Cost Manual For The Direct Discharge Segment of the Petroleum Refining Industry

Prepared by:

Effluent Guidelines Division
Office of Water and Hazardous Materials
U.S. Environmental Protection Agency
Washington, D. C. 20460

John Cunningham, Project Officer

and

Burns and Roe Industrial Services Corp.
283 Rt. 17 South
Paramus, New Jersey 07652

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Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 663 ▪ 283 Route 17 South ▪ Paramus, New Jersey 07652
Telephone N.J. (201) 265-8710 ▪ N.Y. (212) 594-9210 ▪ Telex 134403 ▪ Cable BRISC PARAMUS, N.J.

March 27, 1979

W.O. 4817-01
Revision of Cost Manual

Mr. David Hart, Vice President
Sobotka and Company, Inc.
83 Morgan Street
Stamford, CT 06905

Dear David:

Enclosed are two (2) copies of the following document :

> "Cost Manual for the Direct Discharge Segment of the Petroleum Refining Industry", March 1979.

Please note that there has been a change in the cost estimates for refinery number 196 since the preliminary draft sent to you on March 19.

Although the costing procedure has not changed, some of its wording has been slightly modified to accurately reflect the new tables just prepared.

If you have any questions regarding this document, please do not hesitate to contact John Cunningham, Tom Fieldsend, or me at your earliest convenience.

Very truly yours,

Barry S. Langer, P.E.
Project Manager

BSL/ec
cc: J. Cunningham EPA w/enc.
L. DuPuis EPA w/enc.

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Introduction

This report presents plant-by-plant costs for the direct discharge segment of the petroleum refining industry to meet certain BAT technology options presently under consideration. The cost estimates for each refinery are presented in Table 15 of this report.

The manual also describes the BAT technology model options, along with their development. In addition, the methodology utilized in costing the BAT options is discussed, including a detailed description of the plant-by-plant costing procedure. Refinery data used in this effort was obtained from the 1977 EPA Petroleum Refining Industry Survey and the subsequent Supplemental Flow Questionnaire.

It should be noted that this report is a revision of the document dated April 1978, which should now be considered outdated and void.

BAT Regulatory Options

EPA will shortly be proposing BAT regulations for this industry. Three options were initially considered by EPA, which will be described in detail in the preamble to the regulations. Briefly, the three options considered are as follows:

Option 1 - Set BAT regulations equal to the BPT level.

Option 2 - Base BAT regulations on BPT end-of-pipe treatment technology, with additional reductions in total effluent flow.

Option 3 - Base BAT regulations on the same flow reduction requirements as Option 2, with the additional requirement of granular activated carbon adsorption.

Upon review of the three options, EPA has decided to propose regulations using Option 2 technology.

The proposed regulations present two alternate sets of limitations based on two different flow reduction requirements. Both alternatives are based upon the flow model recently developed using the data collected by the 1977 industry survey. The flow model predicts wastewater generation based on present industry practice, and takes the following form:

$$MF = .004C + .046K + .048\ (A+L)$$

MF = Model Flow in units of million gallons per day.
A, C, K, L are in units of thousand barrels per day, where:

A = Sum of asphalt processes
- P18 Asphalt Production
- P43 Asphalt Oxidizing
- P89 Asphalt Emulsifying

C = Sum of crude processes
- P1 Atmospheric Crude Distillation
- P2 Crude Desalting
- P3 Vacuum Crude Distillation

K = Sum of cracking processes
- P4 Visbreaking
- P5 Thermal Cracking
- P6 Fluid Catalytic Cracking
- P7 Moving Bed Catalytic Cracking
- P10 Hydrocracking

L = Sum of lube processes
- P21 Hydrofining, Hydrofinishing, Lube Hydrofining
- P22 White Oil Manufacture
- P23 Propane Dewaxing, Propane Deasphalting, Propane Fractioning, Propane Deresining
- P24 Duo Sol, Solvent Treating, Solvent Extraction, Duotreating, Solvent Dewaxing, Solvent Deasphalt
- P25 Lube Vac Twr, Oil Fractionation, Batch Still (Naphtha Strip), Bright Stock Treating
- P26 Centrifuge and Chilling
- P27 MEK Dewaxing, Ketone Dewaxing, MEK-Toluene Dewaxing
- P28 Deoiling (wax)
- P29 Naphthenic Lubes Production
- P30 SO_2 Extraction
- P34 Wax Pressing
- P35 Wax Plant (with Neutral Separation)
- P36 Furfural Extracting
- P37 Clay Contacting - Percolation
- P38 Wax Sweating
- P39 Acid Treat
- P40 Phenol Extraction
- P506 Lube and Fuel Additives
- P508 Sulfonate Plant
- P522 MIBK
- P529 Wax Slabbing
- P531 Rust Preventives
- P532 Petrolatum Oxidation
- P563 Grease Mfg. V. Allied Products
- P568 Misc. Blending and Packaging

The two levels of flow reduction being considered by EPA are represented by "Reduction Factors" (R) which are used as multipliers to the flow model. Therefore, Level 1 and Level 2 effluent limitations are based upon discharge flow rates represented by the following equations:

$$\text{Level 1 Flow} = R_1(MF) \quad \text{Million gallons per day}$$
$$\text{Level 2 Flow} = R_2(MF) \quad \text{Million gallons per day}$$

where R_1 and R_2 are the reduction factors for Levels 1 and 2, and are as follows:

$R_1 = 0.73$
$R_2 = 0.48$

The development of these reduction factors will be described in the preamble to the regulations.

General Costing Methodology

The cost procedures used in this manual were developed so that a reasonable amount of manhour expenditures can be utilized in developing conservative costs. It is realized that the most accurate method would be to conduct an engineering evaluation for each refinery. The costs and time associated with this approach far exceed the budget allowed for this effort. Therefore, the following general assumptions have been made:

1. In order to comply with a given BAT option, it is assumed that the refinery must reduce its flow and install a "model" end-of-pipe treatment system. If a refinery has these technologies in place, or is already planning to install the necessary equipment, then no costs have been allocated. It is assumed that all refineries have some type of biological treatment already in place.

2. Although there are many methods to reduce flow, recycle of treated wastewater is easily definable in terms of developing costs and will be the assumed technique for each refinery that requires effluent reduction. Although a given refinery may choose a different method, the costs allocated in this manual are expected to be conservative.

3. Although a refinery may choose to upgrade its biological treatment system in other ways, rotating biological contactors (RBC) and powdered activated carbon can be readily priced as add-on systems. Costs for these systems are also expected to be conservative estimates.

4. Although the costs are based on one approach to achieving effluent quality, there are many alternatives available to this industry. A given refinery may choose to add sophisticated end-of-pipe treatment systems, rather than reduce flow. Alternatively, a refinery may choose to drastically reduce its flow and install minimal end-of-pipe treatment. However, in order to produce conservative costs within a reasonable manhour expenditure, the costs included in this manual rely heavily on end-of-pipe treatment alternatives, which can be directly defined. The cost procedures include reducing flow to Level 1 requirements only. Beyond this, sophisticated end-of-pipe treatment (biological polishing with RBC's or powdered activated carbon) are used to represent the costs associated with meeting Level 2 requirements.

5. Effluent flow is considered to be flow to NPDES discharge. All other forms of disposal (i.e., evaporation, deep well, etc.), except indirect discharge, are considered flow reduction techniques.

6. Some refineries discharge partly to POTW's and partly to surface waters. Only those plants that directly discharge the majority of their wastewaters are included in this analysis. For these plants, the wastewater discharged to a POTW is assumed to be included with the direct discharge flow.

General Procedure

The following control techniques are required to meet the Level 1 and Level 2 requirements:

Level	Flow Reduction	End-of-Pipe Treatment
1	To Level 1 flow	Equalization, filtration
2	Same	Same, plus RBC's or powdered activated carbon

If any of these control technologies are already in place or planned by the refinery, then costs will not be allocated.

Planned flow reductions used in this report do not include the elimination of once-through cooling water, as well as other "excluded wastewaters" as described in the Supplemental Flow Question, such as stormwater, ballast water, etc.

Planned flow reductions have been divided into two groups: (1) reductions in flow to end-of-pipe treatment, and (2) reductions in effluent discharge by end-of-pipe methods (i.e., flow recycle, evaporation, etc.). Effluent flow is NPDES discharge minus planned flow reductions from both groups. Refineries that have effluent flow values of 10,000 gallons per day or less above their Level 1 flow are considered to be meeting the Level 1 flow requirement. Wastewater flows to end-of-pipe treatment have been reduced only by the first type of reduction. Therefore, the costs for the treatment of recycled effluent are considered in this analysis. Treatment costs are based on a minimum of 10,000 gallons per day.

Capital and operating costs have been calculated for each refinery. Plants that are not meeting either of the two levels will have two costs calculated: costs associated with meeting Level 1 and costs associated with meeting Level 2. The operating costs presented in Table 15 do not include depreciation and/or interest, which need to be added prior to the economic evaluation.

The previous cost manual included the use of BOD and TSS effluent data as part of the analysis. Similar data are shown in Tables 2 and 3. Table 13 presents those refineries that would have no costs associated with meeting the two options, if their effluent data were considered in this analysis.

Tables 16 through 27 present economic costs for all of the treatment technologies discussed in this manual.

Detailed Costing Procedure[1]

I. Costs to Meet Level 1 Requirements

A. Flow Reduction

1. Each plant that requires flow reduction is listed in Table 12. This value is equal to the NPDES discharge, with planned flow reductions, minus the Level 1 flow rate, as shown in Table 1.

2. If any of these refineries do not have a cooling tower (no cooling tower makeup in Table 6), then indicate this on the work sheet.

