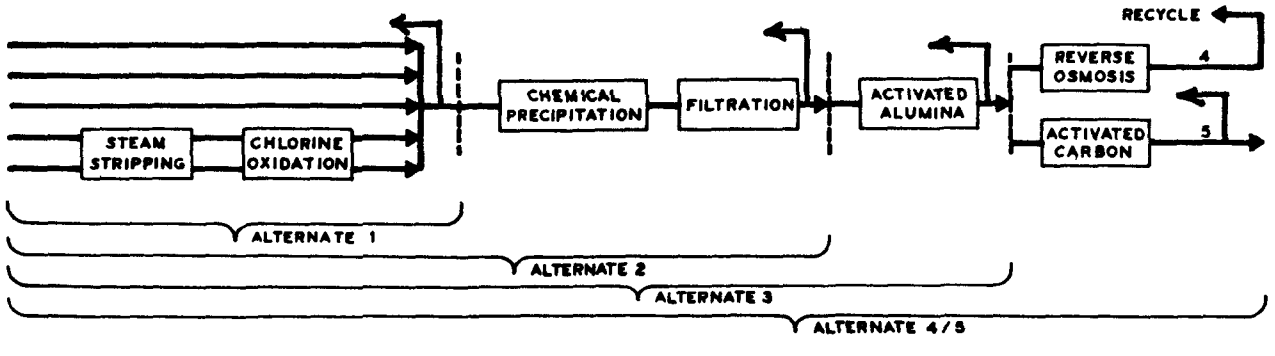



FIGURE VIII-32. SECONDARY ALUMINUM COMB 3, ALT. 3




COMBINATION 1
(ALL WASTE STREAMS)




COMBINATION 2
(ALL WASTE STREAMS)

FIGURE VIII-33. COLUMBIUM / TANTALUM TREATMENT SCHEMES
(ORE TO SALT / METAL)

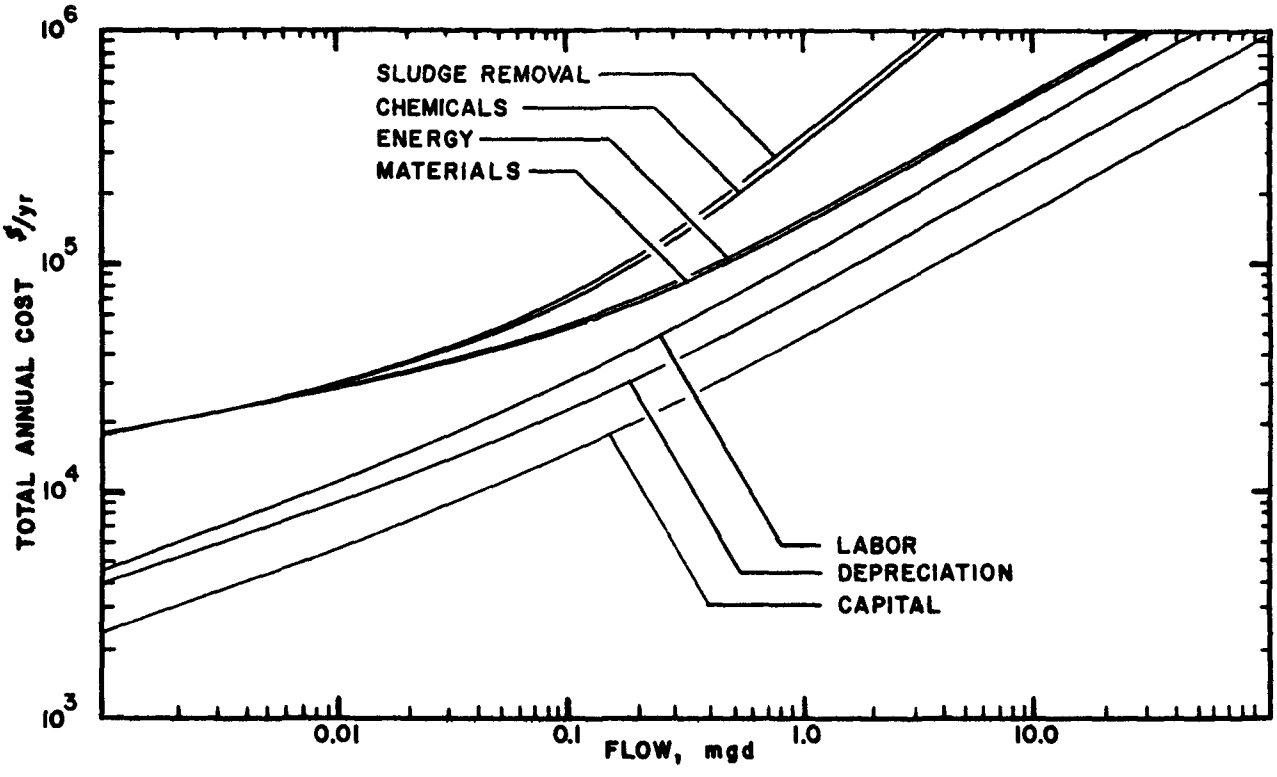



FIGURE VIII-34. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. I, ALT. I

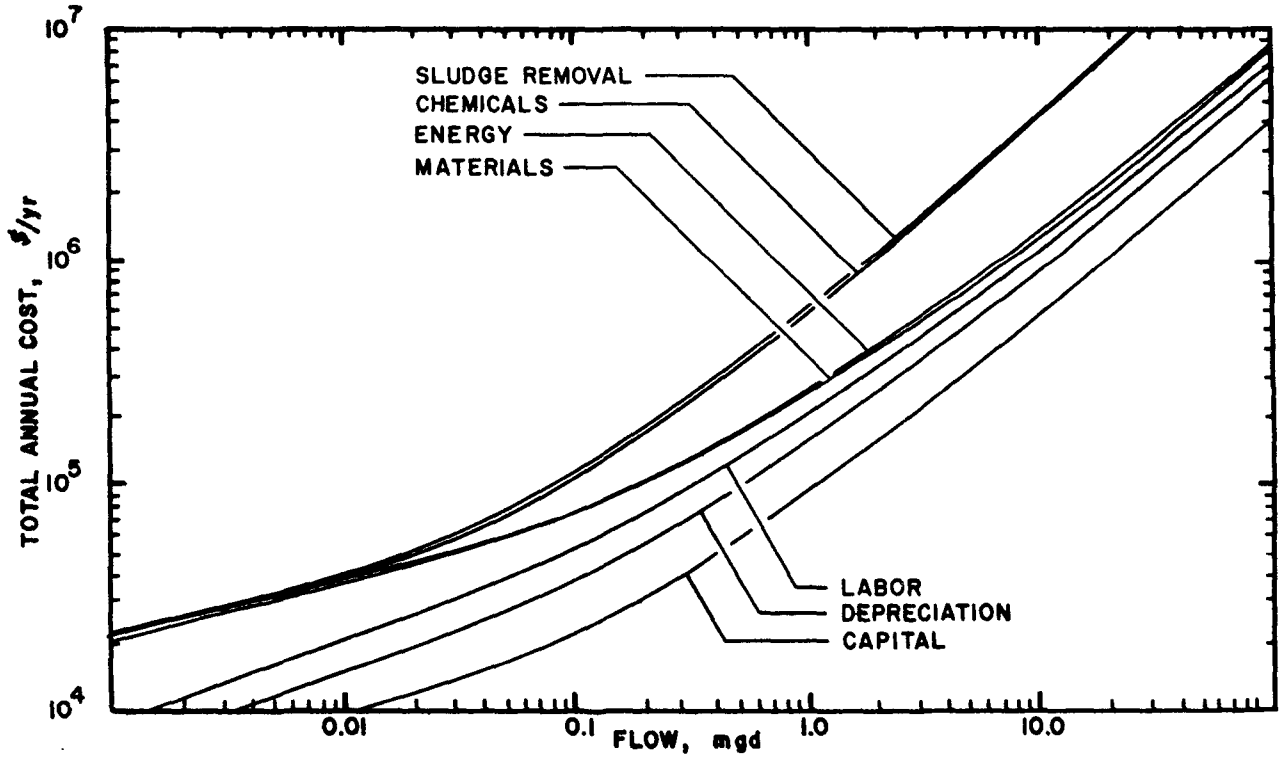



FIGURE VIII-35. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. I, ALT. 2

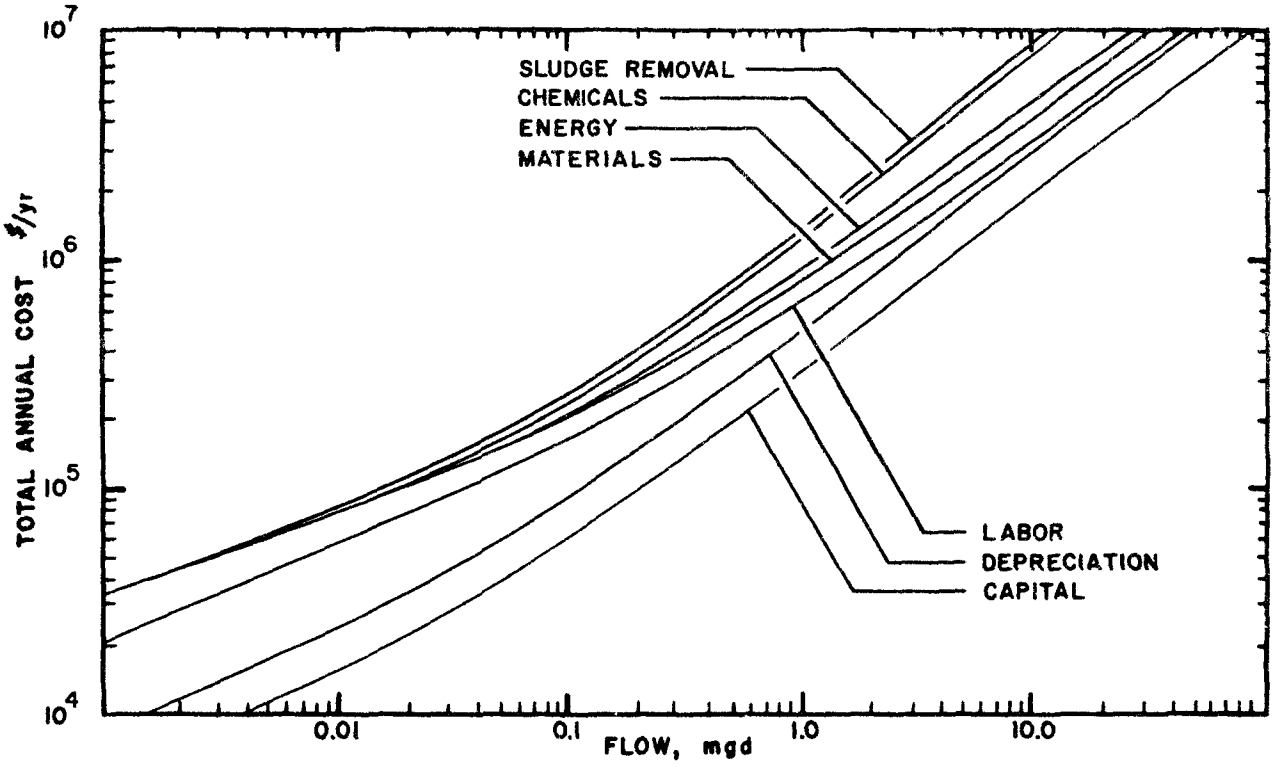



FIGURE VIII-36. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. I, ALT. 3

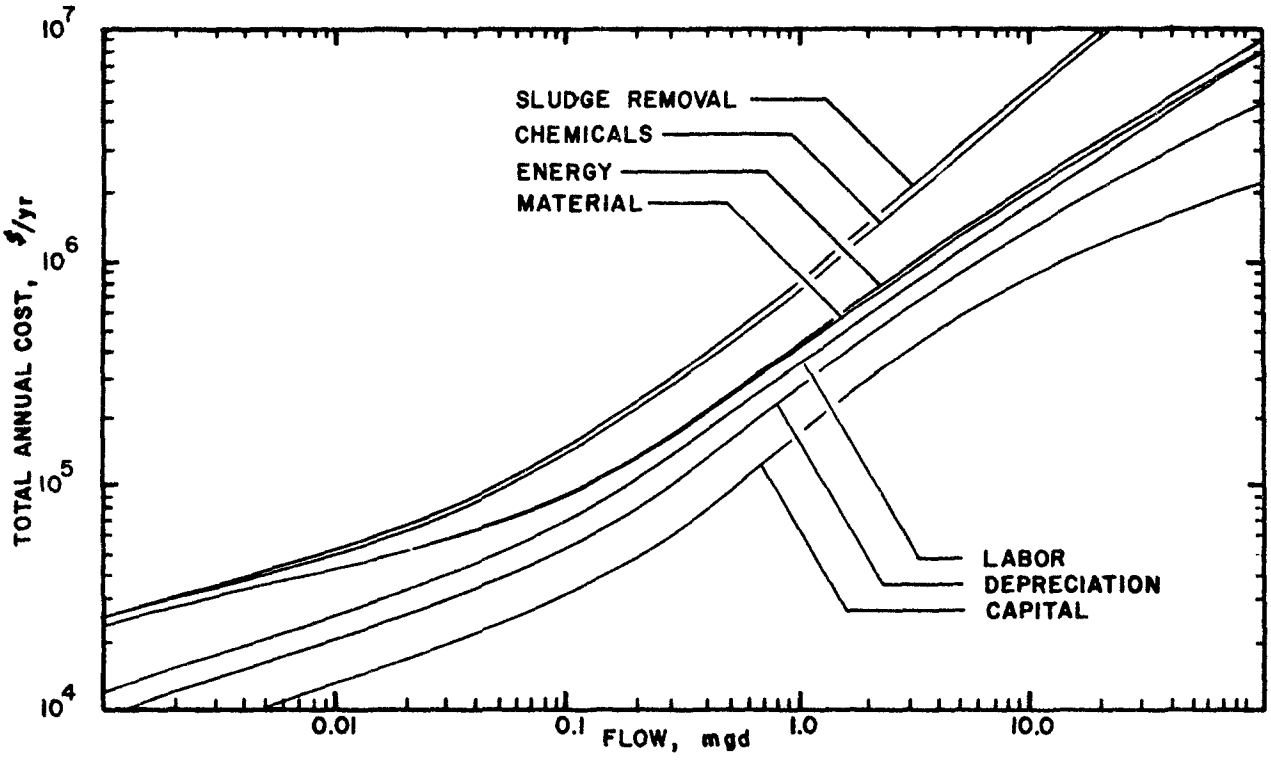



FIGURE VIII-37. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. I, ALT. 4

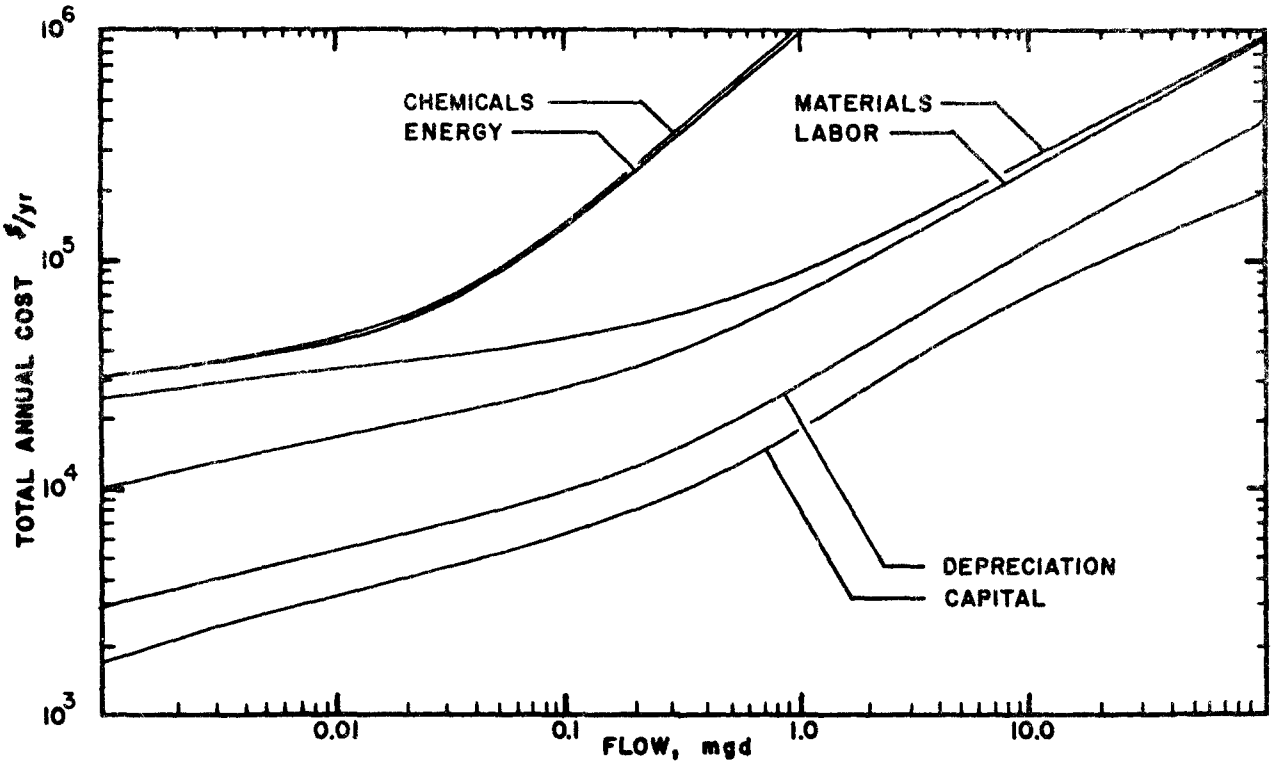



FIGURE VIII-38. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. 2, ALT. 1

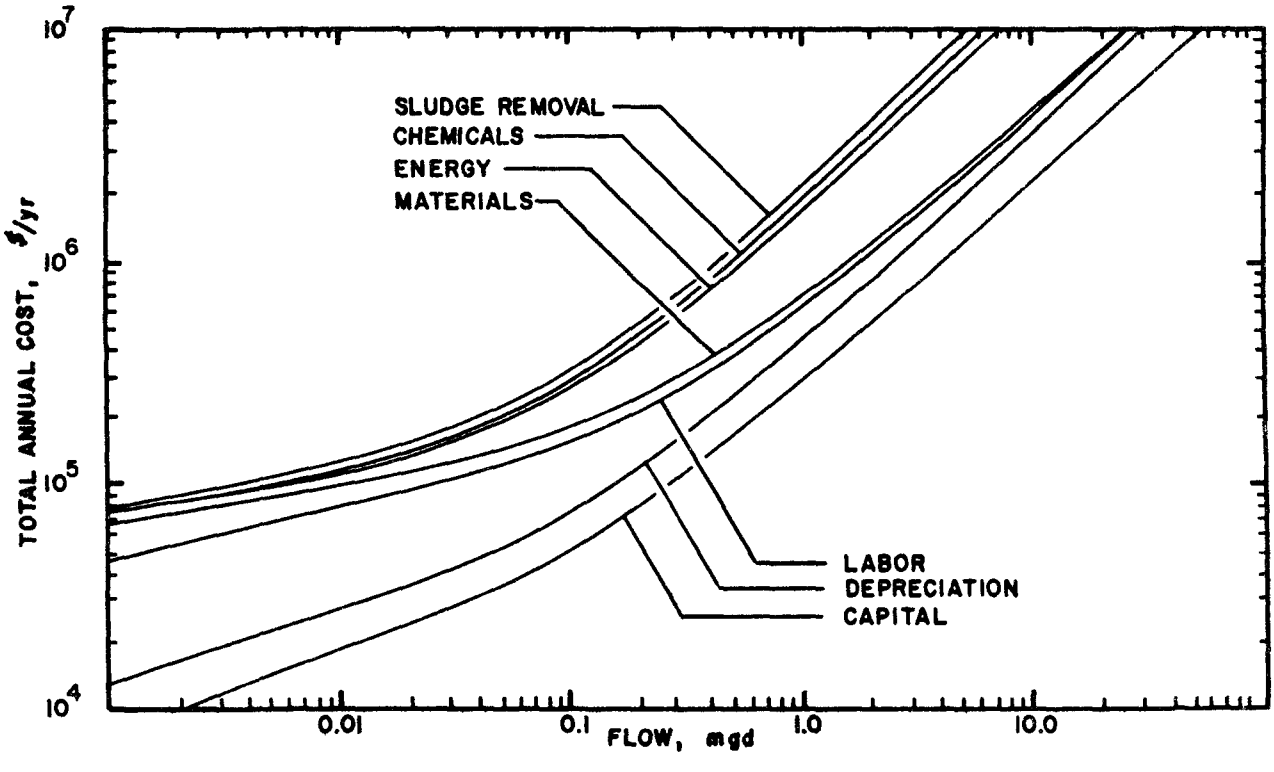



FIGURE VIII-39. COLUMBIUM/TANTALUM(ORE TO SALT/METAL) COMB. 2, ALT. 2

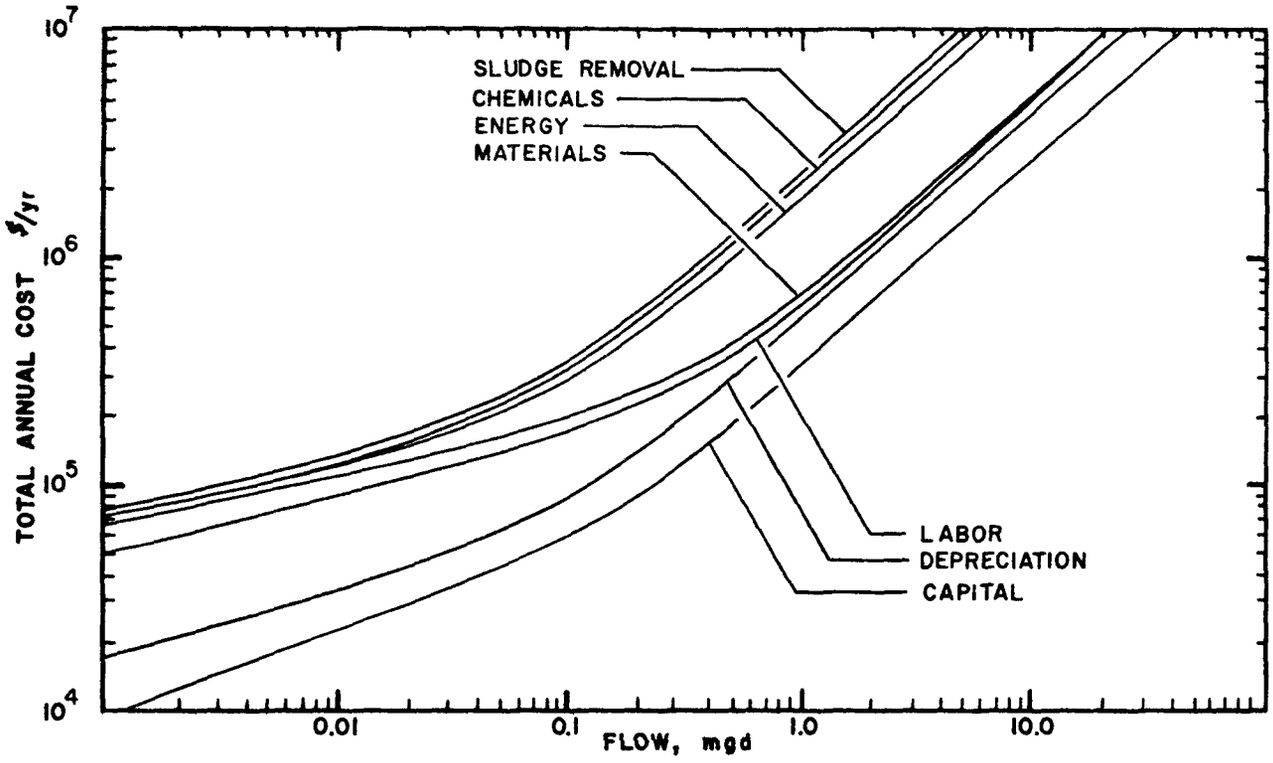



FIGURE VIII-40. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. 2, ALT.3

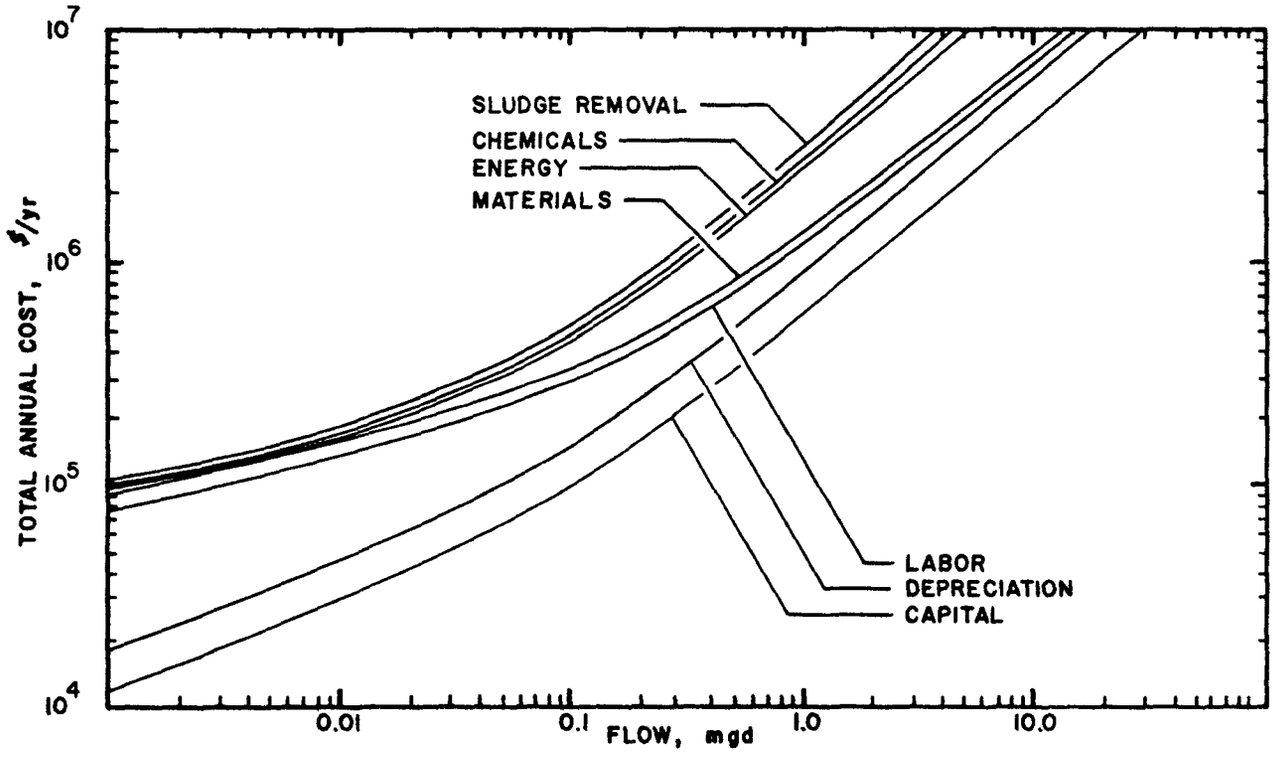



FIGURE VIII-41. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. 2, ALT. 4

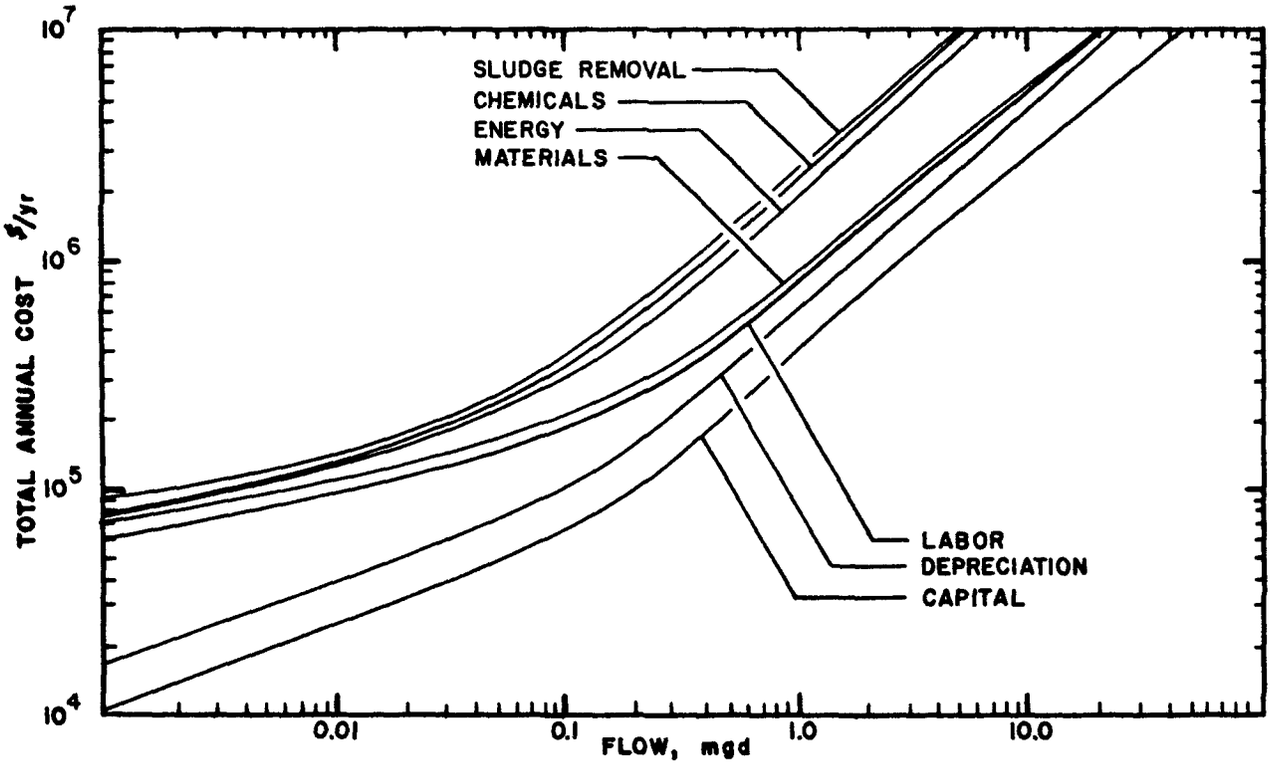
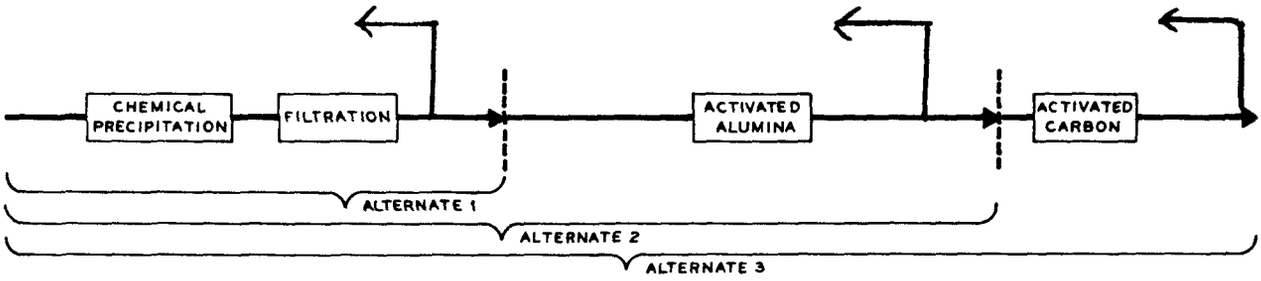



FIGURE VIII-42. COLUMBIUM/TANTALUM (ORE TO SALT/METAL) COMB. 2, ALT. 5




COMBINATION 1
(REDUCTION SCRUBBER AND LEACHATE)

FIGURE VIII-43. COLUMBIUM/TANTALUM TREATMENT SCHEMES (SALT TO METAL)

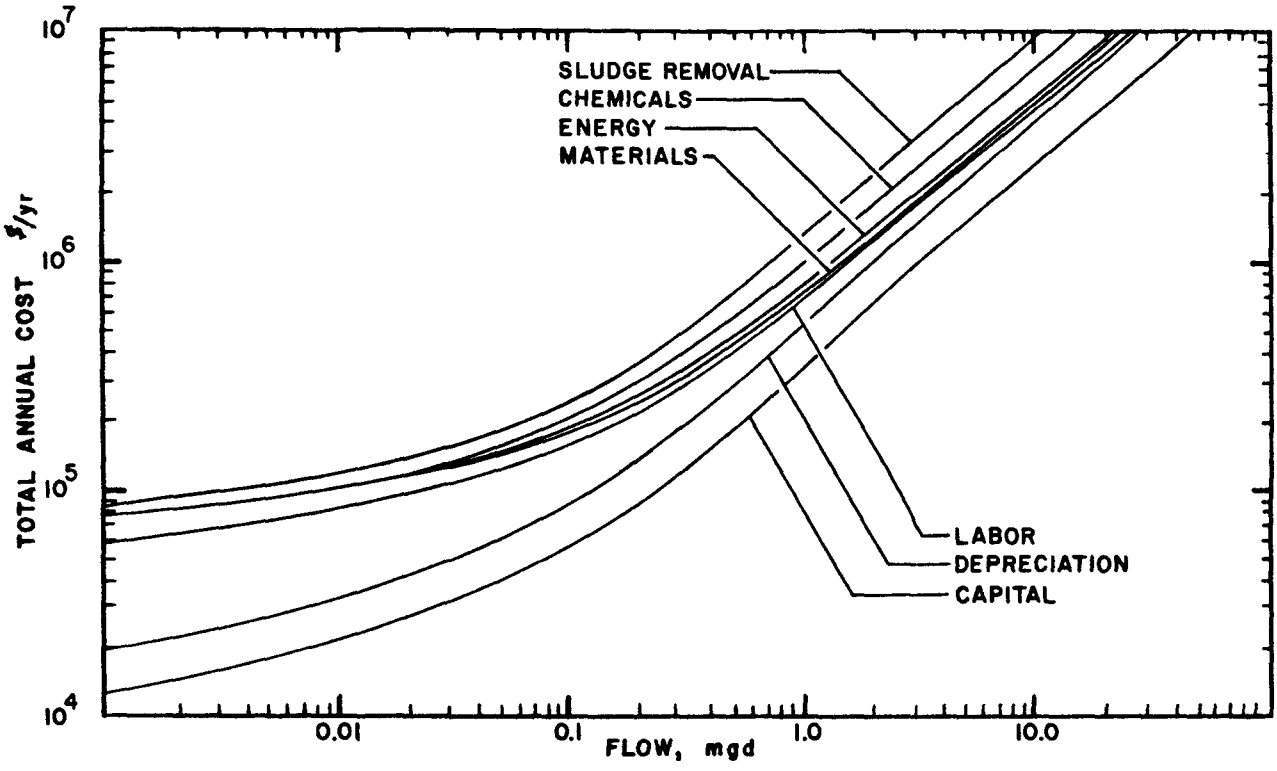



FIGURE VIII-44. COLUMBIUM/TANTALUM (SALT TO METAL) COMB. I, ALT. I

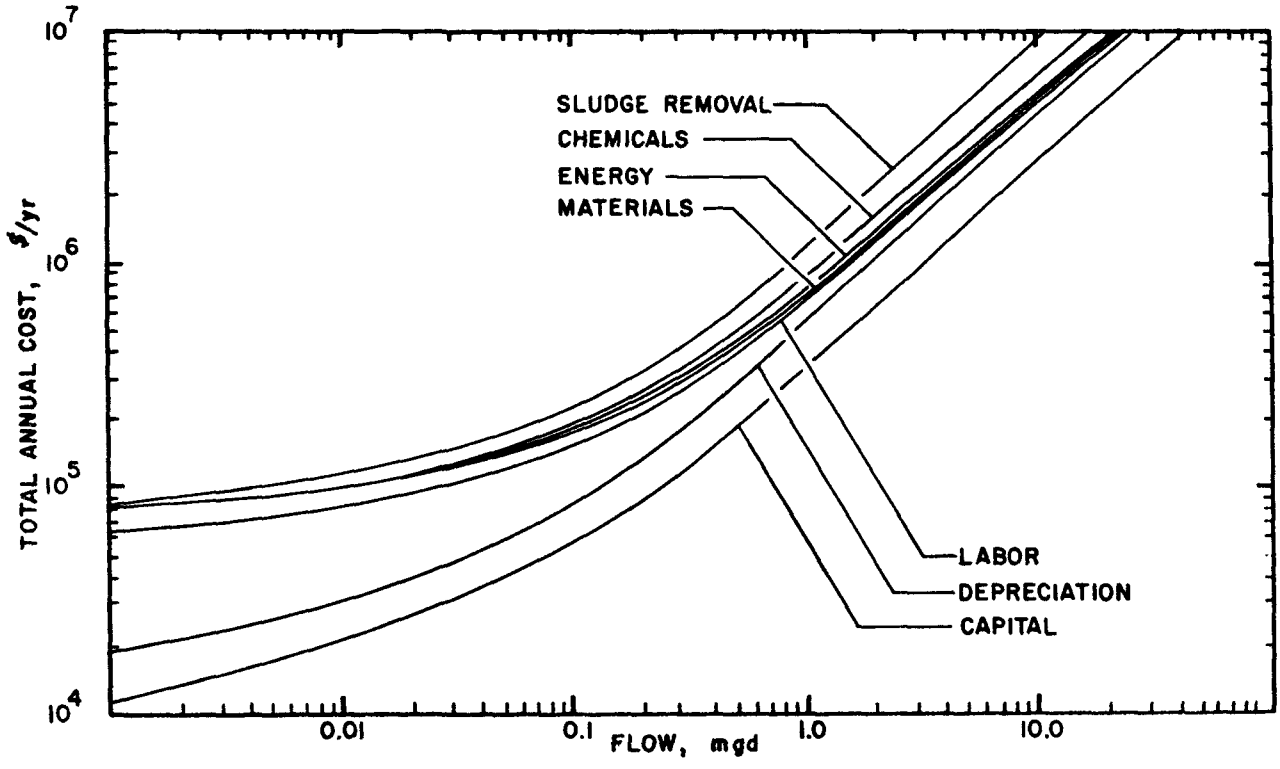



FIGURE VIII-45. COLUMBIUM/TANTALUM (SALT TO METAL) COMB. I, ALT. 2

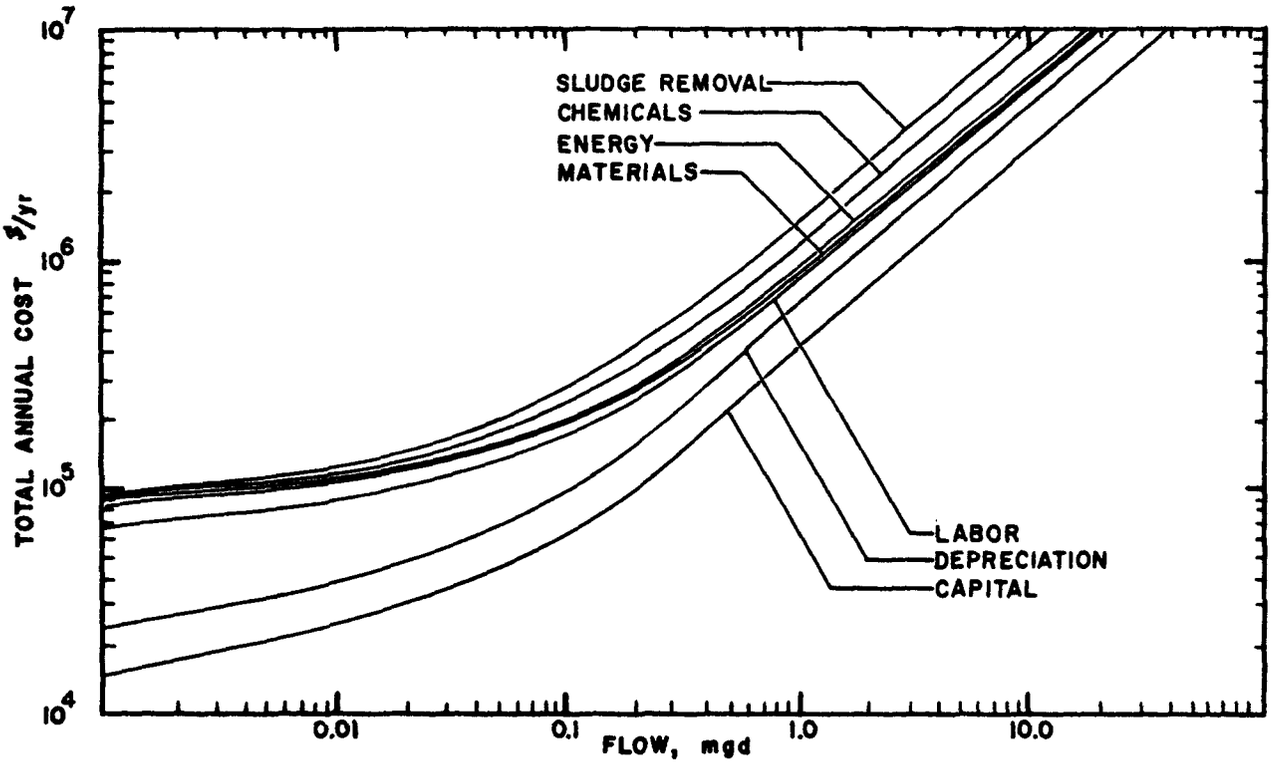
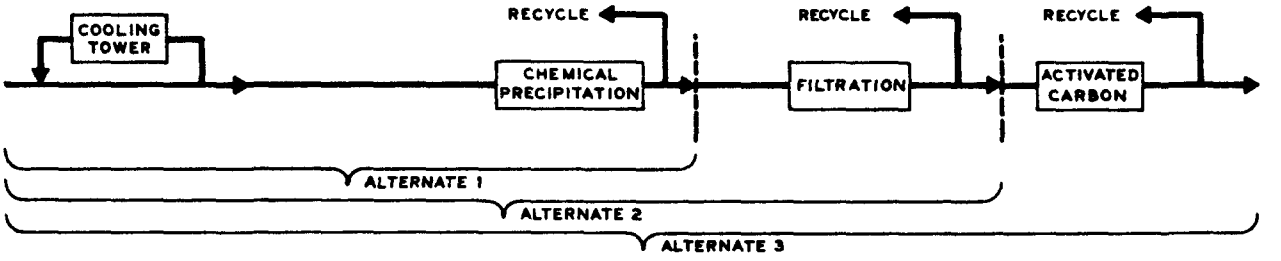
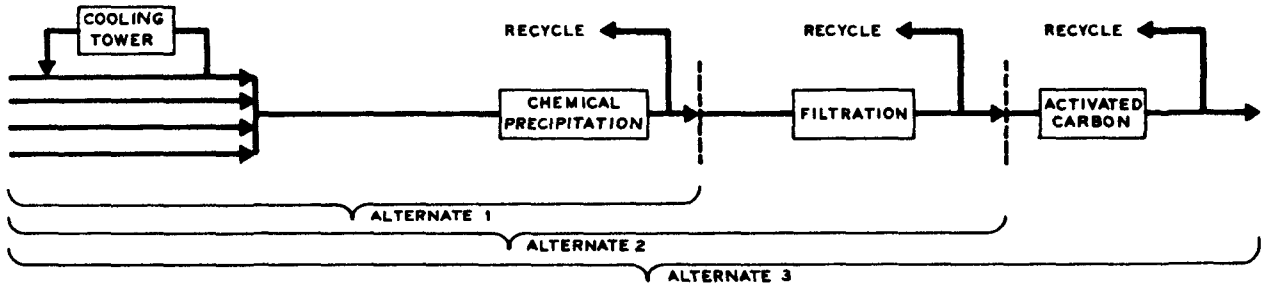



FIGURE VIII-46. COLUMBIUM/TANTALUM (SALT TO METAL) COMB. 1, ALT. 3




COMBINATION 1
(CONTACT COOLING)




COMBINATION 2
(ALL WASTE STREAMS)

