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INTERIM FINAL

Supplement For

PRETREATMENT

to the

Development Document

for the

PETROLEUM REFINING INDUSTRY

Existing Point Source Category

U.S. ENVIRONMENTAL PROTECTION AGENCY

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INTERIM FINAL SUPPLEMENT
FOR
PRETREATMENT
TO THE DEVELOPMENT DOCUMENT
FOR THE
PETROLEUM REFINING INDUSTRY
EXISTING POINT SOURCE CATEGORY

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ABSTRACT

This development document presents the findings of an extensive study of the existing source pretreatment segment of the petroleum refining industry for the purposes of developing pretreatment standards pursuant to Section 307(b) of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500). This document is a supplement to the "Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Petroleum Refining Point Source Category" (April, 1974). Interim final pretreatment standards are present for the industrial segment discharging to publicly owned treatment works (POTW).

The interim final pretreatment standards contained herein are based upon treatment technologies analogous to the application of best practicable control technology currently available (BPCTCA). Selection of pollutant parameters included an evaluation of potential for pass through or interference with the operation of POTW. Supporting data and rationale for the development of the interim final pretreatment standards are contained in this development document.

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SECTION I

CONCLUSIONS

There are presently 26 refineries that have been identified whose process wastewater is discharged to municipal treatment systems. Generally, the geographic distribution of these indirect dischargers is similar to that of the industry as a whole, with the majority being located in California and Texas. Analyses of location, age, economic status, size, wastewater characteristics, and manufacturing processes of indirect versus direct dischargers shows that there are no fundamental differences that would warrant a different method of subcategorization for the indirect discharging segment of the petroleum refining industry. It was determined in this study that the subcategorization scheme for indirect dischargers should be the same as defined in the 1974 Development Document (3). This subcategorization scheme is as follows:

A - Topping;
B - Cracking;
C - Petrochemical;
D - Lube; and
E - Integrated.

Quantitative data describing the effluent characteristics of indirect discharging refineries, industry-wide API separator effluent characteristics, and sour water stripper effluent characteristics were collected and are presented in Section V of this document. The criteria for selection of pollutants to be considered in this study included the ability of a particular pollutant to interfere with or pass through a publicly owned treatment works (POTW). Upon analyses of the available data, the following pollutant parameters were selected for further study:

Ammonia;
Sulfide;
Oil and Grease;
Phenol; and
Chromium

It is concluded that all indirect dischargers should be subject to the same pretreatment standards. Pretreatment standards are imposed on a concentration basis as compared to a mass basis characteristic of effluent limitations and standards of performance for new sources for the petroleum refining point source category (direct dischargers). Additionally, the pollutants of concern for pretreatment purposes are common to all refineries' wastewaters. The treatment technologies available for controlling these pollutants are applicable to refinery wastes in general.

Information on the control and treatment technologies presented in the 1974 Development Document included discussions of the capability of removing the pollutants selected for regulation. This same approach has been applied to the indirect discharging segment of the petroleum refining industry in this document. The technologies discussed herein consider those processes capable of removing pollutant parameters selected for further study (sulfides, ammonia, phenols, oil and grease, and chromium). Analyses of the available data confirm that the major source of ammonia, sulfide, and phenol is the sour water waste stream. Therefore, segregation and treatment of sour waters are of immediate concern relative to pretreatment. Discussion of other significant wastewater sources is also presented in this document. The sources and concentrations of the selected pollutants are generally equivalent between subcategories; therefore, available treatment technologies are applicable to all subcategories.

Based on the effluent data collected, the available control and treatment technologies, and the effect of each pollutant parameter on POTW operations, it was concluded that pretreatment standards should be established for ammonia and oil and grease. Uniform national pretreatment standards for phenol, sulfide, and chromium were judged at this time to be inappropriate for all indirect dischargers. However, this document provides guidance to the operators of POTW relative to chromium, sulfides, and phenolic compounds should these be determined, on an individual basis, to be harmful to or not adequately treated by POTW.

The indirect discharging segment of the industry has been specifically identified relative to their current pretreatment operations. Therefore, total costs for implementation of pretreatment standards have been estimated based on a plant-by-plant evaluation. Model plant evaluations have been utilized to supplement this approach where necessary. The estimated total capital costs for all indirect discharging refineries are summarized by pollutant parameter as follows:

Ammonia	$3,560,000
Oil and Grease	2,370,000
Total	$ 5,930,000

These estimates represent maximum costs that would be experienced if it were necessary that all indirect discharging refineries not having pretreatment technology in-place install facilities for ammonia and secondary oil removal. In actuality, the economic impact of pretreatment standards on the industry should be significantly less than the total costs shown, since many refineries may not require additional facilities in order to meet pretreatment standards for these parameters. It is not anticipated that any serious energy impact or non-water quality environmental impact will result from the implementation of the recommended pretreatment standards.

SECTION II

RECOMMENDATIONS

PRETREATMENT STANDARDS FOR EXISTING SOURCES

It is recommended that the following be established as the pretreatment standards for existing sources within the petroleum refining point source category. They should be applicable to discharges to publicly owned treatment works (POTW) from petroleum refineries, including refineries within the Topping subcategory (subcategory A), the Cracking subcategory (subcategory B), the Petrochemical subcategory (subcategory C), the Lube subcategory (subcategory D), and the Integrated subcategory (subcategory E).

Pretreatment Standards for Existing Sources within the Petroleum Refining Point Source Category (Subparts 419.14, 419.24, 419.34, 419.44, and 419.54)

For the purpose of establishing pretreatment standards under Section 307(b) of the Act for a source within the petroleum refining point source category, the provisions of 40 CFR 128 shall not apply. The recommended pretreatment standards for an existing source within the petroleum refining point source category are set forth below.

(a) No pollutant (or pollutant property) introduced into a publicly owned treatment works shall interfere with the operation or performance of the works. Specifically, the following wastes shall not be introduced into the publicly owned treatment works:

(1) Pollutants which create a fire or explosion hazard in the publicly owned treatment works.

(2) Pollutants which will cause corrosive structural damage to treatment works, but in no case pollutants with a pH lower than 5.0, unless the works is designed to accommodate such pollutants.

(3) Solid or viscous pollutants in amounts which would cause obstruction to the flow in sewers, or other interference with the proper operation of the publicly owned treatment works.

(4) Pollutants at either a hydraulic flow rate or pollutant flow rate which is excessive over relatively short

time periods so that there is a treatment process upset and subsequent loss of treatment efficiency.

(b) In addition to the general prohibitions set forth in paragraph (a) above, the following pretreatment standard establishes the quality or quantity of pollutants or pollutant properties controlled by this subsection which may be introduced into a publicly owned treatment works by a source subject to the provisions of this subpart.

Pollutant or Pollutant Property	Pretreatment Standard
	Maximum for any one day (milligrams per liter)
Ammonia (as N)	100
Oil and grease	100

(c) Any owner or operator of any source to which the pretreatment standards required by paragraph (a) above are applicable, shall be in compliance with such standards upon the effective date of such standards. The time for compliance with standards required by paragraph (b) above shall be within the shortest time but not later than three years from the effective date of such standards.

Guidance to Assist Local Authorities in Implementing Pretreatment Standards for Existing Sources within the Petroleum Refining Point Source Category (Subparts 419.14, 419.24, 419.34, 419.44 and 419.54) in those Individual Cases Where Chromium, Sulfides, or Phenol are Found to Have a Detrimental Effect on POTW

Should it be determined on an individual basis by local authority that sulfides, phenol, or chromium discharged from petroleum refineries have a significant detrimental effect on a POTW, by creating either upset or pass-through problems, the following limitations can be achieved by the application of existing technology. These limitations are meant to serve as guidance to assist local authorities in dealing with their individual problems.

Pollutant or Pollutant Property	Guidance Standard
	Maximum for any one day

	(milligrams per liter)
Total Chromium	1.0
Sulfides	3.0
Phenol	0.35

SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

The Federal Water Pollution Control Act Amendments of 1972 (the "Act") were designed by Congress to achieve an important objective -- to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Primary emphasis for attainment of this goal is placed upon technology-based regulations. Industrial point sources which discharge into navigable waters must achieve limitations based on best practicable control technology currently available (BPCTCA) by July 1, 1977, and best available technology economically achievable (BATEA) by July 1, 1983, in accordance with sections 301(b) and 304(b) of the Act. New sources must comply with new source performance standards (NSPS) based on best available demonstrated control technology under section 306 of the Act. Publicly owned treatment works (POTW) must meet "secondary treatment" by 1977 and best practicable waste treatment technology by 1983 in accordance with sections 301(b), 304(d), and 201(g) (2) (A) of the Act.

Users of POTW also fall within the statutory scheme as set forth in section 301(b). Such sources must comply with pretreatment standards promulgated pursuant to section 307.

Sections 307(b) and (c) are the key sections of the Act with regard to pretreatment. The intent is to require treatment at the point of discharge complementary to the treatment performed by the POTW. Duplication of treatment is not the goal; as stated in the Conference Report (H.R. Rept. No. 92-1465, page 130), "In no event is it intended that pretreatment facilities be required for compatible wastes as a substitute for adequate municipal waste treatment works." On the other hand, pretreatment by the industrial user of a POTW of pollutants which are not susceptible to treatment in a POTW is absolutely critical to attainment of the overall objective of the Act. Pretreatment of pollutants can serve two useful functions -- protecting the POTW from process upset or other interference and preventing discharge of pollutants which would pass through or otherwise remain untreated after treatment at such works. Thus, the fact that an industrial source utilizes a POTW does not relieve it of substantial obligations under the Act.

Section 307(b) of the Act requires the Administrator to promulgate regulations establishing pretreatment standards for the introduction of pollutants into treatment works which are publicly owned for those pollutants which are determined not to be susceptible to treatment by such treatment works, or which would interfere with the operation of such treatment works. Pretreatment standards established under this section shall be established to prevent the discharge of any pollutant through treatment works which are publicly owned which pollutant interferes with, passes through, or otherwise is incompatible with such works.

Section 307(c) provides that the Administrator shall promulgate pretreatment standards for any source which would be a new source subject to section 306 if it were to discharge pollutants to navigable waters. The promulgation of pretreatment standards for new sources is to be simultaneous to the promulgation of standards of performance under section 306 for the equivalent category of new sources. Such pretreatment standards shall prevent the discharge of any pollutant into such treatment works which pollutant may interfere with, pass through, or otherwise be incompatible with such works.

The purpose of this study was to obtain data on that portion of the petroleum refining industry that utilizes POTW as part of its waste management program. Specifically, the study sought to obtain definitive information from the literature, to analyze previous reports relative to the petroleum industry published by the Effluent Guidelines Division of EPA and the National Commission on Water Quality, and to obtain further detailed information through visits of representative plants discharging their effluents to POTW. The data obtained in this manner provided the basis for pretreatment standards for that segment of the industry utilizing POTW (i.e., the indirect discharging segment).

PRETREATMENT STANDARDS DEVELOPMENT PROCEDURE

The information presented in this document relative to petroleum refineries which are indirect dischargers was developed in the following manner.

The 1974 Development Document and the associated supplemental information were reviewed. The indirect discharging segment of the petroleum refining industry was identified through an inventory of refineries discharging to POTW (Table III-1). Data on these plants, including process unit operations (Table IV-1), wastewater characteristics

TABLE III-1

INVENTORY OF PETROLEUM REFINERIES DISCHARGING TO MUNICIPAL SYSTEMS

	POTW (Publicly Owned Treatment Works)
EPA Region IV	
Delta Refining Co., Memphis, Tenn.	Memphis (south) Wastewater Treatment Plant
EPA Region V	
Ashland Petroleum Co., Findlay, Ohio	Findlay Wastewater Treatment Plant
Clark Oil & Refining Corp., Blue Island, Ill.	Chicago MSD - Calumet Plant
EPA Region VI	
Atlantic Richfield Co., Houston, Tex	Gulf Coast Waste Disposal Authority*
Crown Central Petroleum Corp., Houston, Tex.	Gulf Coast Waste Disposal Authority*
LaGloria Oil & Gas Co., Tyler, Tex.	City of Tyler Sewer System - West Plant
Pride Refining, Inc., Abilene, Tex.	Abilene Wastewater Reclamation Plant
Quintana-Howell, Corpus Christi, Tex.	Corpus Christi Wastewater Treatment Works - West Plant
EPA Region VII	
Derby Refining Co., Wichita, Kan.	Wichita Sewage Treatment Plant
EPA Region VIII	
Amoco Oil Co., Salt Lake City, Utah	Salt Lake City Wastewater Reclamation Plant
Husky Oil Co., North Salt Lake, Utah	South Davis County - S. Plant
EPA Region IX	
Atlantic Richfield Co., Carson, Cal.	L.A. County Sanitary District (LACSD)
Douglas Oil Co. of Cal., Paramount, Cal.	(Joint Water Pollution Control Plant)
Edgington Oil Co., Long Beach, Cal.	"
Fletcher Oil & Refining Co., Carson, Cal.	"
Golden Eagle Refining Co., Carson, Cal.	"
Powerine Oil Co., Santa Fe Springs, Cal.	"
Shell Oil Co., Wilmington, Cal.	"
Texaco, Inc., Wilmington, Cal.	"
Union Oil Co. of Cal., Los Angeles, Cal.	"
Lunday-Thagard Oil Co., South Gate, Cal.	"
MacMillan Ring-Free Oil Co., Long Beach, Cal.	"
Mobil Oil Corp., Torrence, Cal.	"
Gulf Oil Co., Santa Fe Springs, Cal.	Los Coyotes Water Renovation Plant (LACSD)
Beacon Oil Co., Hanford, Cal.	Hanford Municipal System
EPA Region X	
Standard Oil of Cal., Portland, Ore.	City of Portland Sewer System

NOTE: Inventory excludes those refineries with only sanitary sewer connections to POTW's.

*GCWDA treats only industrial wastewaters (total plant, raw waste, and major waste streams - Tables V-1, 2, and 3), and pretreatment operations (Table VII-1) were then obtained. POTW receiving refinery wastewater (excluding those receiving only sanitary wastes) were identified and characterized in terms of location (Table III-1), flow, pretreatment operations, and refinery pretreatment requirements (Table VII-2).

This additional information was obtained from a literature search and from direct contact with representatives of industry and the respective municipalities. Twenty-six indirect discharging refineries were identified (see Table III-1). Eleven of these indirect discharging refineries were visited. Representatives of the remaining 15 were contacted by telephone. A visit was made to the County Sanitation Districts of Los Angeles County which receive the effluent from 12 of the 26 refineries that discharge to POTW. Representatives of other refineries (direct discharge refineries) and representatives of the EPA and State and local agencies were also contacted in this endeavor.

The indirect discharging segment was studied to determine whether separate pretreatment standards were appropriate for the different subcategories within the point source category. This analysis included a review of the data base developed as background to the 1974 Development Document and of the newly aquired data to determine whether differences in raw materials used, products produced, manufacturing processes employed, equipment employed, age and size of the facilities, wastewater constituents, or other factors would require development of separate pretreatment standards for different subcategories within the point source category.

The raw waste characteristics of the indirect discharging segment were identified and included in the analysis. The analysis included consideration of: 1) the sources and volume of water used in the processes employed and the sources of pollutants and wastewaters in the refinery, and 2) the constituents of all wastewaters generated at indirect discharging refineries. The constituents of wastewaters to be considered for pretreatment standards were identified.

The full range of control and pretreatment technologies existing within the point source category were identified. This included identification of each distinct control and treatment technology, including an identification in terms of the amounts of constituents and the chemical, physical, and biological characteristics of pollutants, and of the effluent level resulting from the application of each of the pretreatment and control technologies. The problems, limitations, and reliability of each treatment and control technology and the required implementation time were also identified. In addition, the nonwater quality environmental impacts, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, and noise were also identified. The energy requirements of each control and treatment technology were identified as well as the cost of the application of such technology.

The information gathered and the analysis of this information form the basis of the pretreatment standards presented in Section IX of this document. The goal of this study was to develop pretreatment standards on a technology-basis. The study centered on technology currently in use and readily available to the industry for the purpose of controlling selected pollutant parameters which interfere with, are inadequately treated by, or pass through POTW.

GENERAL DESCRIPTION OF THE INDUSTRY SEGMENT UTILIZING POTW

That portion of the petroleum refining industry which discharges to municipal treatment systems represents approximately 10 percent of the total number of refineries in the United States. These plants are generally similar to those representative of the industry as a whole, with the exception of the feasibility of indirect discharge due to plant location (accessibility to a POTW). A general description of the entire industry is contained in the 1974 Development Document (see pages 14-54 of the 1974 Development Document) and is equally applicable to both direct and indirect dischargers.

SECTION IV

INDUSTRY SUBCATEGORIZATION

INTRODUCTION

The petroleum refining point source category was subcategorized during the development of effluent limitations and guidelines and new source performance standards (see the 1974 Development Document). The subcategorization is process oriented; the delineation between subcategories is based upon raw waste load characteristics in relation to the complexity of refinery operations. It is identified in the 1974 Development Document (3) as follows:

Subcategory	Basic Refinery Operations Included
A - Topping	Topping and catalytic reforming whether or not the facility includes any other process in addition to topping and catalytic reforming. This subcategory is not applicable to facilities which include thermal processes (coking, visbreaking, etc.) or catalytic cracking.
B - Cracking	Topping and cracking, whether or not the facility includes any processes in addition to topping and cracking, unless specified in one of the subcategories listed below.
C - Petrochemical	Topping, cracking, and petrochemical operations, whether or not the facility includes any process in addition to topping, cracking and petrochemical operations,* except lube oil manufacturing operations.

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*The term "petrochemical operations" shall mean the production of second generation petrochemicals (i.e., alcohols, ketones, cumene, styrene, etc.) or first generation petrochemicals and isomerization products (i.e., BTX, olefins, cyclohexane, etc.) when 15% or more of refinery production is as first generation petrochemicals and isomerization products.

D - Lube	Topping, cracking and lube oil manufacturing processes, whether or not the facility includes any process in addition to topping, cracking and lube oil manufacturing processes, except petrochemical (*see note on previous page) and integrated operations.
E - Integrated	Topping, cracking, lube oil manufacturing, and petrochemical operations, whether or not the facility includes any processes in addition to topping, cracking, lube oil manufacturing, and petrochemical operations (*see note on previous page).

In developing pretreatment standards for the industry, a comparison of characteristics of indirect dischargers with those of the industry as a whole was made to determine whether or not the subcategorization presented above is applicable to those refineries discharging wastewaters to POTW. The factors considered were:

1. Refinery characteristics
2. Volume and characteristics of wastewater
3. Manufacturing processes employed

FACTORS CONSIDERED IN SUBCATEGORIZATION

Refinery Characteristics

Within the United States, petroleum refineries are concentrated in areas of major crude production (Texas, California, Louisiana, Oklahoma, Illinois, Kansas) and in major population areas (Illinois, Indiana, New Jersey, Ohio, Texas, California). Of the total of 256 operating refineries as of January 1, 1976 (19), 26 refineries were identified that discharge process waste waters to POTW. As shown in Figure IV-1, the geographic distribution of these indirect discharging refineries is similar to that of the industry as a whole, with the majority being located in California and Texas. It is therefore concluded that geographic location is not a significant factor affecting subcategorization.

Most indirect discharging refineries surveyed were first constructed decades ago, as is the case with many facilities throughout the industry. Initial construction, however, is a meaningless characteristic for comparison, since additions to and modifications of existing refineries are the

FIGURE IV-1

GEOGRAPHIC DISTRIBUTION
OF REFINERIES

industry's principal form of expansion. The age of existing plants does not determine either the volume or the quality of wastewater discharged to a POTW and, therefore, is not a valid factor affecting subcategorization.

During the technical study, no general trend was recognized in terms of the economic stature of refineries discharging to municipal treatment systems. There is no reasonable basis for assuming that refineries utilizing POTW for disposal of wastes are significantly different economically than their counterparts that discharge wastewaters directly to navigable waters. (The economic study, which parallels the technical study, has determined that even with the implementation of pretreatment standards for ammonia and oil and grease, indirect discharging refineries have a competitive advantage over direct discharging refineries. See <u>Federal Register</u>, Vol. 42, No. 56, March 23, 1976, p. 15685).

The combined crude throughput of indirect dischargers amounts to about 10% of the 15.7 million barrels/day total capacity of all U.S. petroleum refineries operating in 1976(19). These range in size from a small, 5000 bbl/day topping facility to a large, integrated complex with a 233,500 bbl/day capacity. Table IV-1 indicates that the size distribution of indirect discharging facilities is approximately the same as that for the industry as a whole.

<u>Volume and Characteristics of Wastewater</u>

During the development of effluent limitations for the petroleum refining point source category, it was determined that raw waste loading was the most significant factor affecting subcategorization (see 1974 Development Document at pages 56-62). The 1972 "Petroleum Industry Raw Waste Load Survey" (1) provides a useful tool for comparing raw wastewater characteristics between direct and indirect dischargers. The 1972 study included a survey of API separator effluents from 135 refineries. Table IV-2 presents information obtained in that survey for refineries within the Cracking subcategory (subcategory B). A comparison of median raw waste load values for the identified indirect dischargers to those for the total industry indicates a close similarity for certain key parameters--flow (gal/bbl crude), TOC, oil and grease, and sulfide. Recognizing the limited quantity of data available, the data tend to confirm that raw waste water quality for indirect dischargers does not differ in any significant way from that of the entire industry. A further comparison with raw waste load data gathered for the

TABLE IV-1

DISTRIBUTION OF REFINERIES
BY CRUDE CAPACITY

	Crude Capacity (1000 bbl/day)		
	≤40	40-100	≥100
Indirect Dischargers:			
Number of refineries	13	7	6
Percentage of total	50	27	23
Total Industry*:			
Number of refineries	139	68	49
Percentage of total	54	27	19

*Reference 19

TABLE IV-2

API SEPARATOR EFFLUENT CHARACTERISTICS
FOR SUBCATEGORY B-CRACKING
INDIRECT DISCHARGE REFINERIES
VS.
TOTAL INDUSTRY
(Reference #26)

Indirect Discharge Refinery Code	Effluent Volume		API Separator Effluent Load (lbs./day per 1000 bbl. crude)							
	Total MGD	Gal./Bbl Crude	BOD(5)	COD	TOC	O&G	Phenolics	Sulfide	Chromium	Ammonia
2	7.96	85.82	-	-	-	-	22.21	0.18	-	21.63
3	3.35	47.86	255.95	598.88	140.34	38.35	12.66	0.03	0.18	127.77
7	3.46	26.62	365.37	1432.58	89.23	203.20	0.60	0.40	0.45	103.95
10	0.48	11.21	67.41	211.15	21.44	13.74	17.69	0.00	0.00	56.16
15	0.08	6.93	2.17	17.84	4.12	3.82	0.37	0.03	0.12	0.86
17	0.25	24.49	329.97	590.95	6.45	3.31	3.58	17.48	0.00	3.36
18	1.22	32.71	42.69	148.86	46.67	4.72	0.66	14.22	-0.05	1.56
19	0.22	8.46	-	0.03	20.19	12.00	1.83	0.42	0.01	6.45
25	3.41	36.54	57.99	131.78	20.24	2.81	15.47	1.82	7.68	48.24
4	4.96	55.73	164.48	565.55	73.48	22.68	43.05	0.00	0.13	38.25
Median	2.28	29.67	115.95	211.15	21.44	12.00	8.12	0.29	0.12	34.94
Total Industry										
Median	1.31	40.73	37.96	105.29	18.21	14.52	1.66	0.34	0.03	7.86

establishment of effluent limitations (see Development Document, Table 19, page 65) shows that the data for indirect discharging refineries (Table IV-2) are within the range of values anticipated. Although no comparable data were obtained during this study from indirect dischargers within other subcategories, it is not expected that raw waste water quality will differ in any significant way from that of the industry as a whole. It is expected that additional data will be available to enable further evaluation as a result of the BATEA review for the petroleum refining industry which is being conducted as a result of the order of the U.S. District Court for the District of Columbia entered in Natural Resources Defense Council, et al., v. Train, 8 E.R.C. 2120 (D.D.C. 1976).

Manufacturing Processes Employed

Today's petroleum refinery is a complex combination of interdependent operations which involve the separation of crude molecular constituents, molecular cracking, molecular rebuilding, and solvent finishing to produce a diverse range of products. As shown in Table IV-3, the distribution of indirect discharge refineries in each subcategory is similar to that for the entire industry. Table IV-4 is a summary of the types of manufacturing processes employed by those refineries identified in this study as discharging wastewaters to POTW. No major differences were identified between the refining methods used by these facilities and those employed by the industry in general.

SUMMARY

The subcategorization presented in the 1974 Development Document (3) allows for the definition of logical segments within the refining industry based on factors which affect raw waste load. Further analysis of these factors has shown that there are no fundamental differences between the indirect discharging portion of the industry and the petroleum refining industry as a whole. Therefore, the same method of subcategorization can be used to characterize those refineries discharging to POTW.