3. Piping distance is obtained from Figure 2, based upon plant capacity (Table 5).

4. Pumping capital cost is obtained from Figure 1 using pumping distance and calculated flow reduction.

5. Pumping operating cost is obtained from Figure 11 times the pumping distance.

6. Twenty-five percent of the recycled wastewater is to be softened:

a. Water softening capital cost - Figure 6

b. Water softening operating cost - Figure 12

B. End-of-Pipe Treatment

1. End-of-Pipe Treatment - Costs for equalization and filtration are needed for plants that presently do not have or do not plan to have these treatment operations.

2. Flow rates to be used for costing are obtained from Table 14.

a. Equalization capital costs - Figures 3, 4. Equalization operating costs - Figures 7, 8.

b. Filtration capital costs - Figures 3, 4. Filtration operating costs - Figures 7, 8.

II. Costs to Meet Level 2 Requirements

A. Any flow reduction or end-of-pipe treatment necessary for meeting Level 1 are also required for Level 2. Therefore, costs calculated using the procedures listed below must be added to the Level 1 costs already obtained.

(1) Costs for 10,000 gal/d flows are considered minimum costs.

B. Flow rates to be used for costing are obtained from Table 14.

C. Plants that have, or plan to have, activated sludge, trickling filters, or RBC systems will have powdered activated carbon added:

1. Capital costs - Figure 5 (minimum cost - $35,000)

2. Operating costs - Figures 9, 10

D. Plants that have, or plan to have, aerated lagoons or oxidation ponds or will have RBC's added:

1. Capital costs - Figures 3, 4

2. Operating costs - Figures 9, 10

E. If a plant does not have a biological system or the type of bio system used at a plant is unknown, assume that it has, or will install, an activated sludge system. Therefore, cost powdered activated carbon treatment.

Summary of Direct Discharge Refineries

There are presently 175 refineries discharging all or part of their wastewaters directly to receiving streams. However, 12 refineries were not costed in this analysis for the following reasons:

1. Seven refineries plan to discharge to POTW's in the future.

2. Three refineries presently discharge the majority of their wastewaters to POTW's. These refineries are considered indirect dischargers for the purposes of this analysis.

3. Two refineries discharge at flow rates that can be considered insignificant. In addition, these refineries would most likely meet any BAT option considered by EPA.

Table 15 presents the capital and operating costs for direct dischargers to meet the proposed standards.

TABLE 1

WASTEWATER DISCHARGE VS. BAT FLOW OPTIONS

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow		Wastewater Generated in 1976 (MGD)	NPDES Discharge		Option 2 Flow	
				Level 1 (gal/bbl)	Level 2 (gal/bbl)		In 1976 (MGD)	With Planned Flow Reductions (MGD)	Level 1 (MGD)	Level 2 (MGD)
1	8	35	18	24	16	0.190	0.190	0.190	0.733	0.482
2	3	13	7	7	4	0.054	0.054	0.054	0.131	0.0864
3	13	89	47	45	30	0.014	0.014	0.014	0.0566	0.0372
4	.04	13	7	3	2	0.00055	0	0	0.0360	0.0250
6	4	30	16	23	15	0.075	0.075	0.075	0.508	0.334
7	4	13	7	6	4	0.165	0.165	0.05	0.222	0.146
8	4	39	20	26	17	0.005	0	0	0.131	0.0864
9	11	23	12	18	12	0.036	0.036	0.013	0.0627	0.0412
10	14	78	53	53	35	0.05	0.05	0.05	0.316	0.208
11	35	58	39	37	24	1.5	1.499	0.779	1.73	1.14
12	192	89	47	64	42	0.691	0.075	0.0736	0.286	0.188
13	31	40	25	30	20	5.05	0	0 (considered present POTW only)	5.75	3.78
14	7	14	8	12	8	0.0863	0	0	0.145	0.0956
15	5	20	11	8	5	0.1525	0	0	0.246	0.161
16	9	32	17	23	15	0.324	0	0	1.11	0.731
17	7	47	25	31	20	0.03320	0	0	0.294	0.193
18	14	47	25	29	19	0.228	0	0	0.573	0.377
19	3	78	41	38	25	0.004284	0.000084	0.000084	0.0949	0.0624
20	22	47	26	31	20	1.91	1.91	1.91	3.08	2.02
21	4	13	7	3	2	0.068	0	0	0.0584	0.0384
22	13	43	23	28	19	0.090	0	0	0.310	0.204
23	4	13	7	6	4	0.0488	0	0	0.0934	0.0614
24	7	15	8	6	4	0.3	0.3	0.3	0.325	0.214
25	10	43	24	36	24	0.484	0	0	1.95	1.28
26	9	16	9	19	13	0.149	0	0	0.331	0.218
29	37	56	31	32	21	3.74	0	0	4.22	2.76
30	12	13	7	3	2	0.23702	0.237	0.237	0.0666	0.0438

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Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
31	.6	22	12	17	11	0.006	0	0	0.203	0.134
32	70	51	29	29	19	5.9	3.4	3.4	3.23	2.12
33	10	20	11	20	13	0.398	0	0	0.880	0.579
35	15	13	7	3	2	0.0294	0	0	0.0102	0.00672
36	3	40	21	27	18	0.033	0	0	0.462	0.304
37	31	79	60	53	35	2.36	2.36	2.36	5.49	3.61
38	37	39	22	22	15	3.065	0	0 (considered present POTW only)	2.06	1.36
39	11	13	7	4	3	0.151	0	0	0.111	0.0730
40	34	27	17	16	10	7.8	7.8	6.6	6.40	4.21
41	36	55	42	33	22	9.38	9.38	9.38	12.0	7.59
42	5	13	7	3	2	0.03432	0	0	0.0204	0.0134
43	62	53	30	30	20	2.869	2.149	2.149 (considered present DD only)	2.41	1.58
44	25	30	17	28	19	0.7	0	0	1.13	0.742
45	43	47	26	37	25	3.19	0	0	4.16	2.73
46	22	81	55	45	30	1.31	1.31	0.86	2.95	1.94
48	112	24	13	0	0	0.606	0	0	0	0
49	5	28	16	28	18	0.132	0.132	0.132	0.929	0.611
50	10	24	13	28	18	0.154	0.080	0.028	0.603	0.396
51	67	49	31	26	17	9.9	9.9	9.9	3.89	2.56
52	107	78	41	98	64	0.3	0.3	0.3	0.391	0.257
53	19	47	25	30	20	0.25	0.25	0.15 (considered present DD only)	0.423	0.278
54	6	33	17	24	16	0.017	0.017	0.017	0.0732	0.0482
55	2	14	7	6	4	0.14	0	0	0.352	0.232
56	29	24	13	24	16	1.306	1.306	1.306	0.968	0.636
57	129	32	20	27	18	10.3	10.3	6.0	2.88	1.90
58	26	25	16	24	16	1.43	0	0	1.71	1.13
59	24	33	18	24	16	1.100	1.100	0.99	1.39	0.916
60	11	31	17	18	12	1.9466	1.656	1.650	3.46	2.28

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Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow		Wastewater Generated in 1976 (MGD)	NPDES Discharge		Option 2 Flow	
				Level 1 (gal/bbl)	Level 2 (gal/bbl)		In 1976 (MGD)	With Planned Flow Reductions (MGD)	Level 1 (MGD)	Level 2 (MGD)
61	17	38	21	23	15	2.64	2.64	2.64	4.51	2.97
62	19	89	55	37	25	4.8	4.8	4.8	11.0	7.25
63	36	33	18	30	19	2.73	2.73	2.605	2.69	1.77
64	68	43	24	27	18	4.80	4.80	2.43	2.10	1.38
65	29	35	20	20	13	3.60	3.60	3.60	3.04	2.00
66	UNKNOWN	13	7	3	2	UNKNOWN	0	0	0.00292	0.00192
67	65	58	39	28	19	21.19	21.00	21.00	10.8	7.11
68	41	27	21	28	18	4.86	4.86	4.86	3.87	2.55
70	17	13	7	6	4	0.150	0.150	0.150	0.0618	0.0538
71	13	22	12	22	15	0.2415	0.240	0.240	0.472	0.310
72	23	51	27	28	19	0.152	0.152	0.132	0.241	0.158
73	25	23	13	23	15	0.773	0	0 (considered present POTW only)	1.026	0.674
74	10	41	23	33	22	0.200	0.19975	0.19975	0.752	0.494
76	56	75	51	37	25	2.28	2.28	1.78	1.60	1.05
77	12	20	11	21	14	0.276	0.276	0.276	0.477	0.314
78	26	23	13	20	13	0.68	0	0	0.595	0.391
79	UNKNOWN	14	7	7	5	UNKNOWN	0	0	0.0219	0.0144
80	5	34	19	30	20	0.23	0.08	0.08	1.31	0.956
81	22	28	16	19	12	1.21	1.15	1.15	1.06	0.695
82	281	13	7	6	4	0.576	0	0	0.0584	0.0384
83	35	51	35	37	24	2.446	2.44	2.44	3.32	2.18
84	21	21	13	19	12	1.69	1.41	1.41	1.51	0.992
85	25	38	24	27	18	3.29	3.29	3.29	3.68	2.42
86	15	33	18	28	19	0.346	0	0	0.707	0.465
87	18	13	7	3	2	0.0905	0.09	0.09	0.0152	0.00998
88	6	13	7	5	3	0.228	0.212	0.212	0.235	0.155
89	22	34	23	18	12	0.0603	0.0384	0.0384	0.0736	0.0484
90	25	89	47	87	57	0.045	0.032	0.030	0.191	0.126