FIGURE VIII-47. PRIMARY COPPER TREATMENT SCHEMES

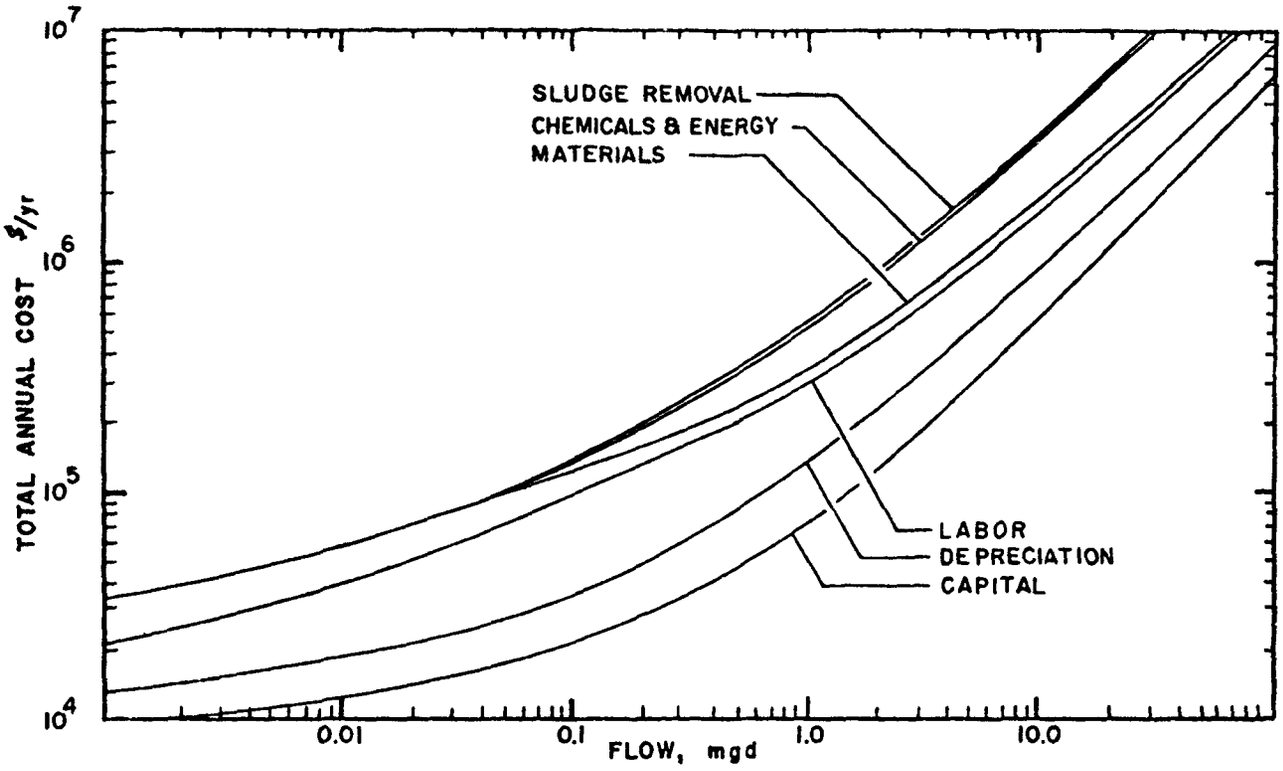



FIGURE VIII-48. PRIMARY COPPER (SMELTING & REFINING) COMB. 1, ALT. 1

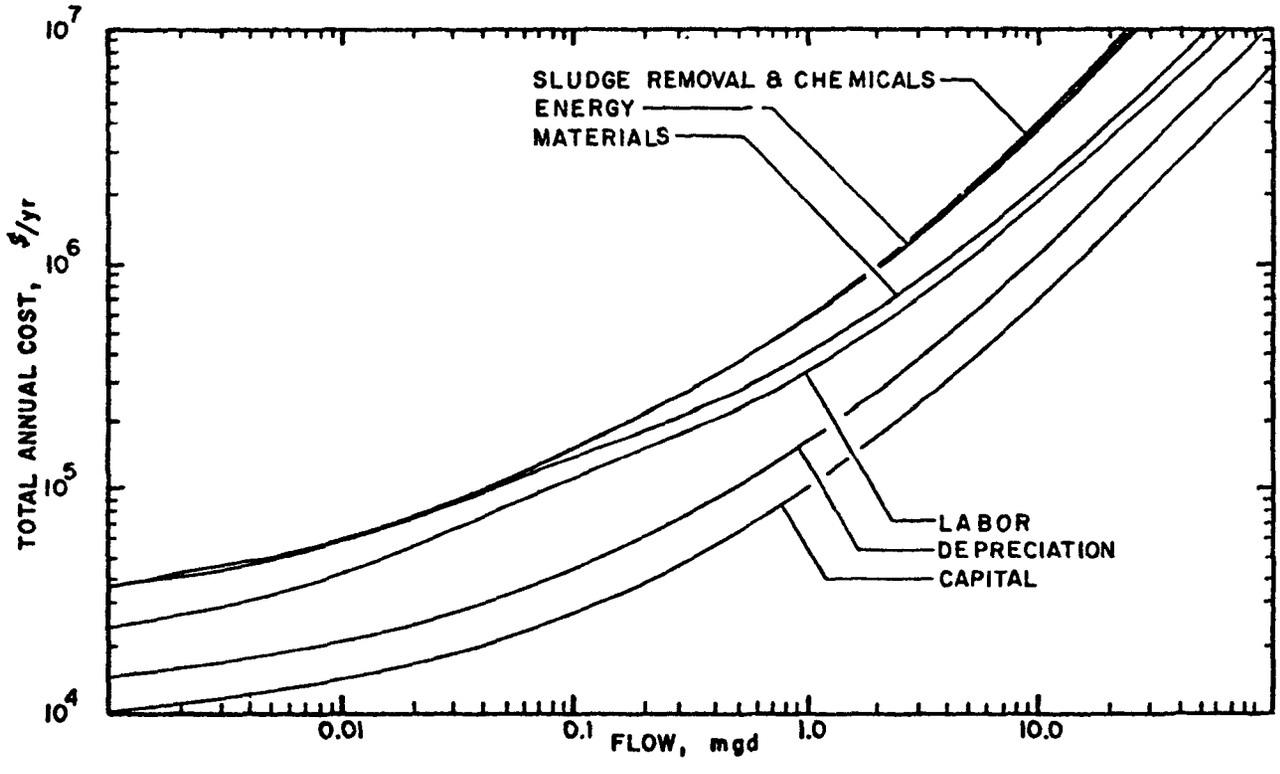



FIGURE VIII-49. PRIMARY COPPER (SMELTING & REFINING) COMB. 1, ALT. 2

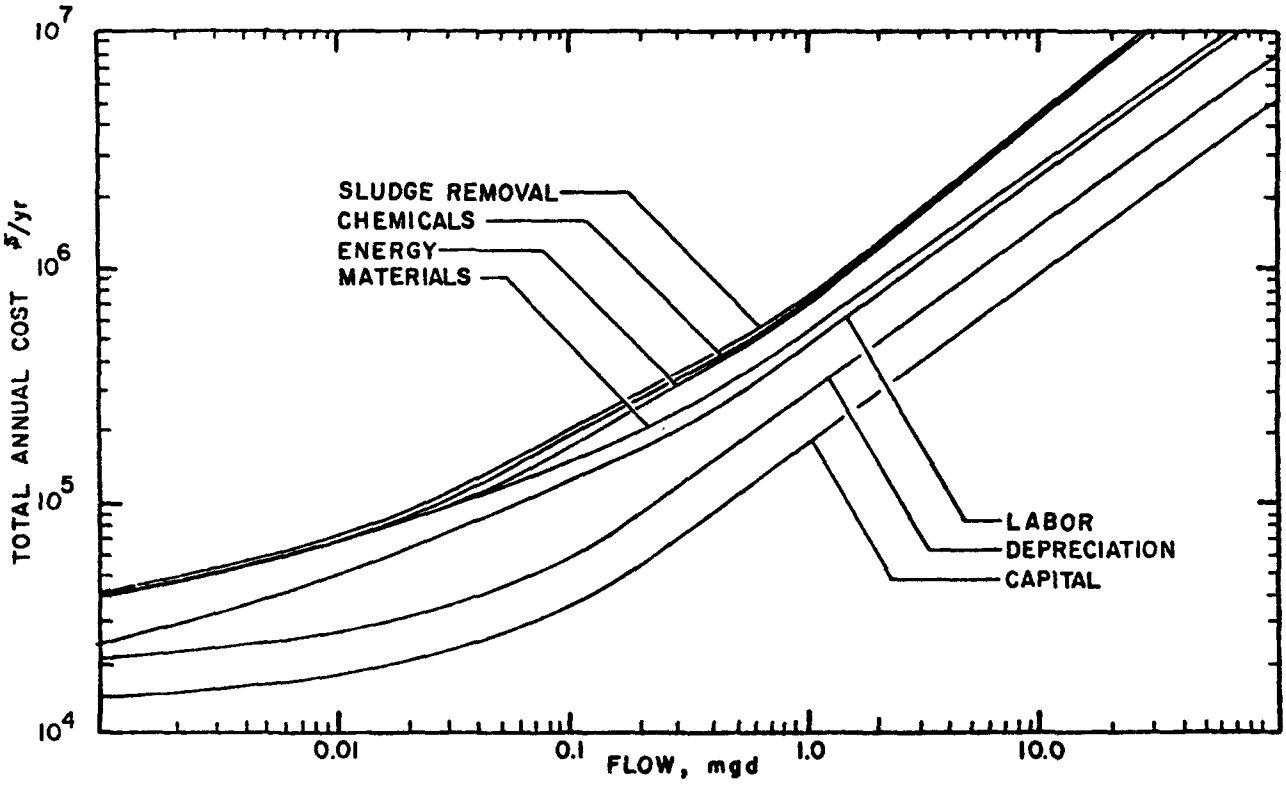



FIGURE VIII-50. PRIMARY COPPER (SMELTING & REFINING) COMB. 1, ALT. 3

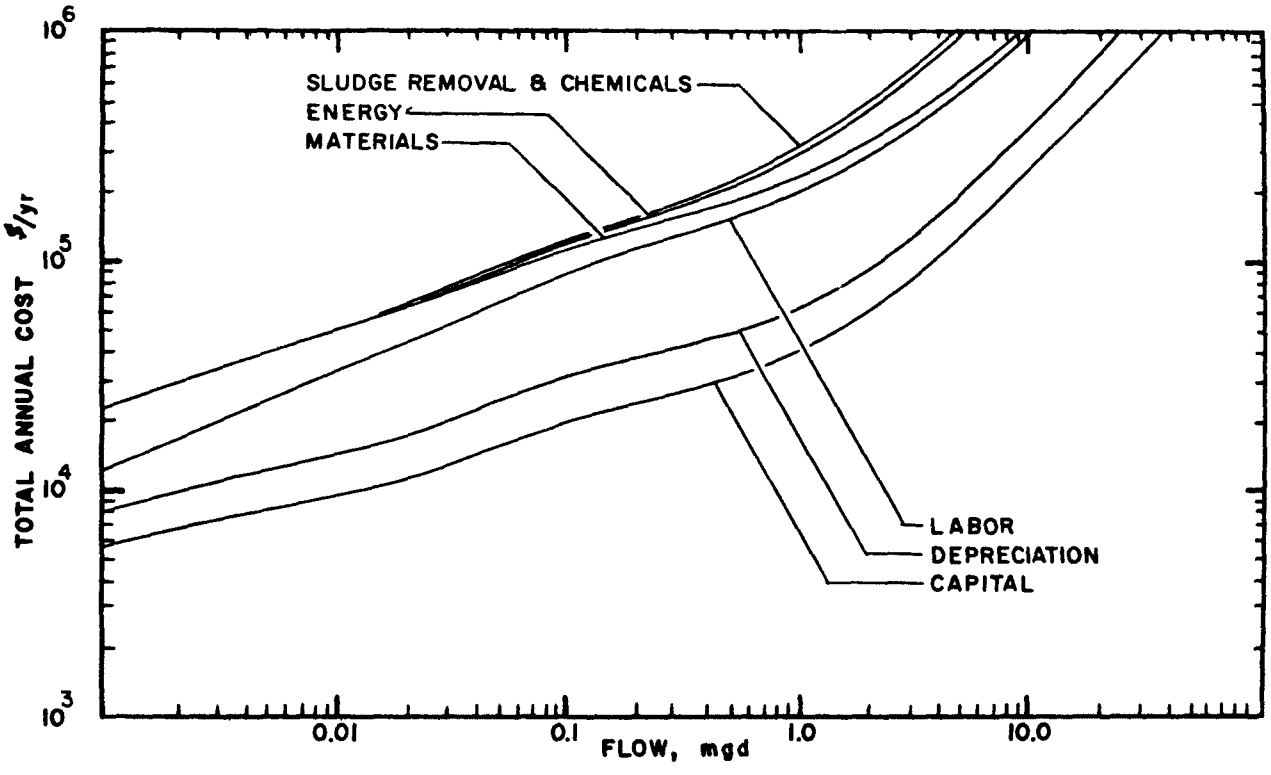



FIGURE VIII-51. PRIMARY COPPER (SMELTING & REFINING) COMB. 2, ALT. 1

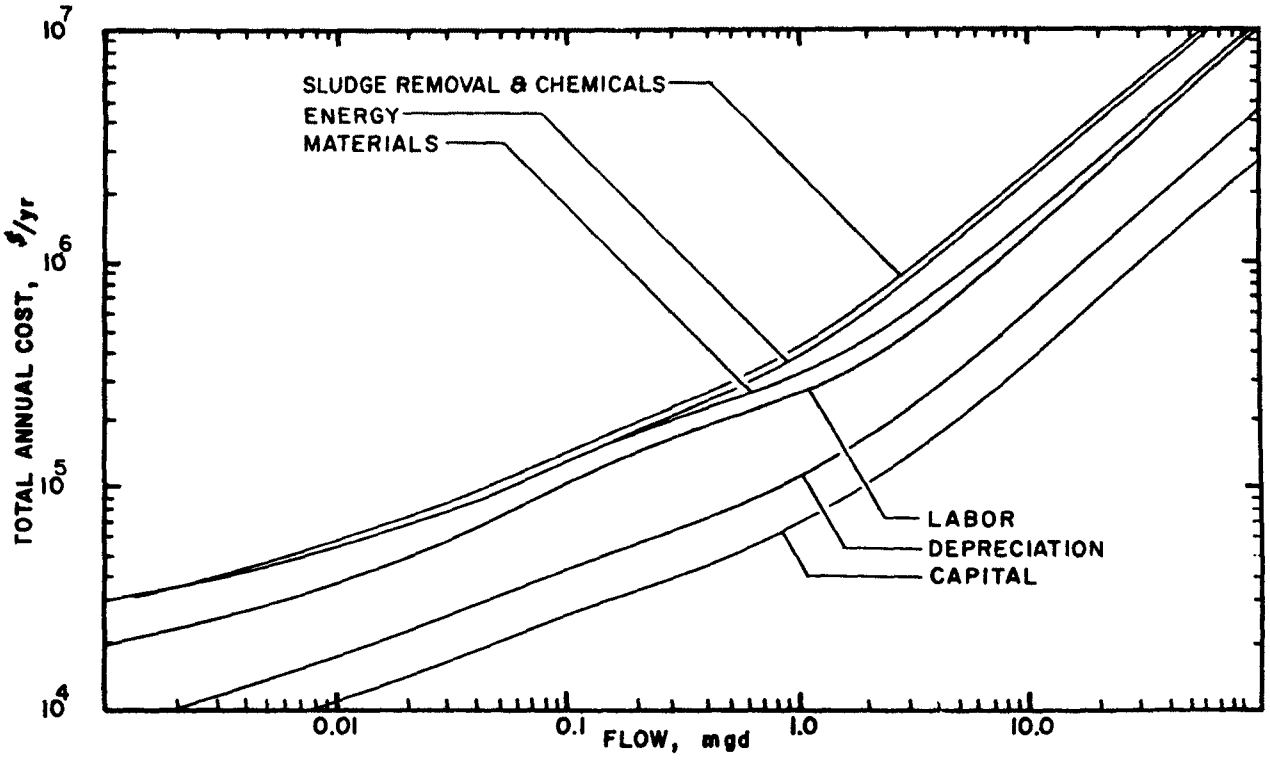



FIGURE VIII-52. PRIMARY COPPER (SMELTING & REFINING) COMB. 2, ALT. 2

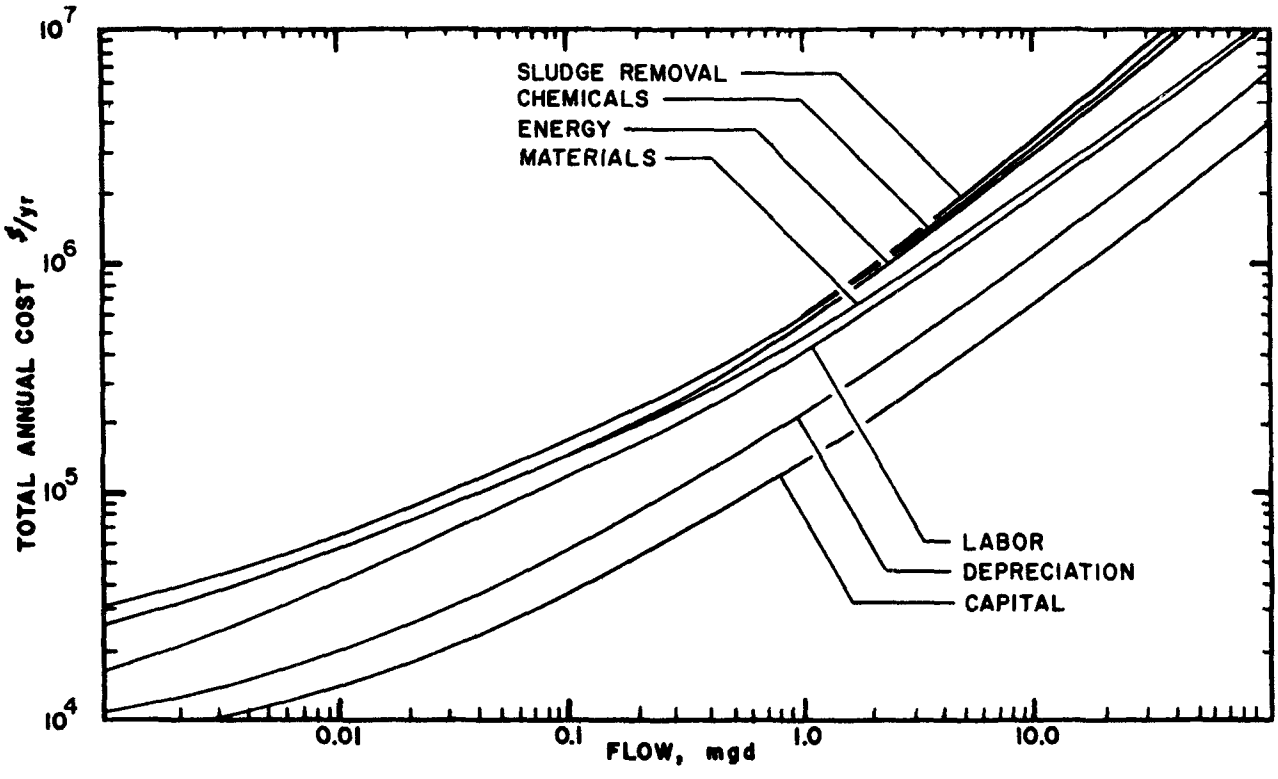



FIGURE VIII-53. PRIMARY COPPER (SMELTING & REFINING) COMB. 2, ALT. 3

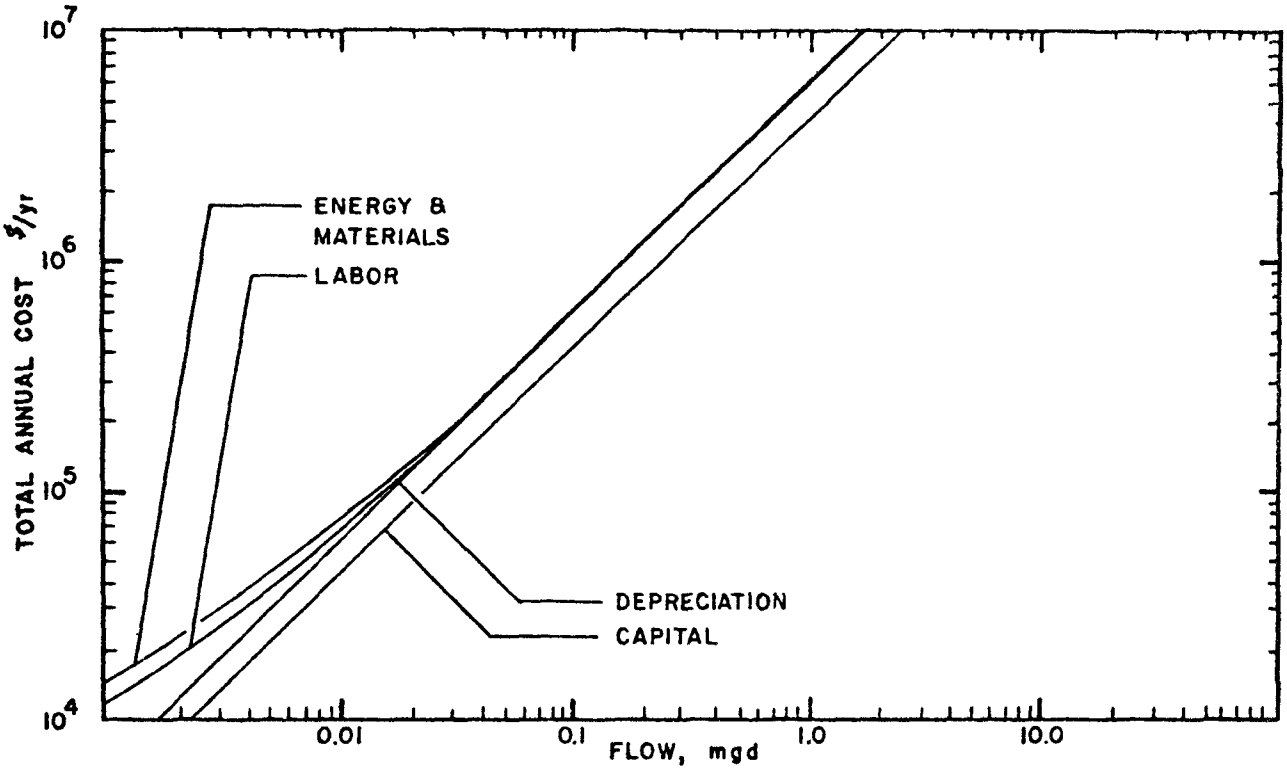



FIGURE VIII-58. PRIMARY COPPER EVAPORATION, 10 INCHES / YEAR

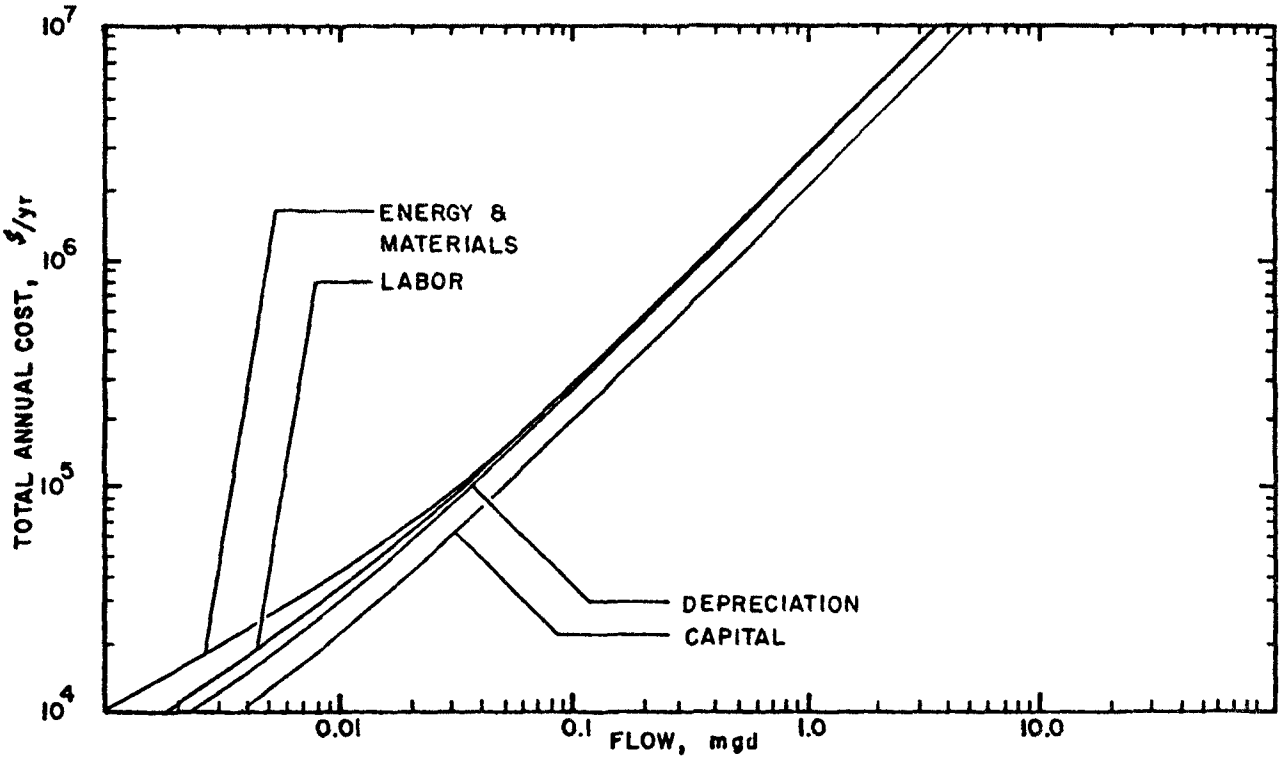



FIGURE VIII-59. PRIMARY COPPER EVAPORATION, 20 INCHES/YEAR

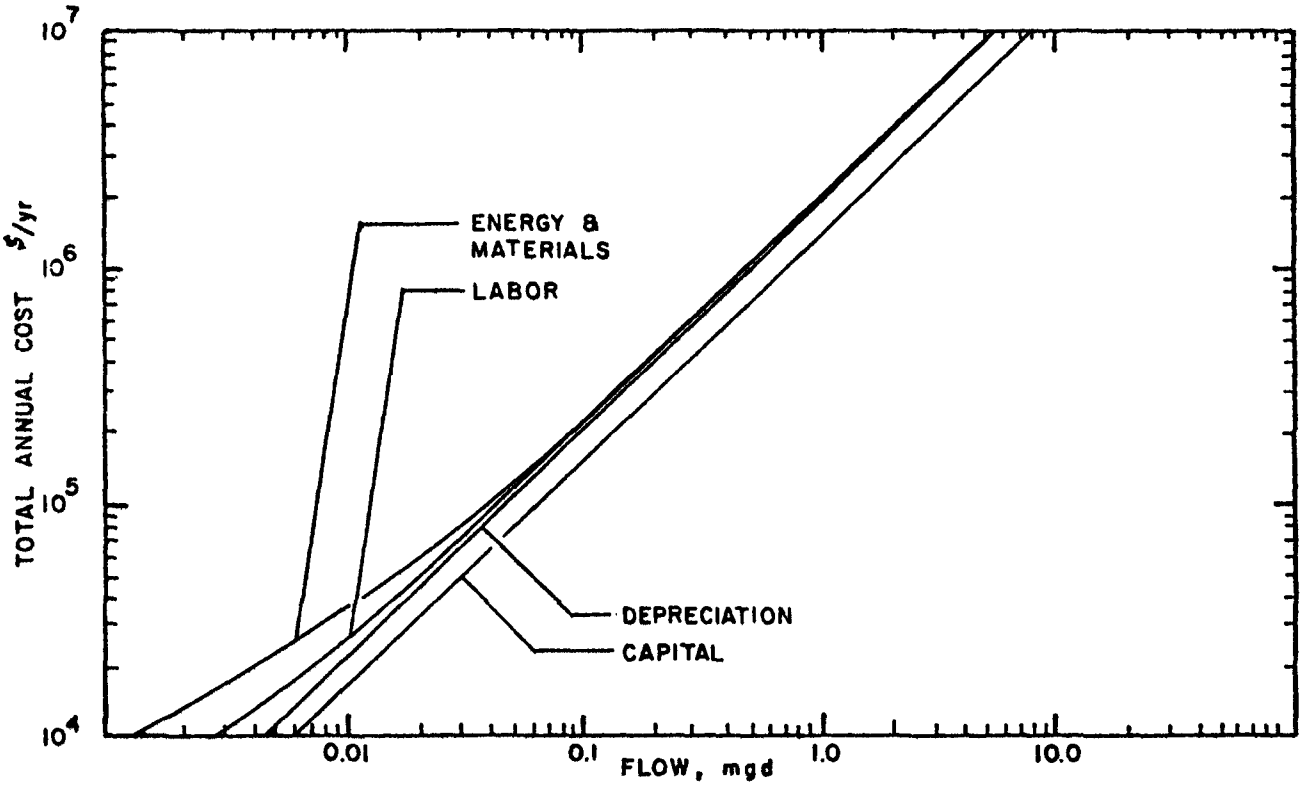



FIGURE VIII-60. PRIMARY COPPER EVAPORATION, 30 INCHES/YEAR

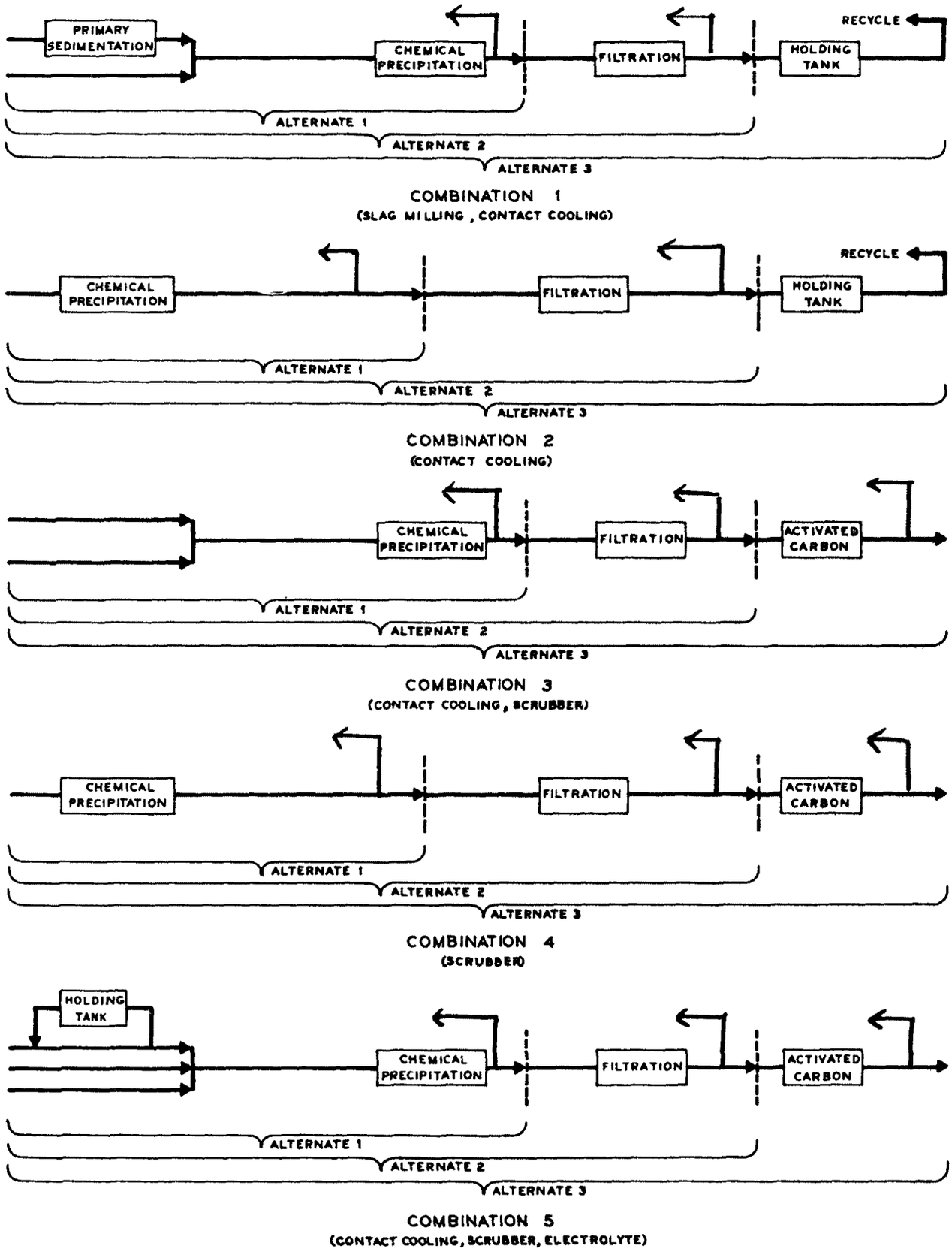



FIGURE VIII-61. SECONDARY COPPER TREATMENT SCHEMES

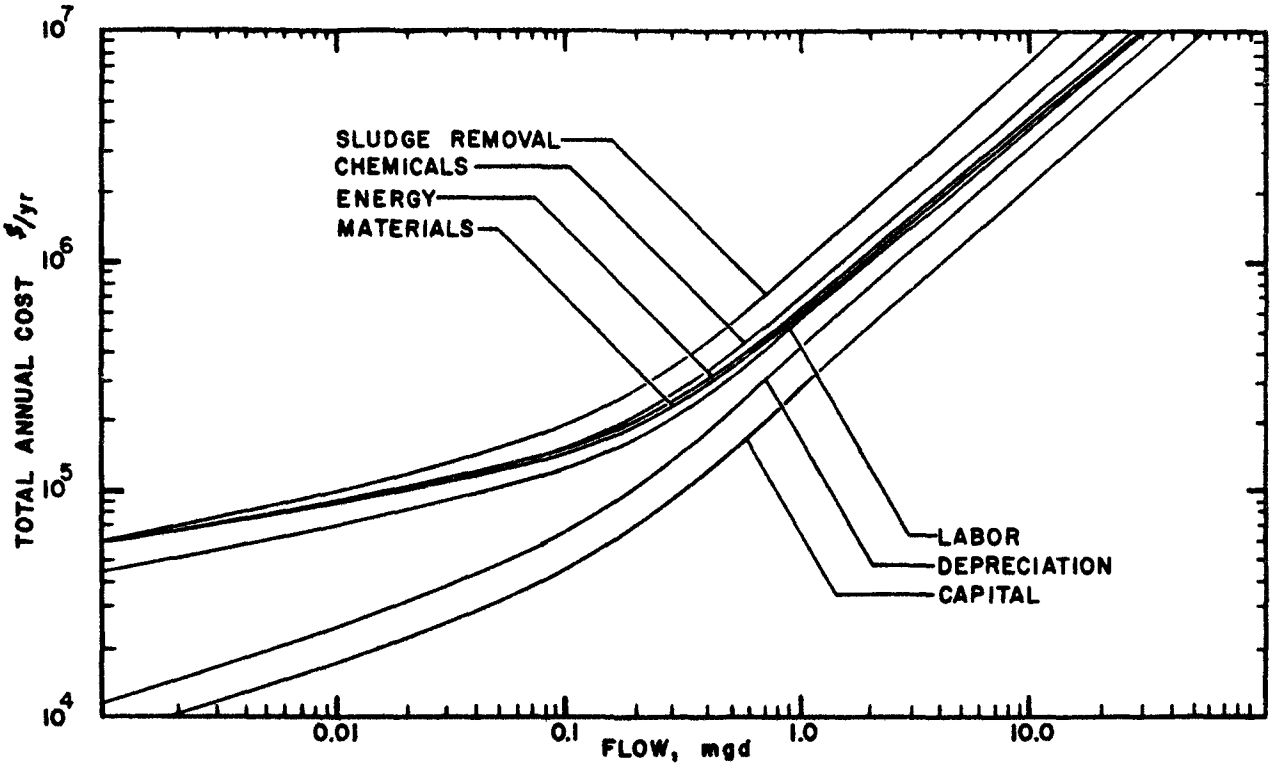



FIGURE VIII-62. SECONDARY COPPER COMB. I, ALT. I

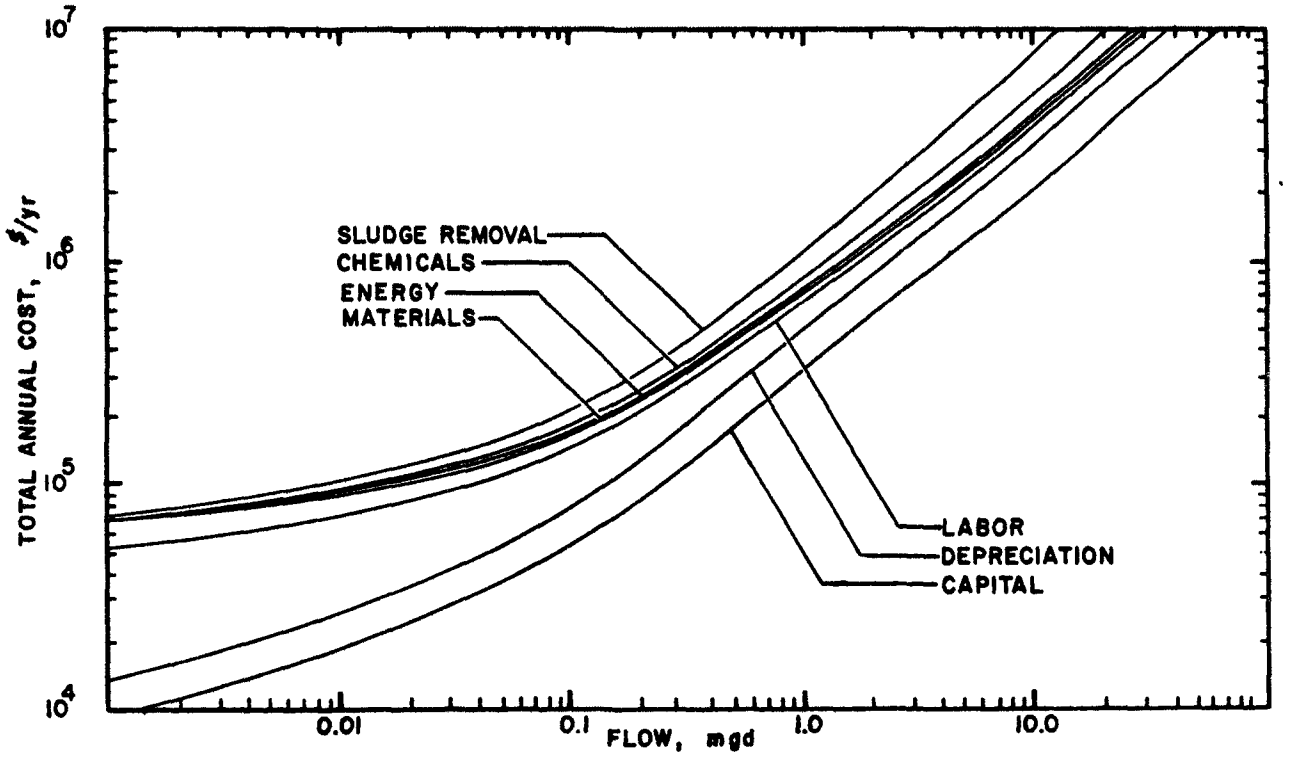



FIGURE VIII-63. SECONDARY COPPER COMB. I, ALT. 2

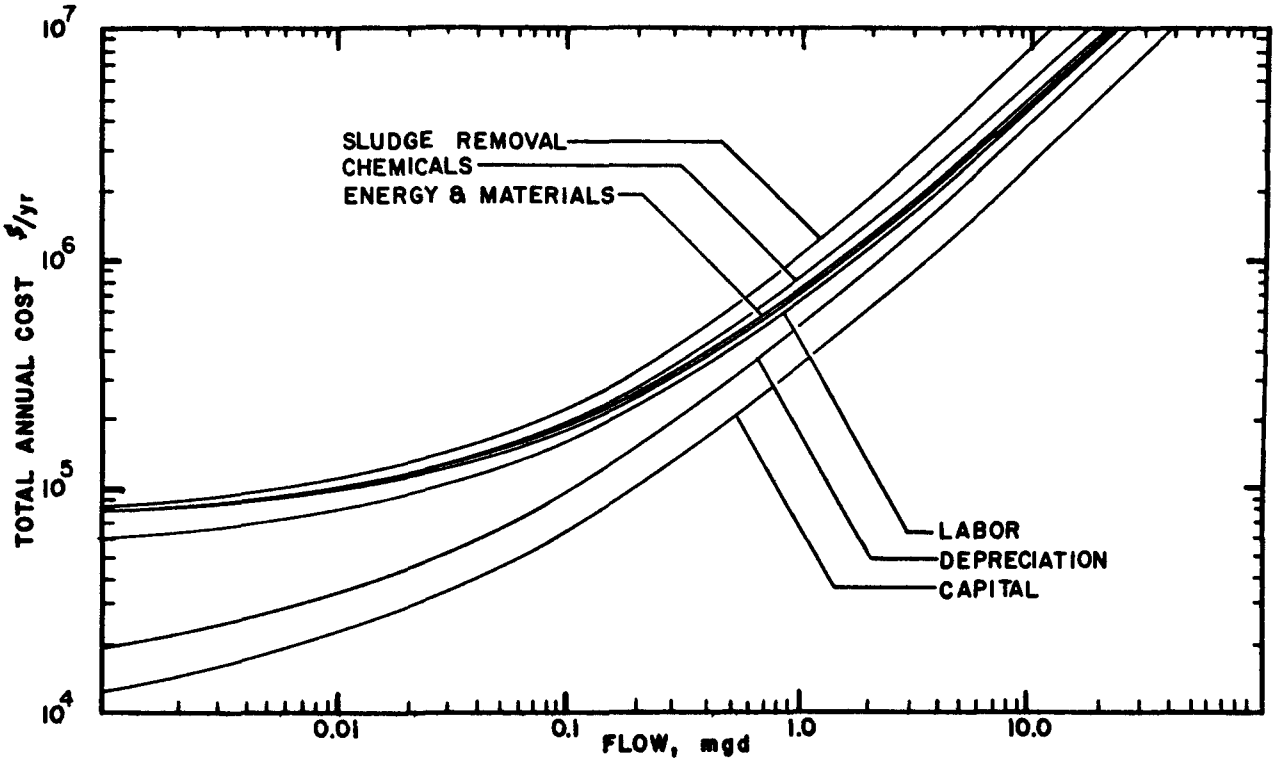



FIGURE VIII-64. SECONDARY COPPER COMB. 1, ALT. 3

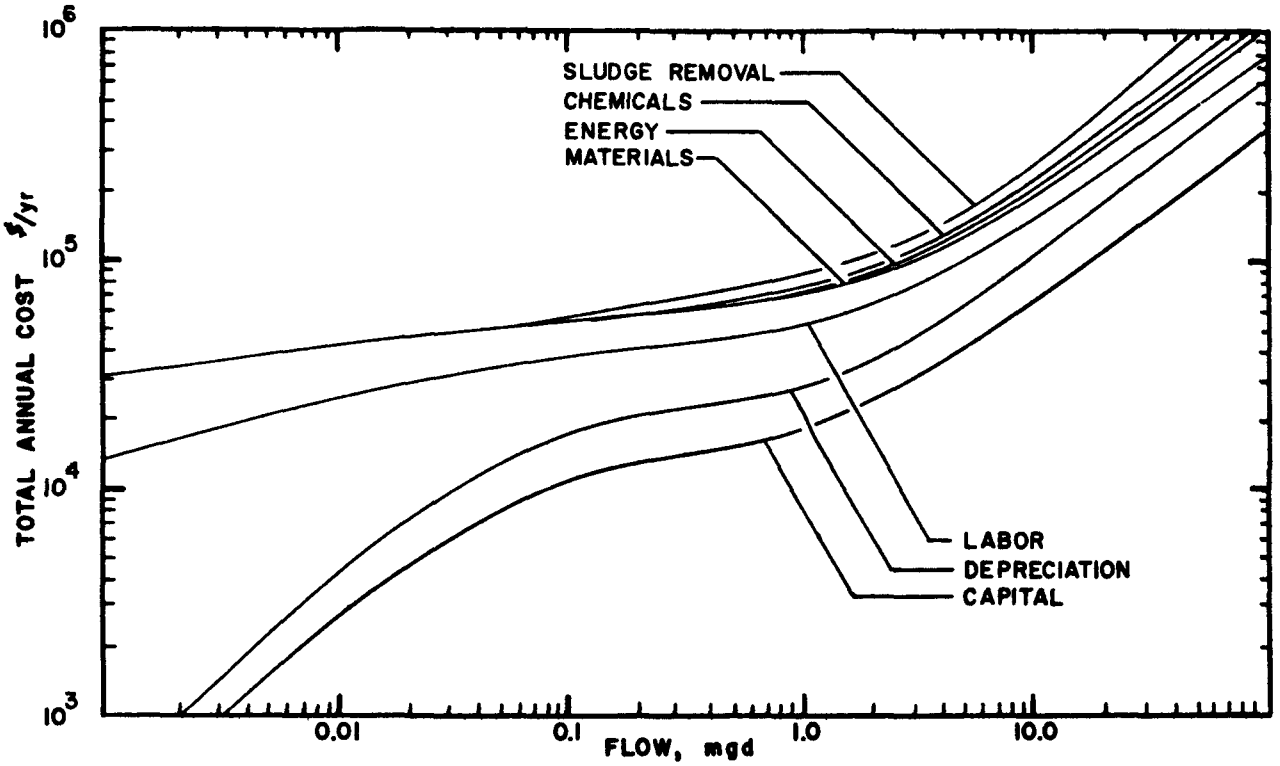



FIGURE VIII-65. SECONDARY COPPER COMB. 2,3,OR 4, ALT. I

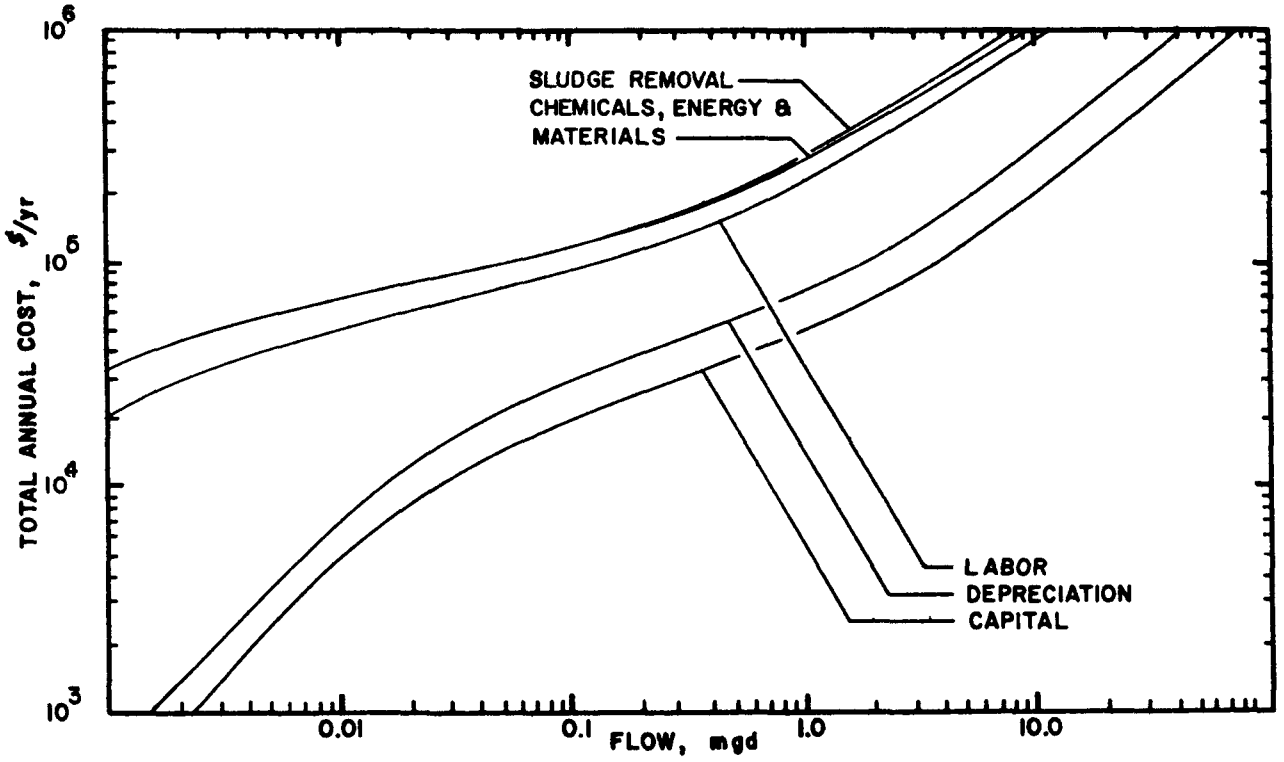



FIGURE VIII-66. SECONDARY COPPER COMB. 2,3,OR 4, ALT. 2

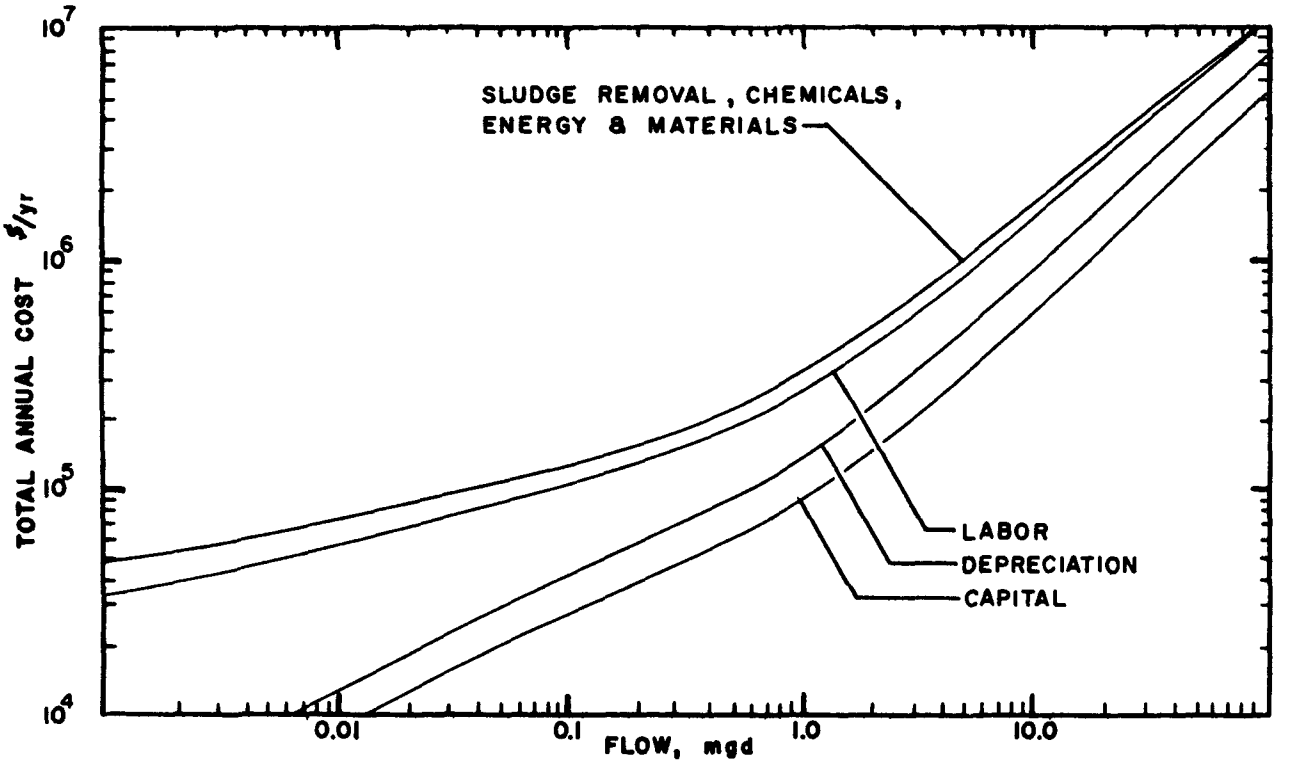



FIGURE VIII-67. SECONDARY COPPER COMB.2, ALT.3

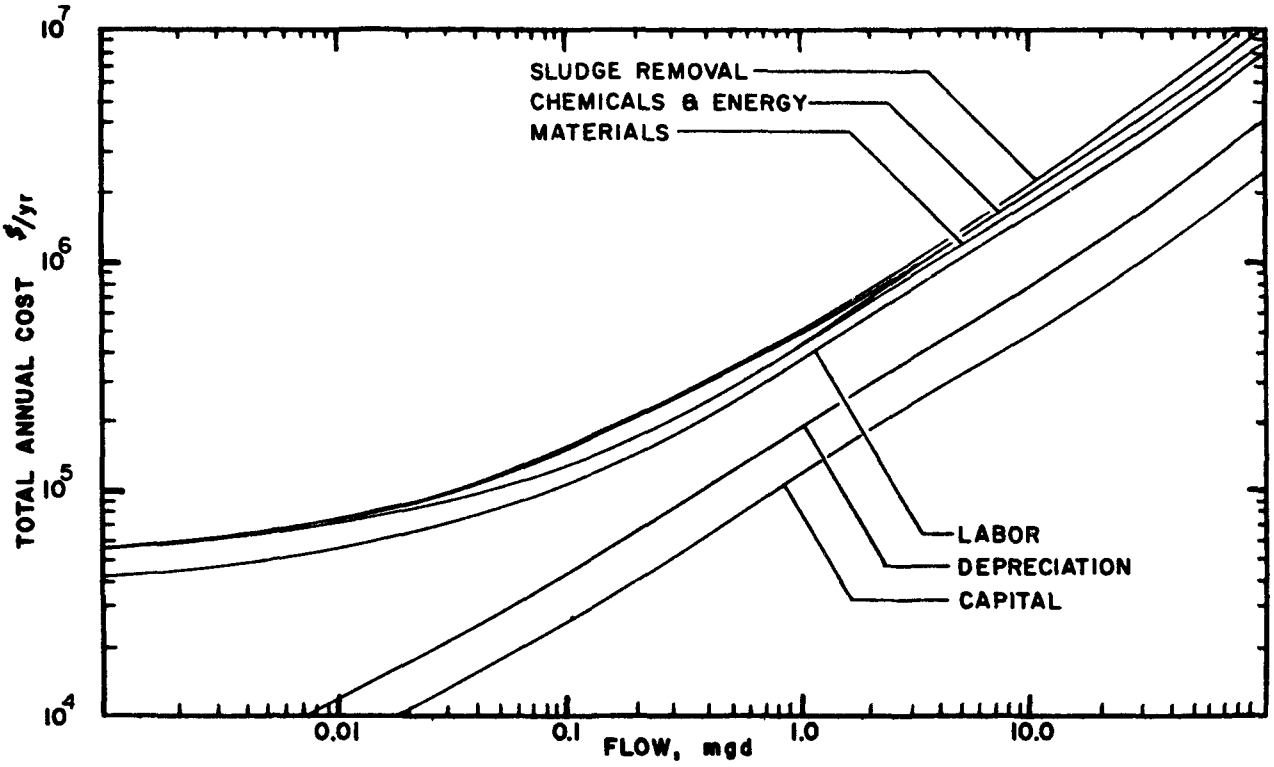



FIGURE VIII-68. SECONDARY COPPER COMB.3 OR 4 , ALT. 3

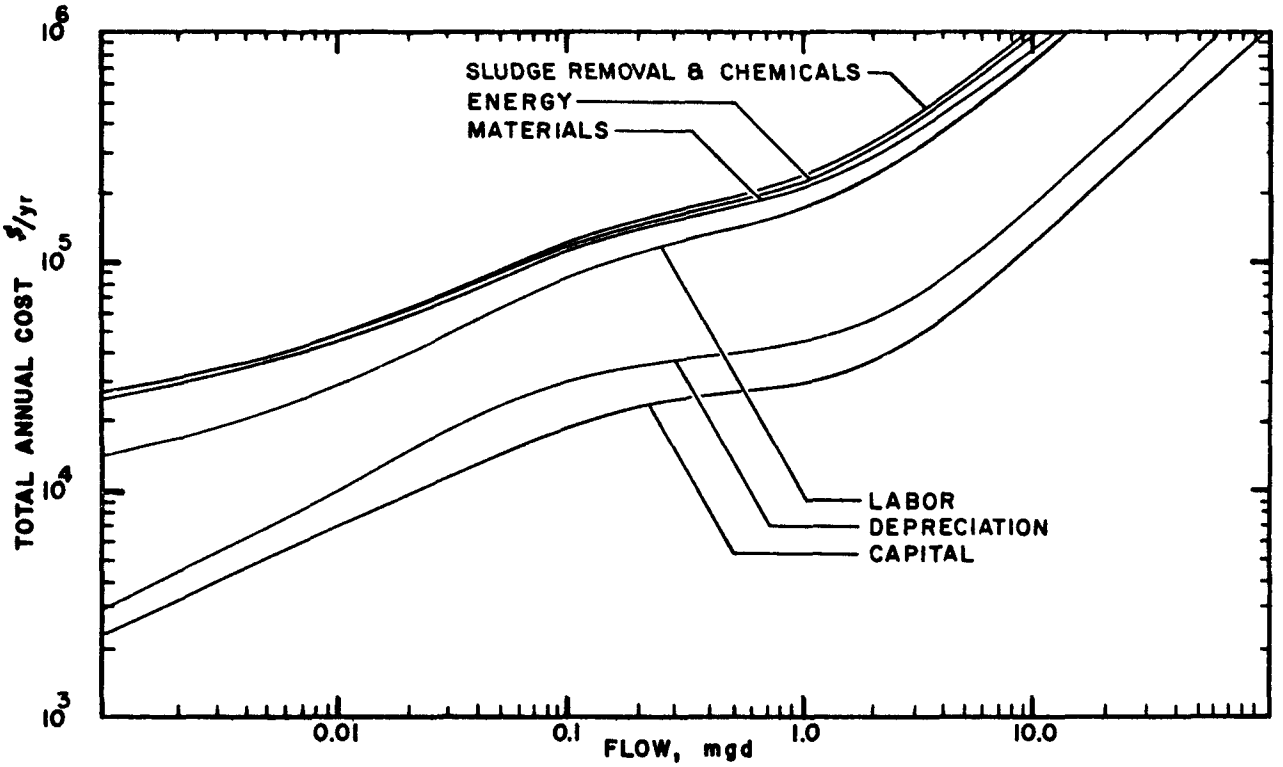



FIGURE VIII-69. SECONDARY COPPER COMB. 5, ALT. 1

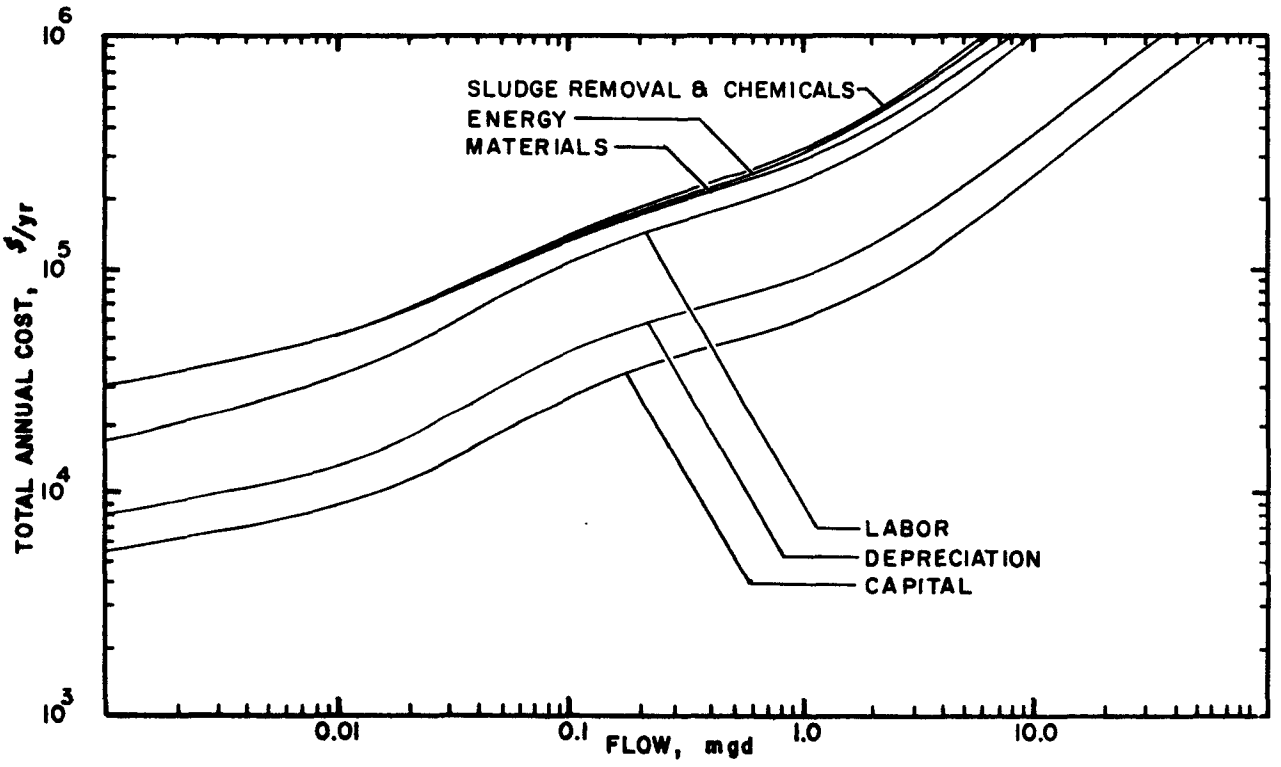



FIGURE VIII-70. SECONDARY COPPER COMB. 5, ALT. 2

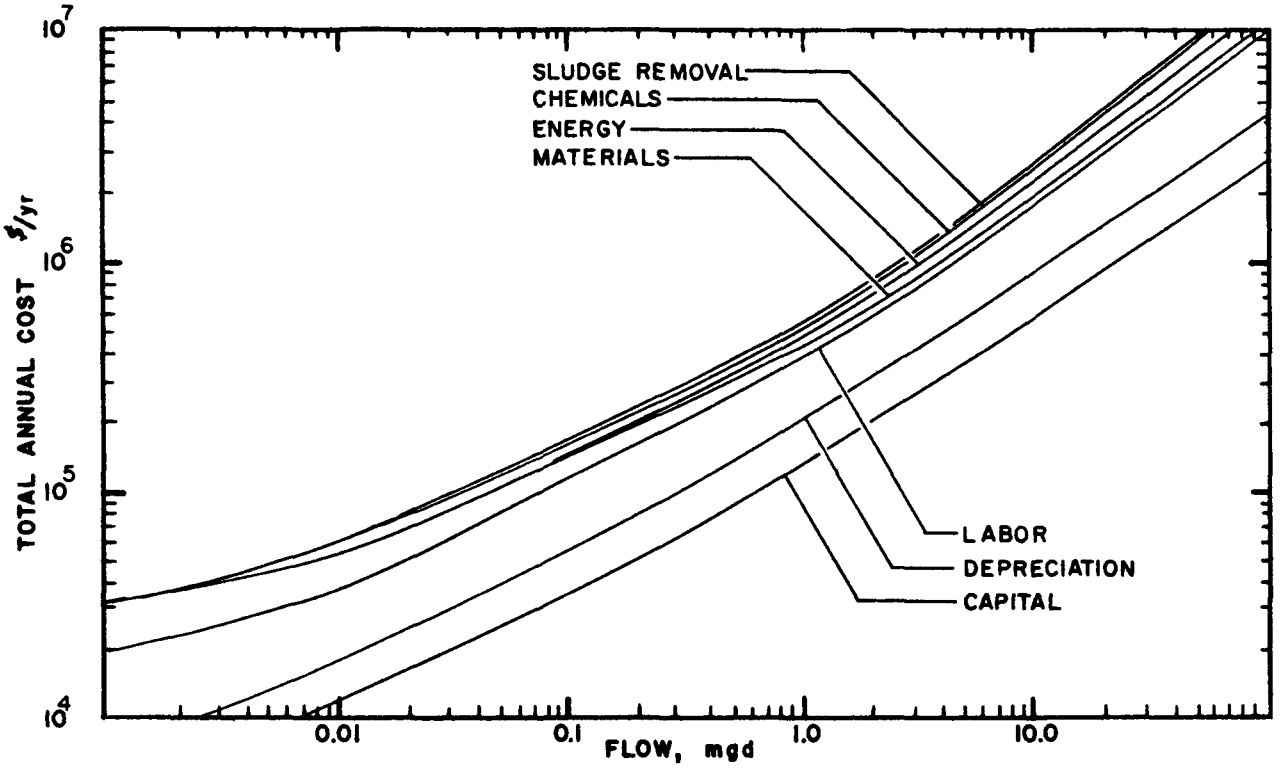
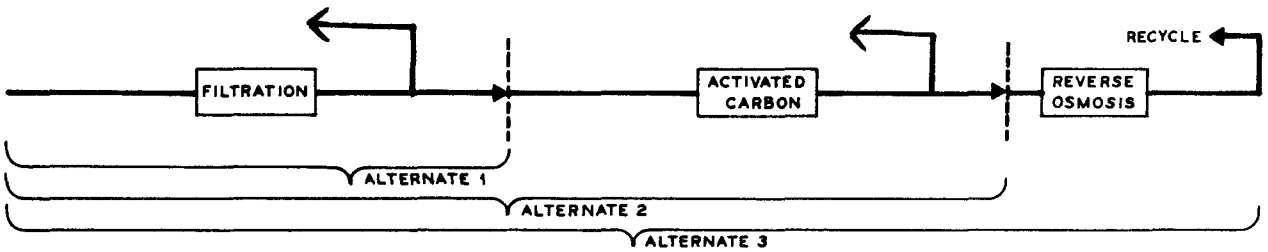



FIGURE VIII-71. SECONDARY COPPER COMB.5, ALT. 3




COMBINATION 1
(COMBINED WASTEWATER)

FIGURE VIII-72. PRIMARY LEAD TREATMENT SCHEMES

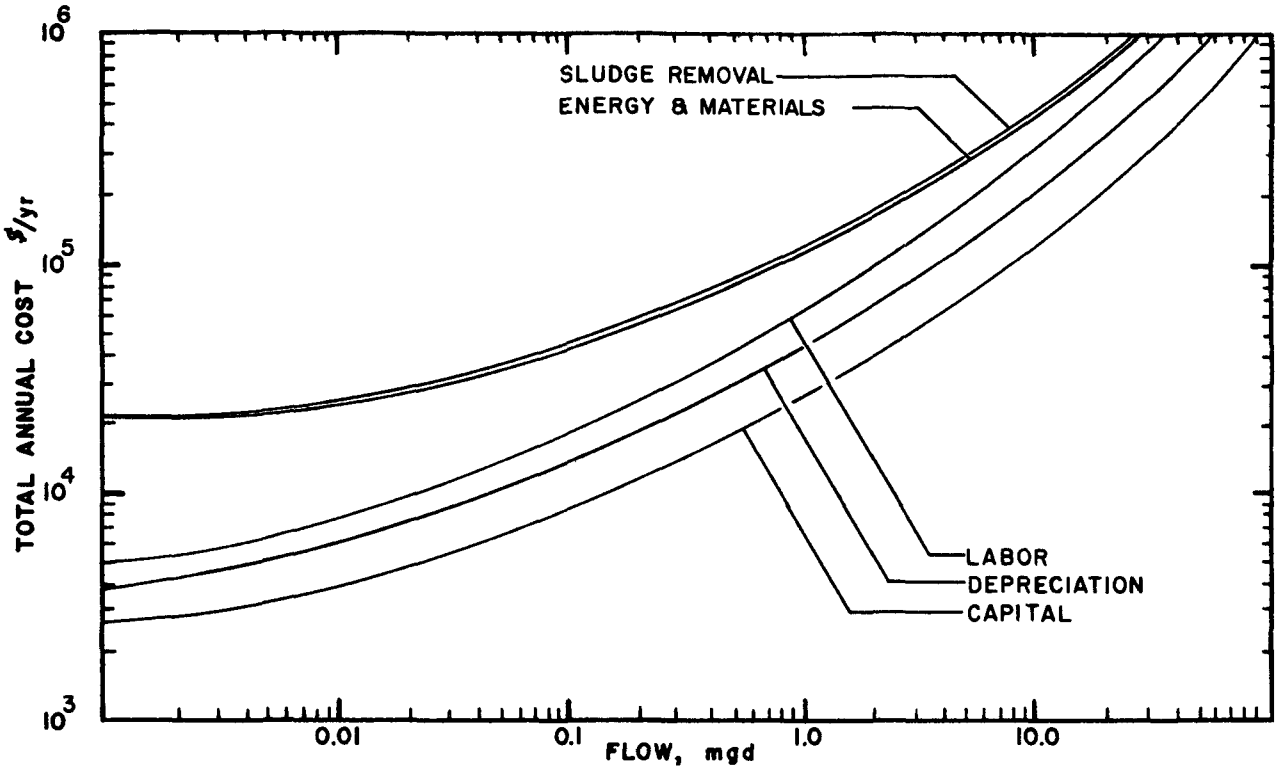



FIGURE VIII - 73. PRIMARY LEAD COMB. 1, ALT. 1

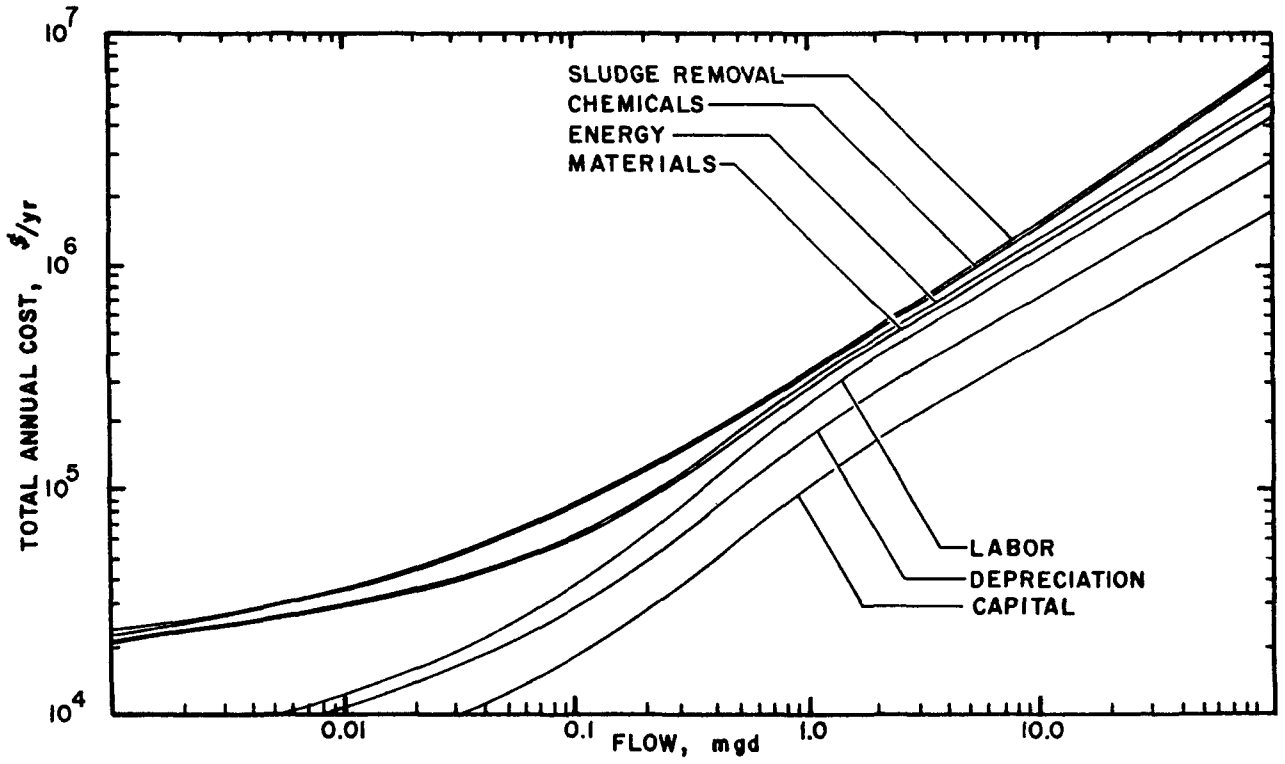



FIGURE VIII - 74. PRIMARY LEAD COMB. 1, ALT. 2

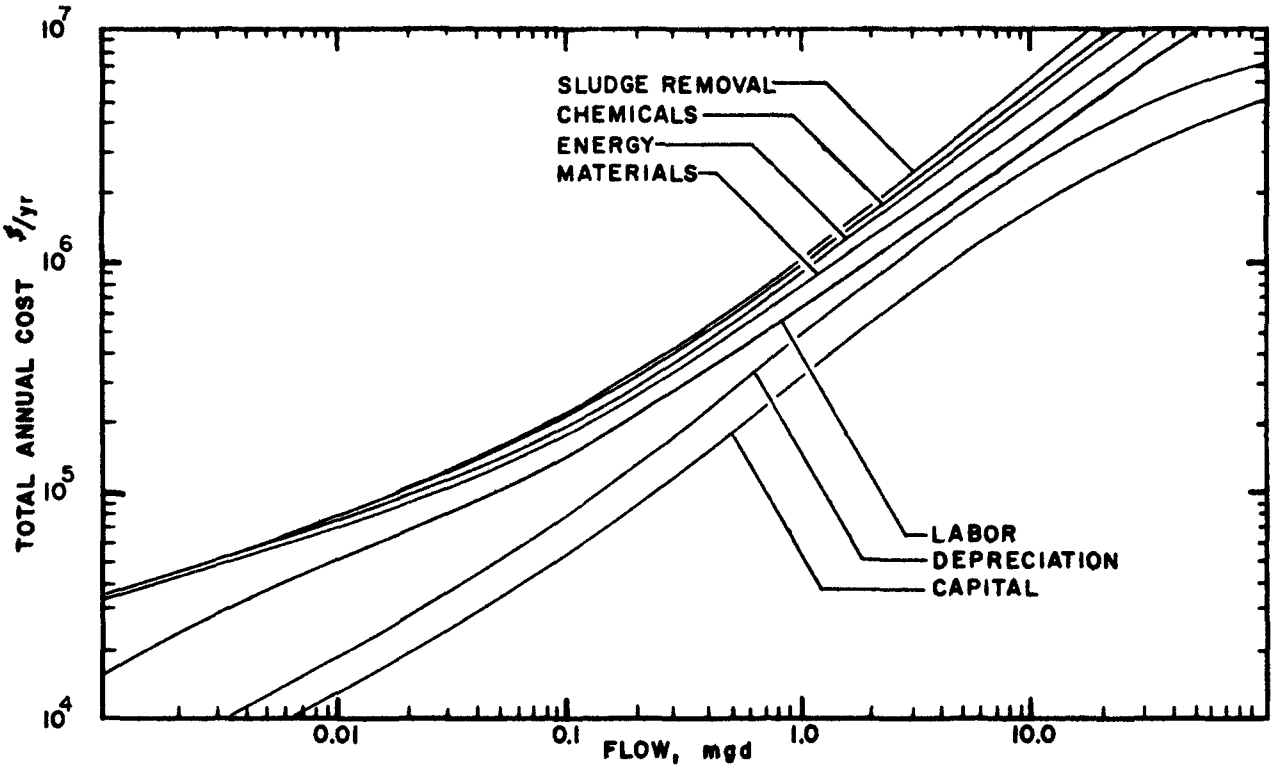
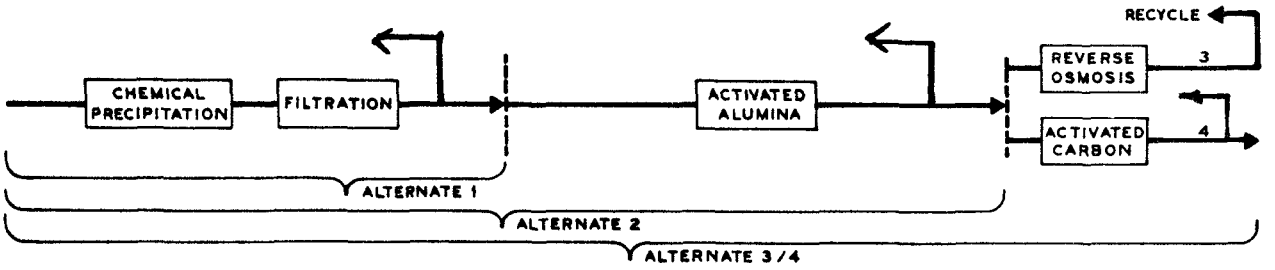
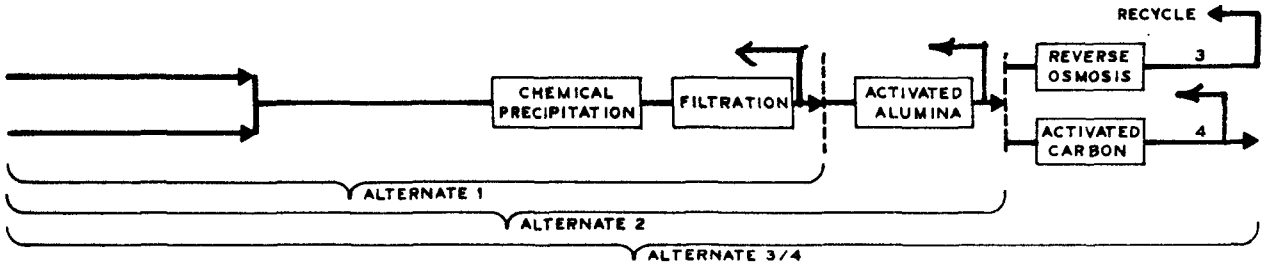



FIGURE VIII-75. PRIMARY LEAD COMB. 1, ALT. 3




COMBINATION 1
(BATTERY ACID AND SAW WATER)




COMBINATION 2
(BATTERY ACID AND SAW WATER, CONTACT COOLING AND/OR SCRUBBER)