TABLE IV-3

DISTRIBUTION OF REFINERIES
BY SUBCATEGORY

	Subcategory				
	A	B	C	D	E
Indirect Dischargers:					
Number of refineries	10	13	2	0	1
Percentage of total	38	50	8	0	4
Total Industry*:					
Number of refineries	96	111	19	22	8
Percentage of total	38	43	7	9	3

*References 19,29

TABLE IV-4

PROCESS SUMMARY
INDIRECT DISCHARGE REFINERIES

Refinery	Region	Sub-Category	Refinery Capacity 1000 bbl/day	Crude Processes 1000 bbl/day	Cracking Processes 1000 bbl/day	Lube Processes 1000 bbl/day	Asphalt Production 1000 bbl/day	Data Source
Standard Oil Co. of Cal. Portland, Ore.	10	A	15.0	D 15.0 A 15.0 V 15.0			8.6	3,29
Union Oil Co. of Cal. Los Angeles, Cal.	9	B	111.0	D 86.0 A 111.0 V 83.0	F 52.0 H 21.0 V 20.0		10.0	3
Texaco Inc. Wilmington, Cal.	9	B	75.0	D 22.0 A 75.0	D 48.0 F 28.0 H 20.0			3,29
Shell Oil Co. Wilmington, Cal.	9	B	101.0	D 101.0 A 101.0 V 60.0	D 37.0 F 40.0	C 7.8 D 24.3 E 1.8 G 18.6 M 7.8		3, RC
Powerine Oil Co. Santa Fe Springs, Cal.	9	B	44.0	D 44.0 A 44.0 V 15.0	F 12.0		5.0	3,19,RC
Mobil Oil Corp. Torrance, Cal.	9	B	123.5	D 100.0 A 123.5 V 95.0	D 46.6 F 56.0 H 18.0 V 16.0			3,RC
MacMillan Ring-Free Oil Co. Long Beach, Cal.	9	A	12.2	A 12.2 V 12.2				19,29
Lunday-Thagard Oil Co. South Gate, Cal.	9	A	5.0	D 5.0 A 5.0 V 3.0			2.15	19,29,RC
Gulf Oil Co. Santa Fe Springs, Cal.	9	B	53.8	D 53.8 A 53.8 V 25.0	F 13.8 H 11.0 V 13.8		4.0	3
Golden Eagle Refining Co. Carson, Cal.	9	A	15.0	D 15.0 A 15.0				19,29,RC
Fletcher Oil & Refining Co. Carson, Cal.	9	A	20.0	D 20.0 A 20.0				19
Edgington Oil Co. Long Beach, Cal.	9	A	30.0	D 30.0 A 30.0 V 19.0			12.0	19,29

TABLE IV-4 (Cont.)

Refinery	Region	Sub-Category	Refinery Capacity 1000 bbl/day	Crude Processes 1000 bbl/day	Cracking Processes 1000 bbl/day	Lube Processes 1000 bbl/day	Asphalt Production 1000 bbl/day	Data Source
Douglas Oil Co. of Cal. Paramount, Cal.	9	A	46.5	D 46.5 A 46.5 V 21.0			18.0	19,29,RC
Beacon Oil Co. Hanford, Cal.	9	B	12.4	D 12.4 A 12.4	G 0.5 V 2.75			3,19,29
Atlantic Richfield Co. Carson, Cal.	9	C	186.4	D 186.4 A 186.4 V 93.0	D 30.0 F 65.0 G 12.5 H 19.7 V 42.0			3,29,RC
Husky Oil Co. North Salt Lake City, Utah	8	B	24.0	D 24.0 A 24.0 V 4.6				3,19,RC
Amoco Oil Co. Salt Lake City, Utah	8	B	39.0	D 39.0 A 39.0	F 22.0		2.5	3
Derby Refining Co. Wichita, Kan.	7	B	27.65	D 27.65 A 27.65 V 8.8	D 3.8 T 12.55			3,19
Quintana-Howell Corpus Christi, Tex.	6	A	44.5	D 44.5 A 44.5				3,19
Pride Refining Inc. Abilene, Tex.	6	A	37.96	D 37.96 A 37.96				3,19
LaGloria Gas & Oil Co. Tyler, Tex.	6	B	29.7	D 29.7 A 29.7	D 12.0 F 15.0 G 3.0			3,19
Crown Central Petroleum Corp. Houston, Tex.	6	B	103.0	D 103.0 A 103.0 V 38.0	D 9.5 F 52.0			3
Atlantic Richfield Co. Houston, Tex.	6	E	233.5	D 233.5 A 233.5 V 70.0	D 27.0 F 74.0 H 4.5	A 5.2 C 3.4 D 0.6 G 4.0 Q 6.2		3
Clark Oil & Refining Corp. Blue Island, Ill.	5	C	70.0	D 70.0 A 70.0 V 27.0	F 25.0 H 11.0		4.5	3
Ashland Petroleum Co. Findlay, Ohio	5	A	21.0	D 21.0 A 21.0 V 8.0			6.5	19,29
Delta Refining Co. Memphis, Tenn.	4	B	44.8	D 44.8 A 44.8 V 15.0	F 12.0 T 12.0		8.0	3,19,29

LEGEND

Crude Processes
- D - Desalting
- A - Atmospheric distillation
- V - Vacuum distillation

Cracking Processes
- D - Delayed coking
- F - Fluid catalytic cracking
- G - Gas-oil cracking
- H - Hydrocracking
- T - Thermal cracking
- V - Visbreaking

Lube Processes
- A - Lube hydrofining
- C - Propane - dewaxing, deasphalting
- D - Duo sol, solvent dewaxing
- E - Lube vac. tower, wax tract.
- G - MEK dewaxing
- M - Furfural extraction
- Q - Phenol extraction

Data Source
- RC - Refinery contact

SECTION V

WASTE CHARACTERIZATION

INTRODUCTION

The purpose of this section of the document is to present quantitative data which describe the effluent characteristics of petroleum refineries which discharge to POTW. In addition, available data on API separator effluent characteristics from all petroleum refineries are included. Finally, sour water stripper effluent characteristics are discussed; this waste stream represents a major source of pollutants which may pass through or interfere with municipal treatment plants. Figure V-1 is a schematic diagram of the relationship of the waste characterization data presented herein.

PRETREATMENT EFFLUENT CHARACTERISTICS

Table V-1 is the summary of available effluent data collected either from representatives of the indirect discharging refineries or the receiving POTW, as indicated. This table includes all pertinent data obtained on indirect dischargers in the industry. It represents the results of specific data requests (in most cases by both telephone and formal letter) to the refineries and/or the receiving POTW listed in the inventory (Table III-1). The data presented is as received from the refinery or the POTW; verification sampling has not been conducted because of the time constraints imposed on completion of this study.

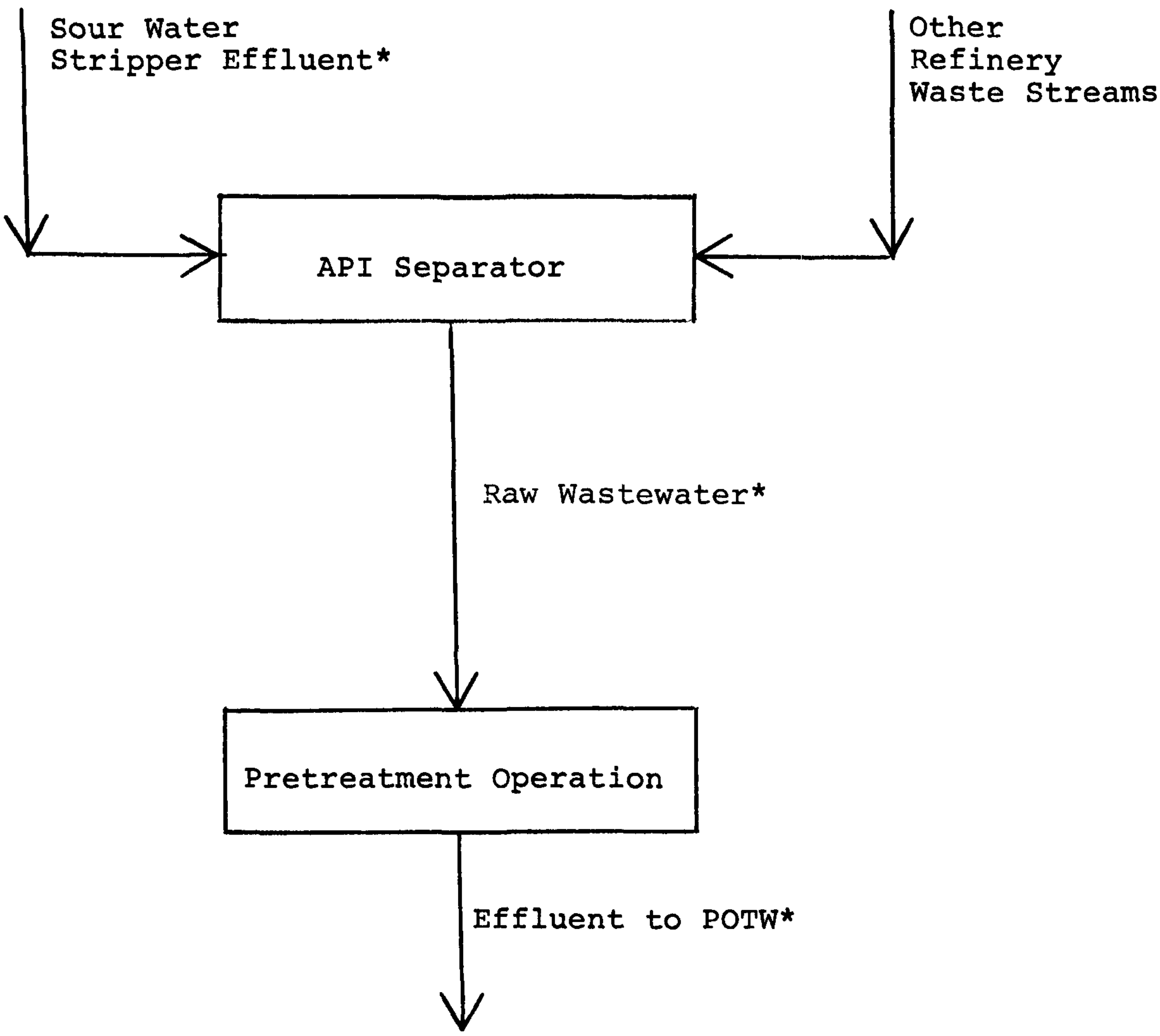
Data collected on the effluent from indirect discharging refineries within the Topping subcategory (subcategory A) are characterized from Table V-1 as follows:

	Max	Min	Median	# of Plants Reporting
Flow (MGD)	.258	.006	0.127	6
BOD5 (mg/l)	323	205	I.D.	1
COD (mg/l)	905	71	275	6
TOC (mg/l)	No Data			
O&G (mg/l)	195	.8	32	6
Phenolics (mg/l)	63.4	LT .05	1.96	6
Sulfides (mg/l)	75.3	LT .01	0.05	6
Total Chromium (mg/l)	8	LT.005	0.62	6
Ammonia (mg/l)	127	.617	34.0	5

Notes: ID - Insufficient data.
LT - Less than.

FIGURE V-1

WASTE CHARACTERIZATION PROCEDURE
FOR INDIRECT DISCHARGE REFINERIES



*Waste Characterization data described in this section

TABLE V-1

SUMMARY OF INDIRECT DISCHARGE REFINERIES' EFFLUENT DATA

Refinery Code	(1) Flow (MGD)	(2) BOD5 (mg/l)	(3) COD (mg/l)	(4) TOC (mg/l)	(5) O&G (mg/l)	(6) Phenolics (mg/l)	(7) Sulfides (mg/l)	(8) Total Chromium (mg/l)	(9) Ammonia (mg/l)	(10) Comments
Category A - Topping										
8	0.006	-	234	-	128	<0.05	<0.10	<0.20	75	Column #1 from reference 29 Columns #2 - 9 obtained from two quarterly grab samples (POTW)
		-	680	-	80	50	<0.10	2.8	22.4	
14	0.258	-	-	-	-	0.14/0.10/ 4.2/2.5/5.1/ 5.5/0.7	<1.0/<0.05/ <0.05/<0.05/ <0.05/<0.05/ <0.01	-	58/64/67/56/ 86/127/34	Data for Column #1 and the first seven sets of data from individual grab samples (Refinery)
	0.216	-	470	-	135	0.65	<0.01	2.75	34	Data for the last set from a single quarterly grab sample (POTW)
11	0.033	-	200	-	12.1	0.70	<0.1	<0.05	30	All data from individual grab sample analyses-the first furnished by the POTW, and the second and third by the refinery.
	-	-	98	-	7.1	0.25	<0.1	<0.05	17	
	-	-	71	-	0.8	0.50	<0.04	<0.005	23	
21	0.14	205	494		195	-	75.3	8		Column #1-General data (POTW) Columns #2-9 - Individual grab samples (POTW)
		323	905		22.3	3.2	54.6	0.03		
12	0.0432	-	390	-	32	2.0	<0.02	0.66	35	All data from quarterly grab samples (POTW)
	0.0446	-	400	-	11	7.5	<0.02	1.7	28	
	0.0687	-	240	-	49	1.3	<0.02	0.62	9.3	
13	0.127	-	127	-	34.5	1.96	0.78	6	32.3	Two individual grab samples (POTW)
	0.136	-	275	-	11.0	63.4	0.33	<0.01	0.617	
Category B - Cracking										
30	0.604	553	-	-	109.9	10.5-58(33.5)	-	-	-	Data for the first four sets of values from monthly averages (POTW). For Column #6, average in parentheses.
	0.401	525	-	-	87.5	15-33.5(22.0)	-	-	-	
	0.476	657	-	-	73.6	13-60 (32.7)	-	-	-	
	0.323	756	-	-	66.0	16-61 (33.7)	-	-	-	
22	1.42	175	321	-	-	4.1	37.0	-	-	Data for Column #1 from POTW Data for Columns #3, 6, & 7 from monthly averages of weekly (on file) grab samples (POTW) Data for Column #2 from monthly grab samples (POTW)
	-	-	390	-	-	3.7	45.0	-	-	
	-	234	275	-	-	3.5	50.0	-	-	
	-	154	265	-	-	4.5	51.3	-	-	
	-	104	285	-	-	2.9	24.9	-	-	
	-	106	268	-	-	3.2	51.6	-	-	
	-	112	275	-	-	4.1	26.6	-	-	
	-	146	258	-	-	4.14	36.6	-	-	
	-	123	179	-	-	2.75	22.2	-	-	
	-	123	226	-	-	4.15	24.1	-	-	
	-	-	<503	-	-	3.62	23.6	-	-	
	-	-	237	-	-	3.03	47.1	-	-	
	-	167	187	-	-	2.87	2.45	-	-	
19	0.25-0.40		423-1300		14-23(19.5)	11-88 (49.5)	nil	0.03-0.63 (0.33)	32-105(68.5)	All data given only as range (POTW) (Averages by B&R)
18	1.32	58	-	-	25	18	2.9	45	5.9	Data for Column #1 from daily averages for each month. Data for Columns #2, 5, & 8 from monthly grab samples. Data for Columns #6, 7 & (from monthly averages of weekly samples (on file). All data obtained from the refinery.
	1.35	48	-	-	21	19	1.1	56	15.2	
	1.26	42	-	-	19	5	0.4	55	7.2	
	1.78	53	-	-	21	16	0.7	51	8.4	
	1.51	47	-	-	17	15	1.2	48	11.2	
	1.38	56	-	-	10	10	2.7	46	14.0	
	1.32	51	-	-	18	23	1.1	210	-	
	1.40	57	-	-	24	20	0.8	230	3.2	
	1.39	67	-	-	24	16	0.6	330	3.9	
	1.41	70	-	-	25	8.3	0.5	212	5.8	
	1.31	68	-	-	17	6.4	3.0	198	6.0	
	1.57	72	-	-	20	33	16	167	22	

TABLE V-1 (Cont.)

SUMMARY OF INDIRECT DISCHARGE REFINERIES' EFFLUENT DATA

Refinery Code	(1) Flow (MGD)	(2) BOD5 (mg/l)	(3) COD (mg/l)	(4) TOC (mg/l)	(5) O&G (mg/l)	(6) Phenolics (mg/l)	(7) Sulfides (mg/l)	(8) Total Chromium (mg/l)	(9) Ammonia (mg/l)	(10) Comments
Category B - Cracking (Cont.)										
17	0.220	-	-	-	-	0.21	0.21	0.48	5.2	Data for Column #1 from
	-	-	-	-	-	0.31	0.29	0.38	14.0	reference #29.
	-	-	-	-	-	0.45	0.67	0.42	14.0	Data for Column #8 from
	-	-	-	-	-	0.85	0.47	0.39	21.4	monthly grab samples
	-	-	-	-	-	1.5	1.0	-	17.0	(refinery).
	-	-	-	-	-	1.25	1.0	-	11.0	Data for Columns #6, 7 & 9
	-	-	-	-	-	1.4	2.3	0.19	17.0	from monthly averages of
	-	-	-	-	-	1.31	2.4	0.25	17.0	8 samples/month (refinery).
	-	-	-	-	-	1.4	2.4	0.21	18	
	-	-	-	-	-	1.41	2.3	0.29	23	
	-	-	-	-	-	1.44	2.8	0.35	18	
	0.385	75	-	-	37	-	-	-	-	Last flow and Columns
	-	38	-	-	13	-	-	-	-	2 & 4 from POTW.
	-	56	-	-	-	-	-	-	-	
15	0.080	47	-	-	-	-	-	-	-	Data for the first two sets
	0.097	103	-	-	50	0.19	-	0.08	-	from single grab samples
	-	-	-	-	-	8.50	1.00	2.79	20.00	(POTW). Data for the third
										set from information
										supplied by the refinery.
10	0.530	-	746	-	46.7	13.5	-	0.9	51	Data from quarterly grab
	0.480	-	723	-	43	52	<0.1	0.44	57	sample (POTW).
	0.540	-	1546	-	66	94	<0.1	1.0	75	
5	0.243	-	2900	-	346	105	0	0.07	460	Three sets of data from one
	0.056	-	600	-	208	<0.05	<0.1	0.15	<1.0	date but three different out-
	-	-	100	-	<1.0	<0.05	<0.1	<0.03	2.0	falls. Data not sufficient
										to obtain total concentrations
										thus not used in data analysis.
7	4.39	-	1113	-	81	65	0.11	0.41	42	**All data from quarterly grab**
	4.02	-	1094	-	53.9	76.2	< 0.015	1.05	39	**samples (POTW).**
	4.42	-	1394	-	51.2	88.5	0.315	0.887	167	
	3.73	-	1008	-	50.1	71.7	0.08	0.59	85	
4	2.92	-	1228	-	96	80	<0.10	1.05	538	All data from quarterly grab
	2.90	-	1231	-	90	147	<0.05	2.47	232	samples (POTW).
	3.00	-	1938	-	69	37	<0.10	1.62	412	
	3.12	-	1186	-	113	60	<0.02	1.08	141	
3	0.58	-	2618	-	51	199	0	0.14	-	All data from quarterly grab
	0.70	-	4150	-	120	178	0	0.09	162	sample (POTW).
	0.36	-	5967	-	101	150	0	0.10	1130	
	0.72	-	5890	-	160	213	0	0.10	953	
2	3.30	-	383	-	5	18.5	< 0.10	0.69	92	All data from quarterly grab
	3.12	-	378	-	2	5.5	< 0.10	0.40	41	sample (POTW).
	3.40	-	370	-	7	4.0	< 0.10	1.0	45	
	4.16	-	329	-	3	2.2	< 0.10	0.8	21	
Category C - Petrochemical										
16	5.51	-	774	-	31	32	<0.10	0.78	35	All data from quarterly grab
	4.03	-	790	-	19	57	<0.10	0.32	27	samples (POTW).
	5.63	-	971	-	57	59	<0.10	0.86	18.5	
	5.68	-	679	-	31	10	<0.10	<1.52	-	
27	1.5	200-375	500-800	-	25-80(52.5)	-	-	1.74-2.56 (2.15)	-	All data given only as range (POTW) (Average by B&R)

Data collected on the effluent from indirect discharging refineries within the Cracking subcategory (subcategory B) are characterized from Table V-1 as follows:

	Max	Min	Median	Number of Plants Reporting
Flow (MGD)	4.42	.080	1.34	11
BOD5 (mg/l)	756	38	75	5
COD (mg/l)	5967	179	463	7
TOC (mg/l)	No Data			
O&G (mg/l)	160	2	40	10
Phenolics (mg/l)	213	0.19	10.5	11
Sulfides (mg/l)	51.6	0	0.9	10
Total Chromium (mg/l)	330	.03	.844	9
Ammonia (mg/l)	1130	3.2	21.4	9

The number of indirect discharging refineries within the Petrochemical subcategory (subcategory C) and the Integrated subcategory (subcategory E) is limited. Therefore, no characterization is presented beyond that data presented in Table V-1 for subcategories C and E. There have been no indirect discharging refineries identified within the Lube (subcategory D). The Agency solicits input regarding the identification of additional refineries discharging to POTW other than those identified in Table III-1.

API SEPARATOR EFFLUENT CHARACTERISTICS

Table V-2 presents a summary of API separator effluent quality data (26) and is based on the 1972 "Petroleum Industry Raw Waste Load Survey" (1). Data pertaining to those refineries identified in this study as being indirect dischargers are summarized. These data represent the refinery waste water quality after passage through an API separator, but before any subsequent pretreatment prior to discharge to the municipal system. Median data for all plants reported in the survey, both direct and indirect dischargers, are also included in the table for purposes of comparison.

SOUR WATER WASTE STREAM CHARACTERISTICS

Refinery wastewater condensates containing sulfides, ammonia, and phenolics are termed sour water. These sour water waste streams constitute the major source of pollutants discharged from petroleum refineries which might be expected to pass through or interfere with POTW. The most significant sources of sour water are condensates from accumulators, reflux drums, flare drums, and knockout pots

TABLE V-2
SUMMARY OF INDIRECT DISCHARGE
REFINERIES' API SEPARATOR EFFLUENT QUALITY
(Reference #26)

Refinery Code	BOD5 (mg/l)	COD (mg/l)	TOC (mg/l)	O&G (mg/l)	Phenolics (mg/l)	Sulfide (mg/l)	Chromium (mg/l)	Ammonia (mg/l)
Category A - Topping (*Median)	23.3	107	20.0	25.0	0.080	0.240	0	2.72
Category B - Cracking								
25	190	432	66.4	9.22	50.8	5.97	25.2	158
19	-	0.425	286	170	25.9	5.95	0.142	91.4
18	156	546	171	17.3	2.42	52.1	-0.183	5.72
17	1615	2893	31.6	16.2	17.5	85.6	0	16.5
15	37.5	309	71.2	66.1	6.40	0.519	2.08	14.9
10	720	2258	229	147	189	0	0	600
7	1646	6453	401	915	2.70	1.80	2.02	468
4	354	1217	158	48.8	92.6	0	0.280	82.3
3	641	1500	352	96.1	31.7	0.075	0.451	320
2	-	-	-	-	31.0	0.25	-	30.2
*Median	138	383	66.3	52.8	6.04	1.24	0.109	28.6
Category C - Petrochemical								
16	202	1096	-	11.9	29.1	0	0.284	353
*Median	144	418	135	44.9	10.0	176	0.471	42.1
Category E - Integrated								
26	94.4	442	167	57.0	0.063	8.93	1.19	15.1
*Median	114	261	51.5	44.1	2.25	1.24	0.272	14.5

*Median data for all plants reporting (municipal dischargers and direct dischargers).

in catalytic reformers, cracking, hydrocracking, coking, and crude distillation units (2). Since most refineries provide sour water stripping for sulfide and ammonia reduction prior to biological treatment, characterization of the effluent quality from stripping units is significant. Data on the quality of stripped sour water was requested for all of the indirect discharging refineries identified in Table III-1. Table V-3 is a summary of the responses received.

Additional data on the quality of stripped sour water waste streams can be found in the "1972 Sour Water Stripping Survey Evaluation" (24). This information is presented in Tables V-4 and V-5. The refineries which provided this data have not been identified as discharging to POTW, and, therefore, are assumed to be primarily direct dischargers. However, the characteristics of stripped sour water waste streams are equally applicable to indirect as well as direct dischargers.

TABLE V-3

DATA SUMMARY OF INDIRECT DISCHARGE REFINERIES' STRIPPED SOUR WATER

Refinery Code	Flow (gpm)	Ammonia (mg/l)	Sulfide (mg/l)	Phenol (mg/l)	Thio Sulfate (mg/l)	Comments
17	-	Max 58	2	-	-	Monthly sampling
		Min 40	0	-	-	6/74 - 12/75
16	-	Max 75	5	-	-	operating
		Min 35	1	-	-	conditions
5	100	2710	0	650	76	design conditions
14	14	138	11	-	-	average performance

Additional data on stripped sour water quality from an API Sour Water Stripper Survey (Reference 24) is presented in Tables V-4 and V-5. The facilities providing this data have not been identified as dischargers to POTW's and consequently can be assumed to be primarily direct dischargers. However, the wastewater characteristics of stripped sour water from direct dischargers is applicable to indirect dischargers as well.