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Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
91	3	13	7	3	2	0.0120	0.0120	0.0120	0.0113	0.00744
92	44	89	60	36	24	11.16	10.69	10.42	9.82	6.45
93	15	13	7	5	3	0.045	0.024	0.024	0.0295	0.0194
94	23	25	14	19	13	1.836	1.836	1.836	1.62	1.07
95	29	13	7	3	2	0.0864	0	0	0.0146	0.00960
96	25	54	37	27	18	11.84	10.38	8.28	14.2	9.36
97	3	19	11	18	12	0.0712	0.0712	0.0712	0.907	0.596
98	13	31	17	19	13	2.59	2.34	2.34	3.94	2.59
99	3	20	11	19	12	0.070	0.070	0.070	0.533	0.350
100	9	13	7	6	4	0.0518	0.0518	0.0518	0.0642	0.0422
102	32	17	10	10	7	1.584	1.584	1.167	0.919	0.604
103	2	13	7	6	4	0.063	0.063	0.063	0.210	0.138
104	30	41	23	27	18	7.43	6.01	6.01	8.05	5.29
105	30	12	13	21	14	2.534	2.381	2.381	1.85	1.22
106	18	38	21	30	20	2.104	1.583	1.583	4.64	3.05
107	4	40	21	27	18	0.03	0.03	0 (future POTW)	0.453	0.298
108	19	89	47	55	36	0.044	0.044	0.044	0.759	0.499
109	21	12	13	29	19	0.24	0.24	0.24	0.678	0.446
110	7	13	7	6	4	0.02	0.02	0 (future POTW)	0.0350	0.0230
111	24	43	24	24	16	1.58	0	0	1.58	1.04
112	36	13	7	6	4	0.203	0.203	0.203	0.0803	0.0528
113	13	25	14	23	15	0.553	0.5	0.428	0.975	0.641
114	12	20	11	20	13	0.250	0.250	0 (future POTW)	0.485	0.319
115	27	56	31	28	18	2.80	2.80	2.72	3.71	2.44
116	21	49	27	41	27	1.2	1.2	1.2	2.81	1.84
117	36	30	17	25	16	1.01	1.01	0.81	0.746	0.491
118	9	88	46	49	32	0.036	0.026	0.026	0.291	0.191
119	16	78	41	39	26	0.150	0.125	0.125	0.431	0.283
120	38	89	47	57	38	0.110	0.100	0.100	0.241	0.159

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Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
121	17	27	17	22	14	4.5	4.5	4.5	6.39	4.20
122	72	47	26	28	18	6.40	6.40	5.70	3.00	1.97
124	14	36	20	30	19	0.475	0.475	0.475	1.25	0.819
125	9	28	16	23	15	0.444	0.444	0.444	1.26	0.831
126	163	36	20	31	20	6.48	2.16	2.16	1.43	0.941
127	30	43	24	40	26	0.173	0.173	0.173	0.261	0.171
128	4	13	7	6	4	0.01	0	0	0.0175	0.0115
129	23	16	9	18	12	0.100	0.100	0.100	0.0885	0.0582
130	31	20	11	20	13	0.165	0	0	0.109	0.0719
131	24	38	21	20	13	2.88	2.88	2.80	3.43	2.25
132	35	41	31	28	19	10.214	10.2	9.5	8.48	5.57
133	86	60	41	29	19	7.93	7.93	7.93	2.91	1.91
134	45	32	20	31	21	4.15	4.15	4.15	3.21	2.11
135	0	13	7	3	2	0	0	0	0.00730	0.00480
136	11	13	7	6	4	0.286	0	0	0.147	0.0966
137	2	13	7	6	4	0.0104	0	0	0.0251	0.0165
138	26	17	10	15	10	0.720	0	0	0.452	0.297
139	2	13	7	3	2	0.014	0	0	0.0219	0.0144
140	9	29	16	30	20	0.11	0	0	0.570	0.375
141	.09	13	7	7	5	0.0002	0	0	0.0285	0.0188
142	26	42	27	35	23	1.584	1.584	0 (future POTW)	2.21	1.45
143	38	43	24	33	22	1.2	1.2	0 (future POTW)	1.47	0.969
144	14	20	11	21	14	0.654	0.199	0.119	1.05	0.691
145	5	13	7	3	2	0.00410	0	0	0.0153	0.0101
146	24	14	8	13	9	0.093	0.093	0.093	0.0653	0.0429
147	9	49	27	35	23	0.576	0.576	0.576	2.29	1.50
148	10	43	23	29	19	0.16	0	0	0.576	0.379
149	27	23	13	23	15	1.179	1.179	1.179	1.00	0.660
150	24	22	12	22	15	1.041	1.040	0.968	1.14	0.752

TABLE 1

WASTEWATER DISCHARGE VS. BAT FLOW OPTIONS

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
151	25	41	28	20	13	3.974	3.974	3.974	3.61	2.33
152	83	40	22	32	21	8.38	8.38	7.98	3.86	2.54
153	35	29	18	28	18	3.89	2.09	1.09	3.46	2.27
154	209	89	47	59	39	1.00	0.11	0.11	0.327	0.215
155	13	35	20	32	21	0.1728	0.0936	0.0936	0.461	0.303
156	20	29	20	24	16	1.00	0.85	0.634	1.30	0.856
157	16	35	24	21	14	2.01	2.01	2.01	2.72	1.79
158	13	26	15	22	14	0.548	0.548	0.548	1.18	0.773
159	15	20	11	20	13	0.277	0.252	0.252	0.383	0.252
160	8	17	10	20	13	0.175	0.175	0.175	0.468	0.307
161	14	16	9	24	16	0.65	0.35	0.35	1.22	0.804
162	30	85	58	41	27	2.45	2.18	1.18	3.65	2.40
163	20	26	15	26	17	1.037	1.037	1.037	1.35	0.887
164	6	13	7	3	2	0.022	0	0	0.0146	0.00960
165	5	47	26	33	21	0.29	0.29	0.29	1.95	1.28
166	16	89	17	67	44	0.11	0	0	0.945	0.621
167	33	31	17	16	11	5.1	4.8	4.8	3.22	2.11
168	19	31	17	21	13	2.88	2.70	2.70	3.49	2.29
169	56	31	17	21	14	8.67	8.53	6.98	3.99	2.62
172	98	66	35	34	22	0.92	0.92	0.764	0.404	0.266
173	224	89	47	77	51	0.628	0.628	0.448	0.270	0.177
174	109	89	47	78	51	0.576	0.576	0.576	0.551	0.362
175	81	67	51	40	26	12.478	11.995	0 (future POTW)	6.52	4.29
176	14	31	17	24	16	0.4649	0.3684	0.3684	1.26	0.826
177	134	89	47	59	39	0.765	0.765	0.765	0.446	0.293
179	1?	49	25	36	24	0.282	0.282	0.282	0.930	0.611
180	46	53	30	25	16	2.767	2.764	2.764	1.96	1.29

TABLE 1

WASTEWATER DISCHARGE VS. BAT FLOW OPTIONS

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
181	47	37	23	28	18	16.04	15.57	12.57	10.09	6.63
182	27	37	28	17	11	6.4	0	0	5.57	3.66
183	13	16	9	12	8	0.640	0.639	0.559	0.735	0.483
184	22	47	26	34	22	1.36	1.36	1.216	2.28	1.50
185	11	24	13	19	12	0.837	0	0	1.42	0.936
186	13	24	15	11	7	1.815	1.815	1.815 (considered present DD only)	1.97	1.30
187	16	43	27	38	25	0.772	0	0	2.15	1.41
188	27	30	17	21	14	2.435	0	0	2.14	1.41
189	3	13	7	3	2	0.015	0.015	0.015	0.0146	0.00960
190	5	13	7	5	3	0.0332	0.0332	0.0332	0.0438	0.0288
191	9	43	24	33	22	0.454	0	0	1.76	1.16
192	201	13	7			0.141	0	0	0	0
193	.2	13	7	3	2	0.00052	0	0	0.00949	0.00624
194	43	60	46	32	21	17.0	16.76	13.76	12.9	8.48
195	1	13	7	3	2	0.00133	0	0	0.00292	0.00192
196	61	50	38	9	2	18.5	18.5	14.5	8.99	5.91
197	16	13	7	3	2	0.008	0.008	0.008	0.0128	0.00845
199	24	13	7	3	2	0.0492	0.0492	0.0492	0.0883	0.0166
200	24	36	20	25	17	0.612	0	0	0.742	0.488
201	14	20	31	21	14	0.95	0.95	0.95	1.38	0.907
202	1	13	7	3	2	0.0001	0	0	0.0102	0.00672
203	44	47	32	28	18	12.94	0	0	9.34	6.14
204	34	29	18	29	19	3.3766	3.366	3.366	2.95	1.94
205	24	23	15	20	13	2.438	2.424	2.424	2.07	1.36
206	3	13	7	6	4	0.093	0	0	0.213	0.140
207	2	13	7	3	2	0.071	0	0	0.134	0.0883
208	18	41	31	26	17	4.99	4.98	4.98	8.20	5.39
209	8	20	11	22	14	0.235	0	0	0.756	0.497
210	3	13	7	6	4	0.039	0.019	0.016	0.106	0.0695