FIGURE VIII-76. SECONDARY LEAD TREATMENT SCHEMES

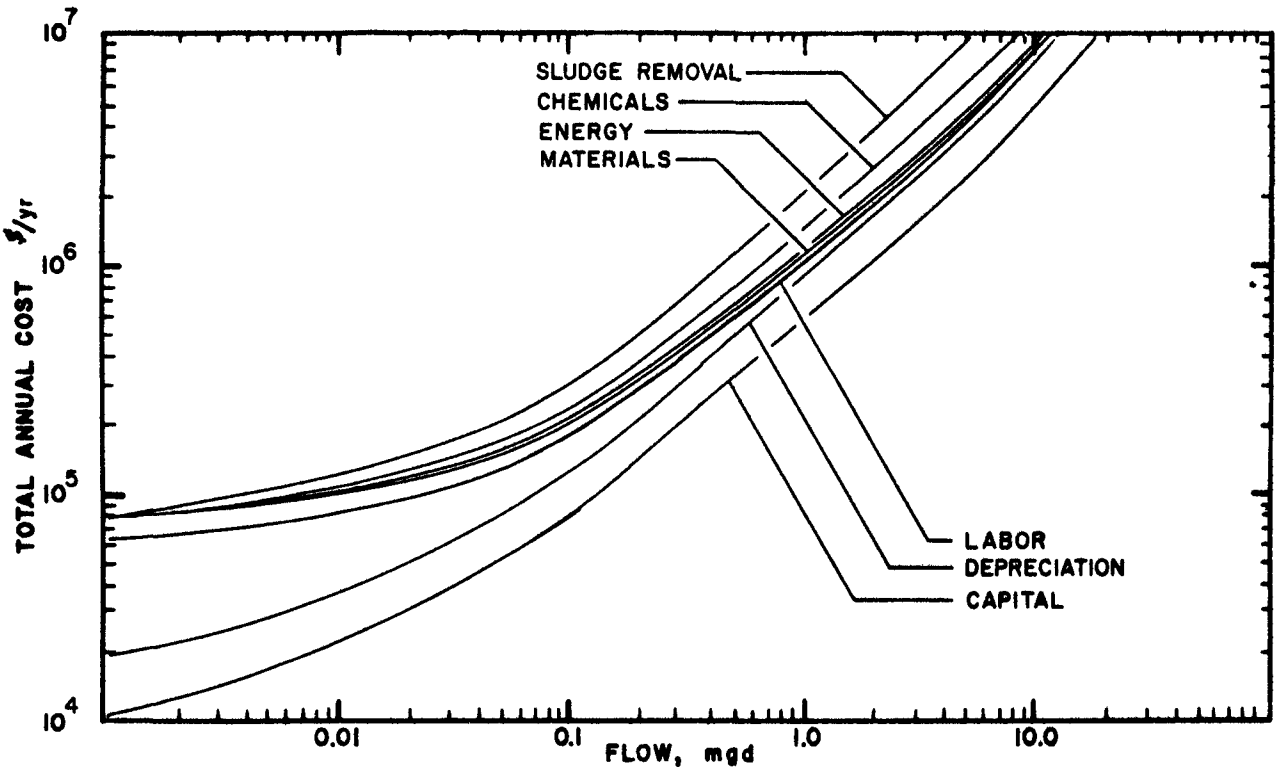



FIGURE VIII-77. SECONDARY LEAD COMB. I, ALT. I

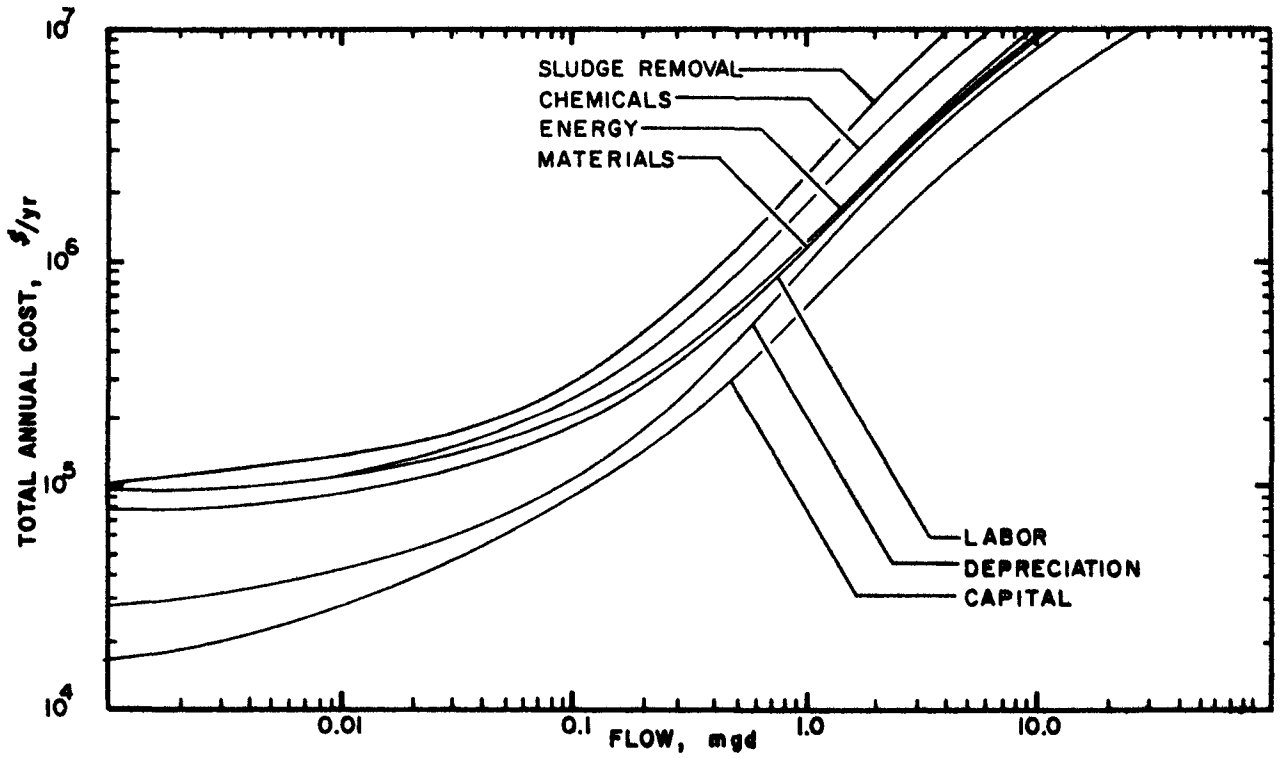



FIGURE VIII-78. SECONDARY LEAD COMB. I, ALT. 2

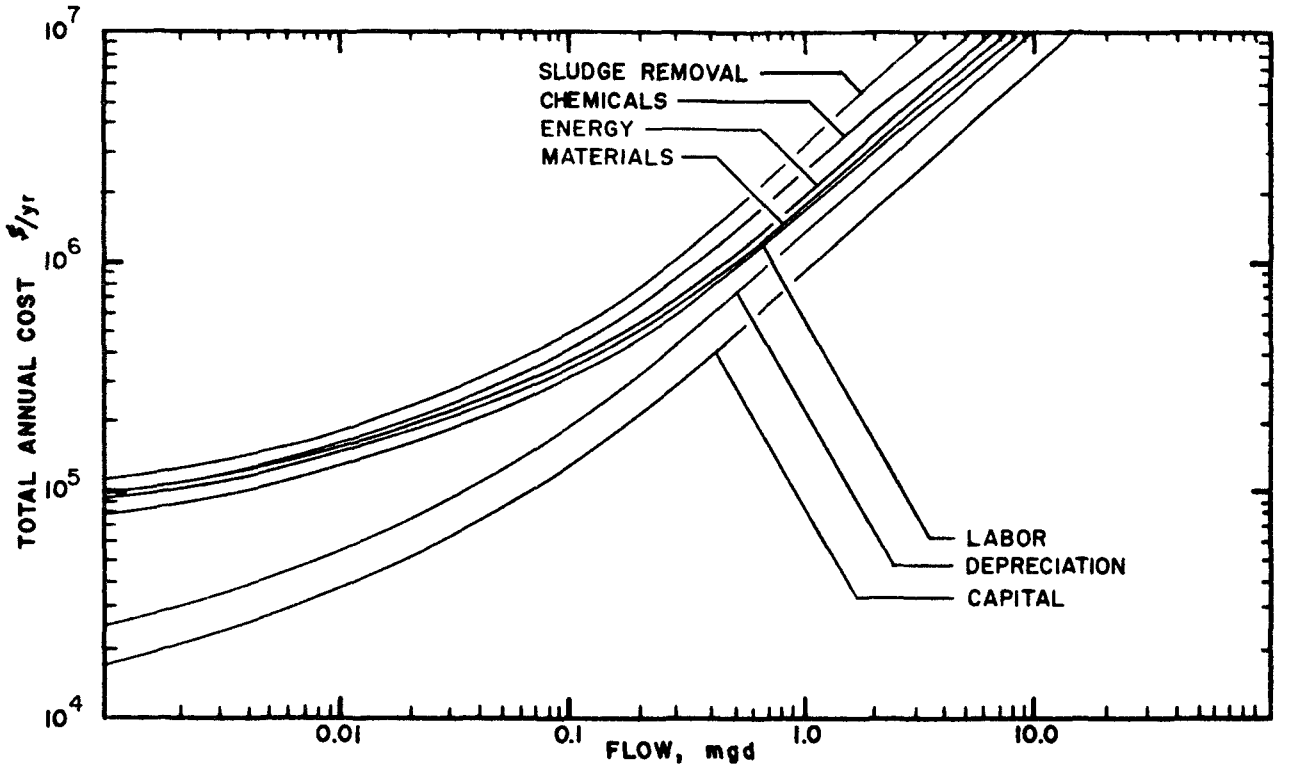



FIGURE VIII-79. SECONDARY LEAD COMB. I, ALT. 3

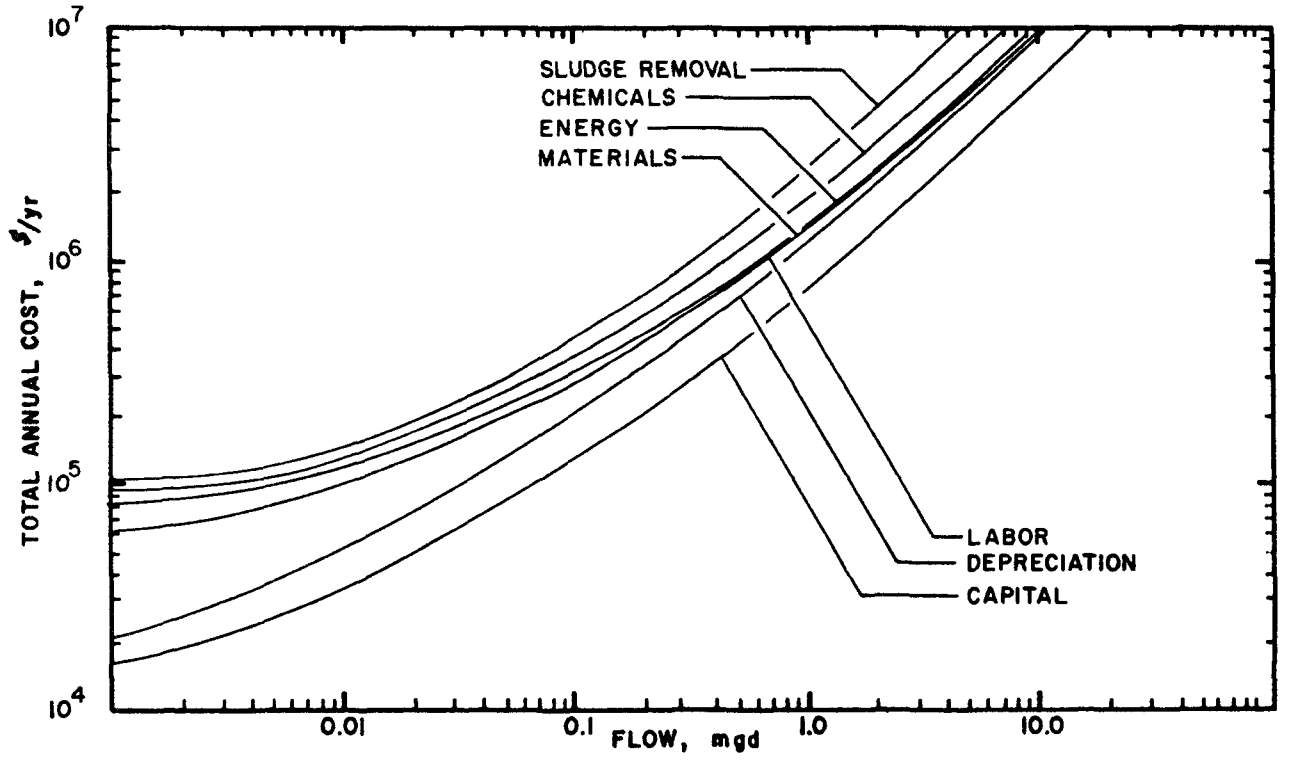



FIGURE VIII-80. SECONDARY LEAD COMB. I, ALT. 4

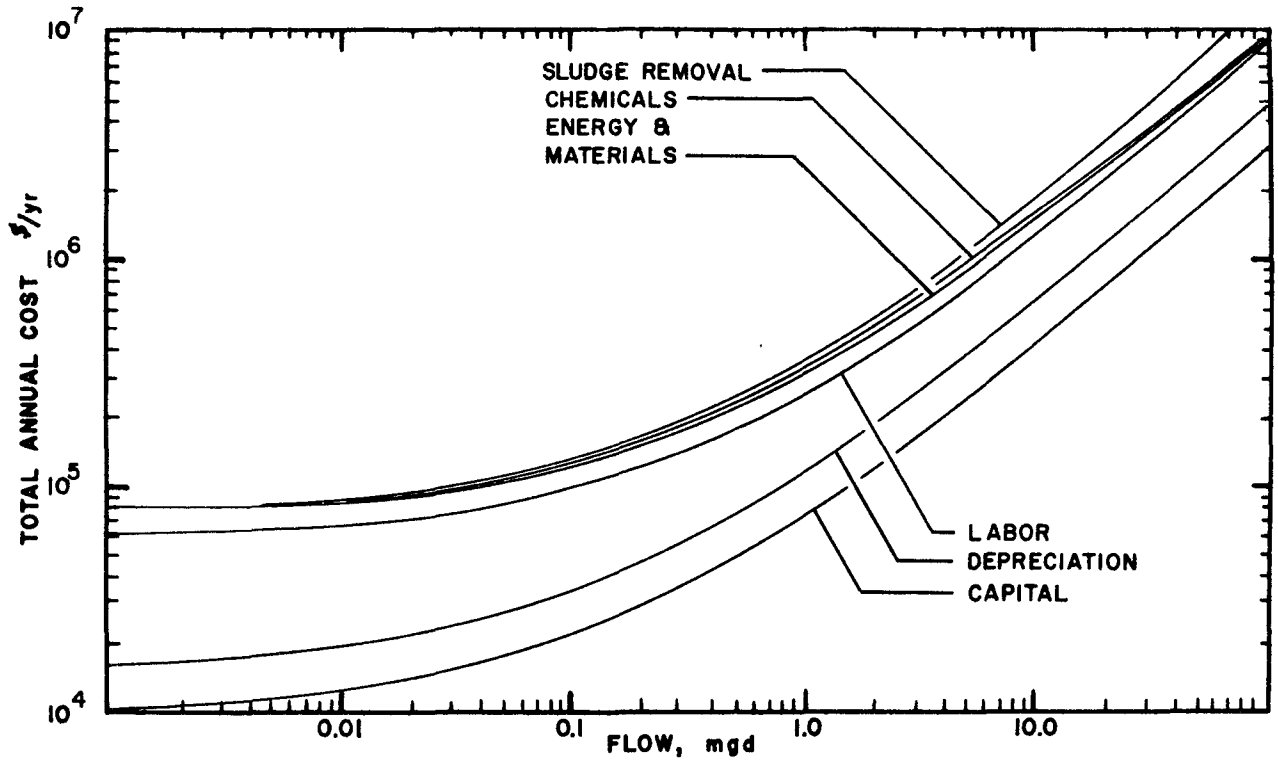



FIGURE VIII-81. SECONDARY LEAD COMB.2,ALT.1

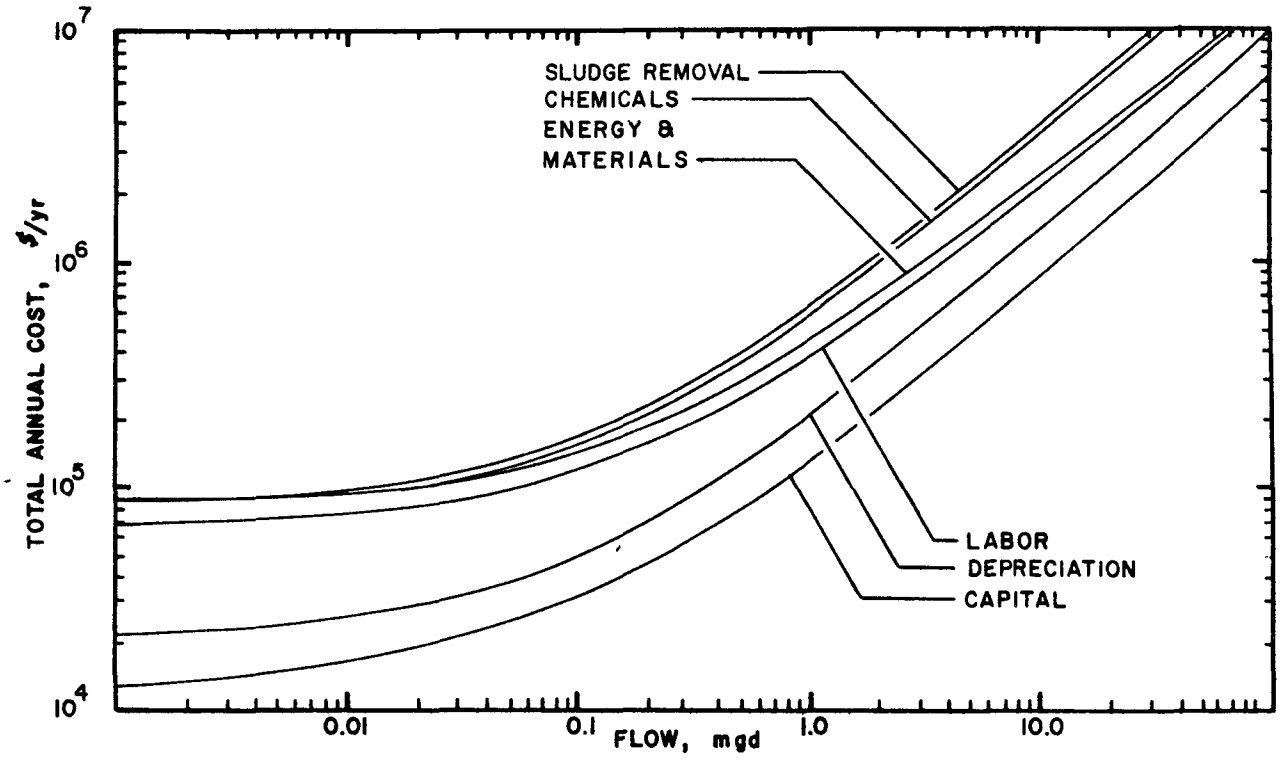



FIGURE VIII-82. SECONDARY LEAD COMB.2,ALT.2

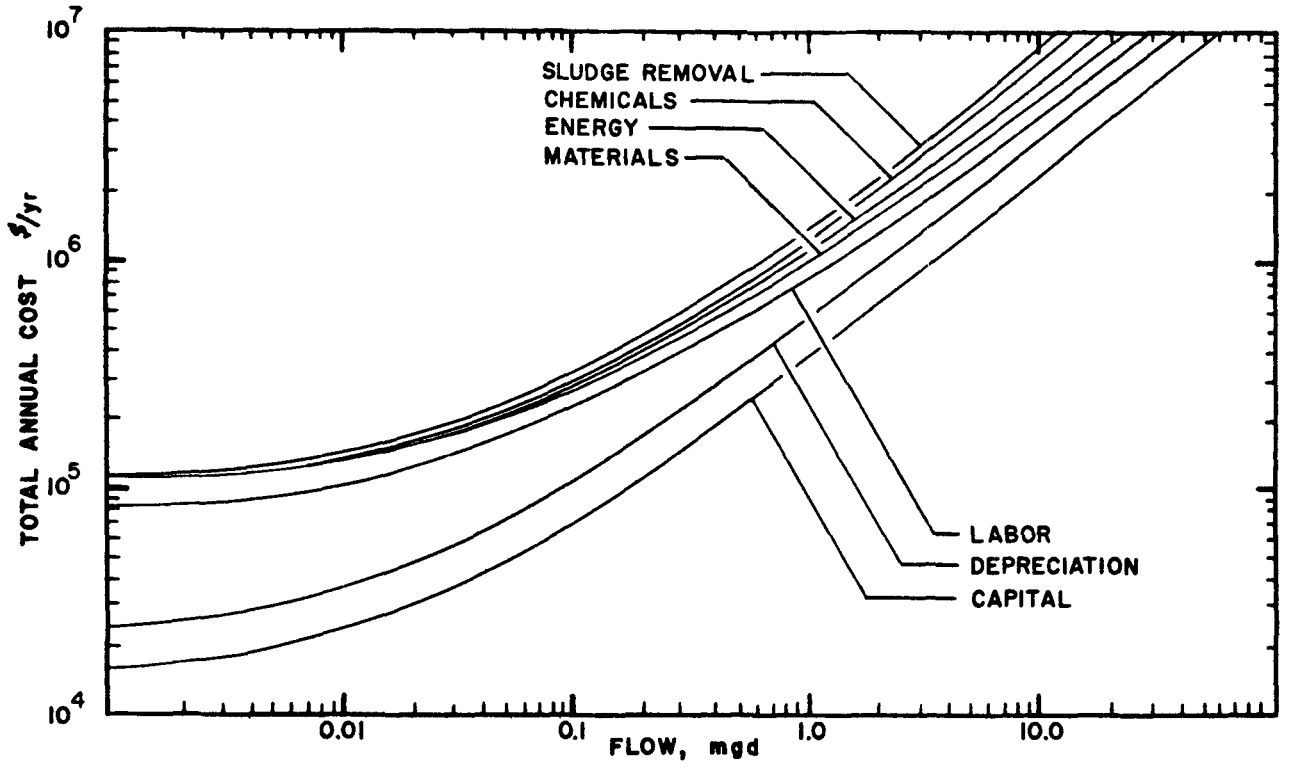



FIGURE VIII-83. SECONDARY LEAD COMB.2, ALT.3

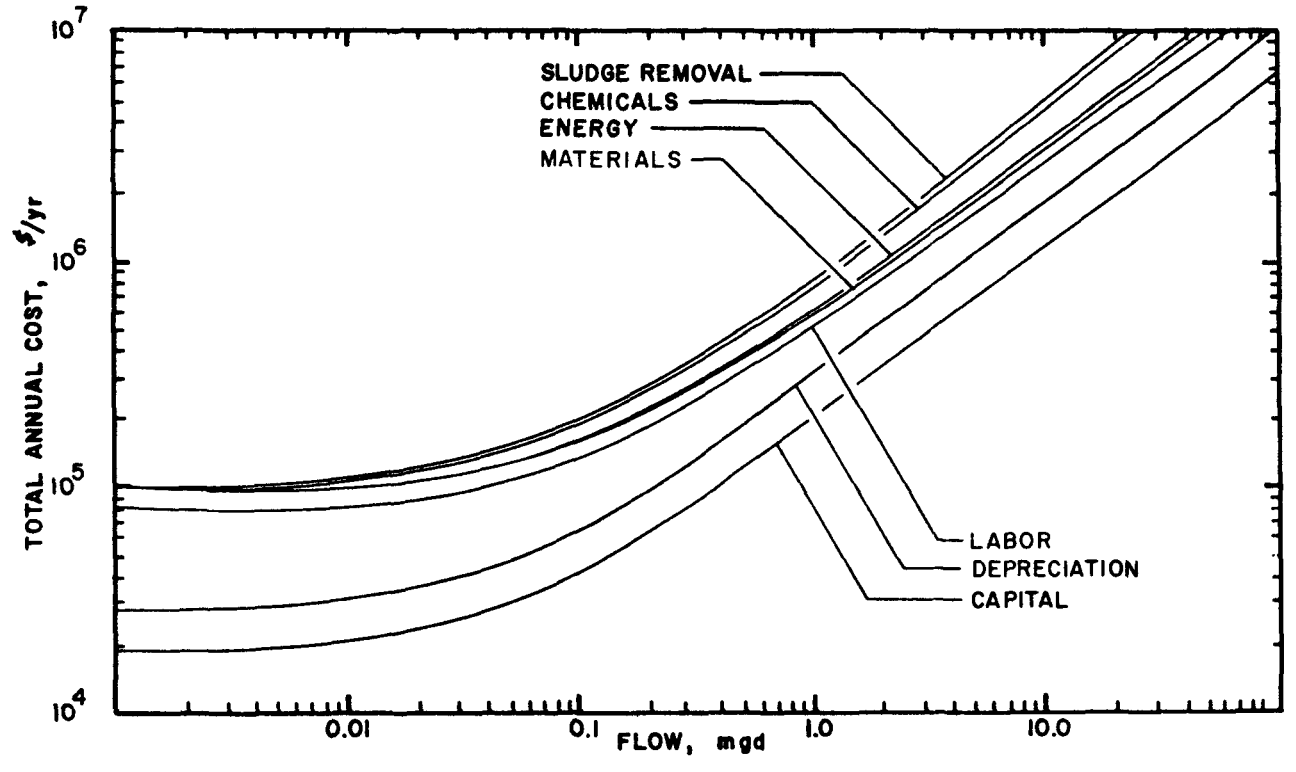
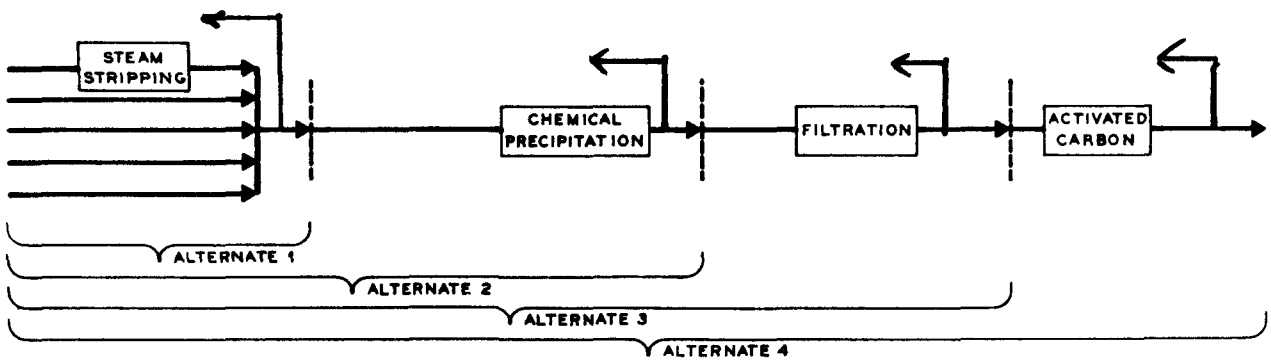



FIGURE VIII-84. SECONDARY LEAD COMB.2, ALT.4




COMBINATION 1
(ALL WASTE STREAMS)

FIGURE VIII - 85. SECONDARY SILVER TREATMENT SCHEMES (PHOTOGRAPHIC)

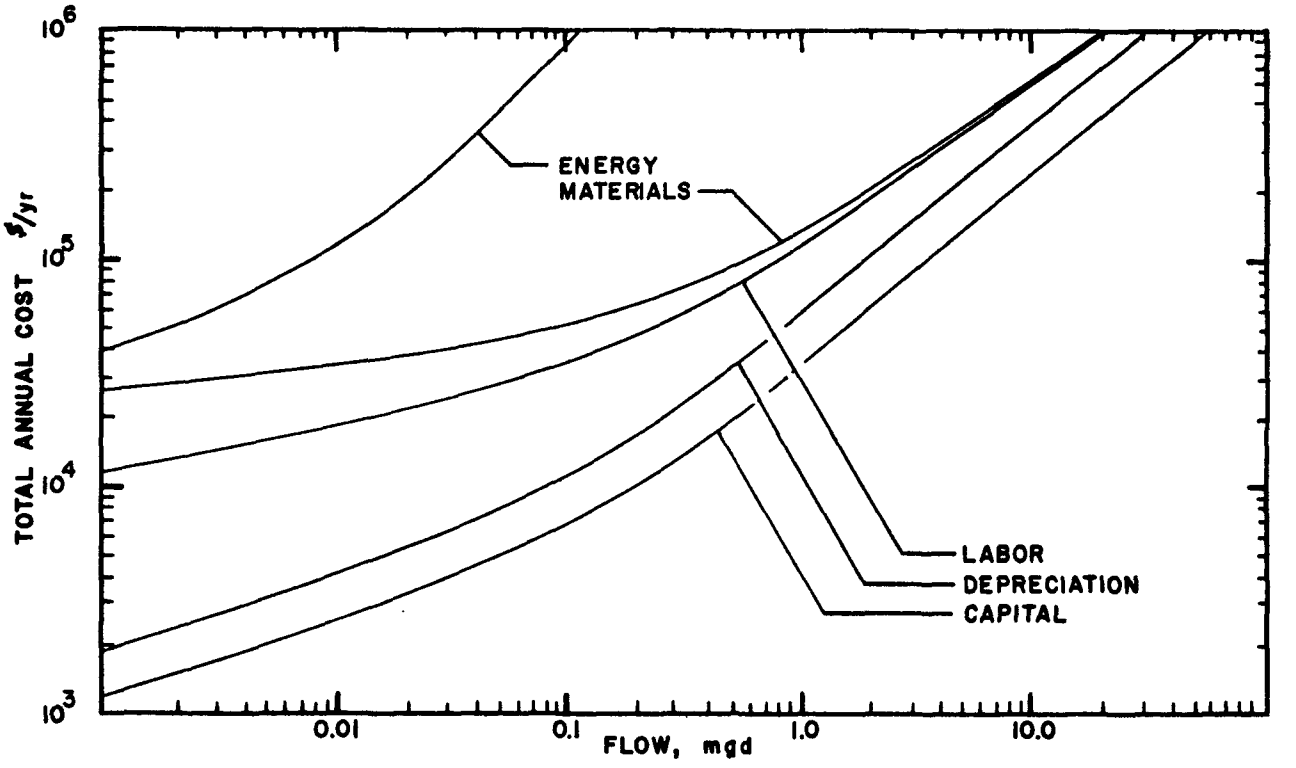



FIGURE VIII-86. SECONDARY SILVER (PHOTOGRAPHIC) COMB. I , ALT. I

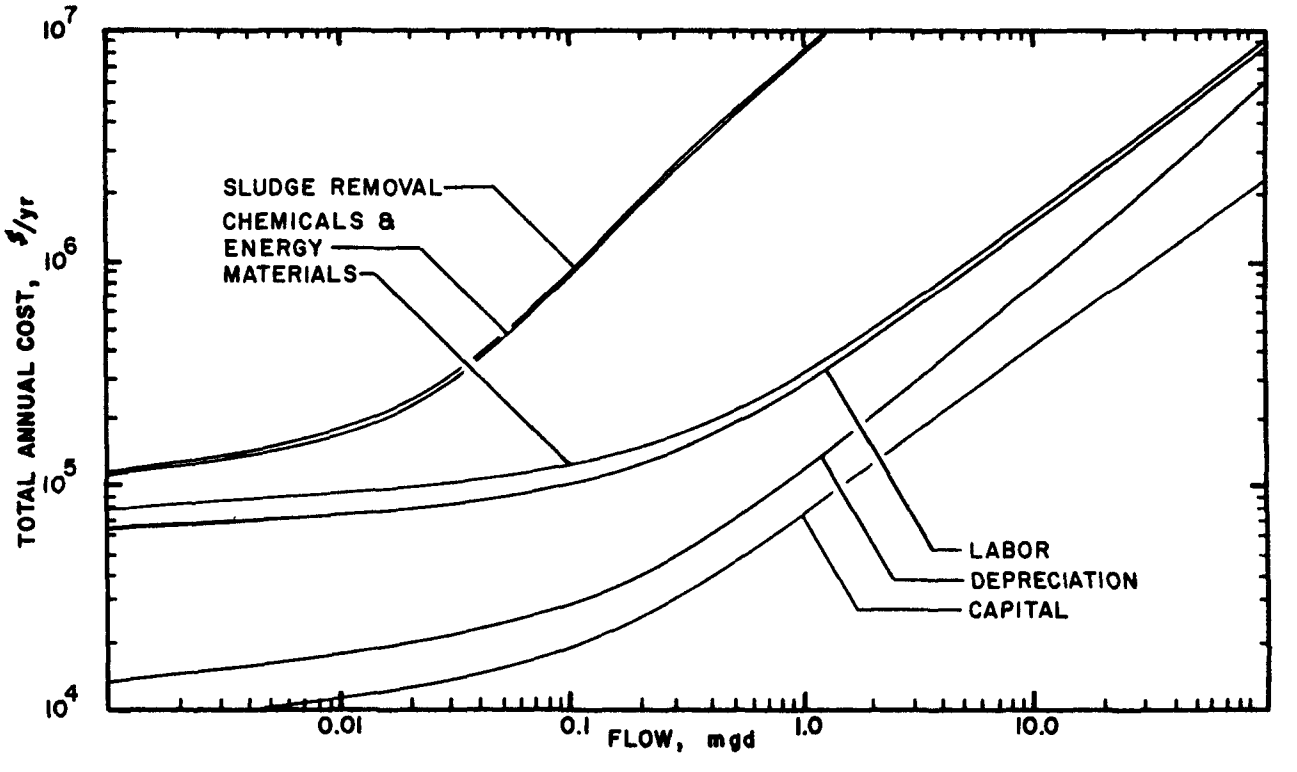



FIGURE VIII-87. SECONDARY SILVER ( PHOTOGRAPHIC ) COMB. I , ALT. 2

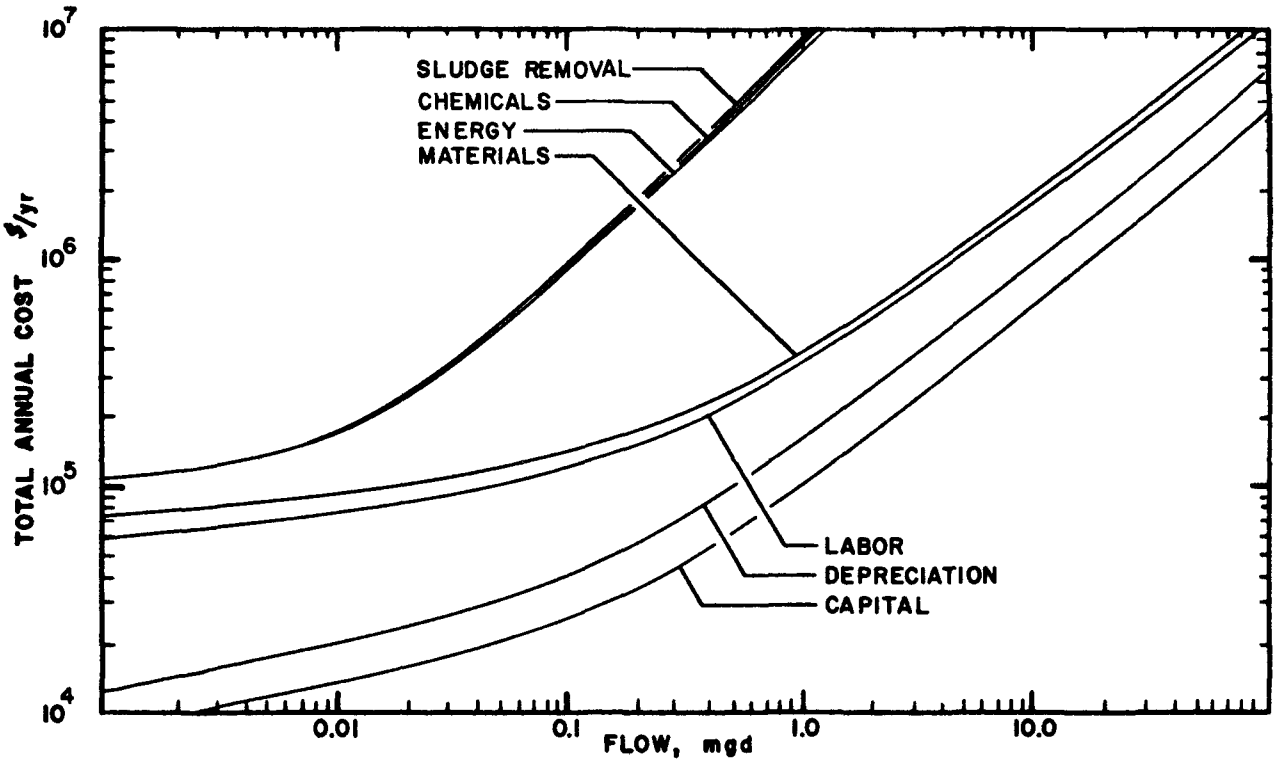



FIGURE VIII-88. SECONDARY SILVER (PHOTOGRAPHIC) COMB. I, ALT. 3

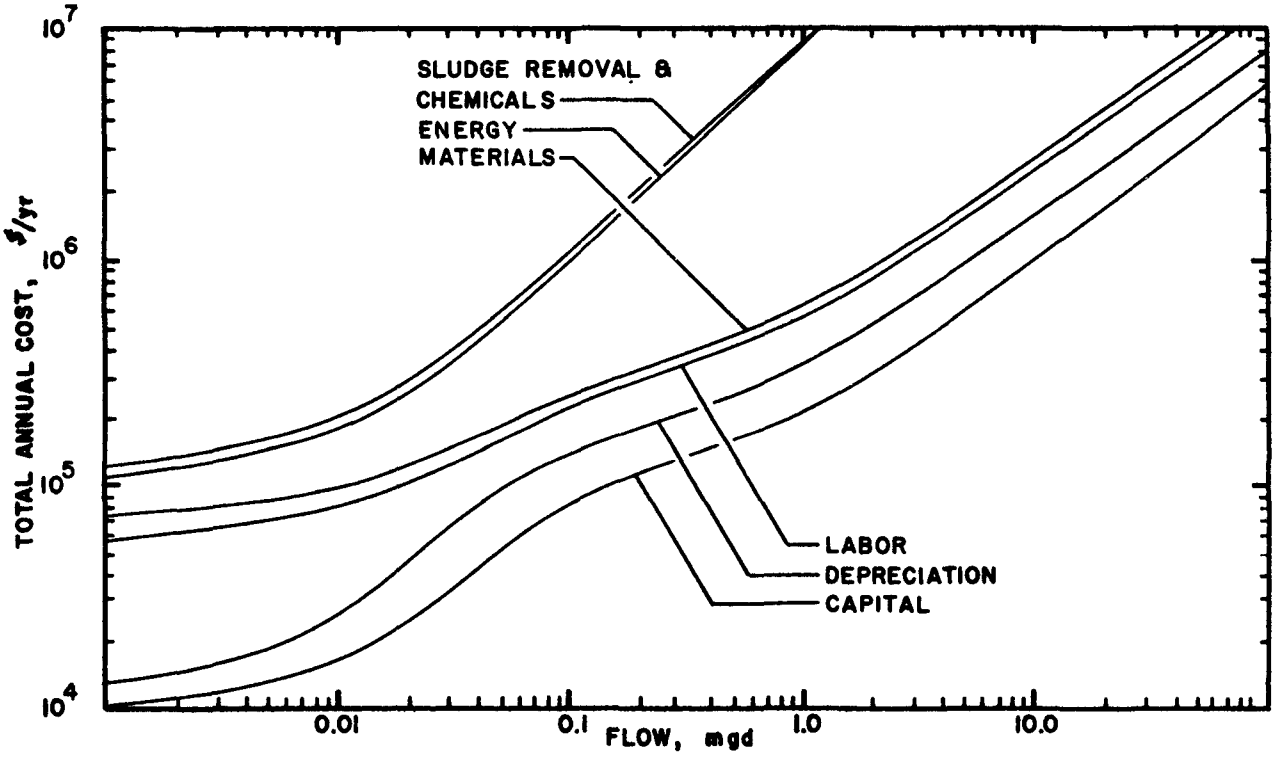
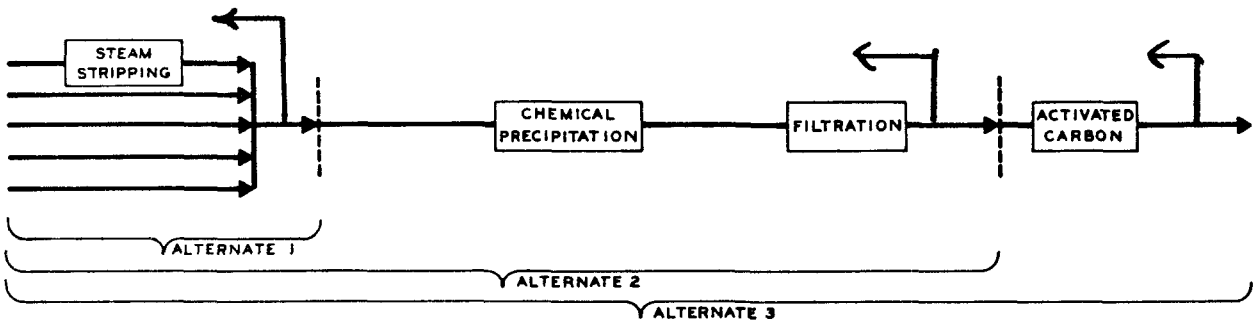



FIGURE VIII-89. SECONDARY SILVER (PHOTOGRAPHIC) COMB. I, ALT. 4




COMBINATION 1
(ALL WASTE STREAMS)

FIGURE VIII-90. SECONDARY SILVER TREATMENT SCHEMES (NON-PHOTOGRAPHIC)

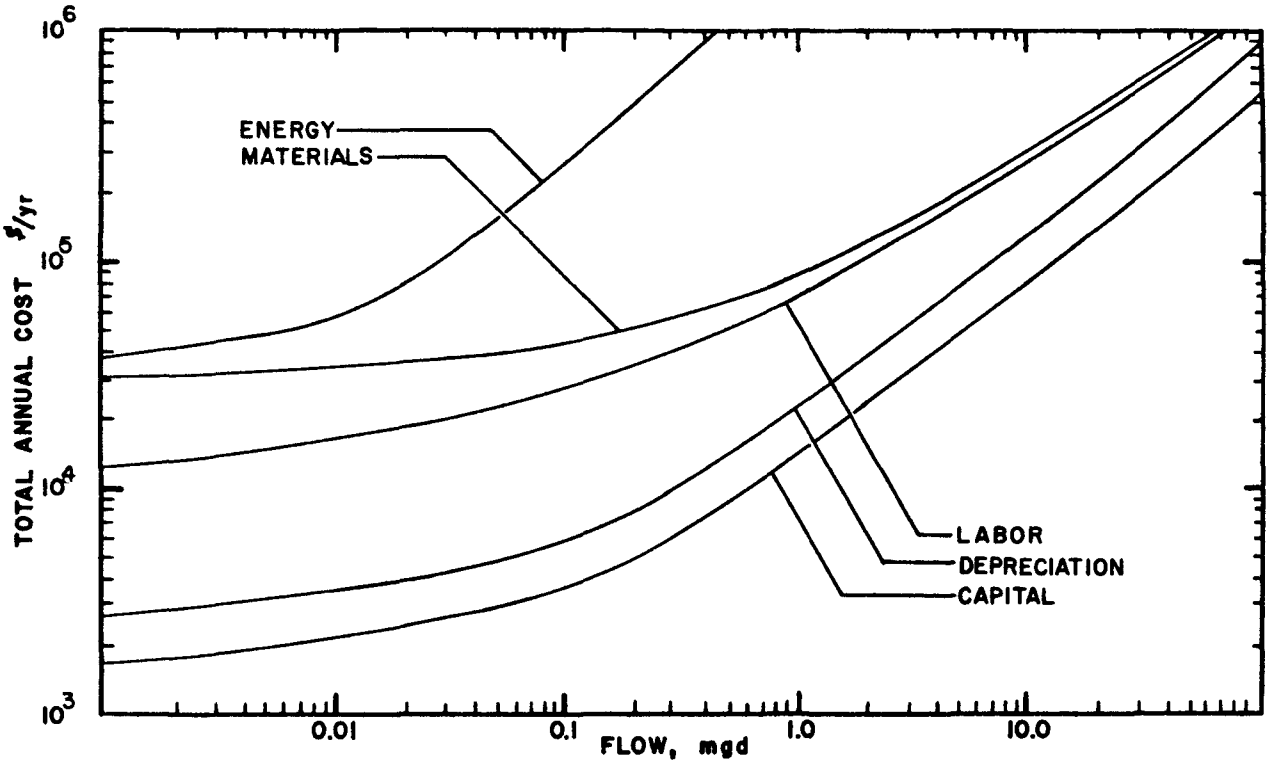



FIGURE VIII-91 . SECONDARY SILVER (NON-PHOTOGRAPHIC) COMB. I, ALT. I

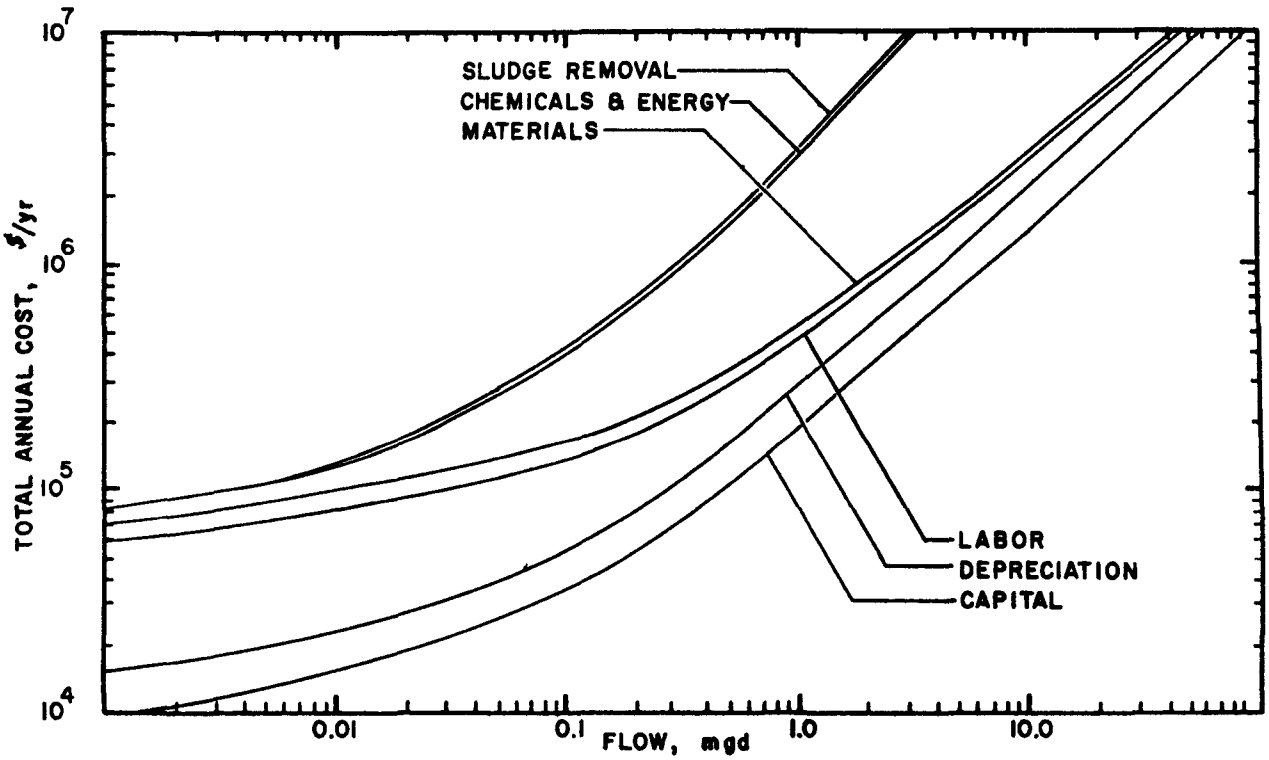



FIGURE VIII-92. SECONDARY SILVER (NON-PHOTOGRAPHIC) COMB.I, ALT 2

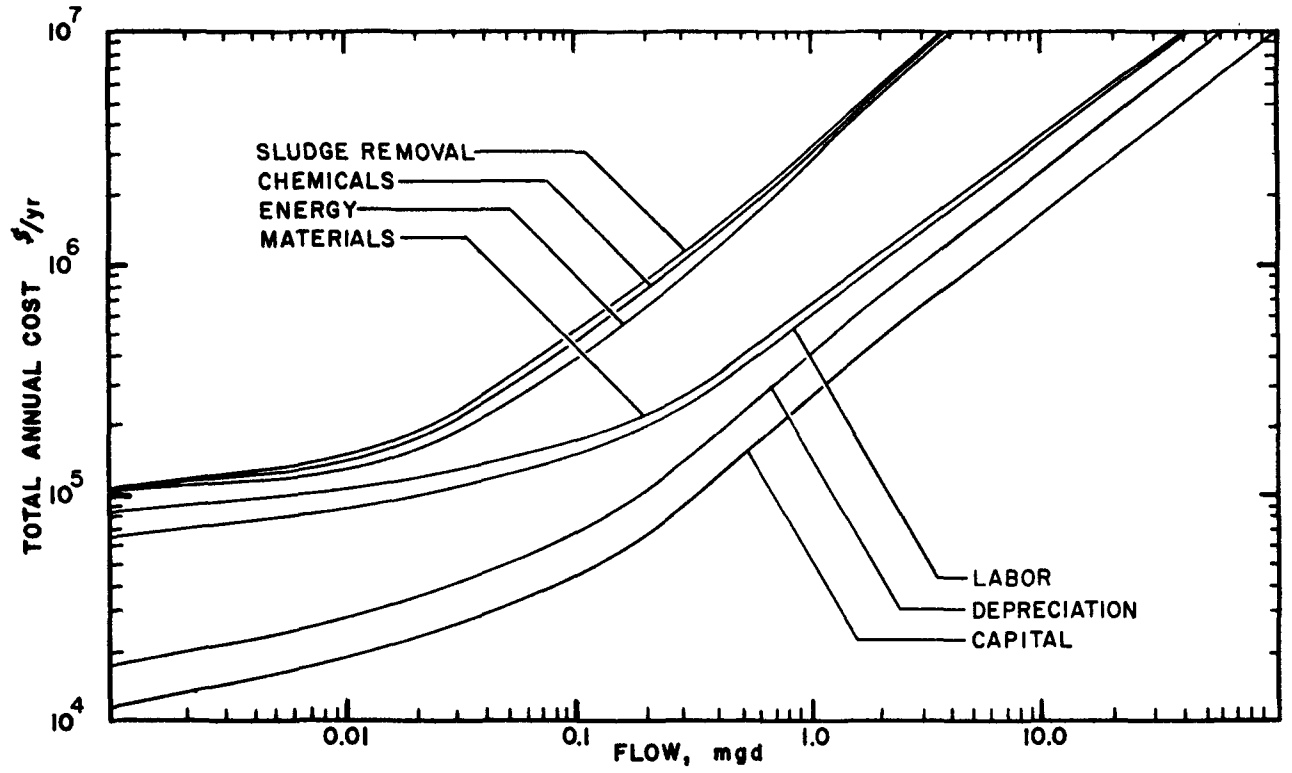
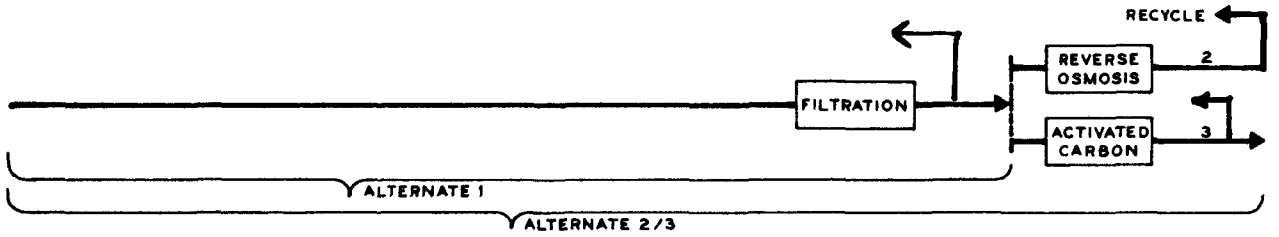
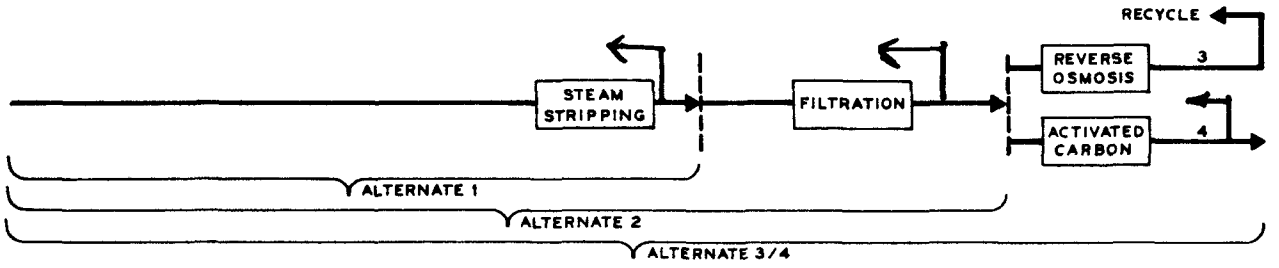



FIGURE VIII-93. SECONDARY SILVER( NON-PHOTOGRAPHIC) COMB. 1, ALT. 3




COMBINATION 1
(COMBINED WASTEWATER)




COMBINATION 2
(COMBINED WASTEWATER)

FIGURE VIII - 94. PRIMARY TUNGSTEN TREATMENT SCHEMES
(ORE TO SALT / METAL)

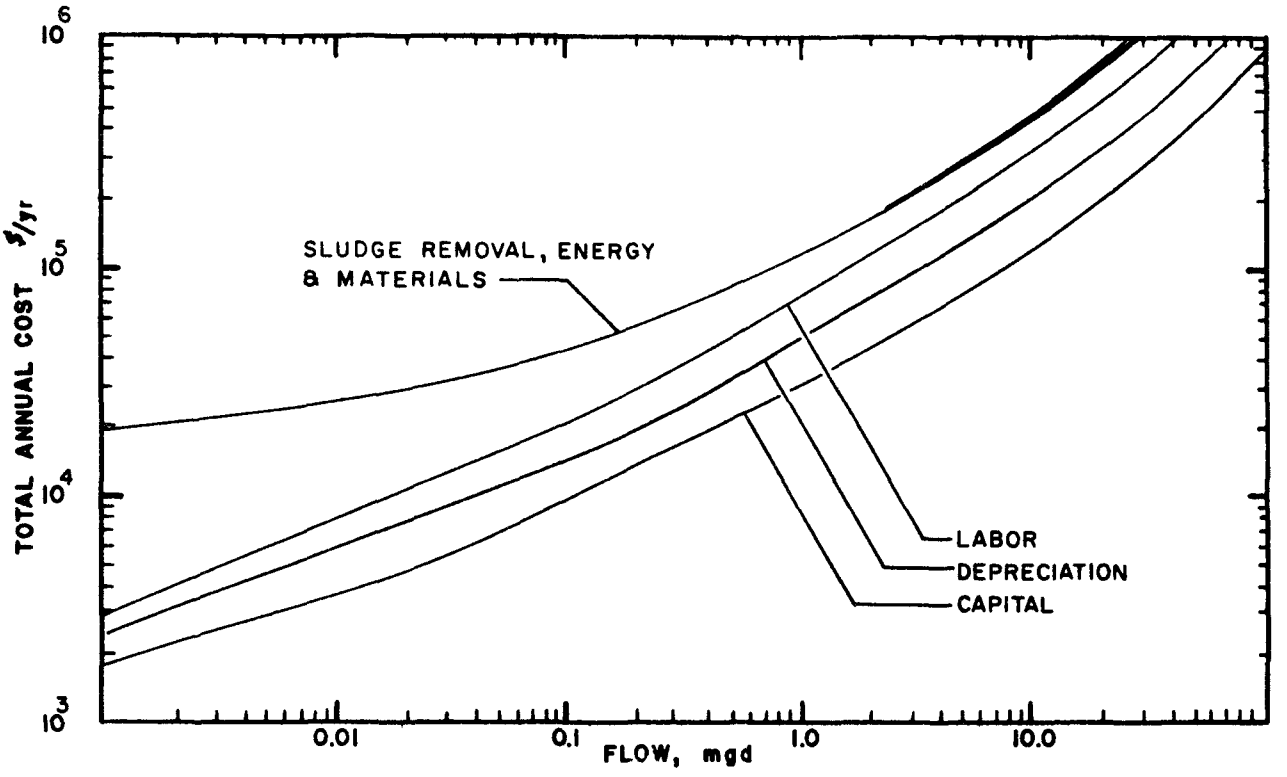



FIGURE VIII-95 . PRIMARY TUNGSTEN (ORE TO SALT/METAL ) COMB. I, ALT. I

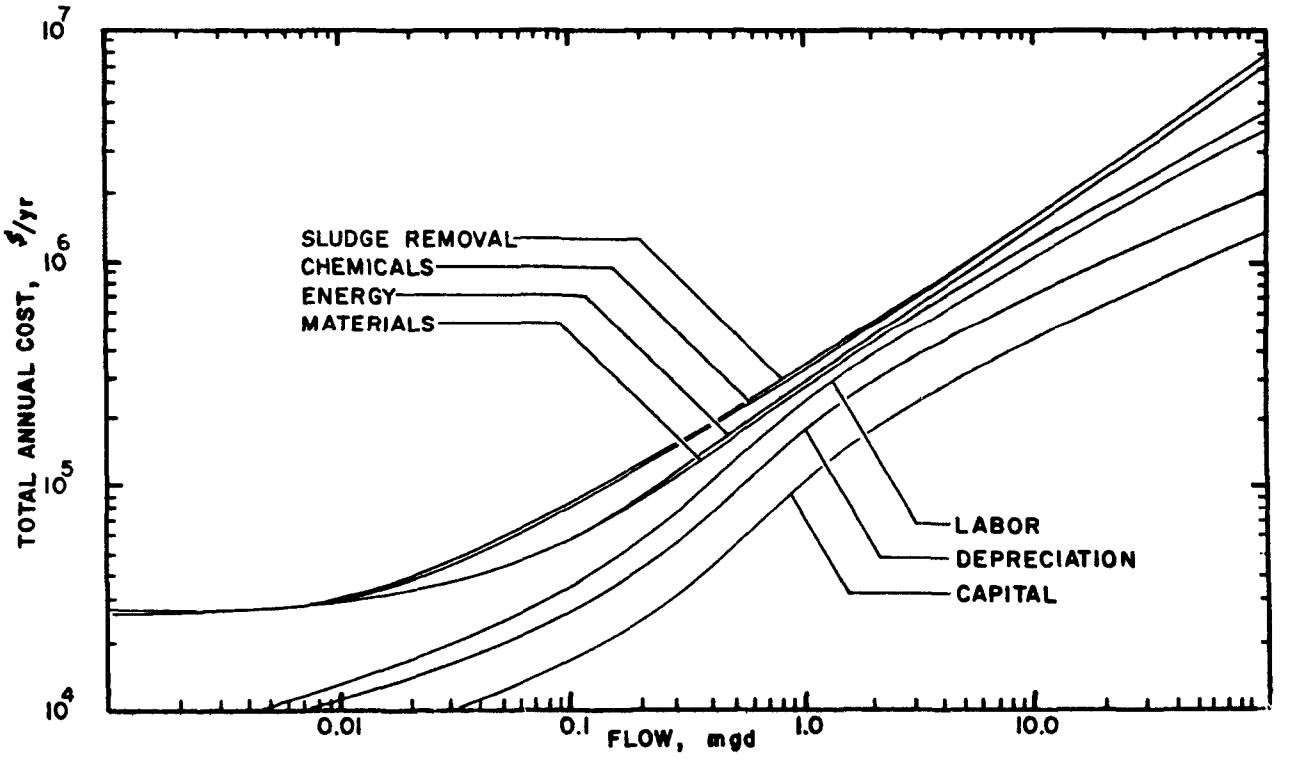



FIGURE VIII-96 .PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. I , ALT. 2

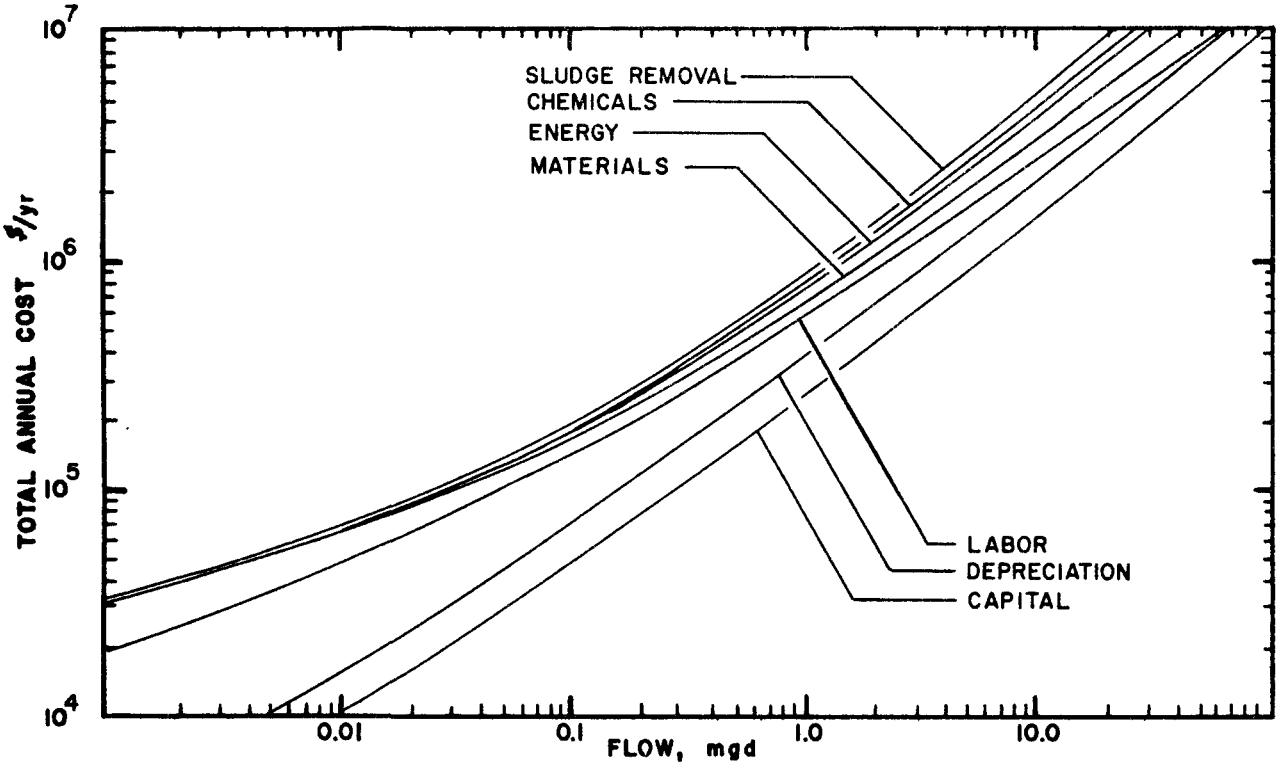



FIGURE VIII-97. PRIMARY TUNGSTEN(ORE TO SALT/METAL) COMB. 1, ALT. 3

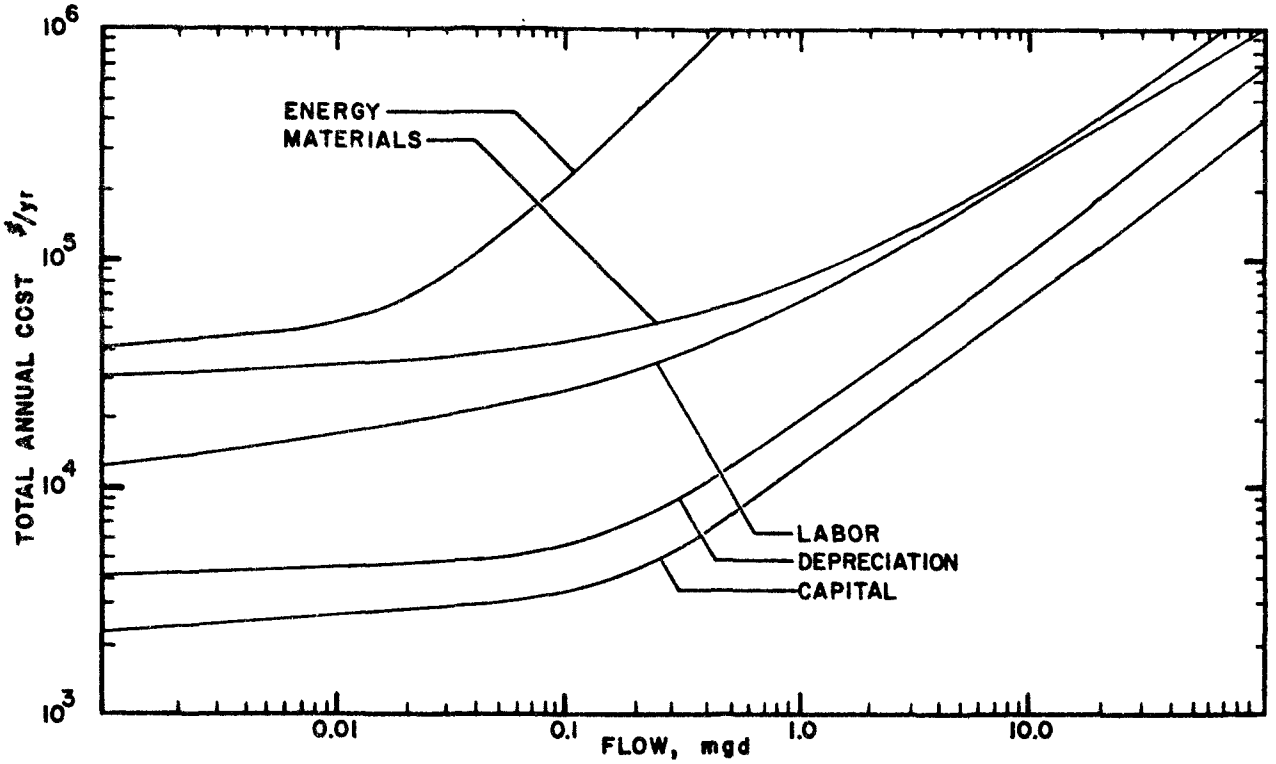



FIGURE VIII-98 .PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 2, ALT. 1

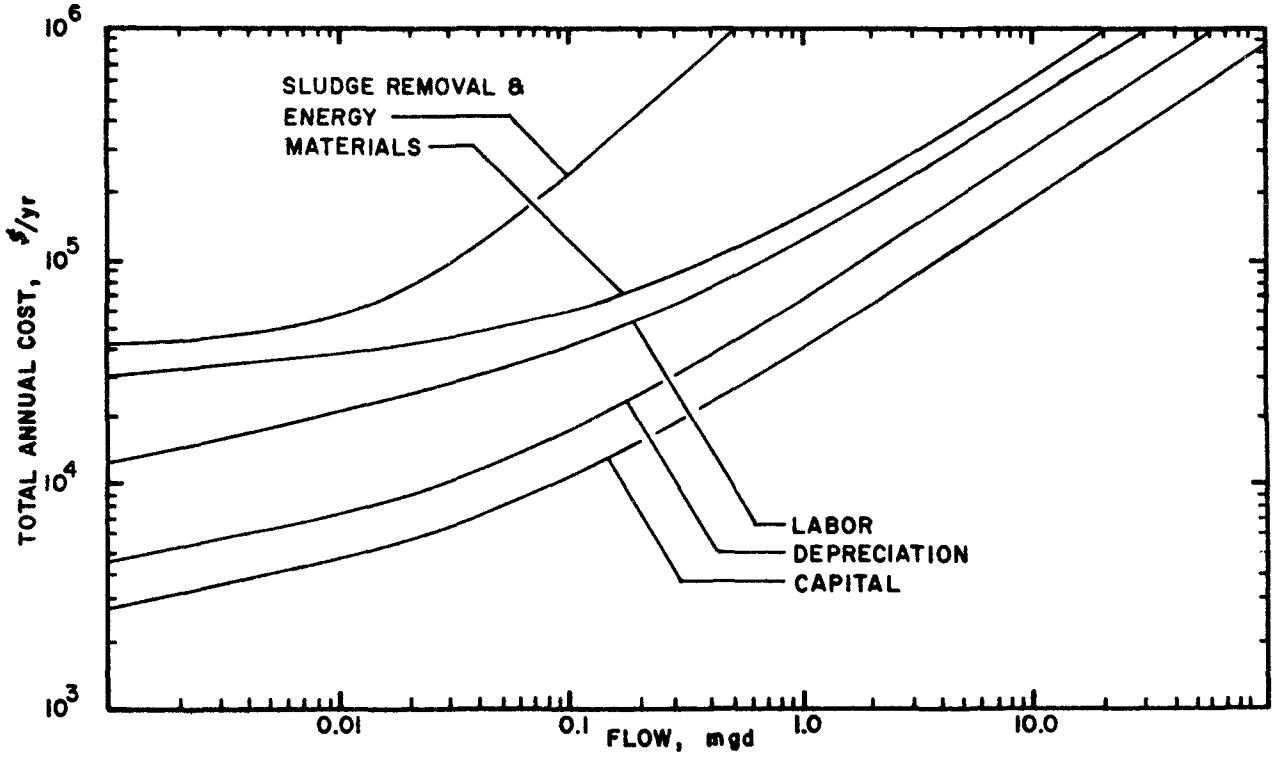



FIGURE VIII-99 .PRIMARY TUNGSTEN(ORE TO SALT/METAL) COMB.2, ALT.2

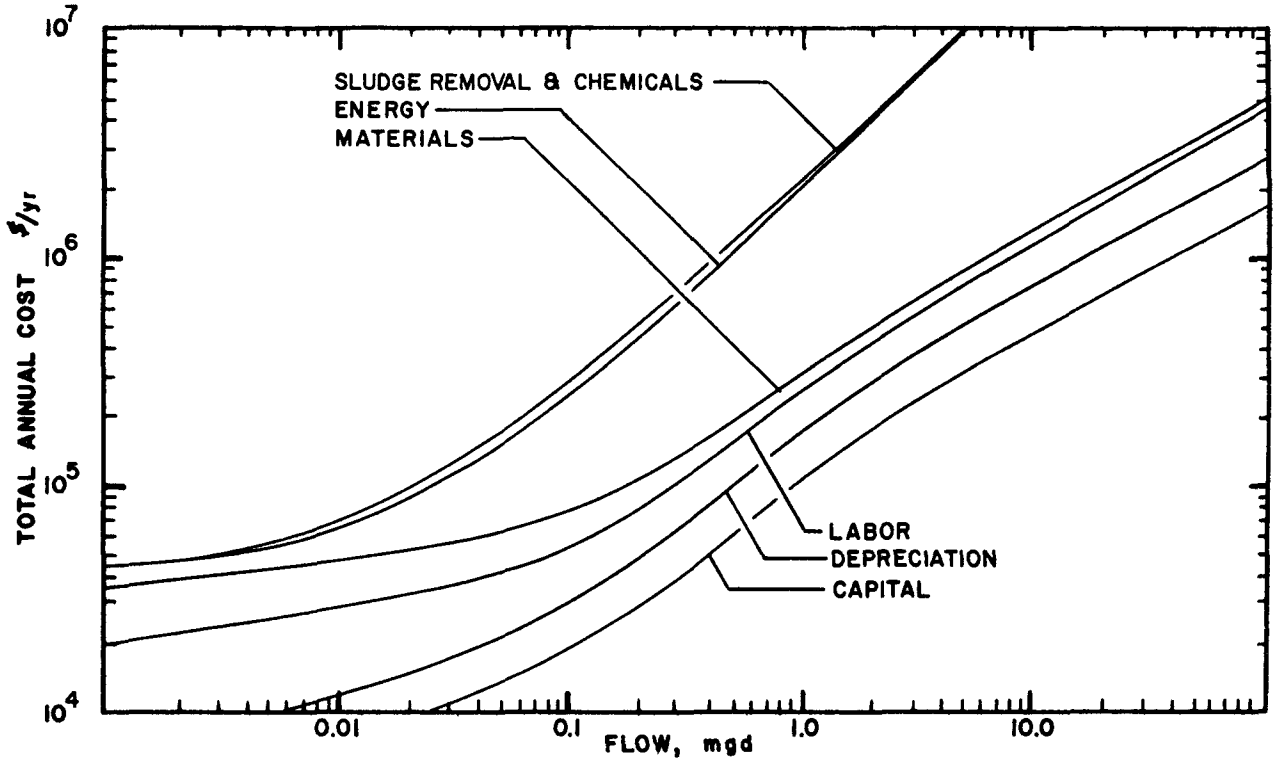



FIGURE VIII-100. PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 2, ALT. 3

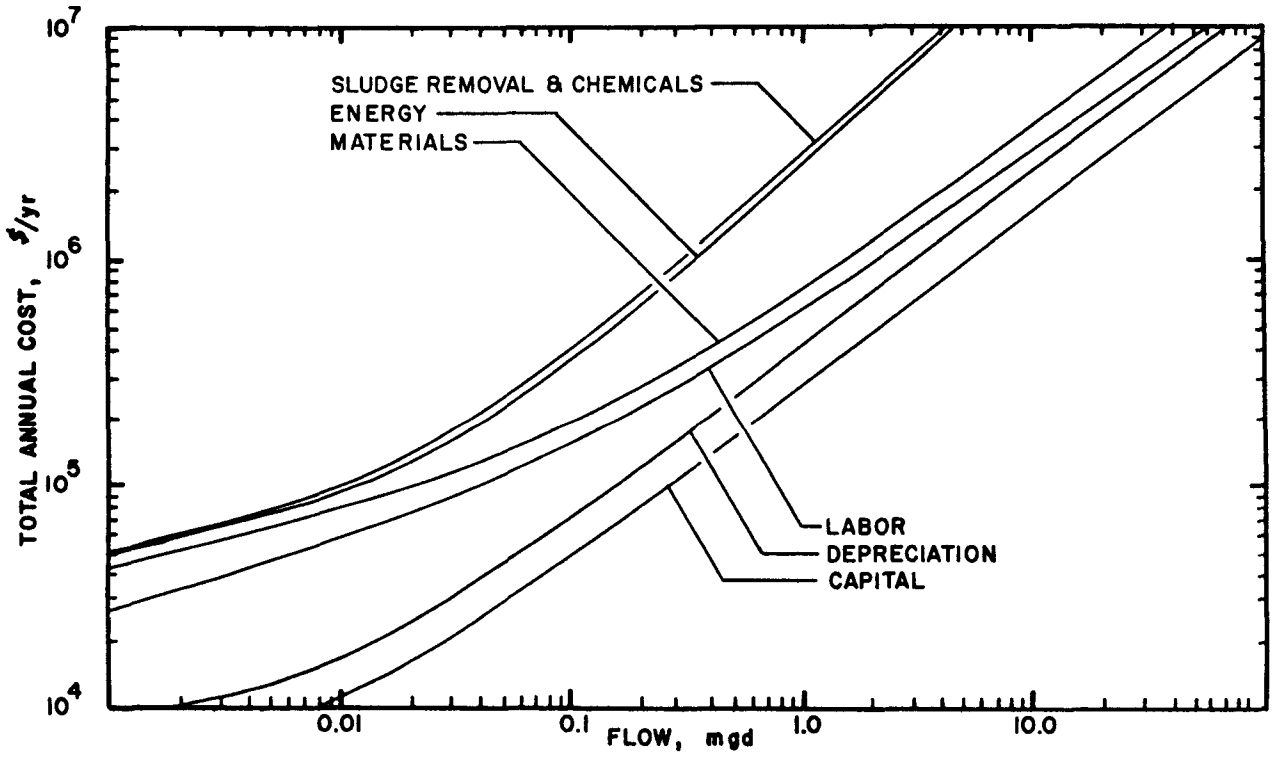
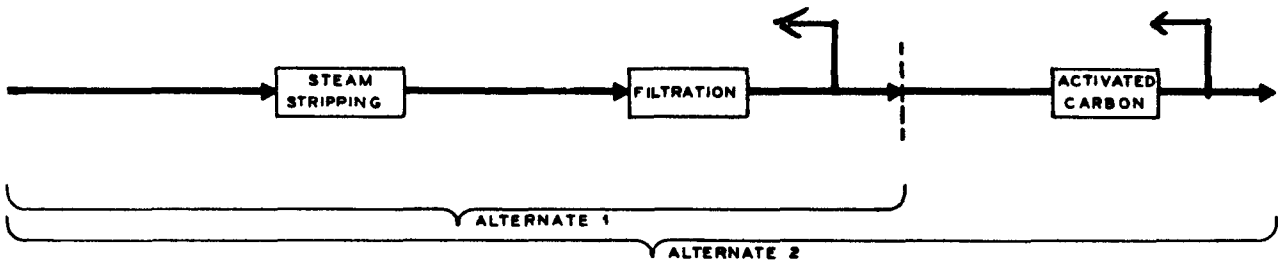



FIGURE VIII-101. PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 2, ALT. 4




COMBINATION 1
(COMBINED WASTEWATER)

FIGURE VIII- 102. PRIMARY TUNGSTEN TREATMENT SCHEMES (SALT TO METAL)

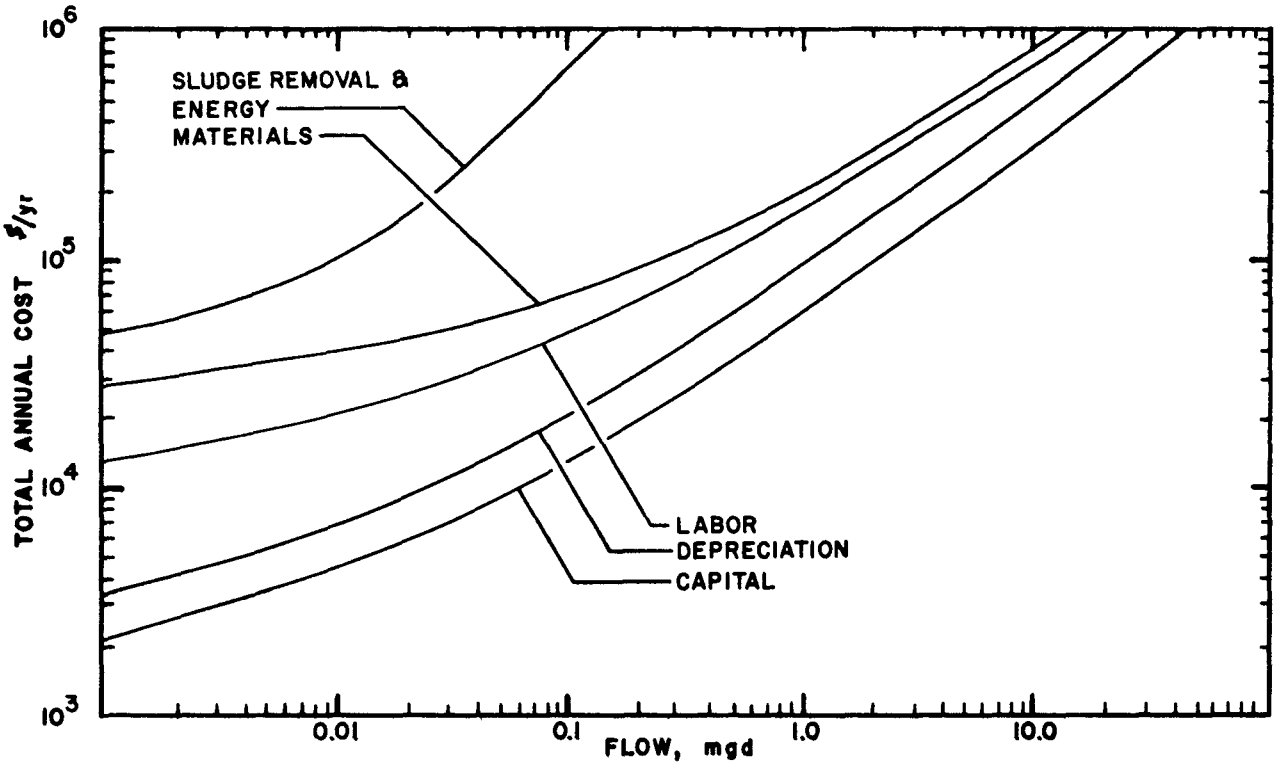



FIGURE VIII-103. PRIMARY TUNGSTEN (SALT TO METAL) COMB. 1, ALT. 1

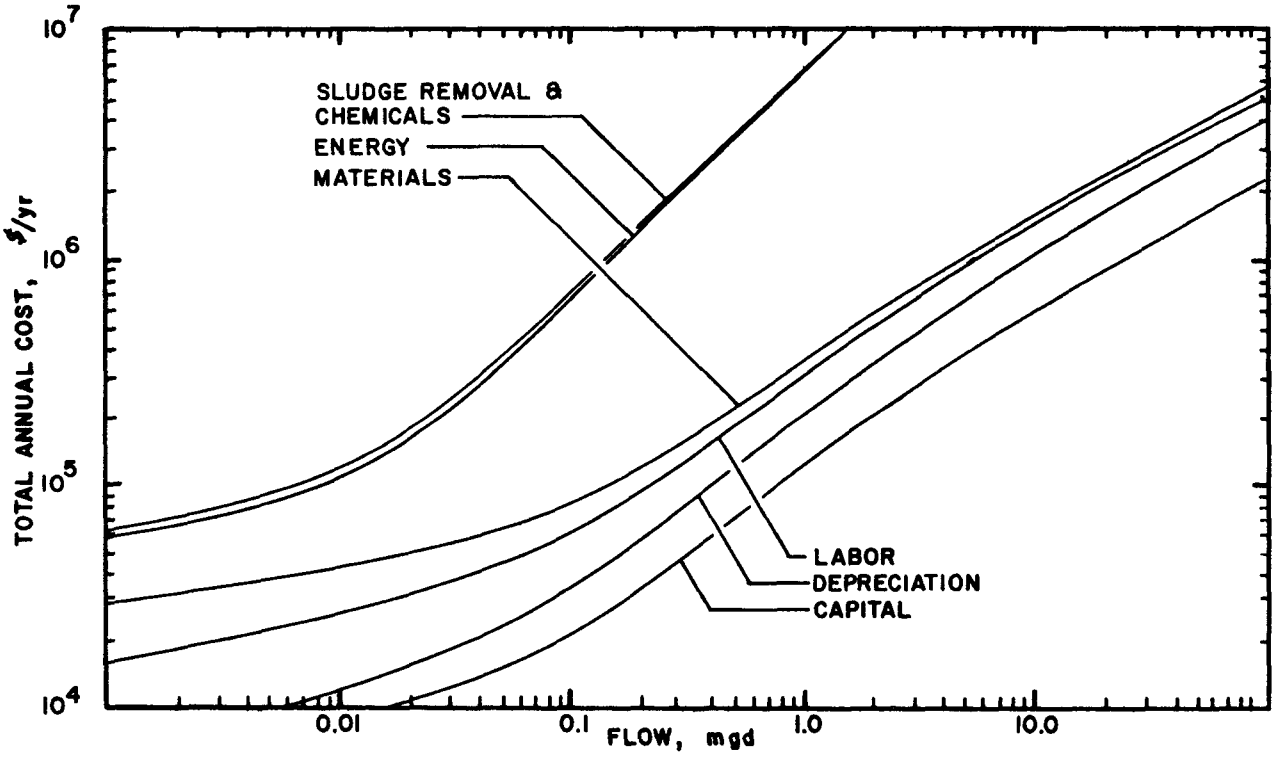
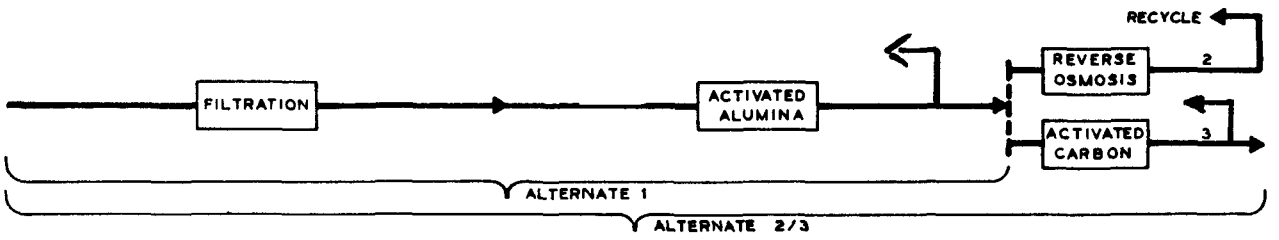