TABLE V-4

AVERAGE QUALITY OF SOUR WATER STRIPPER BOTTOMS
-STEAM STRIPPING-REFLUXED
(Reference #24)

Stripper Code	Flow (gpm)	NH_3 (ppm)	H_2S (ppm)	Phenols (ppm)
3	140	78	1.5	-
12	22	250	1.0	290
13B	-	25	4	10.7
14	85	284	2.8	582
15	270	188	3.5	116
19	80	340	2	155
20A	53	2,055	696	311
20B	175	3,159	665	521
22A	-	68	1	-
22B	-	64	0.1	-
22C	-	63	0.1	-
23	700	100	1	400
25	290	65	16	90
26A	38	45	28	-
27	280	200	20	150
28	562	5000	1500	1000
34	170	80	15	280
36	250	80	5	200
37A	305	600	50	-
37B	259	850	100	-
38A	199	200	60	-
38B	95	500	100	90
41	435	400	200	600
42	90	187	30	-
43	45	15	Trace	375
44	108	56	20	239
55	74	25	1	250
56	-	693	255	410
60	154	1470	65	Nil
61	119	555	Nil	28
Mean	200	590	128	290
Max	700	5000	1500	1000
Min	22	15	Nil	Nil
Median	154	188	16	250

TABLE V-5

AVERAGE QUALITY OF SOUR WATER STRIPPER BOTTOMS
-STEAM STRIPPING-NON-REFLUXED
(Reference #24)

Stripper Code	Flow (gpm)	NH_3 (ppm)	H_2S (ppm)	Phenols (ppm)
5	45	208	3	-
7	57	49.5	30.3	45
8	47	-	20	350
9	177	380	90	400
10	-	96	16	-
13A	120	400	6	200
18	56	265	2	45
21A	427	300	90	479
21B	90	300	300	310
29	53	2600	3000	-
31	80	408	13	31
32	80	65	0.2	20
33	307	200	8	320
47	52	115	5	225
48	80	115	-	-
51	56.3	1017	88	455
52	16.4	56	1	147
53	218	9.8	4.5	-
54A	53	76	6	13
54B	143	350	22	250
57	13.4	860	202	280
58	32.0	11	1	150
59	64	250	10	140
63	101	580	291	63
Mean	103	379	183	206
Max	427	2600	3000	479
Min	13.4	9.8	0.2	13
Median	64	250	13	200

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

INTRODUCTION

Petroleum refinery wastewaters have been characterized in the previous section and in the 1974 Development Document with regard to significant pollutant parameters present in refinery effluents. Certain pollutants, namely BOD, COD, and TOC, are treatable in POTW (BPCTCA for these parameters is based on biological treatment of petroleum refinery waste waters) and, consequently, have not been further considered in this document. Therefore, the pollutant parameters selected for further consideration in the establishment of pretreatment standards for the petroleum refining industry are those pollutants which might be considered to pass through or interfere with POTW.

SELECTED POLLUTANT PARAMETERS

Presented below is a listing of those pollutants present in refinery effluents which may pass through or interfere with the operation of POTW.

Ammonia
Sulfides
Oil and grease
Phenols
Chromium

The environmental significance and sources of these wastewater parameters are discussed in the 1974 Development Document on pages 71 through 90. These discussions are adequate and, therefore, are not repeated in this document. The following discussions consider the removability of the selected parameters by POTW and the effects of the selected parameters on POTW (see reference 37).

Ammonia

Evidence exists that ammonia exerts a toxic effect on all aquatic life depending on the pH, dissolved oxygen level, and the total ammonia concentration in the water. 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 to be oxidized.

At low concentration levels, ammonia serves as an important nutrient in a healthy biological oxidation system. No adverse effects on oxygen consumption are noted at concentrations of up to 100 mg/l. At excessively high levels (about 480 mg/l) ammonia exhibits inhibitory effects on the activated sludge process (see references 42, 44, 46 and 48).

Sulfides

Sulfides can be converted to sulfuric acid in sewers, causing corrosion of concrete pipes used to convey effluent to the treatment plant (i.e., POTW). Sulfides do not pass through biological treatment systems; rather, they are oxidized to sulfates. Therefore, excessive levels of sulfide can interfere with the activated sludge process by depleting the dissolved oxygen transferred in the aeration process. Limited data indicates that 25 to 50 mg/l of sulfide is sufficient to cause interference with the activated sludge process (see references 45, 46, 49, and 55).

Oil and Grease

In addition to partially passing through a biological treatment plant, oil and grease of petroleum origin has been reported to interfere with the aerobic processes of a POTW. It is believed that the principal interference is caused by attachment of floc particles, resulting in a slower settling rate, loss of solids by carryover out of the settling basin, and excessive release of BOD from the POTW to the environment. Additionally, in activated sludge units, oil and grease may coat the biomass, interfering with oxygen transfer. As a consequence of this "smothering" action, a lower degree of treatment may be achieved. Oil and grease may also cause other problems in POTW operation, such as clogging screens and interfering with skimming and pumping operations (see reference 37). Therefore, many municipalities limit the quantity of oil and grease that can be discharged to their treatment systems by industry.

Phenols

There is an extremely diverse reaction caused by the discharge of phenolic wastes to biological treatment systems. This reaction depends upon whether the sludge has been acclimated to this material. Relatively small amounts of phenolics can be inhibitory to unacclimated sludge. However, with acclimation and use of the complete mixing mode of operation, high concentrations of phenol can be tolerated in biological treatment systems (see reference 37).

Chromium

Chromium in its various valence states is hazardous to man. It can produce lung tumors when inhaled and can induce skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Levels of chromate ions that have no effect on man appear to be so low as to prohibit determination. The recommendation for public water supplies is that such supplies contain a maximum of .05 mg/l of total chromium.

The toxicity of chromium salts to fish and other aquatic life varies widely with the species, pH, temperature, valence of the chromium, and synergistic or antagonistic effects. Studies have shown that trivalent chromium is more toxic to fish of some types than hexavalent chromium. Other studies report the opposite effect. Fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium. Chromium also inhibits the growth of algae.

Interferences with biological processes are reported at the 1 mg/l concentration level of hexavalent chromium. However, in the concentration range of 1 to 50 mg/l, the published literature is quite confusing and contradictory, indicating effects ranging from serious interference to insignificant effects. Table VI-1 summarizes the conclusions reached in an earlier study (37) concerning the effects of chromium on biological treatment processes.

TABLE VI-1

EFFECTS OF CHROMIUM ON BIOLOGICAL TREATMENT PROCESSES

Concentration	Effect On				
mg/l	Activated Sludge Processes	Anaerobic Digestion Processes	Nitrification Processes	Comments	References
0.005	B				40
0.05					
0.25			I		54
1	N				40
1	I			$K_2Cr_2O_7$	40
1	T				38
1.5		T			38
2.5			U		43,48,52
5			U		38
5		T			38
7	I			25% Loss in BOD Removal	38
8.8	I			25 mg/l $K_2Cr_2O_7$	41
5-10	I				48,50
10	T				48,50
10	I			29% Loss in BOD Removal	47
15			I	Cr III	48
4			I		44
0-50				Cr III, No Effect on Trickling Filter Operation	48
50	I			3% Loss in BOD Removal	53
50	I				51
50		N			39
50		U			53,50
100			I	Reduced Nitrification by 66-78%	40
100	I			3% Loss in BOD Removal	53
300			I		53
300		U			53
500		U			53
500		U			48
430 & 1440			U		48

NOTES:

B = Beneficial
N = No Effect
T = Threshold for Inhibitory Effects
I = Inhibitory
U = Upset
Concentrations represent influent to the unit processes.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

INTRODUCTION

Pollution abatement and control technologies applicable to this industry are presented in detail in the Development Document (at pages 91 through 112). The technologies that generally apply to indirect discharge facilities are summarized in this section.

The control and treatment technologies considered in the Development Document were based on their capabilities for removing the parameters selected for limitations. This same philosophy applies to this document, in that the technologies presented herein are limited to those treatment techniques capable of removing pollutants which may pass through or interfere with POTW. These pollutants include sulfides, ammonia, phenols, oil and grease, and chromium.

Analysis of the data collected shows that the major source of sulfide, ammonia, and phenols is the sour water waste stream (see Section V). Therefore, segregation and treatment of sour waters are the major areas of concern for pretreatment.

In addition, discussions of other significant wastewater sources are presented. The sources and concentrations of selected pollutants are generally similar between subcategories. Therefore, the treatment technologies available within the various subcategories are identical; the discussions presented herein are applicable throughout the industry without regard to subcategorization.

DISPOSITION OF WASTE STREAMS

Refineries that discharge to POTW do not necessarily discharge all of their waste streams to the sewer. Other discharge outlets are available at some of these refineries and are used for discharging wastewaters such as cooling water and utility blowdown.

Table VII-1 summarizes the disposition of the wastewaters emanating from indirect dischargers and presents other information relating to pretreatment operations employed and flow rates to POTW. The column labeled "Pretreatment Waste Streams" includes those waste streams that are known to be

TABLE VII-1

WASTEWATER OPERATIONS AT INDIRECT DISCHARGE REFINERIES

	Refinery Code	Effluent Flow to POTW (MGD)	Pretreatment Waste Streams to POTW	Final Disposition of Other Wastewater Streams	Pretreatment Operations: Sour Water Stripping	Pretreatment Operations: Other	Data Source
Category A - Topping	28	0.18	Process water, contaminated runoff	Local stream	None	PSEPAR, OSDISA, OSDTEQ	29*
	21	0.14	All, except stormwater	Local creek, Surface containment, Evaporation	None	PSEPAR, OSDTEQ, OSSETB	29*
	20		Cooling tower blowdown, Boiler blowdown, Contaminated runoff	Local channel	None	PSEPAR, OSDTEQ	29*
	14	0.258	All, except stormwater		SWS, OX	PSKIMC, PSEPAR	29*
	13	0.132	All		SWS	PSEPAR, PSEDIM	29*
	12	0.052	Process water, Cooling tower blowdown, Boiler blowdown, tank bottoms	Evaporation, Septic tanks	None	PSEPAR, PSKIMC	29*
	11	0.033	All, except stormwater	Evaporation, Ground percolation	OX	PSEPAR, OSFILT, OSDTEQ	29*
	9	This information not requested of this refinery			None	PSEPAR	29*
	8	0.006	Process water, Cooling tower blowdown, Boiler blowdown, Contaminated runoff	Evaporation, Consumption	None	PSEPAR, OSDISA, OSFILT, OSDTEQ, OSAERT	29*
	1		All, except stormwater		None	PSEPAR	29*
Category B - Cracking	30	0.443	All, except stormwater		SWS	PSEPAR, OSDISA, OSDTEQ	29*
	25		All	Evaporation	SWS	PSEPAR	29,1
	22	1.42	All, except stormwater	Evaporation, Local creek	SWS	PSEPAR, OSDTEQ	29,1
	19	0.25-0.40			SWS	PSEPAR, OSSETB	29,1*
	18	1.42	Sour water, Oily water		SWS	PSEPAR, OSDISA, OSFILT	29,1*
	17	0.220	Process water, Sour water, Cooling tower blowdown, Boiler blowdown	Evaporation	SWS	PSEPAR	29,1*
	15	0.088	Process water, Cooling water, Cooling tower blowdown, Boiler blowdown, Stormwater	Evaporation	None	PDETPD, PSKIMC, PSEPAR, OSDISA	29,1*
	10	0.53	All, except stormwater	Evaporation	SWS, OX	PSEPAR, OSDISA	29,1*
	7	4.14	Process water, Cooling tower blowdown, Utility blowdowns, Tank botoms, Contaminated runoff	Local channel, Evaporation	SWS, OX	PSEPAR, OSDTEQ, PSKIMC OSDISA	29*
	5	0.33	Process water, Sour water, Cooling tower blowdown, Boiler blowdown	Local channel, Evaporation	SWS, OX	PCORRP, PSEPAR, PSKIMC, PSEDIM, OSDTEQ	29*
	3	0.70	Sour water	Local channel	SWS, OX	PDETPD	29,1*
	2	3.5	Process water	Evaporation, Local harbor, Contract disposal	SWS	PSEPAR, OSDISA, OSDTEQ	29*
	4	2.98	Process water, Sour water, Contaminated runoff	Local channel, Evaporation, Contract disposal	SWS, OX	PCORRP, PSEPAR, OSDISA, OSDTEQ	29*
Category C - Petrochemical	27	1.5	All		None	PSEPAR	29*
	16	5.21	Process water, Sour water, Contaminated runoff	Local channel, Evaporation	SWS, OX	PSKIMC, PSEPAR, OSFLOC, OSDISA, OSDETQ	29,1*
Category E - Integrated	26	7.64	All	Evaporation	SWS	PDETPD, PSEPAR, PSEDIM, OSAERL	29,1

*Refinery or POTW contact

Codes for Pretreatment Operations

Sour Water Stripping		Additional Oil and Solids Removal	
Sour Water Stripper	SWS	Dissolved Air Flotation	OSDISA
Oxidation	OX	Detention or Equalizing	OSDTEQ
Primary Separation		Filtration	OSFILT
Detention, Holding Tank	PDETPD	Chemical Flocculation	OSFLOC
API Separator	PSEPAR	Settling Basin	OSSETB
Corrugated Plate Interceptor	PCORRP	Aeration Tank	OSAERT
Oil Skimmer, Trap or Tank	PSKIMC	Aerated Lagoon	OSAERL
		Stabilization Pond without aerators	ORSTBQ

discharged to the sewer. The column headed "Final Disposition of Other Wastewater Streams" lists additional outlets available to indirect dischargers. These include evaporation ponds, local rivers and channels, and contract disposal operations. For refineries discharging process waste waters to POTW, there are no known instances where sour waters are segregated and discharged directly or disposed of in another manner.

Table VII-1 also provides information as to which refineries are presently treating sour water with a sour water stripper (SWS) or by oxidation. There are 17 indirect discharging refineries in this segment of the industry known to have sour water treatment. Nine refineries have been identified that do not have SWS's; however, it has been reported that no sour waters are produced by refinery operations at eight of the nine refineries. Therefore, there has been only one refinery identified that is discharging untreated sour waters to a municipal sewer.

Table VII-2 presents a summary of information gathered relative to the fourteen POTW which are currently receiving refinery wastewaters. Data relative to the refinery average discharge flow versus the total POTW average daily flow, treatment processes employed at the POTW, and effluent limitations required of petroleum refineries by the POTW are included.

IN-PLANT CONTROL TECHNOLOGY

Many newer refineries are being designed or modified with reduction of water use and pollutant loading as a major part of the design criteria. These advances include:

1. Use of improved catalysts that require less regeneration.

2. Replacement of barometric condensers with surface condensers, thereby reducing a major oil-water emulsion source.

3. Substitution of water cooling with air coolers to reduce cooling water requirements.

4. Newer hydrocracking and hydrotreating processes which produce lower waste loadings than the units they replace.

5. Increased use of improved drying, sweetening, and finishing procedures to minimize the production of

TABLE VII-2

DESCRIPTION OF EXISTING POTW RECEIVING REFINERY EFFLUENT

POTW Code	Refinery Code	Category	Average Daily Flow (MGD) POTW	Average Daily Flow (MGD) Refinery	POTW Treatment Operations	Refinery Effluent Limitations (ppm) Phenol	Ammonia	H-Hex T-Total Chromium	Sulfides	O&G
M1	30	B	80-150	0.443	C01	None	None	None	None	None
M3	28	A	7.5	0.18	C06					
M4	27	C	220	1.5	C01	None	None	10(H) 25(T)	None	100
M5	26	E		7.64						
M5	25	B								
M8	22	B	7	1.42	B02	0.10	None	5.0	5.0	100 (1)
M9	21	A	10.5	0.14	C01	None	None	5.0	None	100
M10	20	A	3.03		B02					
M11	19	B	32	0.25-0.40	B01	None	100	Less than Harmful	1.0	100
M12	18	B	42	1.42	B05	0.1	1.0	T-1.8lb/day H.0.005 mg/l	0.3	10
M13	16	C	351	5.21	A01		Less than excessive quantities		0.1	75
M13	14	A	351	0.258	A01		"		0.1	75
M13	13	A	351	0.132	A01		"		0.1	75
M13	12	A	351	0.052	A01		"		0.1	75
M13	11	A	351	0.033	A01		"		0.1	75
M13	9	A	351	Not requested	A01		"		0.1	75
M13	8	A	351	0.006	A01		"		0.1	75
M13	7	B	351	4.14	A01		"		0.1	75
M13	5	B	351	0.33	A01		"		0.1	75
M13	4	B	351	2.98	A01		"		0.1	75
M13	3	B	351	0.70	A01		"		0.1	75
M13	2	B	351	3.5	A01		"		0.1	75
M14	15	B	1.7	0.088	B02	1.0	None	1.0(H)	None	200
M16	1	A	100		C01					
M17	17	B	2.35	0.220	B04					
M18	10	B	19	0.53	C01		Less than excessive quantities		0.1	75

CODES FOR POTW TREATMENT OPERATIONS

A01	Conventional Primary Sedimentation Process
B01	A01 plus Trickling Filter, Clarifier
B02	A01 plus High Rate Trickling Filter, Clarifier
B04	A01 plus 2 Trickling Filters in Series, Clarifier
B05	A01 plus 2 High Rate Trickling Filters in Series, Clarifier
C01	A01 plus Activated Sludge, Clarifier
C06	A01 plus High Rate Activated Sludge, Clarifier

(1) New proposed ordinance sets limit at 50 ppm

spent caustics and acids, water washes, and filter solids requiring disposal.

Additionally, traditional methods utilized in the refining industry for reducing flow and pollutant loading are equally applicable to indirect dischargers. These methods include recycle and reuse of various waste streams and improved housekeeping. A detailed discussion of these procedures is provided in the Development Document (at pages 91 through 95).

AT-SOURCE PRETREATMENT--SEGREGATION

The first step in good pretreatment practice is the segregation of major wastewater streams. Each stream can require individual treatment of a different nature; therefore, segregation can drastically reduce the size of equipment needed for pretreatment. A discussion of some of the significant process waste streams that should be segregated from the oily sewer system is presented below.

Storm Water Runoff

Large volumes of stormwater runoff must be handled at relatively infrequent intervals of varying duration. There are several techniques available and in practice that refiners can employ to minimize storm water loads. In all cases, clean and contaminated storm waters should be kept separated from each other. This ensures that the size of the treatment facilities for handling oily process wastes and contaminated storm water can be kept to a minimum.

One consideration is the use of a separate clean storm water sewer and holding system that provides separate collection facilities for storm water runoff. By controlling hydraulic load, protection is provided relative to the operation of the oil/water separator.

An alternate to the separate sewer system would be the provision of a storm surge pond that would receive polluted waters when the flow to the oil/water separator exceeds design conditions. During non-rainfall conditions, the combined storm water and refinery effluent can be diverted to the oil/water separator and discharged to the treatment system (i.e., POTW).

The design of storm water detention facilities must be determined on an individual basis. The requirements of POTW receiving refinery wastewaters vary greatly and have a significant effect on the design. In many cases, POTW do not accept stormwater runoff either treated or untreated. For example, the County Sanitation Districts of Los Angeles County will accept only the first 15 minutes of a storm; the remainder must be discharged elsewhere.

The degree of pollution by storm water runoff is influenced to a large extent by the degree of housekeeping practiced within the refinery confine. This aspect was discussed in the Development Document (page 100), including specific preventative measures to be utilized to avoid contamination of storm water to the greatest extent possible.

Spent Caustic

Caustic solutions are widely used in refining. Typical uses are to neutralize and extract:

a. acidic materials that may occur naturally in crude oil,
b. acidic reaction products that may be produced by various chemical treating processes, and
c. acidic materials formed during thermal and catalytic cracking such as hydrogen sulfide, phenolics, and organic acids.

Spent caustic solutions may, therefore, contain sulfides, mercaptides, sulfates, sulfonates, phenolates, naphthenates, and other similar organic and inorganic compounds.

Spent caustics usually originate as batch dumps. The batches may be combined and equalized before being treated and discharged with the general refinery waste waters. Spent caustic solutions can also be treated by neutralization with flue gas.

Some refiners process spent caustics to market the phenolics and the sodium hyposulfide. However, the market is limited and most of the spent caustics are very dilute; the cost of shipping the water can make this operation uneconomical. Some refiners neutralize the caustic with spent sulfuric acid from other refining processes and charge it to the sour water stripper where the hydrogen sulfide is removed.

Spent caustic solutions can also be oxidized to transform the sulfides to thiosulfates. This is a similar process to the one described in more detail for the treatment of sour waters.

Indirect dischargers have been identified using all of the technologies described above. In addition, two refineries have been identified from which spent caustics are sent to a landfill. It should be noted that fluidized bed incineration is now being used in some refineries, but no indirect dischargers have been identified as using this process.

Sour Waters

Sour or acid waters are produced in a refinery when steam is used as a stripping medium in the various cracking processes. The hydrogen sulfide, ammonia, and phenols distribute themselves between the water and hydrocarbon phases in the condensate. Historically, the purpose of the treatment of sour water has been the remove sulfides to protect process equipment. Emphasis on the control of waste water pollutants has caused an increased emphasis on the removal of ammonia as well. Sour waters are generally treated by stripping of sulfide with steam or flue gas, or by conversion of hydrogen sulfide to thiosulfates by air oxidation. A discussion of each process is provided in the following section on applicable treatment technologies.

TREATMENT TECHNOLOGY

Sour Water Treatment Systems

Sour Water Stripping. Sour water stripping is a gas/liquid separation process that uses steam or flue gas to remove impurities (i.e., sulfides and ammonia) from the wastewater. The stripper itself is a distillation type column containing either trays or packing material. Columns range from simple one pass systems to sophisticated refluxed columns with reboilers. Some refineries have a number of units operating in parallel, while others use two columns in series to facilitate high ammonia removals (i.e., Chevron WWT process). The vast majority of units used in this country utilize steam as the stripping medium. No indirect discharge refineries have been identified that use anything other than steam as the stripping medium.

There have been a number of major studies done on sour water stripper operations (24,28,29). These projects have addressed removal efficiencies and costs of SWS's. Tables VII-3 through VII-5 have been extracted from the "1972 Sour Water Stripping Survey Evaluation" prepared by the American Petroleum Institute (24). These tables present operating data for sour water strippers that are (1) steam/refluxed

TABLE VII-3

SUMMARY OF OPERATING DATA
SOUR WATER STRIPPERS
(Reference #24)
STEAM STRIPPING - REFLUXED

CODE NO.	3	12	13B	14	15	19	20A	20B
REMARKS	-		1 test run	1 test run				
pH CONTROL	None	None	None	None	None	None	None	None
RAW FEED:								
Flow - gpm	120	21.5	170	80	252	72	50	172
Temp - F, Lower Entrance	240	-	200	235	160	224	200	210
NH_3, Min -- ppm	1,660	2,200	-	-	1,950	-	2,000	2,500
NH_3, Max -- ppm	2,970	6,950	-	-	2,000	-	8,500	5,600
NH_3, Avg -- ppm	2,500	4,900	1,200	1,200	1,975	2,510	3,720	4,390
H_2S, Min -- ppm	2,640	1,650	-	-	3,000	-	2,500	2,400
H_2S, Max -- ppm	6,720	3,700	-	-	3,400	-	10,000	5,500
H_2S, Avg -- ppm	3,770	2,475	1,470	2,000	3,200	3,080	4,460	4,260
Phenols, Min -- ppm	-	215	-	-	167	-	225	175
Phenols, Max -- ppm	-	400	-	-	174	-	700	700
Phenols, Avg -- ppm	-	315	24.3	608	171	174	375	554
Cyanides, Min -- ppm	-	-	-	-	-	-	-	-
Cyanides, Max -- ppm	-	-	-	-	-	-	-	-
Cyanides, Avg -- ppm	-	-	-	<1	11	-	-	-
pH Avg	9.4	8.7	-	-	-	8.7	8.8	8.9
RECYCLE:								
Flow - gpm	-	5	2	5	-	8	-	-
Temperature - °F	238	185	210	223	223	219	-	-
NH_3, Avg -- ppm	20,000	3,900	-	-	-	13,200	-	49,220
H_2S, Avg -- ppm	13,600	1,300	-	-	-	5,820	-	66,900
Phenols, Avg -- ppm	-	270	-	-	-	350	-	110
pH	13.5	-	-	-	-	9.6	-	8.9
Disposition	top tray	feed line	feed drum	feed line	feed drum	feed line	feed drum	feed drum
STRIPPER OFF-GAS:								
Temperature - °F	238	185	-	223	225	219	-	120
NH_3, Avg - lb/hr	180	-	-	-	-	76	-	90
H_2S, Avg - lb/hr	241	-	-	-	-	110	-	400
Phenols, Avg - lb/hr	-	-	-	-	-	0	-	-
Cyanides, Avg - lb/hr	-	-	-	-	-	-	-	-
Water Vapor - lb/hr	1,200	-	-	-	-	360	-	150
Disposition	furnace	furnace	flare	flare	flare	furnace	S. Plant	S. Plant
TOWER BOTTOMS:								
Flow - gpm	140	22	-	85	270	80	53	175
Temperature - °F		225	230	240	230	230	230	230
NH_3, Min. - ppm	25	160	-	-	130	-	970	1,420
NH_3, Max - ppm	-	300	-	-	246	-	-	-
NH_3, Avg - ppm	78	250	25	284	188	340	2,055	3,159
H_2S, Min - ppm	0	0.2	-	-	2	-	400	280
H_2S, Max - ppm	-	5.0	-	-	5	-	-	-
H_2S, Avg - ppm	1.5	1.0	4	2.8	3.5	2	696	665
Phenols, Min - ppm	-	275	-	-	107	-	214	120
Phenols, Max - ppm	-	300	-	-	125	-	-	-
Phenols, Avg - ppm	-	290	10.7	582	116	155	311	521
Cyanides, Min - ppm	-	-	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-	-	-
Cyanides, Avg - ppm	-	-	-	<1	<1	-	-	-
pH Avg	9.4	8.4	-	-	-	9.25	9.5	9.7
Disposition	Sewer	Desalter	Desalter	Sewer	Cooling Tower	Desalter	Desalter	Desalter
REMOVAL:								
NH_3 - %	96.9	94.9	97.9	76.33	90.5	86.45	44.8	38.1
H_2S - %	99.96	99.96	99.7	99.86	99.89	99.94	84.4	84.5
Phenols - %	-	7.9	56.0	4.28	32.2	10.9	17.1	6.0
Cyanides - %	-	-	-	0	-	-	-	-
STEAM:								
Heating - Mlb/hr	1.5 (3)	-	2.6 (4)	0.2 (1)	8.9	0.9 (1)	0.8 (1)	1.8 (1)
Stripping - Mlb/hr	10 (4)	-	9.8 (4)	4.55 (4)	16.7	3.8 (4)	3.2 (4)	1.6 (4)
Total - Mlb/hr	11.5	-	12.4	4.75	25.6	4.7	4.0	3.4
Stripping - lb/gal of raw feed	1.4	-	1.0	1.0	1.1	0.9	1.1	0.2
Total - lb/gal of raw feed	1.6	-	1.2	1.0	1.7	1.1	1.3	0.3
TOWER:								
Diameter - ft.	4	3	5	5	6	3.5	4	6
Height - ft.	39.5	25.5	24.5	28	24	42	10	33
No. of Trays	10	12	8	6	-	-	-	5
Type of Trays	Valve Caps	Sieve	Valve	Bubble Cap	-	-	-	Bubble Cap
Depth of Packing - ft.	-	-	-	-	13	16	3	8
Type of Packing	-	-	-	-	1" CS Rings	3" Raschig Rings	1" Raschig Rings	1" Raschig Rings
Top Temp. - °F	-	215	225	234	[illegible]	230	200	[illegible]
Top Press. - psig	-	3	4	10	7.3	10.7	10	15.5