TABLE 1

WASTEWATER DISCHARGE VS. BAT FLOW OPTIONS

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
211	7	21	12	10	7	0.8135	0.8135	0.8135	1.26	0.831
212	13	20	13	18	12	0.703	0.703	0.703	1.05	0.692
213	4	13	7	6	4	0.051	0.046	0.046	0.126	0.0830
214	DATA NOT SUBMITTED.	-	-	-	-	-	0	0	-	-
215	DATA NOT SUBMITTED.	-	-	-	-	-	0	0	-	-
216	54	45	34	28	18	20.4	13.2	8.64	13.4	8.79
218	.1	13	7	3	2	0.0007	0	0	0.0175	0.0115
219	17	28	16	25	17	1.2	1.2	1.2	2.03	1.33
220	2	85	45	37	25	0.023	0	0	0.374	0.246
221	29	17	13	22	15	3.312	3.312	3.312	2.86	1.89
222	42	10	6	13	9	0.35	0.35	0.35	0.175	0.115
224	12	14	8	12	8	0.1745	0	0	0.245	0.161
225	35	36	20	30	20	1.19	0	0	1.22	0.799
226	8	13	17	8	5	0.036	0.036	0.036	0.0621	0.0408
227	37	25	14	22	14	1.27	0.55	0.5068	0.971	0.638
228	16	14	8	14	9	0.208	0	0	0.352	0.231
229	3	27	15	34	22	0.0208	0	0	0.189	0.124
230	30	40	17	30	20	0.7	0.7	0.7	0.745	0.490
231	169	13	7	3	2	0.52	0.52	0 (future POTW)	0.0315	0.0207
232	22	29	18	24	16	1.09	1.09	1.09	1.35	0.885
233	10	33	18	19	13	1.00	1.00	1.00	1.92	1.26
234	18	53	30	21	14	1.0	1.0	1.0	1.55	1.02
235	21	36	20	30	20	1.50	1.499	1.499	2.85	1.87
236	28	33	17	24	16	0.12	0.12	0.094	0.108	0.0708
237	10	89	47	52	34	0.028	0.028	0.028 (considered present DD only)	0.260	0.171
238	27	20	11	19	13	1.914	1.914	1.914	1.51	0.995
239	10	19	10	15	10	0.126	0.126	0.126	0.340	0.224
240	130	89	47	64	42	0.6	0.6	0.23	0.354	0.233

TABLE 1

WASTEWATER DISCHARGE VS. BAT FLOW OPTIONS

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
241	76	89	47	65	43	0.660	0.432	0.432	0.781	0.514
242	147	89	47	69	45	0.64	0.64	0.28	0.359	0.235
243	6	18	10	17	11	0.168	0.168	0.168	0.700	0.461
244	54	28	19	24	16	1.83	0	0	1.09	0.716
245	26	29	16	28	19	0.600	0	0	0.689	0.453
246	53	41	23	32	21	0.565	0	0	0.344	0.226
247	12	14	8	12	8	0.2072	0	0	0.316	0.208
248	.01	13	7	3	2	0.00001	0	0	0.00292	0.00192
249	21	16	9	22	14	0.832	0	0	1.12	0.736
250	0	13	7	3	2	0	0	0	0.00292	0.00192
251	0	13	7	3	2	0	0	0	0.00146	0.00096
252	21	20	11	19	12	0.139	0.139	0.123	0.201	0.132
253	DATA NOT SUBMITTED.	-	-	-	-	-	0	0	-	-
254	.7	89	47	6	4	0.0001	0	0	0.00584	0.00384
255	4	13	7	6	4	0.129	0.125	0.125	0.185	0.121
256	11	17	10	14	9	0.365	0.365	0.365	0.564	0.371
257	16	31	17	22	14	2.03	2.03	2.03	3.27	2.15
258	15	110	58	29	19	1.0	1.0	1.0	2.47	1.62
259	4	19	10	7	5	2.19	2.19	2.118	4.50	2.96
260	13	89	47	133	88	0.025	0.025	0.025	0.400	0.263
261	14	14	8	6	4	0.47	0.43	0.43	0.257	0.169
264	5	13	7	6	4	0.0150	0	0	0.148	0.0972
265	12	25	13	11	7	1.108	1.108	0.571	2.14	1.41
266	25	13	7	6	4	0.06705	0.067	0.067 (considered present DD, ZD only)	0.0346	0.0227
278	0	13	7	3	2	0	0	0	0.00876	0.00576
291	12	13	7	3	2	0.142	0	0	0.0444	0.0292
292	UNKNOWN	13	7	3	2	UNKNOWN	UNKNOWN	UNKNOWN	0.00292	0.00192
295	129	13	7	0	0	0.2586	0.2376	0.2376	0	0

TABLE 1

WASTEWATER DISCHARGE VS. BAT FLOW OPTIONS

Refinery No.	Wastewater Generated in 1976 (gal/bbl)	Option 1 - Calculated BPT Flow (gal/bbl)	Calculated 1974 BAT Flow (gal/bbl)	Option 2 Flow Level 1 (gal/bbl)	Option 2 Flow Level 2 (gal/bbl)	Wastewater Generated in 1976 (MGD)	NPDES Discharge In 1976 (MGD)	NPDES Discharge With Planned Flow Reductions (MGD)	Option 2 Flow Level 1 (MGD)	Option 2 Flow Level 2 (MGD)
296	0	13	7	3	2	0	0	0	0.0292	0.0192
298	1	13	7	3	2	0.013	0	0	0.0438	0.0288
302	.04	13	7	3	2	0.00008	0	0	0.00642	0.00422
303	0	13	7	3	2	0	0	0	0.00292	0.00192
305	4	13	7	6	4	0.0463	0	0	0.0759	0.0500
307	0	13	7	3	2	0	0	0	0.00219	0.00144
308	0	13	7	3	2	0	0	0	0.000146	0.000096
309	18	18	11	0	0	0.968	0.582	0.432	0	0
310	.9	13	7	3	2	0.0026	0	0	0.00876	0.00576

TABLE 2

BOD$_5$ MASS DISCHARGE VS. BAT MASS OPTIONS

Refinery No.	BOD$_5$ Mass Discharge (lb/d) July 1, 1977 NPDES Permit Limitation- Daily Average	BOD$_5$ Mass Discharge (lb/d) December 1976 DMR Value Daily Average	BOD$_5$ Mass Limitations (lb/d) Option 1- BPT	BOD$_5$ Mass Limitations (lb/d) Option 2- Level 1	BOD$_5$ Mass Limitations (lb/d) Option 2- Level 2
1	215.9	18.3	223	156	103
2	44.9	16.4	55	28	18
3	11.58	25.0	24	12	8
4	-	-	36	8	5
6	68.0	55.2	140	108	71
7	-	-	105	47	31
8	-	-	42	28	18
9	16.0	6.37	17	13	9
10	-	-	100	67	44
11	402.0	1113.9	581	368	243
12	83.0	-	85	61	40
13	1726.0	ND	1640	1220	805
14	-	-	37	31	20
15	-	-	136	52	34
16	-	-	327	236	156
17	-	-	95	63	41
18	-	-	195	122	80
19	-	-	42	20	13
20	1000	350	1000	656	430
21	-	-	55	12	8
22	-	-	101	66	43
23	166	-	44	20	13
24	160	18	170	69	46
25	-	-	493	415	273
26	-	-	58	71	46
29	-	-	1560	899	592
30	-	-	63	14	9
31	-	-	56	43	29
32	1243	1132	1190	688	452
33	-	-	187	187	123
35	-	-	10	2	1
36	-	-	145	98	65
37	1730	240	1730	1170	769
38	-	-	733	439	290
39	-	-	72	24	16
40	-	-	2330	1360	897
41	4800	11400	4280	2560	1680
42	-	-	19	4	3
43	938	-	903	513	337
44	-	-	256	241	158
45	-	-	1110	886	581
46	1080	2719	1130	628	413
48	-	-	51	0	0
49	209	194	200	198	130
50	101	22.7	110	128	84
51	2161	4406	1570	829	545
52	-	-	66	83	55
53	-	49	140	90	59
54	16	1.9	21	16	10
55	-	-	180	75	49
56	220	185	204	206	135
57	944	1338	729	613	405
58	-	-	373	364	241
59	122	185.01	400	296	195
60	-	-	1290	737	486
61	-	-	1620	961	633
62	-	-	5590	2340	1540
63	673	196	640	573	377
64	742	-	714	447	294
65	-	-	1150	648	426
66	-	-	3	1	1
67	3372	5650	4700	2300	1510
68	570	609	805	824	543
70	-	11.03	36	17	11
71	71	-	98	101	66
72	24	13.8	92	51	34
73	-	-	218	219	144
74	-	-	196	160	105
76	287.3	860.8	678	341	224
77	-	-	99	102	69
78	-	-	146	127	83
79	-	-	9	5	3
80	100	8	377	322	212
81	337	170	340	226	148
82	-	-	28	12	8
83	935	2169	978	707	464
84	626	116	358	322	211
85	1204	898	1120	784	515

TABLE 2 (Cont'd.)