FIGURE VIII-104. PRIMARY TUNGSTEN (SALT TO METAL) COMB. 1, ALT. 2




COMBINATION 1
(COMBINED WASTEWATER)

FIGURE VIII-105. PRIMARY ZINC TREATMENT SCHEMES

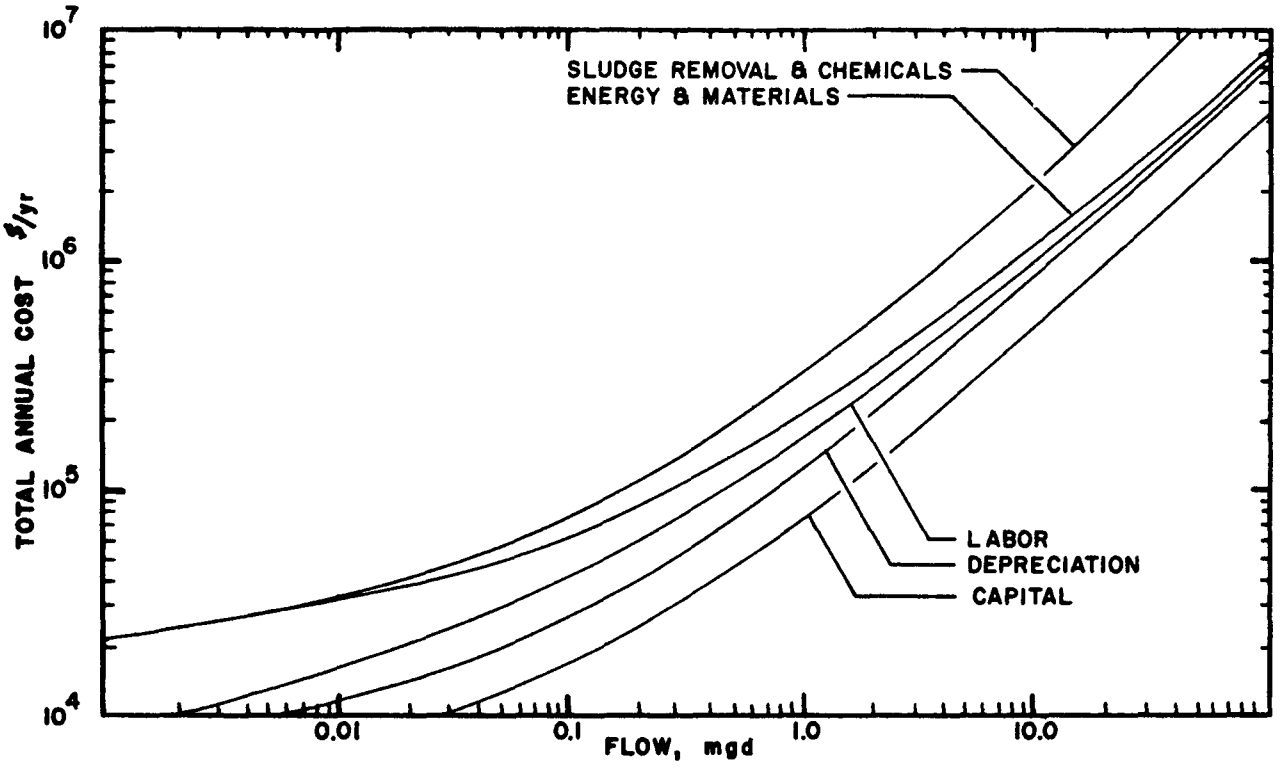



FIGURE VIII-106. PRIMARY ZINC COMB. I, ALT. I

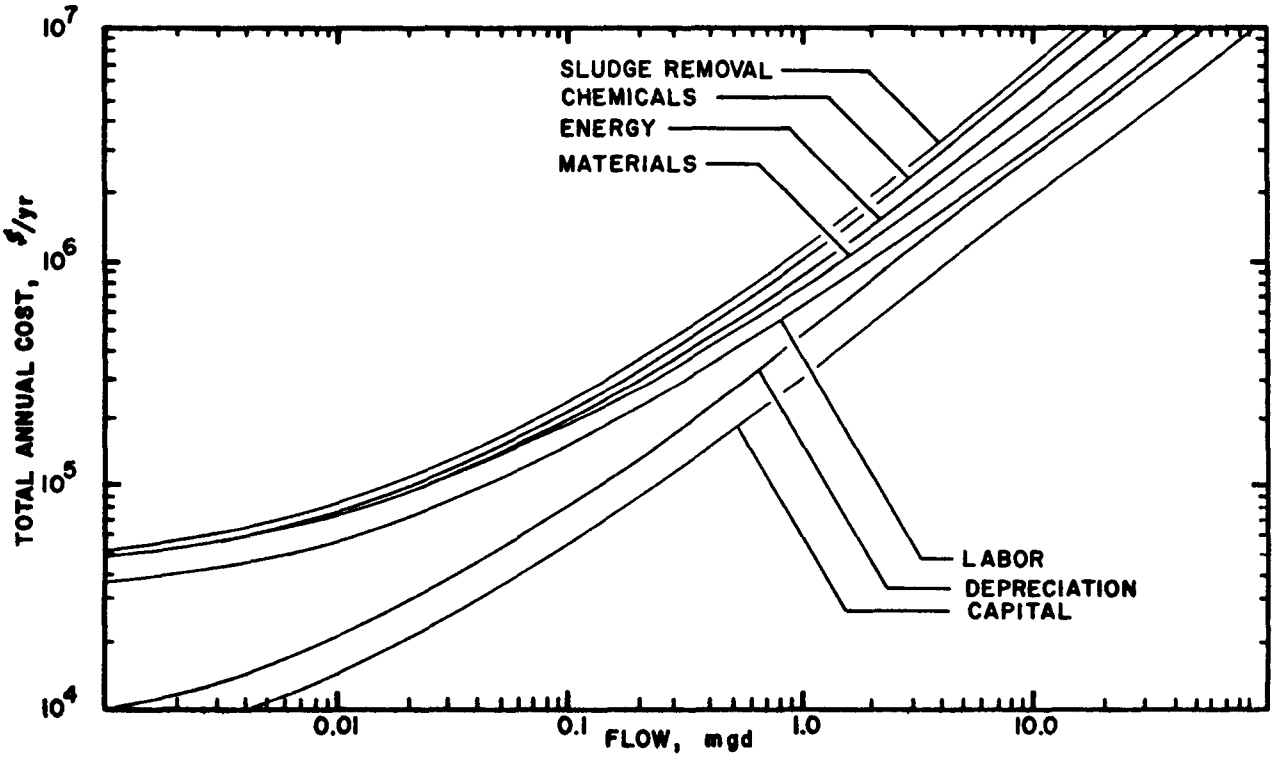



FIGURE VIII-107. PRIMARY ZINC COMB. I, ALT. 2

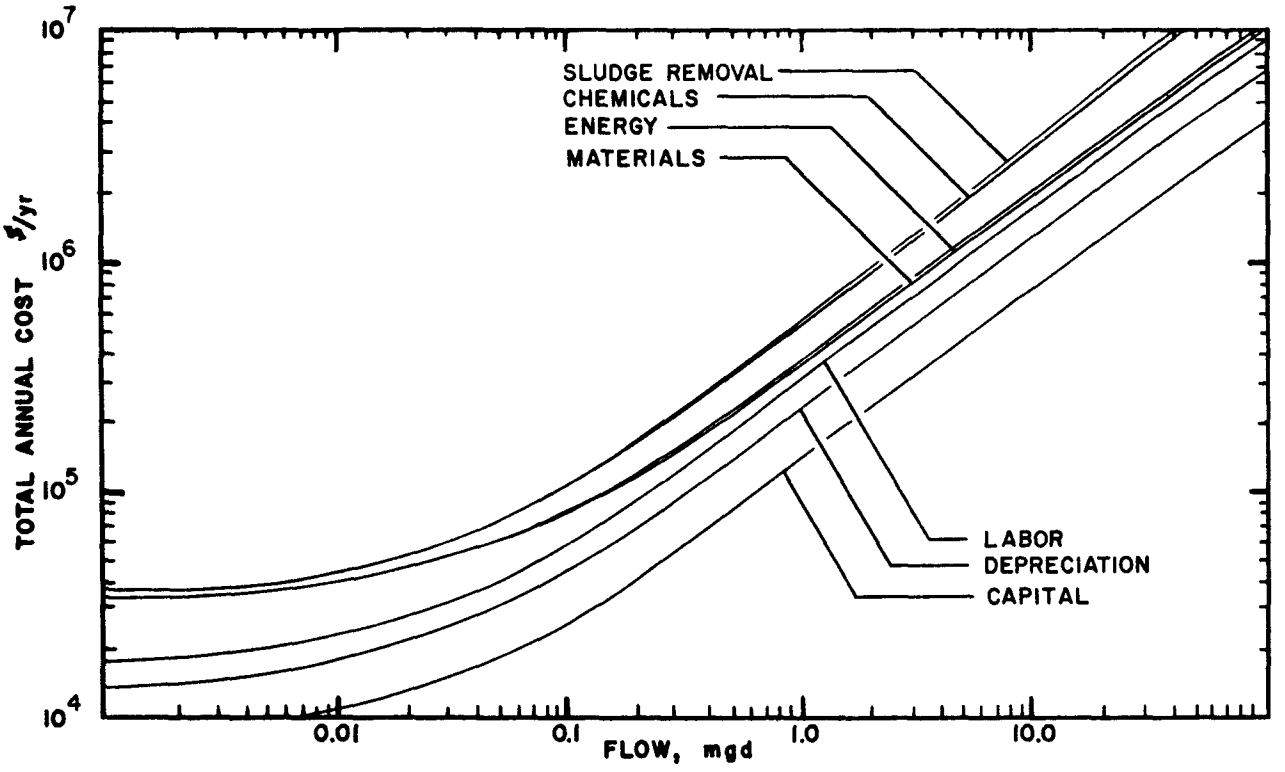
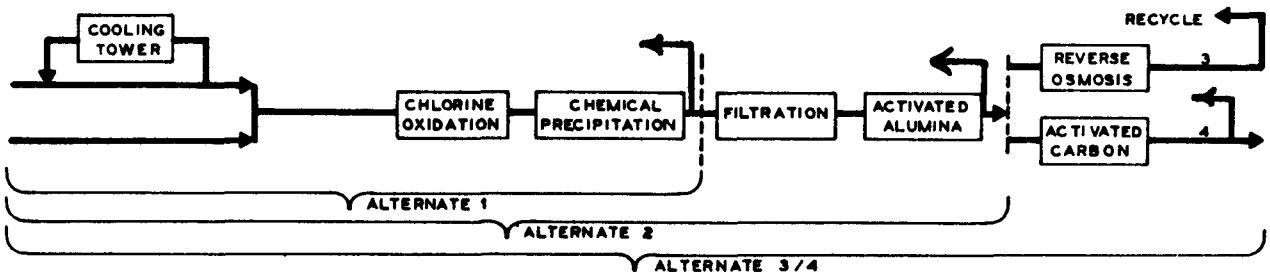
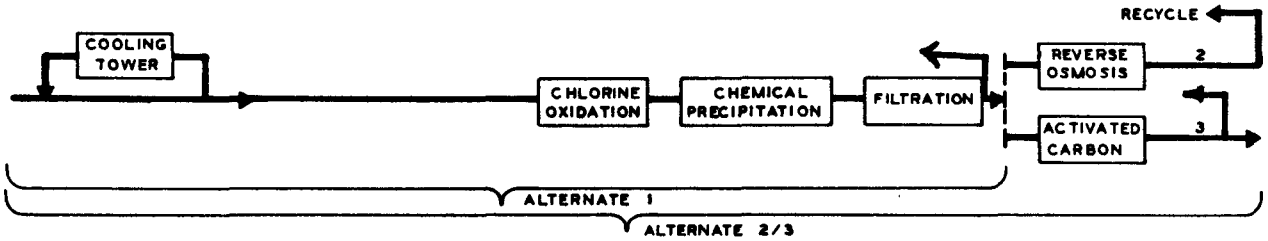



FIGURE VIII-108. PRIMARY ZINC COMB. 1, ALT. 3




COMBINATION 1
(CONTACT COOLING, CRYOLITE)




COMBINATION 2
(CONTACT COOLING)

FIGURE VIII-109. PRIMARY ALUMINUM
NEW SOURCE TREATMENT SCHEMES

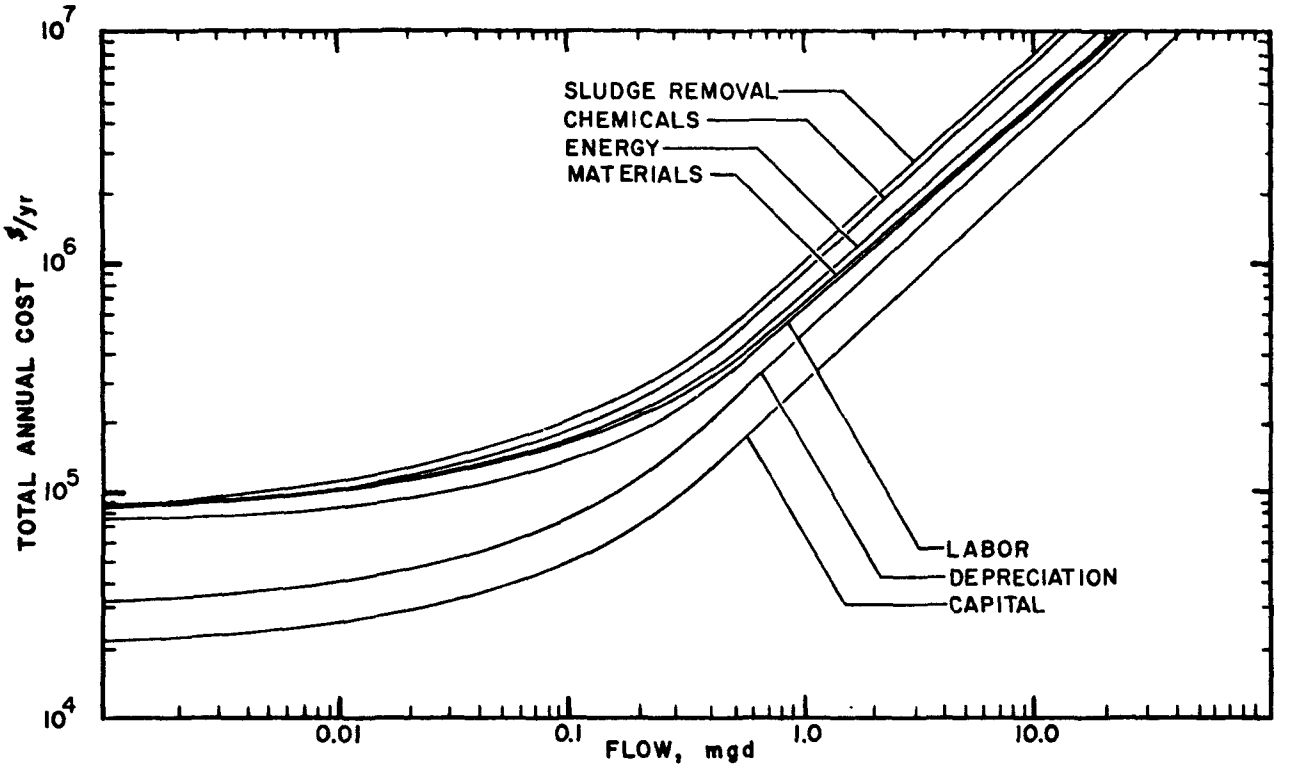



FIGURE VIII-110. PRIMARY ALUMINUM COMB. I, ALT I
(NEW SOURCES)

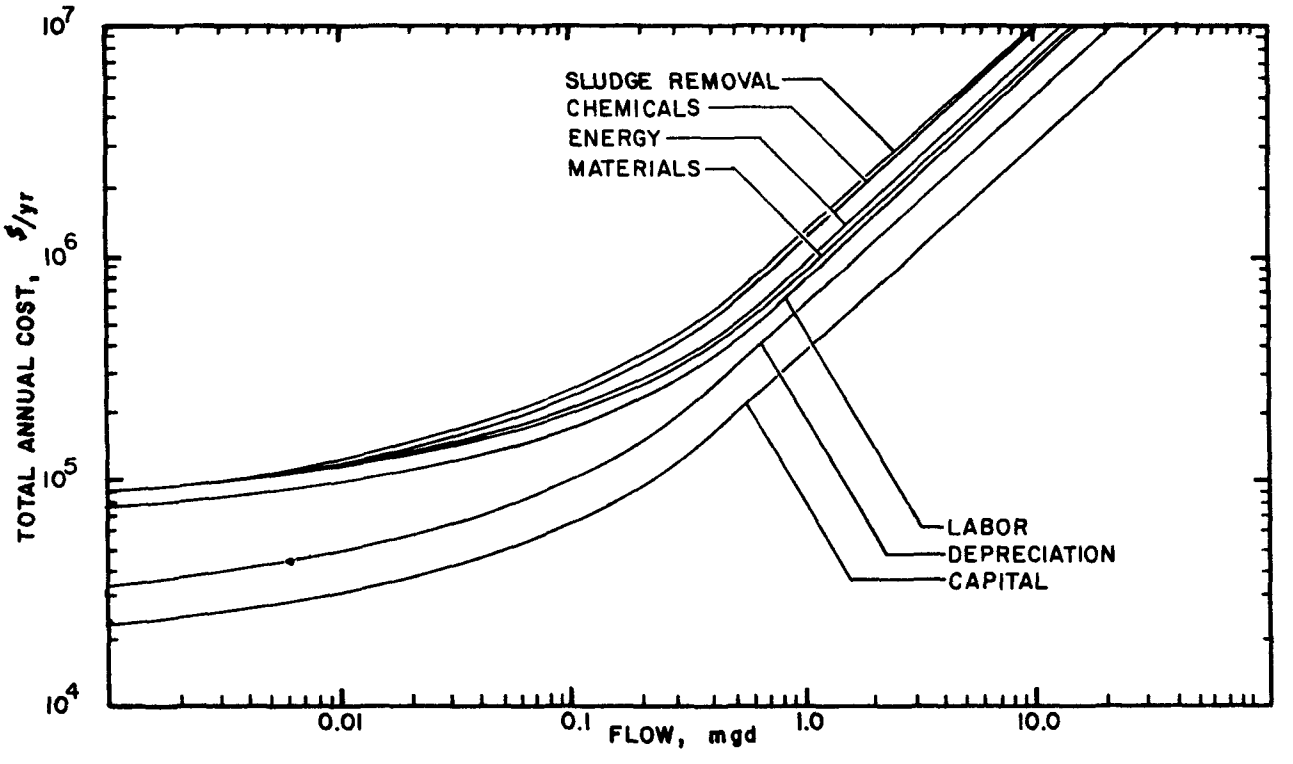



FIGURE VIII-111 PRIMARY ALUMINUM COMB. I, ALT. 2
(NEW SOURCES)

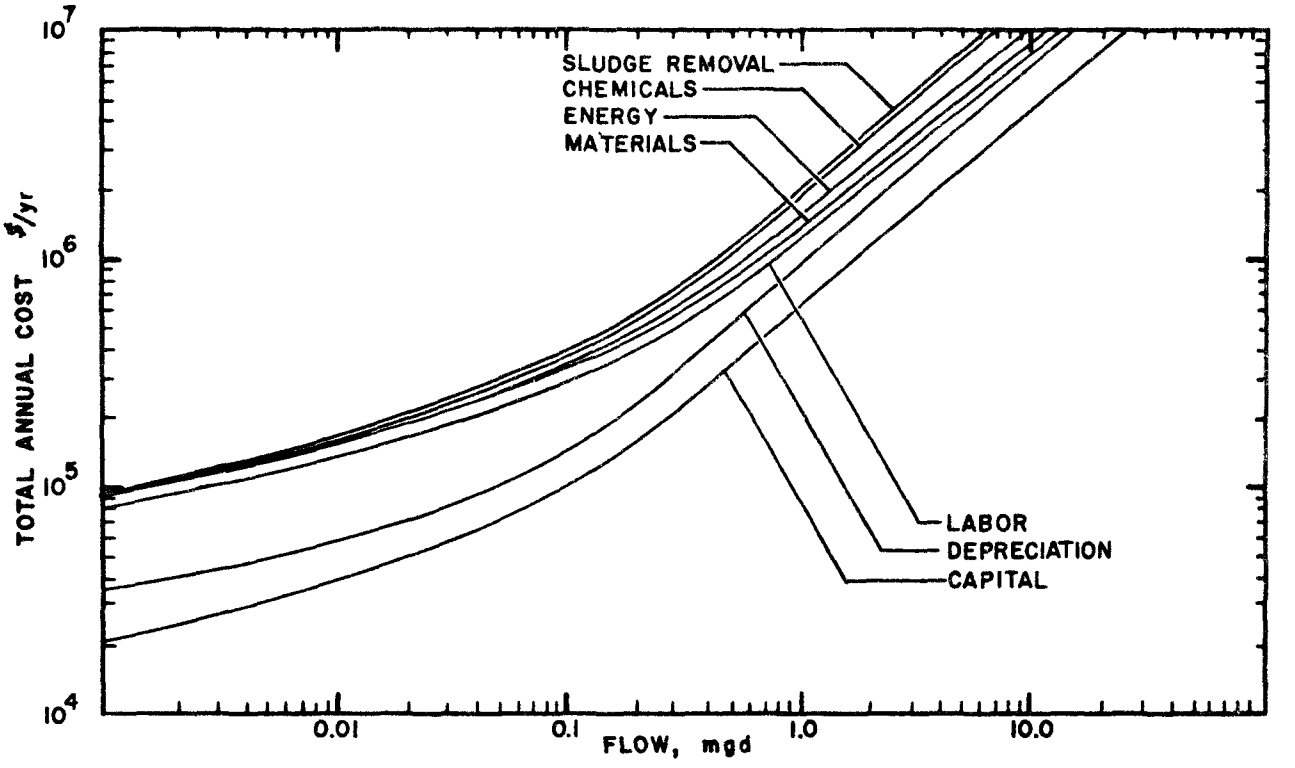



FIGURE VIII-112. PRIMARY ALUMINUM COMB. 1, ALT. 3
(NEW SOURCES)

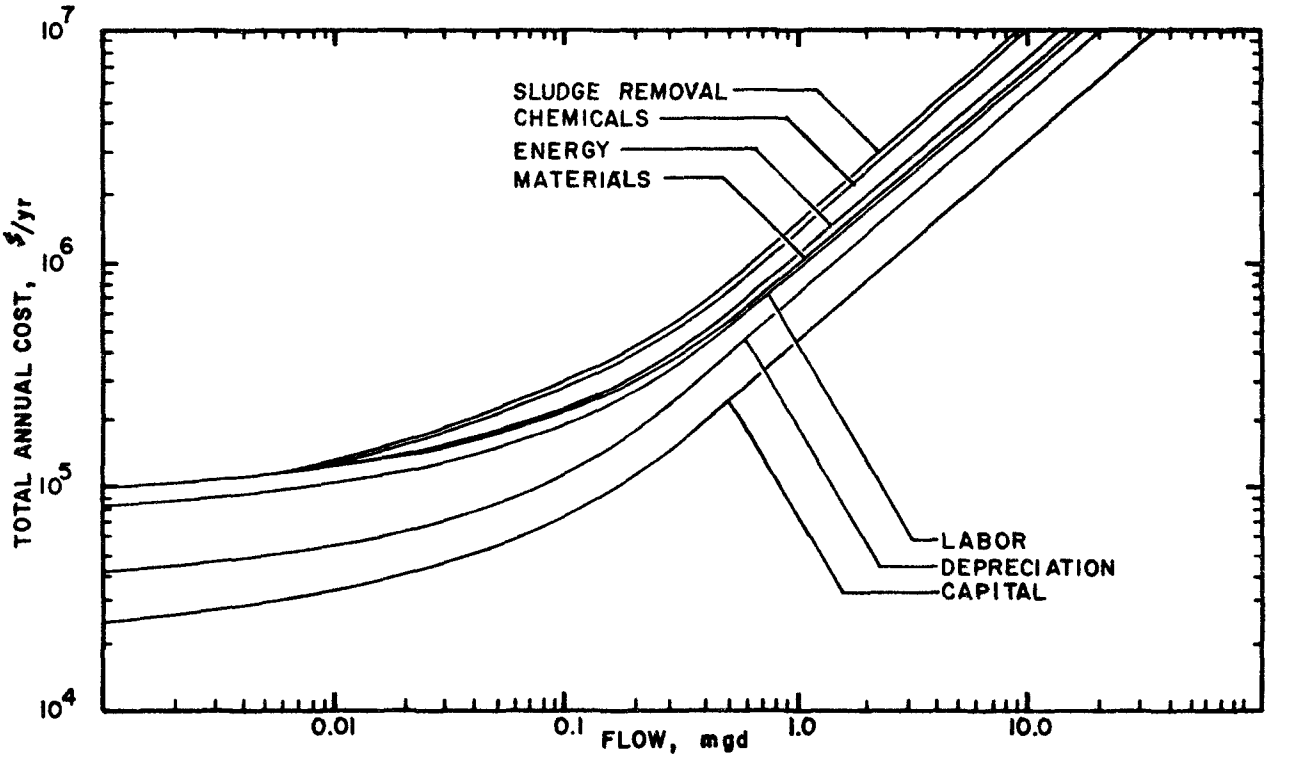
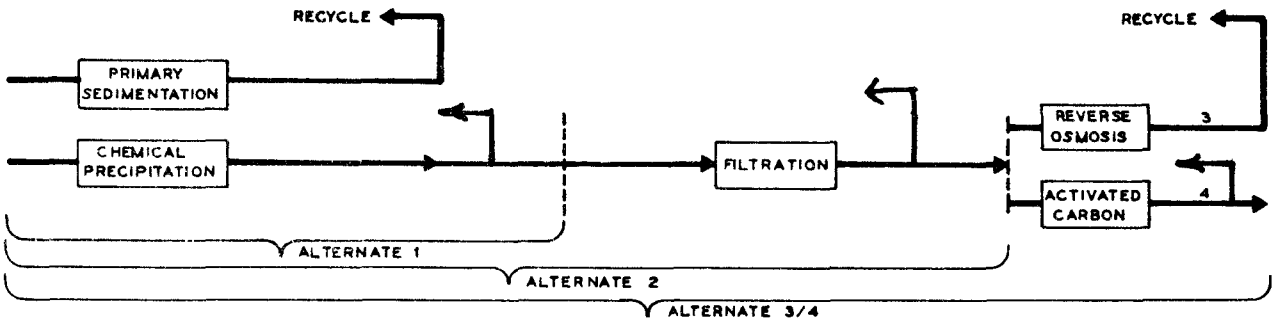
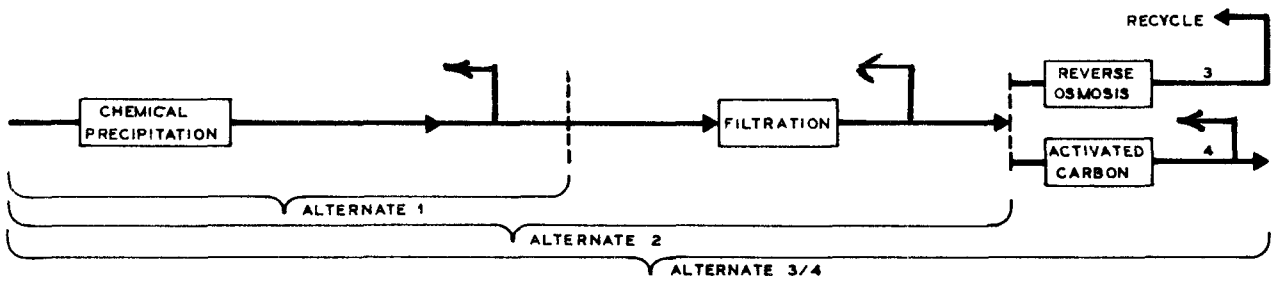


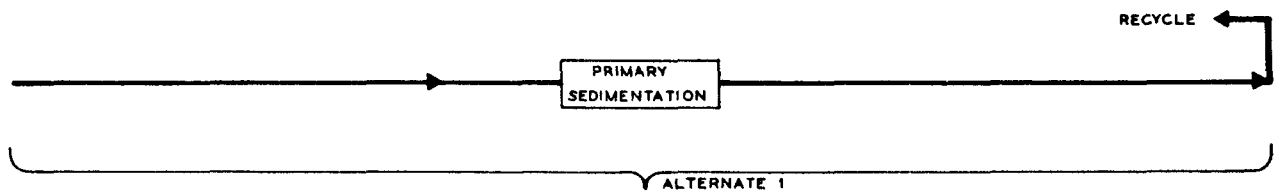

FIGURE VIII-113. PRIMARY ALUMINUM COMB. 1, ALT. 4
(NEW SOURCES)




COMBINATION 1
(SLAG MILLING, FUME SCRUBBER)




COMBINATION 2
(FUME SCRUBBER)




COMBINATION 3
(SLAG MILLING)

FIGURE VIII-117. SECONDARY ALUMINUM
NEW SOURCE TREATMENT SCHEMES

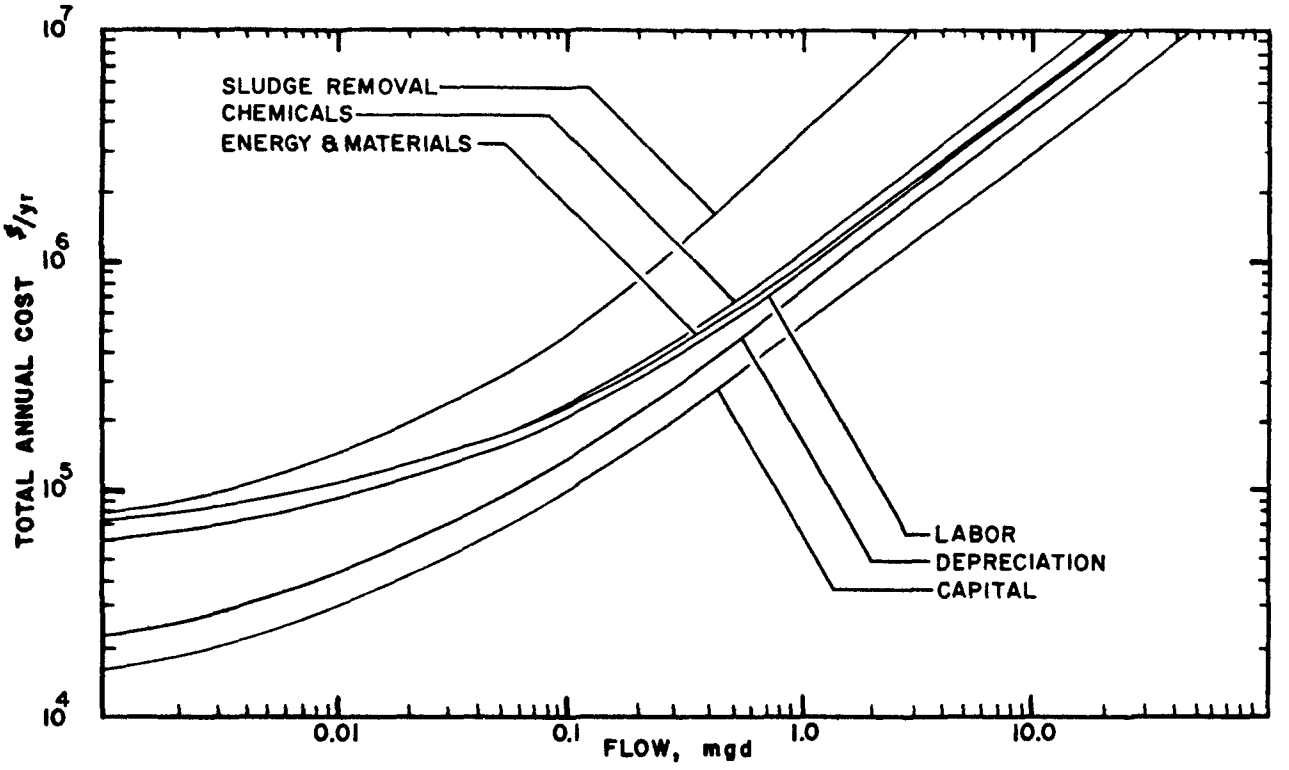



FIGURE VIII-118. SECONDARY ALUMINUM COMB. I, ALT. I

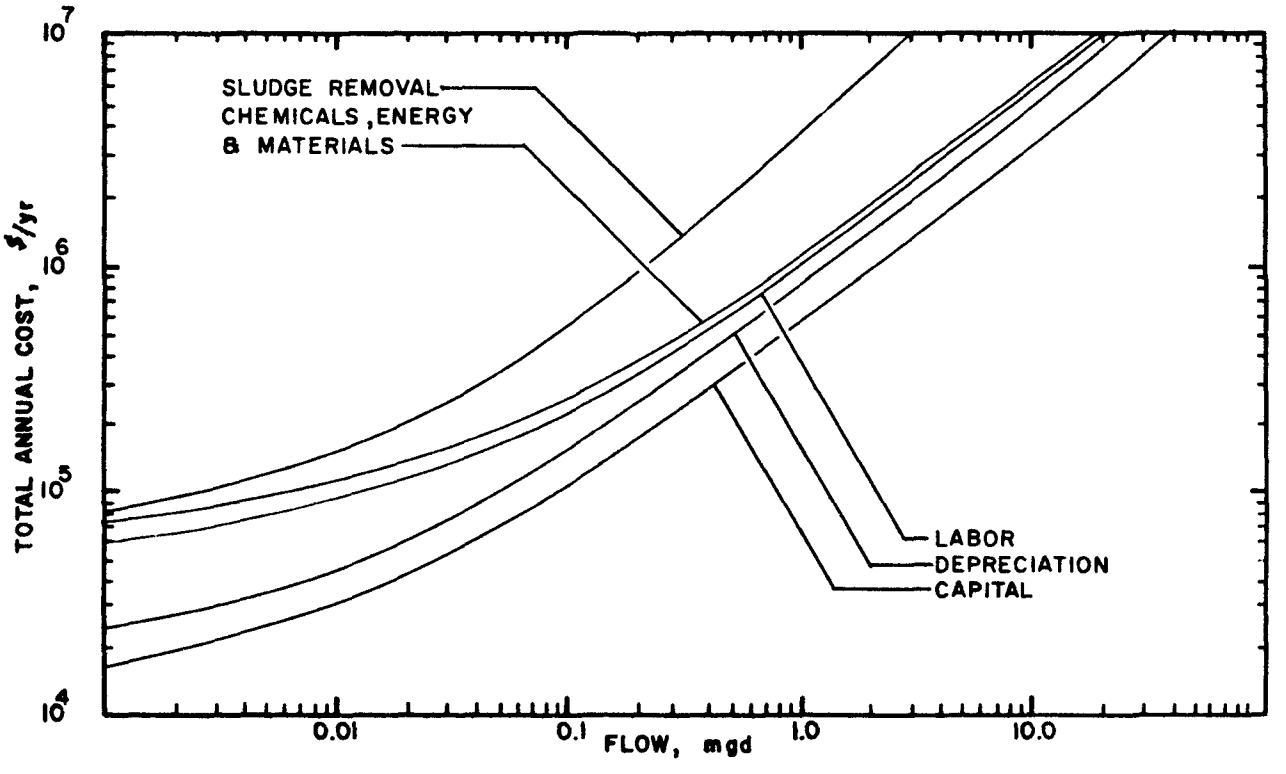



FIGURE VIII-119. SECONDARY ALUMINUM COMB. I, ALT. 2

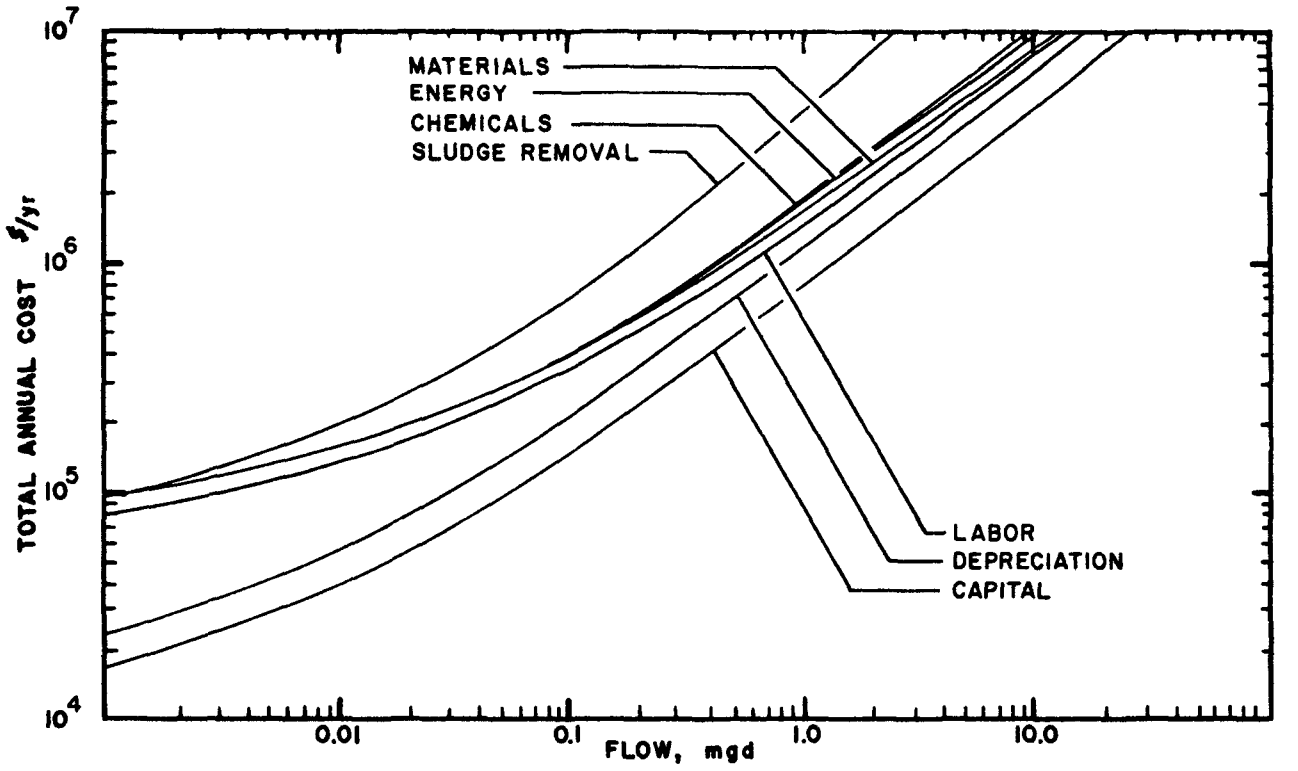



FIGURE VIII-120. SECONDARY ALUMINUM COMB. 1, ALT. 3

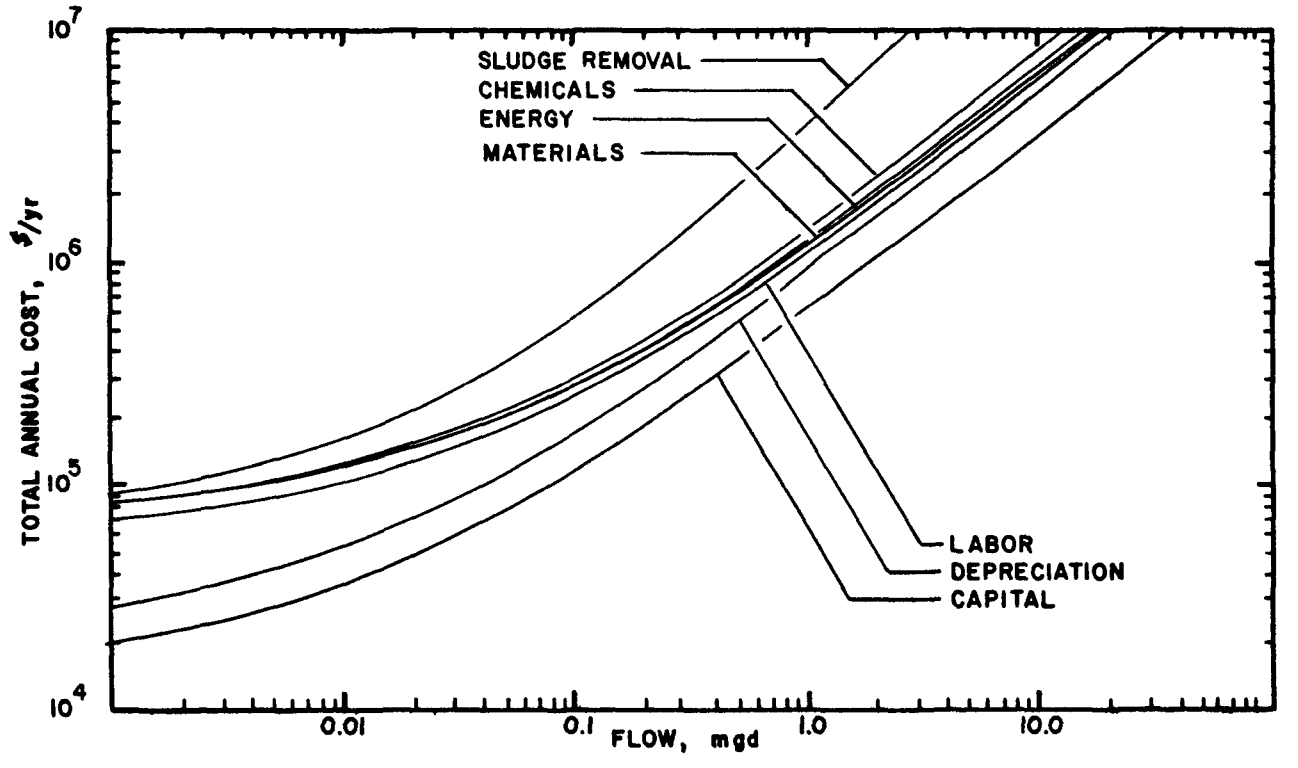



FIGURE VIII-121. SECONDARY ALUMINUM COMB. 1, ALT. 4

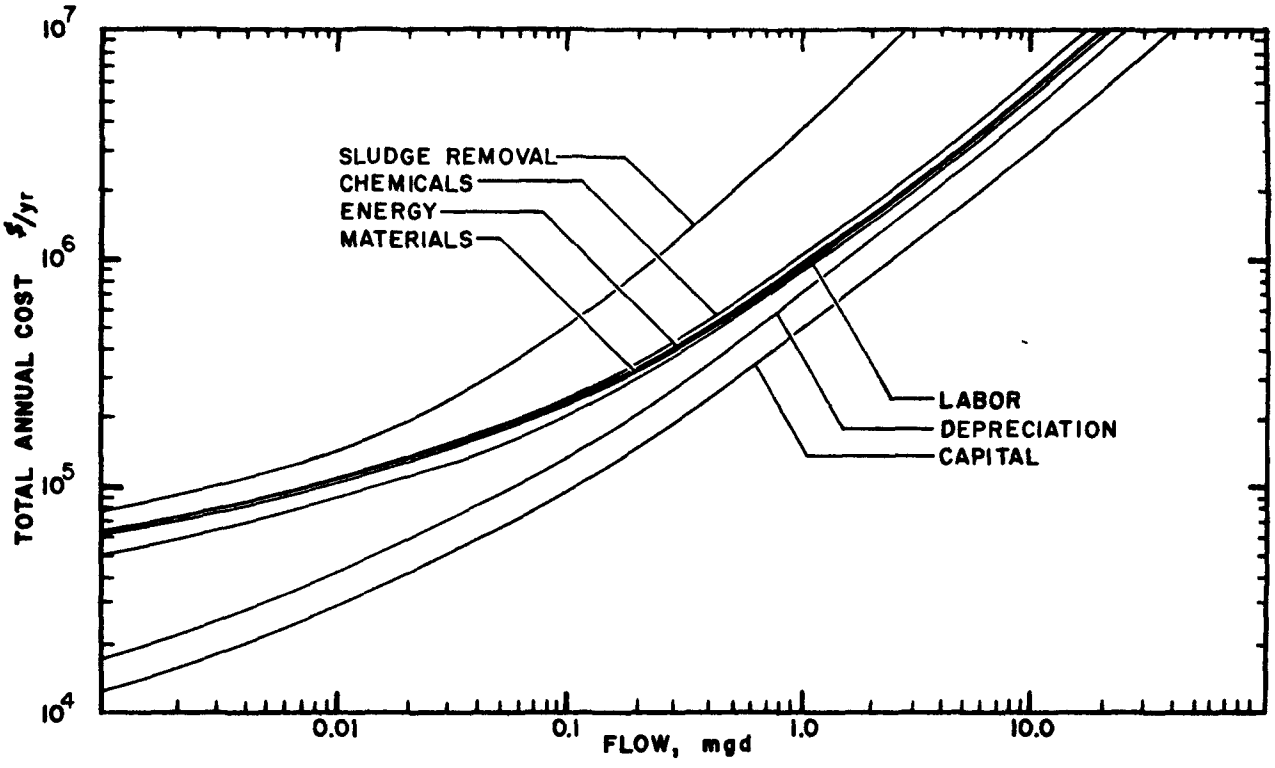



FIGURE VIII-122. SECONDARY ALUMINUM COMB. 2, ALT. 1

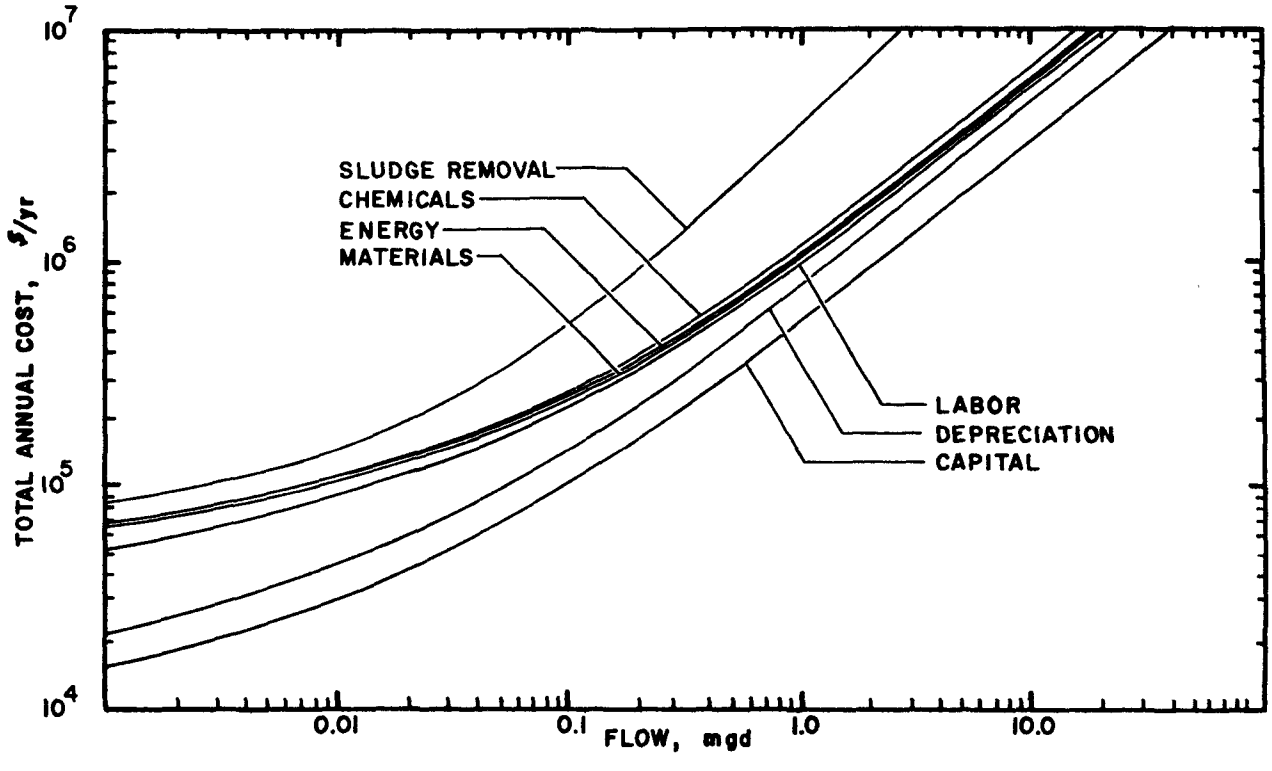



FIGURE VIII-123. SECONDARY ALUMINUM COMB. 2, ALT. 2

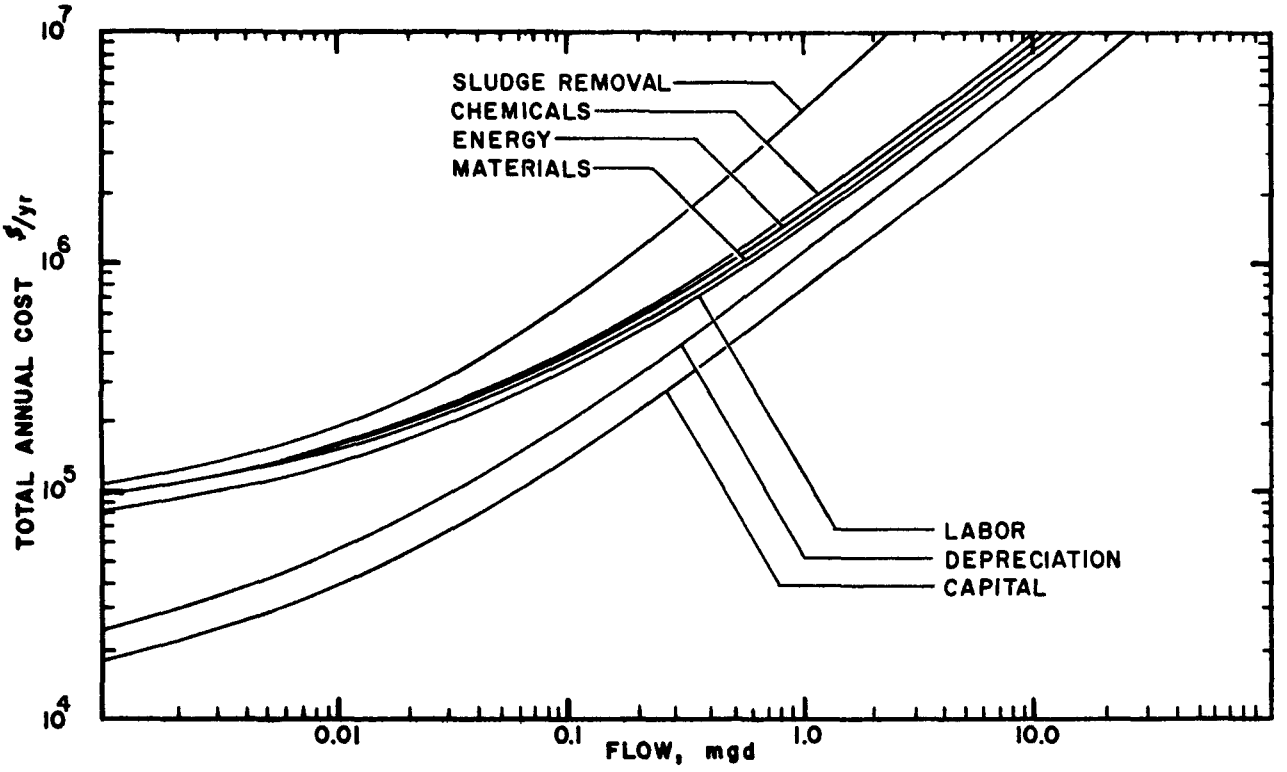



FIGURE VIII-124. SECONDARY ALUMINUM COMB. 2 ,ALT. 3

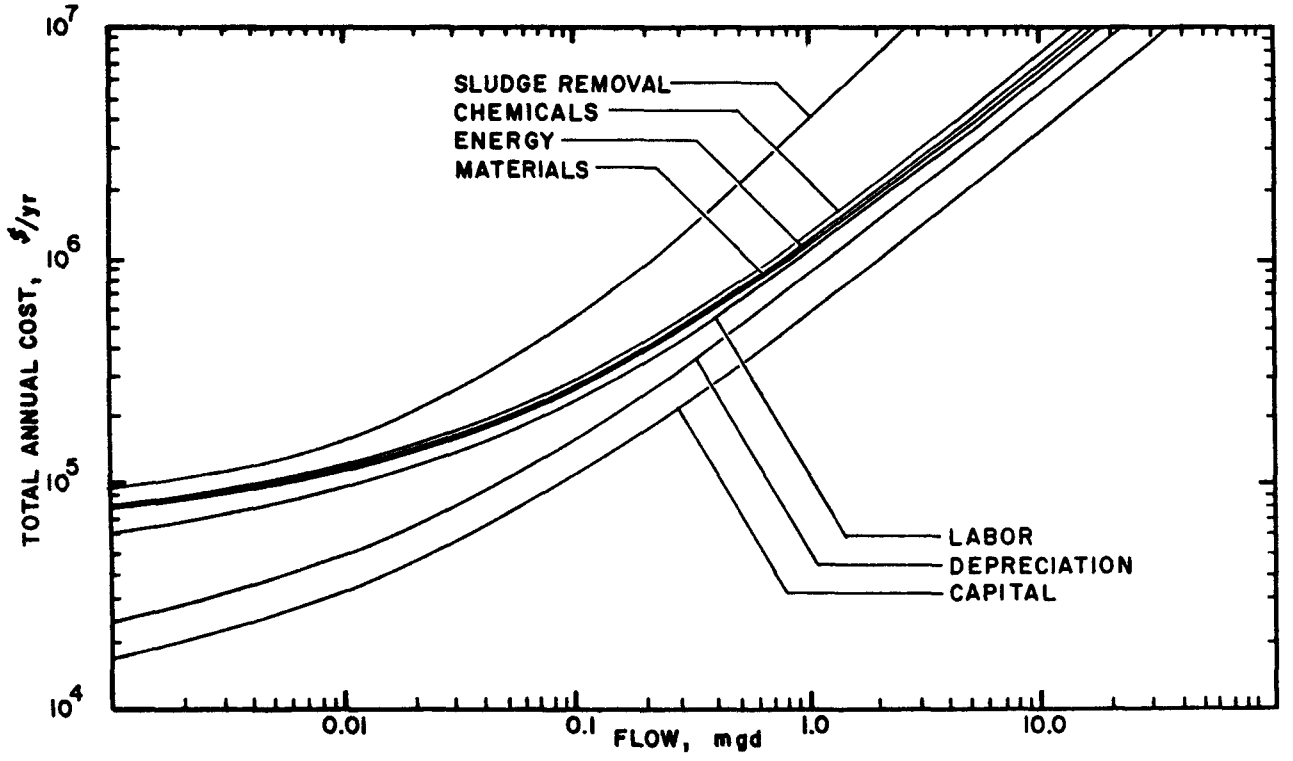



FIGURE VIII-125. SECONDARY ALUMINUM COMB. 2 , ALT. 4

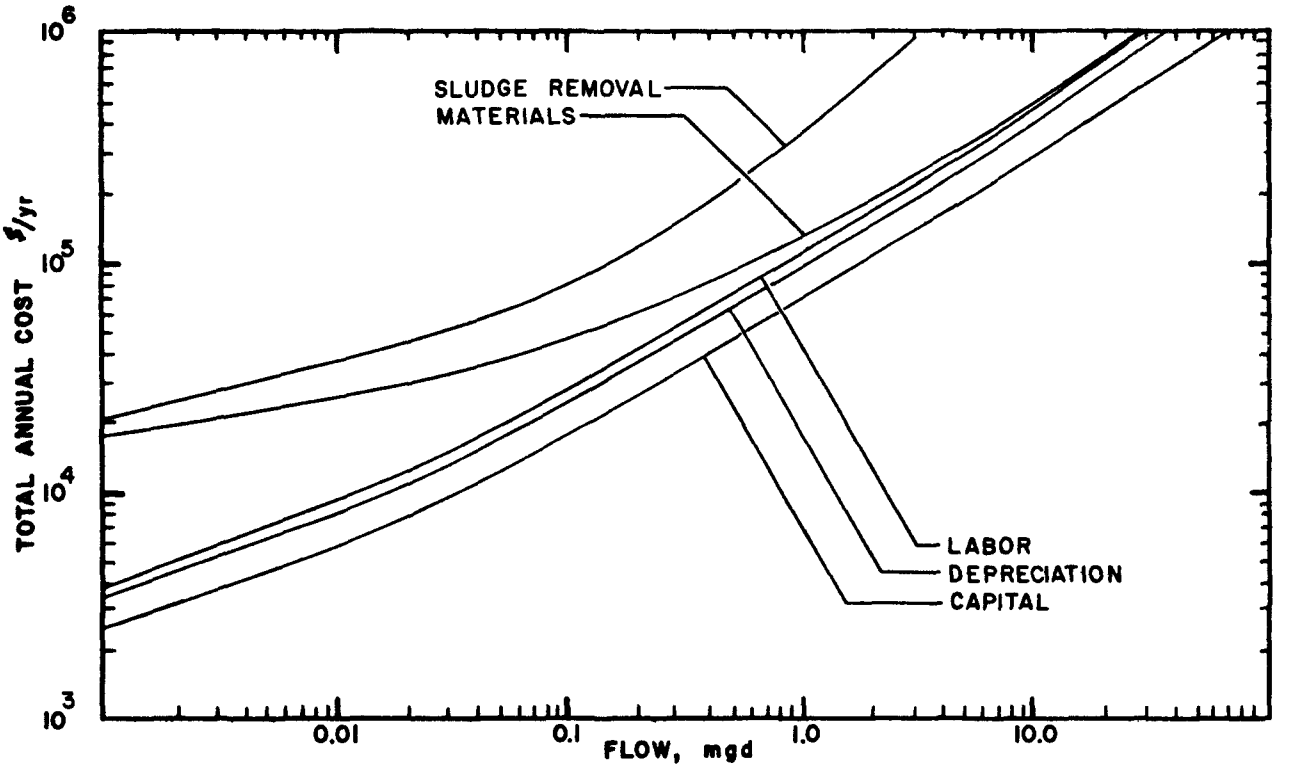
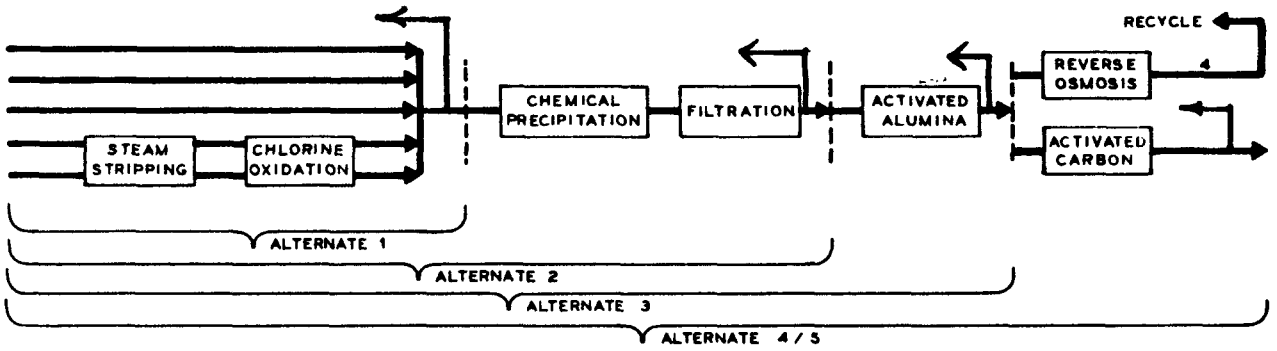



FIGURE VIII-126. SECONDARY ALUMINUM COMB. 3, ALT. 1




COMBINATION 1
(ALL WASTE STREAMS)