CODE	22A	22B	22C	23	25	
REMARKS	Phenolic Stripper	[illegible]-Phenolic Stripper	Desalter Water Stripper		1st Stage	2nd Stage
pH Control	None	None	None	None	None	None
RAW FEED:						
Flow - gpm	210	68	206	700	250	290
Temp. - °F, Tower Entrance	198	213	198	195	240	240
NH_3, Min -- ppm	-	300	5	-	-	-
NH_3, Max -- ppm	-	500	100	-	-	-
NH_3, Avg -- ppm	1,720	430	74	4,000	1,600	890
H_2S, Min -- ppm	-	-	-	-	-	-
H_2S, Max -- ppm	-	-	-	-	-	-
H_2S, Avg -- ppm	1,650	570	32	5,000	3,500	160
Phenols, Min - ppm	100	-	-	-	-	-
Phenols, Max - ppm	200	-	-	-	-	-
Phenols, Avg - ppm	-	-	-	800	140	-
Cyanides, Min - ppm	-	-	1.5	-	-	-
Cyanides, Max - ppm	-	-	2.0	-	-	-
Cyanides, Avg - ppm	13	-	1.8	-	-	-
pH - Avg	8.6	8.5	7.7	9.1	8.7	10.0
RECYCLE:						
Flow - gpm	14.5	19.5	1.5	120	-	-
Temperature - °F	-	-	-	190	-	-
NH_3, Avg - ppm	-	-	-	60,000	-	-
H_2S, Avg - ppm	-	-	-	40,000	-	-
Phenols, Avg - ppm	-	-	-	1,000	-	-
pH	-	-	-	9.9	-	-
Disposition	Top Tray	Top Tray	Top Tray	feed drum	tower	
STRIPPER OFF-GAS:						
Temperature - °F	190	205	236	190	240	240
NH_3, Avg - lb/hr	-	-	-	1,400	46	170
H_2S, Avg - lb/hr	-	-	-	1,750	440	15
Phenols, Avg - lb/hr	-	-	-	-	-	-
Cyanides, Avg - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	-	-	-	2,000	-	-
Disposition	S. Plant	S. Plant	S. Plant	S. Plant	Flare	Furnace
TOWER BOTTOMS:						
Flow - gpm	-	-	-	700	290	-
Temperature - °F	243	244	250	245*	-	-
NH_3, Min - ppm	-	-	-	40	-	-
NH_3, Max - ppm	-	-	-	-	-	-
NH_3, Avg - ppm	68	64	63	100	890	65
H_2S, Min - ppm	-	-	-	0.2	-	-
H_2S, Max - ppm	-	-	-	-	-	-
H_2S, Avg - ppm	1	0.1	0.1	1	180	16
Phenols, Min - ppm	100	25	30	250	-	-
Phenols, Max - ppm	200	65	65	-	-	-
Phenols, Avg - ppm	-	-	-	400	-	90
Cyanides, Min - ppm	2	-	-	-	-	-
Cyanides, Max - ppm	5	-	-	-	-	-
Cyanides, Avg - ppm	3.5	-	-	-	-	-
pH Avg	-	-	-	-	10.0	9.2
Disposition	Desalter	FCC Unit	Bio-Unit	Sewer	To 2nd Stage	Sewer
REMOVAL:						
NH_3 - %	96.0	85.1	14.9	97.5	44.3	92.3
H_2S - %	99.94	99.8	99.69	99.98	94.86	91.11
Phenols - %	0	-	-	50.0	-	35.7
Cyanides - %	73	-	-	-	-	-
STEAM:						
Heating - Mlb/hr	Reboiler	Reboiler	Reboiler	Reboiler	-	-
Stripping - Mlb/hr	-	-	-	-	-	-
Total - Mlb/hr	13.6	10.2	7.0	80	-	-
Stripping - lb/gal of raw feed	-	-	-	-	-	-
Total - lb/gal of raw feed	1.1	2.5	0.6	1.9	-	-
TOWER:						
Diameter - ft	4.5	4.5	4	8.5	6	6
Height - ft	70	70	60	50	70.75	78.1
No. of Trays	30	30	24	23	22	30
Type of Trays	Sieve	Sieve	Sieve	Sieve	Valve	Valve
Depth of Packing - ft.	-	-	-	-	-	-
Type of Packing	-	-	-	-	-	-
Top Temp - °F	228	237	240	235	-	-
Top Press. - psig	-	-	-	9.3	-	-

TABLE VII-3 (Cont.)

CODE NO.	26A	26B	27	28	34	36
REMARKS				2-parallel stripper		
pH CONTROL	None	None	None	None	None	None
RAW FEED:						
Flow - gpm	35	50	255	545	150	280
Temp. - °F, Tower Entrance	190	220	230	120	200	245
NH_3, Min - ppm	735	433	1,500	5,000	1,200	-
NH_3, Max - ppm	9,440	8,660	2,450	6,000	3,000	-
NH_3, Avg - ppm	5,410	3,550	2,000	5,500	1,400	19,000
H_2S, Min - ppm	2,900	925	3,500	10,000	2,400	-
H_2S, Max - ppm	14,500	7,800	5,800	17,000	6,900	-
H_2S, Avg - ppm	11,243	4,002	4,250	12,000	3,200	17,000
Phenols, Min - ppm	-	-	200	800	230	-
Phenols, Max - ppm	-	-	400	1,100	610	-
Phenols, Avg - ppm	-	-	300	1,000	440	750
Cyanides, Min - ppm	-	-	2	-	-	-
Cyanides, Max - ppm	-	-	5	-	-	-
Cyanides, Avg - ppm	-	-	3	10	-	-
pH - Avg	8.0	8.3	9.0	8.5	8.5	-
RECYCLE:						
Flow - gpm	-	-	30	-	22	83
Temperature - °F	-	-	175	-	-	190
NH_3, Avg - ppm	-	-	80,000	-	-	90,000
H_2S, Avg - ppm	-	-	115,000	-	-	56,000
Phenols, Avg - ppm	-	-	-	-	-	1,000
pH	-	-	10.0	-	-	-
Disposition	Feed Drum	To Tower	Feed Line	Top Tray	Feed Line	Feed Tank
STRIPPER OFF-GAS:						
Temperature - °F	-	-	-	-	200	190
NH_3, Avg - lb/hr	-	-	225	-	377	2,710
H_2S, Avg - lb/hr	-	-	550	-	446	2,411
Phenols, Avg - lb/hr	-	-	-	-	19	71
Cyanides, Avg - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	-	-	77	-	900	1,308
Disposition	Furnace	Furnace	Flare	Furnace	Furnace	S. Plant
TOWER BOTTOMS:						
Flow - gpm	36 (1)	-	280 (5)	562 (5)	170 (5)	250
Temperature - °F	230	-	270	170	230	278
NH_3, Min - ppm	19	37	25	4,000	7	-
NH_3, Max - ppm	71	3,200	300	5,000	-	-
NH_3, Avg - ppm	45	-	200	5,000	80	80
H_2S, Min - ppm	0	1	5	-	5	-
H_2S, Max - ppm	56	406	50	-	-	-
H_2S, Avg - ppm	28	-	20	1,500	15	5
Phenols, Min - ppm	-	-	100	800	140	-
Phenols, Max - ppm	-	-	200	1,000	-	-
Phenols, Avg - ppm	-	-	150	1,000	280	200
Cyanides, Min - ppm	-	-	2	-	-	-
Cyanides, Max - ppm	-	-	5	-	-	-
Cyanides, Avg - ppm	-	-	3	-	-	-
pH - Avg	8.4	9.3	9	9	-	-
Disposition	Sewer	Sewer	Bio-Unit	Oxidizer	Sewer	Desalter
REMOVAL:						
NH_3 - %	99.2	-	90.0	9.1	94.3	99.6
H_2S - %	99.75	-	99.54	87.5	99.53	99.97
Phenols - %	-	-	50.0	0	36.4	73.3
Cyanides - %	-	-	0	-	-	-
STEAM:						
Heating - Mlb/hr	0.7	-	3.3	12 (1)	3.1 (3)	Reboiler
Stripping - Mlb/hr	16.3	-	26.7	4 (4)	13.7	-
Total - Mlb/hr	17	4	30	16	16.8	-
Stripping - lb/gal of raw feed	7.8	-	1.8	0.1	1.5	-
Total - lb/gal of raw feed	8.1	1.3	2.0	0.5	1.9	-
TOWER:						
Diameter - ft.	5	2.5	5	5	7	7
Height - ft.	23.1	55	35	34	35	-
No. of Trays	5	-	10	15	-	18
Type of Trays	Glitsch	-	Flexitrays	Bubble Cap	-	-
Depth of Packing - ft.	-	20	-	-	15	-
Type of Packing	-	3" Raschig Rings	-	-	3" Raschig Rings	-
Top Temp.	216	-	250	225	225	258
Top Press. -psig	5.5	-	45	-	8	29

TABLE VII-3 (Cont.)

CODE NO.	37A	37B	38A	38B	41	42
REMARKS						
pH CONTROL	None	None	None	None	None	None
RAW FEED						
Flow - gpm	285	245	186	80	400	80
Temp. - °F, Tower Entrance	149	195	170	109	210	165
NH_3, Min - ppm	-	-	-	-	-	[illegible]
NH_3, Max - ppm	-	-	-	-	-	4,300
NH_3, Avg - ppm	1,400	1,500	270	3,000	1,400	1,900
H_2S, Min - ppm	-	-	-	-	-	1,200
H_2S, Max - ppm	-	-	-	-	-	8,000
H_2S, Avg - ppm	2,575	2,800	400	3,800	1,700	3,400
Phenols, Min - ppm	-	-	-	-	-	-
Phenols, Max - ppm	-	-	-	-	-	-
Phenols, Avg - ppm	-	-	544	1,000	975	-
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	-	-	-	-	-	-
pH - Avg	8.0	8.5	8.0	8.0	-	-
RECYCLE:						
Flow - gpm	-	-	5	-	50	-
Temperature - °F	-	-	173	-	170	-
NH_3, Avg - ppm	-	-	-	-	85,000	-
H_2S, Avg - ppm	-	-	-	-	85,000	-
Phenols, Avg - ppm	-	-	-	-	2,700	-
pH	-	-	-	-	-	-
Disposition	Feed Tank	Feed Tank	Feed Line	Feed Line	Feed Line	Feed Line
STRIPPER OFF-GAS:						
Temperature - °F	216	225	173	-	170	-
NH_3, Avg - lb/hr	-	-	5	100	200	-
H_2S, Avg - lb/hr	-	-	31	150	300	-
Phenols, Avg - lb/hr	-	-	-	35	75	-
Cyanides, Avg - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	-	-	13	3,900	225	-
Disposition	S. Plant	S. Plant	Furnace	CO boiler	Absorber	Scrubber
TOWER BOTTOMS						
Flow - gpm	305 (5)	259	199 (1)	95 (1)	435 (1) (5)	90
Temperature - °F	225	235	210	236	240	233
NH_3, Min - ppm	-	-	-	-	-	10
NH_3, Max - ppm	-	-	-	-	-	1,000
NH_3, Avg - ppm	600	850	200	500	400	187
H_2S, Min - ppm	-	-	-	-	-	0
H_2S, Max - ppm	-	-	-	-	-	175
H_2S, Avg - ppm	50	100	60	100	200	30
Phenols, Min - ppm	-	-	-	-	-	-
Phenols, Max - ppm	-	-	-	-	-	-
Phenols, Avg - ppm	-	-	-	90	600	-
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	-	-	-	-	-	-
pH - Avg	10	10	9.5	9.7	9.5	-
Disposition	Sewer	Desalter	Bio-Unit	Bio-Unit	Desalter	Desalter
REMOVAL:						
NH_3 - %	57.2	43.3	18.5	83.3	74.4	90.2
H_2S - %	98.06	96.43	85.0	97.37	88.24	99.12
Phenols - %	-	-	-	91.0	38.5	-
Cyanides - %	-	-	-	-	-	-
STEAM:						
Heating - Mlb/hr	11.1 (1)	4.9	4.1 (1)	5.3 (1)	6.2 (1)	2.7 (3)
Stripping - Mlb/hr	13.9 (4)	4.1 (4)	2.3 (4)	3.9 (4)	22.6 (4)	1.9
Total - Mlb/hr	25	9	6.4	9.2	28.8	4.6
Stripping - lb/gal of raw feed	0.8	0.3	0.2	0.8	0.9	0.5
Total - lb/gal of raw feed	1.5	0.6	0.6	1.9	1.2	1.0
TOWER:						
Diameter - ft	6	4	5	5	6.5	3.5
Height - ft.	-	-	-	-	40	72
No. of Trays	-	18	20	20	16	24
Type of Trays	-	-	Shower	Shower	Valve	Bubble Cap
Depth of Packing - ft.	35	-	-	-	-	-
Type of Packing	2" Al Rings	-	-	-	-	-
Top Temp - °F	216	225	217	-	230	205
Top Press. - psig	2.5	4.5	0.7	8.8	-	4.3

CODE NO.	43	44	55	56	60	61
REMARKS		Feed + Recycle				Caustic in Feed
pH Control	None	None	Caustic	None	None	Acid
RAW FEED:						
Flow - gpm	-	67.5	72	12	141	116
Temp - °F, Tower Entrance	-	130	206	100	180	225
NH_3, Min - ppm	1,500	-	1,200	647	-	-
NH_3, Max - ppm	2,500	-	3,100	1,733	-	-
NH_3, Avg - ppm	2,000	32,200	1,600	1,384	810	1,440
H_2S, Min - ppm	2,000	-	1,600	874	-	-
H_2S, Max - ppm	4,000	-	3,400	2,293	-	-
H_2S, Avg - ppm	3,000	45,000	2,500	874	4,080	1,200
Phenols, Min - ppm	300	-	-	484	-	-
Phenols, Max - ppm	500	-	-	580	-	-
Phenols, Avg - ppm	400	278	440	532	< 10	71
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	-	-	-	0.7	-	-
pH - Avg	9.2	9.8	8.3	-	9.0	9.4
RECYCLE:						
Flow - gpm	-	23	11.7	-	22	-
Temperature - °F	-	105	180	180	135	-
NH_3, Avg - ppm	-	150,000	-	-	61,000	-
H_2S, Avg - ppm	-	182,000	-	-	121,600	-
Phenols, Avg - ppm	-	12,000	-	-	-	-
pH	-	-	9.4	-	9.6	-
Disposition	Feed Drum	Feed Drum	Feed Line	Feed Drum	Feed Line	Feed Drum
STRIPPER OFF-GAS:						
Temperature - °F	-	180	180	-	-	180
NH_3, Avg - lb/hr	40	-	56.5	-	-	-
H_2S, Avg - lb/hr	60	-	90.0	-	-	34.3
Phenols, Avg - lb/hr	-	-	-	-	-	-
Cyanides, Avg - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	-	-	77	-	-	3,900
Disposition	Furnace	Flare	Furnace	Flare	S. Plant	-
TOWER BOTTOMS:						
Flow - gpm	45	108 (1)	74	-	154	119 (5)
Temperature - °F	-	-	235	224	230	270
NH_3, Min - ppm	10	-	7	287	1,000	-
NH_3, Max - ppm	-	-	-	908	2,000	-
NH_3, Avg - ppm	15	56	25	693	1,470	555
H_2S, Min - ppm	0	-	0	129	50	-
H_2S, Max - ppm	-	-	-	312	200	-
H_2S, Avg - ppm	Trace	20	1	255	65	Nil
Phenols, Min - ppm	-	-	-	299	-	-
Phenols, Max - ppm	-	-	-	695	-	-
Phenols, Avg - ppm	375	239	250	410	Nil	28
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	-	-	-	0.3	-	-
pH - Avg	7.3	8.5	9.0	9.6	9.7	8.4
Disposition	Desalter	Desalter	Desalter	Desalter	Sewer	Sewer
REMOVAL:						
NH_3 - %	99.3	-	98.4	49.9	- -	61.5
H_2S - %	99.98	-	99.96	70.8	98.41	99.92
Phenols - %	6.3	-	43.2	22.9	-	60.6
Cyanides - %	-	-	-	57.1	-	-
STEAM:						
Heating - Mlb/hr	0	4.7	Reboiler	0.3	-	2.7
Stripping - Mlb/hr	-	6.6	-	-	-	4.1
Total - Mlb/hr	4.5	11.3	-	-	10.2	6.8
Stripping - lb/gal of raw feed	-	1.2	-	-	-	0.6
Total - lb/gal of raw feed	-	2.1	-	-	1.2	1.0
TOWER:						
Diameter - ft.	3.3	4	3.3	2.5	4.5	3
Height - ft.	36.5	33.5	52	8	25	35
No. of Trays	20	12	20	3	10	10
Type of Trays	Bubble Cap	Socony	Sieve	Dual Flow	Bubble Cap	Koch
Depth of Packing - ft	-	-	-	-	-	-
Type of Packing	-	-	-	-	-	-
Top Temp - °F	220	215	225	222	221	252
Top Press. - psig	3.0	15	5.3	3.5	3	29

TABLE VII-4

SUMMARY OF OPERATING DATA
SOUR WATER STRIPPERS
(Reference #24)
STEAM STRIPPING - NON-REFLUXED

CODE NO.	5	7	6	9	10	13A
REMARKS	1-Sample				Data is Design	1-Sample
pH CONTROL	None	None	None	None	None	None
RAW FEED:						
Flow - gpm	40	54	45	167	95	120
Temp. - °F, Tower Entrance	160	143	170	236	-	-
NH_3, Min - ppm	1,000	900	-	-	-	-
NH_3, Max - ppm	2,000	1,250	-	-	-	-
NH_3, Avg - ppm	1,700	960	-	2,150	1,850	1,700
H_2S, Min - ppm	1,000	1,500	2,000	-	-	-
H_2S, Max - ppm	14,000	4,000	6,000	-	-	-
H_2S, Avg - ppm	-	2,600	3,000	2,560	1,070	2,080
Phenols, Min - ppm	200	76	200	-	-	-
Phenols, Max - ppm	600	215	900	-	-	-
Phenols, Avg - ppm	-	128	700	500	-	330
Cyanides, Min - ppm	-	2	-	-	-	-
Cyanides, Max - ppm	-	5.1	-	-	-	-
Cyanides, Avg - ppm	0.5	3.3	-	-	-	<1
pH Avg.	8.0	8.4	8.5	8.3	-	-
TOWER BOTTOMS:						
Flow - gpm	45	57 (5)	47	177 (1) (5)	-	120 (5)
Temp. - °F	230	204	212	240	-	225
NH_3, Min - ppm	-	29.8	-	-	-	-
NH_3, Max - ppm	-	-	-	-	-	-
NH_3, Avg - ppm	208	49.5	-	380	96	400
H_2S, Min - ppm	0	29.2	-	-	-	-
H_2S, Max - ppm	9	-	-	-	-	-
H_2S, Avg - ppm	3	30.3	20	90	16	6
Phenols, Min - ppm	150	-	100	-	-	-
Phenols, Max - ppm	450	-	600	-	-	-
Phenols, Avg. - ppm	-	45	350	400	-	200
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	1.2	0.3	-	-	-	0
pH Avg.	8.5	9.4	7.1	8.0	-	-
Disposition	Bio-Unit	Desalter	Sewer	Desalter	Desalter	Sewer
REMOVAL:						
NH_3 - %	88	96.9	-	82.5	94.8	76.5
H_2S - %	-	98.88	99.33	96.5	98.5	99.7
Phenols - %	-	64.8	50.0	20.0	-	39.4
Cyanides - %	-	90.9	-	-	-	-
STRIPPER OFF-GAS:						
Temp. - °F	215	201	-	254	-	224
NH_3, Avg - lb/hr	-	24.6	-	150	81	-
H_2S, Avg - lb/hr	-	70.2	-	222	51	-
Phenols, Avg. - lb/hr	-	2.2	-	2	-	-
Cyanides, Avg - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	-	4,800	-	10,400	-	-
Disposition	CO-boiler	CO-boiler	CO-boiler	Furnace	Flare	Flare
STEAM:						
Heating - Mlb/hr	1.36	1.6 (3)	0.9 (3)	0.4 (3)	-	-
Stripping - Mlb/hr	1.34	4.8 (4)	3.6 (4)	10.6 (4)	-	-
Total - Mlb/hr	2.7	6.4	4.5	11.0	1.7	4.1
Stripping - lb/gal of raw feed	0.6	1.5	1.3	1.1	-	-
Total - lb/gal of raw feed	1.1	2.0	1.7	1.1	0.3	0.6
TOWER:						
Diameter - ft.	5.5	4.5	3	-	2	3.5
Height - ft.	3.7	23	39.7	48	15	20
No. of Trays	12	8	12	10	6	-
Type of Trays	Glitsch	Bubble Cap	Glitsch	Valve	Shower	-
Depth of packing - ft.	-	-	-	-	-	-
Type of Packing	-	-	-	-	-	1" rings
Top Temp. - °F	215	201	-	-	-	-
Bot. Temp - °F	230	204	212	-	292	225
Top Pressure - psig	3	-	-	17	-	4

TABLE VII-4 (Cont.)

CODE NO.	18	21A	21A	21B	29	31
REMARKS		1st stage	2nd Stage			1-sample
pH CONTROL	None	None	None	None	None	None
RAW FEED:						
Flow - gpm	40	403	403	86	50	73
Temp. - °F, Tower Entrance	170	216	227	210	220	21[illegible]
NH_3, Min - ppm	2,400	1,900	1,500	-	-	-
NH_3, Max - ppm	4,500	3,900	2,600	-	-	-
NH_3, Avg - ppm	4,460	2,800	2,000	2,500	3,700	5,305
H_2S, Min - ppm	2,400	2,800	200	-	-	-
H_2S, Max - ppm	5,200	5,900	800	-	-	-
H_2S, Avg - ppm	2,480	4,000	500	1,300	8,750	21,760
Phenols, Min - ppm	180	360	380	-	-	-
Phenols, Max - ppm	400	740	700	-	-	-
Phenols, Avg. - ppm	188	629	584	2,400	-	232
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	<15	-	-	-	-	28
pH Avg.	8.6	8.9	-	9.7	9.1	8.7
TOWER BOTTOMS:						
Flow - gpm	56 (5)	407 (5)	427 (5)	90 (5)	53 (5)	80 (5)
Temp. - °F	209	227	272	235	273	238
NH_3, Min - ppm	150	1,500	200	-	-	-
NH_3, Max - ppm	500	2,600	1,300	-	-	-
NH_3, Avg. - ppm	265	2,000	300	300	2,600	408
H_2S, Min - ppm	2	200	10	-	-	-
H_2S, Max - ppm	9	800	300	-	-	-
H_2S, Avg - ppm	2	500	90	300	3,000	13
Phenols, Min - ppm	45	380	320	-	-	-
Phenols, Max - ppm	150	700	700	-	-	-
Phenols, Avg - ppm	45	584	479	310	-	31
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	-	-				[illegible]1.6
pH Avg.	-	-	-	6.3	9.5	9.0
Disposition	Desalter	2nd Stage	Desalter	Bio-Unit	Sewer	Desalter
REMOVAL:						
NH_3, - %	94.1	28.6	85.0	88.0	29.7	92.3
H_2S - %	99.92	87.5	82.0	76.9	65.7	99.94
Phenols - %	76.1	7.2	18.00	87.1	-	86.6
Cyanides - %	-	-	-	-	-	58.6
STRIPPER OFF-GAS:						
Temp - °F	218	220	266	237	-	230
NH_3, Avg - lb/hr	101.9	158	342	93	-	-
H_2S, Avg - lb/hr	51.4	704	83	42	-	-
Phenols, Avg. - lb/hr	2.9	7	17	89	-	-
Cyanides, Avg - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	9,570	3,392	7,987	1,616	-	-
Disposition	CO-boiler	S. Plant	CO-boiler	Furnace	Furnace	Furnace
STEAM:						
Heating - Mlb/hr	1.03	2.3 (1)	9.5 (1)	1.0 (3)	1.1 (3)	1.0 (1)
Stripping - Mlb/hr	9.23	1.7 (4)	12.0 (4)	2.9 (4)	1.1 (4)	5.8 (4)
Total - Mlb/hr	10.3	4.0	21.5	3.9	2.2	6.8
Stripping - lb/gal of raw feed	3.9	0.07	0.5	0.6	0.4	1.3
Total - lb/gal of raw feed	4.3	0.2	0.9	0.8	0.7	1.6
TOWER:						
Diameter - ft.	3.3	6	6.5	3.5	3.5	5
Height - ft.	39	30.5	41	42.5	22	28
No. of Trays	-	9	15	15	-	8
Type of Trays	-	Bubble Cap	Ballast	Sieve	-	Koch
Depth of Packing - ft.	16	-	-	-	12	-
Type of Packing	3" Saddles	-	-	-	1½" Saddles	-
Top Temp - °F	218	220	266	237	-	230
Bot. Temp - °F	-	227	272	235	273	238
Top Pressure - psig	-	7	33	8.7	57	12

TABLE VII-4 (Cont.)