BOD$_5$ MASS DISCHARGE VS. BAT MASS OPTIONS

Refinery No.	BOD$_5$ Mass Discharge (lb/d) July 1, 1977 NPDES Permit Limitation- Daily Average	BOD$_5$ Mass Discharge (lb/d) December 1976 DMR Value Daily Average	BOD$_5$ Mass Limitations (lb/d) Option 1- BPT	Option 2- Level 1	Option 2- Level 2
86	-	238	176	151	99
87	7.8	-	14	1	2
88	121	27.6	125	50	33
89	-	-	29	16	10
90	34.7	4.3	42	41	27
91	-	2.1	11	2	2
92	1951	21936	5120	2090	1370
93	11	0.299	18	6	4
94	320	479	453	345	228
95	12.5	14	14	3	2
96	-	-	6070	3020	1990
97	-	-	202	193	127
98	1745	2175	1330	839	552
99	117	24	122	113	75
100	29	30.53	30	14	9
102	377	349	326	196	129
103	132	35	100	45	29
104	2285	-	2600	1710	1130
105	552	1170	398	394	260
106	1403	198	1250	988	650
107	26.3	48	145	96	63
108	50	4.4	262	162	106
109	160	-	105	144	95
110	-	-	17	7	5
111	-	-	605	337	222
112	-	39.6	35	11	7
113	160	121	224	138	91
114	-	-	102	69	45
115	584	3564	1570	527	346
116	-	-	710	399	261
117	-	-	192	106	70
118	14.6	580	112	41	27
119	24.2	23.5	183	61	40
120	14.9	14.2	80	34	23
121	974	452	1700	907	596
122	1100	2423	1070	426	280
124	-	42.1	322	178	116
125	265	92	334	179	118
126	265	92	353	305	200
127	42.61	40.4	60	56	36
128	-	-	8	4	2
129	20	27.3	17	19	12
130	-	-	23	23	15
131	1470	3179	1360	731	479
132	3670	-	2620	1810	1190
133	1700	-	1280	620	407
134	-	-	702	684	449
135	-	-	7	2	1
136	-	-	70	31	21
137	-	-	13	5	4
138	-	-	108	96	63
139	-	-	21	5	3
140	-	-	117	121	80
141	-	-	11	6	4
142	3800	2553	564	471	309
143	400	419	403	313	206
144	254	1.19	213	224	147
145	-	-	15	3	2
146	-	22	14	14	9
147	686	24.6	678	488	320
148	-	-	183	123	81
149	270	397	216	213	141
150	-	-	239	243	160
151	-	-	1550	769	507
152	1540	338	1020	822	541
153	670	470	772	737	484
154	-	-	104	70	46
155	-	-	108	98	65
156	-	-	340	277	182
157	-	-	971	579	381
158	-	-	302	251	165
159	-	-	81	82	54
160	-	-	85	100	65
161	-	-	174	260	171
162	1427	2449	1630	777	511

TABLE 2 (Cont'd.)

BOD_5 MASS DISCHARGE VS. BAT MASS OPTIONS

Refinery No.	BOD_5 Mass Discharge (lb/d) July 1, 1977 NPDES Permit Limitation- Daily Average	BOD_5 Mass Discharge (lb/d) December 1976 DNR Value Daily Average	BOD_5 Mass Limitations (lb/d) Option 1- BPT	Option 2- Level 1	Option 2- Level 2
163	292	326	288	288	189
164	-	-	14	3	2
165	-	-	601	415	273
166	-	-	265	201	132
167	1331	650	1290	686	449
168	1657	1887	1120	743	488
169	1278	732	1240	850	558
172	-	-	169	86	57
173	60	258	66	58	38
174	129	416	135	117	77
175	-	-	2360	1390	914
176	354	-	343	268	176
177	132	543	144	95	62
179	89	40	249	198	130
180	457	575	903	417	275
181	5183	4138	2860	2150	1410
182	-	18183	2560	1190	780
183	515	137	215	157	103
184	184	588	671	486	320
185	-	-	383	302	199
186	440	3202	946	420	277
187	-	-	513	457	300
188	-	-	639	456	300
189	-	-	14	3	2
190	12.5	12	25	9	6
191	-	-	490	375	247
192	-	-	3	0	0
193	-	-	9	2	1
194	3405	1775	5180	275	1810
195	-	-	3	1	1
196	-	-	3400	1910	1260
197	8.2	-	12	3	2
199	57.4	-	27	6	4
200	-	-	225	158	104
201	370	154	281	294	193
202	-	-	10	2	1
203	28200	-	3360	1990	1310
204	934	2341	636	628	413
205	450	317	506	441	290
206	-	-	101	45	30
207	-	-	127	29	19
208	1200	4884	2710	1750	1150
209	-	-	149	161	106
210	3.34	-	50	23	15
211	217	49	559	268	177
212	496	63	256	224	147
213	25	6.77	60	27	18
214	-	-	-	-	-
215	-	-	-	-	-
216	-	3319	4560	2850	1870
218	-	-	17	4	2
219	530	-	481	432	283
220	-	-	181	80	52
221	835	445	469	609	400
222	80	43.4	29	37	24
224	-	-	60	52	34
225	-	-	310	260	170
226	-	-	21	13	9
227	262	45	240	207	136
228	-	-	75	75	49
229	-	-	32	40	26
230	154	84	213	159	104
231	-	-	28	7	4
232	406	989	340	288	189
233	800	116	703	409	268
234	410	0	847	330	217
235	660	340	721	607	398
236	-	-	32	23	15
237	-	-	95	55	36
238	450	600	332	322	212
239	91	16.24	92	72	48
240	-	219	104	75	50
241	158	589.3	227	166	109
242	-	208	99	76	50
243	-	53.6	161	149	98
244	-	-	265	232	153
245	-	-	149	147	96

TABLE 2 (Cont'd.)

BOD_5 MASS DISCHARGE VS. BAT MASS OPTIONS

Refinery No.	BOD_5 Mass Discharge (lb/d)		BOD_5 Mass Limitations (lb/d)		
	July 1, 1977 NPDES Permit Limitation- Daily Average	December 1976 DMR Value Daily Average	Option 1- BPT	Option 2- Level 1	Level 2
246	106	225	94	73	48
247	-	-	76	67	44
248	-	-	3	1	1
249	-	-	173	239	156
250	-	-	3	1	1
251	-	-	1	1	1
252	60	208	45	43	28
253	-	-	-	-	-
254	-	-	19	1	1
255	-	-	82	39	26
256	170	54.5	145	120	79
257	620	15306	990	697	458
258	818	495	2008	526	345
259	2620	2083	2650	959	630
260	-	-	57	85	56
261	-	-	119	55	16
264	-	-	64	32	21
265	344	-	1070	456	300
266	12	85	16	7	5
278	-	-	8	2	1
291	-	-	42	9	6
292	-	-	3	1	1
295	-	2.9	10	0	0
296	-	-	28	6	4
298	-	-	41	9	6
302	-	-	6	1	1
303	-	-	3	6	4
305	-	-	36	9	6
307	-	-	2	1	1
308	-	-	1	1	1
309	614	161	211	0	0
310	-	-	8	2	1

TABLE 3

TSS MASS DISCHARGE VS. BAT MASS OPTIONS

Refinery No.	TSS Mass Discharge (lb/d)		TSS Mass Limitations (lb/d)		
	July 1, 1977 NPDES Permit Limitation- Daily Average	December 1976 DMR Value Daily Average	Option 1- BPT	Option 2- Level 1	Level 2
1	147.3	33.2	149	104	68
2	30.8	6.7	37	19	12
3	2.92	17	16	8	5
4	-	-	24	5	4
6	-	-	93	72	47
7	-	-	70	31	21
8	-	-	28	19	12
9	11	13.8	11	9	6
10	-	-	67	45	30
11	286	1070.3	387	246	162
12	56	-	57	41	27
13	1129	-	1090	817	537
14	-	-	25	21	14
15	-	-	91	35	23
16	-	-	218	158	104
17	-	-	63	42	27
18	-	-	130	81	54
19	-	-	28	13	9
20	657	570	667	437	287
21	-	-	37	8	5
22	-	-	67	44	29
23	-	-	29	13	9
24	134	66	113	46	30
25	-	-	329	277	182
26	-	-	39	47	31
29	-	-	1043	599	395
30	-	-	42	9	6
31	-	-	37	29	19
32	994	2009	793	459	301
33	-	-	125	125	82
35	-	-	7	1	1
36	-	-	97	66	43
37	1430	778	1150	780	513
38	-	-	489	293	193
39	-	-	48	16	10
40	-	-	1350	909	598
41	3200	12900	2850	1700	1120
42	-	-	13	3	2
43	614	-	602	342	224
44	-	-	171	160	105
45	-	-	740	591	388
46	772	187	753	419	275
48	-	-	34	0	0
49	167	124	133	132	87
50	87	16.5	73	86	56
51	2000	4010	1050	552	363
52	-	-	44	56	36
53	-	35	93	60	39
54	14	1.4	14	10	7
55	-	-	120	50	33
56	290	278	136	137	90
57	618	1979	486	409	270
58	-	-	249	243	160
59	160	107.79	267	197	130
60	-	-	860	491	324
61	-	-	1080	640	422
62	-	-	3730	1560	1030
63	537	362	427	382	251
64	594	1049	476	298	196
65	634	214	767	432	284
66	-	-	2	1	1
67	4530	3750	3130	1530	1010
68	747	1601	537	550	362
70	-	13.67	24	12	8
71	47	-	65	67	44
72	16	14	61	34	22
73	-	-	145	146	96
74	-	-	131	107	70
76	205.2	107.1	452	227	149
77	-	-	66	68	45
78	-	-	97	84	56
79	-	-	6	3	2
80	130	18.2	251	214	141
81	200	187	227	151	99
82	-	-	19	8	5
83	822	769	652	471	310
84	427	325	239	214	141
85	789	786	747	523	344
86	-	-	117	100	66
87	5.3	1.3	9	2	1
88	83	65.7	83	33	22

TABLE 3 (Cont.)