FIGURE VIII-127. COLUMBIUM / TANTALUM (ORE TO SALT / METAL)
NEW SOURCE TREATMENT SCHEMES

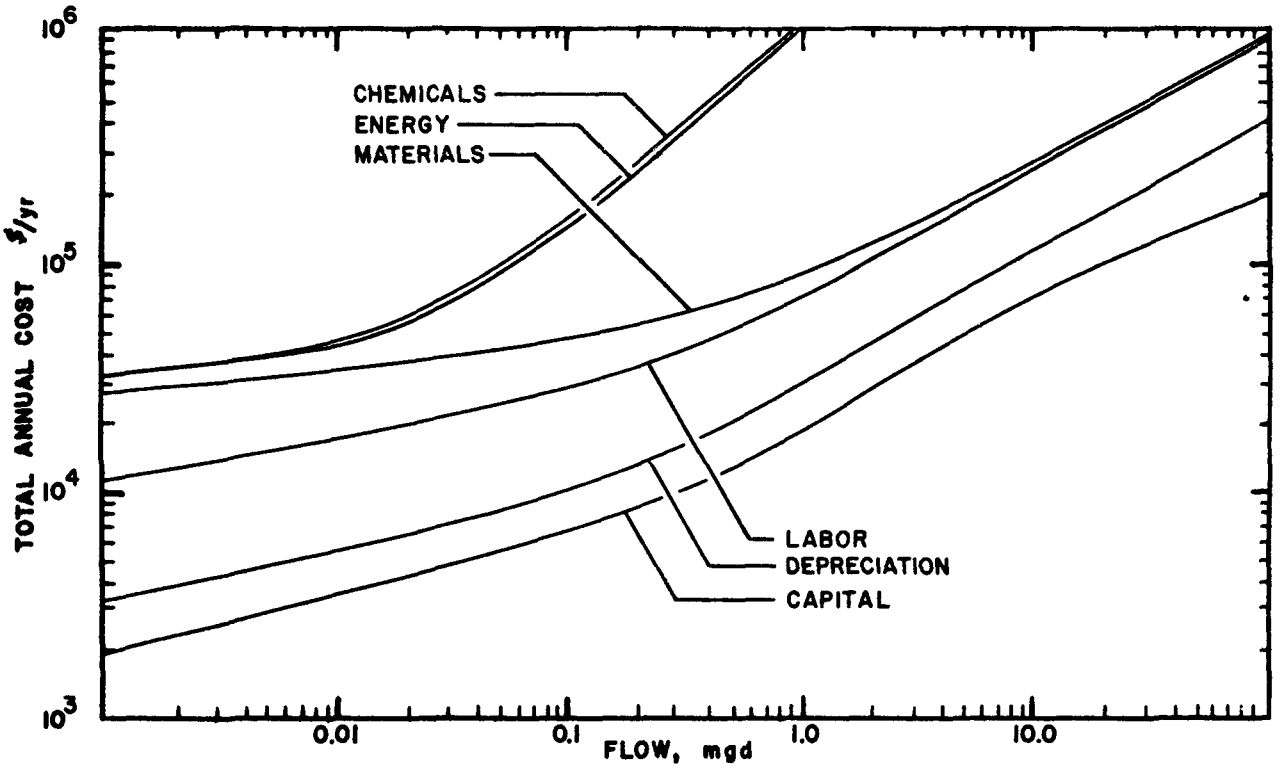



FIGURE VIII-128. COLUMBIUM / TANTALUM (ORE TO SALT/METAL) COMB. I, ALT. I

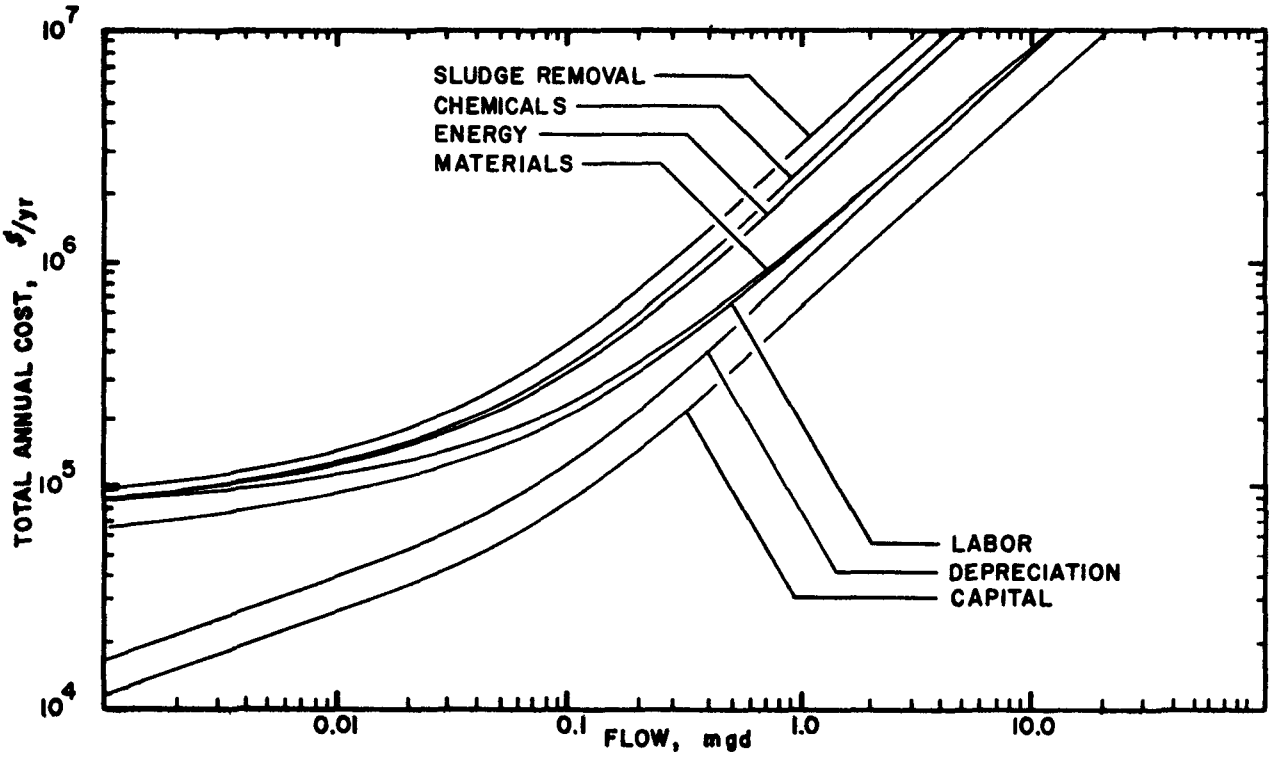



FIGURE VIII-129. COLUMBIUM / TANTALUM (ORE TO SALT/METAL) COMB. I, ALT. 2

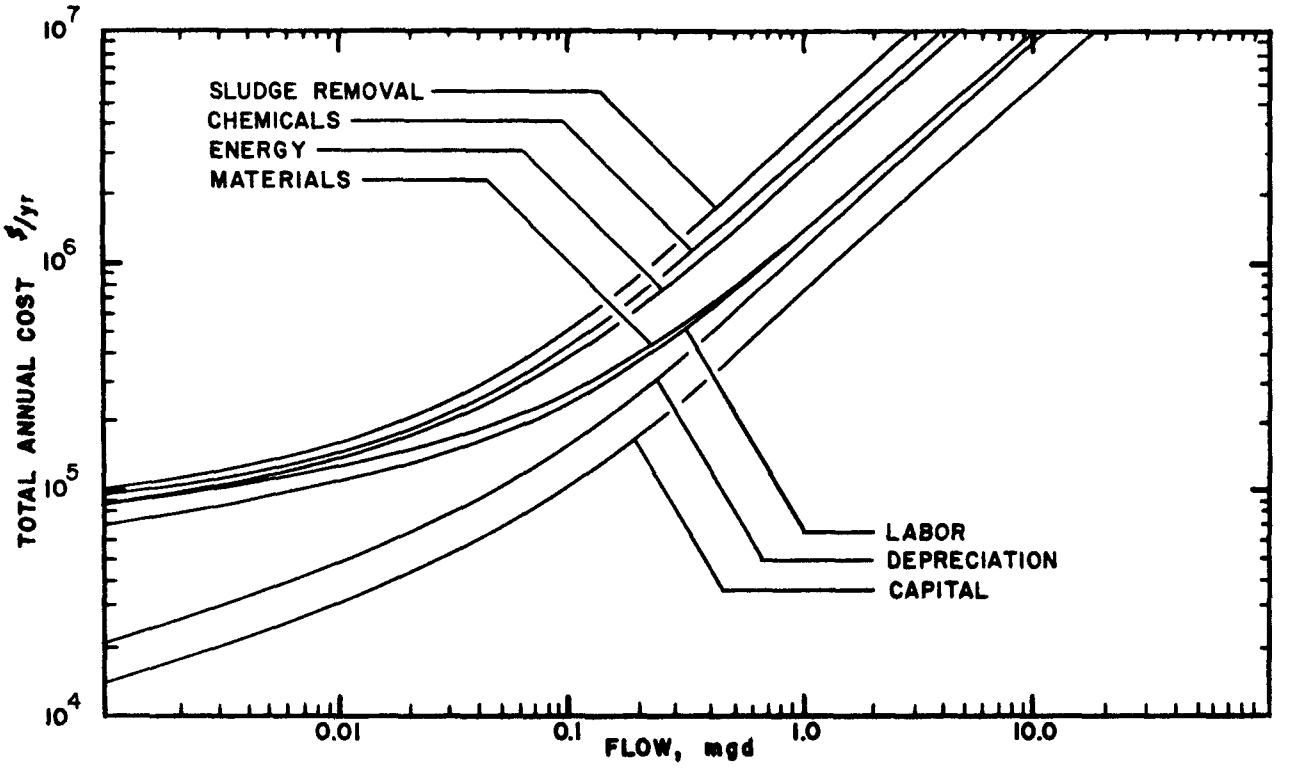



FIGURE VIII-130. COLUMBIUM / TANTALUM ( ORE TO SALT/METAL) COMB. I, ALT. 3

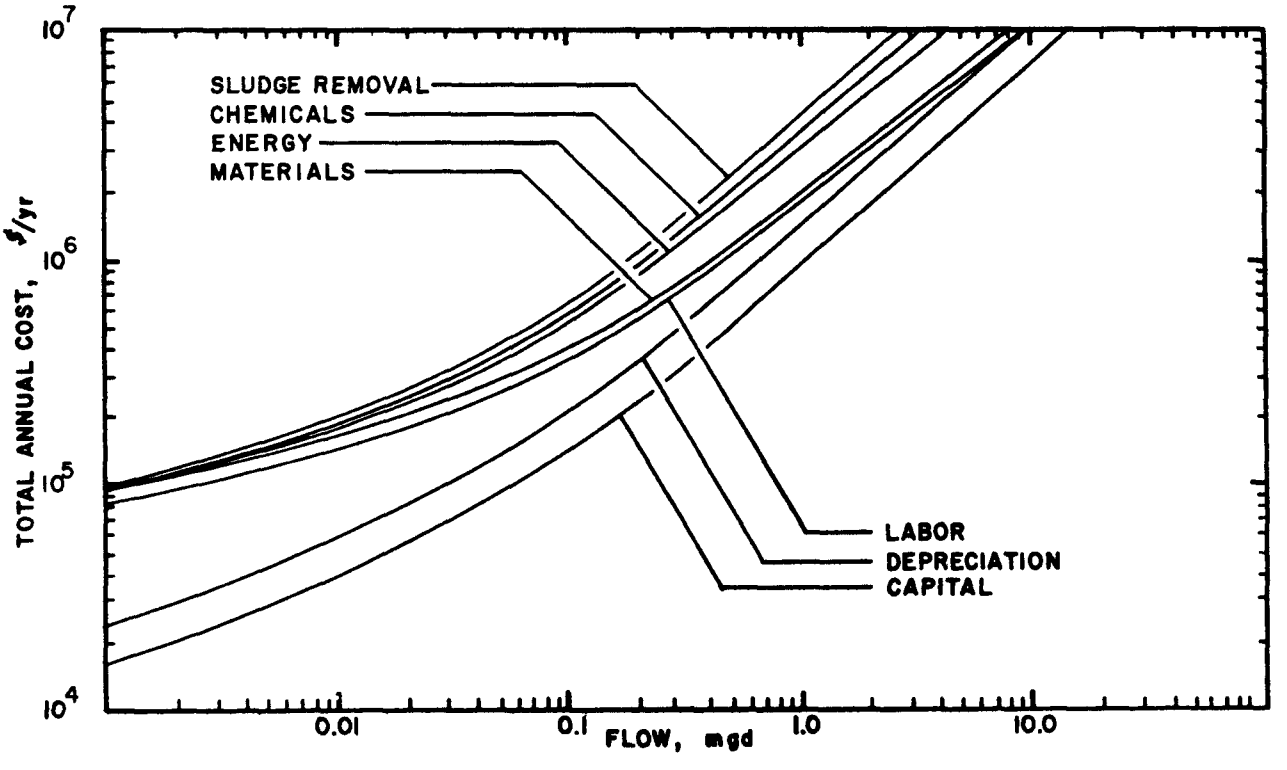



FIGURE VIII-131 . COLUMBIUM / TANTALUM (ORE TO SALT/METAL) COMB. I, ALT. 4

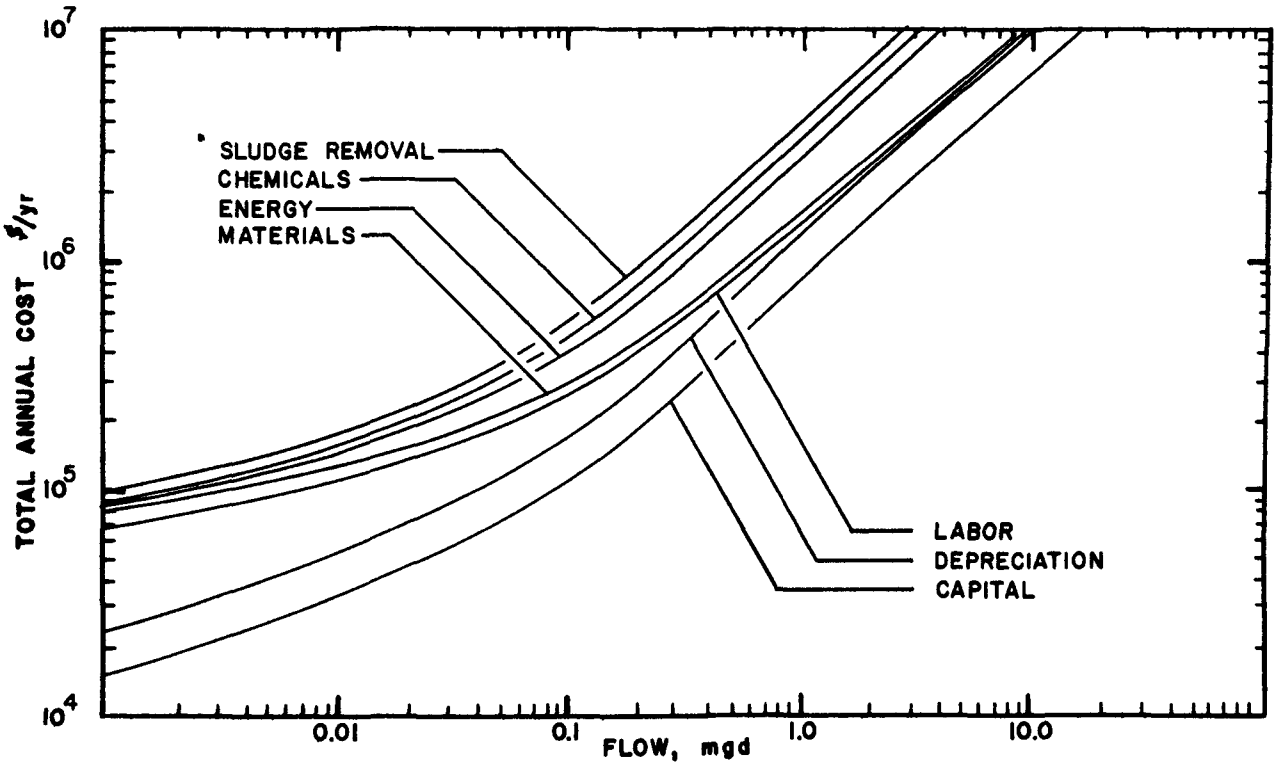
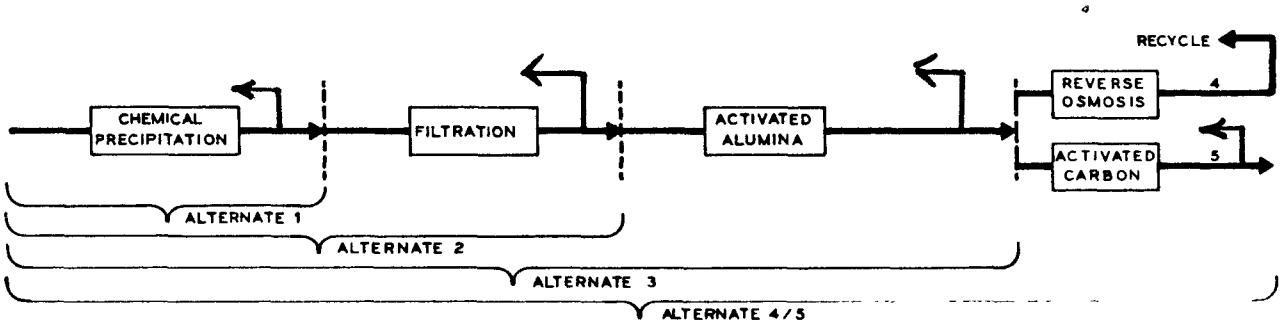



FIGURE VIII-132. COLUMBIUM / TANTALUM (ORE TO SALT/METAL) COMB. 1, ALT. 5




COMBINATION 1
(REDUCTION SCRUBBER AND LEACHATE)

FIGURE VIII-133. COLUMBIUM / TANTALUM (SALT TO METAL) NEW SOURCE TREATMENT SCHEMES

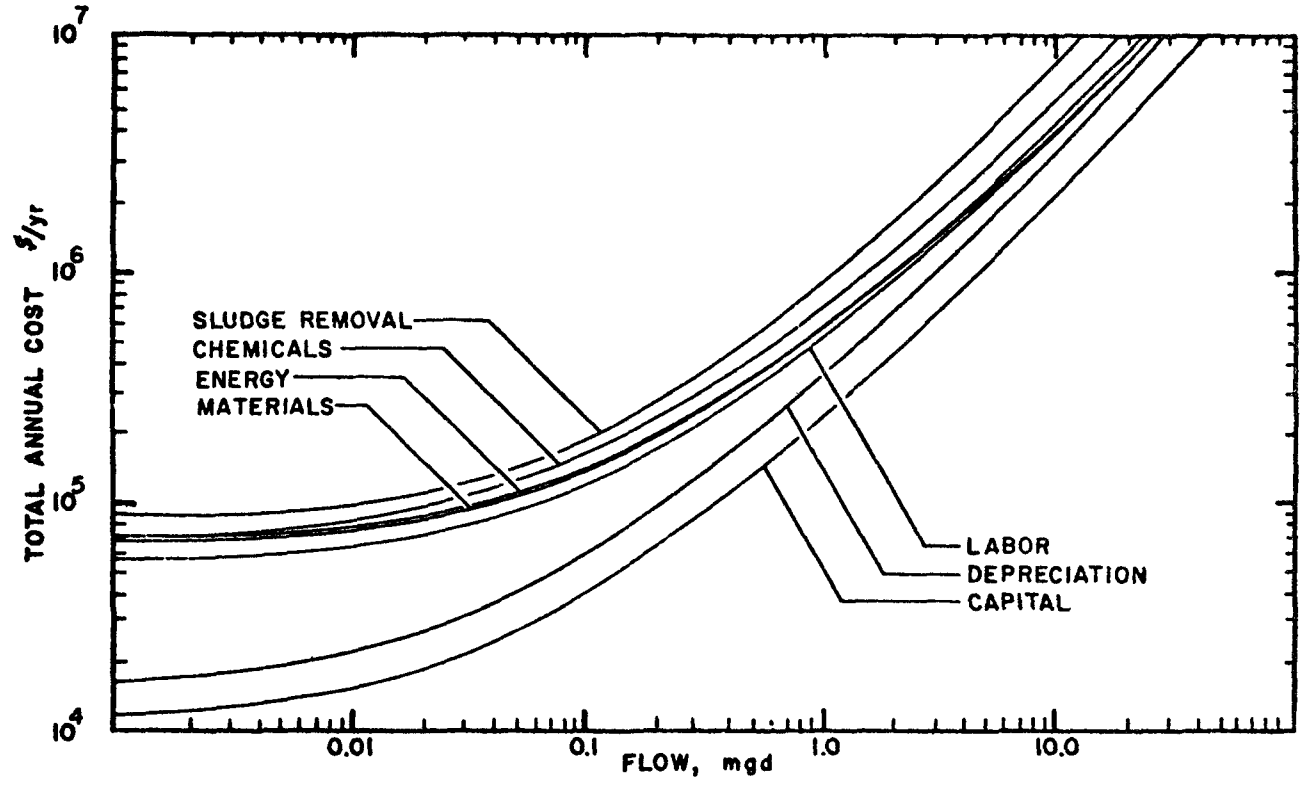



FIGURE VIII-134. COLUMBIUM / TANTALUM (SALT TO METAL) COMB. I ALT. I

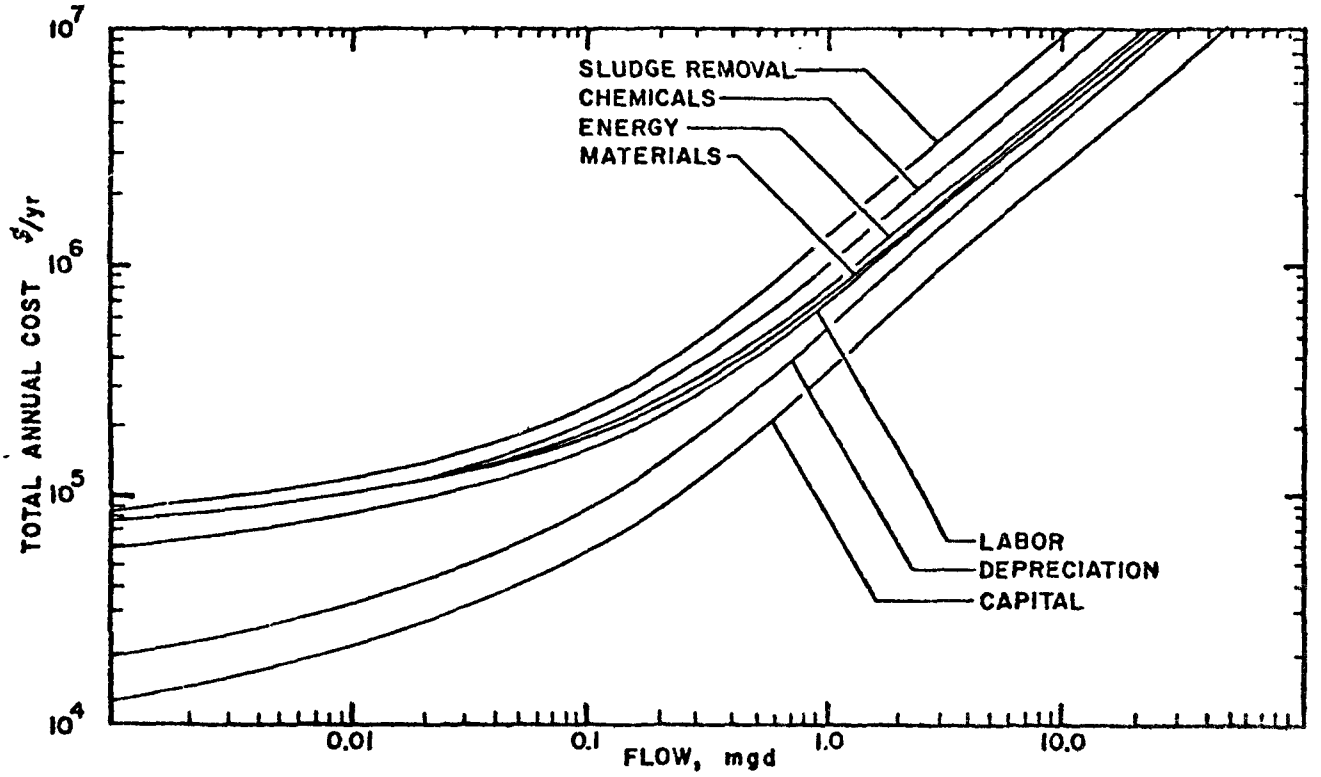



FIGURE VIII-135. COLUMBIUM/TANTALUM (SALT TO METAL) COMB. I, ALT. I

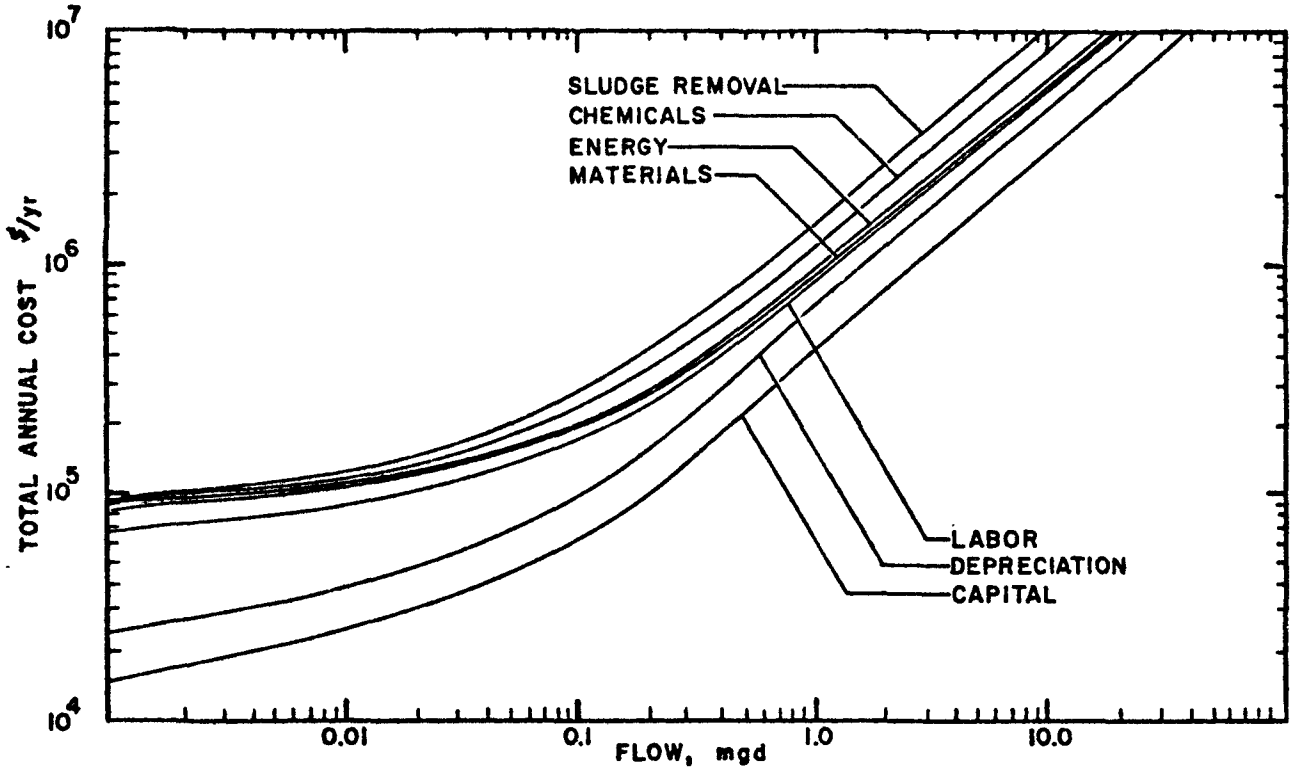



FIGURE VIII-136. COLUMBIUM / TANTALUM (SALT TO METAL) COMB. I , ALT. 3

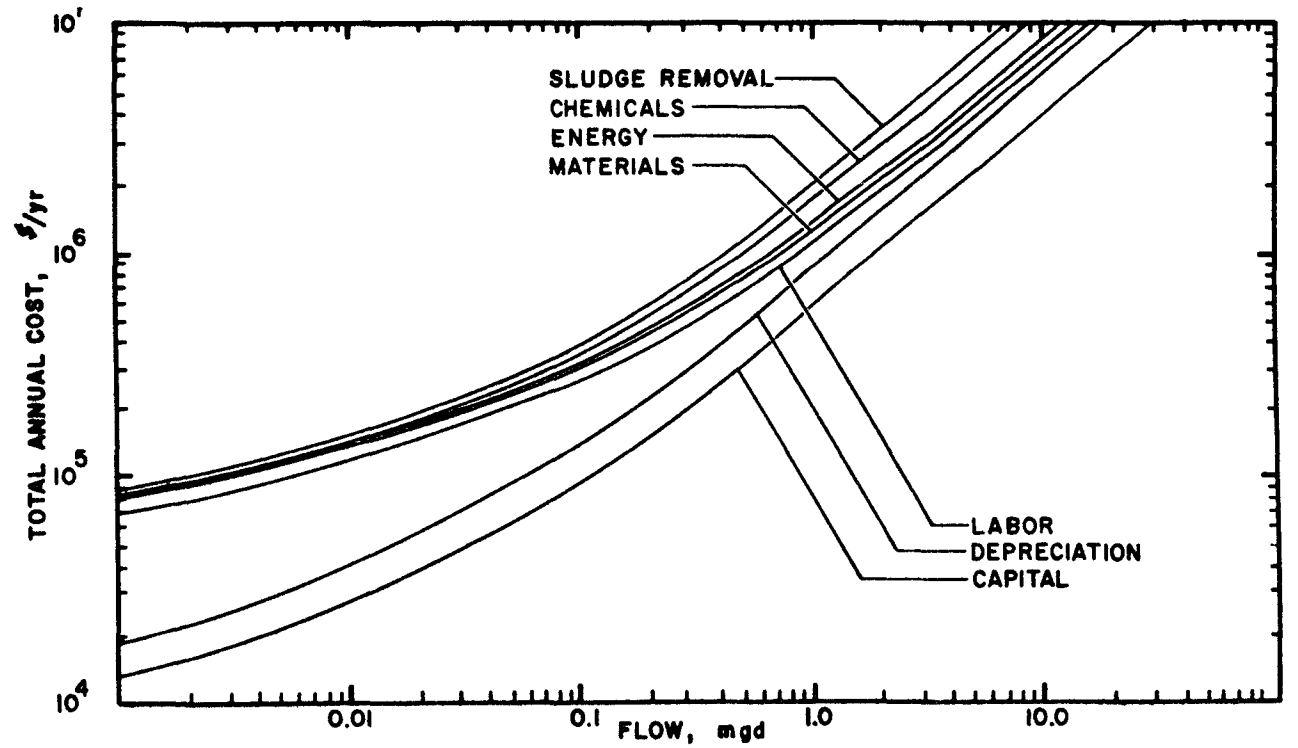



FIGURE VIII-137. COLUMBIUM / TANTALUM ( SALT TO METAL) COMB. I , ALT. 4

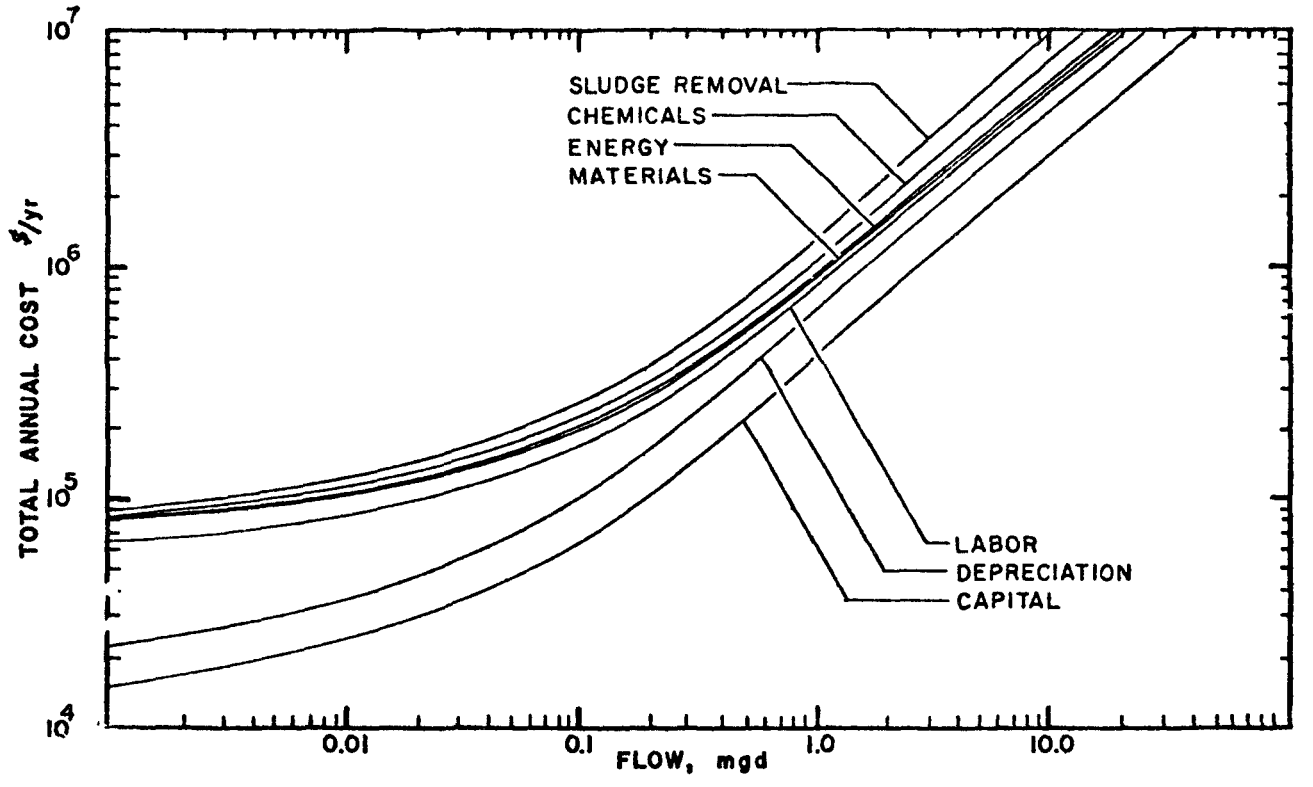
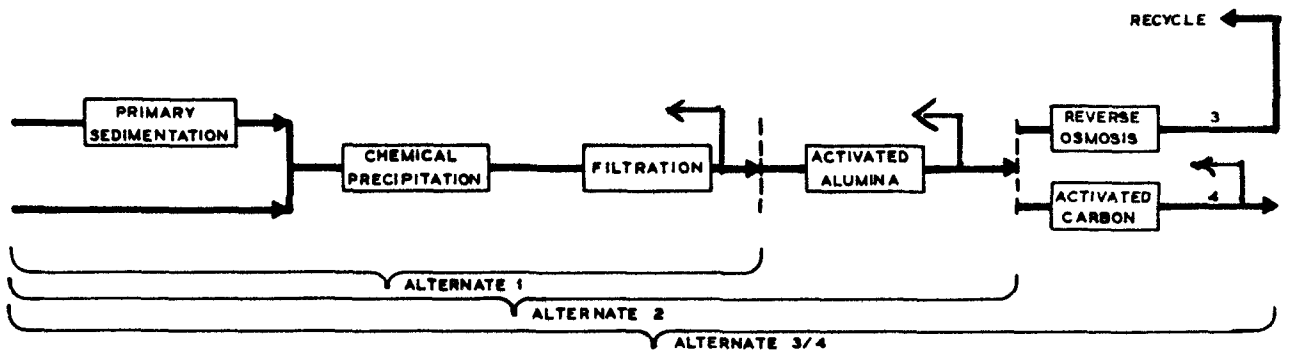



FIGURE VIII-138. COLUMBIUM / TANTALUM (SALT TO METAL) COMB. 1, ALT. 5




COMBINATION 1
(SCRUBBER, CONTACT COOLING)

FIGURE VIII-139. PRIMARY COPPER (SMELTING AND REFINING)
NEW SOURCE TREATMENT SCHEMES

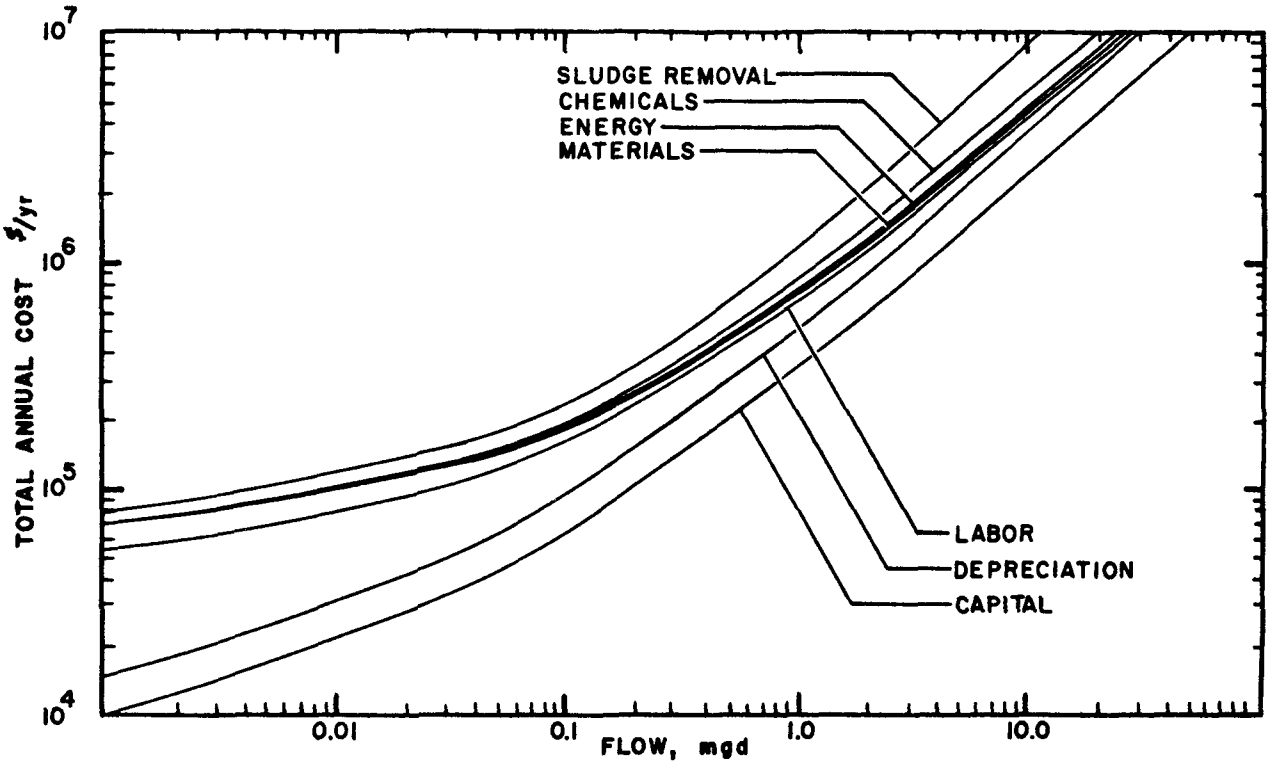



FIGURE VIII-140. PRIMARY COPPER (SMELTING & REFINING) COMB.1, ALT.1

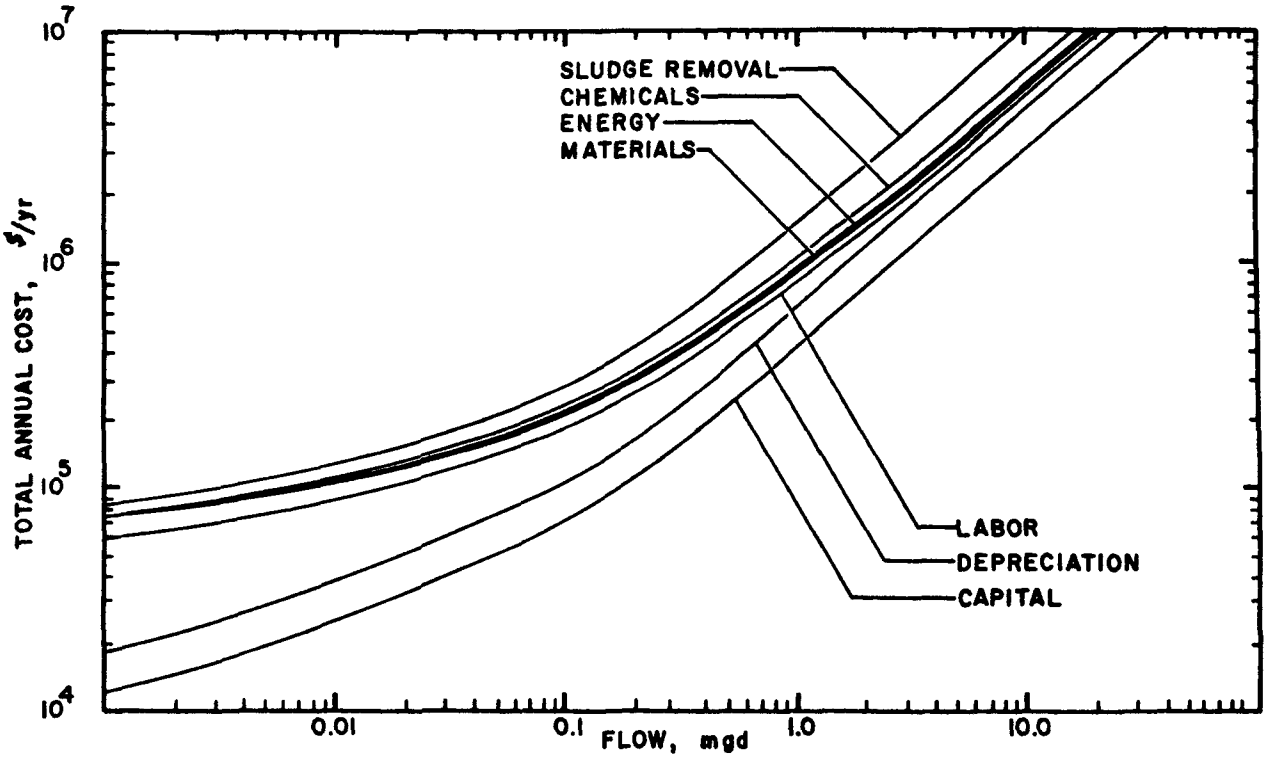



FIGURE VIII-141 . PRIMARY COPPER (SMELTING & REFINING) COMB. 1, ALT. 2

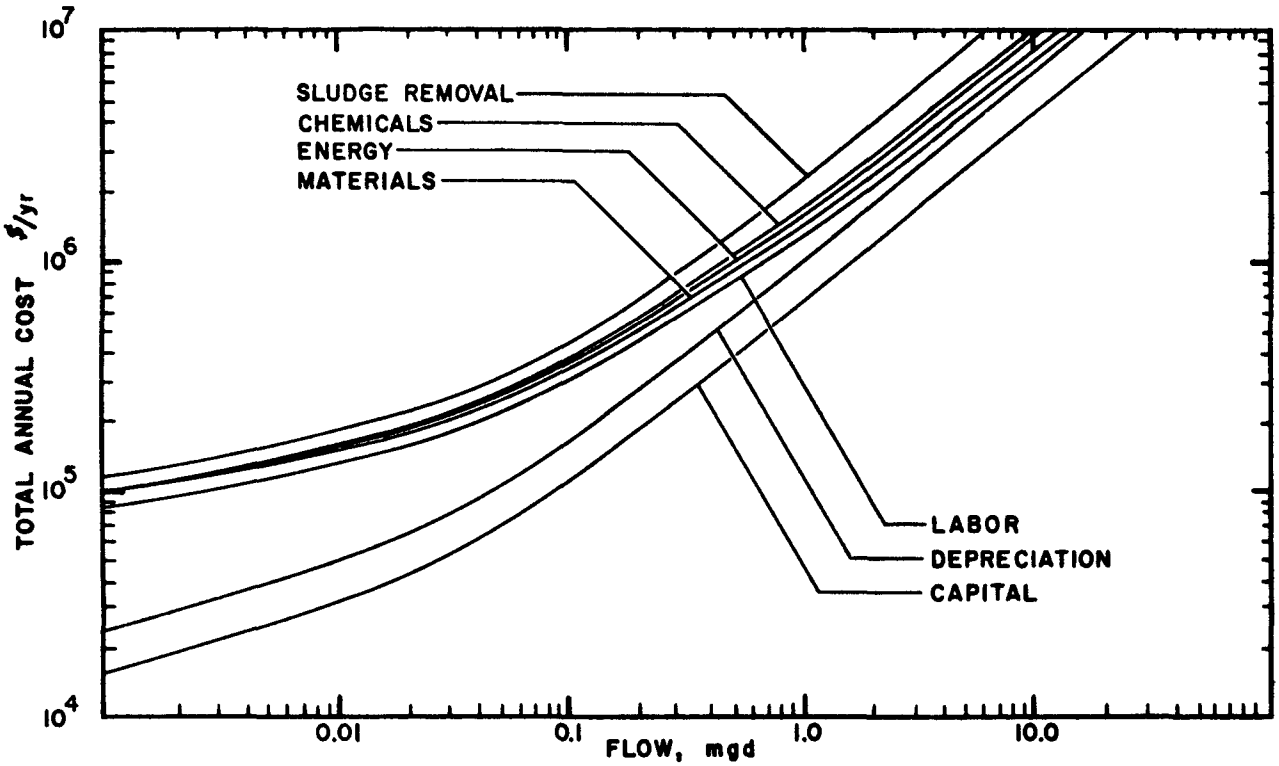



FIGURE VIII-142. PRIMARY COPPER (SMELTING & REFINING) COMB. 1, ALT. 3

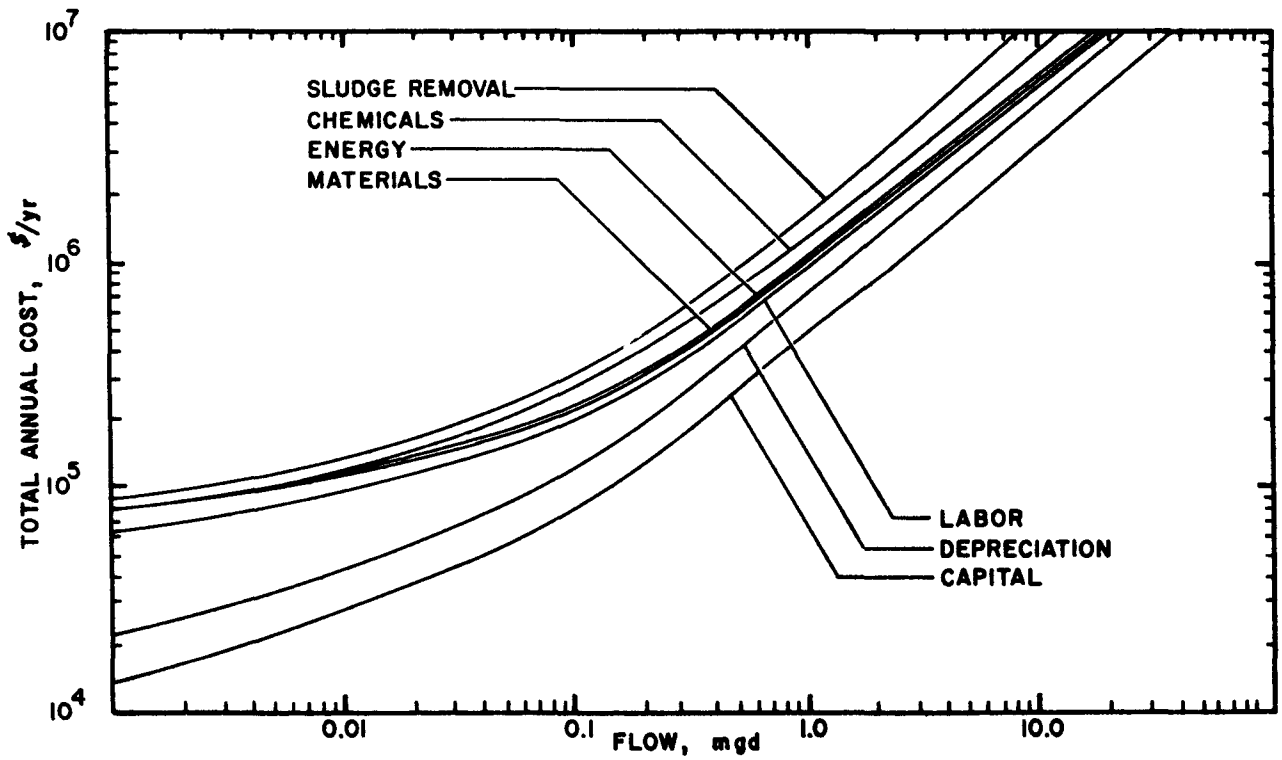
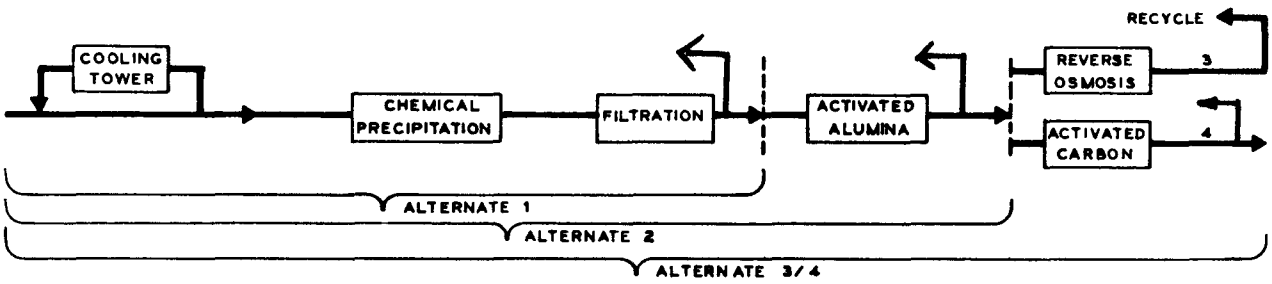



FIGURE VIII-143. PRIMARY COPPER (SMELTING & REFINING) COMB. 1, ALT. 4




COMBINATION 1
(CONTACT COOLING)

FIGURE VIII-144. PRIMARY COPPER (REFINING)
NEW SOURCE TREATMENT SCHEMES

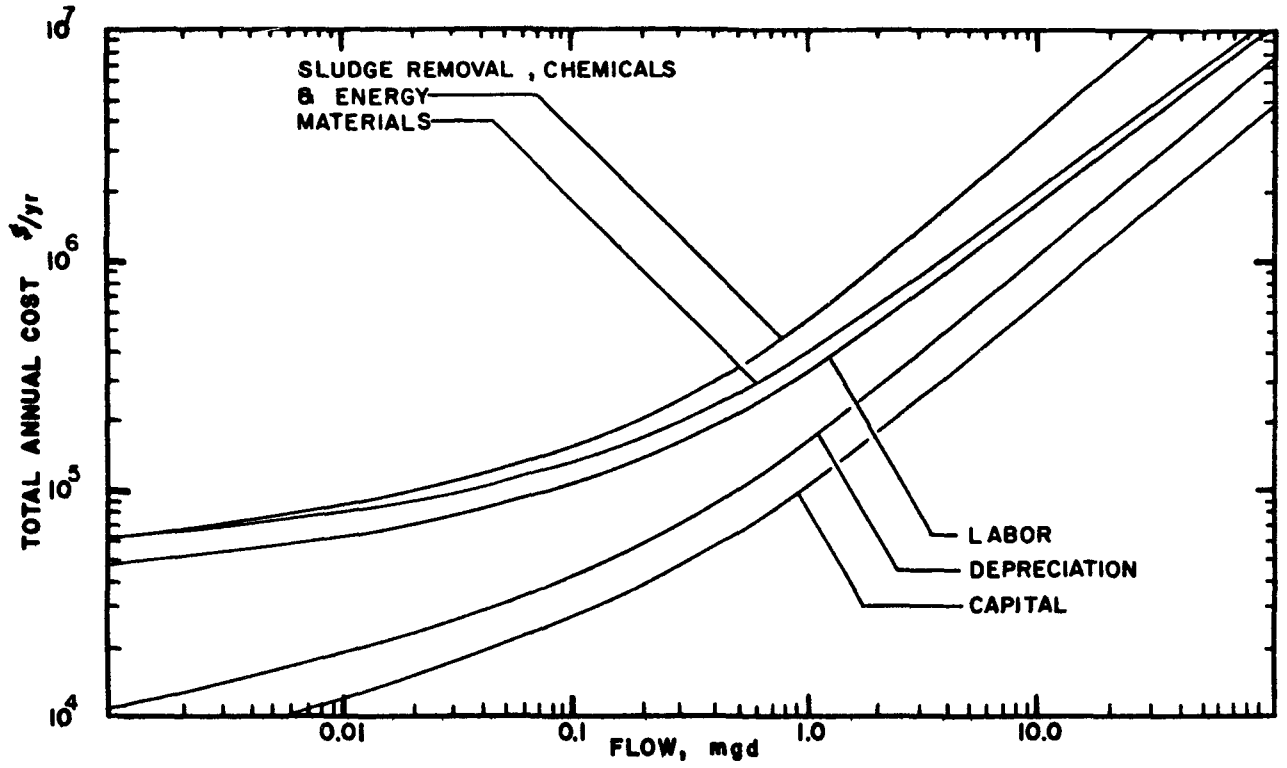



FIGURE VIII-145. PRIMARY COPPER (REFINING) COMB. 1, ALT. 1

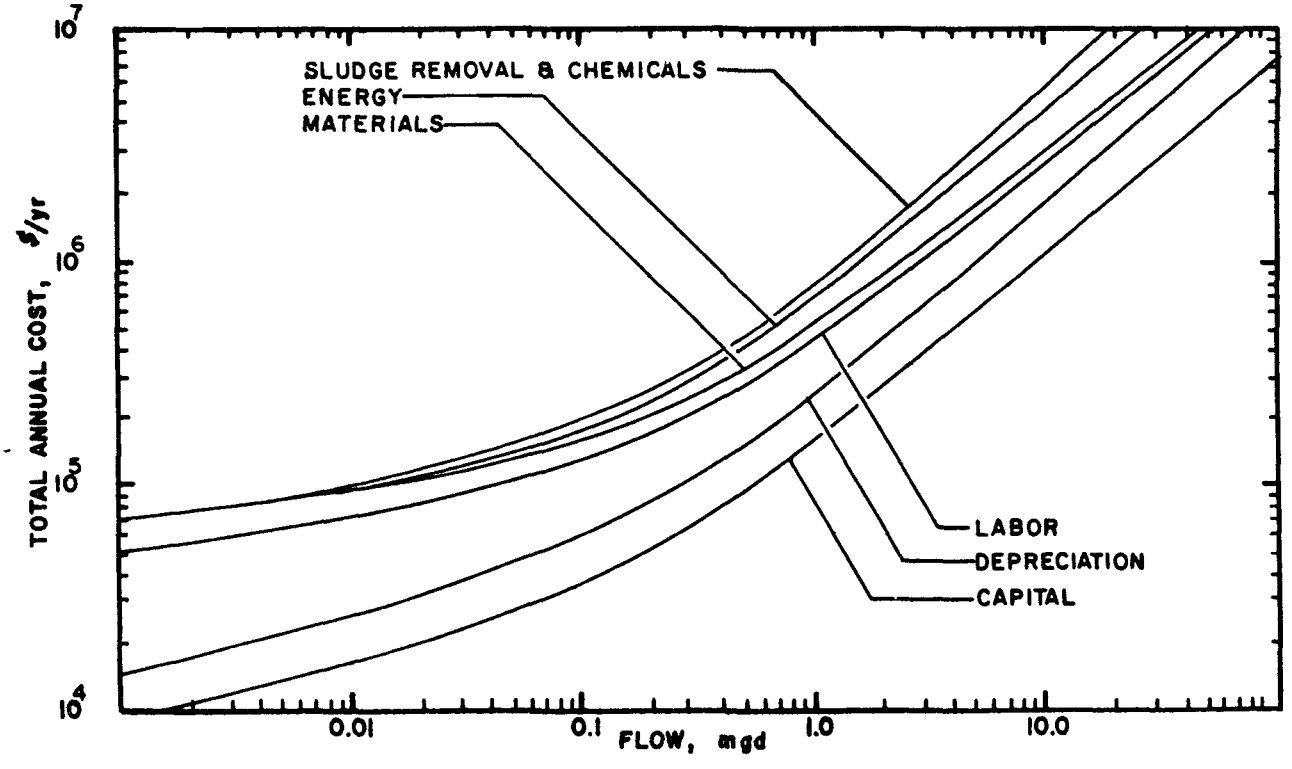



FIGURE VIII-146. PRIMARY COPPER (REFINING) COMB. 1, ALT. 2

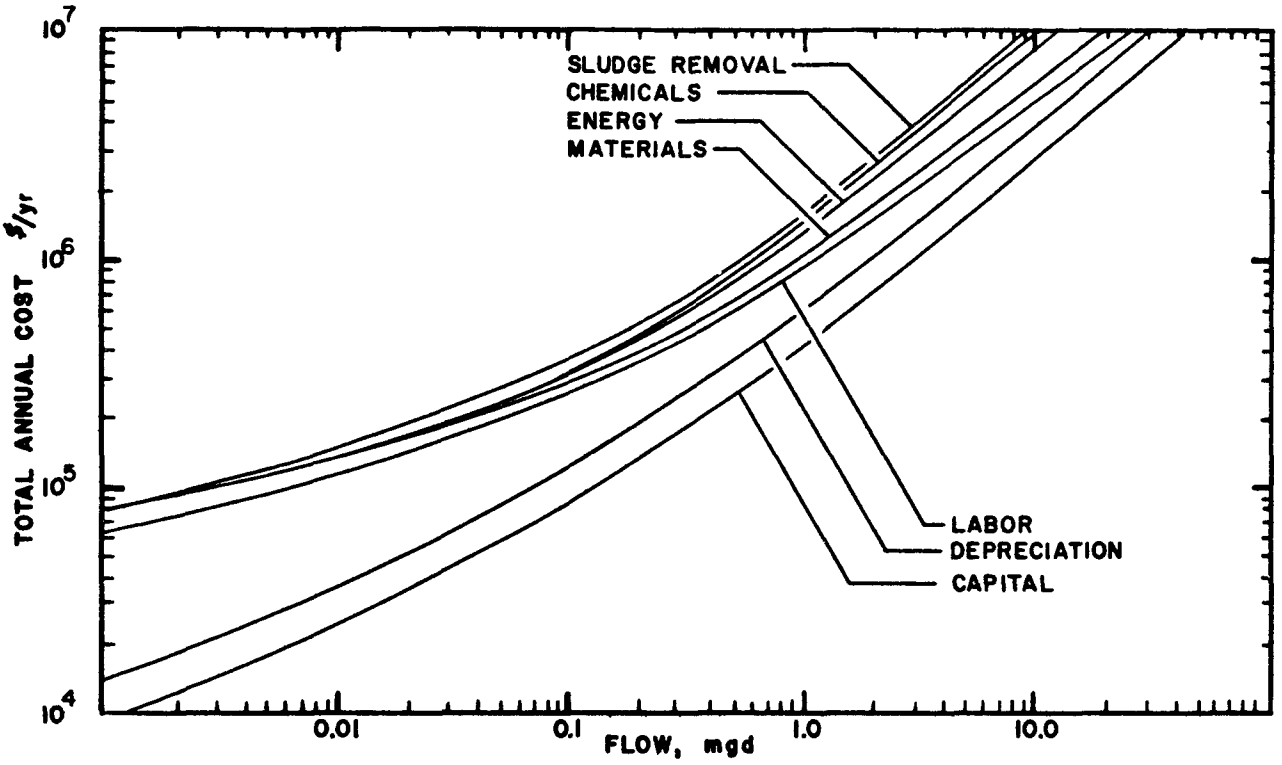



FIGURE VIII-147. PRIMARY COPPER (REFINING) COMB. 1, ALT. 3

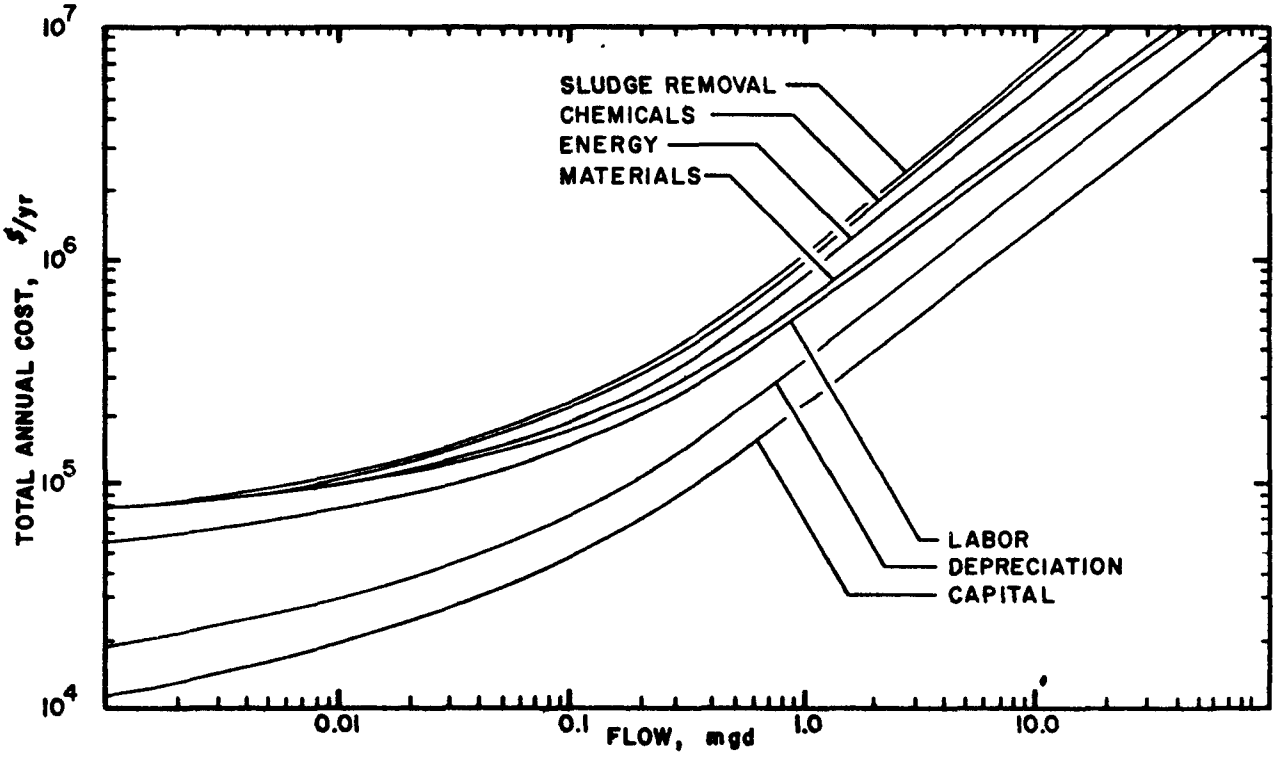
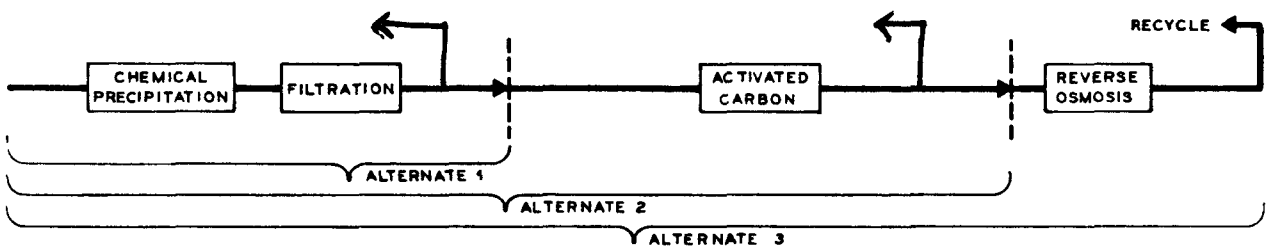



FIGURE VIII-148. PRIMARY COPPER (REFINING) COMB.1, ALT. 4




COMBINATION 1
(ACID PLANT BLOWDOWN)

FIGURE VIII-157. PRIMARY LEAD
NEW SOURCE TREATMENT SCHEMES

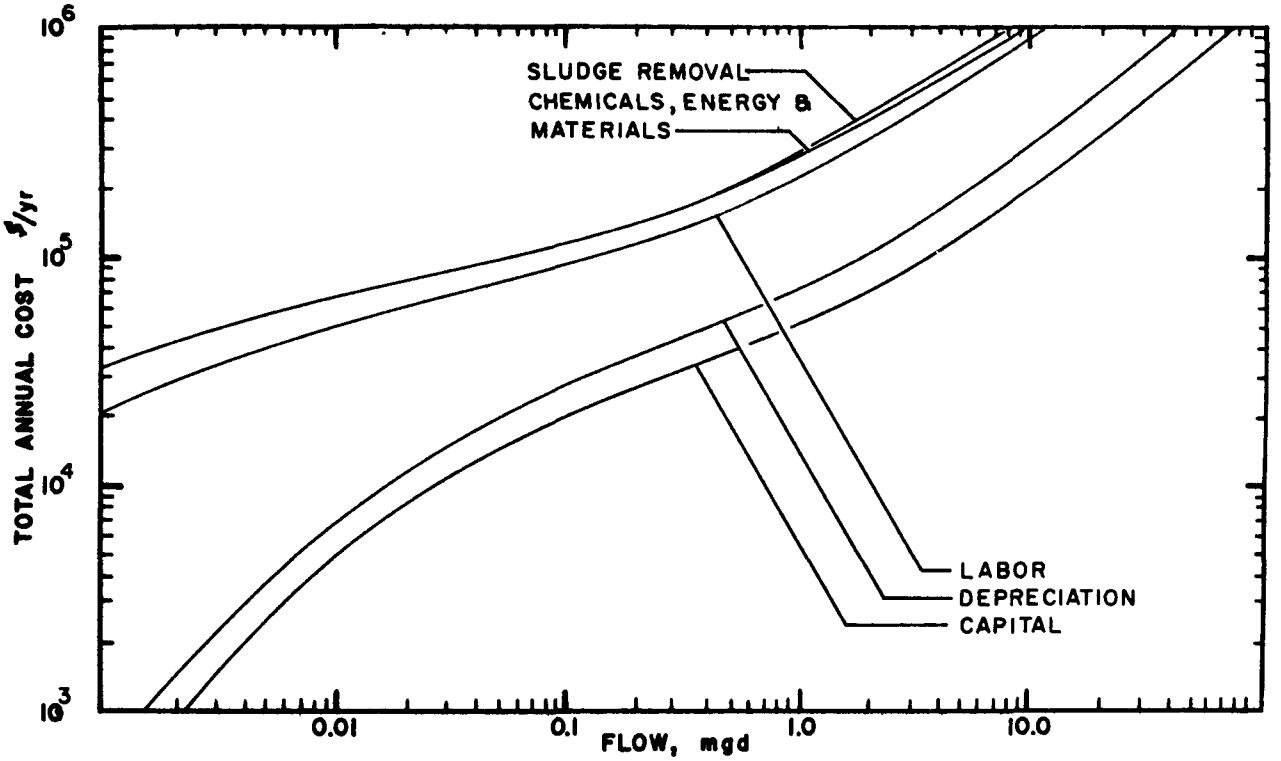



FIGURE VIII-158. PRIMARY LEAD COMB. 1, ALT. 1

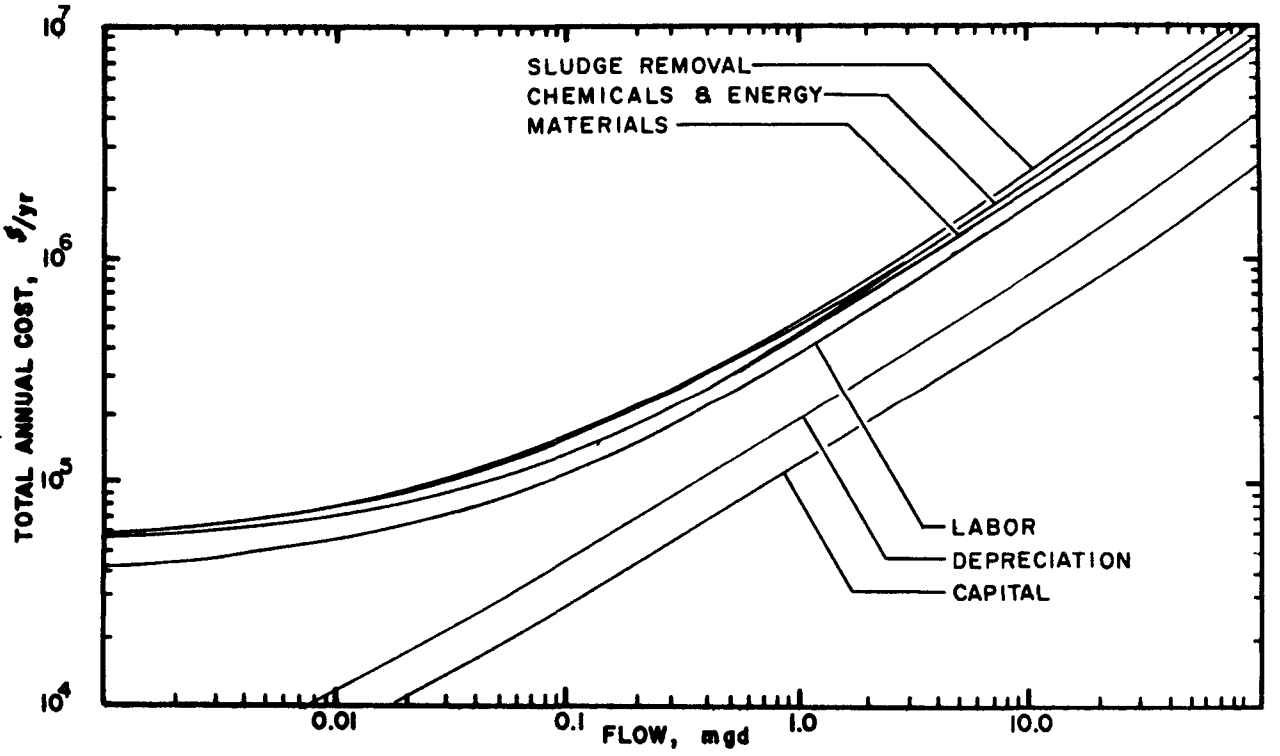



FIGURE VIII-159. PRIMARY LEAD COMB. 1, ALT. 2

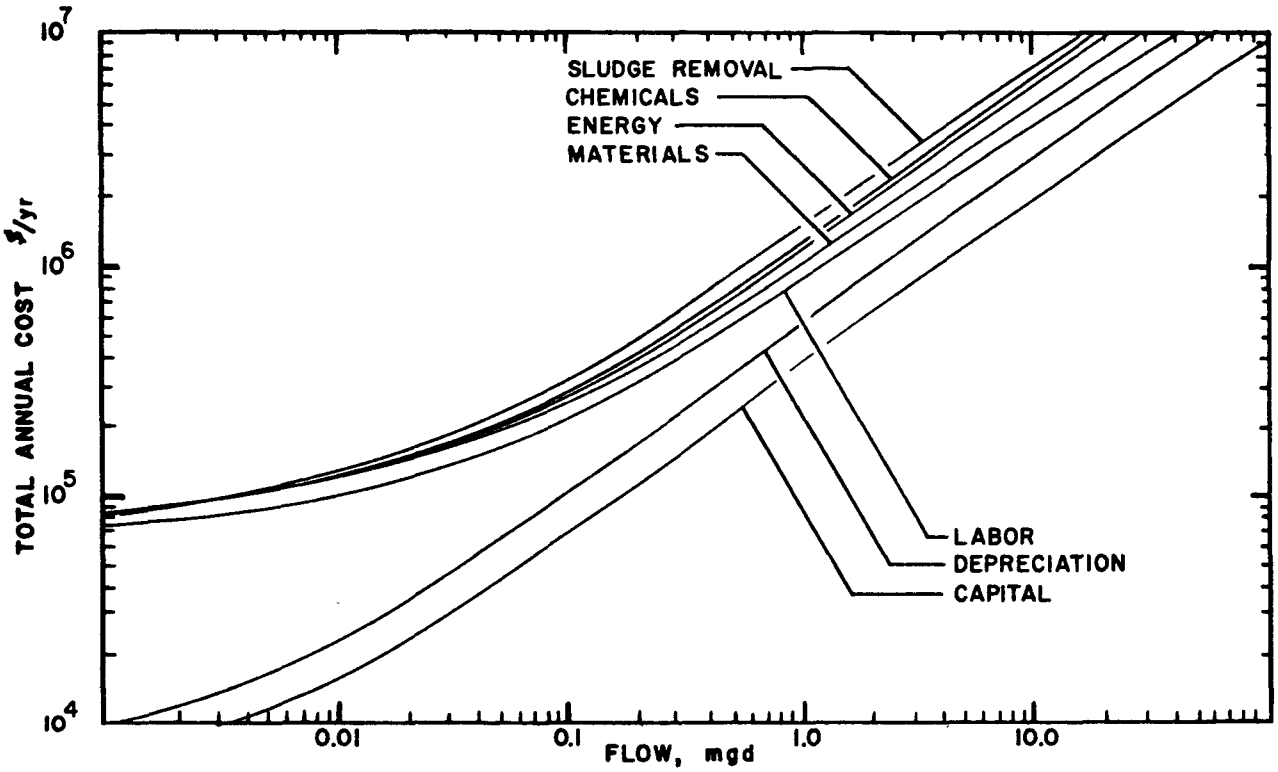
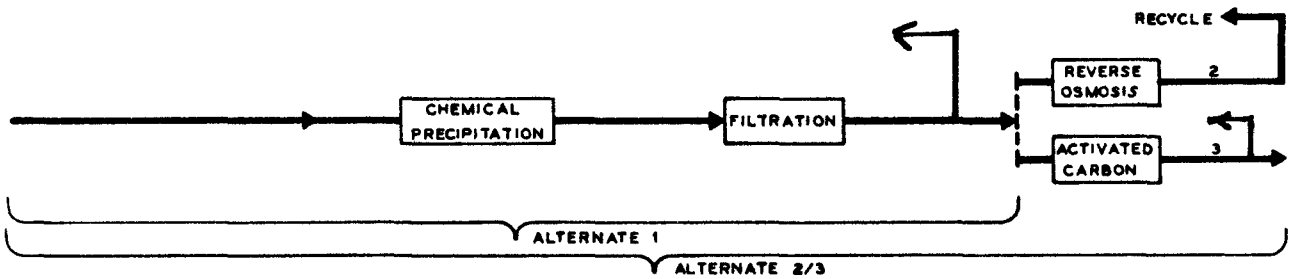
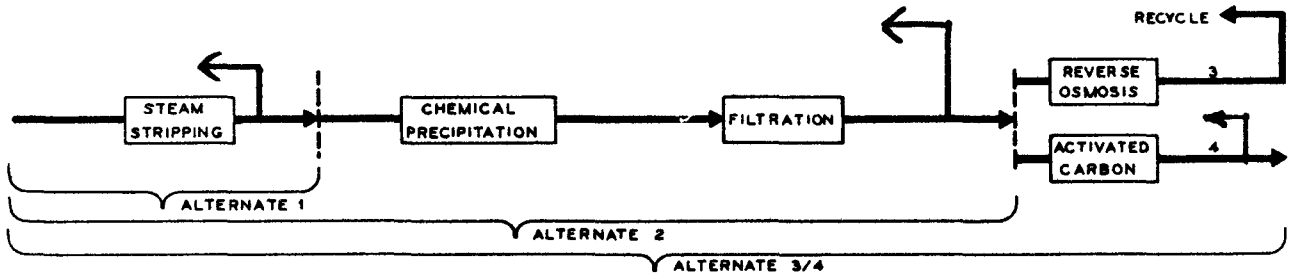