CODE NO.	32	33	47	48	48	51
REMARKS				1st Stage	2nd Stage	
pH CONTROL	None	None	None	None	None	None
RAW FEED:						
Flow - gpm	75	283	50	80	80	55
Temp - °F, Tower Entrance	118	190	210	205	225	242
NH_3, Min - ppm	1,110	2,300	600	2,000	-	-
NH_3, Max - ppm	1,310	3,000	1,350	5,000	-	-
NH_3, Avg - ppm	1,200	2,600	1,000	2,500	1,050	4,400
H_2S, Min - ppm	300	4,350	2,100	3,000	-	-
H_2S, Max - ppm	1,200	5,400	2,900	6,000	-	-
H_2S, Avg - ppm	600	5,250	2,550	3,800	215	3,743
Phenols, Min - ppm	31	310	270	-	-	-
Phenols, Max - ppm	122	570	800	-	-	-
Phenols, Avg - ppm	75	530	550	-	-	398
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg. - ppm	-	-	-	-	-	0.45
pH Avg.	8.3	8.6	7.5	8.5	-	9.1
TOWER BOTTOMS:						
Flow - gpm	80 (5)	307 (1)	52 (5)	86 (1)	80 (5)	56.3 (1)
Temp - °F	215	225	225	225	235	208
NH_3, Min - ppm	36	34	115	-	-	-
NH_3, Max - ppm	124	250	280	-	-	-
NH_3, Avg - ppm	65	200	115	1,050	115	1,017
H_2S, Min - ppm	0	0	5	-	-	-
H_2S, Max - ppm	4	12	100	-	-	-
H_2S, Avg - ppm	0.2	8	5	215	N.D.	68
Phenols, Min - ppm	14	310	225	-	-	-
Phenols, Max - ppm	39	390	450	-	-	-
Phenols, Avg - ppm	20	320	225	-	-	455
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm						0.35
pH Avg.	-	8.6	8.0	-	-	-
Disposition	Desalter	Lagoon	Desalter	2nd Stage	Desalter	Bio-Pond
REMOVAL:						
NH_3 - %	94.6	92.3	88.5	79.0	89.1	76.9
H_2S - %	99.97	99.85	99.8	94.3	-	97.65
Phenols - %	73.3	39.6	59.1	-	-	-
Cyanides - %	-	-	-	-	-	22
STRIPPER OFF-GAS:						
Temp - °F	180	225	215	210	230	224
NH_3, Avg - lb/hr	-	119	22	55	41	88
H_2S, Avg - lb/hr	-	242	64	143	9	68
Phenols, Avg - lb/hr	-	15	8	-	-	1
Cyanides, Avg - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	-	7,950	-	-	-	2,390
Disposition	B.D. Stack	CO-boiler	CO-boiler	To Atmos.	To Atmos.	Furnace
STEAM:						
Heating - Mlb/hr	3.7 (1)	5.1 (1)	0.4 (1)	0.8 (1)	0.4 (1)	-
Stripping - Mlb/hr	2.8 (4)	2.9 (4)	5.6 (4)	2.1 (4)	4.3 (4)	-
Total - Mlb/hr	6.5	8.0	6.0	2.9	4.7	2.6
Stripping - lb/gal of raw feed	0.6	0.2	1.9	0.4	0.9	-
Total - lb/gal of raw feed	1.4	0.5	2.0	0.6	1.0	0.8
TOWER:						
Diameter - ft.	4	3.5	5	3.5	4	4
Height - ft.	20.8	29	48.5	31.5	47.1	36.5
No. of Trays	-	-	19	-	12	-
Type of Trays	-	-	Bubble Cap	-	V-grid	-
Depth of Packing - ft.	15	15	-	20	-	10
Type of Packing	3" Rings	3" Saddles	-	3" Raschig Rings	-	3" Raschig Rings
Top Temp. - °F	180	225	215	210	230	224
Bot. Temp. - °F	200	230	225	225	235	242
Top Pressure - psig	1	8	1.5	1	7	4.5

TABLE VII-4 (Cont.)

CODE NO.	52	53	53	54A	54B	54B
REMARKS		1st Stage	2nd Stage	Crude Unit Stripper	1st Stage	2nd Stage
pH CONTROL	None	None	Caustic	None	None	None
RAW FEED:						
Flow - gpm	14	231	203	50	135	137
Temp - °F, Tower Entrance	90	171	212	224	210	225
NH_3, Min - ppm	-	-	-	-	-	-
NH_3, Max - ppm	-	-	-	-	-	-
NH_3, Avg - ppm	5,450	2,625.	1,425	215	2,500	2,330
H_2S, Min - ppm	-	-	-	-	-	-
H_2S, Max - ppm	-	-	-	-	-	-
H_2S, Avg - ppm	5,215	3,400	375	417	4,200	425
Phenols, Min - ppm	-	-	-	-	-	-
Phenols, Max - ppm	-	-	-	-	-	-
Phenols, Avg - ppm	202	-	-	20	390	336
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg - ppm	1.2	-	-	-	-	-
pH Avg.	9.1	8.3	9.6	7.3	8.6	-
TOWER BOTTOMS:						
Flow - gpm	16.4	231 (5)	218 (1)	53 (1)	137 (5)	143 (1)
Temp. - °F	222	212	234	224	225	218
NH_3, Min - ppm	-	-	-	-	-	-
NH_3, Max - ppm	-	-	-	-	-	-
NH_3, Avg - ppm	56	1,425	9.8	76	2,330	350
H_2S, Min - ppm	-	-	-	-	-	-
H_2S, Max - ppm	-	-	-	-	-	-
H_2S, Avg - ppm	1	375	4.5	6	425	22
Phenols, Min - ppm	-	-	-	-	-	-
Phenols, Max - ppm	-	-	-	-	-	-
Phenols, Avg. - ppm	147	-	-	13	336	250
Cyanides, Min - ppm	-	-	-	-	-	-
Cyanides, Max - ppm	-	-	-	-	-	-
Cyanides, Avg. - ppm	1.23	-	-	-	-	-
pH Avg.	8.6	9.6	-	9.3	-	9.7
Disposition	Bio-Pond	2nd Stage	Desalter	Wash Water	Desalter	Desalter
REMOVAL:						
NH_3 - %	98.9	45.7	99.3	64.6	6.8	85.0
H_2S - %	99.98	89.0	98.8	*98.56	89.88	17.7
Phenols - %	27.2	-	-	35.0	13.9	25.6
Cyanides - %	-	-	-	-	-	-
STRIPPER OFF-GAS:						
Temp. - °F	220	194	223	225	216	214
NH_3, Avg - lb/hr	38	133	156	3.5	10	137
H_2S, Avg. - lb/hr	37	334	41	10.3	255	27.5
Phenols, Avg. - lb/hr	0.3	-	-	0.1	0.6	5.9
Cyanides, Avg. - lb/hr	-	-	-	-	-	-
Water Vapor - lb/hr	1,610	-	-	1,350	975	6,000
Disposition	Furnace	Gas Plant	Vent Stack	Furnace	Furnace	Furnace
STEAM:						
Heating - Mlb/hr	0.9	4.8 (1)	2.0 (1)	0.2 (1)	1.2 (1)	-
Stripping - Mlb/hr	1.6	0.9 (4)	9.4 (4)	1.2 (4)	0.8 (4)	-
Total - Mlb/hr	2.5	5.7	11.4	1.4	2.0	6.0
Stripping - lb/gal of raw feed	1.9	0.07	0.8	0.4	0.1	-
Total - lb/gal of raw feed	3.0	0.4	0.9	0.5	0.3	0.7
TOWER:						
Diameter - ft.	2.5	5	3.5	2.5	3	3
Height - ft.	27	25	56.5	18	25	24.7
No. of Trays	8	8	20	5	-	10
Type of Trays	Valve	Bubble Cap	Bubble Cap	Valve	-	Bubble Cap
Depth of Packing - ft.	-	-	-	-	15	-
Type of Packing	-	-	-	-	2" Raschig Rings	-
Top Temp. - °F	220	194	223	225	216	214
Bot. Temp. - °F	222	212	234	230	227	221
Top Pressure - psig	3	3	5	6	6	1

TABLE VII-4 (Cont.)

CODE NO.	57	58	59	63
REMARKS				
pH CONTROL	None	None	None	None
RAW FEED:				
Flow - gpm	-	28	57	94
Temp. - °F, Tower Entrance	145	145	137	214
NH_3, Min - ppm	-	1,000	1,375	-
NH_3, Max - ppm	-	8,100	1,630	806
NH_3, Avg - ppm	3,842	4,400	1,548	767
H_2S, Min - ppm	-	600	1,585	-
H_2S, Max - ppm	-	2,730	3,042	1,550
H_2S, Avg. - ppm	2,885	2,300	2,300	1,325
Phenols, Min - ppm	-	175	152	-
Phenols, Max - ppm	-	225	270	71
Phenols, Avg. - ppm	260	190	210	68
Cyanides, Min - ppm	-	-	7	-
Cyanides, Max - ppm	-	-	9	-
Cyanides, Avg - ppm	0.6	1.01	8	-
pH Avg.	9.2	8.8	7.8	8.1
TOWER BOTTOMS:				
Flow - gpm	13.4	32.0 (1)	64 (1)	101 (1)
Temp. - °F	200	215	207	235
NH_3, Min - ppm	-	10	183	-
NH_3, Max - ppm	-	45	324	890
NH_3, Avg. - ppm	860	11	250	580
H_2S, Min - ppm	-	0	0	-
H_2S, Max - ppm	-	10	20	582
H_2S, Avg. - ppm	202	1	10	291
Phenols, Min - ppm	-	100	94	-
Phenols, Max - ppm	-	400	184	-
Phenols, Avg. - ppm	280	150	140	63
Cyanides, Min - ppm	-	-	1	-
Cyanides, Max - ppm	-	-	3	-
Cyanides, Avg. - ppm	0.3	1.05	2	-
pH Avg.	9.6	8.3	9.0	9.6
Disposition	Lagoon	Bio-Unit	Bio-Pond	Sewer
REMOVAL:				
NH_3 - %	77.6	99.8	83.6	24.4
H_2S - %	93.0	99.96	99.57	78.0
Phenols - %	-	21.1	33.3.	7.4
Cyanides - %	50.0	-	75.0	-
STRIPPER OFF-GAS:				
Temp. - °F	-	213	205	232
NH_3, Avg. - lb/hr	18.5	77	35	25
H_2S, Avg. - lb/hr	16.9	35	57	2,000
Phenols, Avg. - lb/hr	-	0.15	1.4	-
Cyanides, Avg. - lb/hr	-	-	-	-
Water Vapor - lb/hr	-	3,840	1,300	-
Disposition	To Atmos.	Burner	Vent Stack	S. Plant
STEAM:				
Heating - Mlb/hr	-	1.2	1.6 (1)	0.9 (1)
Stripping - Mlb/hr	-	4.5	2.4 (4)	0.5 (4)
Total - Mlb/hr	-	5.7	4.0	1.4
Stripping - lb/gal of raw feed	-	2.7	0.7	0.09
Total - lb/gal of raw feed	-	3.4	1.2	0.3
TOWER:				
Diameter - ft.	2.5	3	4	5.7
Height - ft.	18.1	23	25	48.3
No. of Trays	-	8	-	22
Type of Trays	-	Koch	-	Bubble Cap
Depth of Packing - ft.	10	-	18	-
Type of Packing	1" Raschig Rings	-	3" Raschig Rings	-
Top Temp. - °F	-	213	205	232
Bot. Temp. - °F	200	215	207	235
Top Pressure - psig	-	0.5	0.1	8

NOTES FOR TABLES VII-3 AND VII-4

(1) Calculated bottoms rate or steam rates. See explanation in Notes (2) and (4) below.

(2) Heating steam rates designated as calculated were determined by taking the enthalpy change in raising the feet at the temperature entering the tower to the tower operating temperature and converting it to a steam rate based on the indicated steam temperature and pressure.

(3) The reported steam rate does not equal the calculated rate.

(4) Stripping steam rates were determined by taking the difference between the total steam and the heating steam.

(5) The reported bottoms rate does not equal the sum of the feed plus the condensed heating steam. The reported bottoms rates should not be used as a basis for estimating the stripping steam rate.

(6) The following strippers are presently not in service: 13B, 27, 10, and 31.

TABLE VII-5

SUMMARY OF OPERATING DATA
SOUR WATER STRIPPERS
(Reference #24)
FLUE GAS AND FUEL GAS STRIPPERS

CODE NO.	4	11	35	40	62	2	39A
REMARKS		Feed includes KO Pot					
pH CONTROL	None	None	None	None	None	None	Acid
RAW FEED:							
Flow - gpm	200	24	225	49	84	51	250
Temp. - °F	140	175	-	87	190	177	110
NH_3, Min - ppm	-	-	1,900	3,300	400	4,060	-
NH_3, Max - ppm	-	-	2,300	3,800	900	6,250	-
NH_3, Avg - ppm	-	3,800	2,200	3,600	700	5,320	1,800
H_2S, Min - ppm	616	-	2,900	3,600	800	6,850	-
H_2S, Max - ppm	3,736	-	4,100	3,900	1,600	10,000	-
H_2S, Avg - ppm	2,176	6,000	3,840	3,800	1,700	8,590	2,500
Phenols, Min - ppm	-	-	-	100	90	91	-
Phenols, Max - ppm	-	-	-	150	135	181	-
Phenols, Avg - ppm	220	330	491	110	100	143	-
Cyanides, Avg. ppm	0.29	-	5	nil	-	-	-
pH Avg	8.5	8.5	8.1	9.3	8.7	9.0	6.7
TOWER BOTTOMS:							
Flow - gpm	200	24	225	51	87	53	276
Temp. - °F	204	200	165	141	180	236	285
NH_3, Min - ppm	-	-	410	780	-	431	-
NH_3, Max - ppm	-	-	-	-	-	637	-
NH_3, Avg - ppm	-	1,500	535	870	700	537	1,670
H_2S, Min - ppm	0	0	6	nil	-	11	-
H_2S, Max - ppm	4	20	-	-	-	22	-
H_2S, Avg - ppm	4	-	12	nil	65	15	6
Phenols, Min - ppm	-	-	-	80	-	68	-
Phenols, Max - ppm	-	-	-	-	-	136	-
Phenols, Avg - ppm	130	250	422	90	100	101	-
Cyanides, Avg - ppm	0.25	-	13	nil	-	-	-
ph Avg.	6.5	8.3	7.9	94	8.7	9.6	10
Disposition	Sewer	Bio-Unit	Sewer	Pond	Sewer	Sewer	Desalter
REMOVAL							
NH_3 - %	-	60.5	75.7	75.6	0	89.9	7.2
H_2S - %	99.62	99.83	99.69	99.95	96.18	99.83	99.76
Phenols - %	40.9	24.2	14.1	18.2	0	29.4	-
Cyanides - %	13.8	-	-	-	-	-	-
STRIPPER OFF-GAS:							
Temp. - °F	-	160	165	156	200	233	205
NH_3, Avg - lb/hr	-	33.5	-	64	-	146	nil
H_2S, Avg - lb/hr	-	87.5	-	92	-	230	312
Phenols, Avg - lb/hr	-	1.2	-	0.34	-	1	-
Cyanides, Avg - lb/hr	-	-	-	nil	-	-	-
Water Vapor - lb/hr	-	200	-	1,180	-	3,730	250
CO_2 - lb/hr	-	904	-	24	9	-	-
Disposition	CO-Boiler	Incinerator	CO-Boiler	Stack	Incinerator	Furnace	Coker Fractionator
STRIPPING MEDIUM:							
Stripping Gas	Flue Gas	Flue Gas	Flue Gas	Flue Gas	Flue Gas	Fuel Gas	Fuel Gas
Quality							
CO_2 - %	9.1	8.0	10	8.3	10	-	-
CO - %	12.5	13.0	12	-	9	-	-
O_2 - %	0	0.1	Trace	2.5	1	-	-
N_2 - %	-	78.9	66	72.5	71	-	-
H_2O - %	-	-	12	16.7	9	-	-
Quantity - lb/hr	-	4,000	-	-	-	795	200
Quantity - SCFH	278,300	-	-	80,150	25,000	-	-
Pressure - psig	-	5-10	5	-	7	-	-
Temp. - °F	856	300	1,275	335	600	51	-
STEAM:							
Temp. - °F	-	350	-	-	-	430	285
Pressure - psig	45	-	70	-	-	144	35.3
Lb/Hr	5,100	200	6,700	2,098	-	5,084	13,000
TOWER:							
Diameter - ft.	5	2.5	6	6	2.7	3	4
Height - Ft.	40	33	40	21.7	30	31	-
No. of Trays	10	13	13	-	-	18	16
Type of Trays	Valve	Bubble Cap	Sieve	-	-	Baffle	-
Depth of Packing	-	-	-	16	22	-	-
Type of Packing	-	-	-	1½" Raschig Rings	1½" Saddles	-	-
Top Pressure - psig	-	5	2	3.5	-	14	35.3

(2) steam/non-refluxed, and (3) flue gas and fuel gas stripped, respectively.

The results of this survey show that 18 of the 31 refluxed and 11 of the 24 non-refluxed SWS's and 6 of the 7 SWS's using flue or fuel gas as the stripping medium achieve greater than 99% removal of sulfides. In addition, nine refluxed and three non-refluxed units achieve greater than 99% removal of sulfides and 95% or greater removal of ammonia in the same unit. It should be noted that many other columns are performing nearly as well as the removals indicated. It is interesting to note that of the five two-stage units for which data are reported, only one unit achieves high removals of both parameters. From the data, it appears that refluxed columns are yielding better overall removals of both pollutants.

The average effluent of all units that are achieving greater than 99% sulfide removal is 5.8 mg/l. The average effluent from all units achieving 95% or greater ammonia removal is 62.5 mg/l. These averages are based upon a wide range of influent and effluent values.

Table VII-6 presents the data collected during this study for the sour water stripper at indirect discharging refinery #17.

<u>Sour Water Oxidizers</u>. Another way of treating sour water is to oxidize by aeration. Compressed air is injected into the waste with sufficient steam to raise the reaction temperature to at least 190 degrees F. Reaction pressure of 50 - 100 psig is required. Oxidation proceeds rapidly and converts practically all of the sulfides to thiosulfates and about 10% of the thiosulfates to sulfates. Air oxidation, however, is much less effective than stripping in regard to reduction of the oxygen demand of sour waters, since the remaining thiosulfates can later be oxidized to sulfates by aquatic microorganisms.

Oxidation systems using peroxide and chlorine have also been identified during this project. These systems operate in open tanks, without the use of steam.

Due to the very low limits required by the County Sanitation Districts of Los Angeles County, refineries discharging to this sewer system use both sour water strippers and sour water oxidizers, in series. Levels of less than 0.1 mg/l sulfides in the effluent are consistently maintained by these refineries. Los Angeles County also maintains a

TABLE VII-6

SOUR WATER STRIPPER OPERATING DATA
FOR
Refinery #17

Operating Data

Date	Hydrogen Sulfide In	Hydrogen Sulfide Out	Ammonia In	Ammonia Out
6/74	126	2	112	52
7/74	120	1	105	50
8/74	100	3	95	48
9/74	104	0	100	50
10/74	95	0	90	46
11/74	112	1	102	51
12/74	102	1	98	47
1/75	80	0	85	40
2/75	86	0	87	44
3/75	78	0	84	46
4/75	92	1	98	50
5/75	100	1	110	55
6/75	98	0	110	56
7/75	115	1	120	58
8/75	110	2	118	58
9/75	120	1	124	55
10/75	116	0	120	56
11/75	98	1	104	48
12/75	80	1	92	44

restriction of 50 mg/l of thiosulfates to control the chlorine demand at the sewage treatment plant.

Table VII-7 has been extracted from the "1972 API Sour Water Stripping Survey Evaluation" (24). As can readily be seen, these treatment systems are capable of removing virtually all of the sulfides present in the wastewater regardless of the raw feed concentration.

Phenol Removal Systems

The removal of phenols by end-of-pipe treatment systems has been demonstrated in this as well as in other industries. Phenol removal as a pretreatment operation involves the treatment of sour waters prior to dilution by other process waste streams. There are two major techniques practiced by the refining industry for the pretreatment of phenols--biological treatment and the use of sour waters as make-up to the desalter.

Recycling to the Desalter. The use of sour waters as make-up to the desalter is a proven technology in the industry. Phenol removal efficiencies will vary greatly depending on a number of factors, but the most important factor is the type of crude being refined.

Data were obtained on the removal efficiencies accomplished through the application of this technology at Refinery #18 and are presented in Table VII-8. A total of three indirect discharge refineries (numbers 17, 18 and 22) have been identified that treat their sour waters by recycling to the desalter after stripping.

Industry has suggested that the crude source can have a significant effect on the practicality of recycling sour water stripper bottoms to the desalter. For example, it has been contended that the use of sour waters to desalt heavy California crudes can lead to the formation of emulsions in the desalter effluent. The Agency solicits information relative to this contention such that the existence of desalter effluent emulsions and their effects on end-of-pipe treatment can be quantified.

Biological Treatment. Biological oxidation has been used successfully to treat industrial wastes containing phenol at various concentrations. Since phenol is a bactericide, it can have the effect of inhibiting biological action in a treatment plant not acclimated to phenolic wastes. However, biota can become acclimated to the phenol by developing strains of organisms resistant to phenol that are able to

TABLE VII-7

SUMMARY OF OPERATING DATA
SOUR WATER OXIDIZERS
(Reference #24)

CODE NO.	16		39B	45	46
REMARKS	1st Stage Oxidizer	2nd Stage Ammonia Stripper			2 parallel Oxidizers
pH Control	Caustic	None	-	Caustic	Caustic
RAW FEED					
Flow - gpm	29	19.6	175	110	530
Temp - °F	100	210	-	110	109
NH_3, Avg. - ppm	2,000	1,700	9,000	3,550	6,510
H_2S, Avg - ppm	1,160	0	10,000	4,740	8,800
Phenols, Avg - ppm	38	34	-	1,100	141
pH, Avg. -	12	10	9.5	8.2	-
TREATED WATER					
Flow - gpm	31.8	20.4	185	115	-
Temp. - °F	210	245	200	200	198
NH_3, Avg. - ppm	1,700	200	7,100	2,760	3,800
H_2S, Avg. - ppm	0	0	0	<1	0
Phenols, Avg. - ppm	34	32	-	1,000	141
Thiosulfate - ppm	2,800	-	-	-	8,800
pH Avg.	10	-	10	9	-
Disposition	2nd Stage	Sewer	Storage	Sewer	Sewer
STEAM					
Flow - SCFM	23	-	-	-	-
Flow - lb/hr	-	1,500	3,300	3,000	8,350
AIR					
Flow - SCFM	217	-	-	500	5,600
Flow - lb/hr	-	-	5,400	-	-
TOWER					
Diameter	4.5	3	7	6	9.5
Height	50	40	50	83	50
No. of Trays	-	15	-	26	-
Type of Trays	-	Valve	-	Bubble Cap	-
Stages	4	-	4	-	4
Temp. Top	210	235	220	200	210
Temp. Bot.	200	245	200	187	200
Pressure Top	37	10	85	40	40
Pressure Bot.	85.	15	140	72	85

TABLE VII-8

OPERATING DATA FOR THE
REMOVAL OF PHENOLS IN THE DESALTER

Refinery #18

	Phenol Concentration, mg/l	
Date	Influent	Effluent
5/13/76	55	8
5/14/76	55	10
5/17/76	104	14
5/18/76	93	25
5/21/76	63	8

utilize phenol as food material. Biological treatment systems can thrive on phenolic-bearing wastes and oxidize the phenols to innocuous substances. The most effective technique for biological treatment appears to be the completely mixed activated sludge process with detention times of about 24 hours in the aeration tank. This technique tends to minimize the adverse effects of sudden changes in concentration (i.e., shock loads) of phenols or other pollutant parameters. It is also possible to minimize these fluctuations in influent phenol concentrations by the use of waste water equalization techniques.