Refinery No.	TSS Mass Discharge (lb/d)		TSS Mass Limitations (lb/d)		
	July 1, 1977 NPDES Permit Limitation- Daily Average	December 1976 DMR Value Daily Average	Option 1- BPT	Option 2- Level 1	Level 2
89	-	-	19	10	7
90	24.8	1.0	28	27	18
91	-	3.4	7	2	1
92	1600	49353	3410	1390	916
93	-	-	12	4	3
94	420	564	302	230	152
95	8.3	23.9	9	2	1
96	4000	5976	4050	2020	1330
97	-	-	135	129	85
98	1351	1491	887	559	368
99	76	36	81	76	50
100	20	0.66	20	9	6
102	248	240	217	130	86
103	89	53	67	30	20
104	1830	-	1730	1140	750
105	362	1663	199	263	173
106	918	7749	833	659	433
107	34.7	8	97	64	42
108	50	4.3	175	108	71
109	100	-	70	96	63
110	-	-	11	5	3
111	-	-	403	224	148
112	21	35.1	23	17	11
113	175	63	149	208	137
114	-	-	68	103	68
115	701	769	1050	790	520
116	-	-	473	599	392
117	161.7	245	128	159	105
118	9.9	3.92	75	62	41
119	20	18.4	122	92	60
120	10.2	9.7	53	51	34
121	1871	726	1130	1360	895
122	885	1047	713	639	420
124	-	-	215	266	174
125	227	145	223	268	177
126	441	0	235	203	134
127	34.09	21.8	40	37	24
128	-	-	5	3	1
129	14.1	0.02	11	13	8
130	-	-	15	15	10
131	-	-	907	487	320
132	965	260	1750	1200	791
133	1400	-	853	413	271
134	-	-	468	456	300
135	-	-	5	1	1
136	-	-	47	21	14
137	-	-	9	4	2
138	-	-	72	64	42
139	-	-	14	3	2
140	-	-	78	81	53
141	-	-	7	4	3
142	380	Nil	376	314	206
143	815	334	269	209	138
144	-	-	142	149	98
145	-	-	10	2	1
146	-	-	9	9	6
147	549	168.1	452	325	213
148	-	-	122	82	54
149	177	148	144	142	94
150	-	-	159	162	107
151	-	-	1030	513	338
152	1230	2364	680	548	361
153	660	493	515	491	322
154	-	-	69	46	31
155	-	-	72	65	43
156	-	-	227	185	122
157	-	-	647	386	254
158	-	-	201	168	110
159	-	-	54	54	36
160	-	-	57	66	44
161	-	-	116	173	114
162	1006	1300	1090	518	341
163	233	390	192	192	126
164	-	-	9	2	1
165	-	-	401	277	182
166	-	-	177	134	88
167	1065	0	860	457	300
168	1326	1419	747	496	325
169	836	3301	827	567	372
172	-	-	113	57	38
173	105	294	39	38	25
174	109	453	90	78	51

TABLE 3 (Cont.)

Refinery No.	TSS Mass Discharge (lb/d)		TSS Mass Limitations (lb/d)		
	July 1, 1977 NPDES Permit Limitation- Daily Average	December 1976 DMR Value Daily Average	Option 1- BPT	Option 2- Level 1	Option 2- Level 2
175	-	-	1570	926	609
176	283	-	229	179	117
177	112	25	96	63	42
179	116	38	166	132	87
180	427	328	602	278	183
181	4681	3479	1910	1430	940
182	-	13011	1710	791	520
183	560	229	143	104	69
184	295	662	447	324	213
185	-	-	255	202	133
186	520	425	631	280	185
187	-	-	342	305	200
188	-	-	426	304	200
189	-	-	9	2	1
190	17.1	8	17	6	4
191	-	-	326	250	165
192	-	-	2	0	0
193	-	-	6	1	1
194	7744	3500	3450	1830	1200
195	-	-	2	1	1
196	-	-	2270	1280	839
197	5.6	-	8	2	1
199	-	-	18	4	3
200	-	-	150	105	69
201	243	262	187	196	129
202	-	-	7	1	1
203	28200	-	2240	1330	872
204	1022	429	424	419	275
205	750	597	337	294	193
206	-	-	67	30	20
207	-	-	84	19	13
208	2300	4180	1810	1160	765
209	-	-	99	107	71
210	3.34	6.36	33	15	10
211	217	82	372	179	118
212	327	475	171	149	98
213	-	8.55	40	18	12
214	-	-	-	-	-
215	-	-	-	-	-
216	-	4344	3040	1900	1250
218	-	-	11	3	1
219	424	-	321	288	189
220	-	-	121	53	35
221	835	1112	313	406	267
222	52	92	19	25	16
224	-	-	40	34	23
225	-	-	207	173	113
226	-	-	14	9	6
227	209	37	160	138	91
228	-	-	50	50	33
229	-	-	21	27	18
230	123	112	142	106	70
231	-	-	19	4	3
232	325	815	227	192	126
233	650	196	469	273	179
234	330	197	565	220	145
235	440	180	481	405	266
236	-	-	21	15	10
237	-	-	63	37	24
238	400	429	221	214	141
239	62	18.18	61	48	32
240	-	310	69	50	33
241	-	214.6	151	111	73
242	-	95	66	51	33
243	-	40.7	107	99	65
244	-	-	177	155	102
245	-	-	99	98	64
246	57	13	63	49	32
247	-	-	91	45	30
248	-	-	2	1	1
249	-	-	115	159	104
250	-	-	2	1	1
251	-	-	1	1	1
252	47.8	82.2	30	29	19
253	-	-	-	-	-
254	-	-	13	1	1
255	-	-	55	26	17
256	110	167	97	80	53
257	405	3850	660	464	305
258	580	482	1330	351	230
259	2277	1735	1170	639	420
260		-	38	57	37

TABLE 3 (Cont.)

Refinery No.	TSS Mass Discharge (lb/d)		TSS Mass Limitations (lb/d)		
	July 1, 1977 NPDES Permit Limitation- Daily Average	December 1976 DMR Value Daily Average	Option 1- BPT	Option 2- Level 1	Option 2- Level 2
261	-	-	79	36	24
264	-	-	43	21	14
265	287	-	713	304	200
266	9	45.7	11	5	3
278	-	-	5	1	1
291	-	-	28	6	4
292	-	-	2	1	1
295	-	-	7	0	0
296	-	-	19	4	3
298	-	-	27	6	4
302	-	-	4	1	1
303	-	-	2	4	3
305	-	-	24	6	4
307	-	-	1	1	1
308	-	-	1	1	1
309	535	218.2	141	0	0
310	-	-	5	1	1

TABLE 4

COST WORKSHEET

W.O. No. 4796-03 Date _____ Book No. _____ Page No. _____

Drawing No. _____ Calc. No. _____ Sheet _____ of _____

By _____ Checked _____ Approved _____

Title BAT COST WORKSHEET FOR PETROLEUM REFINING INDUSTRY

Refinery No. _____ Capacity (10^3 bbl/day) _____

		Capital Cost	Annual Oper. Cost
Flow Reduction Costs			
Cooling tower make-up (MGD)	=		
Recycle flow rate:			
NPDES discharge with planned flow reduction (MGD)	=		
− Option 2 Level 1 flow (MGD)	= _____		
= Recycle flow rate (MGD)	=		
× 694 (gpm)	=		
Pumping distance (miles)	=		
Recycle capital cost		=	
Recycle ann. oper. cost/mile	=		
× Pumping distance			
= Recycle annual operating cost			=
Water softening:			
25% recycle (gpm)	=		
Capital and annual operating costs		=	=
Treatment Costs			
Flow to EOP treatment (MGD)	=		
Option 2 Level 1:			
Equalization: Present ☐ Future ☐ No ☐	=	=	
Filtration: Present ☐ Future ☐ No ☐	= _____	= _____	
Total capital and annual operating costs for Level 1	=	=	
Option 2 Level 2:			
Activated sludge: Present ☐ Future ☐ Assumed ☐			
Trickling filter: Present ☐ Future ☐ No ☐			
PACT capital and annual operating costs	=	=	
Aerated lagoon: Present ☐ Future ☐ No ☐			
Oxidation pond: Present ☐ Future ☐ No ☐			
Other:			
RBC capital and annual operating costs	= _____	= _____	
Total capital and annual operating costs for Level 2	=	=	

TABLE 5

REFINERY CRUDE CAPACITIES AND THROUGHPUTS

REFINERY NO.	CRUDE CAPACITY (1000 bbl/day)	THROUGHPUT IN 1976 (1000 bbl/day)	REFINERY NO.	CRUDE CAPACITY (1000 bbl/day)	THROUGHPUT IN 1976 (1000 bbl/day)
1	30.0	24.7	86	25.0	23.6
2	20.0	16.9	87	5.2	5.0
3	1.25	1.1	88	45.0	35.28
4	13.0	13.0	89	4.0	2.8
6	22.0	21.3	90	2.2	1.8
7	38.0	38.0	91	3.873	5.0
8	5.0	1.4	92	270.	251.
9	3.5	3.378	93	6.5	3.0
10	6.0	3.6	94	85.0	81.578
11	47.0	43.4	95	5.0	3.0
12	4.5	3.6	96	528.0	472.0
13	193.	161.5	97	50.0	26.0
14	12.4	12.3	98	202.3	202.3
15	32.0	30.7	99	28.7	22.0
16	48.0	36.05	100	11.0	5.5
17	9.5	4.875	102	90.	71.6
18	19.5	16.2	103	36.	34.9
19	2.5	1.5	104	298.0	247.0
20	100.	86.6	105	89.0	85.085
21	20.	16.	106	154.9	119.4
22	11.	7.2	107	17.	8.3
23	16.	11.	108	13.8	2.3
24	53.3	41.6	109	23.5	11.17
25	53.8	49.2	110	6.	3.
26	17.	15.763	111	66.	65.
29	131.1	100.0	112	12.5	5.7
30	22.8	20.14	113	42.	41.
31	12.	10.	114	24.0	21.3
32	110.0	84.3	115	131.9	102.2
33	44.0	38.3	116	68.	56.8
35	3.5	2.0	117	30.	27.7
36	17.0	11.8	118	6.0	4.2
37	103.0	77.2	119	11.	9.1
38	93.0	83.9	120	4.2	2.87
39	26.	13.3	121	295.	259.2
40	405.	230.1	122	107.	88.5
41	365.	260.	124	42.	34.566
42	7.	6.5	125	56.	47.8
43	80.0	46.1	126	46.	39.8
44	40.	27.842	127	6.5	5.7
45	111.	74.2	128	3.	2.4
46	65.5	58.5	129	5.	4.3
48	10.	5.425	130	5.38	5.26
49	33.5	29.274	131	168.	121.5
50	21.5	14.93	132	300.	288.
51	150.	148.	133	100.	92.3
52	4.	2.812	134	103.0	82.0
53	14.0	13.0	135	2.5	1.625
54	3.	2.9	136	25.147	25.549
55	60.300	56.200	137	4.523	4.587
56	40.	45.	138	29.93	27.62
57	107.0	79.7	139	7.5	6.775
58	70.0	55.0	140	19.0	12.8
59	57.0	46.099	141	4.020	2.301
60	195.0	173.0	142	63.0	61.2
61	200.0	159.6	143	44.0	31.4
62	295.0	252.0	144	49.9	46.9
63	91.0	76.3	145	5.25	0.837
64	78.0	70.6	146	4.856	3.805
65	154.0	124.9	147	65.0	62.8
66	1.0	0.2	148	20.00	15.79
67	380.0	328.0	149	44.	44.
68	140.0	118.0	150	51.	42.9
70	13.0	8.76	151	177.0	160.3
71	21.0	18.4	152	120.	100.5
72	8.50	6.58	153	125.	112.0
73	44.5	31.5	154	5.5	4.775
74	22.5	19.25	155	14.5	13.7
76	42.452	40.933	156	55.	51.073
77	23.159	22.336	157	130.3	125.3
78	29.9	25.8	158	54.600	42.801
79	3.	3.	159	19.0	17.963
80	52.0	47.0	160	23.5	20.6
81	57.	54.15	161	51.	44.87
82	10.0	2.05	162	90.	82.3
83	90.0	70.8	163	52.0	51.0
84	80.0	78.8	164	5.0	3.9
85	138.0	132.4	165	60.	53.