FIGURE VIII-160. PRIMARY LEAD COMB. 1, ALT. 3




COMBINATION 1
(COMBINED WASTEWATER)




COMBINATION 2
(COMBINED WASTEWATER)

FIGURE VIII-179. PRIMARY TUNGSTEN (ORE TO SALT/METAL)
NEW SOURCE TREATMENT SCHEMES

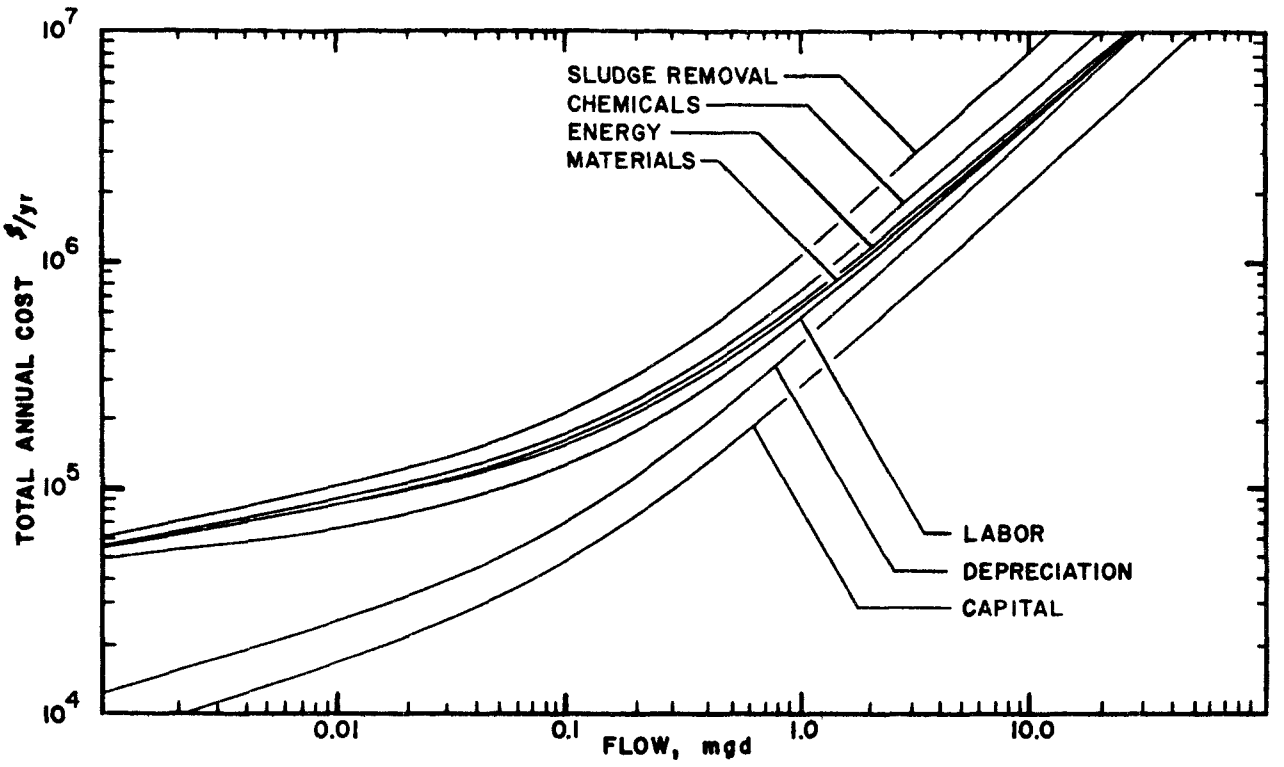



FIGURE VIII-180. PRIMARY TUNGSTEN(ORE TO SALT/METAL) COMB. I, ALT. I

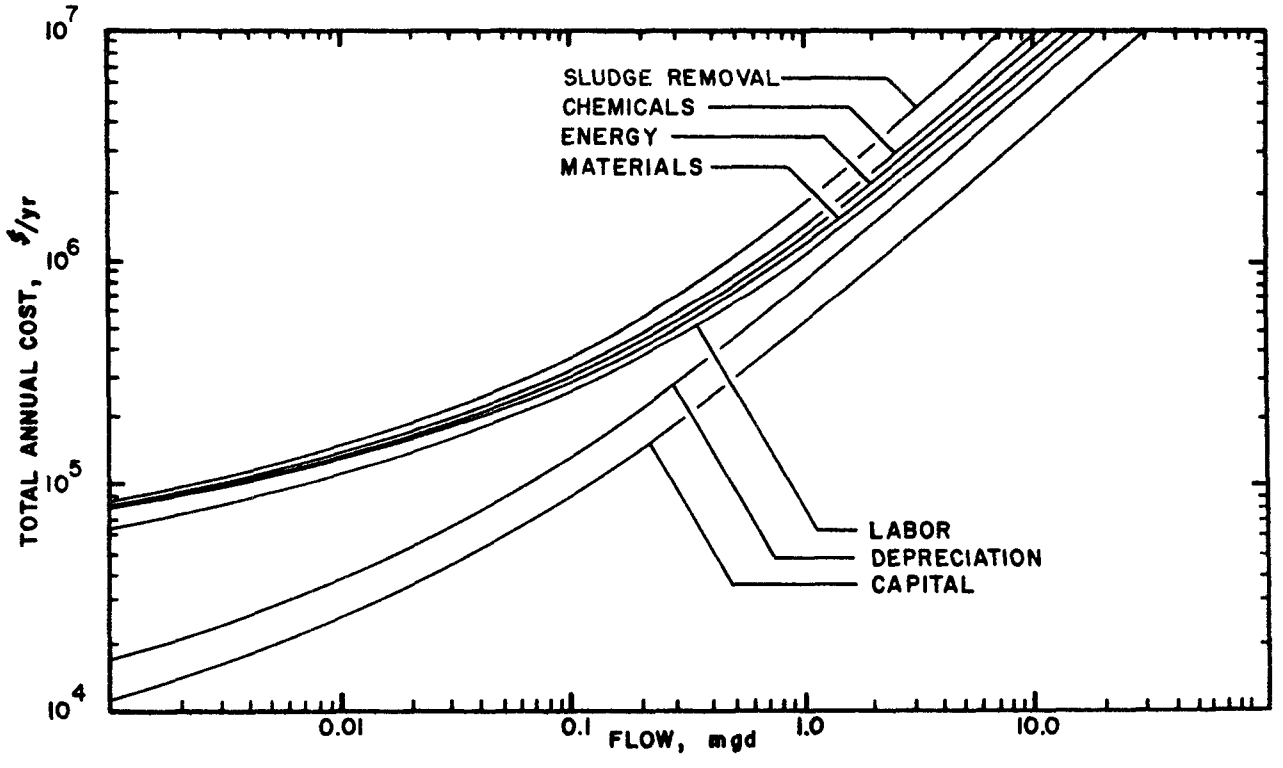



FIGURE VIII-181. PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. I, ALT. 2

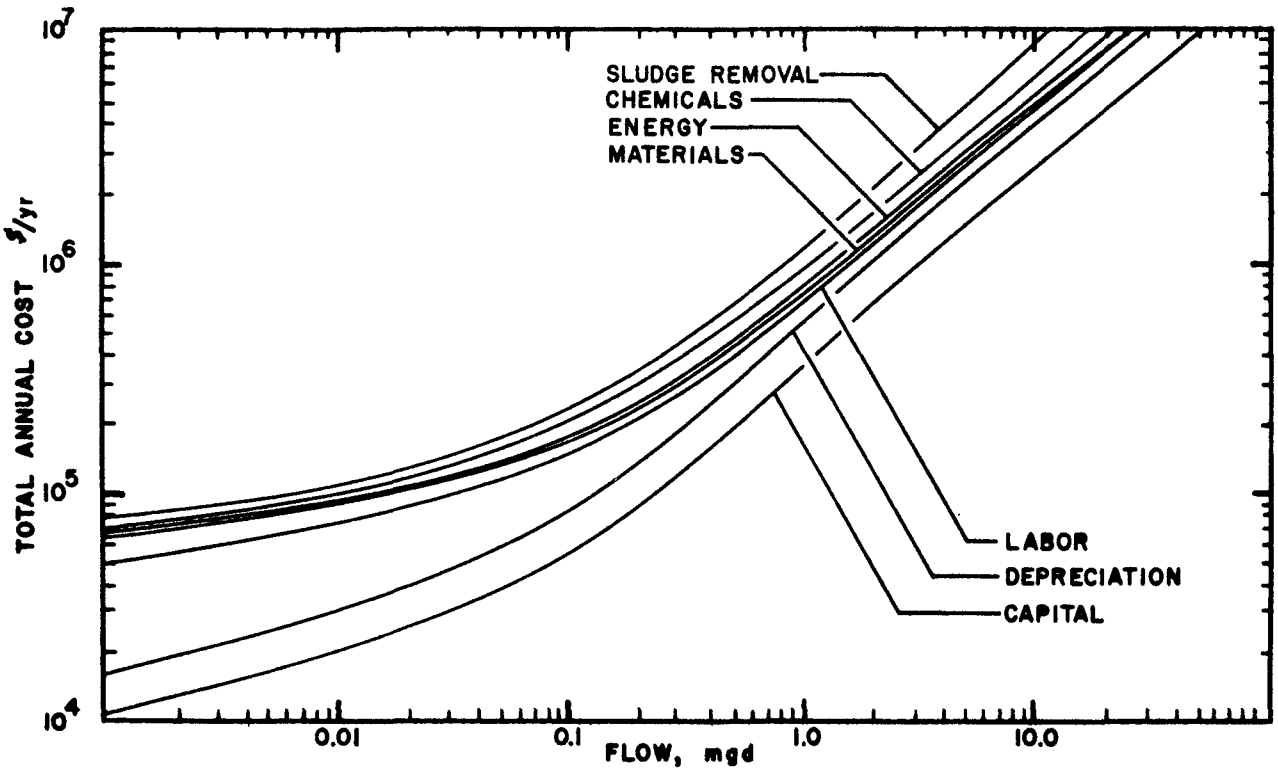



FIGURE VIII-182. PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 1, ALT. 3

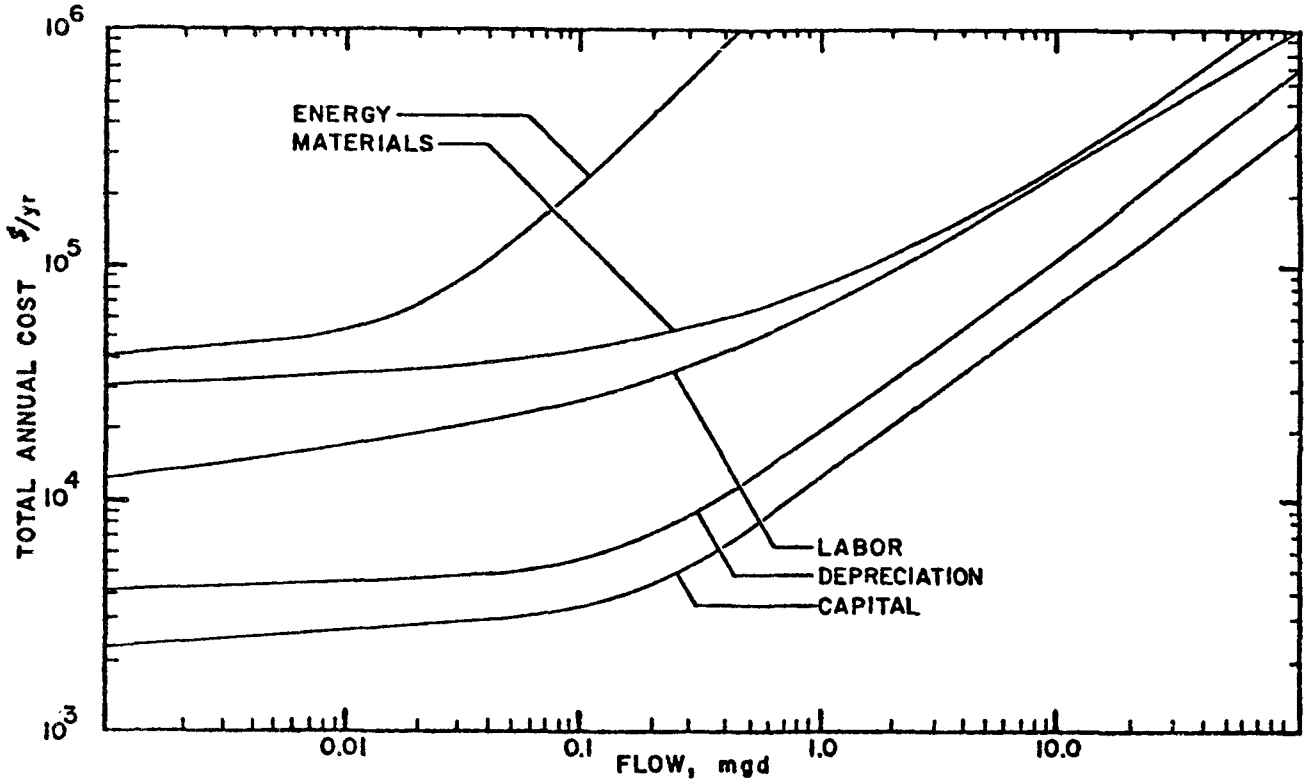



FIGURE VIII-183 PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 2, ALT. 1

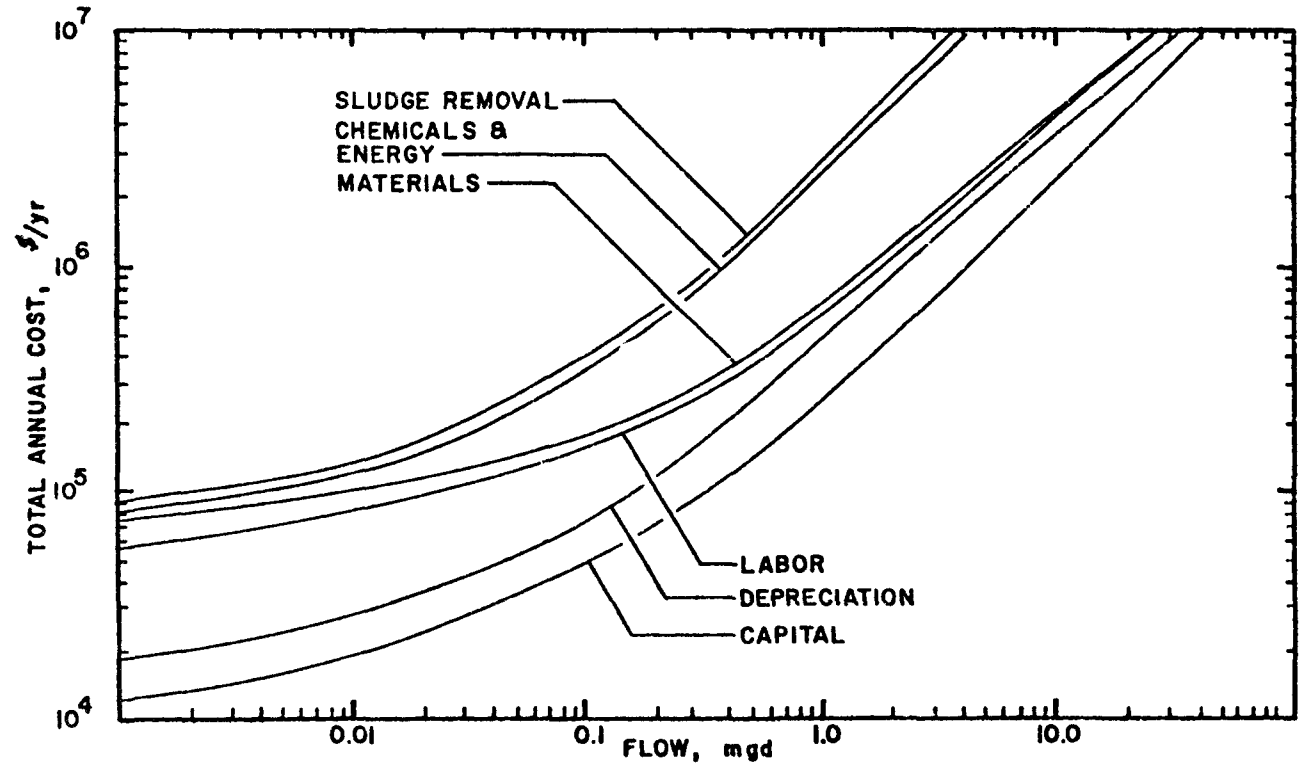



FIGURE VIII-184. PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 2, ALT. 2

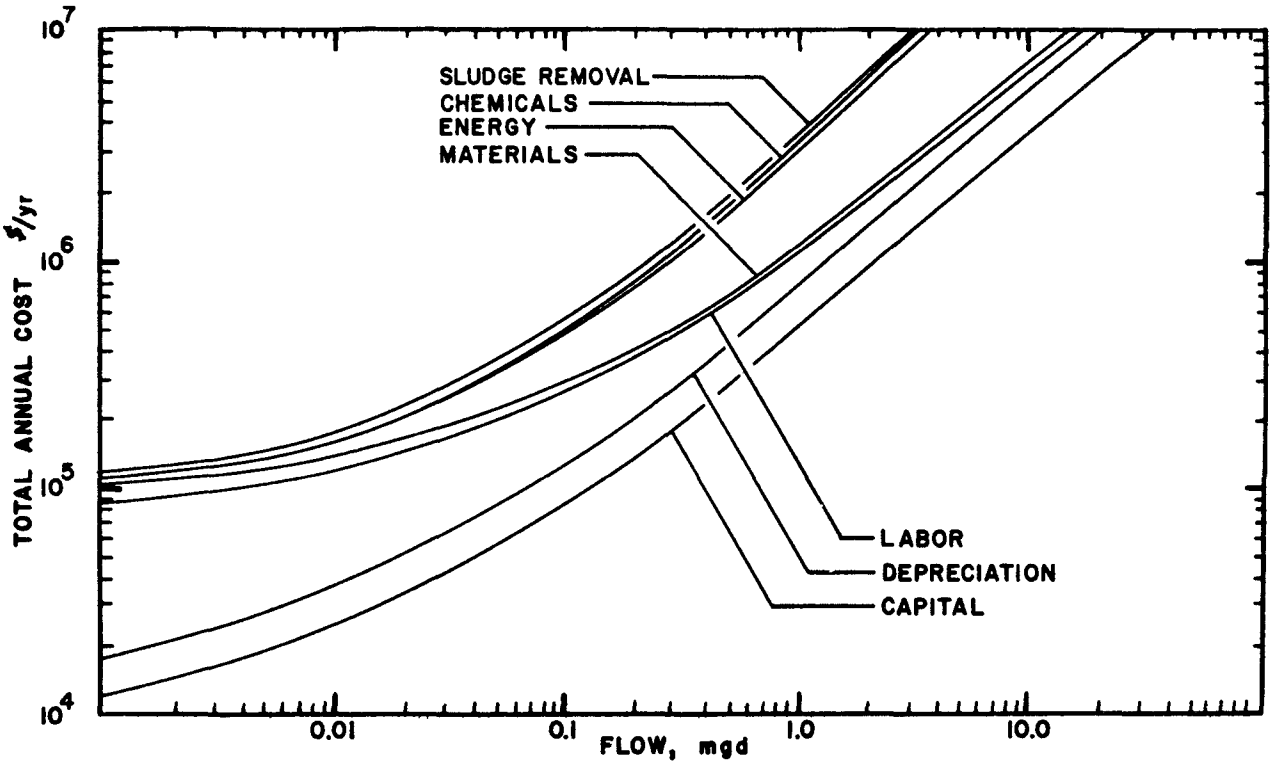



FIGURE VIII-185. PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 2 , ALT. 3

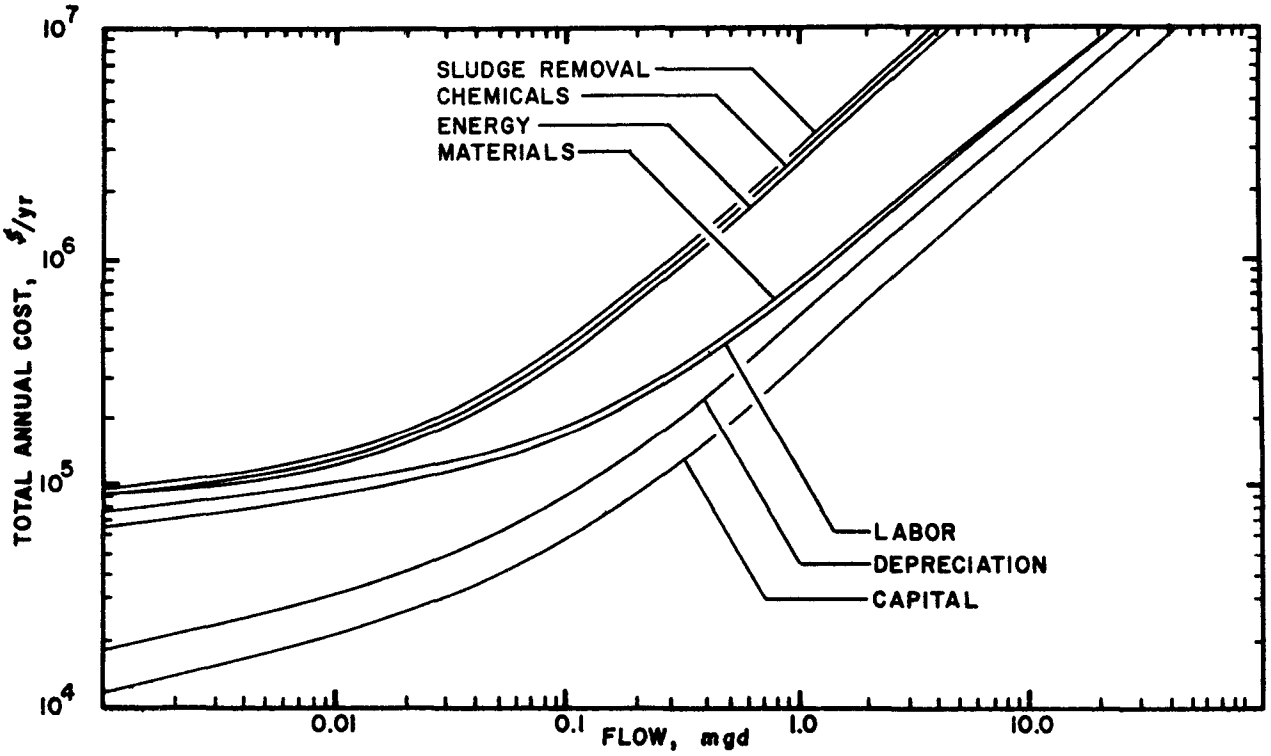



FIGURE VIII-186 .PRIMARY TUNGSTEN (ORE TO SALT/METAL) COMB. 2 , ALT. 4

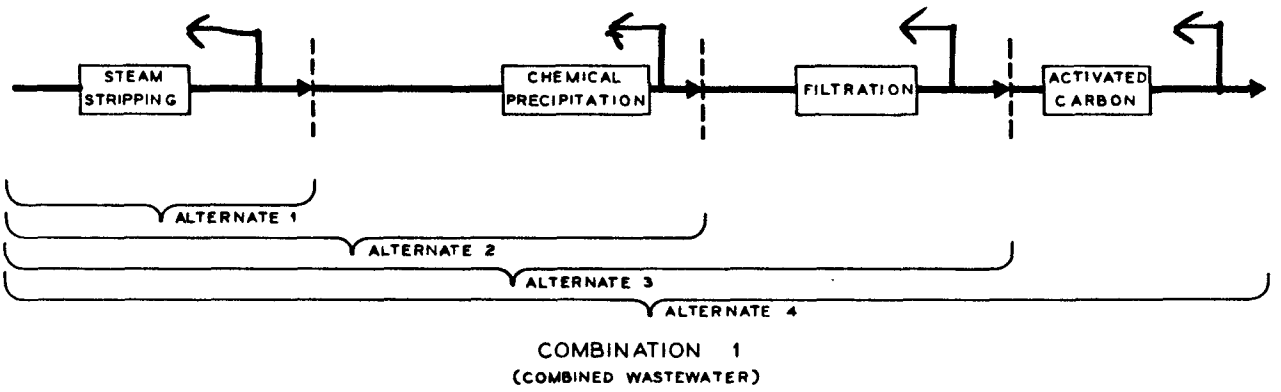



FIGURE VIII-187. PRIMARY TUNGSTEN (SALT TO METAL) NEW SOURCE TREATMENT SCHEMES

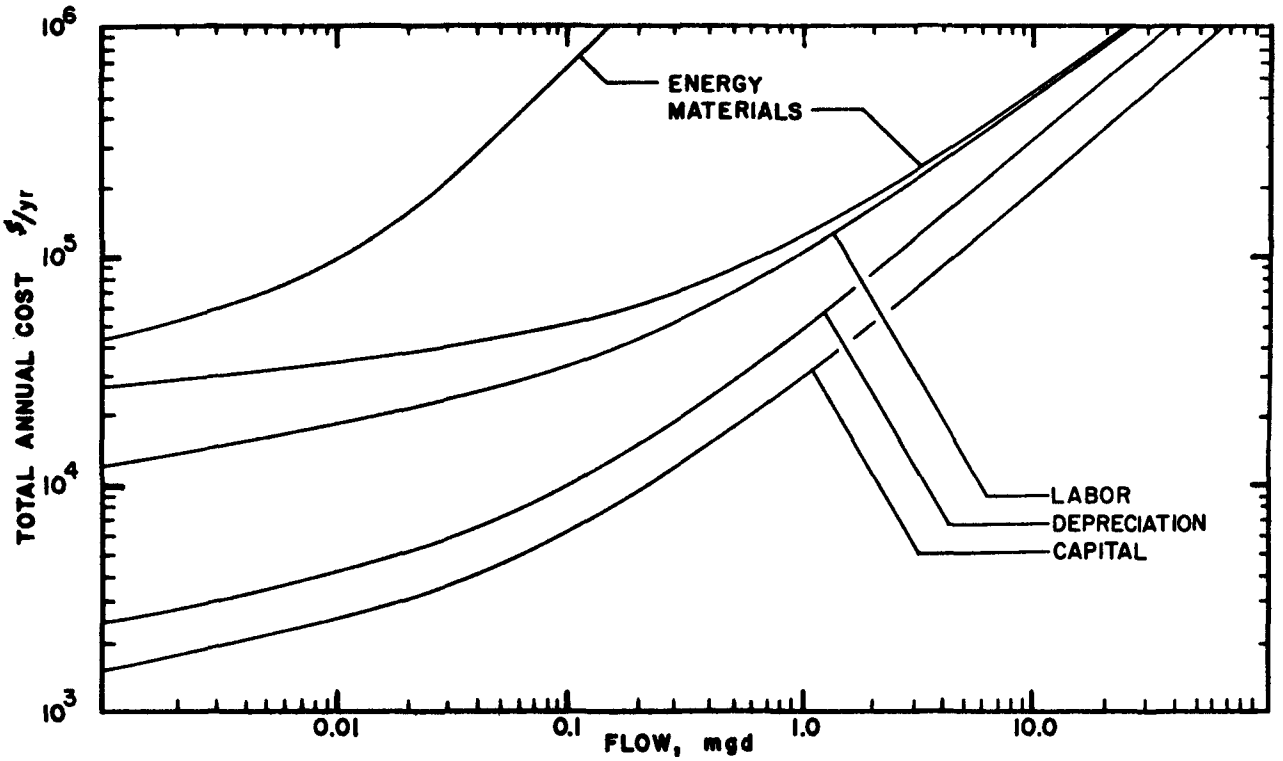



FIGURE VIII-188. PRIMARY TUNGSTEN (SALT TO METAL) COMB. 1, ALT. 1

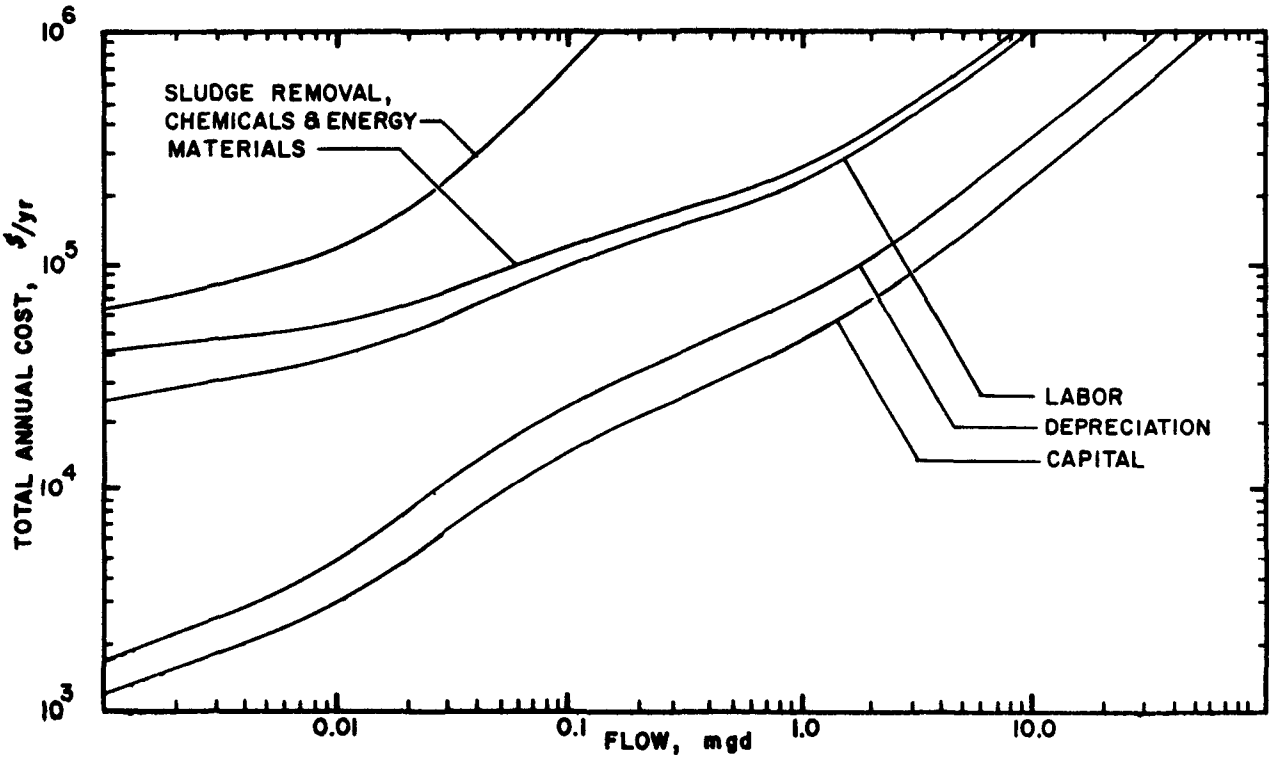



FIGURE VIII-189. PRIMARY TUNGSTEN (SALT TO METAL) COMB. 1, ALT. 2

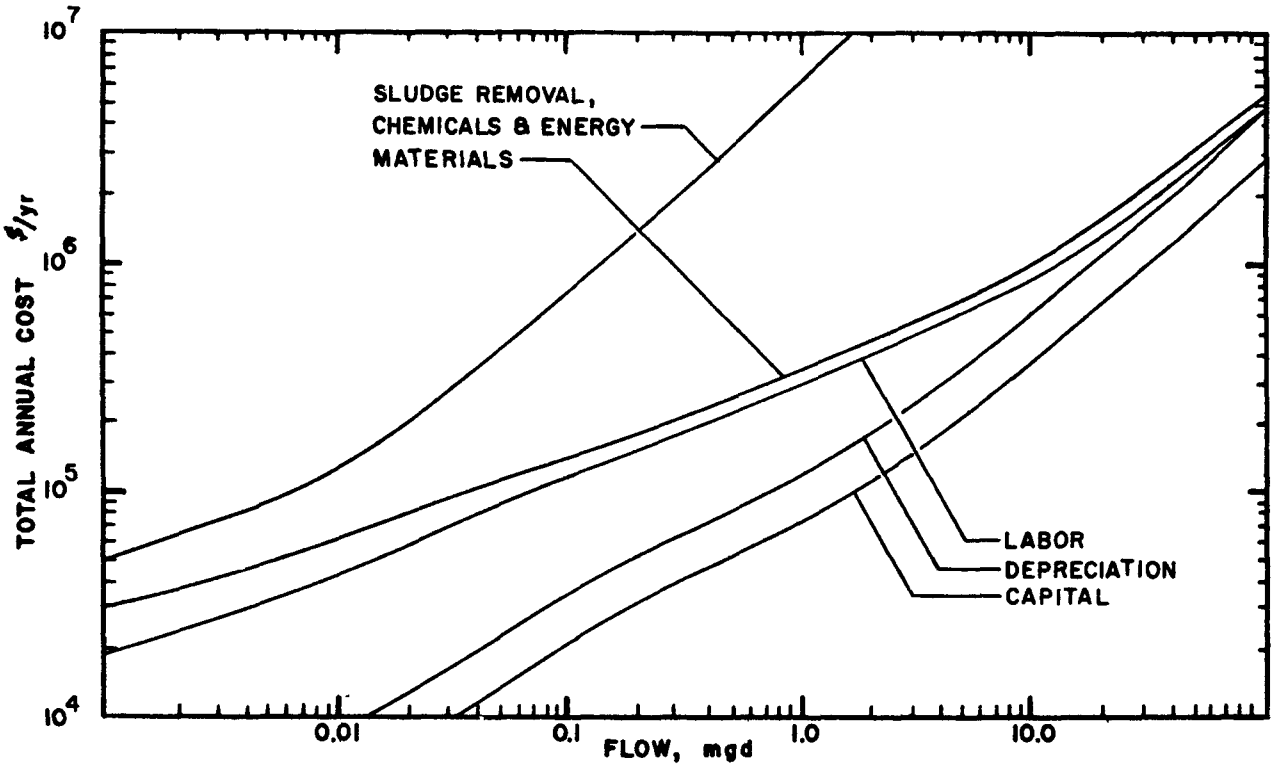



FIGURE VIII-190. PRIMARY TUNGSTEN (SALT TO METAL) COMB. 1, ALT. 3

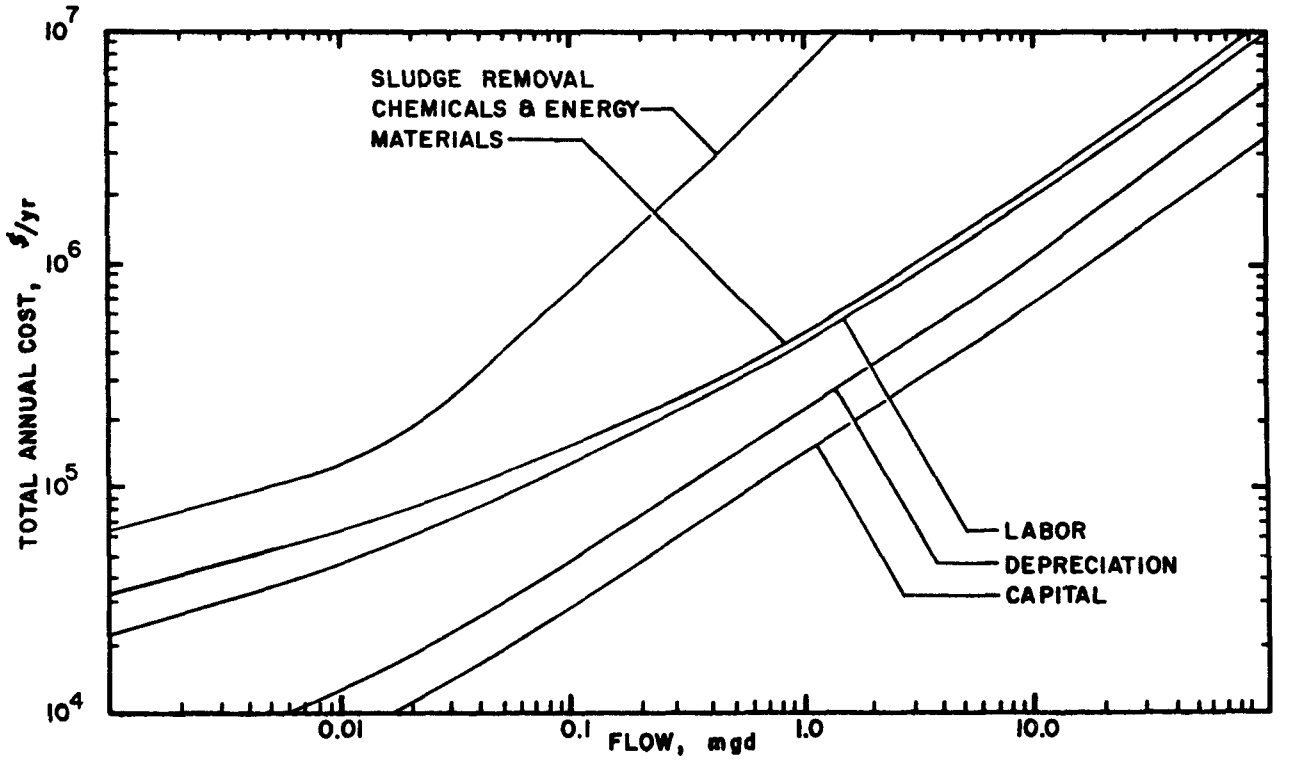
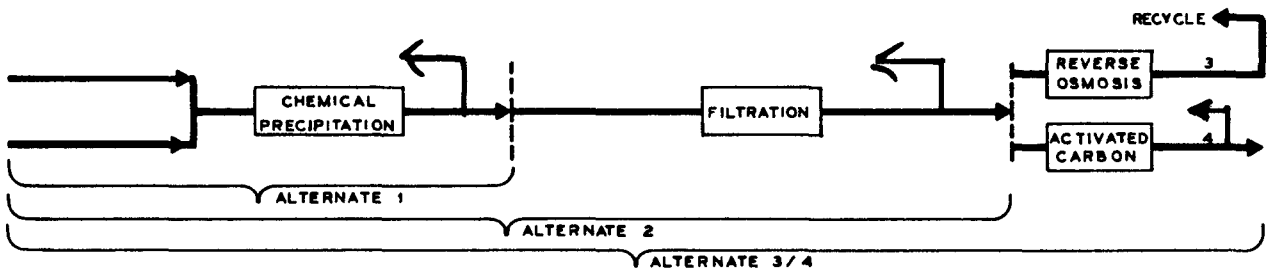



FIGURE VIII-191 . PRIMARY TUNGSTEN (SALT TO METAL) COMB. 1, ALT. 4




COMBINATION 1
(ACID PLANT BLOWDOWN, LEACHING SCRUBBER)

FIGURE VIII-192. PRIMARY ZINC
NEW SOURCE TREATMENT SCHEMES

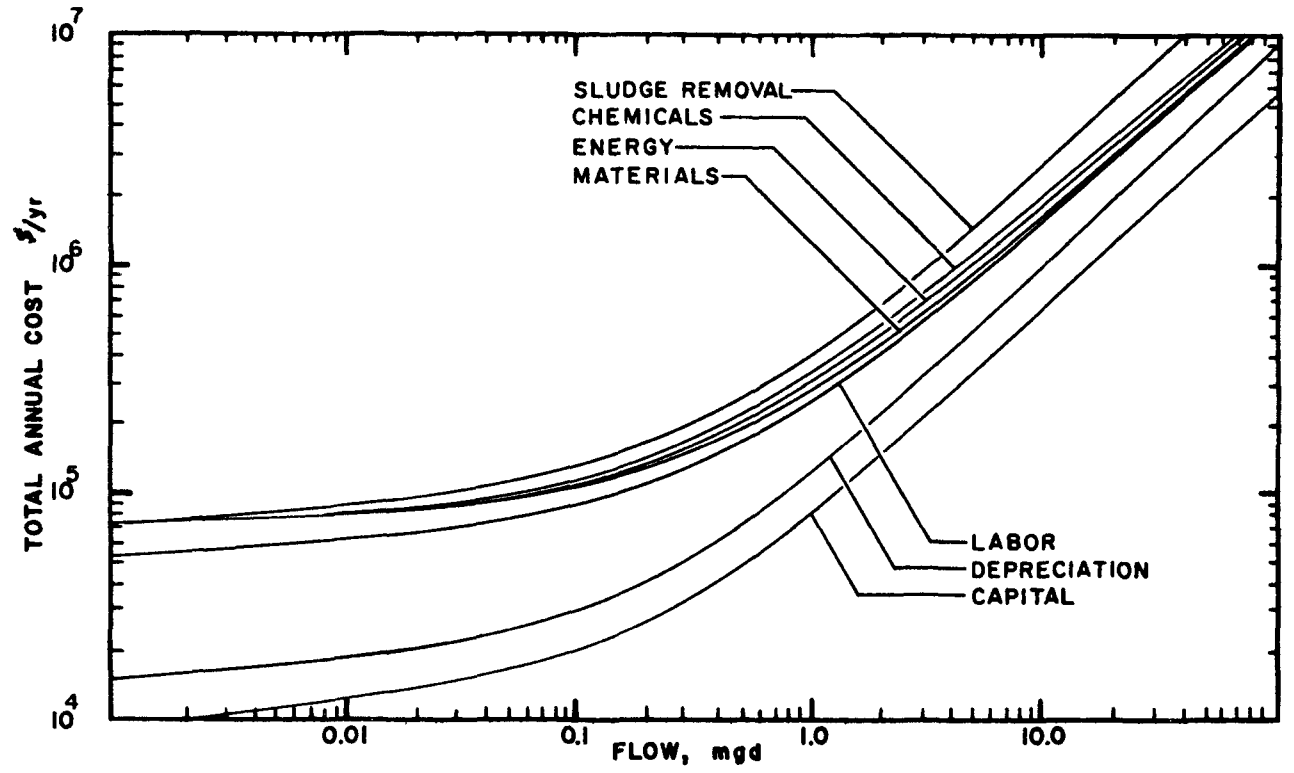



FIGURE VIII-193. PRIMARY ZINC COMB. I , ALT. I

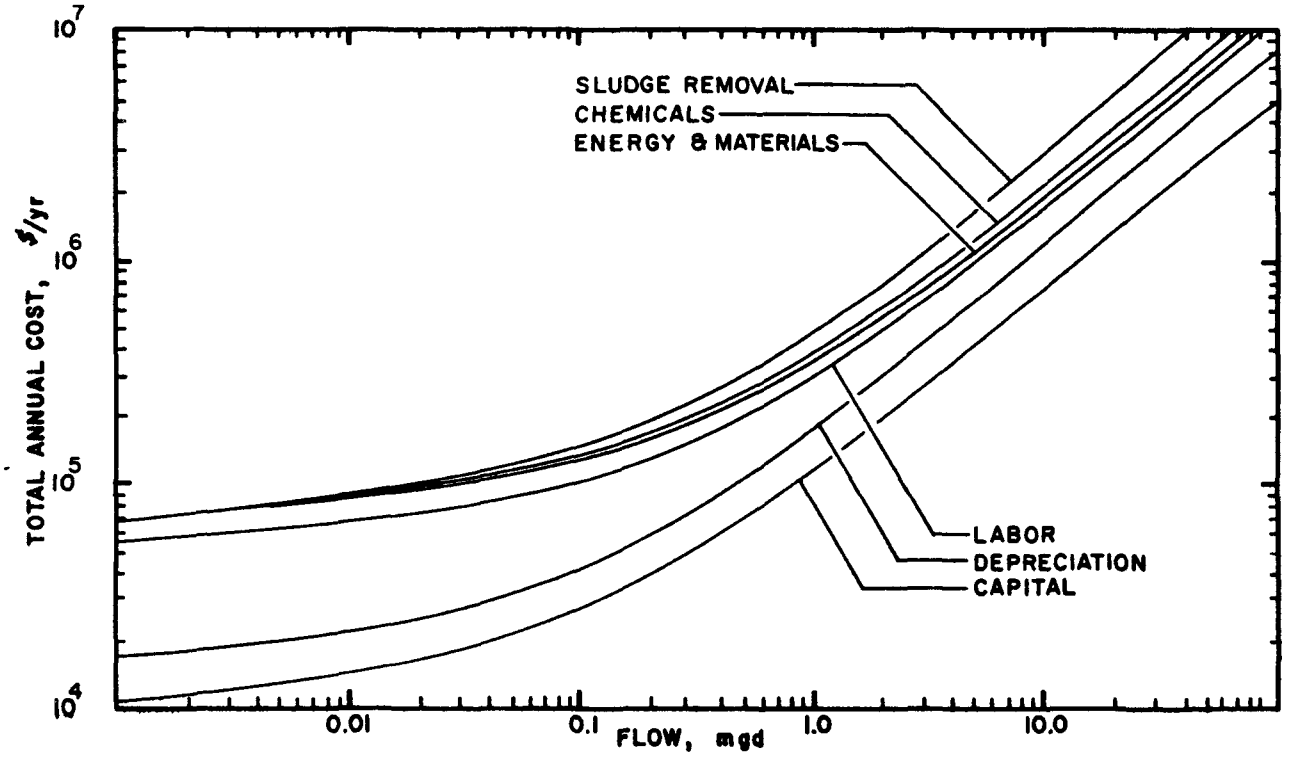



FIGURE VIII-194. PRIMARY ZINC COMB. I , ALT. 2

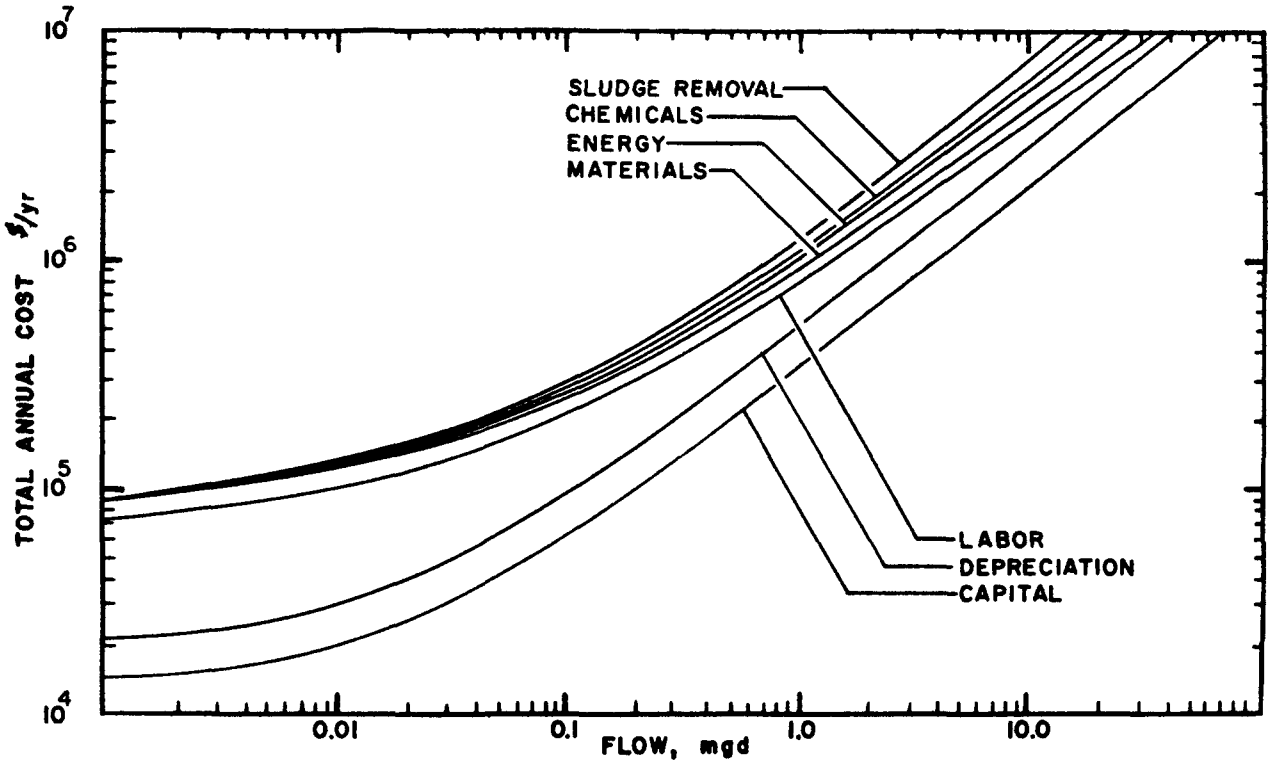



FIGURE VIII-195. PRIMARY ZINC COMB. I , ALT. 3

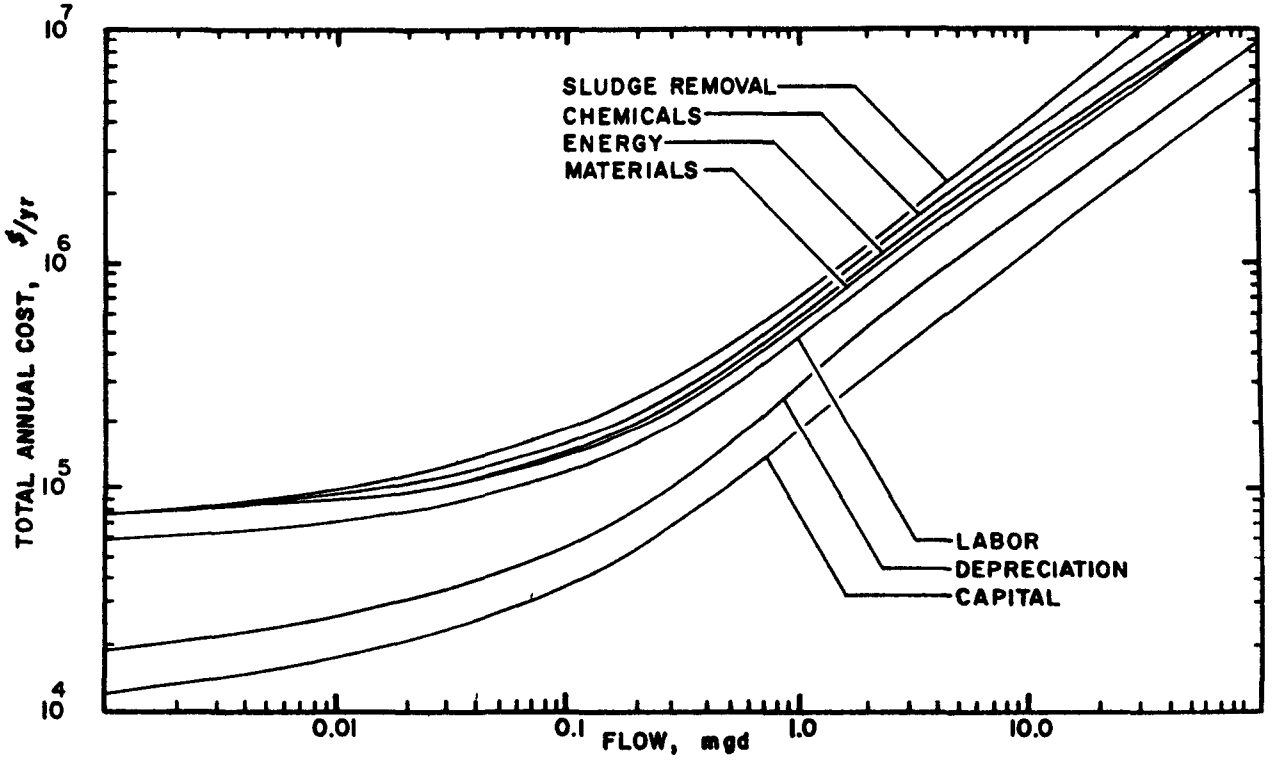



FIGURE VIII-196. PRIMARY ZINC COMB. I , ALT. 4

# TABLE VIII-1
## EFFLUENT QUALITY

Stream: Primary Aluminum, Paste Production
Combination: 3, 5

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent – mg/l | 2 Effluent – mg/l | 3 Effluent – mg/l | 4 Effluent – mg/l |
|---|---|---|---|---|---|
| pH | (7) | (6-9) | (6-9) | (6-9) | (6-9) |
| TSS | nt *1 | 40 | 10 | 0.5 | 10 |
| Phenolics | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Cyanide | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |
| Hg | 0.002 | 8.E-5 | 8.E-5 | 8.E-5 | 8.E-5 |
| Pb | 0.05 | 0.05 | 0.05 | 5.E-4 | 0.01 |
| Cr | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |
| As | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Pyrene | 0.04 | 0.04 | 0.03 | 3.E-5 | 3.E-4 |
| Chrysene | 0.05 | 0.05 | 0.03 | 3.E-5 | 3.E-4 |
| Benzo(a)pyrene | 0.06 | 0.06 | 0.04 | 4.E-5 | 4.E-4 |
| Methylene Chloride | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 |
| Fluoranthene | 0.05 | 0.05 | 0.006 | 6.E-6 | 6.E-5 |
| Acenophthene | 0.002 | 0.002 | 0.001 | 0.001 | 1.E-5 |

WATER USE = 612. GAL/TON
WATER DISCHARGE = 60. GAL/TON

*1 - nt = "not tested for"

# TABLE ~~VIII~~-2
## EFFLUENT QUALITY

Stream: Primary Aluminum, Bake Plant Scrubbers
Combination: 1

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent – mg/l | 2 Effluent – mg/l | 3 Effluent – mg/l |
|---|---|---|---|---|
| pH | (6) | (6-9) | (6-9) | (6-9) |
| TSS | 800 | 10 | 0.5 | 10. |
| Phenolics | 0.4 | 0.4 | 0.4 | 0.01 |
| Fluoride | 70. | 15. | 0.4 | 4. |
| Cyanide | 0.01 | 0.01 | 0.01 | 0.01 |
| Hg | 0.005 | 1.E-4 | 1.E-4 | 1.E-4 |
| Pb | 0.1 | 0.05 | 5E-4 | 0.01 |
| Cr | 0.4 | 0.04 | 0.04 | 0.04 |
| As | 0.06 | 0.06 | 0.06 | 0.06 |
| Pyrene | 0.2 | 0.09 | 9.E-5 | 9.E-4 |
| Chrysene | 0.2 | 0.05 | 5.E-5 | 5.E-4 |
| Benzo(a)pyrene | 0.6 | 0.04 | 4.E-5 | 4.E-4 |
| Methylene Chloride | 0.01 | 0.01 | 0.01 | 0.01 |
| Fluoranthene | 0.3 | 0.04 | 4.E-5 | 4.E-4 |
| Acenophthene | 0.05 | 0.007 | 0.007 | 7.E-5 |

# TABLE VIII-3
## EFFLUENT QUALITY

Stream: Primary Aluminum – Potline Air Scrubbing
Combination: 3,4,5

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent – mg/l | 2 Effluent – mg/l | 3 Effluent – mg/l | 4 Effluent – mg/l |
|---|---|---|---|---|---|
| pH | (9.) | (6-9.) | (6-9.) | (6-9.) | (6-9.) |
| TSS | 800. | 200. | 10. | 0.5 | 10. |
| Phenolics | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| Cyanide | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Fluoride | 70. | 70. | 4. | 0.4 | 4. |
| As | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Cr | 0.4 | 0.4 | 0.4 | 0.04 | 0.04 |
| Pb | 0.1 | 0.06 | 0.03 | 3.E-4 | 0.005 |
| Hg | 0.004 | 1.E-4 | 1.E-4 | 1.E-4 | 1.E-4 |
| Acenaphthene | 0.05 | 0.01 | 0.007 | 0.007 | 7.E-5 |
| Fluoranthene | 0.3 | 0.08 | 0.04 | 4.E-5 | 4.E-4 |
| Methylene Chloride | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Benzo (a) pyrene | 0.6 | 0.04 | 0.03 | 3.E-5 | 3.E-4 |
| Chrysene | 0.2 | 0.01 | 0.01 | 1.E-5 | 1.E-4 |
| Pyrene | 0.2 | 0.1 | 0.07 | 7.E-5 | 7.E-4 |

WATER USE = 7575. GAL/TON
WATER DISCHARGE = 225. GAL/TON

# TABLE VIII-4
# EFFLUENT QUALITY

Stream: Primary Aluminum, Potroom Air Scrubber
Combination: 3, 4, 5

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 Effluent - mg/l | 3 Effluent - mg/l | 4 Effluent - mg/l |
|---|---|---|---|---|---|
| pH | (6.) | (6-9) | (6-9) | (6-9) | (6-9) |
| TSS | 50. | 10. | 10. | 0.5 | 10. |
| Phenolics | 0.4 | 0.4 | 0.4 | 0.4 | 0.01 |
| Cyanide | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Fluoride | 50. | 10. | 3. | 0.4 | 3. |
| As | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Cr | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Pb | 0.05 | 0.05 | 0.05 | 5.E-4 | 0.01 |
| Hg | 0.005 | 1.E-4 | 1.E-4 | 1.E-4 | 1.E-4 |
| Acenaphthene | 0.002 | 0.002 | 0.001 | 0.001 | 1.E-5 |
| Fluoranthene | 0.3 | 0.05 | 0.03 | 3.E-5 | 3.E-4 |
| Benzo (a) pyrene | 0.1 | 0.1 | 0.07 | 7.E-5 | 7.E-4 |
| Chrysene | 0.07 | 0.07 | 0.05 | 5.E-5 | 5.E-4 |
| Pyrene | 0.1 | 0.1 | 0.09 | 9.E-5 | 9.E-4 |

WATER USE = 25,102. GAL/TON

WATER DISCHARGE = 550. GAL/TON

# TABLE VIII-5
## EFFLUENT QUALITY

Stream: Primary Aluminum - Contact Cooling Water
Combination: 3,4,5

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent mg/l | 2 Effluent mg/l | 3 Effluent mg/l |
|---|---|---|---|---|
| pH | (7.) | (6-9) | (6-9) | (6-9) |
| TSS | 40. | 10. | 0.5 | 10. |
| Phenolics | 0.4 | 0.4 | 0.4 | 0.01 |
| Cyanide | 1. | 1. | 0.3 | 1. |
| As | 0.01 | 0.01 | 0.01 | 0.01 |
| Cr | 0.01 | 0.01 | 0.01 | 0.01 |
| Pb | 0.02 | 0.02 | 0.0002 | 0.004 |
| Hg | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Acenaphthene | 0.0006 | 0.0004 | 4E-7 | 4E-6 |
| Pyrene | 0.004 | 0.003 | 3E-6 | 3E-5 |

WATER USE = 8499. GAL/TON
WATER DISCHARGE = 120. GAL/TON

*/- nt = "Not tested for"

TABLE VIII - 6

EFFLUNT QUALITY

Stream: Primary Aluminum, Cryolite Plant
Combination : 5

| | TREATMENT ALTERNATIVES | | | | |
|---|---|---|---|---|---|
| POLLUTANT | RAW mg/l | 1 | 2 | 3 | 4 |
| | | EFFLUENT mg/l | | | |
| pH | (12) | (9) | (9) | (9) | (9) |
| TSS | 300 | 200 | 10 | 0.5 | 10 |
| Phenolics | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Cyanide | 100 | 100 | 100 | 20 | 100 |
| $NH_3$ | 50 | 50 | 50 | 0.5 | 50 |
| As | 0.05 | 0.05 | 0.05 | 0.005 | 0.05 |
| Cr | 0.2 | 0.2 | 0.2 | 0.02 | 0.02 |
| Pb | 3 | 0.2 | 0.06 | 6E-4 | 0.01 |
| Hg | 1E-4 | 1E-4 | 1E-4 | 1E-5 | 1E-4 |
| Pyrene | 0.004 | 0.004 | 0.004 | 4E-6 | 4E-5 |
| Chrysene | 0.002 | 0.002 | 0.002 | 2E-6 | 2E-5 |
| Methylene Chloride | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Fluoranthene | 0.004 | 7E-4 | 7E-4 | 4E-7 | 4E-6 |
| Fluoride | 1000 | 70 | 10 | 0.9 | 10 |

# TABLE VIII-7
## EFFLUENT QUALITY

Stream: Secondary Aluminum - Demagging Fume Scrubbing
Combination: 2

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | Effluent - mg/l | | | |
| pH | (3) | (6-9) | (6-9) | (6-9) | (6-9) |
| TOC | 100. | 100. | 100. | 100. | 100. |
| TSS | 2000. | 200. | 10. | 0.5 | 10. |
| $NH_3$ | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Cd | 2. | 0.05 | 0.03 | 0.009 | 0.003 |
| Cr | 0.1 | 0.1 | 0.1 | 0.03 | 0.01 |
| Cu | 1. | 0.09 | 0.08 | 0.08 | 0.08 |
| Pb | 2. | 0.2 | 0.05 | 0.0005 | 0.009 |
| Zn | 40. | 0.4 | 0.4 | 0.01 | 0.04 |

WATER USE = 200. GAL/TON
WATER DISCHARGE = 70. GAL/TON

# TABLE VIII - 8
# EFFLUENT QUALITY

Subcategory = SECONDARY ALUMINUM

Combination = 1; Dross Milling, Scrubber

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | mg/l | | Effluent mg/l | | |
| TSS | 6000 | 70 | 10 | 0.5 | 0.5 |
| $NH_3$ | 200 | 7 | 7 | 0.3 | 0.3 |
| Sb | 0.1 | 0.001 | 0.001 | 0.001 | 0.001 |
| As | 0.02 | 0.005 | 0.004 | 0.001 | 0.001 |
| Be | 0.5 | 0.2 | 0.1 | 0.01 | 0.01 |
| Cd | 0.5 | 0.01 | 0.01 | 0.001 | 0.001 |
| Cr | 2 | 1 | 1 | 0.05 | 0.05 |
| Cu | 9 | 0.1 | 0.1 | 0.01 | 0.01 |
| Pb | 7 | 0.2 | 0.05 | 0.01 | 0.01 |
| Hg | 0.0007 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 1 | 0.2 | 0.05 | 0.001 | 0.001 |
| Se | 0.01 | 0.004 | 0.004 | 0.001 | 0.001 |
| Tl | 1 | 0.3 | 0.3 | 0.01 | 0.01 |
| Zn | 7 | 1 | 0.3 | 0.01 | 0.01 |
| | ug/l | | Effluent ug/l | | |
| Di-n-butyl phthalate | 20 | 2 | 1 | 1 | 1 |

# TABLE VIII - 9
# EFFLUENT QUALITY

Subcategory = SECONDARY ALUMINUM

Combination = 2; Scrubber, Contact Cooling

| | | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|---|
| POLLUTANT | Raw | 1 | 2 | 3 | 4 |
| | mg/l | | Effluent mg/l | | |
| TSS | 2000 | 60 | 9 | 0.5 | 0.05 |
| $NH_3$ | 1 | 0.5 | 0.5 | 0.5 | 0.02 |
| Sb | 0.12 | 0.001 | 0.001 | 0.001 | 0.001 |
| As | 0.01 | 0.002 | 0.002 | 0.001 | 0.001 |
| Cu | 0.3 | 0.05 | 0.05 | 0.002 | 0.001 |
| Pb | 2 | 0.2 | 0.05 | 0.005 | 0.001 |
| Hg | 0.03 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Se | 0.01 | 0.005 | 0.005 | 0.001 | 0.001 |
| Tl | 0.1 | 0.05 | 0.02 | 0.01 | 0.001 |
| Zn | 3 | 1 | 0.5 | 0.05 | 0.001 |
| Cyanide | 0.3 | 0.2 | 0.2 | 0.02 | 0.001 |
| Be | 0.2 | 0.1 | 0.05 | 0.001 | 0.001 |
| Cd | 0.5 | 0.02 | 0.02 | 0.001 | 0.001 |
| Cr | 0.05 | 0.05 | 0.05 | 0.005 | 0.001 |
| Ni | 0.5 | 0.1 | 0.1 | 0.002 | 0.001 |
| | ug/l | | Effluent ug/l | | |
| Dichlorobromo-methane | 5 | 1 | 1 | 1 | 1 |
| Di-n-butyl phthalate | 20 | 2 | 1 | 1 | 1 |

TABLE VIII - 10
EFFLUENT QUALITY

Subcategory = SECONDARY ALUMINUM

Combination = 3; Contact Cooling

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | mg/l | | Effluent mg/l | |
| TSS | 4000 | 90 | 9 | 0.5 |
| Sb | 2 | 0.1 | 0.1 | 0.002 |
| As | 0.2 | 0.05 | 0.05 | 0.001 |
| Be | 0.02 | 0.001 | 0.001 | 0.001 |
| Cd | 0.05 | 0.001 | 0.001 | 0.001 |
| Cr | 0.1 | 0.005 | 0.001 | 0.001 |
| Cu | 4 | 0.2 | 0.1 | 0.01 |
| Pb | 4 | 0.2 | 0.02 | 0.001 |
| Hg | 0.1 | 0.001 | 0.0001 | 0.0001 |
| Ni | 0.1 | 0.02 | 0.02 | 0.001 |
| Tl | 2 | 0.5 | 0.5 | 0.02 |
| Zn | 20 | 0.5 | 0.5 | 0.05 |
| | ug/l | | Effluent ug/l | |
| Di-n-butyl phthalate | 1000 | 100 | 50 | 50 |

TABLE VIII - II
EFFLUENT QUALITY

Stream: Primary Columbium/Tantalum - salt to metal
Combination: /

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 Effluent - mg/l | 3 Effluent - mg/l |
|---|---|---|---|---|
| pH | (6.) | (6-9) | (6-9) | (6-9) |
| TSS | 200. | 10. | 10. | 10. |
| $NH_3$ | 0.3 | 0.3 | 0.3 | 0.3 |
| Fluoride | 10,000. | 100. | 1. | 1. |
| Cd | 0.04 | 0.002 | 0.002 | 2.E-4 |
| Cr | 0.2 | 0.2 | 0.2 | 0.02 |
| Cu | 0.6 | 0.06 | 0.06 | 0.06 |
| Pb | 0.6 | 0.07 | 0.05 | 0.01 |
| Hg | 3.E-4 | 3.E-4 | 3.E-4 | 3.E-4 |
| Ni | 0.1 | 0.1 | 0.1 | 0.01 |
| Zn | 3. | 0.5 | 0.5 | 0.05 |
| 1,2-Dichloroethane | 0.002 | 2.E-4 | 2.E-4 | 9E-6 |
| Bis (2-ethylhexyl) phthalate | 0.3 | 0.08 | 0.08 | 0.05 |
| Tetrachloroethylene | 0.008 | 0.002 | 0.002 | 2.E-4 |
| PCB-1254 | 0.004 | 0.002 | 0.002 | 0.002 |
| PCB-1248 | 0.004 | 0.002 | 0.002 | 0.002 |

WATER USE = 13. GAL/LB reduction capacity.
WATER DISCHARGE = 12. GAL/LB.