Biological treatment for phenol removal is practiced in a number of refineries at which the combined plant effluent is treated biologically for removal of oxygen demand in addition to phenol reduction. However, treatment for specific removal of phenol in the sour water stream by biological means has been identified to be in use at only one refinery. This refinery is a direct discharger and is coded #52 in the "1972 API Sour Water Stripping Survey Evaluation" (24) discussed previously. No refineries that are presently discharging to a POTW have been identified as using this technology.

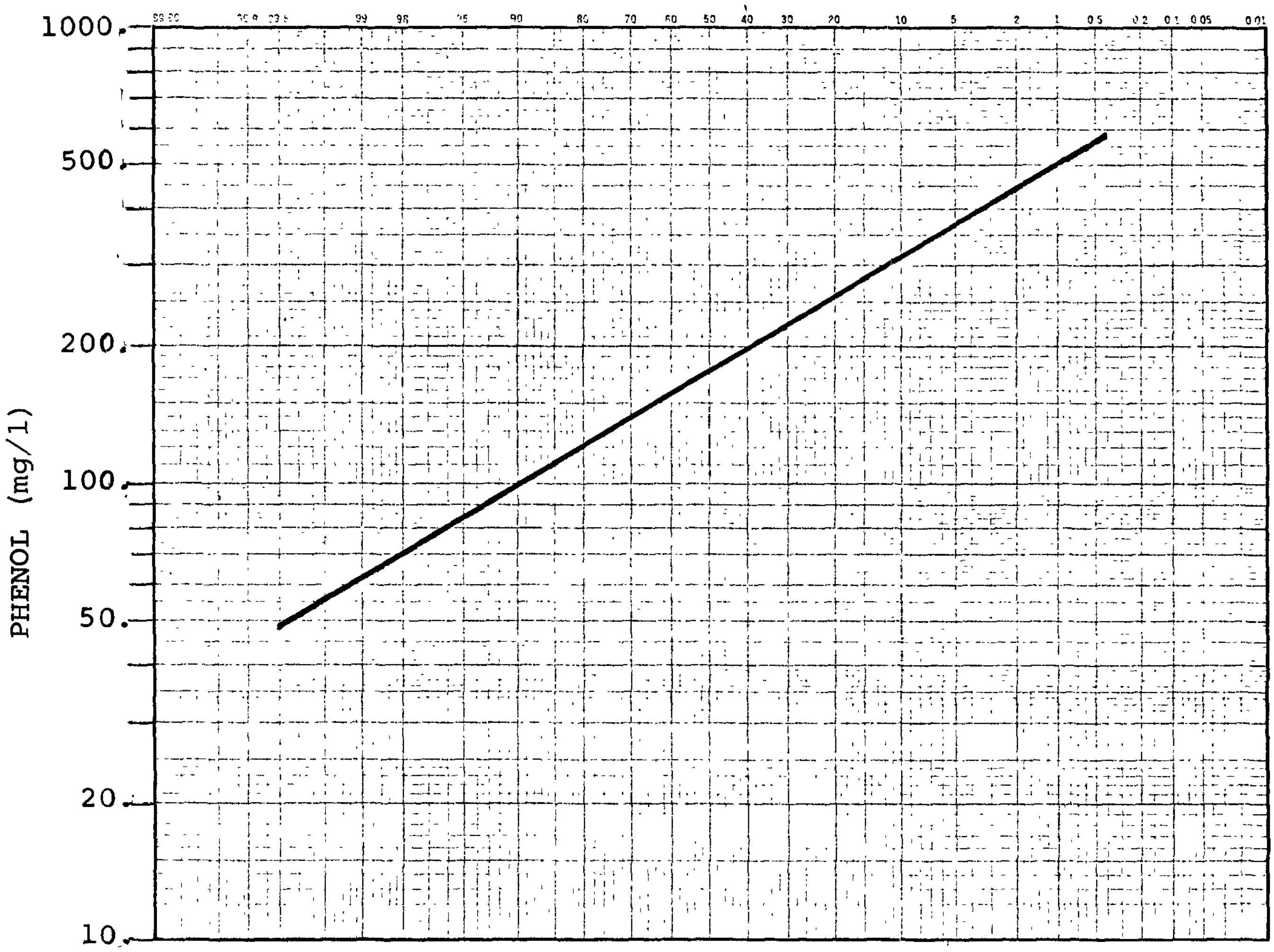
The phenol pretreatment system at plant #52 consists of an aeration tank with a detention time of 3.6 days at the design flow rate of 100 gpm. Two 20 HP surface aeraters are used to supply the oxygen.

Figures VII-1 and VII-2 present probability plots for the phenol concentrations entering and exiting the bio unit. This facility is averaging 99% removal of phenols. It should be noted that the unit has experienced foaming problems that have affected the plant's operations periodically. The data presented in the probability plots are based upon approximately 150 daily samples taken over an eight month period.

Activated Carbon. The capability of activated carbon to adsorb phenol is well established in the literature. However, the pollutant category of "phenol" can include many compounds with widely varying rates of adsorption on carbon. Activated carbon is in general a nonselective adsorbent. It will adsorb other organics as well as phenols; important factors to the effectiveness and economics of the process are the relative concentration of the various organic compounds, the rate of adsorption, the equilibrium concentration, and the capacity of the carbon.

FIGURE VII-1

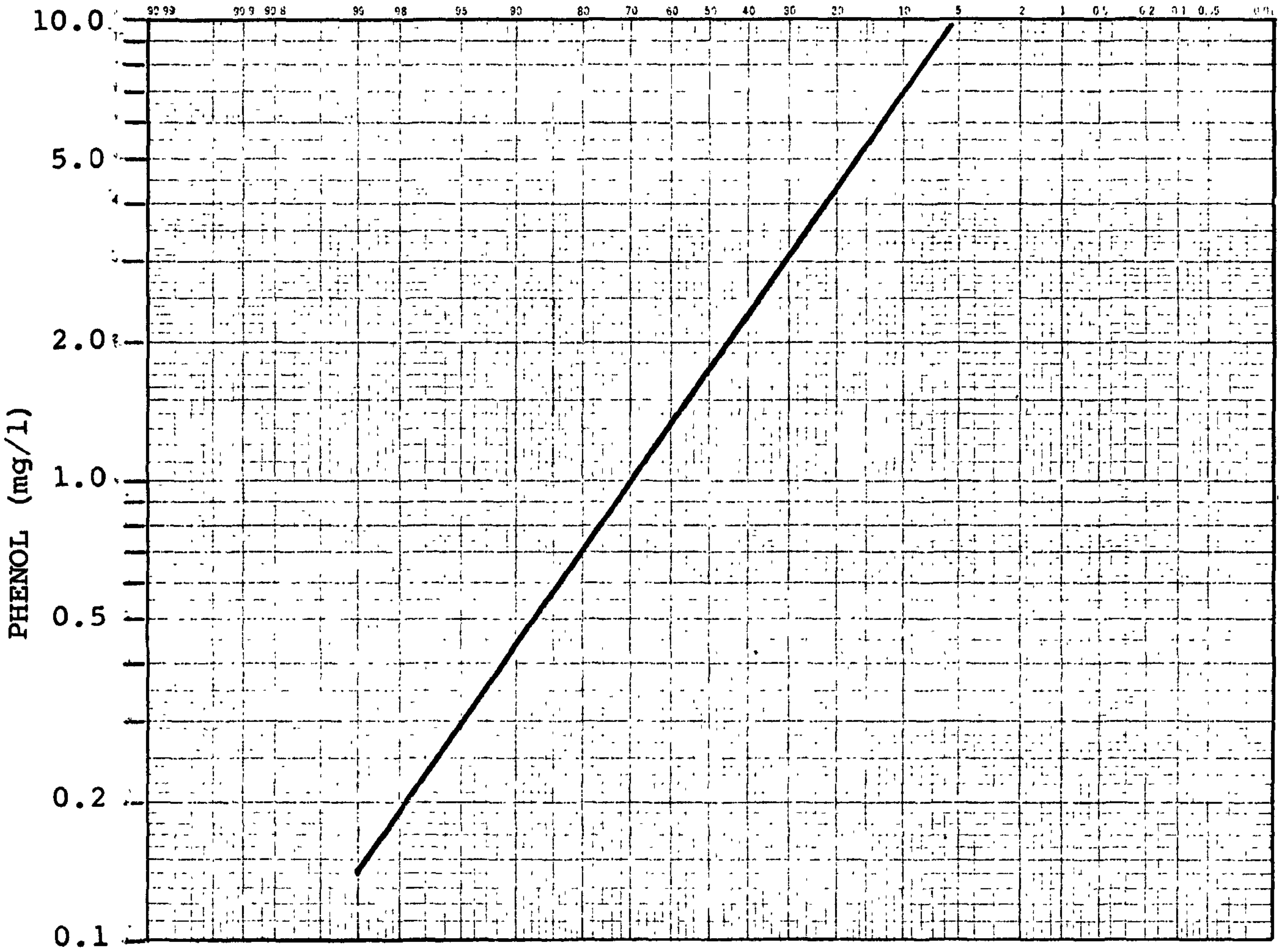
INFLUENT PHENOL CONCENTRATION
TO BIO-UNIT AT PLANT 52
(API STRIPPER SURVEY CODE)



PROBABILITY PLOT

FIGURE VII-2

EFFLUENT PHENOL CONCENTRATION
FROM BIO-UNIT AT PLANT 52
(API STRIPPER SURVEY CODE)



PROBABILITY PLOT

The use of activated carbon for phenol removal is not widely practiced in the refining industry. There were no indirect dischargers identified that used activated carbon pretreatment for phenol reduction prior to discharge to the POTW.

Chemical Oxidation. A number of relatively common oxidizing agents are capable of oxidizing phenol. These include ozone, hydrogen peroxide, chlorine, chlorine dioxide, and potassium permanganate.

Ozone is a powerful oxidizing agent capable of destroying most of the organic compounds, including phenols, which contribute to pollutants such as BOD, COD, and TOC. Since ozone is too unstable to ship and store, it must be generated on site with an ozone generator. The generator produces ozone by passing air or oxygen through an electrical discharge. While the use of oxygen results in a more efficient generation of ozone than the use of air, its use can usually be justified only in larger installations.

Aside from ozone, hydrogen peroxide is the preferred oxidizing agent in the remaining group of chemicals. Chlorine and chlorine dioxide are relatively low cost commercial chemicals, but could tend to form chlorophenols which may be more toxic than unchlorinated phenols. Potassium permanganate is significantly more costly than hydrogen peroxide for equivalent oxidation capacity.

Chemical oxidation is not widely utilized for phenol reduction, and no indirect discharge refineries were identified that employ this technology.

Removal of Chromium

Chromium will appear in the wastewaters from oil refineries when it is used as a scale preventative and biocide in cooling towers. This type of cooling tower treatment is prevalent throughout the industry and is used by many indirect dischargers.

Chromium will be present in the wastewater in both the trivalent and hexavalent forms. The first step in chromium removal involves the reduction of hexavalent chromium to the trivalent state. This is usually accomplished through the addition to the waste water of a reducing agent, such as sulfur dioxide, ferrous sulfate, or sodium bisulfite, and agitating for an appropriate period of time. The trivalent chromium is then precipitated by adding lime or caustic to the wastewater to raise the pH to alkaline conditions, at which chromium has the least solubility in water. Flocculants and flocculant aids, such as ferric chloride, alum, and polymers, can be added to increase removal efficiencies. The wastewater is then fed to a clarifier where adequate detention time must be afforded to allow the flocculated metallic hydroxide particles to settle out of the wastewater. Filtration would usually follow the clarification unit to remove suspended solids.

There are no pretreatment techniques for chromium removal presently being used by indirect discharging refineries; therefore, removal efficiency data are not available.

Removal of Oil and Grease

A major waste emanating from oil refineries is commonly referred to as the oily stream. These wastewaters are normally generated from many sources and operations within a refinery, including pad washings, tank bottom washings, and contaminated storm runoff. This waste stream can either be treated separately or in combination with the other refinery wastewaters. The control and treatment technology for oil and grease removal is well known and has been widely demonstrated throughout the industry (see Development Document, pages 101, 102, and 107).

Gravity separation is the unit operation employed for primary oil and grease removal. The most common piece of equipment used in this industry is the API separator. Gravity separation is universally utilized in petroleum refineries and is described in considerable detail in the Development Document (pages 101 and 102). All indirect dischargers presently have gravity oil separators as part of their pretreatment systems.

Another type of separator finding increasing use in refineries is the parallel plate separator. This technology is described in the Development Document (page 102). Refineries #4 and #5 are the only indirect dischargers that have been identified that use this type of treatment unit as part of their pretreatment systems.

Secondary oil and grease removal may be achieved by several unit processes. One of the most effective and widely used in petroleum refineries is dissolved air flotation (DAF) (see Development Document, page 107). Thirteen indirect discharging refineries have been identified that pretreat their wastewaters with DAF systems. It is also possible to employ multi-media filtration as a pretreatment technique to further reduce oil and grease discharges (see Development

Document, pages 102, 110, and 111). No indirect discharging refineries have been identified that employ filtration as pretreatment prior to discharge to POTW.

SECTION VIII

COST, ENERGY, AND NON-WATER QUALITY ASPECTS

INTRODUCTION

This section addresses the costs, energy requirements, and non-water quality environmental impacts associated with the control and treatment technology presented in Section VII. The cost estimates presented do not include land costs. It is assumed that ample space is available for the construction of any necessary pretreatment systems. In addition, the estimates are based on the assumption that no unusual foundation or site preparation problems exist. These factors are not included in the estimates because they are site specific. Land costs and site conditions may vary from one refinery to another. Land requirements are relatively minimal compared to those for refinery process equipment and the land areas required for installation of pretreatment systems are expected to be available to indirect discharging petroleum refineries.

The entire segment of the industry discharging to POTW has been identified and, except for a few instances, the pretreatment systems presently employed at these refineries are known. Total costs can be calculated for all indirect discharging refineries and are presented in this section. In some cases, costs are based on a model plant approach, while in other cases, a plant by plant evaluation is made.

COST AND ENERGY

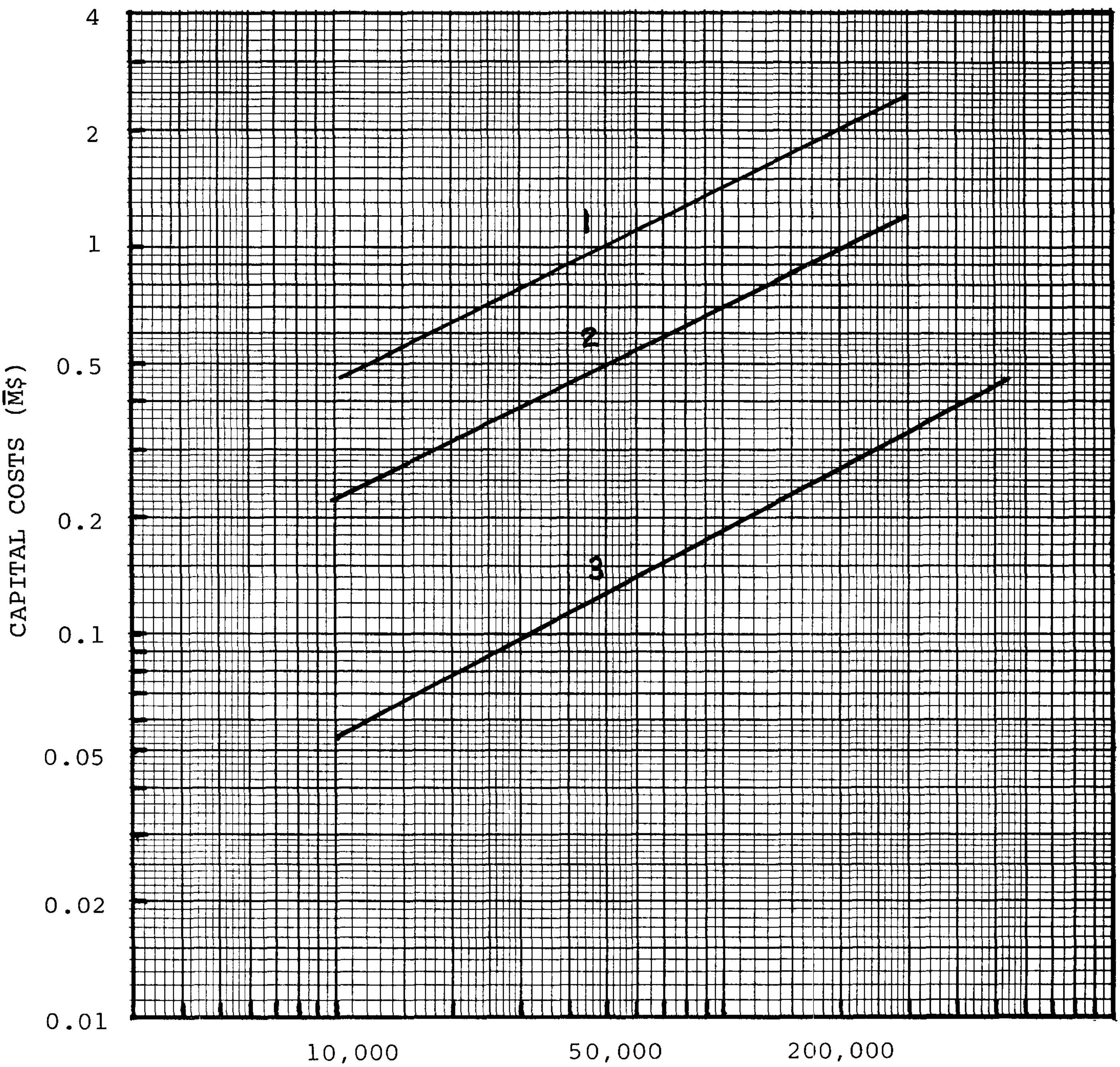
Sour Water Strippers

As discussed in Section VII, the major pretreatment process available to the petroleum refining industry for removal of sulfides and ammonia from sour waters is stripping.

The source of cost data for this technology is the "Economics of Refinery Wastewater Treatment" prepared by the American Petroleum Institute (31). The estimates of total capital cost as presented in the reference document are shown in Figure VIII-1. These estimates include the costs of sour water collection and steam supply to the stripper as well as the cost of the stripping facilities themselves. The costs shown in Figure VIII-1 are presented in 1972 dollars; therefore, costs were adjusted by a factor of 1.35

FIGURE VIII-1

CAPITAL COST
SOUR WATER STRIPPING



LEGEND:
1- High nitrogen crude installations
2- New installations for H_2S stripping
3- Revisions for NH_3 stripping

Reference 31

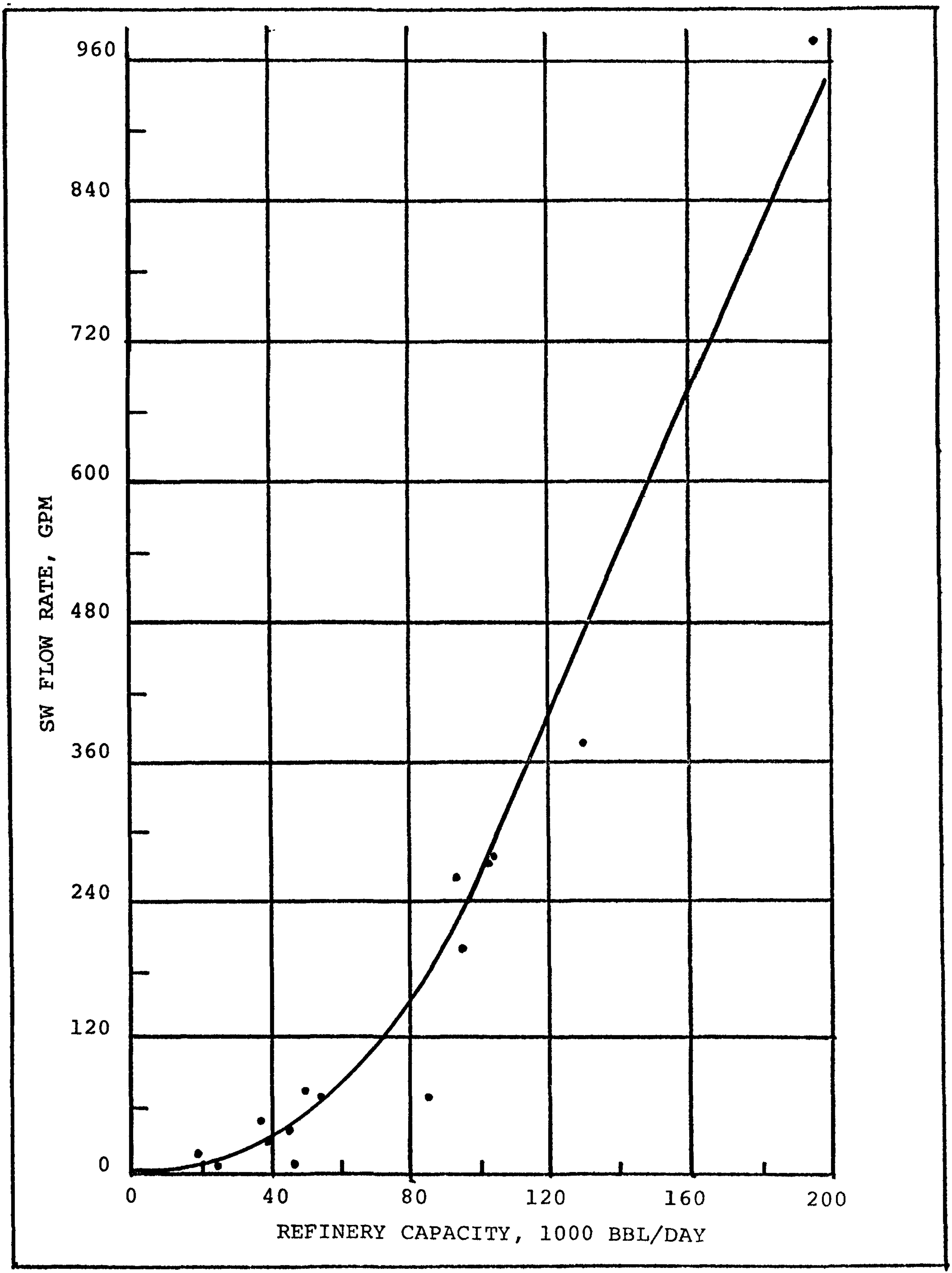


FIGURE VIII-2

REFINERY CAPACITY VS. SOUR WATER FLOW RATE (calculated from Consumer Price Index) to update the figures to 1976 costs.

In order to verify the relationship between sour water stripping capital cost and refinery capacity, sour water flow rate data obtained during this project were plotted against corresponding refinery throughput. This plot is shown in Figure VIII-2. The results indicate an adequate correlation between these two parameters for the purpose of estimating capital costs associated with the installation of sour water strippers for removal of hydrogen sulfide and ammonia.

Sulfide Removal. Nine refineries were identified that do not have a sour water stripper as part of their pretreatment operations. It was determined that at eight of these refineries stripping technology was not required since there are no sour waters produced by their operations.

Based on this analysis, only one refinery could be affected to any significant degree by the requirement of pretreatment standards for sulfides. The following table summarizes the capital costs associated with the installation of sour water stripping at this refinery:

Refinery Code	Refinery Capacity 1000 BBL/Day	Capital Cost Dollars
27	70	$785,000
Total	70	$785,000

Minor costs may be experienced at the remaining refineries to revamp certain portions of their stripping systems to improve the effluent quality. The costs, however, are generally not major and are expected to be on the same order of magnitude as maintenance costs.

Ammonia Removal. The refineries that are presently discharging to municipal sewers are not required by the POTW to meet ammonia limitations. Therefore, it is assumed that the SWS's at the refineries contacted are not being operated for optimum ammonia removals. Within the scope and time constraints of this study, it was not possible to determine how many of the present systems can be easily modified to meet ammonia pretreatment standards or at how many refineries it will be required that a second stripper be installed to remove ammonia. Because there is no available method of determining which refineries definitely need to install ammonia removal equipment, it was assumed that all indirect discharging refineries that generate sour waters will need to install additional equipment to meet ammonia standards. This approach results in an estimate of the maximum cost possible. Table VIII-1 presents estimated capital expenditures for the 26 refineries in the indirect discharging segment to attain pretreatment standards for ammonia. The estimates are based on the assumption that at all refineries where sour waters are generated, additional ammonia removal facilities will be installed. These estimates are taken from the "Revisions for Ammonia Removal" curve on Figure VIII-1. The estimated total costs to the indirect discharging portion of the industry are also presented in Table VIII-1.

Operating Costs and Energy Requirements. The estimated operating costs for sour water strippers are shown in Table VIII-2. Three typical sizes were chosen that represent the size range of refineries that are presently discharging to POTW.

Costs incurred by individual refineries can vary for reasons that are site specific such as the amount of steam used, the redundancy of equipment, and the distance that waste waters are pumped. Other operating costs, such as the treatment of off-gases and pH adjustment of the sour waters are not included in the estimates presented in Table VIII-2, because it is extremely difficult to determine costs for these items that are representative of the entire industry. However, these factors, if applicable, could have a significant effect on the total operating cost of sour water stripping. The Agency solicits specific information relative to these factors.

The energy requirements associated with sour water stripping are: (1) electrical power for pumping, and (2) the energy associated with the production of steam. Total energy consumption can range from 1,000,000 BTU/hour for a 20,000 BBL/ Day refinery to 33,000,000 BTU/hour for a 150,000 BBL/Day refinery.