TABLE 5 (continued)

REFINERY CRUDE CAPACITIES AND THROUGHPUTS

REFINERY NO.	CRUDE CAPACITY (1000 bbl/day)	THROUGHPUT IN 1976 (1000 bbl/day)
166	14.	6.9
167	195.0	155.1
168	170.	132.1
169	188.	154.
172	12.	9.36
173	3.5	2.8
174	7.1	5.3
175	165.0	154.0
176	52.	34.4
177	7.6	5.7
179	26.	23.5
180	80.0	60.0
181	363.	344.6
182	324.5	237.7
183	63.	47.6
184	67.	63.2
185	75.0	73.0
186	185.	136.
187	56.0	49.6
188	100.	89.9
189	5.	5.
190	9.	7.2
191	53.5	51.5
192	1.0	0.7
193	3.250	2.594
194	405.	392.4
195	1.0	<1.0
196	319	304.5
197	4.4	0.5
199	9.7	2.027
200	29.3	25.7
201	66.	65.9
202	3.5	0.1
203	335.	291.5
204	103.	98.754
205	103.37	101.94
206	36.5	27.
207	46.	39.
208	310.0	283.0
209	35.0	31.3
210	18.1	13.5
211	125.0	116.37
212	60.0	54.4
213	21.615	21.201
214	20.0	20.0
215	17.0	17.0
216	476.0	375.6
218	6.0	6.0
219	80.7	70.2
220	10.0	9.3
221	129.5	115.3
222	13.5	8.34
224	20.0	14.2
225	40.4	34.0
226	7.5	4.4
227	45.0	43.5
228	25.	13.4
229	5.6	6.
230	25.	23.1
231	10.0	3.080
232	55.0	49.6
233	100.	99.2
234	75.0	55.9
235	94.0	73.0
236	4.5	4.3
237	5.0	2.9
238	78.0	70.4
239	22.7	12.574
240	5.5	4.6
241	12.0	8.74
242	5.2	4.35
243	42.0	27.4
244	44.5	34.1
245	24.2	23.2
246	10.80	10.618
247	25.5	17.143
248	1.	1.
249	50.852	39.208
250	1.	<1.0
251	0.5	0.3
252	10.6	6.68
253	21.0	21.0
254	1.	0.15
255	29.5	29.175
256	40.	34.7
257	150.	124.
258	85.5	67.
259	655.0	523.0
260	3.	2.
261	40.	34.
264	23.	3.27
265	200.	140.1
266	5.92	2.71
278	3.	0.5
291	15.2	11.9
292	1.	1.
295	3.5	2.0
296	10.0	10.0
298	15.	9.3
302	2.2	2.1
303	1.	1.0
305	13.	12.4
307	0.75	0.2
308	0.05	0.05
309	55.0	52.7
310	3.	3.

TABLE A
[illegible] WATER MAKE-UP FLOW RATE
AT THE [illegible] PETROLEUM REFINERIES

REFINERY NUMBER	MAKE-UP FLOW (MGD)	DIVIDED BY TOTAL EFFLUENT FLOW	AT BIU BY COOLING TOWERS.
1	0.359600	[illegible]	[illegible]
2	0.114800	2.133937	100.0000
3	0.0	0.0	100.0000
4	NOT APP.	NOT APP.	0.0
6	NOT APP.	NOT APP.	0.0
7	0.107000	< 0.022455	70.1000
8	0.010000	3.333333	30.0000
9	0.025000	0.378788	UNKNOWN
10	0.020000	0.400000	UNKNOWN
11	2.909999	1.372124	94.0000
12	0.500000	100.000015	UNKNOWN
13	7.303997	1.476211	95.0000
14	0.034488	0.570238	UNKNOWN
15	0.084500	1.111842	100.0000
16	0.382100	1.412236	72.0000
17	0.018500	0.419121	40.0000
18	0.108000	0.551021	UNKNOWN
19	0.013000	3.250002	100.0000
20	1.450000	0.759162	30.0000
21	0.298000	4.257142	UNKNOWN
22	0.094500	1.073863	73.0000
23	NOT APP.	NOT APP.	0.0
24	0.350000	1.794871	15.0000
25	0.867000	2.731567	58.0000
26	0.210600	4.387499	79.0000
29	1.709998	0.462162	75.0000
30	0.193000	> 0.815372	100.0000
31	> 0.0	> 0.0	UNKNOWN
32	4.969995	2.839998	76.8000
35	NOT APP.	NOT APP.	0.0
36	0.036000	0.765957	93.5000
37	6.808996	2.764512	43.0000
38	3.299996	1.081141	UNKNOWN
39	0.165000	1.099999	UNKNOWN
40	6.614997	1.691815	90.0000
41	6.621992	0.705969	4.5000
42	0.030000	0.232425	UNKNOWN
43	3.759996	2.055278	99.9000
44	> 0.0	> 0.0	95.0000
45	4.348996	1.371923	53.6000
46	1.462999	1.030281	50.0000
48	> 0.140500	> 0.962329	95.0000
49	0.650000	4.924242	65.0000
50	0.235000	1.311676	80.0000
51	NOT APP.	NOT APP.	0.0
52	NOT APP.	NOT APP.	0.0
53	0.050000	0.223214	98.0000
54	0.030000	1.363636	100.0000
55	NOT APP.	NOT APP.	0.0
56	1.600000	1.290323	31.0000
57	9.499997	11.506521	99.0000
58	1.514149	1.022853	66.0000
59	1.925500	5.001368	47.8000
61	3.052498	1.295357	40.0000

TABLE 6 CONTINUED
COOLING TOWER MAKE-UP FLOW RATES
IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	PERCENT APPLIED BY BTU BY COOLING TOWERS
61	1.599999	1.529967	47.0000
62	5.344997	0.862096	74.0000
63	1.355000	0.490054	91.4100
64	4.308998	0.874036	66.0000
65	2.484499	0.664305	40.0000
66	0.000050	UNKNOWN	100.0000
67	8.829994	0.352495	65.6000
68	8.348999	1.714373	74.4000
70	0.0	0.0	UNKNOWN
71	0.359000	1.495832	100.0000
72	0.021000	0.127273	10.0000
73	0.468000	1.658162	75.0000
74	0.471500	2.162844	95.0000
76	1.933998	0.640397	96.5000
77	0.630000	37.472398	59.0000
78	0.075500	0.243548	90.0000
79	> 0.0	UNKNOWN	UNKNOWN
80	2.129998	16.384598	85.4000
81	0.776500	1.772830	100.0000
82	0.216000	0.367863	100.0000
83	1.929999	> 0.988863	60.0000
84	2.204995	< 1.510271	75.0000
85	> 5.394799	> 1.332707	80.0000
86	0.440950	1.102650	97.0000
87	NOT APP.	NOT APP.	0.0
88	0.735000	3.325790	89.2000
89	0.0	0.0	28.0000
90	0.017000	< 0.145299	60.0000
91	0.005000	4.999999	UNKNOWN
92	6.552999	0.650551	48.0000
93	> 0.0	> 0.0	UNKNOWN
94	> 0.0	> 0.0	86.5000
95	0.0	0.0	100.0000
96	19.014984	1.513931	100.0000
97	0.014040	0.197191	UNKNOWN
98	4.289999	2.370166	39.4000
99	NOT APP.	NOT APP.	0.0
100	NOT APP.	NOT APP.	0.0
102	0.0	0.0	0.9000
103	0.025000	0.324675	UNKNOWN
104	> 6.684999	> 0.759659	71.0000
105	NOT APP.	NOT APP.	0.0
106	2.250000	1.039742	100.0000
107	0.045000	1.499999	100.0000
108	0.126000	2.245589	99.0000
109	0.200000	0.487805	7.6000
110	NOT APP.	NOT APP.	0.0
111	2.842497	1.794505	46.0000
112	0.302500	1.475609	35.0000
113	0.529300	1.059000	49.4000
114	0.350000	1.025640	28.0000
115	1.983199	0.708285	58.8000
116	0.864000	0.417593	40.0000
117	1.350000	1.387558	99.0000