# TABLE VIII - 12
## EFFLUENT QUALITY

Stream: Primary Columbium/Tantalum-ore to purified salt
Combination: 2

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | | Effluent - mg/l | | | | |
| pH | (2) | (6-9) | (6-9) | (6-9) | (6-9) | 6-9) |
| TSS | 30,000. | 30,000. | 10. | 10. | 0.5 | 10. |
| $NH_3$ | 30,000. | 300. | 300. | 300. | 10. | 300. |
| Fluoride | 10,000. | 10,000. | 100. | 1. | 0.2 | 1. |
| Cu | 90. | 90. | 0.9 | 0.9 | 0.2 | 0.09 |
| Cd | 7. | 7. | 0.2 | 0.1 | 0.05 | 0.01 |
| Cr | 200. | 200. | 2. | 2. | 0.2 | 0.2 |
| Pb | 200. | 200. | 5. | 2. | 0.02 | 0.5 |
| Hg | 0.01 | 0.01 | 8E-4 | 3E-4 | 3E-4 | 3E-4 |
| Ni | 7. | 7. | 0.5 | 0.1 | 0.1 | 0.01 |
| Zn | 300. | 300. | 6. | 3. | 0.08 | 0.3 |
| 1,2,4-Trichlorobenzene | 0.8 | 0.8 | 0.3 | 0.3 | 0.3 | 0.003 |
| 1,2-Dichloroethane | 0.07 | 0.07 | 0.007 | 0.007 | 0.007 | 3E-4 |
| Tetrachloroethylene | 0.2 | 0.2 | 0.05 | 0.05 | 0.05 | 0.006 |
| Bis(2-ethylhexyl) phthalate | 0.6 | 0.6 | 0.2 | 0.2 | 2E-4 | 0.1 |
| PCB-1254 | 1. | 1. | 0.1 | 0.1 | 1E-4 | 0.007 |
| PCB-1248 | 0.9 | 0.9 | 0.1 | 0.1 | 1.E-4 | 0.006 |

WATER USE = 15. GAL/# precipitation capacity

WATER DISCHARGE = 15. GAL/#

TABLE VIII-13
EFFLUENT QUALITY

Stream: Primary Copper - refining
Combination: 1

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 Effluent - mg/l | 3 Effluent - mg/l |
|---|---|---|---|---|
| pH | (1-7) | (6-9) | (6-9) | (6-9) |
| TSS | 400 | 30 | 10 | 10 |
| As | 0.09 | 0.09 | 0.09 | 0.09 |
| Cr | 0.09 | 0.09 | 0.09 | 0.009 |
| Cu | 6. | 0.2 | 0.1 | 0.1 |
| Pb | 0.2 | 0.07 | 0.03 | 0.006 |
| Hg | 0.002 | 1.E-4 | 7.E-5 | 7.E-5 |
| Ni | 300. | 6. | 3. | 0.3 |
| Se | 0.05 | 0.05 | 0.05 | 0.01 |
| Ag | 0.08 | 0.02 | 0.02 | 0.002 |

WATER USE = 131. GAL/TON = WATER DISCHARGE

*/- nt = "not tested for"

# TABLE XIII-14
# EFFLUENT QUALITY

Subcategory = SECONDARY COPPER

Combination = 1; Slag, Contact Cooling

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | mg/l | | Effluent mg/l | |
| TSS | 6000 | 70 | 20 | |
| $NH_3$ | 0.1 | 0.1 | 0.1 | |
| Phenolics | 0.1 | 0.1 | 0.05 | |
| Sb | 0.2 | 0.001 | 0.001 | |
| As | 0.2 | 0.03 | 0.02 | |
| Be | 0.1 | 0.05 | 0.05 | |
| Cd | 0.3 | 0.01 | 0.01 | |
| Cr | 0.2 | 0.2 | 0.2 | |
| Cu | 60 | 0.3 | 0.3 | |
| Pb | 50 | 0.5 | 0.3 | |
| Hg | 0.005 | 0.0001 | 0.0001 | |
| Ni | 1 | 0.2 | 0.1 | |
| Se | 0.2 | 0.1 | 0.1 | |
| Ag | 0.2 | 0.1 | 0.1 | |
| Zn | 700 | 4 | 3 | |
| | ug/l | | Effluent ug/l | |
| Fluoranthene | 2 | 1 | 1 | |
| Bis(2-ethylhexyl) phthalate | 300 | 200 | 100 | |
| Di-n-butyl phthalate | 10 | 1 | 1 | |
| Pyrene | 1 | 1 | 1 | |
| PCB-1254 | 0.5 | 0.5 | 0.1 | |
| PCB-1248 | 0.5 | 0.2 | 0.1 | |

same as Column 2

# TABLE XII-15
# EFFLUENT QUALITY

Subcategory = SECONDARY COPPER

Combination = 2; Contact Cooling

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | mg/l | | Effluent mg/l | |
| TSS | 0.02 | 0.02 | 0.02 | |
| Phenolics | 0.2 | 0.1 | 0.1 | |
| Sb | 2 | 0.02 | 0.02 | |
| As | 0.2 | 0.05 | 0.02 | |
| Be | 0.02 | 0.01 | 0.01 | |
| Cd | 0.2 | 0.01 | 0.005 | |
| Cr | 0.3 | 0.3 | 0.3 | |
| Cu | 10 | 0.1 | 0.1 | |
| Pb | 0.6 | 0.2 | 0.05 | |
| Hg | 0.002 | 0.0001 | 0.0001 | |
| Ni | 0.3 | 0.1 | 0.05 | |
| Se | 0.2 | 0.1 | 0.05 | |
| Ag | 0.05 | 0.02 | 0.01 | |
| Zn | 7 | 1 | 0.3 | |
| | ug/l | | Effluent ug/l | |
| Fluoranthene | 5 | 1 | 1 | |
| Bis(2-ethylhexyl) phthalate | 20 | 20 | 10 | |
| Di-n-butyl phthalate | 5 | 1 | 1 | |
| Pyrene | 5 | 1 | 1 | |
| PCB-1254 | 0.5 | 0.5 | 0.1 | |
| PCB-1248 | 0.5 | 0.5 | 0.1 | |

Same as Column 2

# TABLE VIII-16
# EFFLUENT QUALITY

Subcategory = SECONDARY COPPER

Combination = 3; Contact Cooling, Scrubber

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | mg/l | | Effluent mg/l | |
| TSS | 4 | 4 | 0.001 | 0.001 |
| Phenolics | 0.01 | 0.005 | 0.005 | 0.001 |
| Sb | 0.1 | 0.001 | 0.001 | 0.001 |
| As | 0.01 | 0.002 | 0.002 | 0.001 |
| Be | 0.005 | 0.001 | 0.001 | 0.001 |
| Cd | 0.01 | 0.001 | 0.001 | 0.001 |
| Cr | 0.2 | 0.2 | 0.2 | 0.01 |
| Cu | 20 | 0.1 | 0.1 | 0.05 |
| Pb | 0.5 | 0.1 | 0.05 | 0.001 |
| Hg | 0.0002 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 8 | 0.1 | 0.1 | 0.01 |
| Se | 0.01 | 0.005 | 0.005 | 0.001 |
| Ag | 0.05 | 0.01 | 0.01 | 0.001 |
| Zn | 2 | 0.5 | 0.3 | 0.02 |
| | ug/l | | Effluent ug/l | |
| Fluoranthene | 5 | 1 | 1 | 1 |
| Bis(2-ethylhexyl) phthalate | 20 | 20 | 10 | 5 |
| Di-n-butyl phthalate | 5 | 1 | 1 | 1 |
| Diethyl phthalate | 1 | 1 | 1 | 1 |
| Pyrene | 5 | 1 | 1 | 1 |
| PCB-1254 | 0.5 | 0.5 | 0.1 | 0.1 |
| PCB-1248 | 0.5 | 0.2 | 0.1 | 0.1 |

| | | | |
|---|---|---|---|
| ($) Total Capital: | 160,000 | 360,000 | 650,000 |
| ($/yr) Total Annual: | 76,000 | 180,000 | 310,000 |
| ($/yr) Add'l. Annual: (over previous alternative) | 76,000 | 104,000 | 130,000 |
| (acres) Land Required: | 0.61 | 0.65 | 0.69 |

TABLE VIII-17
EFFLUENT QUALITY

Subcategory = SECONDARY COPPER

Combination = 4; Scrubber

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | mg/l | | Effluent mg/l | |
| TSS | 4 | 4 | 0.001 | 0.001 |
| Phenolics | 0.005 | 0.005 | 0.005 | 0.001 |
| Sb | 0.10 | 0.001 | 0.001 | 0.001 |
| As | 0.01 | 0.002 | 0.002 | 0.001 |
| Be | 0.001 | 0.001 | 0.001 | 0.001 |
| Cd | 0.01 | 0.001 | 0.001 | 0.001 |
| Cr | 0.2 | 0.2 | 0.2 | 0.01 |
| Cu | 20 | 0.1 | 0.1 | 0.002 |
| Pb | 0.5 | 0.1 | 0.05 | 0.001 |
| Hg | 0.0002 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 8 | 0.1 | 0.1 | 0.01 |
| Se | 0.01 | 0.005 | 0.005 | 0.001 |
| Ag | 0.03 | 0.01 | 0.01 | 0.001 |
| Zn | 2 | 0.5 | 0.3 | 0.02 |
| | ug/l | | Effluent ug/l | |
| Fluoranthene | 2 | 1 | 1 | 1 |
| Bis(2-ethylhexyl) phthalate | 200 | 100 | 50 | 50 |
| Di-n-butyl phthalate | 10 | 2 | 1 | 1 |
| Diethyl phthalate | 1 | 1 | 1 | 1 |
| PCB-1254 | 5 | 2 | 0.5 | 0.1 |
| PCB-1248 | 2 | 2 | 0.5 | 0.1 |

# TABLE VIII - 18
# EFFLUENT QUALITY

Subcategory = SECONDARY COPPER

Combination = 5; Contact Cooling, Scrubber, Electrolyte

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | mg/l | | Effluent mg/l | |
| TSS | 8 | 8 | 8 | 0.2 |
| Phenolics | 0.01 | 0.005 | 0.005 | 0.001 |
| Sb | 0.3 | 0.005 | 0.005 | 0.001 |
| As | 0.1 | 0.02 | 0.02 | 0.001 |
| Be | 0.005 | 0.002 | 0.002 | 0.001 |
| Cd | 0.1 | 0.005 | 0.002 | 0.001 |
| Cr | 0.2 | 0.2 | 0.2 | 0.01 |
| Cu | 6 | 0.2 | 0.1 | 0.005 |
| Pb | 1 | 0.2 | 0.1 | 0.01 |
| Hg | 0.0002 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 10 | 0.2 | 0.1 | 0.02 |
| Se | 0.1 | 0.05 | 0.05 | 0.001 |
| Ag | 0.3 | 0.1 | 0.01 | 0.01 |
| Zn | 4 | 1 | 0.5 | 0.05 |
| | ug/l | | Effluent ug/l | |
| Fluoranthene | 20 | 5 | 2 | 1 |
| Bis(2-ethylhexyl) phthalate | 100 | 100 | 50 | 20 |
| Di-n-butyl phthalate | 50 | 10 | 5 | 2 |
| Fluorene | 50 | 10 | 5 | K 1 |
| Pyrene | 100 | 20 | 10 | K 1 |
| PCB-1254 | 1 | 0.5 | K 0.1 | K 0.1 |
| PCB-1248 | 0.5 | 0.5 | K 0.1 | K 0.1 |

# TABLE VIII-19
## EFFLUENT QUALITY

Stream: Primary Lead - Smelting
Combination: 1

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 2 Effluent - mg/l | 3 |
|---|---|---|---|
| TSS | | 40 | 10 | 0.5 |
| pH | | 6-9 | 6-9 | 6-9 |
| Cd | 0.1 | 0.04 | 0.0006 | 0.0001 |
| Cu | 0.07 | 0.07 | 0.07 | 0.004 |
| Pb | 2. | 0.07 | 0,02 | 0.002 |
| Zn | 2. | 1. | 0.05 | 0.002 |

WATER USE FACTOR = 440 GALLONS/TON = 1.83 l/kg

WATER DISCHARGE FACTOR = 310. GALLONS/TON = 1.3 l/kg

# TABLE VIII-20
## EFFLUENT QUALITY

Stream Secondary Lead Battery Cracking
Combination: 1 & 2

| | | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|---|
| POLLUTANT | Raw mg/l | 1 | 2 Effluent mg/l | 3 | 4 |
| TSS | 1000 | 10 | 10 | 0.5 | 10 |
| pH | (2) | (6-9) | (6-9) | (6-9) | (6-9) |
| Sb | 20 | 0.2 | 0.2 | 0.2 | 0.1 |
| As | 3 | 0.03 | 0.003 | 0.003 | 0.003 |
| Cd | 1 | 0.02 | 0.02 | 0.005 | 0.005 |
| Cr | 0.5 | 0.5 | 0.5 | 0.04 | 0.05 |
| Cu | 2 | 0.09 | 0.09 | 0.09 | 0.09 |
| Pb | 20 | 0.2 | 0.2 | 0.02 | 0.1 |
| Ni | 0.8 | 0.08 | 0.08 | 0.08 | 0.008 |
| Ag | 0.2 | 0.05 | 0.05 | 0.005 | 0.005 |
| Zn | 3 | 0.6 | 0.6 | 0.07 | 0.07 |
| Bis (2-ethylhexyl) phthalate | 0.1 | 0.04 | 0.04 | 0.0001 | 0.02 |
| Di-n-butyl phthalate | 0.03 | 0.002 | 0.002 | 3E-5 | 8E-4 |
| Di-n-octyl phthalate | 0.003 | 0.002 | 0.002 | 3E-6 | 9E-4 |
| Chrysene | 0.07 | 0.05 | 0.05 | 7E-5 | 0.05 |
| PCB 1242, 1254, 1221 | 0.001 | 0.001 | 0.001 | 5E-7 | 5E-4 |
| PCB 1016, 1232, 1248, 1260 | 0.0006 | 0.0006 | 0.0006 | 5E-7 | 5E-4 |

TABLE VIII - 21

EFFLUENT QUALITY

Stream: Secondary Lead = Furnace Scrubbers
Combination: 2

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 Effluent - mg/l | 3 Effluent - mg/l | 4 Effluent - mg/l |
|---|---|---|---|---|---|
| pH | 2 | (6-9) | (6-9) | (6-9) | (6-9) |
| TSS | 1000 | 10 | 10 | 0,5 | 10 |
| Sb | 20 | 0,2 | 0,2 | 0,2 | 0,1 |
| As | 3 | 0.03 | 0,003 | 0,003 | 0.003 |
| Cd | 1 | 0.02 | 0,02 | 0.005 | 0,005 |
| Cr | 0,5 | 0,5 | 0,5 | 0,04 | 0.05 |
| Cu | 2 | 0,09 | 0.09 | 0,09 | 0,09 |
| Pb | 20. | 0,2 | 0,2 | 0.02 | 0,1 |
| Ni | 0,8 | 0.08 | 0,08 | 0,08 | 0,008 |
| Ag | 0,2 | 0,05 | 0,05 | 0,005 | 0.005 |
| Zn | 3. | 0,6 | 0,4 | 0,07 | 0,07 |
| Bis (2-ethylhexyl) phthalate | 0,1 | 0,04 | 0,04 | 0.0001 | 0,02 |
| Di-n-butyl phthalate | 0,03 | 0,002 | 0,002 | 3,E-5 | 8 E-4 |
| Di-n-octyl phthalate | 0,003 | 0,002 | 0,002 | 3.E-6 | 9E-4 |
| Chrysene | 0,07 | 0,05 | 0,05 | 7,E-5 | 0,05 |
| PCB-1254 | 0.0012 | 0,0012 | 0,0012 | 5,E-7 | 5E-4 |
| PCB-1248 | 6E-4 | 6E-4 | 6.E-4 | 5E-7 | 3E-4 |

# TABLE VIII - 22
## EFFLUENT QUALITY

Stream: Secondary Silver - photographic
Combination: 1

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 Effluent - mg/l | 3 Effluent - mg/l | 4 Effluent - mg/l |
|---|---|---|---|---|---|
| pH | | (6-9) | (6-9) | (6-9) | (6-9) |
| COD | 40,000. | 40,000. | 2000. | 1000. | 400. |
| TSS | 900. | 900. | 100. | 10. | 10. |
| $NH_3$ | 5000. | 50. | 50. | 50. | 50. |
| Phenolics | 20. | 20. | 20. | 20. | 0.2 |
| Cyanide | 2. | 2. | 2. | 2. | 2. |
| Sb | 3. | 3. | 0.5 | 0.03 | 0.03 |
| As | 0.9 | 0.9 | 0.7 | 0.009 | 0.009 |
| Cd | 6. | 6. | 3. | 0.1 | 0.06 |
| Cr | 20. | 20. | 8. | 0.2 | 0.2 |
| Cu | 7. | 7. | 1. | 0.1 | 0.1 |
| Pb | 4. | 4. | 3. | 0.04 | 0.04 |
| Ni | 0.8 | 0.8 | 0.1 | 0.08 | 0.008 |
| Se | 0.4 | 0.4 | 0.3 | 0.3 | 0.07 |
| Ag | 0.2 | 0.2 | 0.06 | 0.06 | 0.006 |
| Zn | 200. | 200. | 5. | 2. | 2. |
| Butyl Benzyl Phthalate | 0.04 | 0.04 | 0.02 | 0.008 | 0.005 |
| Benzene | 0.08 | 0.08 | 0.06 | 0.007 | 0.0008 |
| 1,2-Dichloroethane | 0.2 | 0.2 | 0.1 | 0.008 | 0.002 |
| 1,1-Dichloroethylene | 1. | 1. | 0.3 | 0.1 | 0.04 |
| Methylene Chloride | 1. | 1. | 0.9 | 0.01 | 0.01 |
| Bis(2-ethylhexyl) phthalate | 0.1 | 0.1 | 0.07 | 0.03 | 0.02 |
| Di-n-octyl phthalate | 0.03 | 0.03 | 0.01 | 0.005 | 0.003 |
| Tetrachloroethylene | 0.05 | 0.05 | 0.03 | 0.009 | 0.001 |
| Trichloroethylene | 0.9 | 0.9 | 0.3 | 0.3 | 0.3 |
| PCB-1254 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 |
| PCB-1248 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 |

WATER USE = 0.25 gal/Tr oz

WATER DISCHARGE = 0.08 gal/Tr oz

# TABLE VIII-23
## EFFLUENT QUALITY

Stream: Secondary Silver, nonphotographic
Combination: 1

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent – mg/l | 2 Effluent – mg/l | 3 Effluent – mg/l |
|---|---|---|---|---|
| pH | | 6-9 | 6-9 | 6-9 |
| COD | 5000. | 5000. | 600. | 50. |
| TSS | 200. | 200. | 10. | 10. |
| $NH_3$ | 2000. | 200. | 200. | 200. |
| Phenolics | 0.03 | 0.03 | 0.03 | 0.03 |
| Cyanide | 0.08 | 0.08 | 0.08 | 0.08 |
| Sb | 0.2 | 0.2 | 0.2 | < 0.04 |
| As | 0.09 | 0.09 | 0.02 | 0.02 |
| Cd | 20. | 20. | 0.5 | 0.2 |
| Cr | 7. | 7. | 0.07 | 0.07 |
| Cu | 100. | 100. | 1. | 1. |
| Pb | 20. | 20. | 0.2 | 0.2 |
| Ni | 200. | 200. | 2. | 2. |
| Se | 0.02 | 0.02 | 0.02 | < 0.003 |
| Ag | 0.5 | 0.5 | 0.1 | 0.01 |
| Zn | 400. | 400. | 4. | 4. |
| Benzene | 0.05 | 0.05 | 0.01 | 0.0005 |
| Bis (2-ethylhexyl) phthalate | 0.08 | 0.08 | 0.03 | 0.02 |
| Butyl Benzyl phthalate | 0.2 | 0.2 | 0.04 | 0.02 |
| Di-n-octyl phthalate | 0.09 | 0.09 | 0.07 | 0.01 |
| Tetrachloroethylene | 0.08 | 0.08 | 0.02 | 0.002 |
| PCB 1254 | 0.006 | 0.006 | 0.0006 | 0.0006 |
| PCB 1248 | 0.0006 | 0.0006 | 0.0006 | 0.0006 |

WATER USE = 25 GAL/LB
WATER DISCHARGE = 0.787 GAL/TROY OZ, = 0.096 l/gram.

# TABLE VIII-24
## EFFLUENT QUALITY

Stream: Primary Tungsten - Ore to APT
Combination: 2

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 | 3 | 4 |
|---|---|---|---|---|---|
| pH | | 6-9 | 6-9 | 6-9 | 6-9 |
| TSS | 4000. | 400. | 10. | 0.5 | 4. |
| $NH_3$ | 1000. | 10. | 10. | 1. | 10. |
| Cr | 0.4 | 0.05 | 0.02 | 0.004 | 0.02 |
| Cu | 1. | 0.2 | 0.07 | 0.01 | 0.07 |
| Pb | 4. | 0.2 | 0.04 | 0.004 | 0.04 |
| Ag | 0.1 | 0.04 | 0.04 | 0.004 | 0.004 |
| Tetrachloroethylene | 0.01 | 0.007 | 0.003 | 0.003 | 0.003 |

WATER USE = WATER DISCHARGE = 11.5 GAL/LB APT = 96. l/kg.

# TABLE VIII - 25
# EFFLUENT Quality

Stream: Primary Tungsten Combined Wastes ..PT to Metal
Combination : 1

Treatment Alternative

| Pollutant | Raw | 1 | 2 |
|---|---|---|---|
| | | Effluent mg/l | |
| pH | | 9 | 9 |
| TSS | 70 | 10 | 10 |
| $NH_3$ | 400 | 4 | 4 |
| Cr | 0.04 | 0.04 | 0.04 |
| Cu | 0.006 | 0.006 | 0.006 |
| Pb | 0.02 | 0.02 | 0.004 |
| Ag | 0.02 | 0.006 | 0.0006 |

TABLE VIII - 26
EFFLUENT QUALITY

Stream: Primary Zinc, electrolytic
Combination: /

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | | Effluent - mg/l | | |
| pH | - | - | - | - |
| TSS | 0 | 0 | 0 | 0 |
| As | 0 | 0 | 0 | 0 |
| Cd | 2. | 0.04 | 0.0008 | 0.004 |
| Cr | 1. | 0.01 | 0.01 | 0.01 |
| Cu | 0 | 0 | 0 | 0 |
| Pb | 0 | 0 | 0 | 0 |
| Hg | 0 | 0 | 0 | 0 |
| Ni | 8. | 0.08 | 0.08 | 0.008 |
| Se | 0.2 | 0.2 | 0.02 | 0.04 |
| Ag | 0 | 0 | 0 | 0 |
| Zn | 0 | 0 | 0 | 0 |
| Methylene Chloride .... | 0.004 | 0.004 | 0.004 | 0.004 |

Water use = water discharge rate = 1200 gal/ton.

TABLE VIII-27
EFFLUENT QUALITY

Stream: Primary Zinc, pyrolytic
Combination: /

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 Effluent - mg/l | 3 Effluent - mg/l |
|---|---|---|---|---|
| pH | — | — | — | — |
| TSS | 7. | 7. | 0.7 | 7. |
| As | 0 | 0 | 0 | 0 |
| Cd | 0.2 | 0.007 | 0.007 | 7.E-4 |
| Cr | 0 | 0 | 0 | 0 |
| Cu | 0 | 0 | 0 | 0 |
| Pb | 0.4 | 0.04 | 4.E-4 | 0.009 |
| Hg | 0.003 | 1.E-4 | 1.E-5 | 1.E-4 |
| Ni | 0 | 0 | 0 | 0 |
| Se | 0 | 0 | 0 | 0 |
| Ag | 0 | 0 | 0 | 0 |
| Zn | 7. | 0.7 | 0.02 | 0.07 |
| Methylene Chloride | 0.5 | 0.005 | 0.005 | 0.005 |

Water use = water discharge rate = 320 gal/ton

# TABLE VIII-28
# EFFLUENT QUALITY

Stream: Acid Plant
Combination: 1 of 10 Zn

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 Effluent - mg/l | 2 Effluent - mg/l | 3 Effluent - mg/l |
|---|---|---|---|---|
| TSS | 200. | 10. | 0.5 | 10. |
| As | 0.9 | 0.009 | 0.0009 | 0.009 |
| Cr | 0.2 | 0.2 | 0.02 | 0.02 |
| Cu | 8. | 0.2 | 0.02 | 0.2 |
| Pb | 10. | 0.1 | 0.01 | 0.02 |
| Hg | 0.04 | 0.0001 | 0.0001 | 0.001 |
| Ni | 0.3 | 0.06 | 0.06 | 0.007 |
| Se | 0.4 | 0.4 | 0.04 | 0.08 |
| Ag | 0.09 | 0.03 | 0.003 | 0.003 |
| $NH_3$ | 2. | 2. | 0.3 | 2. |
| Be | 0.02 | 0.02 | 0.02 | 0.02 |
| Sb | 4. | 0.04 | 0.04 | 0.007 |
| Cd | 10. | 0.2 | 0.07 | 0.02 |
| Zn | 600. | 6. | 0.6 | 0.6 |
| Methylene Chloride | 0.6 | 0.006 | 0.006 | 0.006 |
| Bis (2-ethylhexyl) phthalate | 0.2 | 0.07 | 0.0002 | 0.05 |
| PH | | 6-9 | 6-9 | 6-9 |

WATER USE = 752 - 868. GAL/TON
WATER DISCHARGE = 550. GAL/TON

TABLE VIII - 29
EFFLUENT QUALITY

Subcategory = PRIMARY ALUMINUM (New Sources)

Combination = 1; Contact Cooling, Cryolite

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | mg/l | | Effluent mg/l | | |
| TSS | 200 | 20 | 2 | 0.02 | 0.02 |
| $NH_3$ | 30 | 2 | 2 | 0.2 | 0.3 |
| Phenolics | 0.2 | 0.1 | 0.1 | 0.1 | 0.005 |
| Cyanide | 100 | 4 | 4 | 1 | 0.2 |
| Sb | 0.1 | 0.001 | 0.001 | 0.001 | 0.001 |
| As | 0.05 | 0.02 | 0.001 | 0.001 | 0.001 |
| Cd | 0.1 | 0.002 | 0.002 | 0.001 | 0.001 |
| Cr | 0.2 | 0.2 | 0.2 | 0.01 | 0.01 |
| Cu | 0.2 | 0.05 | 0.05 | 0.002 | 0.002 |
| Pb | 2 | 0.2 | 0.1 | 0.005 | 0.005 |
| Hg | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 1.0 | 0.2 | 0.1 | 0.005 | 0.005 |
| Se | 0.01 | 0.005 | 0.005 | 0.001 | 0.001 |
| Ag | 0.05 | 0.01 | 0.01 | 0.001 | 0.001 |
| Zn | 0.5 | 0.3 | 0.01 | 0.005 | 0.005 |
| | ug/l | | Effluent ug/l | | |
| Fluoranthene | 100 | 20 | 20 | 1 | 1 |

TABLE VIII-31
EFFLUENT QUALITY

Subcategory = SECONDARY ALUMINUM (New Sources)

Combination = 1; Milling, Scrubber

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | mg/l | | Effluent mg/l | | |
| TSS | 2000 | 60 | 10 | 0.5 | 0.5 |
| $NH_3$ | 1 | 1 | 0.5 | 0.5 | 0.02 |
| Sb | 0.1 | 0.001 | 0.0001 | 0.001 | 0.001 |
| As | 0.01 | 0.002 | 0.002 | 0.001 | 0.001 |
| Be | 0.2 | 0.1 | 0.1 | 0.005 | 0.005 |
| Cd | 0.5 | 0.02 | 0.01 | 0.001 | 0.001 |
| Cr | 0.05 | 0.05 | 0.05 | 0.005 | 0.005 |
| Cu | 0.2 | 0.05 | 0.05 | 0.002 | 0.002 |
| Pb | 2 | 0.2 | 0.05 | 0.001 | 0.001 |
| Hg | 0.001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Se | 0.01 | 0.005 | 0.005 | 0.001 | 0.001 |
| Tl | 0.1 | 0.05 | 0.02 | 0.001 | 0.001 |
| Zn | 3 | 0.5 | 0.5 | 0.02 | 0.02 |
| | ug/l | | Effluent ug/l | | |
| Dichlorobromo-methane | 3 | 1 | 1 | 1 | 1 |
| Di-n-butyl phthalate | 5 | 1 | 1 | 1 | 1 |

TABLE VIII-32

EFFLUENT QUALITY

Subcategory = SECONDARY ALUMINUM (New Sources)

Combination = 2; Fume Scrubber

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | mg/l | | Effluent mg/l | | |
| TSS | 2000 | 60 | 10 | 0.5 | 0.5 |
| $NH_3$ | 1 | 0.5 | 0.5 | 0.5 | 0.02 |
| Sb | 0.1 | 0.001 | 0.001 | 0.001 | 0.001 |
| As | 0.01 | 0.002 | 0.002 | 0.001 | 0.001 |
| Be | 0.2 | 0.1 | 0.1 | 0.005 | 0.005 |
| Cd | 0.5 | 0.02 | 0.01 | 0.001 | 0.001 |
| Cr | 0.05 | 0.05 | 0.05 | 0.005 | 0.005 |
| Cu | 0.2 | 0.05 | 0.05 | 0.002 | 0.002 |
| Pb | 2 | 0.2 | 0.05 | 0.001 | 0.001 |
| Hg | 0.001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Se | 0.01 | 0.005 | 0.005 | 0.001 | 0.001 |
| Tl | 0.1 | 0.05 | 0.02 | 0.001 | 0.001 |
| Zn | 3 | 0.5 | 0.5 | 0.02 | 0.02 |
| | ug/l | | Effluent ug/l | | |
| Dichlorobromo-methane | 3 | 1 | 1 | 1 | 1 |
| Di-n-butyl phthalate | 5 | 1 | 1 | 1 | 1 |

TABLE VIII-33

EFFLUENT QUALITY

Subcategory = COLUMBIUM/TANTALUM (ORE TO SALT/METAL - New Sources)

Combination = 1; Combined Wastewater

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | mg/l | | Effluent mg/l | | | |
| TSS | 90 | 90 | 10 | 10 | 0.5 | 0.5 |
| NH3 | 6000** | 20 | 1 | 1 | 1 | 1 |
| Fluoride | 8000 | 8000 | 60 | 20 | 20 | 1 |
| Sb | 2 | 2 | 0.01 | 0.01 | 0.01 | 0.002 |
| As | 0.1 | 0.1 | 0.02 | 0.005 | 0.005 | 0.005 |
| Be | 0.01 | 0.01 | 0.005 | 0.005 | 0.001 | 0.001 |
| Cd | 0.1 | 0.1 | 0.002 | 0.002 | 0.001 | 0.001 |
| Cr | 0.1 | 0.1 | 0.1 | 0.1 | 0.005 | 0.005 |
| Cu | 0.02 | 0.02 | 0.005 | 0.005 | 0.001 | 0.001 |
| Pb | 4 | 4 | 0.05 | 0.05 | 0.005 | 0.005 |
| Hg | 0.001 | 0.001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 0.5 | 0.5 | 0.05 | 0.05 | 0.005 | 0.005 |
| Ag | 0.1 | 0.1 | 0.05 | 0.05 | 0.002 | 0.002 |
| Zn | 2 | 2 | 0.5 | 0.5 | 0.02 | 0.02 |
| | ug/l | | Effluent ug/l | | | |
| 1,2,4-Trichloro-benzene | 50 | 50 | 5 | 2 | 2 | 1 |
| 1,2-Dichloro-ethane | 50 | 50 | 2 | 2 | 2 | 1 |
| Bis(2-ethylhexyl) phthalate | 200 | 200 | 100 | 100 | 1 | 50 |
| Tetrachloro-ethylene | 20 | 20 | 5 | 5 | 5 | 1 |
| PCB-1254 | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 |
| PCB-1248 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 |

** Calculated for a segregated stream.

TABLE VIII-34

EFFLUENT QUALITY

Subcategory = COLUMBIUM/TANTALUM (SALT TO METAL - New Sources)

Combination = 1; Combined Wastewater

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4* | 5 |
|---|---|---|---|---|---|---|
| | mg/l | | | Effluent mg/l | | |
| TSS | 80 | 20 | 8 | 8 | 0.5 | 0.5 |
| $NH_3$ | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.005 |
| Fluoride | 5000 | 50 | 50 | 9 | 9 | 0.5 |
| Sb | 0.2 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| As | 0.01 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Be | 0.01 | 0.005 | 0.005 | 0.005 | 0.001 | 0.001 |
| Cd | 0.02 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Cr | 0.1 | 0.1 | 0.1 | 0.1 | 0.005 | 0.005 |
| Cu | 0.3 | 0.05 | 0.05 | 0.05 | 0.005 | 0.005 |
| Pb | 0.01 | 0.005 | 0.002 | 0.002 | 0.001 | 0.001 |
| Hg | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 0.05 | 0.05 | 0.02 | 0.02 | 0.001 | 0.001 |
| Ag | 0.05 | 0.02 | 0.02 | 0.02 | 0.001 | 0.001 |
| Zn | 1 | 0.5 | 0.3 | 0.3 | 0.01 | 0.01 |
| | ug/l | | Effluent ug/l | | | |
| Bis(2-ethylhexyl) phthalate | 60 | 40 | 20 | 20 | 1 | 10 |

* Quality of treated water available for recycle, no discharge

TABLE VIII-35

EFFLUENT QUALITY

Subcategory = PRIMARY COPPER (SMELTING, AND SMELTING AND REFINING - New Sources)

Combination = 1; Scrubber, Contact Cooling

| | | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|---|
| POLLUTANT | Raw mg/l | 1 | 2 Effluent mg/l | 3* | 4 |
| TSS | 3000 | 10 | 10 | 0.5 | 0.5 |
| Sb | 2 | 0.01 | 0.01 | 0.001 | 0.01 |
| As | 2000 | 9 | 0.5 | 0.01 | 0.01 |
| Cd | 7 | 0.2 | 0.2 | 0.01 | 0.01 |
| Cu | 300 | 1 | 1 | 0.05 | 0.05 |
| Pb | 100 | 1 | 1 | 0.05 | 0.05 |
| Hg | 0.05 | 0.0005 | 0.0005 | 0.0001 | 0.0001 |
| Ni | 6 | 0.1 | 0.1 | 0.005 | 0.005 |
| Se | 0.01 | 0.005 | 0.001 | 0.001 | 0.001 |
| Ag | 0.5 | 0.2 | 0.01 | 0.001 | 0.001 |
| Tl | 0.1 | 0.05 | 0.05 | 0.002 | 0.002 |
| Zn | 90 | 0.5 | 0.5 | 0.02 | 0.02 |

* Quality of treated water available for recycle, no discharge

TABLE VIII-36

EFFLUENT QUALITY

Subcategory = PRIMARY COPPER (REFINING - New Sources)

Combination = 1; Contact Cooling

| | | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|---|
| POLLUTANT | Raw mg/l | 1 | 2 Effluent mg/l | 3 | 4 |
| TSS | 400 | 20 | 10 | 0.5 | 0.5 |
| Sb | 1 | 0.01 | 0.01 | 0.001 | 0.001 |
| As | 0.2 | 0.02 | 0.001 | 0.001 | 0.001 |
| Cd | 0.1 | 0.001 | 0.001 | 0.001 | 0.001 |
| Cr | 0.2 | 0.2 | 0.2 | 0.01 | 0.01 |
| Cu | 30 | 0.1 | 0.1 | 0.01 | 0.01 |
| Pb | 0.5 | 0.05 | 0.05 | 0.001 | 0.001 |
| Hg | 0.01 | 0.0002 | 0.0002 | 0.0001 | 0.0001 |
| Ni | 0.4 | 0.05 | 0.05 | 0.005 | 0.005 |
| Se | 0.3 | 0.02 | 0.02 | 0.005 | 0.005 |
| Ag | 0.5 | 0.01 | 0.01 | 0.01 | 0.01 |
| Tl | 2 | 0.5 | 0.5 | 0.1 | 0.1 |
| Zn | 0.6 | 0.2 | 0.2 | 0.01 | 0.01 |

TABLE VIII-39

EFFLUENT QUALITY

Subcategory = PRIMARY LEAD (New Sources)

Combination = 1; Acid Plant, Sinter Scrubber

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 | 2 | 3* |
|---|---|---|---|---|
| | | Effluent mg/l | | |
| $NH_3$ | 2 | 1 | 0.05 | 0.05 |
| Sb | 0.01 | 0.001 | 0.001 | 0.001 |
| As | 0.2 | 0.02 | 0.001 | 0.001 |
| Be | 0.001 | 0.001 | 0.001 | 0.001 |
| Cd | 0.3 | 0.01 | 0.002 | 0.002 |
| Cu | 2 | 0.1 | 0.01 | 0.01 |
| Pb | 40 | 0.5 | 0.01 | 0.01 |
| Hg | 0.0002 | 0.0001 | 0.0001 | 0.0001 |
| Ni | 0.02 | 0.02 | 0.005 | 0.001 |
| Se | 0.005 | 0.002 | 0.002 | 0.001 |
| Ag | 0.001 | 0.001 | 0.001 | 0.001 |
| Zn | 60 | 0.3 | 0.01 | 0.005 |

* Quality of treated water available for recycle, no discharge

TABLE VIII-44

EFFLUENT QUALITY

Subcategory = PRIMARY TUNGSTEN (ORE TO SALT/METAL)

Combination = 1; Combined Wastewater

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|---|
| | | | Effluent mg/l | |
| TSS | 200 | 10 | 0.5 | 0.5 |
| Cyanide | 0.01 | 0.2 | 0.01 | 0.01 |
| As | 4 | 0.005 | 0.001 | 0.001 |
| Cd | 0.05 | 0.02 | 0.001 | 0.001 |
| Cr | 0.05 | 0.005 | 0.001 | 0.001 |
| Cu | 0.1 | 0.5 | 0.05 | 0.05 |
| Pb | 10 | 0.05 | 0.002 | 0.002 |
| Hg | 0.002 | 0.005 | 0.0002 | 0.0002 |
| Ni | 0.1 | 0.05 | 0.002 | 0.002 |
| Se | 0.02 | 0.02 | 0.002 | 0.002 |
| Ag | 0.05 | 0.01 | 0.001 | 0.001 |
| Tl | 0.5 | 0.1 | 0.005 | 0.005 |
| Zn | 2 | 0.2 | 0.01 | 0.01 |

* Quality of treated water available for recycle, no discharge

TABLE VIII-45

EFFLUENT QUALITY

Subcategory = PRIMARY TUNGSTEN (ORE TO SALT/METAL - New Sources)

Combination = 2; Combined Wastewater

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 | 2 Effluent mg/l | 3* | 4 |
|---|---|---|---|---|---|
| TSS | 200 | 200 | 10 | 0.5 | 0.5 |
| $NH_3$ | 800 | 40 | 20 | 1 | 2 |
| Cyanide | 0.01 | 0.01 | 0.2 | 0.01 | 0.01 |
| As | 4 | 4 | 0.005 | 0.001 | 0.001 |
| Cd | 0.05 | 0.05 | 0.02 | 0.001 | 0.001 |
| Cr | 0.05 | 0.05 | 0.005 | 0.001 | 0.001 |
| Cu | 0.1 | 0.1 | 0.5 | 0.05 | 0.05 |
| Pb | 11 | 11 | 0.05 | 0.002 | 0.002 |
| Hg | 0.002 | 0.002 | 0.005 | 0.0002 | 0.002 |
| Ni | 0.1 | 0.1 | 0.05 | 0.002 | 0.002 |
| Se | 0.02 | 0.02 | 0.02 | 0.002 | 0.002 |
| Ag | 0.05 | 0.05 | 0.01 | 0.001 | 0.001 |
| Tl | 0.5 | 0.5 | 0.1 | 0.005 | 0.005 |
| Zn | 2 | 2 | 0.2 | 0.01 | 0.01 |

* Quality of treated water available for recycle, no discharge.

TABLE VIII-46

EFFLUENT QUALITY

Subcategory = PRIMARY TUNGSTEN (SALT TO METAL - New Sources)

Combination = 1; Combined Wastewater

| POLLUTANT | Raw mg/l | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | | Effluent mg/l | | |
| TSS | 200 | 200 | 20 | 10 | 0.5 |
| $NH_3$ | 500 | 20 | 20 | 20 | 1 |
| As | 0.01 | 0.01 | 0.002 | 0.005 | 0.001 |
| Cd | 0.05 | 0.05 | 0.02 | 0.002 | 0.001 |
| Cr | 0.05 | 0.05 | 0.002 | 0.02 | 0.001 |
| Cu | 0.01 | 0.01 | 0.002 | 0.005 | 0.001 |
| Pb | 0.02 | 0.02 | 0.01 | 0.02 | 0.001 |
| Ni | 0.05 | 0.05 | 0.05 | 0.005 | 0.001 |
| Se | 0.01 | 0.01 | 0.005 | 0.01 | 0.001 |
| Ag | 0.02 | 0.02 | 0.01 | 0.02 | 0.002 |
| Tl | 0.1 | 0.1 | 0.05 | 0.1 | 0.005 |
| Zn | 0.05 | 0.05 | 0.05 | 0.1 | 0.005 |

TABLE VIII-47

EFFLUENT QUALITY

Subcategory = PRIMARY ZINC (New Sources)

Combination = 1; Combined Wastewater

| POLLUTANT | Raw | TREATMENT ALTERNATIVE 1 | 2 | 3* | 4 |
|---|---|---|---|---|---|
| | mg/l | | Effluent mg/l | | |
| TSS | 20 | 10 | 5 | 0.2 | 0.2 |
| Cyanide | 0.1 | 0.05 | 0.05 | 0.01 | 0.001 |
| Sb | 1 | 0.005 | 0.005 | 0.001 | 0.001 |
| As | 0.5 | 0.05 | 0.02 | 0.005 | 0.005 |
| Cd | 7 | 0.2 | 0.2 | 0.01 | 0.01 |
| Cr | 1 | 1 | 1 | 0.05 | 0.05 |
| Cu | 4 | 0.2 | 0.1 | 0.01 | 0.01 |
| Pb | 5 | 0.2 | 0.02 | 0.005 | 0.005 |
| Hg | 0.1 | 0.001 | 0.001 | 0.0001 | 0.0001 |
| Ni | 2 | 0.1 | 0.05 | 0.005 | 0.005 |
| Se | 0.2 | 0.1 | 0.1 | 0.005 | 0.005 |
| Ag | 0.2 | 0.05 | 0.05 | 0.005 | 0.005 |
| Tl | 0.2 | 0.05 | 0.05 | 0.002 | 0.002 |
| Zn | 900 | 5 | 4 | 0.2 | 0.2 |
| | ug/l | | Effluent ug/l | | |
| Methylene chloride | 200 | 2 | 2 | 2 | 1 |
| Bis(2-ethylhexyl) phthalate | 30 | 20 | 10 | 1 | 10 |

* Quality of treated water available for recycle, no discharge

TABLE VIII-48

ENERGY REQUIREMENTS

| SUBCATEGORY | MEDIAN OF TOTAL PLANT ENERGY CONSUMPTION (Btu/yr) | MEDIAN SIZE PLANT BY FLOW (gpd) | MAXIMUM ENERGY REQUIREMENT (Btu/yr) & ESTIMATED % OF PLANT TOTAL TOTAL END-OF-PIPE TECHNOLOGIES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LEVEL 1 | | LEVEL 2 | | LEVEL 3 | | LEVEL 4 | | LEVEL 5 | |
| | | | USAGE | % | USAGE | % | USAGE | % | USAGE | % | USAGE | % |
| 1°Al | $4.389 \times 10^{11}$ | 1,200,000 | $1.284 \times 10^{9}$ | .29 | $1.547 \times 10^{9}$ | .35 | $1.281 \times 10^{10}$ | 2.92 | $3.729 \times 10^{9}$ | .85 | | |
| 2°Al | $2.785 \times 10^{11}$ | 4,280 | $6.893 \times 10^{7}$ | .02 | $7.599 \times 10^{7}$ | .03 | $1.323 \times 10^{8}$ | .05 | $8.390 \times 10^{7}$ | .03 | | |
| Cb/Ta* | $1.733 \times 10^{12}$ | 59,000 | $2.228 \times 10^{8}$ | .01 | $3.107 \times 10^{8}$ | .02 | $3.174 \times 10^{8}$ | .02 | $9.828 \times 10^{8}$ | .06 | $4.160 \times 10^{8}$ | .02 |
| 1°Cu | $8.709 \times 10^{11}$ | 1,640,000 | $1.323 \times 10^{9}$ | .15 | $1.332 \times 10^{9}$ | .15 | $1.481 \times 10^{9}$ | .17 | | | | |
| 2°Cu | $1.146 \times 10^{11}$ | 7,600 | $5.596 \times 10^{7}$ | .05 | $5.674 \times 10^{7}$ | .05 | $7.104 \times 10^{7}$ | .06 | | | | |
| 1°Pb | $4.292 \times 10^{11}$ | 1,240,000 | $1.655 \times 10^{8}$ | .04 | $2.467 \times 10^{9}$ | .57 | $1.424 \times 10^{10}$ | 3.32 | | | | |
| 2°Pb | $7.824 \times 10^{10}$ | 5,760 | $8.316 \times 10^{7}$ | .11 | $8.964 \times 10^{7}$ | .11 | $1.647 \times 10^{8}$ | .21 | $9.919 \times 10^{7}$ | .13 | | |
| 2°Ag | $3.498 \times 10^{10}$ | 521 | $2.388 \times 10^{7}$ | .07 | $2.393 \times 10^{7}$ | .07 | $2.472 \times 10^{7}$ | .07 | $3.648 \times 10^{7}$ | .10 | | |
| 1°W | $1.244 \times 10^{11}$ | 172,000 | $3.514 \times 10^{7}$ | .03 | $2.833 \times 10^{8}$ | .23 | $5.984 \times 10^{8}$ | .48 | $2.126 \times 10^{9}$ | 1.71 | | |
| 1°Zn | $1.115 \times 10^{12}$ | 675,000 | $1.45 \times 10^{8}$ | .01 | $6.799 \times 10^{9}$ | .61 | $1.383 \times 10^{9}$ | .12 | | | | |

* Based on one plant

TABLE VIII-49
EXISTING SLUDGE TREATMENT METHODS*

| | Gravity Thickening | Vacuum Filter | Filter Press | Centri-fuge | Kiln Drying | Incin-eration | Calci-nation | Contractor Disposal | Drying Beds | Lagooning | Land-fill | Sale | Reuse/ Recycle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary Aluminum | 7 | 5 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 13 | 11 | 1 | 5 |
| Secondary Aluminum | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 6 | 1 | 0 |
| Columbium/ Tantalum (Ore) | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Columbium/ Tantalum (Salt) | 1 | 0 | 0 | 1 | 0 | 0. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Primary Copper (Smelters) | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 0 | 0 | 3 |
| Primary Copper (Refiners) | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 2 | 0 | 0 |
| Secondary Copper | 4 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 3 | 4 |
| Primary Lead | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |

TABLE VIII-49 (Continued)
EXISTING SLUDGE TREATMENT METHODS

| | Gravity Thickening | Vacuum Filter | Filter Press | Centri-fuge | Kiln Drying | Incin-eration | Calci-nation | Contractor Disposal | Drying Beds | Lagooning | Land-fill | Sale | Reuse/ Recycle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Secondary Lead | 4 | 6 | 1 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 7 | 0 | 9 |
| Secondary Silver (Photo) | 3 | 2 | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 5 | 4 |
| Secondary Silver (Non-Photo) | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 4 | 2 | 2 | 0 | 4 |
| Primary Tungsten (Ore) | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 0 |
| Primary Tungsten (Salt) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| Primary Zinc | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 1 | 2 |
| TOTAL | 45 | 27 | 10 | 5 | 1 | 4 | 1 | 10 | 12 | 37 | 41 | 13 | 37 |

* Number of plants using sludge disposal and treatment methods.

TABLE VIII-50

METAL CONCENTRATIONS IN SLUDGES

| Sub-Category | Comb. | Alt. | ESTIMATED METAL CONCENTRATIONS IN SLUDGES (mg/kg) | | | | | | | | | | | | | Estimated Quantity (kg/cu m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Tl | Zn | Total | |
| Primary Aluminum | 1 | 1 | 2,489 | 208 | 34 | 50 | 258 | 406 | 495 | 9.9 | 495 | * | * | 1,212 | 5,657 | 0.19 |
| | | 2 | 55 | 6 | 1 | 1 | 6 | 11 | 15 | 0.2 | 15 | | | 35 | 147 | 8.70 |
| | | 3 | 2,489 | 208 | 34 | 50 | 258 | 406 | 495 | 9.9 | 495 | * | * | 1,212 | 5,657 | 0.19 |
| | 2 | 1 | 2,476 | 223 | 16 | 48 | 247 | 436 | 445 | 2.4 | 87 | | | 1,153 | 5,143 | 0.80 |
| | | 2 | 215 | 21 | 2 | 4 | 21 | 43 | 43 | 0.2 | 10 | | | 127 | 486 | 0.01 |
| | | 3 | 2,476 | 223 | 16 | 48 | 247 | 436 | 445 | 2.4 | 87 | | | 1,153 | 5,143 | 0.80 |
| | 3 | 1 | 188 | 58 | 5 | 45 | 509 | 16 | 124 | 0.5 | 92 | | | 78 | 1,116 | 3.65 |
| | | 2 | 94 | 33 | 3 | 22 | 254 | 8 | 72 | 0.3 | 53 | | | 53 | 592 | 7.34 |
| | | 3 | 44 | 15 | 2 | 11 | 118 | 5 | 36 | 0.1 | 28 | | | 32 | 291 | 15.85 |
| | | 4 | 94 | 33 | 3 | 22 | 254 | 8 | 72 | 0.3 | 53 | | | 53 | 592 | 7.34 |
| | 4 | 1 | 187 | 56 | 4 | 44 | 508 | 15 | 124 | 0.2 | 89 | | | 77 | 1,104 | 3.94 |
| | | 2 | 113 | 38 | 3 | 27 | 306 | 2 | 88 | 0.2 | 62 | | | 63 | 702 | 6.53 |
| | | 3 | 49 | 17 | 2 | 12 | 134 | 5 | 41 | 0.1 | 31 | | | 36 | 327 | 15.04 |
| | | 4 | 113 | 38 | 3 | 27 | 306 | 2 | 88 | 0.2 | 62 | | | 63 | 702 | 6.53 |
| | 5 | 1 | 137 | 22 | 5 | 19 | 125 | 30 | 241 | 0.2 | 83 | | | 71 | 733 | 5.16 |
| | | 2 | 92 | 18 | 3 | 12 | 87 | 20 | 176 | 0.1 | 62 | | | 65 | 535 | 7.72 |
| | | 3 | 44 | 9 | 2 | 6 | 42 | 12 | 87 | 0.1 | 34 | | | 41 | 277 | 16.23 |
| | | 4 | 92 | 18 | 3 | 12 | 87 | 20 | 176 | 0.1 | 62 | | | 65 | 535 | 7.72 |
| Secondary Aluminum | 1 | 1 | 4 | 0 | 8 | 17 | 69 | 346 | 287 | 0 | 30 | | 25 | 274 | 1,060 | 24.15 |
| | | 2 | 4 | 0 | 9 | 17 | 69 | 346 | 290 | 0 | 34 | | 26 | 288 | 1,083 | 24.25 |
| | | 3 | 3 | 0 | 10 | 13 | 52 | 259 | 216 | 0 | 26 | | 26 | 221 | 826 | 32.75 |
| | | 4 | 4 | 0 | 9 | 17 | 69 | 346 | 290 | 0 | 34 | | 26 | 288 | 1,083 | 24.25 |

TABLE VIII-50 (Continued)

METAL CONCENTRATIONS IN SLUDGES

| Sub-Category | Comb. | Alt. | ESTIMATED METAL CONCENTRATIONS IN SLUDGES (mg/kg) | | | | | | | | | | | | Estimated Quantity (kg/cu m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Tl | Zn | Total | |
| Secondary Aluminum | 2 | 1 | 16 | 1 | 15 | 62 | 8 | 26 | 230 | 0.4 | 46 | 1 | 11 | 308 | 724 | 6.27 |
| | | 2 | 16 | 1 | 16 | 62 | 8 | 28 | 249 | 0.4 | 54 | 1 | 12 | 330 | 777 | 6.31 |
| | | 3 | 7 | 0 | 11 | 27 | 3 | 13 | 110 | 0.2 | 27 | 1 | 7 | 170 | 376 | 14.82 |
| | | 4 | 16 | 1 | 16 | 62 | 8 | 28 | 249 | 0.4 | 54 | 1 | 12 | 330 | 777 | 6.31 |
| | 3 | 1 | 438 | 33 | 5 | 11 | 132 | 744 | 755 | 27 | 5 | 27 | 317 | 1,756 | 4,250 | 0.22 |
| | | 2 | 428 | 32 | 5 | 11 | 134 | 738 | 754 | 27 | 16 | 27 | 332 | 2,343 | 4,847 | 0.22 |
| | | 3 | 428 | 32 | 5 | 11 | 134 | 738 | 754 | 27 | 16 | 27 | 332 | 2,343 | 4,847 | 0.22 |
| Columbium / Tantalum | 1 | 1 | 1,731 | 120 | 10 | 80 | 90 | 20 | 3,742 | 0 | 410 | 10 | 80 | 2,261 | 8,554 | 0.05 |
| | | 2 | 33 | 46 | 0 | 2 | 2 | 0 | 72 | 0 | 8 | 0 | 2 | 44 | 209 | 2.59 |
| | | 3 | 22 | 11 | 1 | 7 | 8 | 2 | 321 | 0.1 | 35 | 1 | 7 | 194 | 609 | 11.10 |
| | | 4 | 33 | 46 | 0 | 2 | 2 | 0 | 72 | 0 | 8 | 0 | 2 | 44 | 209 | 2.59 |
| | | 1 | NO SLUDGE | | | | | | | | | | | | | |
| | | 2 | * | * | 3 | 1 | 707 | 105 | 700 | * | 126 | | | 1,338 | 2,980 | 4.22 |
| | | 3 | | | 2 | 1 | 441 | 66 | 437 | | 78 | | | 835 | 1,860 | 6.77 |
| | | 4 | | | 1 | 0 | 196 | 32 | 196 | | 39 | | | 392 | 856 | 15.28 |
| | | 5 | | | 2 | 1 | 441 | 66 | 437 | | 78 | | | 835 | 1,860 | 6.77 |

TABLE VIII-50 (Continued)

METAL CONCENTRATIONS IN SLUDGES

| Sub-Category | Comb. | Alt. | ESTIMATED METAL CONCENTRATIONS IN SLUDGES (mg/kg) | | | | | | | | | | | | | Estimated Quantity (kg/cu m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Tl | Zn | Total | |
| Columbium Tantalum Salt to Metal | 1 | 1 | 12 | 0 | 0 | 1 | 6 | 16 | 15 | 0 | 2 | 0 | 5 | 62 | 119 | 13.00 |
| | | 2 | 10 | 0 | 0 | 1 | 5 | 13 | 12 | 0 | 2 | 0 | 4 | 52 | 99 | 15.54 |
| | | 3 | 10 | 0 | 0 | 1 | 5 | 13 | 12 | 0 | 2 | 0 | 4 | 52 | 99 | 15.54 |
| Primary Copper Smelting | 1 | 1 | 9,861 | 1,110 | 357 | * | 1,883 | 305,679 | 8,860 | 255 | 9,080 | | | 8,645 | 345,730 | 0.10 |
| | | 2 | 9,392 | 1,136 | 368 | | 1,869 | 291,156 | 9,418 | 242 | 9,228 | | | 11,228 | 334,037 | 0.11 |
| | | 3 | 9,392 | 1,136 | 368 | | 1,869 | 291,156 | 9,418 | 242 | 9,228 | | | 11,228 | 334,037 | 0.11 |
| | 2 | 1 | 764 | 35,338 | 12 | 1,802 | 109 | 70,585 | 32,076 | 20 | 1,391 | | | 23,153 | 165,250 | 0.50 |
| | | 2 | 756 | 34,982 | 13 | 1,795 | 108 | 69,875 | 31,913 | 19 | 1,489 | | | 22,920 | 163,870 | 0.50 |
| | | 3 | 756 | 34,982 | 13 | 1,795 | 108 | 69,875 | 31,913 | 19 | 1,489 | | | 22,920 | 163,870 | 0.50 |
| Primary Copper Refining | 1 | 1 | 9,861 | 1,110 | 357 | | 1,183 | 305,679 | 8,860 | 225 | 9,080 | | | 8,645 | 345,700 | 0.10 |
| | | 2 | 9,392 | 1,136 | 368 | | 1,869 | 291,156 | 9,418 | 242 | 9,228 | | | 11,228 | 334,037 | 0.11 |
| | | 3 | 9,392 | 1,136 | 368 | | 1,869 | 291,156 | 9,418 | 242 | 9,228 | | | 11,228 | 334,037 | 0.11 |
| Secondary Copper | 1 | 1 | 25 | 17 | 23 | 33 | 21 | 6,401 | 5,113 | 0.4 | 128 | 13 | 5 | 73,850 | 85,629 | 9.09 |
| | | 2 | 25 | 18 | 6 | 4 | 22 | 6,366 | 5,095 | 0.4 | 133 | 14 | 13 | 73,520 | 85,216 | 9.14 |
| | | 3 | 25 | 18 | 6 | 4 | 22 | 6,366 | 5,095 | 0.4 | 133 | 14 | 13 | 73,520 | 85,216 | 9.14 |

TABLE VIII-50 (Continued)

METAL CONCENTRATIONS IN SLUDGES

| Sub-Category | Comb. | Alt. | ESTIMATED METAL CONCENTRATIONS IN SLUDGES (mg/kg) Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Tl | Zn | Total | Estimated Quantity (kg/cu m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Secondary Copper | 2 | 1 | 14,592 | 623 | 44 | 495 | 872 | 46,044 | 1,481 | 7 | 550 | | | 21,777 | 36,485 | 0.27 |
| | | 2 | 14,327 | 644 | 47 | 490 | 893 | 45,347 | 1,735 | 7 | 720 | | | 22,571 | 86,781 | 0.28 |
| | | 3 | 14,327 | 644 | 47 | 490 | 893 | 45,347 | 1,735 | 7 | 720 | | | 22,571 | 86,781 | 0.28 |
| | 3 | 1 | 1,102 | 64 | 15 | 73 | 1,311 | 133,552 | 3,184 | | 64,609 | | | 8,800 | 212,710 | 0.12 |
| | | 2 | 1,056 | 65 | 16 | 71 | 1,256 | 128,194 | 3,620 | | 61,954 | | | 10,230 | 206,462 | 0.12 |
| | | 3 | 1,056 | 65 | 16 | 71 | 1,256 | 128,194 | 3,620 | | 61,954 | | | 10,230 | 206,462 | 0.12 |
| | 4 | 1 | 860 | 69 | * | 86 | 1,308 | 135,101 | 3,200 | | 65,783 | | | 8,671 | 215,078 | 0.12 |
| | | 2 | 824 | 66 | | 82 | 1,303 | 129,626 | 3,661 | | 63,053 | | | 10,092 | 208,707 | 0.12 |
| | | 3 | 824 | 66 | | 82 | 1,303 | 129,626 | 3,661 | | 63,053 | | | 10,092 | 208,707 | 0.12 |
| | 5 | 1 | 3,097 | 707 | | 800 | 1,974 | 55,626 | 8,646 | | 129,519 | | | 30,676 | 231,045 | 0.10 |
| | | 2 | 2,943 | 711 | | 770 | 1,955 | 53,127 | 9,213 | | 123,703 | | | 29,753 | 222,175 | 0.10 |
| | | 3 | 2,943 | 711 | | 770 | 1,955 | 53,127 | 9,213 | | 123,703 | | | 29,753 | 222,175 | 0.10 |
| Primary Lead | 1 | 1 | 10 | 200 | | 800 | 10 | 60 | 3,002 | 2 | 50 | 440 | 10 | 1,291 | 5,875 | 0.05 |
| | | 2 | 10 | 200 | | 800 | 10 | 60 | 3,002 | 2 | 50 | 440 | 10 | 1,291 | 5,875 | 0.05 |
| | | 3 | 1 | 2 | | 19 | 1 | 7 | 100 | 0 | 6 | 51 | 1 | 153 | 341 | 8.56 |
| Secondary Lead | 1 | 1 | 3,442 | 408 | | 133 | 45 | 266 | 1,797 | 0.4 | 86 | 0 | 34 | 447 | 6,658 | 22.15 |
| | | 2 | 3,087 | 368 | | 119 | 40 | 239 | 1,612 | 0.4 | 77 | 0 | 30 | 401 | 5,973 | 24.69 |
| | | 3 | 2,318 | 274 | | 90 | 30 | 181 | 1,204 | 0.3 | 60 | 0 | 30 | 301 | 4,488 | 33.20 |
| | | 4 | 3,087 | 368 | | 119 | 40 | 239 | 1,612 | 0.4 | 77 | 0 | 30 | 401 | 5,973 | 24.69 |

TABLE VIII-50 (Continued)

METAL CONCENTRATIONS IN SLUDGES

| Sub-Category | Comb. | Alt. | ESTIMATED METAL CONCENTRATIONS IN SLUDGES (mg/kg) | | | | | | | | | | | | | Estimated Quantity (kg/cu m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Tl | Zn | Total | |
| Secondary Lead | 2 | 1 | 28,690 | 4,432 | 13 | 773 | 619 | 3,667 | 215,981 | 2 | 980 | 3 | 109 | 4,210 | 259,473 | 0.97 |
| | | 2 | 7,915 | 1,230 | 6 | 218 | 172 | 1,038 | 59,930 | 0.5 | 229 | 1 | 40 | 1,356 | 72,197 | 3.52 |
| | | 3 | 2,317 | 360 | 2 | 64 | 50 | 304 | 17,536 | 0.1 | 85 | 0 | 12 | 397 | 21,127 | 12.03 |
| | | 4 | 7,915 | 1,230 | 6 | 218 | 172 | 1,038 | 59,930 | 0.5 | 229 | 1 | 40 | 1,356 | 72,197 | 3.52 |
| Secondary Silver (Photo) | 1 | 1 | NO SLUDGE | | | | | | | | | | | | | |
| | | 2 | 460 | 105 | 8 | 7,901 | 2,765 | 1,929 | 892 | 0.6 | 409 | 67 | 216 | 259,196 | 273,949 | 0.71 |
| | | 3 | 457 | 111 | 8 | 7,885 | 2,687 | 1,967 | 1,009 | 0.6 | 484 | 72 | 230 | 257,639 | 272,550 | 0.72 |
| | | 4 | 457 | 111 | 8 | 7,885 | 2,687 | 1,967 | 1,009 | 0.6 | 484 | 72 | 230 | 257,639 | 272,550 | 0.72 |
| Secondary Silver (Nonphoto) | 1 | 1 | 15 | 6 | 1 | 8,614 | 2,248 | 9,218 | 5,578 | | 88,333 | 1 | | 218,502 | 332,516 | 6.76 |
| | | 2 | 15 | 6 | 1 | 8,740 | 2,252 | 9,211 | 5,591 | | 88,268 | 1 | | 218,339 | 332,424 | 6.76 |
| | | 3 | 15 | 6 | 1 | 8,740 | 2,252 | 9,211 | 5,591 | | 88,268 | 1 | | 218,339 | 332,424 | 6.76 |
| Primary Tungsten Ore to Salt | 1 | 1 | 20 | 40 | | 40 | 5 | 305 | 600 | | 25 | 15 | 60 | 80 | 1,190 | 0.10 |
| | | 2 | 20 | 40 | | 40 | 5 | 305 | 600 | | 25 | 15 | 60 | 80 | 1,190 | 0.10 |
| | | 3 | 1 | 1 | | 2 | 1 | 67 | 11 | | 6 | 3 | 13 | 18 | 123 | 8.61 |
| | 2 | 1 | NO SLUDGE | | | | | | | | | | | | | |
| | | 2 | 20 | 40 | | 40 | 5 | 305 | 600 | | 25 | 15 | 60 | 80 | 1,190 | 0.10 |
| | | 3 | 20 | 40 | | 40 | 5 | 305 | 600 | | 25 | 15 | 60 | 80 | 1,190 | 0.10 |
| | | 4 | 1 | 1 | | 2 | 1 | 67 | 11 | | 6 | 3 | 13 | 18 | 123 | 8.61 |

TABLE VIII-50 (Continued)

METAL CONCENTRATIONS IN SLUDGES

| Sub-Category | Comb. | Alt. | ESTIMATED METAL CONCENTRATIONS IN SLUDGES (mg/kg) Sb | As | Be | Cd | Cr | Cu | Pb | Hg | Ni | Se | Tl | Zn | Total | Estimated Quantity (kg/cu m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary Tungsten Salt to Metal | 1 | 1 | NO SLUDGE | | | | | | | | | | | | | |
| | | 2 | 500 | 40 | 0 | 4 | 150 | 3 | 10 | | 2 | 90 | 50 | 30 | 879 | 0.10 |
| | | 3 | 500 | 40 | 0 | 4 | 150 | 3 | 10 | | 2 | 90 | 50 | 30 | 879 | 0.10 |
| Primary Zinc | 1 | 1 | 8 | 317 | | 8 | 3 | 4 | 20 | 0.2 | * | 2 | 1 | 317 | 680 | 2.55 |
| | | 2 | 5 | 73 | | 14 | 14 | 3 | 7 | 0.1 | | 9 | 5 | 315 | 481 | 11.06 |
| | | 3 | 8 | 317 | | 8 | 3 | 4 | 20 | 0.2 | | 2 | 1 | 317 | 680 | 2.55 |

* Metal concentrations in sludges were not calculated when the concentration of the pollutant in the raw wastewater was less than the following values: Sb = 0.2 mg/l, As = 0.05 mg/l, Be = 0.1 mg/l, Cd = 0.01 mg/l, Hg = 0.001 mg/l, Ni = 0.1 mg/l, Se = 0.1 mg/l, and Tl = 0.01 mg/l.

# SECTION IX

# BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

The best practicable control technology currently available (BPT) has been established for a number of subcategories in the nonferrous metals industry. In accordance with the Act, BPT was to be implemented by all industrial dischargers by July 1, 1978.

BPT effluent limitations are based on the average of the best performance by exemplary plants found in the industry, taking into account:

1. The total cost of application of the technology in relation to the effluent reduction benefits to be achieved from such application.
2. The age of the equipment and plant facilities involved.
3. The production process employed.
4. The engineering aspects of the application of various types of control techniques.
5. Process changes.
6. Non-water quality environmental impact (including energy requirements).

While BPT normally emphasizes end-of-pipe treatment, it may also include the control technologies within the process that are considered normal practice within the industry.

## PRESENT STATUS OF BPT LIMITATION GUIDELINES

Effluent limitations representing the degree of reduction attainable by the application of BPT have been promulgated for several of the subcategories within the industry. Effluent limitations for bauxite, primary aluminum, and secondary aluminum were published the Federal Register on April 4, 1974. BPT limitations for primary copper, secondary copper, primary lead and primary zinc were published on February 27, 1975.

BPT alternatives for the columbium-tantalum, secondary lead, secondary silver, and tungsten subcategories, are evaluated in this report.

## BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

### Alternatives For Best Practicable Control Technologies

The purpose of this report is to evaluate wastewater characteristics and control and treatment methods for the

industry, and to present alternative treatment and control schemes that yield various levels of effluent quality. For those subcategories of the nonferrous metals industry for which BPT limitations have been published, the data base accumulated for this report was reviewed to evaluate those BPT limitations in light of the Clean Water Act (PL 95-217). In all cases, the existing BPT limitations were judged adequate.

For those subcategories for which BPT limitations were never established, alternative treatment technologies for BPT are presented herein. In each case, the effluent quality from the application of the given alternative is presented. This information could serve as an input to the selection of BPT limitations.

The alternatives for BPT effluent limitations are based on the average of the best plants in the subcategory.