Phenol Removal

The technology most likely to be used in a refinery for phenol removal is biological treatment. For the purpose of determining the costs for pretreatment, the use of packaged biological treatment plants has been assumed. Table VIII-3 presents the estimated capital costs for biological

TABLE VIII-1
COSTS FOR INSTALLING SOUR WATER STRIPPERS
FOR
AMMONIA REMOVAL

Refinery Code		Refinery Capacity 1,000 BBL/Day	Capital Cost
2		111.0	$ 260,000
3		75.0	212,000
4		101.0	243,000
5		44.0	158,000
7		123.5	273,000
10		53.8	176,000
11		15.0	89,000
13		30.0	130,000
14		46.5	162,000
16		186.4	338,000
17		24.0	115,000
18		39.0	149,000
19		27.65	126,000
22		29.7	130,000
25		103.0	250,000
26		233.5	385,000
27		70.0	203,000
30		44.8	161,000
	TOTAL	1358	$3,560,000

TABLE VIII-2

OPERATING COSTS
SOUR WATER STRIPPERS

Description	Annual Cost, Dollars 20,000 bbl/day	95,000 bbl/day	150,000 bbl/day
	Sulfide Removal		
Steam - $3.00/1000 lbs.	$ 50,000	$ 620,000	$860,000
Pumping - .06 hp/gpm $0.04/kwh	500	5,000	8,000
Labor (1/2 man-year)	10,000	10,000	10,000
Depreciation (20% of total capital cost)	86,500	185,000	230,000
Maintenance (3% of total capital cost)	13,000	28,000	35,000
Total Annual Cost	$160,000	$848,000	$1,143,000
	Ammonia Removal		
Steam	$ 50,000	$ 620,000	$860,000
Pumping	500	5,000	8,000
Labor	0	0	0
Depreciation	21,600	48,600	62,000
Maintenance	3,400	7,400	9,000
Total Annual Cost	$75,500	$681,000	$939,000

TABLE VIII-3

CAPITAL COSTS
PRETREATMENT FOR PHENOL REMOVAL

Description	Cost, Dollars 0.02 MGD 20,000 BBL/Day	Cost, Dollars 0.4 MGD 95,000 BBL/Day
Biological Treatment Unit with Sludge Holding Tank	$ 30,000	$ 120,000
Pumps and Wetwell	10,000	20,000
Subtotal	40,000	140,000
Piping (10%)	4,000	14,000
Other Auxiliary Equipment (10%)	4,000	14,000
Total Equipment Cost	48,000	168,000
Installation (50%)	24,000	84,000
Total Constructed Cost	72,000	252,000
Engineering (15%)	10,800	37,800
Contingency Cost	12,200	40,200
Total Capital Cost	$ 95,000	$ 330,000

treatment systems at different flow rates. Each flow rate has been correlated to a refinery capacity, based upon the sour water flow rate information provided in Figure VIII-2. The two model sizes were determined by dividing the indirect discharge refineries into two capacity ranges, those with capacities greater than 40,000 BBL/Day, and those with less than 40,000 BBL/Day capacity. The average of the refinery capacities in the former range is 21,000 BBL/Day, whereas the average capacity of the latter range is 95,000 BBL/Day.

The total cost for all of the indirect discharging refineries to pretreat their sour waters for phenol removal is estimated as follows:

Cost Per Refinery	No. of Refineries	Total Capital Cost
$ 95,000 per small system	13	$ 1,235,000
$330,000 per larger system	13	$ 4,290,000
Total	26	$ 5,525,000

Estimated operating costs for the phenol removal systems are shown in Table VIII-4. Items included in the operating costs are electrical power for aeration and pumping, labor, depreciation, and maintenance. As can be seen by the data presented, depreciation is the largest factor in determining the total operating costs for each facility.

The major uses of energy are associated with the aeration and pumping systems. Total energy requirements for the 20,000 BBL/Day model refinery are estimated to be 3.5 H.P.; the total energy requirement for the 95,000 BBL/Day model refinery is estimated at 30 H.P.

Chromium Removal

Most refineries should be able to take advantage of the reducing environment in sewers and the detention time and settling capabilities of oil removal systems to effect reductions in chromium discharges. However, no data are available at the present time to enable a quantification of these phenomena. In the development of cost estimates, it was assumed that it would be necessary that treatment technology be installed to effect removal of chromium. The technology on which the cost estimates are based is that described in Section VII--the reduction of hexavalent

TABLE VIII-4

OPERATING COSTS
PHENOL REMOVAL SYSTEMS

Description	Annual Cost, Dollars	
	20,000 BBL/Day	95,000 BBL/Day
Aeration	$ 750	$ 5,500
Pumping	750	5,500
Labor (1/2 manyear)	10,000	10,000
Depreciation (20% of total capital cost)	19,000	66,000
Maintenance (3% of total capital cost)	3,000	10,000
Total Annual Cost	$ 33,500	$ 97,000

chromium to trivalent chromium followed by precipitation and clarification.

Cost estimates require meaningful determinations of the flow associated with segregated cooling tower blowdown. Model flow rate data were obtained from the "Economics of Refinery Waste Water Treatment" (31). Costs associated with the installation of chromium removal technology at three typical sized refineries were determined. The three model refineries are representative of the size distribution of indirect discharging refineries. The characteristics of the three model refineries are:

Refinery Capacity (M Bbl/day)	Typical Subcategory	Cooling Tower Flow Rate (gpm)
15	A	31
39	A/B	160
119	B	720

Table VIII-5 presents capital cost estimates for chromium removal for the three refineries described above. Table VIII-6 presents estimates of operating costs for the chromium removal systems.

The only energy uses are associated with chemical feed pumps and mixers. Total energy requirements are estimated to range from approximately 2 hp for the 15,000 bbl/day refinery to roughly 10 hp for the 119,000 bbl/day refinery.

Oil and Grease Removal

All identified indirect dischargers have gravity oil separation as part of their pretreatment systems. Therefore, cost estimates associated with the installation of this type of treatment facility are not presented.

Dissolved air flotation is presently being used at 13 refineries that are discharging to POTW. Of the remaining 13 refineries, it is not known at how many the installation of DAF systems would be required to comply with pretreatment standards for oil and grease. The costs associated with the installation of DAF systems at four model refineries were

TABLE VIII-5

CAPITAL COSTS

Chromium Removal Systems

Description	Cost, Dollars 15,000 bbl/day	39,000 bbl/day	119,000 bbl/day
Detention Tank (45 minutes), with Mixer	$ 5,000	$ 15,000	$ 35,000
Acid and SO_2 Feed Systems	15,000	25,000	40,000
pH and ORP Control Systems	10,000	10,000	10,000
Solids Contact Clarifier (0.6 gpm/ft^2 settling rate)	30,000	40,000	80,000
Caustic Feed System	10,000	15,000	20,000
Pumps	5,000	10,000	15,000
Subtotal	75,000	115,000	200,000
Misc. Auxiliary Equipment (10%)	7,500	11,500	20,000
Piping (10%	7,500	11,500	20,000
Total Equipment Cost	90,000	138,000	240,000
Installation (50%)	45,000	69,000	120,000
Total Construction Cost	135,000	207,000	360,000
Engineering (15%)	20,000	31,000	54,000
Contingency	20,000	31,000	54,000
TOTAL CAPITAL COST	$175,000	$269,000	$468,000

TABLE VIII-6

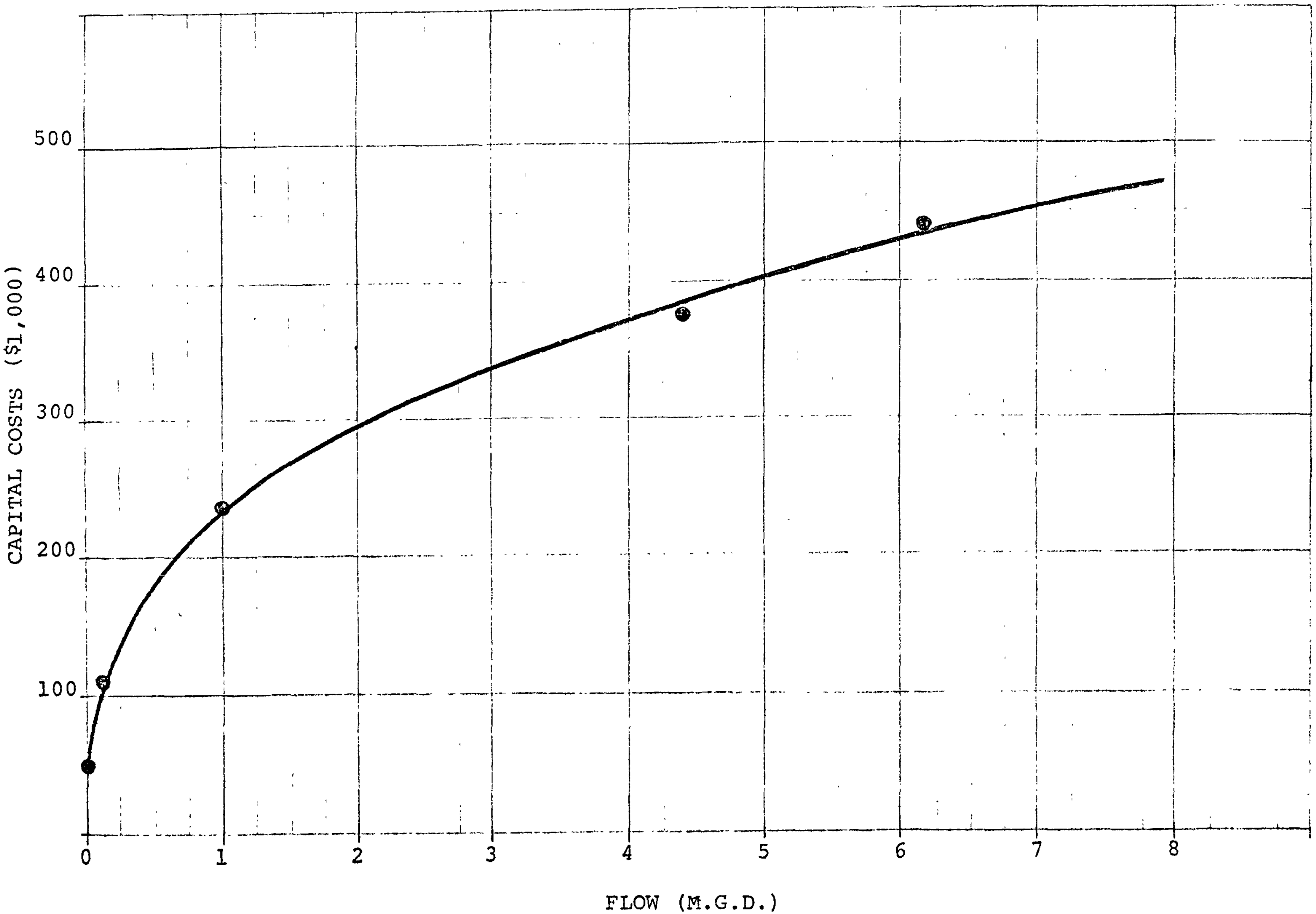
OPERATING COSTS

Chromium Removal Systems

Description	Annual Costs, Dollars 15,000 bbl/day	39,000 bbl/day	119,000 bbl/day
Energy and Chemical Costs	$ 2,000	$ 11,000	$ 47,000
Labor (.25 man-year)	5,000	5,000	5,000
Depreciation (20% of total capital cost)	35,000	54,000	94,000
Maintenance (3% of total capital cost)	5,000	8,000	14,000
TOTAL ANNUAL COST	$47,000	$78,000	$160,000

FIGURE VIII-3

CAPITAL COST VERSUS TOTAL WASTEWATER FLOW
FOR DISSOLVED AIR FLOTATION



estimated. These cost data are presented in Table VIII-7. Figure VIII-3 presents the relationship between capital cost of installing DAF systems and total effluent flow rate. Table VIII-8 presents the total cost to the industry if all 13 remaining refineries were to install new DAF systems. The estimates shown in this table are based on Figure VIII-3. A minimum capital cost of $50,000 has been assumed regardless of flow rate.

Table VIII-9 presents operating costs for the four model DAF systems. Operating costs include chemical addition, power requirements, labor, depreciation, and maintenance. The two major cost items for DAF systems are electric power and depreciation.

Energy consumption for DAF systems consists of the horsepower requirements for skimming and for the recirculation of wastewater within the unit itself. In most cases pumping between the gravity oil separator and the DAF unit is not necessary.

Total energy requirements for DAF units are estimated to range from six H.P. for a 20,000 BBL/Day refinery to 180 H.P. for a 200,000 BBL/Day refinery.

NON-WATER QUALITY ASPECTS

Non-water quality considerations associated with in-plant controls and end-of-pipe treatment in petroleum refineries were discussed in the Development Document (see pages 111, 112, and 141). The specific non-water quality environmental impact of the installation of the pretreatment facilities discussed herein relate to the following:

1. Gaseous hydrogen sulfide and ammonia streams created by new or additional sour water stripping facilities.

2. Sludges generated by the use of biological treatment for phenol removal.

3. Sludge and oily froth from DAF systems.

Generally the gaseous stream from a sour water stripper is either incinerated or directed to a recovery facility. If a second stripper is added in series for ammonia removal, it is not anticipated that the disposition of the gaseous stream will create serious problems within the refinery. In fact, the use of two strippers in series allows for the

TABLE VIII-7

CAPITAL COSTS
DISSOLVED AIR FLOTATION

Description	Cost, Dollars, at Selected Flow Rates MGD .08	1	4.4	6.2
Dissolved Air Flotation Unit with instruments and controls	$35,000	$80,000	$130,000	$150,000
Chemical Injection equipment	15,000	30,000	45,000	55,000
Subtotal	50,000	110,000	175,000	205,000
Piping (10%)	5,000	11,000	17,500	20,500
Total Equipment Cost	55,000	121,000	192,500	225,500
Installation (50%)	27,500	60,500	96,500	112,500
Total Constructed Cost	82,500	181,500	289,000	338,000
Engineering (15%)	12,500	27,300	43,500	51,000
Contingency	15,000	26,200	42,500	51,000
Total Capital Cost	$110,000	$235,000	$375,000	$440,000

TABLE VIII-8

TOTAL CAPITAL COSTS
DISSOLVED AIR FLOTATION

Refinery Code		Capacity 1000 BBL/Day	Effluent Flow Rate MGD	Capital Cost Dollars
1		15.0	.05 (1)	$ 85,000
5		44.0	0.33	150,000
9		5.0	.03 (1)	65,000
11		15.0	.033	65,000
12		20.0	.052	85,000
13		30.0	.132	112,000
17		24.0	.220	130,000
20		44.5	.833 (1)	220,000
21		37.96	.14	115,000
22		29.7	1.42	263,000
25		103.0	3.2 (1)	340,000
26		233.5	7.64	465,000
27		70.0	1.5	270,000
	TOTAL	671.7	15.58	$2,370,000

(1) No flow data available; estimate based on flow of similar sized refineries.

TABLE VIII-9

OPERATING COSTS
DISSOLVED AIR FLOTATION

Description	Annual Costs, Dollars, For Selected Flow Rates			
MGD	.08	1	4.4	6.2
Chemicals				
Alum	$1,000	$14,000	$62,000	$86,000
Polyelectrolyte	500	6,000	27,000	39,000
Power (Electricity)				
DAF Unit Requirements	1,400	8,000	35,000	50,000
Chemical Feed Pumps and Mixers	200	400	2,000	3,000
Labor (.25 man-years)	5,000	5,000	5,000	5,000
Depreciation (20%)	22,000	47,000	75,000	88,000
Maintenance (3% of total capital cost)	3,500	7,000	11,000	13,000
Total Annual Cost	$33,600	$87,400	$217,000	$284,000

production of high purity sulfide and ammonia off-gases which can be recovered and disposed of more readily. In some refineries, ammonia is recovered in the aqueous or anhydrous form and sold as a by-product of the stripping operation (9). The Agency solicits information which provides cost and other data regarding sulfide and ammonia off-gas recovery and disposal.

Sludges created by biological treatment systems removing phenol could be combined with other semi-solid wastes generated in the refinery. This sludge should not be offensive in nature, since it will not contain sanitary sewage. Similarly, sludge generated by a DAF system could be combined with separator sludge for treatment and disposal. The oily froth could be directed to the refinery slop oil system or disposed of by incineration.

In most cases the sludges described above are nonhazardous substances requiring only minimal custodial care. However, some constituents may be hazardous and may require special consideration. In order to ensure long term protection of the environment from these hazardous or harmful constituents, special consideration of disposal sites must be made. All landfill sites where such hazardous wastes are disposed should be selected so as to prevent horizontal and vertical migration of these contaminants to ground or surface waters. In cases where geologic conditions may not reasonably ensure this, adequate legal and mechanical precautions (i.e., impervious liners) should be taken to ensure long term protection to the environment from hazardous materials. Where appropriate, the location of solid, hazardous materials disposal sites should be permanently recorded in the appropriate office of legal jurisdiction.

Other nonwater quality aspects, such as noise levels, will not be perceptibly affected. Most refineries generate fairly high noise levels (85-95 dB(A)) within the battery limits because of equipment such as pumps, compressors, steam jets, flare stacks, etc. Equipment associated with in-process or end-of-pipe control systems would not add significantly to these levels. There are no radioactive nuclides used in the industry, other than in instrumentation. Thus, no radiation problems will be expected. Compared to the odor emissions possible from other refinery sources, odors from the waste water treatment plants are not expected to create a significant problem. However, odors are possible from the wastewater facilities, especially from the possible stripping of ammonia and sulfides in the air flotation units.

In summary, it is not anticipated that any serious non-water quality environmental impact will result from the implementation of the pretreatment operations described herein.

SECTION IX

PRETREATMENT STANDARDS

INTRODUCTION

The purpose of this section is to present pretreatment standards for indirect discharging refineries in accordance with the requirements of Section 307(b) of Public Law 92-500. Earlier sections of this document covering waste characterization, selection of pollutant parameters, control and treatment technology, and cost and non-water quality aspects, form the basis for the recommended pretreatment standards. The following discussion includes an analysis of existing conditions in terms of local pretreatment requirements now in effect and the rationale for the development of pretreatment standards for selected pollutant parameters.

EXISTING LOCAL PRETREATMENT REQUIREMENTS

Existing pretreatment standards for selected pollutant parameters as reported for nine of the 15 POTW receiving waste waters from indirect discharging refineries are summarized below:

Pollutant Parameter	Number of POTW Reporting	Existing Pre-treatment Standards
Phenol	3	0.01 - 1.0 mg/l
	5	None or LTEQ
Ammonia	2	1.0 - 100 mg/l
	6	None or LTEQ
Chromium (Hex.)	3	0.005 - 10 mg/l
	4	None, LTEQ, or LTH
(Total)	4	5 - 25 mg/l
	4	None, LTEQ, or LTH
Sulfide	5	0.1 - 5 mg/l
	4	None
Oil and Grease	8	10 - 200 mg/l
	1	None

Notes: LTEQ - less than excessive quantities
LTH - less than harmful

Existing treatment operations reported at 13 of the 14 POTW receiving refinery process wastewaters are summarized below:

Type of Treatment Employed	Number of POTW Reporting	Number of Refineries Accepted
Primary Sedimentation	1	12
Trickling Filter	6	6
Activated Sludge	6	6

The table indicates that only one of the POTW currently accepting refinery process wastewaters is at the primary treatment level. It should be noted that this plant has secondary treatment facilities planned for the near future.

In conversations with the operators of the POTW employing biological treatment, it was noted that refinery wastewater, within the limits of local pretreatment requirements, is essentially compatible and does not create significant plant upset or pass-through conditions. However, it should be pointed out that because of dilution effects, the pass-through of pollutants may not be readily apparent.

SUBCATEGORIZATION

The petroleum refining point source category was subcategorized primarily on the basis of process considerations during the development of effluent limitations and guidelines. In the course of establishing a subcategorization scheme for the indirect discharging segment of this industry, it has been determined that, on the basis of location, age, economic status, size, waste water characteristics, and manufacturing processes, no fundamental differences exist that would warrant a different method of subcategorization (see Section IV).

RATIONALE FOR DEVELOPMENT OF PRETREATMENT STANDARDS FOR SELECTED POLLUTANT PARAMETERS

The following discussions relate to the parameters chosen for consideration as to the establishment of uniform national pretreatment standards--ammonia, oil and grease, phenolics, chromium, and sulfides (see Section VI).

It has been determined that all indirect dischargers should be subject to the same pretreatment standards, regardless of subcategory. The pollutants under consideration for pretreatment standards are common to all refineries' waste waters, regardless of subcategorization. Additionally, pretreatment standards are based on an attainable concentration rather than the mass basis used in the establishment of effluent limitations and guidelines for direct dischargers.

Phenolics

Phenolic compounds are biodgradable by biota that become acclimated to them. Many POTW are able to accept industrial effluents containing phenolic compounds without experiencing either upset or pass-through problems. The limited data available indicate that the efficiency of removal of phenolics by individual POTW should be considered in the development of pretreatment standards for this parameter.

It is, therefore, recommended that pretreatment standards for phenolics be established on an individual basis by POTW receiving refinery waste waters. The promulgated BPCTCA effluent limitation for phenol can be used as a guide by POTW. In those cases where it is determined that the POTW is unable to adequately treat phenolics in a specific refinery's waste waters, a phenolics limitation of 0.35 mg/l (daily maximum) can be achieved (see Development Document, pages 144-149). The model technology which supports this limitation is biological treatment of segregated sour water stripper bottoms (see Section VII).

Chromium

None of the indirect discharging refineries were identified as having specific treatment technology for the removal of chromium. Therefore, removal data for specific technologies were not available from the industry. Removal of chromium by POTW utilizing biological treatment has been reported. In a recent survey of 112 POTW, the mean chromium removal was 42 percent, with a mean effluent concentration of 218 ug/l.

The best practicable control technology currently available effluent limitations for chromium were based on the observed discharge of chromium subsequent to biological treatment. Therefore, the logic used in the establishment of best practicable pretreatment standards for existing sources, to be consistent with direct discharge standards, would be biological treatment as represented by the POTW.

The establishment of a specific national pretreatment standard for chromium discharged in wastewaters from petroleum refineries is judged to be inappropriate at this time. This pollutant will be studied more thoroughly in light of the order of the U.S. District Court for the District of Columbia entered in Natural Resources Defense Council, et al. v. Train, 8 E.R.C. 2120 (D.D.C. 1976). The Agency solicits additional information relating to the effects of chromium on POTW in terms of both treatability and sludge disposal.

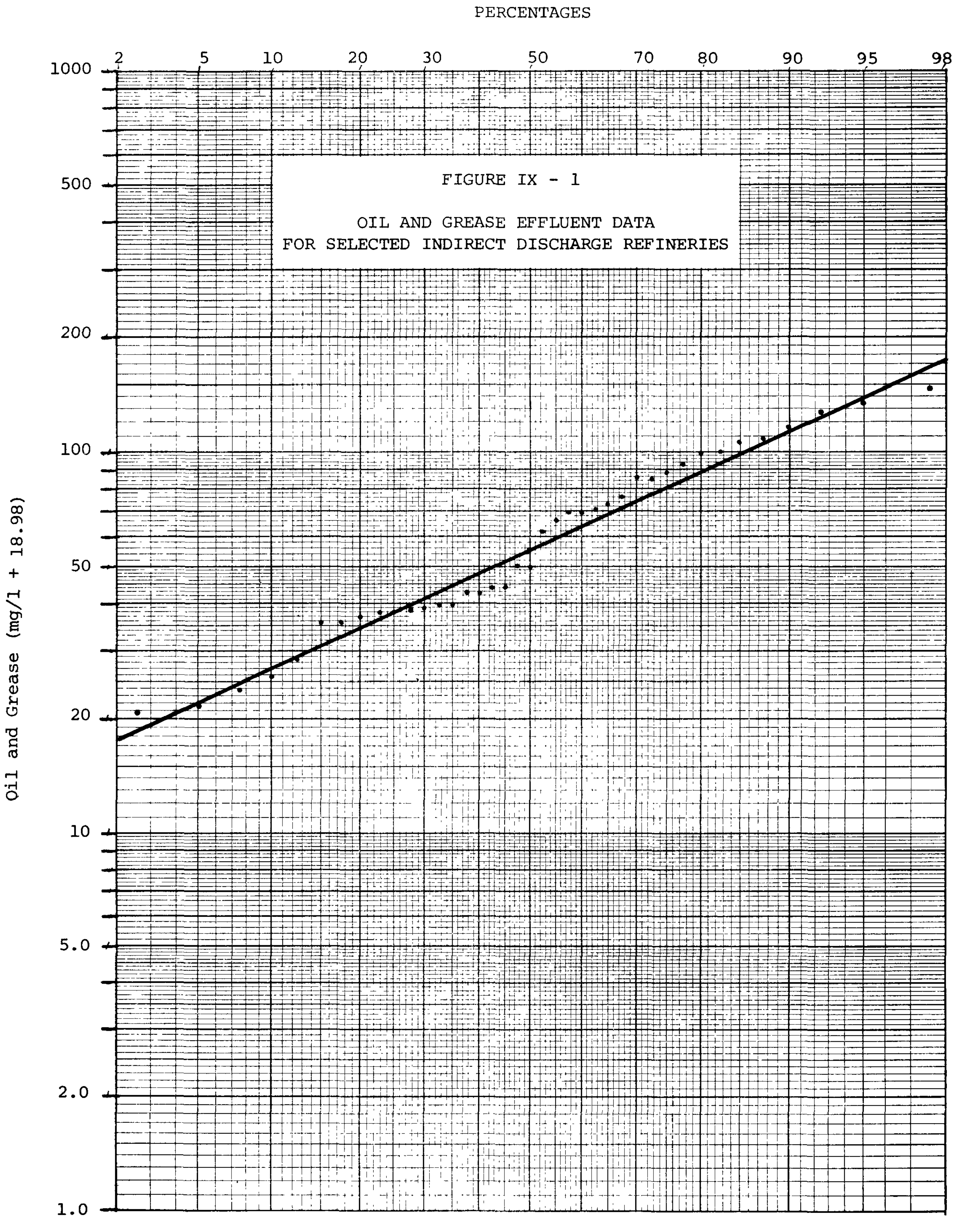
In those individual cases where chromium levels are determined to be having a significant detrimental effect on a POTW, by creating either upset or pass-through problems, a total chromium limitation of 1.0 mg/l (daily maximum) can be achieved and is included as guidance for the purpose of assisting local authorities. The model technology which supports this limitation is the treatment of segregated cooling tower blowdown by clarification, subsequent to reduction of hexavalent chromium to trivalent chromium with the addition of sulfur dioxide (see Section VII).