Primary Columbium-Tantalum (Ore to Salt). Alternatives 1 and 2 may be used for BPI. These alternatives include steam stripping and chlorine oxidation of high ammonia streams, and chemical precipitation and filtration of the combined streams. Effluent mass loadings are presented below.

| | TREATMENT ALTERNATIVE | |
|---|---|---|
| | 1 | 2 |
| Pollutant | EFFLUENT mg/kg | |
| pH | (6-9) | 6-9, |
| TSS | 3.E6 | 1000. |
| NH3 | 3.E4 | 3.E4 |
| Fluoride | 2.E6 | 2.E4 |
| Cu | 1.E4 | 100, |
| Cd | 900, | 30. |
| Cr | 2.E4 | 200. |
| Pb | 3.E4 | 600. |
| Hg | 2. | 0.1 |
| Ni | 900. | 60. |
| Zn | 3.E4 | 800. |
| 1,2,4-Trichlorobenzene | 100. | 40. |
| 1,2-Dichloroethane | 9. | 0.8 |
| Tetrachloroethylene | 30, | 6. |
| Bis(2-ethylhexyl)phthalate | 80. | 20. |
| PCB-1254 | 100. | 20. |
| PCB-1248 | 100. | 10. |

These loadings are based on a flow rate of 15 gal/lb of precipitation capacity, achieved by 2 out of 3 plants.

Primary Columbium-Tantalum (Salt to Metal). Alternative 1 may be used for BPT for treating the reduction scrubber and leachate wastewater. This alternative includes lime precipitation and filtration. The effluent mass loadings are presented below.

| | TREATMENT ALTERNATIVE 1 |
|---|---|
| Pollutant | EFFLUENT mg/kg |
| pH | 6-9 |
| TSS | 1000. |
| $NH_3$ | 30. |
| Fluoride | 1.E4 |
| Cd | 0.2 |
| Cr | 20. |
| Cu | 6. |
| Pb | 7. |
| Hg | 0.04 |
| Ni | 10. |
| Zn | 50. |
| 1,2-Dichloroethane | 0.02 |
| Bis (2-ethylhexyl) phthalate | 8. |
| Tetrachloroethylene | 0.2 |
| PCB-1254 | 0.2 |
| PCB-1248 | 0.2 |

These loadings are based on a flow rate of 16 gal/lb of reduction capacity, achieved by 2 out of 4 plants.

Secondary Lead. Alternative 1 may be used for BPT. This alternative includes lime precipitation and filtration and is utilized to treat the battery acid and saw water. The effluent mass loadings are presented below.

Battery Cracking

| | TREATMENT ALTERNATIVE 1 |
|---|---|
| Pollutant | EFFLUENT mg/kg |
| TSS | 4 |
| pH | (6 – 9) |
| Sb | 0.09 |
| As | 0.01 |
| Cd | 0.008 |
| Cr | 0.2 |
| Cu | 0.04 |
| Pb | 0.09 |
| Ni | 0.03 |
| Ag | 0.02 |
| Zn | 0.2 |
| Bis(2-ethylhexyl) phthalate | 0.02 |
| Di-n-butyl phthalate | 0.0007 |
| Di-n-octyl phthalate | 0.0006 |
| Chrysene | 0.02 |
| PCB 1242, 1254, 1221 | 0.0005 |
| PCB 1016 1248 | 0.0003 |

These loadings are based on a flow rate of 100 gal/ton of lead produced by the cracking operation, achieved by 17 out of 32 plants.

Reverb & Blast Furnace Scrubbers

| Pollutant | TREATMENT ALTERNATIVE 1 EFFLUENT mg/kg |
|---|---|
| pH | 6-9 |
| TSS | 6.9 |
| Sb | 0.14 |
| As | 0.02 |
| Cd | 0.01 |
| Cr | 0.35 |
| Cu | 0.62 |
| Pb | 0.14 |
| Ni | 0.06 |
| Ag | 0.03 |
| Zn | 0.41 |
| Bis (2-ethylhexyl) phthalate | 0.03 |
| Di-n-butyl phthalate | 0.001 |
| Di-n-octyl phthalate | 0.001 |
| Chrysene | 0.03 |
| PCB-1254 | 8E-4 |
| PCB-1248 | 4E-4 |

These loadings are based on a flow rate of 165 gal/ton of furnace capacity, achieved by 3 out of 7 plants, including the plant with the highest water use.

Kettle and Other Furnace Scrubbers

Tentative BPT effluent limitations are zero discharge of pollutants, achieved by 7 out of 9 plants.

Casting

Tentative BPT effluent limitations are zero discharge of pollutants, achieved by 6 out of 8 plants.

Secondary Silver (Photographic). Alternatives 1, 2, and 3 may be used for BPT. These alternatives include steam stripping of the high ammonia stream and combining the wastewaters for treatment by chemical precipitation and filtration. The effluent mass loadings are presented below.

Film Stripping and Precipitation

| Pollutant | TREATMENT ALTERNATIVES 1 | 2 | 3 |
|---|---|---|---|
| | Effluent mg/kg | | |
| COD | 2E5 | 1E4 | 6000. |
| TSS | 5000 | 600 | 60 |
| $NH_3$ | 300 | 300 | 300 |
| phenolics | 100 | 100 | 100 |
| Cyanide | 10 | 10 | 10 |
| Sb | 20 | 3 | 0.2 |
| As | 5 | 4 | 0.05 |
| Cd | 40 | 20 | 0.6 |
| Cr | 100 | 50 | 1 |
| Cu | 40 | 6 | 0.6 |
| Pb | 20 | 20 | 0.2 |
| Ni | 5 | 0.6 | 0.5 |
| Se | 2 | 2 | 2 |
| Ag | 1 | 0.4 | 0.4 |
| Zn | 1000 | 30 | 10 |
| Butyl Benzyl Phthate | 0.2 | 0.1 | 0.05 |
| Benzene | 0.5 | 0.4 | 0.04 |
| 1,2-Dichloroethane | 1 | 0.6 | 0.05 |
| 1,1-Dichloroethylene | 6 | 2 | 0.6 |
| Methylene Chloride | 6 | 6 | 0.06 |
| Bis(2-ethylhexyl) phthate | 0.6 | 0.5 | 0.2 |
| Di-n-octyl phthalate | 0.2 | 0.06 | 0.03 |
| Tetrachloroethylene | 0.3 | 0.2 | 0.05 |
| Trichloroethylene | 6 | 2 | 2 |
| PCB-1254 | 0.01 | 0.01 | 0.01 |
| PCB-1248 | 0.01 | 0.01 | 0.01 |

Water discharge factor = 0.05 gal/Tr Oz = 6.1 l/kg

These loadings are based on a flow rate of 50 gal/1000 troy ounces silver produced by the operation, achieved by 3 out of 4 plants.

## Solution Silver Recovery

| | TREATMENT ALTERNATIVES | | |
|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 |
| | EFFLUENT mg/1000 ℓ | | |
| COD | 40 | 2 | 1 |
| TSS | 0.9 | 0.1 | 0.01 |
| $NH_3$ | 0.05 | 0.05 | 0.05 |
| phenolics | 0.02 | 0.02 | 0.02 |
| Cyanide | 0.002 | 0.002 | 0.002 |
| Sb | 0.003 | 0.0005 | 3E-5 |
| As | 0.0009 | 0.0007 | 9E-6 |
| Cd | 0.006 | 0.003 | 1E-4 |
| Cr | 0.02 | 0.008 | 2E-4 |
| Cu | 0.007 | 0.001 | 1E-4 |
| Pb | 0.004 | 0.003 | 4E-5 |
| Ni | 8E-4 | 1E-4 | 8E-5 |
| Se | 0.0004 | 3E-4 | 3E-4 |
| Ag | 0.0002 | 6E-5 | 6E-5 |
| Zn | 0.2 | 0.005 | 0.002 |
| Butyl Benzyl Phthate | 4E-5 | 2E-5 | 8E-6 |
| Benzene | 8E-5 | 6E-5 | 7E-6 |
| 1,2-Dichloroethane | 0.0002 | 1E-4 | 8E-6 |
| 1,1-Dichloroethylene | 0.001 | 3E-4 | 1E-4 |
| Methylene chloride | 0.001 | 9E-4 | 1E-5 |
| Bis(2-ethylhexyl) phthate | 0.0001 | 7E-5 | 3E-5 |
| Di-n-octyl phthalate | 3E-5 | 1E-5 | 5E-6 |
| Tetrachloroethylene | 5E-5 | 3E-5 | 9E-6 |
| Trichloroethylene | 0.0009 | 3E-4 | 3E-4 |
| PCB-1254 | 2E-6 | 1E-6 | 1E-6 |
| PCB-1248 | 2E-6 | 1E-6 | 1E-6 |

These loadings are based on a flow rate of the amount of solution processed.

## Furnace Scrubbers

Tentative BPT effluent limitations are zero discharge of pollutants, achieved by 5 out of 6 plants.

## Electrolytic Refining

| Pollutant | TREATMENT ALTERNATIVE 1 EFFLUENT | 2 EFFLUENT | 3 mg/kg |
|---|---|---|---|
| COD | 100000 | 5000 | 2000 |
| TSS | 2000 | 200 | 20 |
| $NH_3$ | 100 | 100 | 100 |
| phenolics | 50 | 50 | 50 |
| Cyanide | 5 | 5 | 5 |
| Sb | 7 | 1 | 0.07 |
| As | 2 | 2 | 0.02 |
| Cd | 15 | 7 | 0.2 |
| Cr | 50 | 20 | 0.5 |
| Cu | 20 | 2 | 0.2 |
| Pb | 10 | 7 | 0.1 |
| Ni | 2 | 0.2 | 0.2 |
| Se | 1 | 0.7 | 0.7 |
| Ag | 0.5 | 0.2 | 0.2 |
| Zn | 500 | 10 | 5 |
| Butyl Benzyl Phthate | 0.1 | 0.05 | 0.02 |
| Benzene | 0.2 | 0.2 | 0.02 |
| 1,2-Dichloroethone | 0.5 | 0.2 | 0.02 |
| 1,1-Dichloroethylene | 2 | 0.7 | 0.2 |
| Methylene Chloride | 2 | 2 | 0.02 |
| Bis (2-ethylhexyl) phthate | 0.2 | 0.2 | 0.07 |
| Di-n-octyl phthalate | 0.7 | 0.02 | 0.01 |
| Tetrachloroethylene | 0.1 | 0.07 | 0.02 |
| Trichloroethylene | 2 | 0.7 | 0.7 |
| PCB-1254 | 5E-3 | 2E-3 | 2E-3 |
| PCB-1248 | 5E-3 | 2E-3 | 2E-3 |

These loadings are based on a flow rate of 20 gal/1000 troy ounces refined silver, achieved by 12 out of 15 plants.

Casting

| POLLUTANT | TREATMENT ALTERNATIVES 1 EFFLUENT | 2 mg/kg | 3 |
|---|---|---|---|
| COD | 600000 | 3000 | 1000 |
| TSS | 1000 | 100 | 10 |
| NH3 | 70 | 70 | 70 |
| phenolics | 30 | 30 | 30 |
| Cyanide | 3 | 3 | 3 |
| Sb | 4 | 4 | 0.04 |
| As | 1 | 1 | 0.01 |
| Cd | 9 | 4 | 0.2 |
| Cr | 30 | 12 | 0.3 |
| Cu | 10 | 1 | 0.2 |
| Pb | 6 | 4 | 0.06 |
| Ni | 1 | 0.1 | 0.1 |
| Se | 0.6 | .4 | 0.4 |
| Ag | 0.3 | .09 | 0.09 |
| Zn | 300 | 7 | 3 |
| Butyl Benzyl Phthate | 0.06 | 0.03 | 0.01 |
| Benzene | 0.1 | 0.09 | 0.01 |
| 1,2-Dichloroethane | 0.3 | 0.2 | 0.01 |
| 1,1-Dichloroethylene | 1 | 0.4 | 0.2 |
| Methylene Chloride | 1 | 1 | 0.01 |
| Bis(2-ethylhexyl) phthate | 0.1 | 0.1 | 0.04 |
| Di-n-octyl phthalate | 0.04 | 0.01 | 7E-3 |
| Tetrachloroethylene | 0.07 | 0.04 | 0.01 |
| Trichloroethylene | 1.3 | 0.4 | 0.4 |
| PCB-1254 | 3E-3 | 1E-3 | 1E-3 |
| PCB-1248 | 3E-3 | 1E-3 | 1E-3 |

These loadings are based on a flow rate of 12 gal/1000 troy ounces of silver cast, achieved by 4 out of 7 plants using water.

Secondary Silver (Non-Photographic). Alternatives 1 and 2 may be used for BPT. The alternatives are used to treat the combined wastewaters and include chemical precipitation and filtration. The effluent mass loadings are presented below.

Leaching/Precipitation/Filtration

| POLLUTANT | TREATMENT ALTERNATIVE 1 EFFLUENT mg/kg | TREATMENT ALTERNATIVE 2 EFFLUENT mg/kg |
|---|---|---|
| COD | 200,000 | 20,000 |
| TSS | 6000 | 300 |
| $NH_3$ | 600 | 600 |
| phenolics | 0.9 | 0.9 |
| Cyanide | 2 | 2 |
| Sb | 6 | 6 |
| As | 3 | 0.6 |
| Cd | 600 | 15 |
| Cr | 200 | 2 |
| Cu | 3000 | 30 |
| Pb | 600 | 6 |
| Ni | 6000 | 60 |
| Se | 0.6 | 0.6 |
| Ag | 15 | 3 |
| Zn | 10,000 | 100 |
| Butyl Benzyl Phthate | 6 | 1 |
| Benzene | 2 | 0.3 |
| Bis (2-ethylhexyl) phthate | 2 | 0.9 |
| Di-n-octyl phthalate | 3 | 3 |
| Tetrachloroethylene | 2 | 0.6 |
| PCB-1254 | 0.2 | 0.2 |
| PCB-1248 | 0.2 | 0.2 |

These loadings are based on a flow rate of 240 gal/1000 troy ounces of silver recovered, achieved by 5 out of 13 plants.

Leaching/Precipitation/Filtration Scrubbers

| POLLUTANT | TREATMENT ALTERNATIVE 1 Effluent mg/kg | 2 |
|---|---|---|
| COD | 300,000 | 40,000 |
| TSS | 10,000 | 600 |
| $NH_3$ | 1000 | 1000 |
| phenolics | 2 | 2 |
| Cyanide | 5 | 5 |
| Sb | 10 | 10 |
| As | 6 | 1 |
| Cd | 1000 | 30 |
| Cr | 400 | 4 |
| Cu | 6000 | 60 |
| Pb | 1000 | 10 |
| Ni | 10,000 | 100 |
| Se | 1 | 1 |
| Ag | 30 | 6 |
| Zn | 30,000 | 300 |
| Butyl Benzyl Phthate | 10 | 3 |
| Benzene | 3 | 0.6 |
| Bis (2-ethylhexyl) phthate | 5 | 2 |
| Di-n-octyl phthalate | 6 | 4 |
| Tetrachloroethylene | 5 | 1 |
| PCB-1254 | 0.4 | 0.4 |
| PCB-1248 | 0.4 | 0.4 |

These loadings are based on a flow rate of 515 gal/1000 troy ounces silver recovered, achieved by 5 out of 10 plants.

Furnace Scrubbers

Tentative BPT effluent limitations are zero discharge of pollutants, achieved by 5 out of 6 plants.

Electrolytic Refining

| POLLUTANT | TREATMENT ALTERNATIVE 1 EFFLUENT mg/kg | 2 |
|---|---|---|
| COD | 10000 | 1000 |
| TSS | 500 | 20 |
| $NH_3$ | 50 | 50 |
| phenolics | 0.07 | 0.07 |
| Cyanide | 0.2 | 0.2 |
| Sb | 0.5 | 0.5 |
| As | 0.2 | 0.05 |
| Cd | 50 | 1 |
| Cr | 20 | 0.2 |
| Cu | 200 | 2 |
| Pb | 50 | 0.5 |
| Ni | 500 | 5 |
| Se | 0.05 | 0.05 |
| Ag | 1 | 0.2 |
| Zn | 1000 | 10 |
| Butyl Benzyl Phthate | 0.5 | 0.1 |
| Benzene | 0.1 | 0.02 |
| Bis (2-ethylhexyl) phthate | 0.2 | 0.07 |
| Di-n-octyl phthalate | 0.2 | 0.2 |
| Tetrachloroethylene | 0.2 | 0.05 |
| PCB-1254 | 1 E-3 | 1 E-3 |
| PCB-1248 | 1 E-3 | 1 E-3 |

These loadings are based on a flow rate of 20 gal/1000 troy ounces refined silver, achieved by 12 out of 15 plants.

Casting

| POLLUTANT | TREATMENT ALTERNATIVES 1 (mg/l) | 2 (mg/l) |
|---|---|---|
| COD | 7000 | 900 |
| TSS | 300 | 14 |
| $NH_3$ | 30 | 30 |
| phenolics | 0.04 | 0.04 |
| Cyanide | 0.1 | 0.1 |
| Sb | 0.3 | 0.3 |
| As | 0.1 | 0.03 |
| Cd | 30 | 0.7 |
| Cr | 10 | 0.1 |
| Cu | 100 | 2 |
| Pb | 30 | 0.3 |
| Ni | 300 | 2 |
| Se | 0.03 | 0.02 |
| Ag | 0.7 | 0.1 |
| Zn | 600 | 6 |
| Butyl Benzyl Phthate | 0.3 | 0.06 |
| Benzene | 0.07 | 0.01 |
| Bis (2-ethylhexyl) phthate | 0.1 | 0.04 |
| Di-n-octyl phthalate | 0.1 | 0.1 |
| Tetrachloroethylene | 0.1 | 0.03 |
| PCB-1254 | 9 E-4 | 9 E-4 |
| PCB-1248 | 9 E-4 | 9 E-4 |

These loadings are based on a flow rate of 12 gal/1000 troy ounces of silver cast, achieved by 4 out of 7 plants using water.

Primary Tungsten (Ore to Salt). Alternatives 1 and 2 may be used for BPT. The alternatives are used to treat the combined wastewaters and include steam stripping and filtration. The effluent mass loadings are presented below.

Ore to Salt

| | TREATMENT ALTERNATIVE | |
|---|---|---|
| | 1 | 2 |
| POLLUTANT | EFFLUENT mg/kg | |
| pH | (6-9) | (6-9) |
| TSS | 40,000. | 1000. |
| $NH_3$ | 1000. | 1000. |
| Cr | 5. | 2. |
| Cu | 20. | 6. |
| Pb | 20. | 4. |
| Ag | 2. | 4. |
| Tetrachloroethylene | 0.7 | 0.3 |

These loadings are based on a flow rate of 11.5 gal/lb of ammonium paratungstate capacity, achieved by 4 out of 5 plants.

Primary Tungsten (Salt to Metal). Alternative 1 may be used for BPT. This alternative includes steam stripping and filtration of the combined wastewater. The effluent mass loadings are presented below.

Salt to Metal

| | TREATMENT ALTERNATIVE |
|---|---|
| POLLUTANT | EFFLUENT mg/kg |
| pH | 9 |
| TSS | 90 |
| $NH_3$ | 40 |
| Cr | 0.4 |
| Cu | 0.06 |
| Pb | 0.2 |
| Ag | 0.06 |

These loadings are based on a flow rate of 1.12 gal/lb of tungsten metal, achieved by 3 out of 5 plants.

# SECTION X

## ALTERNATIVES FOR BEST AVAILABLE TECHNOLOGY FOR DIRECT AND INDIRECT DISCHARGERS

The effluent limitations that must be achieved by July 1, 1984, are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable (BAT).

Consideration must also be given to:

1. The age of equipment and facilities involved
2. The process employed
3. The engineering aspects of the application of various types of control techniques
4. Process changes
5. Cost of achieving the required effluent reduction
6. Non-water quality environmental impact (including energy requirements)

BAT assesses the availability of in-process controls, as well as control or additional treatment techniques employed at the end of a production process.

### INDIRECT DISCHARGERS

Industrial wastewaters discharged to publicly owned treatment works (POTWs) are regulated by 301(b) of the Federal Water Pollution Control Act as amended in 1977. Such sources are obligated to comply with pretreatment standards promulgated pursuant to Section 307 of the Act. The objectives of the Federal Pretreatment Standards as outlined in The National Pretreatment Stategy, 40 CFR 403, are:

1. To prevent inhibition/interference with the operation of POTWs, including contamination of municipal sludge,
2. To correct inadequate treatment by industry and by POTW of many pollutants prior to their release to the environment, and
3. To improve opportunities to recycle and reclaim wastewaters and the sludges resulting from wastewater treatment.

In order to achieve these objectives, EPA has established two sets of pretreatment standards: Prohibited-Discharge Standards and Categorical Pretreatment Standards. These are specified in the General Pretreatment Standards, 40 CFR 403.

Prohibited-discharge standards prohibit the discharge by a user of a publicly owned treatment work of any non-domestic waste

containing pollutants that would substantially interfere with the operation of the POTW. All industrial users, regardless of size or industrial subcategory, are subject to these regulations. The Prohibited-Discharge Standards specifically prohibit the introduction of the following pollutants into POTWs:

1. Pollutants that create a fire or explosion hazard in the POTW
2. Pollutants that will cause corrosive structural damage, unless the POTW is specifically designed to accommodate such discharges
3. Solid or viscous pollutants in amounts that will cause obstruction in sewers or otherwise interfere with POTW operations.
4. Discharges of pollutants, including oxygen demand, in such volume or concentration that they interfere with the treatment process
5. Heat in amounts that will inhibit biological activity in POTWs; in no case can temperature at the influent to a POTW exceed 40°C.

The categorical pretreatment standards apply to existing and new sources in a specific industrial category. In compliance with the consent decree, the 65 classes of toxic pollutants are to be reviewed and standards set for any of the pollutants found not to be susceptible to treatment by POTWs, or which interfere with the operation of the POTW. The wastewaters of the nonferrous metals industry contain significant concentrations of toxic pollutants. It is known that heavy metals can inhibit biological wastewater treatment. If the metals are not in high enough concentrations to inhibit biological treatment, they may concentrate in the sludge or may pass through the POTW essentially untreated (28). Many of the organics that pose potential problems in the nonferrous metals industry are not biodegradable and thus will pass through a POTW. Therefore, it is recommended that wastewaters from the nonferrous metals industry that are discharged to POTWs must receive the same treatment as wastewaters discharged directly to rivers and lakes. Indeed, many municipalities have already issued very strict pretreatment regulations governing some priority pollutants (28). Thus, the treatment technologies for indirect and direct dischargers, contained in this report are identical.

This report has presented the wastewater characteristics and several wastewater treatment alternatives for the nonferrous metals industry. Each combination of wastewaters is associated with a series of treatment alternatives. The alternatives are arranged so that unit operations are added to the previous alternative to improve effluent quality. Thus, each series of alternative treatment schemes presents a range of effluent

quality. Furthermore, the cost of the treatment generally increases as the effluent quality is improved.

This section presents a summary by subcategory of the alternative treatment schemes and the effluent loadings associated with each scheme.

## BEST AVAILABLE TREATMENT

### BAT Treatment Alternatives

Each subcategory in the nonferrous metals industry is composed of a wide variety of plants that produce specific metals by many different processes. Each process may have a unique combination of wastewaters. Sections VII and VIII of this report present in detail the treatment methods for each combination of wastewaters and the cost of each treatment method (alternative). Section VIII also indicates the quality of the wastewater treated by each method.

Following is a presentation of the effluent mass loading per unit production produced by treatment alternatives that are suitable for BAT for each subcategory. In some subcategories, Alternative 1 is equivalent to BPT; these are omitted from the following presentation and discussed in Section IX. In all cases, recycle of process wastewater is included as part of the treatment scheme. In some subcategories, the level of recycle may be less than in others.

Primary Aluminum. The various alternative levels of treatment include:

1. Chlorine oxidation and chemical precipitation,
2. Filtration and activated alumina added to level 1,
3. Reverse osmosis and complete recycle added to level 2,
4. Activated carbon added to level 2.

Paste Plant

| | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|
| POLLUTANT | 1* | 2* | 3* | 4* |
| | Effluent - mg/kg | | | |
| pH | (6-9) | (6-9) | No | (6-9) |
| TSS | 200 | 40 | Discharge | 40 |
| Phenolics | 0.03 | 0.03 | of | 0.03 |
| | | | Pollutants | |
| Cyanide | 1.E-3 | 1.E-3 | | 1.E-3 |
| Hg | 2.E-5 | 2.E-5 | | 2.E-5 |
| Pb | 0.01 | 0.01 | | 3.E-3 |
| Cr | 1.E-3 | 1.E-3 | | 1.E-3 |
| As | 3.E-3 | 3.E-3 | | 3.E-3 |
| Pyrene | 0.01 | 8.E-3 | | 8.E-5 |
| Chrysene | 0.01 | 9.E-3 | | 9.E-5 |
| Benzo(a)pyrene | 0.02 | 0.01 | | 1.E-4 |
| Methylene Chloride | 0.002 | 2.E-3 | | 2.E-3 |
| Fluoranthene | 0.01 | 1.E-3 | | 1.E-5 |
| Acenophthene | 5.E-4 | 4.E-4 | | 4.E-6 |

These loadings are based on a flow rate of 60 gal/ton of paste, achieved by 1 of the four plants.

*Treatment consists of systems described above. See also Figure VIII-C combinations 3, 4, or 5.

Anode Baking

| POLLUTANT | TREATMENT ALTERNATIVE 1* | 2* | 3* |
|---|---|---|---|
| | Effluent – mg/kg | | |
| pH | 6-9 | No | 6-9 |
| TSS | 0.4 | Discharge | 0.4 |
| Phenolics | 0.2 | of | 4E-4 |
| Fluoride | 0.63 | Pollutants | 0.2 |
| Cyanide | 4.E-4 | | 4.E-4 |
| Hg | 4.E-6 | | 4.E-6 |
| Pb | 0.002 | | 4.E-4 |
| Cr | 0.002 | | 0.002 |
| As | 0.003 | | 0.003 |
| Pyrene | 0.004 | | 4.E-5 |
| Chrysene | 0.002 | | 2.E-5 |
| Benzo(a)pyrene | 0.002 | | 2E-5 |
| Methylene Chloride | 4.E-4 | | 4E-4 |
| Fluoranthene | 0.002 | | 2E-5 |
| Acenophthene | 3.E-4 | | 3E-6 |

These loadings are based on a flow rate of 20 gal/ton of baked anodes, achieved by 7 out of 9 plants.

*Alternative 1 is cooling, chlorination, chemical precipitation, and filtration; Alternative 2 is alternative 1 plus reverse osmosis; Alternative 3 is alternative 1 plus activated carbon. See also Figure VIII-6.

Cryolite

| POLLUTANT | TREATMENT ALTERNATIVES 1* | 2* | 3* | 4* |
|---|---|---|---|---|
| | Effluent mg/kg | | | |
| pH | (6-9) | 6-9 | No | (6-9) |
| TSS | 60 | 3 | Discharge | 3 |
| Phenolics | 0.006 | 0.006 | of | 0.006 |
| Cyanide | 30 | 30 | Pollutants | 30 |
| $NH_3$ | 10 | 10 | | 10 |
| As | 0.01 | 0.01 | | 0.01 |
| Cr | 0.05 | 0.05 | | 0.005 |
| Pb | 0.06 | 0.02 | | 0.003 |
| Hg | 3E-5 | 3E-5 | | 3E-5 |
| Pyrene | 0.001 | 0.001 | | 1E-5 |
| Chrysene | 5E-4 | 5E-4 | | 5E-6 |
| Methylene Chloride | 0.004 | 0.004 | | 0.004 |
| Fluoranthene | 0.001 | 1E-4 | | 1E-6 |
| Fluoride | 20 | 3 | | 3 |

These loadings are based on a flow rate of 65 gal/ton of aluminum production, achieved by four out of six plants using water. Aluminum production, in this case, means the production at all the plants from which the spent cathodes came.

*Treatment is described above and also in Figure VIII-6, combination 3, 4, or 5.

Cathode Making

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 3 out of 4 plants which use water for this operation.

Primary Potline Scrubbing

| POLLUTANT | TREATMENT ALTERNATIVE 1* | 2* | 3* | 4* |
|---|---|---|---|---|
| | Effluent - mg/kg | | | |
| pH | (9) | (9) | No Discharge of Pollutants | (9) |
| TSS | 200. | 9. | | 9. |
| Phenolics | 0.04 | 0.04 | | 0.04 |
| Cyanide | 0.009 | 0.009 | | 0.009 |
| Fluoride | 60. | 3. | | 3. |
| As | 0.06 | 0.06 | | 0.06 |
| Cr | 0.4 | 0.4 | | 0.04 |
| Pb | 0.06 | 0.02 | | 0.005 |
| Hg | 1.E-4 | 1.E-4 | | 1.E-4 |
| Acenaphthene | 0.01 | 0.007 | | 7.E-5 |
| Fluoranthene | 0.08 | 0.03 | | 3.E-4 |
| Methylene Chloride | 0.01 | 0.01 | | 0.01 |
| Benzo (a) pyrene | 0.04 | 0.03 | | 3.E-4 |
| Chrysene | 0.01 | 0.009 | | 9.E-5 |
| Pyrene | 0.09 | 0.07 | | 7.E-4 |

These loadings are based on a flow rate of 225 gal/ton aluminum, achieved by 8 out of 12 plants.

*Treatment is described above and also in Figure VIII-6, combination 3, 4, or 5.

Secondary Potroom Scrubbing

| | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|
| POLLUTANT | 1* | 2* | 3* | 4* |
| | Effluent – mg/kg | | | |
| pH | (9) | (9) | No Discharge of Pollutants | (9) |
| TSS | 30. | 20. | | 20. |
| Phenolics | 0.9 | 0.9 | | 0.03 |
| Cyanide | 0.02 | 0.02 | | 0.02 |
| Fluoride | 30. | 7. | | 7. |
| As | 0.06 | 0.06 | | 0.06 |
| Cr | 0.02 | 0.02 | | 0.02 |
| Pb | 0.1 | 0.1 | | 0.03 |
| Hg | 3.E-4 | 3.E-4 | | 3.E-4 |
| Acenaphthene | 0.004 | 0.003 | | 3.E-5 |
| Fluoranthene | 0.1 | 0.07 | | 7.E-4 |
| Benzo (a) pyrene | 0.2 | 0.2 | | 2.E-3 |
| Chrysene | 0.2 | 0.1 | | 1.E-3 |
| Pyrene | 0.3 | 0.2 | | 2.E-3 |

These loadings are based on a flow rate of 550 gal/ton of aluminum produced in the potroom, achieved by three out of seven plants.

*Treatment consists of systems described above and also described in Figure ~~VIII~~-6, combination 3, 4, 5.

Casting-DC

| POLLUTANT | TREATMENT ALTERNATIVE 1* | 2* | 3* |
|---|---|---|---|
| | Effluent - mg/kg | | |
| pH | 6-9 | No Discharge of Pollutants | 6-9 |
| TSS | 5. | | 5. |
| Phenolics | 0.2 | | 0.006 |
| Cyanide | 0.7 | | 0.7 |
| As | 0.005 | | 0.005 |
| Cr | 0.005 | | 0.005 |
| Pb | 0.01 | | 0.002 |
| Hg | 5.E-5 | | 5E-5 |
| Acenaphthene | 2.E-4 | | 2.E-6 |
| Pyrene | 0.002 | | 2.E-5 |

These loadings are based on a flow rate of 120 gal/ton of cast aluminum, achieved by 10 out of 28 plants.

* Alternative 1 is cooling tower, chlorination, chemical precipitation, filtration; Alternative 2 is reverse osmosis added to Alternative 1; Alternative 3 is activated carbon added to alternative 1. See also Figure VIII - 6, combination 2.

Casting-Sows & Pigs

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 11 out of 12 plants.

Secondary Aluminum. The various levels of treatment include:

1. Settling and steam stripping of slag milling water; and lime precipitation of the combined streams;
2. Filtration added to level 1;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2.

Chlorine Demagging

| | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 | 4 |
| | Effluent - mg/kg | | | |
| pH | 6-9 | 6-9 | No Discharge of Pollutants | 6-9 |
| TSS | 60. | 3. | | 3. |
| $NH_3$ | 0.2 | 0.2 | | 0.2 |
| Cd | 0.01 | 0.009 | | 0.0009 |
| Cr | 0.03 | 0.03 | | 0.003 |
| Cu | 0.03 | 0.02 | | 0.02 |
| Pb | 0.06 | 0.01 | | 0.003 |
| Zn | 0.1 | 0.1 | | 0.01 |

These loadings are based on a flow rate of 75 gal/ton of degassed aluminum, achieved by 5 out of 10 plants.

Dross Milling

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 3 out of 4 plants that use water for this process.

Casting

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 9 out of 14 plants that use water for this process.

Aluminum Fluoride Demagging

Tentative BAT effluent limitations are zero discharge of pollutants.

Primary Columbium-Tantalum (Ore to Salt). The alternative levels of treatment include:

1. Steam stripping and chlorine oxidation of the high ammonia streams;
2. Chemical precipitation and filtration of the combined streams;
3. Activated alumina added to level 2;
4. Reverse osmosis and complete recycle added to level 3; and
5. Activated carbon added to level 3.

| | TREATMENT ALTERNATIVE | | | | |
|---|---|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 | 4 | 5 |
| | Effluent mg/kg | | | | |
| pH | 6-9 | 6-9 | 6-9 | No Discharge of Pollutants | 6-9 |
| TSS | 3.E6 | 1000. | 1000. | | 1000. |
| NH3 | 3.E4 | 3.E4 | 3.E4 | | 3.E4 |
| Fluoride | 2.E6 | 2.E4 | 200. | | 200. |
| Cu | 1.E4 | 100. | 100. | | 10. |
| Cd | 900. | 30. | 20. | | 2. |
| Cr | 2.E4 | 200. | 200. | | 20. |
| Pb | 3.E4 | 600. | 300. | | 60. |
| Hg | 2. | 0.1 | .04 | | 0.04 |
| Ni | 900. | 60. | 20. | | 2. |
| Zn | 3.E4 | 800. | 300. | | 30. |
| 1,2,4-Trichlorobenzene | 100. | 40. | 40. | | 0.4 |
| 1,2-Dichloroethane | 9. | 0.8 | 0.8 | | 0.04 |
| Tetrachloroethylene | 30. | 6. | 6. | | 0.7 |
| Bis(2-ethylhexyl)phthalate | 80. | 20. | 20. | | 20. |
| PCB-1254 | 100. | 20. | 20. | | 0.9 |
| PCB-1248 | 100. | 10. | 10. | | 0.7 |

These loadings are based on a flow rate of 15 gal/lb of precipitation capacity, achieved by 2 out of 3 plants.

Primary Columbium-Tantalum (Salt to Metal). The alternative levels of treatment include:

1. Chemical precipitation and filtration;
2 Activated alumina added to level 1; and
3. Activated carbon added to level 2.

| | TREATMENT ALTERNATIVE | | |
|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 |
| | Effluent - mg/kg | | |
| pH | 6-9 | 6-9 | 6-9 |
| TSS | 1000. | 1000. | 1000. |
| $NH_3$ | 30. | 30. | 30. |
| Fluoride | 1.E4 | 100. | 100. |
| Cd | 0.2 | 0.2 | 0.02 |
| Cr | 20. | 20. | 2. |
| Cu | 6. | 6. | 6. |
| Pb | 7. | 5. | 1. |
| Hg | 0.04 | 0.03 | 0.03 |
| Ni | 10. | 10. | 1. |
| Zn | 50 | 50. | 5. |
| 1,2-Dichloroethane | 0.02 | 0.02 | 9.E-4 |
| Bis (2-ethylhexyl) phthalate | 8. | 8. | 5. |
| Tetrachloroethylene | 0.2 | 0.2 | 0.02 |
| PCB-1254 | 0.2 | 0.2 | 0.2 |
| PCB-1248 | 0.2 | 0.2 | 0.2 |

These loadings are based on a flow rate of 12 gal/lb of reduction capacity, achieved by 2 out of 4 plants.

Primary Copper (Smelting). The alternative levels of treatment include:

1. Chemical precipitation with recycle;
2. Filtration and recycle added to level 1; and
3. Activated carbon and recycle added to level 2.

Tentative BAT effluent limitations are zero discharge of pollutants.

Primary Copper (Refining). The alternative levels of treatment include:

1. Recycle of contact cooling water with a blowdown treated by chemical precipitation;
2. Filtration added to level 1; and
3. Activated carbon added to level 2.

Refining

| | TREATMENT ALTERNATIVE | | |
|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 |
| | Effluent - mg/kg | | |
| pH | 6-9 | 6-9 | 6-9 |
| As | 0.05 | 0.05 | 0.05 |
| Cr | 0.05 | 0.05 | 0.005 |
| Cu | 0.09 | 0.06 | 0.06 |
| Pb | 0.04 | 0.02 | 0.003 |
| Hg | 5.E-5 | 4.E-5 | 4.E-5 |
| Ni | 3. | 2. | 0.2 |
| Se | 0.03 | 0.03 | 0.006 |
| Ag | 0.01 | 0.01 | 0.001 |

These loadings are based on a flow rate of 131 gal/ton of refined copper, achieved by 7 out of 10 plants.

Secondary Copper. The alternative levels of treatment include:

1. Primary settling of the slag milling water, with the supernatant combined with the contact cooling water for treatment by chemical precipitation;
2. Filtration is added to level 1; and
3. Storage in a holding tank

Tentative BAT effluent limitations are zero discharge of pollutants.

Primary Lead. The alternative levels of treatment include:

1. Filtration;
2. Activated carbon added to level 1; and
3. Reverse osmosis and complete recycle added to level 2.

Smelting

| | TREATMENT ALTERNATIVE | | |
|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 |
| | Effluent - mg/kg | | |
| TSS | 50 | 10 | No Discharge of Pollutants |
| pH | 6-9 | 6-9 | |
| Cd | 0.05 | 0.0007 | |
| Cu | 0.09 | 0.09 | |
| Pb | 0.09 | 0.02 | |
| Zn | 2. | 0.06 | |

These loadings are based on a flow rate of 310 gal/ton of furnace bullion, achieved by 4 out of 6 plants.

Refining

Tentative BAT effluent limitations are zero discharge of pollutants.

Secondary Lead. The various alternative levels of treatment include:

1. Chemical precipitation and filtration;
2. Activated alumina added to level 1;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2.

Battery Cracking

| | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 | 4 |
| | Effluent mg/kg | | | |
| TSS | 4/ | 4/ | No Discharge of Pollutants | 4/ |
| pH | 6-9 | 6-9 | | 6-9 |
| Sb | 0.09 | 0.09 | | 0.05 |
| As | 0.01 | 0.001 | | 0.001 |
| Cd | 0.008 | 0.008 | | 0.002 |
| Cr | 0.2 | 0.2 | | 0.02 |
| Cu | 0.04 | 0.04 | | 0.04 |
| Pb | 0.09 | 0.09 | | 0.05 |
| Ni | 0.03 | 0.03 | | 0.004 |
| Ag | 0.02 | 0.02 | | 0.002 |
| Zn | 0.2 | 0.2 | | 0.03 |
| Bis(2-ethylhexyl) phthalate | 0.02 | 0.02 | | 0.009 |
| Di-n-butyl phthalate | 0.0007 | 0.0007 | | 3E-4 |
| Di-n-octyl phthalate | 0.0006 | 0.0006 | | 4E-4 |
| Chrysene | 0.02 | 0.02 | | 0.02 |
| PCB 1242, 1254, 1221 | 0.0005 | 0.0005 | | 2E-4 |
| PCB 1016 1248 | 0.0003 | 0.0003 | | 2E-4 |

These loadings are based on a flow rate of 100 gal/ton of lead produced by the cracking operation, achieved by 17 out of 32 plants.

Reverb & Blast Furnace Scrubbers

| POLLUTANT | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | Effluent - mg/kg | | | |
| pH | 6-9 | 6-9 | No Discharge of Pollutants | 6-9 |
| TSS | 6.9 | 6.9 | | 6.9 |
| Sb | 0.14 | 0.14 | | 0.07 |
| As | 0.02 | 0.002 | | 0.002 |
| Cd | 0.01 | 0.01 | | 0.003 |
| Cr | 0.35 | 0.35 | | 0.03 |
| Cu | 0.62 | 0.62 | | 0.62 |
| Pb | 0.14 | 0.14 | | 0.07 |
| Ni | 0.06 | 0.06 | | 0.006 |
| Ag | 0.03 | 0.03 | | 0.003 |
| Zn | 0.41 | 0.41 | | 0.48 |
| Bis (2-ethylhexyl) phthalate | 0.03 | 0.03 | | 0.01 |
| Di-n-butyl phthalate | 0.001 | 0.001 | | 6.E-4 |
| Di-n-octyl phthalate | 0.001 | 0.001 | | 6E-4 |
| Chrysene | 0.03 | 0.03 | | 0.03 |
| PCB-1254 | 8E-4 | 8.E-4 | | 3E-4 |
| PCB-1248 | 4E-4 | 4.E-4 | | 3E-4 |

These loadings are based on a flow rate of 165 gal/ton of furnace capacity, achieved by 3 out of 7 plants, including the plant with the highest water use.

Kettle and Other Furnace Scrubbers

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 7 out of 9 plants.

Casting

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 6 out of 8 plants.

Secondary Silver (Photographic). The treatment levels for this subcategory include:

1. Steam stripping of the high ammonia streams;
2. Chemical precipitation of the combined streams;
3. Filtration added to level 2; and
4. Activated carbon added to level 3.

Film Stripping and Precipitation

| Pollutant | TREATMENT ALTERNATIVES 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | Effluent mg/kg | | | |
| pH | 6-9 | 6-9 | 6-9 | 6-9 |
| TSS | 5000 | 600 | 60 | 60 |
| $NH_3$ | 300 | 300 | 300 | 50 |
| phenolics | 100 | 100 | 100 | 1 |
| Cyanide | 10 | 10 | 10 | 10 |
| Sb | 20 | 3 | 0.2 | 0.2 |
| As | 5 | 4 | 0.05 | 0.05 |
| Cd | 40 | 20 | 0.6 | 0.4 |
| Cr | 100 | 50 | 1 | 1 |
| Cu | 40 | 6 | 0.6 | 0.6 |
| Pb | 20 | 20 | 0.2 | 0.2 |
| Ni | 5 | 0.6 | 0.5 | 0.05 |
| Se | 2 | 2 | 2 | 0.4 |
| Ag | 1 | 0.4 | 0.4 | 0.04 |
| Zn | 1000 | 30 | 10 | 10 |
| Butyl Benzyl Phthate | 0.2 | 0.1 | 0.05 | 0.03 |
| Benzene | 0.5 | 0.4 | 0.04 | 5E-3 |
| 1,2-Dichloroethane | 1 | 0.6 | 0.05 | 0.01 |
| 1,1-Dichloroethylene | 6 | 2 | 0.6 | 0.2 |
| Methylene Chloride | 6 | 6 | 0.06 | 0.06 |
| Bis (2-ethylhexyl) phthate | 0.6 | 0.5 | 0.2 | 0.1 |
| Di-n-octyl phthalate | 0.2 | 0.06 | 0.03 | 0.02 |
| Tetrachloroethylene | 0.3 | 0.2 | 0.05 | 0.01 |
| Trichloroethylene | 6 | 2 | 2 | 2 |
| PCB-1254 | 0.01 | 0.01 | 0.01 | 0.01 |
| PCB-1248 | 0.01 | 0.01 | 0.01 | 0.01 |

These loadings are based on a flow rate of 50 gal/1000 troy ounces silver produced by the operation, achieved by 3 out of 4 plants.

Solution Silver Recovery

| Pollutant | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | EFFLUENT mg/1000 ℓ | | | |
| pH | 6-9 | 6-9 | 6-9 | 6-9 |
| TSS | 0.9 | 0.1 | 0.01 | 0.01 |
| $NH_3$ | 0.05 | 0.05 | 0.05 | 0.05 |
| phenolics | 0.02 | 0.02 | 0.02 | 2E-4 |
| Cyanide | 0.002 | 0.002 | 0.002 | 0.002 |
| Sb | 0.003 | 0.0005 | 3E-5 | 3E-5 |
| As | 0.0009 | 0.0007 | 9E-6 | 9E-6 |
| Cd | 0.006 | 0.003 | 1E-4 | 6E-5 |
| Cr | 0.02 | 0.008 | 2E-4 | 2E-4 |
| Cu | 0.007 | 0.001 | 1E-4 | 1E-4 |
| Pb | 0.004 | 0.003 | 4E-5 | 4E-5 |
| Ni | 8E-4 | 1E-4 | 8E-5 | 8E-6 |
| Se | 0.0004 | 3E-4 | 3E-4 | 7E-5 |
| Ag | 0.0002 | 6E-5 | 6E-5 | 6E-6 |
| Zn | 0.2 | 0.005 | 0.002 | 0.002 |
| Butyl Benzyl Phthate | 4E-5 | 2E-5 | 8E-6 | 5E-6 |
| Benzene | 8E-5 | 6E-5 | 7E-6 | 8E-7 |
| 1,2-Dichloroethane | 0.0002 | 1E-4 | 8E-6 | 2E-6 |
| 1,1-Dichloroethylene | 0.001 | 3E-4 | 1E-4 | 4E-5 |
| Methylene Chloride | 0.001 | 9E-4 | 1E-5 | 1E-5 |
| Bis(2-ethylhexyl) phthate | 0.0001 | 7E-5 | 3E-5 | 2E-5 |
| Di-n-octyl phthalate | 3E-5 | 1E-5 | 5E-6 | 3E-6 |
| Tetrachloroethylene | 5E-5 | 3E-5 | 9E-6 | 1E-6 |
| Trichloroethylene | 0.0009 | 3E-4 | 3E-4 | 3E-4 |
| PCB-1254 | 2E-6 | 1E-6 | 1E-6 | 1E-6 |
| PCB-1248 | 2E-6 | 1E-6 | 1E-6 | 1E-6 |

These loadings are based on a flow rate of the amount of solution processed.

Furnace Scrubbers

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 5 out of 6 plants.

## Electrolytic Refining

| | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| POLLUTANT | EFFLUENT mg/kg | | | |
| pH | 6-9 | 6-9 | 6-9 | 6-9 |
| TSS | 2000 | 200 | 20 | 20 |
| NH3 | 100 | 100 | 100 | 100 |
| phenolics | 50 | 50 | 50 | 0.5 |
| Cyanide | 5 | 5 | 5 | 5 |
| Sb | 7 | 1 | 0.07 | 0.07 |
| As | 2 | 2 | 0.02 | 0.02 |
| Cd | 15 | 7 | 0.2 | 0.2 |
| Cr | 50 | 20 | 0.5 | 0.5 |
| Cu | 20 | 2 | 0.2 | 0.2 |
| Pb | 10 | 7 | 0.1 | 0.1 |
| Ni | 2 | 0.2 | 0.2 | 0.02 |
| Se | 1 | 0.7 | 0.7 | 0.2 |
| Ag | 0.5 | 0.2 | 0.2 | 0.01 |
| Zn | 500 | 10 | 5 | 5 |
| Butyl Benzyl Phthate | 0.1 | 0.05 | 0.02 | 0.01 |
| Benzene | 0.2 | 0.2 | 0.02 | 2E-3 |
| 1,2-Dichloroethane | 0.5 | 0.2 | 0.02 | 5E-3 |
| 1,1-Dichloroethylene | 2 | 0.7 | 0.2 | 0.1 |
| Methylene Chloride | 2 | 2 | 0.02 | 0.02 |
| Bis (2-ethylhexyl) phthate | 0.2 | 0.2 | 0.07 | 0.05 |
| Di-n-octyl phthalate | 0.7 | 0.02 | 0.01 | 0.01 |
| Tetrachloroethylene | 0.1 | 0.07 | 0.02 | 2E-3 |
| Trichloroethylene | 2 | 0.7 | 0.7 | 0.7 |
| PCB-1254 | 5E-3 | 2E-3 | 2E-3 | 2E-3 |
| PCB-1248 | 5E-3 | 2E-3 | 2E-3 | 2E-3 |

These loadings are based on a flow rate of 20 gal/1000 troy ounces refined silver, achieved by 12 out of 15 plants.

Casting

| Pollutant | TREATMENT ALTERNATIVE 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | EFFLUENT mg/kg | | | |
| pH | 6-9 | 6-9 | 6-9 | 6-9 |
| TSS | 1000 | 100 | 10 | 10 |
| $NH_3$ | 70 | 70 | 70 | 70 |
| phenolics | 30 | 30 | 30 | 0.3 |
| Cyanide | 3 | 3 | 3 | 3 |
| Sb | 4 | 4 | 0.04 | 0.04 |
| As | 1 | 1 | 0.01 | 0.01 |
| Cd | 9 | 4 | 0.2 | 0.09 |
| Cr | 30 | 12 | 0.3 | 0.3 |
| Cu | 10 | 1 | 0.2 | 0.1 |
| Pb | 6 | 4 | 0.06 | 0.06 |
| Ni | 1 | 0.1 | 0.1 | 0.01 |
| Se | 0.6 | .4 | 0.4 | 0.1 |
| Ag | 0.3 | .09 | 0.09 | 0.009 |
| Zn | 300 | 7 | 3 | 3 |
| Butyl Benzyl Phthate | 0.06 | 0.03 | 0.01 | 7E-3 |
| Benzene | 0.1 | 0.09 | 0.01 | 1E-3 |
| 1,2-Dichloroethane | 0.3 | 0.2 | 0.01 | 3E-3 |
| 1,1-Dichloroethylene | 1 | 0.4 | 0.2 | 0.06 |
| Methylene Chloride | 1 | 1 | 0.01 | 0.02 |
| Bis(2-ethylhexyl) phthate | 0.1 | 0.1 | 0.04 | 0.03 |
| Di-n-octyl phthalate | 0.04 | 0.01 | 7E-3 | 4E-3 |
| Tetrachloroethylene | 0.07 | 0.04 | 0.01 | 1E-3 |
| Trichloroethylene | 1.3 | 0.4 | 0.4 | 0.4 |
| PCB-1254 | 3E-3 | 1E-3 | 1E-3 | 1E-3 |
| PCB-1248 | 3E-3 | 1E-3 | 1E-3 | 1E-3 |

These loadings are based on a flow rate of 12 gal/1000 troy ounces of silver cast, achieved by 4 out of 7 plants using water.

Secondary Silver (Non-Photographic). The alternative levels of treatment include:

1. Steam stripping of the high ammonia streams;
2. Chemical precipitation and filtration of the combined streams; and
3. Activated carbon added to level 2.

Leaching/Precipitation/Filtration

| Pollutant | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|
| | Effluent mg/kg | | |
| TSS | 6000 | 300 | 300 |
| NH3 | 600 | 600 | 600 |
| phenolics | 0.9 | 0.9 | 0.9 |
| Cyanide | 2 | 2 | 2 |
| Sb | 6 | 6 | 1 |
| As | 3 | 0.6 | 0.6 |
| Cd | 600 | 15 | 6 |
| Cr | 200 | 2 | 2 |
| Cu | 3000 | 30 | 30 |
| Pb | 600 | 6 | 20 |
| Ni | 6000 | 60 | 60 |
| Se | 0.6 | 0.6 | 0.09 |
| Ag | 15 | 3 | 0.3 |
| Zn | 10,000 | 100 | 100 |
| Butyl Benzyl Phthate | 6 | 1 | 0.6 |
| Benzene | 2 | 0.3 | 0.01 |
| Bis (2-ethylhexyl) phthate | 2 | 0.9 | 0.6 |
| Di-n-octyl phthalate | 3 | 2 | 0.3 |
| Tetrachloroethylene | 2 | 0.6 | 0.06 |
| PCB-1254 | 0.2 | 0.2 | 0.2 |
| PCB-1248 | 0.2 | 0.2 | 0.2 |
| pH | 6-9 | 6-9 | 6-9 |

These loadings are based on a flow rate of 240 gal/1000 troy ounces of silver recovered, achieved by 5 out of 13 plants.

## Leaching/Precipitation/Filtration Scrubbers

| | | | |
|---|---|---|---|
| TSS | 10,000 | 600 | 600 |
| $NH_3$ | 1000 | 1000 | 1000 |
| phenolics | 2 | 2 | 2 |
| Cyanide | 5 | 5 | 5 |
| Sb | 10 | 10 | 3 |
| As | 6 | 1 | 1 |
| Cd | 1000 | 30 | 10 |
| Cr | 400 | 4 | 4 |
| Cu | 6000 | 60 | 60 |
| Pb | 1000 | 10 | 10 |
| Ni | 10,000 | 100 | 100 |
| Se | 1 | 1 | 0.2 |
| Ag | 30 | 6 | 0.6 |
| Zn | 30,000 | 300 | 300 |
| Butyl Benzyl Phthate | 10 | 3 | 1 |
| Benzene | 3 | 0.6 | 0.03 |
| Bis (2-ethylhexyl) phthate | 5 | 2 | 1 |
| Di-n-octyl phthalate | 6 | 4 | 0.6 |
| Tetrachloroethylene | 5 | 1 | 0.1 |
| PCB-1254 | 0.4 | 0.4 | 0.4 |
| PCB-1248 | 0.4 | 0.4 | 0.4 |
| PH | 6-9 | 6-9 | 6-9 |

These loadings are based on a flow rate of 515 gal/1000 troy ounces silver recovered, achieved by 5 out of 10 plants.

## Furnace Scrubbers

Tentative BAT effluent limitations are zero discharge of pollutants, achieved by 5 out of 6 plants.

## Electrolytic Refining

| | TREATMENT ALTERNATIVE | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| | Effluent mg/kg | | |
| TSS | 500 | 20 | 20 |
| $NH_3$ | 50 | 50 | 50 |
| phenolics | 0.07 | 0.07 | 0.07 |
| Cyanide | 0.2 | 0.2 | 0.2 |
| Sb | 0.5 | 0.5 | 0.1 |
| As | 0.2 | 0.05 | 0.05 |
| Cd | 50 | 1 | 0.5 |
| Cr | 20 | 0.2 | 0.2 |
| Cu | 200 | 2 | 2 |
| Pb | 50 | 0.5 | 0.5 |
| Ni | 500 | 5 | 5 |
| Se | 0.05 | 0.05 | 0.01 |
| Ag | 1 | 0.2 | 0.02 |
| Zn | 1000 | 10 | 10 |
| Butyl Benzyl Phthate | 0.5 | 0.1 | 0.05 |
| Benzene | 0.1 | 0.02 | 1E-3 |
| Bis (2-ethylhexyl) phthate | 0.2 | 0.07 | 0.05 |
| Di-n-octyl phthalate | 0.2 | 0.2 | 0.02 |
| Tetrachloroethylene | 0.2 | 0.05 | 5E-3 |
| PCB-1254 | 1E-3 | 1E-3 | 1E-3 |
| PCB-1248 | 1E-3 | 1E-3 | 1E-3 |
| PH | 6-9 | 6-9 | 6-9 |

These loadings are based on a flow rate of 20 gal/1000 troy ounces refined silver, achieved by 12 out of 15 plants.

Casting

| Pollutant | TREATMENT ALTERNATIVES 1 | 2 | 3 |
|---|---|---|---|
| | Effluent Loading | | |
| TSS | 300 | 14 | 14 |
| $NH_3$ | 30 | 30 | 30 |
| phenolics | 0.04 | 0.04 | 0.04 |
| Cyanide | 0.1 | 0.1 | 0.1 |
| Sb | 0.3 | 0.3 | 0.06 |
| As | 0.1 | 0.03 | 0.03 |
| Cd | 30 | 0.7 | 0.3 |
| Cr | 10 | 0.1 | 0.1 |
| Cu | 100 | 2 | 2 |
| Pb | 30 | 0.3 | 0.3 |
| Ni | 300 | 3 | 3 |
| Se | 0.03 | 0.02 | 4E-3 |
| Ag | 0.7 | 0.1 | 0.01 |
| Zn | 600 | 6 | 6 |
| Butyl Benzyl Phthate | 0.3 | 0.06 | 0.03 |
| Benzene | 0.07 | 0.01 | 7E-4 |
| Bis (2-ethylhexyl) phthate | 0.1 | 0.04 | 0.03 |
| Di-n-octyl phthalate | 0.1 | 0.1 | 0.01 |
| Tetrachloroethylene | 0.1 | 0.03 | 3E-3 |
| PCB-1254 | 9E-4 | 9E-4 | 9E-4 |
| PCB-1248 | 9E-4 | 9E-4 | 9E-4 |
| PH | 6-9 | 6-9 | 6-9 |

These loadings are based on a flow rate of 12 gal/1000 troy ounces of silver cast, achieved by 4 out of 7 plants using water.

Primary Tungsten (Ore to Salt). The various alternative treatment levels are:

1. Steam stripping;
2. Filtration added to level one;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2.

| | TREATMENT ALTERNATIVE | | | |
|---|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 | 4 |
| | Effluent - mg/kg | | | |
| pH | (6-9) | (6-9) | (6-9) | (6-9) |
| TSS | 40,000. | 1000. | 1000. | 400. |
| $NH_3$ | 1000. | 1000. | 100. | 1000. |
| Cr | 5. | 2. | 0.4 | 2. |
| Cu | 20. | 6. | 1. | 6. |
| Pb | 20. | 4. | 0.4 | 4. |
| Ag | 2. | 4. | 0.4 | 0.4 |
| Tetrachloroethylene | 0.7 | 0.3 | 0.3 | 0.03 |

These loadings are based on a flow rate of 11.5 gal/lb of ammonium paratungstate capacity, achieved by 4 out of 5 plants.

Primary Tungsten (Salt to Metal). The levels of treatment for this subcategory are:

1. Steam stripping and filtration; and
2. Activated carbon added to level 1.

| Pollutant | TREATMENT ALTERNATIVE 1 | 2 |
|---|---|---|
| | Effluent mg/kg | |
| pH | 6-9 | 6-9 |
| TSS | 90 | 90 |
| $NH_3$ | 40 | 40 |
| Cr | 0.4 | 0.4 |
| Cu | 0.06 | 0.06 |
| Pb | 0.2 | 0.04 |
| Ag | 0.06 | 0.006 |

These loadings are based on a flow rate of 1.12 gal/lb of tungsten metal, achieved by 3 out of 5 plants.

Primary Zinc. The levels of treatment for this subcategory are:

1. Filtration and activated alumina;
2. Reverse osmosis and complete recycle added to level 1; and 3. Activated carbon added to level 1.

Pyrometallurgical Zinc

| | TREATMENT ALTERNATIVE | | |
|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 |
| | Effluent - mg/kg | | |
| pH | 6-9 | 6-9 | 6-9 |
| TSS | 10. | 0.7 | 10. |
| As | 0 | 0 | 0 |
| Cd | 0.009 | 0.009 | 9.E-4 |
| Cr | 0 | 0 | 0 |
| Cu | 0 | 0 | 0 |
| Pb | 0.06 | 6E-4 | 0.01 |
| Hg | 1.E-4 | 1.E-5 | 1.E-4 |
| Ni | 0 | 0 | 0 |
| Se | 0 | 0 | 0 |
| Ag | 0 | 0 | 0 |
| Zn | 0.9 | 0.03 | 0.09 |
| Methylene Chloride | 0.006 | 0.006 | 0.006 |

These loadings are based on a flow rate of 320 gal/ton of zinc, achieved by 1 out of 2 plants.

Electrolytic Zinc

| POLLUTANT | TREATMENT ALTERNATIVE 1 | 2 | 3 |
|---|---|---|---|
| | Effluent - mg/kg | | |
| pH | 6 – 9 | 6 – 9 | 6 – 9 |
| TSS | 0 | 0 | 0 |
| As | 0 | 0 | 0 |
| Cd | 0.2 | 0.004 | 0.02 |
| Cr | 0.07 | 0.07 | 0.07 |
| Cu | 0 | 0 | 0 |
| Pb | 0 | 0 | 0 |
| Hg | 0 | 0 | 0 |
| Ni | 0.4 | 0.4 | 0.04 |
| Se | 1. | 0.1 | 0.2 |
| Ag | 0 | 0 | 0 |
| Zn | 0 | 0 | 0 |
| Methylene Chloride | 0.02 | 0.02 | 0.02 |

These loadings are based on a flow rate of 1200 gal/ton of electrolytic zinc, achieved by 2 out of 4 plants.

Metallurgical Acid Plants. The levels of treatment for this subcategory are the same as those discussed under Primary Zinc.

| | TREATMENT ALTERNATIVE | | |
|---|---|---|---|
| POLLUTANT | 1 | 2 | 3 |
| | Effluent - mg/kg | | |
| TSS | 20. | 20. | 20. |
| As | 0.02 | 0.002 | 0.02 |
| Cr | 0.5 | 0.05 | 0.05 |
| Cu | 0.4 | 0.04 | 0.4 |
| Pb | 0.3 | 0.03 | 0.05 |
| Hg | 0.001 | 0.0003 | 0.003 |
| Ni | 0.1 | 0.1 | 0.02 |
| Se | 0.9 | 0.09 | 0.2 |
| Ag | 0.07 | 0.007 | 0.007 |
| Cd | 0.6 | 0.2 | 0.06 |
| Zn | 10. | 0.1 | 1. |
| Methylene Chloride | 0.01 | 0.01 | 0.1 |
| Bis (2-ethylhexyl) phthalate | 0.2 | 0.0005 | 0.1 |
| pH | (6-9) | (6-9) | (6-9) |

These loadings are based on a flow rate of 550 gal/ton of 100% sulfuric acid , achieved by over 13 out of 21 plants.

# SECTION XI

# ALTERNATIVES FOR NEW SOURCES

## INTRODUCTION

A new source is defined in the Act as "any source, the construction of which is commenced after publication of proposed regulations prescribing a standard of performance." .The alternatives developed for new sources discharging directly to a stream, river, etc., are identical to the alternatives for indirect dischargers. A discussion of the reasoning for this is given in the beginning of Section X.

New source treatment alternatives are developed by determining what higher levels of pollution control and treatment beyond BAT are available through the use of improved production processes and/or treatment techniques. Thus, in addition to considering the best in-plant and end-of-pipe controls and treatments, new source technology is based upon an analysis of how the effluent load may be reduced by changing the production process itself. Alternative processes, operating methods, or other alternatives must be considered. Consideration must also be given to the applicability of a no discharge of pollutants standard for new sources.

The following production process factors are considered in assessing new source treatment technology:

1. The type of process employed and/or employable;
2. Operating methods;
3. Batch as opposed to continuous operations;
4. Use of alternative raw materials and mixes of raw materials;
5. Use of dry rather than wet processes.

## NEW SOURCE PRETREATMENT AND PERFORMANCE STANDARDS

### Alternative Technologies

The purpose of this report is to evaluate wastewater characteristics, and control and treatment methods. In addition, alternative control and treatment schemes that yield various levels of effluent quality are presented with tabulations that describe the effluent quality for each subcategory.

Primary Aluminum. The various alternative levels of treatment for new sources include:

1. Recycle of contact cooling with a blowdown combined with the cryolite stream for treatment by chlorine oxidation and lime precipitation;
2. Filtration and activated alumina added to level 1;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2.

The control techniques applicable to primary aluminum plants are the elimination of potline scrubbing, paste plant scrubbing and anode bake plant scrubbing wastewater by the use of baghouses or dry scrubbing. Additionally, by the use of the best hooding and primary control techniques, the need for secondary (potroom) scrubbing can be eliminated. Possible new source standards for these operations are zero discharge of pollutants. Possible new source standards for contact cooling water and cryolite recovery are the same as for BAT.

Secondary Aluminum. The various levels of treatment include:

1. Complete recycle of slag milling water following sedimentation, and lime precipitation;
2. Filtration added to level 1;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2.

Possible new source standards for chlorine demagging scrubber process wastewater are the same as for BAT for this operation. Possible new source standards for the other operations are zero discharge of pollutants.

Primary Columbium-Tantalum (Ore to Salt). The alternative levels of treatment include:

1. Steam stripping and chlorine oxidation of the high ammonia streams;
2. Chemical precipitation and filtration of the combined streams;
3. Activated alumina added to level 2;
4. Reverse osmosis and complete recycle added to level 3; and
5. Activated carbon added to level 3.

Possible new source standards are the same as for BAT.

Primary Columbium-Tantalum (Salt to Metal). The alternative levels of treatment include:

1. Chemical precipitation;
2. Filtration added to level 1;
3. Activated alumina added to level 2;
4. Reverse osmosis and complete recycle added to level 3; and

5. Activated carbon added to level 3.

Possible new source standards corresponding to alternatives 2, 3 and 5 are the same as for BAT alternatives 1, 2 and 3. Possible new source standards for alternative 4 are zero discharge of pollutants.

Primary Copper (Smelting). The alternative levels of treatment include:

1. Primary settling of the scrubber water with the supernatant combined with the cooling water followed by chemical precipitation, filtration and recycle;
2. Activated alumina added to level 1, followed by recycle;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2, followed by recycle.

Possible new source standards for this subcategory are zero discharge of pollutants.

Primary Copper (Refining). The alternative levels of treatment include:

1. Recycle of contact cooling water with a blowdown treated by chemical precipitation, filtration and recycle;
2. Activated alumina added to level 1, followed by recycle;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2, followed by recycle.

Possible new source standards for alternatives 1 and 4 are the same as for BAT alternatives 2 and 3. Possible new source standards for alternative 3 are zero discharge of pollutants.

Secondary Copper. The alternative levels of treatment include:

1. Primary settling of the slag milling water, with the supernatant combined with the contact cooling water for treatment by chemical precipitation;
2. Filtration is added to level 1; and
3. Storage in a holding tank for complete recycle.

Possible new source standards are zero discharge of pollutants, the same as for BAT.

Primary Lead. Possible new source standards are zero discharge of pollutants. All wastewater, apart from acid plant blowdown, can be eliminated.

Secondary Lead. The various alternative levels of treatment include:

1. Chemical precipitation and filtration;
2. Activated alumina added to level 1;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2.

Possible new source standards are the same as for BAT.

Secondary Silver (Photographic). The treatment levels for this subcategory include:

1. Steam stripping of the high ammonia streams;
2. Chemical precipitation of the combined streams;
3. Filtration added to level 2; and
4. Activated carbon added to level 3.

Possible new source standards for electrolytic refining and casting are zero discharge of pollutants. For the other operations, possible new source standards are the same as for BAT.

Secondary Silver (Non-Photographic). The alternative levels of treatment include:

1. Steam stripping of the high ammonia streams;
2. Chemical precipitation and filtration of the combined streams; and
3. Activated carbon added to level 2.

Possible new source standards for electrolytic refining and casting are zero discharge of pollutants. For the other operations, possible new source standards are the same as for BAT.

Primary Tungsten (Ore to Salt). The various alternative treatment levels are:

1. Steam stripping;
2. Chemical precipitation and filtration added to level 1;
3. Reverse osmosis and complete recycle added to level 2, and
4. Activated carbon added to level 2.

Possible new source standards are the same as for BAT.

Primary Tungsten (Salt to Metal). The levels of treatment for this subcategory are:

1. Steam stripping;

2. Chemical precipitation added to level 1;
3. Filtration added to level 2; and
4. Activated carbon added to level 3.

Possible new source standards are the same as for BAT.

Primary Zinc. The levels of treatment for this subcategory are:

1. Chemical precipitation;
2. Filtration added to level 1;
3. Reverse osmosis and complete recycle added to level 2; and
4. Activated carbon added to level 2.

For electrolytic plants, possible new source standards corresponding to alternatives 2, 3 and 4 are the same as for BAT alternatives 1, 2 and 3. For pyrolytic and electrothermic plants, possible new source standards are zero discharge.

Metallurgical Acid Plants. The alternative treatment and control levels for this subcategory, and the corresponding possible new source standards, are the same as for BAT.

# SECTION XII

## ACKNOWLEDGEMENTS

The author is grateful to the hundreds of people that have assisted in the development of this report. It is not possible to acknowledge all of them by name, but some who have been especially helpful are recognized below.

Mr. Ernst Hall of the Effluent Guidelines Division who provided project guidance and valuable insights throughout the study.

The personnel of Sverdrup & Parcel and Associates, particularly Dr. James Buzzell, Dr. Donald Washington and Mr. Garry Aronberg, who directed and performed much of the work associated with this study.

Ms. Ellen Gonter and Ms. Linda Deans of the Analytical Services Laboratory of NUS Corporation.

Mr. Jack Eagan of Vulcan Materials Company and the Aluminum Recycling Association, and Mr. Seymour G. Epstein of the Aluminum Association.

We acknowledge with appreciation the hundreds of nonferrous metals industry personnel who completed data collection portfolios and assisted during sampling visits.

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☆U.S. GOVERNMENT PRINTING OFFICE: 1979-300-947/6443