Oil and Grease

BPCTCA has been identified to include both primary oil removal (API separators or baffle plate separators) and secondary oil removal (dissolved air flotation or its equivalent) (see Development Document, page 143). These technologies are employed to ensure effective removal of oil and grease prior to biological treatment. Oil/water separation techniques equivalent to those employed at direct discharging refineries should be employed at indirect discharging refineries to ensure protection of POTW from slug loadings of oil and grease.

Available effluent data for oil and grease discharges from those indirect discharging refineries with dissolved air flotation or an equivalent treatment technology installed are presented in Figure IX-1. Data for refineries No. 2, 4, 7, 8, 10, 15, 16, 18, and 30 are included. Due to the time constraints imposed, no attempt has been made to screen this data to verify that the treatment facilities have been properly maintained and operated; all data from refineries that have the recommended pretreatment technology installed are presented.

The recommended pretreatment standard for oil and grease is 100 mg/l (daily maximum). This standard is based on the necessity to minimize to possibility of slug loadings of oil and grease being discharged to POTW. The capability for


PERCENTAGES
2
5
10
20
30
50
70
80
90
95
98
1000
500
200
100
50
20
10
5.0
2.0
1.0
Oil and Grease (mg/l + 18.98)
FIGURE IX - 1
OIL AND GREASE EFFLUENT DATA
FOR SELECTED INDIRECT DISCHARGE REFINERIES

consistent reduction of oil and grease below this recommended standard by use of the identified pretreatment technologies (API separators and DAF units) is well-established in the petroleum refining industry (1,26).

Sulfides and Ammonia

The available data for sulfide and ammonia discharges from refineries after the application of sour water stripping and/or oxidation are presented in Figures IX-2 and IX-3 respectively. The lack of availability of influent data relative to sour water treatment did not permit a selection of sour water teratment systems exhibiting the best performance. Refineries with obvious poor performance (based on effluent data) were excluded from presentation. Figure IX-2 includes data relating to sour water treatment system performance at Refineries 2, 7, 10, 11, 13, 14, 16, 17, and 18.

Sulfides. Sulfides discharged by refineries may interfere with the operation of a POTW, particularly with regard to corrosion of concrete pipes that are used to convey effluent to the treatment plant itself. Sulfide removal techniques are universally employed at refineries to protect process equipment from corrosion. However, if sulfide levels discharged by refineries are determined, for the individual case, to have a significant detrimental effect on a POTW, a sulfide standard of 3 mg/l (daily maximum) can be achieved. This number is included as guidance to assist local authorities. This recommended standard represents the highest reported value at the refineries whose data are presented in Figure IX-2. This standard is also supported by the results of the 1972 API sour water stripping survey (see Section VII).

Ammonia. High concentrations of ammonia can exhibit inhibitory effects on the activated sludge process (see Section VI). At concentrations of up to 100 mg/l, no adverse effects on oxygen consumption are noted. It is recommended that pretreatment for ammonia be implemented to the extent that it is employed by direct discharging refineries--steam stripping of ammonia prior to discharge to biological treatment. It is well-documented that the application of steam stripping techniques for ammonia removal can ensure that ammonia levels in excess of 100 mg/l (daily maximum) can be avoided. This standard is also supported by the data presented in Figure IX-3 which are representative of indirect discharging refineries. Ninety-six percent of the reported values upon which Figure IX-3 is based are less than 100 mg/l. Better operation, the

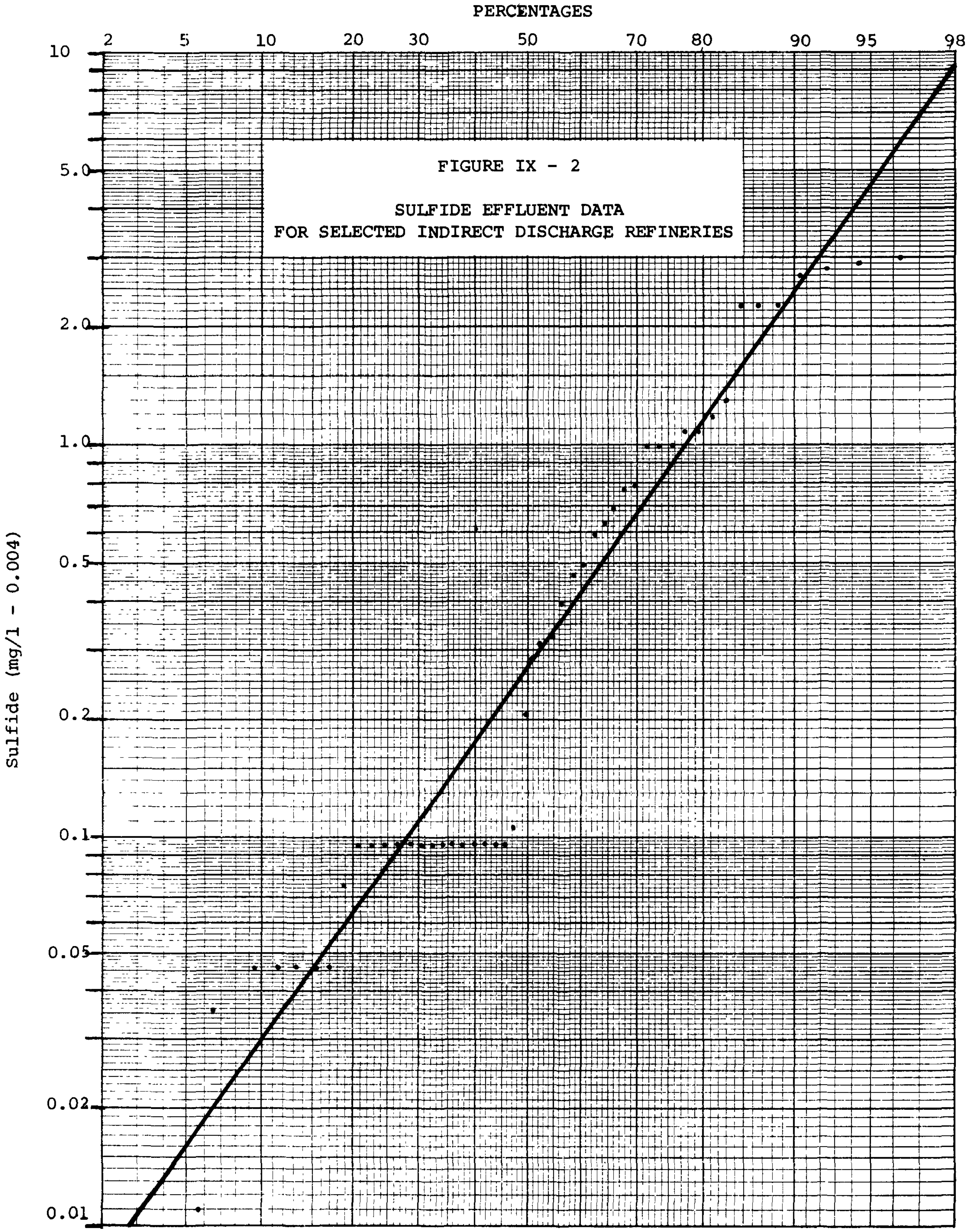
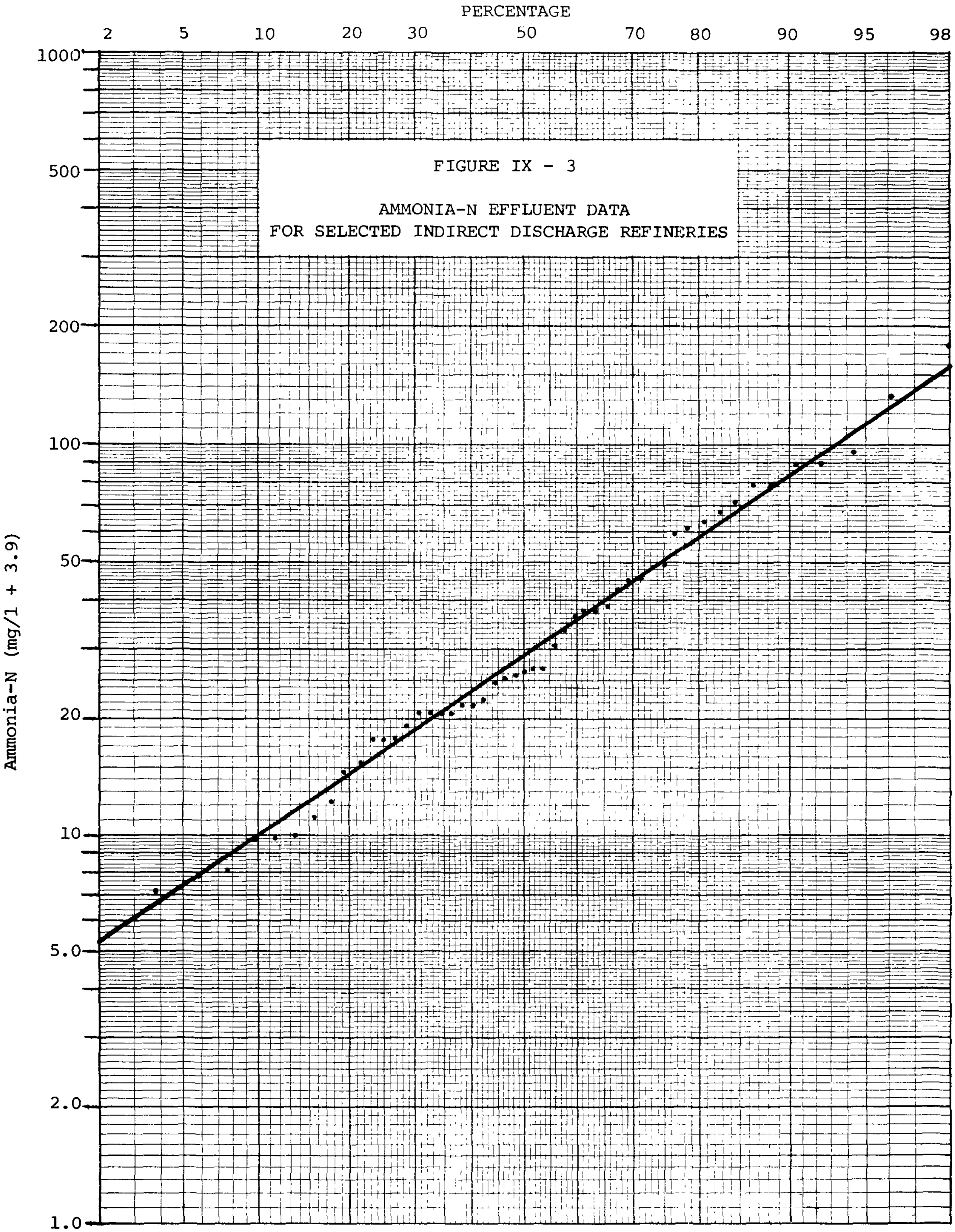


FIGURE IX - 2

SULFIDE EFFLUENT DATA
FOR SELECTED INDIRECT DISCHARGE REFINERIES


PERCENTAGE
2
5
10
20
30
50
70
80
90
95
98
1000
500
200
100
50
20
10
5.0
2.0
1.0
Ammonia-N (mg/1 + 3.9)
FIGURE IX - 3
AMMONIA-N EFFLUENT DATA
FOR SELECTED INDIRECT DISCHARGE REFINERIES

addition of more steam, and increasing the number of trays or the height of packing are ways in which refineries experiencing poor ammonia removal can obtain better performance.

SUMMARY

The recommended pretreatment standards for existing sources within the petroleum refining category are based on those pretreatment techniques employed at direct discharging refineries. These pretreatment steps employed to protect biological treatment systems from upset conditions include (1) oil and grease removal through the application of API separators and dissolved air flotation or other similar processes and (2) ammonia removal through the application of steam stripping of sour water waste streams.

The recommended standards are:

Oil and grease:	100 mg/l (daily maximum)
Ammonia:	100 mg/l (daily maximum)

In addition, the Agency recommends that sulfides, phenol, and chromium be controlled as needed on an individual basis by local authorities. The data available to the Agency at the present time do not support the implementation of uniform national pretreatment standards for these pollutants. Should it be determined that either sulfides, phenol, or chromium create either upset or pass-through problems, the application of appropriate pretreatment technology will allow the attainment of the following standards:

Chromium (total):	1 mg/l (daily maximum)
Phenol:	0.35 mg/l (daily maximum)
Sulfides:	3 mg/l (daily maximum)

SECTION X

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Paul D. Lanik, P.E.	-	Environmental Engineer
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Ashland, Kentucky

Atlantic Richfield Co.
Carson, California

Edgington Oil Co.
Long Beach, California

Exxon Co., U.S.A.
Billings, Montana

Fletcher Oil & Refining Co.
Carson, California

Beacon Oil Co.
Hanford, California

Chevron Oil Co.
Salt Lake City, Utah

Clark Oil & Refining Corp.
Blue Island, Illinois

Delta Refining Co.
Memphis, Tennessee

Douglas Oil Co. of California
Paramount, California

LaGloria Oil & Gas Co.
Tyler, Texas

MacMillan Ring-Free Oil Co.
Long Beach, California

Mobil Oil Corp.
New York, New York

Mobil Oil Corp.
Torrance, California

Phillips Petroleum
Woods Cross, Utah

Powerine Oil Co.
Santa Fe Springs, California

Pride Refining Inc.
Abilene, Texas

Quintana-Howell
Corpus Christi, Texas

Shell Oil Co.
Carson, California

Shell Oil Co.
Houston, Texas

Texaco, Inc.
Lockport, Illinois

Golden Eagle Refining Co.
Carson, California

Gulf Oil Co.
Philadelphia, Pennsylvania

Gulf Oil Co.
Santa Fe Springs, California

Gulf Oil Co.
Toledo, Ohio

Husky Oil Co.
North Salt Lake, Utah

City of Abilene Water Utilities
Abilene, Texas

City of Hanford
Dept. of Public Works
Hanford, California

City of Memphis
Division of Public Works
Memphis, Tennessee

City of Portland
Portland, Oregan

City of Tyler Sanitary Sewer
System
Tyler, Texas

City of Wichita Water Dept.
Wichita, Kansas

Corpus Christi Wastewater
Services
Corpus Christi, Texas

County Sanitation Districts
of Los Angeles, County
Whittier, California

Metropolitan Sanitary District
of Greater Chicago
Chicago, Illinois

Texaco, Inc.
Wilmington, California

South Davis County Sewer
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Woods Cross, Utah

American Petroleum Institute
Washington, D.C.

Salt Lake City Wastewater
Reclamation Plant
Salt Lake City, Utah

Engineering-Science, Inc.
Austin, Texas

SECTION XI

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SECTION XII

GLOSSARY AND ABBREVIATIONS

GLOSSARY

Acid Oil - Straight chain and cyclic hydrocarbon with carboxyl group(s) attached.

Act - The Federal Water Pollution Act Amendments of 1972.

Aerobic - In the presence of oxygen.

Anaerobic - Living or active in absence of free oxygen.

Best Available Demonstrated Control Technology (BADT) - Treatment required for new sources as defined by section 306 of the Act.

Best Available Technology Economically Achievable (BATEA) - Treatment required by July 1, 1983 for industrial discharge to surface waters as defined by section 301 (b) (2) (A) of the Act.

Best Practicable Control Technology Currently Available (BPCTCA) - Treatment required by July 1, 1977 for industrial discharge to surface waters as defined by section 304 (b) (1) (A) of the Act.

Biochemical Oxygen Demand (BOD_5) - Oxygen used by bacteria in consuming a waste substance (Measured in a five-day BOD test).

Blowdown - A discharge from a system designed to prevent a buildup of some material, as in boiler and cooling tower to control dissolved solids.

By-Product - Material which, if recovered, would accrue some economic benefit, but not necessarily enough to cover the cost of recovery.

Capital Costs - Financial charges which are computed as the cost of capital times the capital expenditures for pollution control. The cost of capital is based upon a weighted average of the separate costs of debt and equity.

Catalyst - A substance which can change the rate of a chemical reaction, but which is not itself involved in the reaction.

Category and Subcategory - Delineation of all industries (categories) and divisions within specific industries (subcategories) which possess different traits that affect water quality and treatability.

Chemical Oxygen Demand (COD) - Oxygen consumed through chemical oxidation of a waste.

Clarification - The process of removing undissolved materials from a liquid. Specifically, removal of solids either by settling or filtration.

Coke Petroleum - Solid residue, 90 to 95 percent of which is fixed carbon.

Compatible Pollutants - Parameters of organic pollution (namely, BOD, COD and TOC) which are treatable by POTW.

Cracking Plant - Refinery having basic operations of topping and cracking.

Depletion or Loss - The volume of water which is evaporated, embodied in product, or otherwise disposed of in such a way that it is no longer available for reuse in the plant or available for reuse by others outside the plant.

Depreciation - The cost reflecting the deterioration of a capital asset over its useful life.

Direct Discharger - Refinery which disposes of its wastewater directly to the environment without discharging any industrial wastewater to a municipal treatment system.

Emulsion - A liquid system in which one liquid is finely dispersed in another liquid in such a manner that the two will not separate through the action of gravity alone.

End-of-Pipe Treatment - Treatment of overall refinery wastes, as distinguished from treatment at individual processing units.

Filtration - Removal of solid particles or liquids from other liquids or gas streams by passing the liquid or gas stream through a filter media.

Fractionator - A generally cylindrical tower in which a mixture of liquid components is vaporized and the components separated by carefully varying the temperature and sometimes pressure along the length of the tower.

Gasoline - A mixture of hydrocarbon compounds with a boiling range between 100 and 400 degrees F.

Grease - A solid or semi-solid composition made up of animal fats, alkali, water, oil and various additives.

Hydrocarbon - A compound consisting of carbon and hydrogen.

Hydrogenation - The contacting of unsaturated or impure hydrocarbons with hydrogen gas at controlled temperatures and pressures for the purpose of obtaining saturated hydrocarbons and/or removing various impurities such as sulfur and nitrogen.

Incompatible Pollutants - Pollution parameters which may pass through POTW or which may, in sufficient quantity, interfere with the operation of a POTW.

Indirect Discharger - Refinery which disposes of its industrial wastewater to the environment through a municipal treatment system.

Industrial Waste - All wastes streams within a plant. Included are contact and non-contact waters. Not included are wastes typically considered to be sanitary wastes.

Integrated Plant - Refinery including the following basic operations: Topping, cracking, lube oil manufacturing processes, and petrochemical operations.

Investment Costs - The capital expenditures required to bring the treatment or control technology into operation. These include the traditional expenditures such as design, purchase of land and materials, site preparation, construction and installation, etc., plus any additional expenses required to bring the technology into operation including expenditures to establish related necessary solid waste disposal.

Isomer - A chemical compound that has the same number, and kinds of atoms as another compound, but a different structural arrangement of the atoms.

Lube Plant - Refinery including the following basic operations: Topping, cracking, and lube oil manufacturing processes.

New Source - Any building, structure, facility, or installation from which there is or may be a discharge of pollutants and whose construction is commenced after the publication of the proposed standards.

No Discharge of Pollutants - No net increase (or detectable gross concentration if the situation dictates) of any parameter designated as a pollutant to the accuracy that can be determined from the designated analytical method.

Olefins - Unsaturated straight-chain hydrocarbon compounds seldom present in crude oil, but frequently present after the application of cracking processes.

Operation and Maintenance - Costs required to operate and maintain pollution abatement equipment. They include labor, material, insurance, taxes, solid waste disposal, etc.

Overhead Accumulator - A tank in which the condensed vapors from the tops of the fractionators, steam strippers, or stabilizers are collected.

Petrochemical Operations - Production of second generation petrochemicals (i.e., alcohols, ketones, cumene, styrene, etc.) or first generation petrochemicals and isomerization products (i.e., BTX, olefins, cyclohexene, etc.) when 15% or more of refinery production is as first generation petrochemicals and isomerization products.

Petrochemical Plant - Refinery including the following basic operations: Topping, cracking and petrochemical operations.

Petroleum - A complex liquid mixture of hydrocarbons and small quantities of nitrogen, sulfur, and oxygen.

pH - A measure of the relative acidity or alkalinity of water. A pH of 7.0 indicates a neutral condition. A greater pH indicates alkalinity and lower pH indicates acidity. A one unit change in pH indicates a 10 fold change in acidity and alkalinity.

Phenolics - Class of cyclic organic derivatives with the basic formula C_6H_5OH.

Plant Effluent or Discharge After Treatment - The volume of wastewater discharge from the industrial plant. In this definition, any waste treatment device is considered part of the industrial plant.

Pretreatment - Treatment provided prior to discharge to a publicly owned treatment works (POTW).

Process Effluent or Discharge - The volume of water emerging from a particular use in the plant.

Process Upset - Disruption of the operation of a POTW as the result of the introduction of excessive concentration of incompatible pollutants.

Publicly Owned Treatment Works - A municipal facility whose function is the final treatment of wastewater to be discharged to the environment.

Raw - Untreated or unprocessed.

Reduced Crude - The thick, dark, high-boiling residue remaining after crude oil has undergone atmospheric and/or vacuum fractionation.

Secondary Treatment - Biological treatment provided beyond primary clarification.

Sludge - The settled solids from a thickener or clarifier. Generally, almost any flocculated settled mass.

Sour - Denotes the presence of sulfur compounds, such as sulfides and mercaptans, that cause bad odors.

Spent Caustic - Aqueous solution of sodium hydroxide that has been used to remove sulfides, mercaptans, and organic acids from petroleum fractions.

Stabilizer - A type of fractionator used to remove dissolved gaseous hydrocarbons from liquid hydrocarbon products.

Stripper - A unit in which certain components are removed from a liquid hydrocarbon mixture by passing a gas, usually steam, through the mixture.

Supernatant - The layer floating above the surface of a layer of solids.

Surface Waters - Navigable waters. The waters of the United States, including the territorial seas.

Sweet - Denotes the absence of odor-causing sulfur compounds, such as sulfides and mercaptans.

Topping Plant - Refinery having the basic operations of topping and catalytic reforming.

Total Suspended Solids (TSS) - Any solids found in wastewater or in the stream which in most cases can be removed by filtration. The origin of suspended matter may be man-made wastes or natural sources such as silt from erosion.

Waste Discharged - The amount (usually expressed as weight) of some residual substance which is suspended or dissolved in the plant effluent after treatment, if any.

Waste Generated - The amount (usually expressed as weight) of some residual substance generated by a plant process or the plant as a whole that is suspended or dissolved in water. This quantity is measured before treatment.

Waste Loading - Total amount of pollutant substance, generally expressed as pounds per day or pounds per unit of production.

ABBREVIATIONS

API - American Petroleum Institute

BADT - Best Available Demonstrated Technology

BATEA - Best Available Technology Economically Achievable

bbl - Barrel

BOD - Biochemical Oxygen Demand

bpcd - Barrels per calendar day

BPCTCA	-	Best Practicable Control Technology Currently Available
bpsd	-	Barrels per stream day (operating day)
COD	-	Chemical Oxygen Demand
cu m	-	cubic meter(s)
DAF	-	Dissolved Air Flotation
gpm	-	gallons per minute
k	-	thousand (i.e., thousand cubic meters)
kg	-	kilogram(s)
l	-	liter
lb	-	pound(s)
M	-	Thousand (i.e., thousand barrels)
MBCD	-	Thousand Barrels per Calendar Day
MBSD	-	Thousand Barrels per Stream Day
mgd	-	million gallons per day
mg/l	-	milligrams per liter (parts per million)
MM	-	Million (i.e., million pounds)
O&G	-	Oil and Grease
POTW	-	Publicly Owned Treatment Works
ppm	-	parts per million
psig	-	pounds per square inch, gauge
scf	-	standard cubic feet of gas at 60 degrees F and 14.7 psig
SWS	-	Sour Water Strippers
TOC	-	Total Organic Carbon

METRIC UNITS

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS) by TO OBTAIN (METRIC UNITS)

ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	F^{o}	$0.555(^{o}F-32)$*	^{o}C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
tons (short)	t	0.907	kkg	metric tons (1000 kilograms)
yard	y	0.9144	m	meters

*Actual conversion, not a multiplier