TABLE A CONTINUED
COOLING TOWER MAKE-UP FLOW RATES
IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	PERCENT COOLING BY BTU BY COOLING TOWERS
118	0.036500	1.013887	30.0000
119	0.100500	0.670000	28.0000
120	0.175000	1.590909	30.0000
121	6.750000	1.071428	65.0000
122	3.323500	0.416218	97.0000
124	0.975999	1.951609	100.0000
125	0.766000	1.698447	60.0000
126	0.400000	0.217391	22.0000
127	0.090000	0.517837	99.0000
128	NOT APP.	NOT APP.	0.0
129	0.066600	0.561552	UNKNOWN
130	NOT APP.	NOT APP.	0.0
131	0.330000	0.114583	20.0000
132	1.599999	0.154739	10.0000
133	5.160996	0.515584	85.0000
134	> 0.0	> 0.0	99.5000
135	0.0	UNKNOWN	UNKNOWN
136	0.378000	1.159509	100.0000
137	0.0	> 0.0	100.0000
138	0.466000	1.176767	1.0000
139	0.071000	5.071427	99.9000
140	0.222000	1.420618	UNKNOWN
141	> 0.0	UNKNOWN	100.0000
142	0.502500	0.275554	66.5000
143	0.030000	0.022043	2.0000
144	0.759500	1.130207	100.0000
145	0.004500	1.097560	100.0000
146	0.150000	1.499999	UNKNOWN
147	1.695000	1.810897	89.0000
148	0.126500	0.562222	100.0000
149	0.740000	< 0.616667	77.0000
150	NOT APP.	NOT APP.	0.0
151	> 4.150000	> 1.044288	61.7000
152	3.070000	0.520339	35.0000
153	5.792998	1.418809	63.0000
154	0.063000	0.092240	UNKNOWN
155	0.391700	1.323311	100.0000
156	1.697997	2.149363	60.0000
157	1.119996	1.753190	89.0000
158	0.570800	1.042842	71.5000
159	0.199500	0.488971	60.0000
160	0.328000	3.065420	100.0000
161	2.114997	2.812495	90.0000
162	2.115499	0.836165	UNKNOWN
163	2.732998	2.635488	88.0000
164	0.030000	1.363636	100.0000
165	0.595400	3.335574	49.8000
166	0.050000	0.452899	67.0000
167	3.954999	0.805208	70.0000
168	1.240000	0.381338	20.0000
169	1.794998	0.783737	90.0000
172	0.772000	0.801661	91.3000
173	0.0	0.0	UNKNOWN
174	NOT APP.	NOT APP.	0.0

TABLE 6 CONTINUED
COOLING TOWER MAKE-UP FLOW RATES
IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	% OF GTU BY COOLING TOWERS
175	10.787498	0.856131	UNKNOWN
176	0.086000	0.032966	33.0000
177	0.028000	0.028868	75.0000
179	0.632700	6.025716	82.0000
180	1.870998	0.680363	98.7500
181	> 20.876480	> 1.337379	49.0000
182	> 6.599497	> 0.872307	70.0000
183	2.169648	8.488452	59.7000
184	4.675997	6.585168	75.0000
185	1.771500	2.116487	95.0000
186	2.574697	1.555708	71.0000
187	3.244994	2.561165	60.0000
188	4.653500	2.086771	80.0000
189	> 0.0	UNKNOWN	UNKNOWN
190	0.085000	4.166665	70.0000
191	2.545500	5.606828	100.0000
192	0.028000	UNKNOWN	100.0000
193	> 0.0	UNKNOWN	UNKNOWN
194	11.303490	1.130348	79.0000
195	0.0	0.0	UNKNOWN
196	16.485465	0.720030	91.3000
197	0.002000	0.238095	100.0000
199	0.017200	1.589648	UNKNOWN
200	1.694998	2.769604	70.0000
201	2.156999	2.270524	69.0000
202	0.009500	47.500000	100.0000
203	10.209991	0.768994	65.3000
204	5.268191	2.852299	75.0000
205	2.818796	1.061294	90.6000
206	12.500000	123.762360	100.0000
207	0.180000	4.390242	90.0000
208	2.844998	< 0.459463	47.5000
209	0.413500	3.356877	UNKNOWN
210	0.137000	4.892856	79.9000
211	0.679049	1.226365	UNKNOWN
212	1.763000	2.507822	65.0000
213	0.038880	0.447890	45.0000
214	0.0	UNKNOWN	UNKNOWN
215	0.0	UNKNOWN	UNKNOWN
216	16.507477	1.261749	78.0000
218	7.800000	86.666687	100.0000
219	1.939999	< 0.786699	63.0000
220	0.022000	0.956522	100.0000
221	0.0	UNKNOWN	99.5000
222	0.560000	5.820403	100.0000
224	0.0	> 0.0	UNKNOWN
225	1.679999	1.600000	97.9000
226	0.0	0.0	72.8000
227	1.423199	1.167874	80.2000
228	0.764500	6.394736	100.0000
229	0.113500	0.440960	100.0000
230	1.150000	1.769230	88.0000
231	NOT APP.	NOT APP.	0.0
232	0.0	0.0	10.0000

TABLE 6 CONTINUED
COOLING TOWER MAKE-UP FLOW RATES
IN THE PETROLEUM REFINING INDUSTRY

REFINERY NUMBER	MAKE-UP FLOW (MGD)	MAKE-UP FLOW DIVIDED BY TOTAL EFFLUENT FLOW	% MAKE-UP FLOW BY BTU BY COOLING TOWERS
233	2.450000	2.450000	100.0000
234	0.0	UNKNOWN	UNKNOWN
235	2.499999	1.433332	93.0000
236	0.016000	0.164948	UNKNOWN
237	0.016000	0.571428	90.0000
238	1.999999	1.039500	84.5000
239	0.058000	0.329341	47.0000
240	0.180000	0.158311	UNKNOWN
241	0.334000	1.372881	100.0000
242	0.450000	0.702028	95.0000
243	0.524000	4.568438	69.0000
244	0.612000	0.304024	99.0000
245	0.707000	1.001416	99.6000
246	0.182500	0.401099	UNKNOWN
247	0.558800	3.263120	100.0000
248	0.0	UNKNOWN	100.0000
249	0.380000	0.684685	50.0000
250	0.0	UNKNOWN	UNKNOWN
251	NOT APP.	NOT APP.	0.0
252	0.009000	0.089109	90.0000
253	0.0	UNKNOWN	UNKNOWN
254	0.0	0.0	UNKNOWN
255	0.0	0.0	UNKNOWN
256	0.040000	0.100025	100.0000
257	NOT APP.	NOT APP.	0.0
258	0.792000	0.904649	40.0000
259	NOT APP.	NOT APP.	0.0
260	NOT APP.	NOT APP.	0.0
261	0.640000	1.361701	90.0000
264	0.0	0.0	UNKNOWN
265	1.296000	1.219759	UNKNOWN
266	NOT APP.	NOT APP.	0.0
278	0.0	UNKNOWN	UNKNOWN
291	0.506000	3.373335	90.0000
295	0.610600	1.327391	90.0000
298	> 0.0	> 0.0	100.0000
301	0.144000	0.649526	94.5000
302	NOT APP.	NOT APP.	0.0
303	0.0	UNKNOWN	UNKNOWN
305	0.0	0.0	UNKNOWN
307	0.0	UNKNOWN	UNKNOWN
308	> 0.0	UNKNOWN	UNKNOWN
309	0.720000	2.857141	100.0000

> - DUE TO UNKNOWN MAKE-UP FLOWS FOR SOME COOLING TOWERS, THE NUMBER IS GREATER THAN SHOWN
< - DUE TO UNKNOWN EFFLUENT FLOWS, THE NUMBER IS LESS THAN SHOWN
NOT APP. - NOT APPLICABLE BECAUSE OF 0.0 % COOLING BY COOLING TOWERS

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations	Ref. No.	Treatment Operations
001	Corr. Plate Sep. DAF Act. Sludge	015	Chemical Floc. OAF
002	Chemical Floc.	016	None
003	RBC	017	Chemical Floc. Evap. or Perc. Pond
004	None	018	None
006	DAF Aerated Lag.	019	None
007	DAF Aerated Lag.	020	Chemical Floc. DAF Act. Sludge Pol. Pond
008		021	None
009	Aerated Lag. Pol. Pond	022	DAF
010	Stab. Pond	023	Filtration Evap. or Perc. Pond
011		024	DAF Aerated Lag. Other Org. Rem.
012	Pre-Filtration Stab. Pond	025	DAF Other Org. Rem.
013	Chemical Floc. DAF	026	Other Org. Rem.
014		027	

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations	Ref. No.	Treatment Operations
028		041	Corr. Plate Sep. Aerated Lag. Stab. Pond Pol. Pond
029	OAF	042	Chemical Floc. Aerated Lag. Evap. or Perc. Pond
030	Evap. or Perc. Pond	043	DAF Stab. Pond
031	DAF	044	Filtration Evap. or Perc. Pond
032	DAF Aerated Lag. Stab.. Pond	045	Chemical Floc. DAF OAF
033		046	Chemical Floc. DAF
034		047	
035	None	048	Evap. or Perc. Pond
036	Evap. or Perc. Pond	049	Aerated Lag. Pol. Pond
037	DAF Aerated Lag. Pol. Pond	050	DAF Aerated Lag. Stab. Pond Filtration
038	Corr Plate Sep. DAF	051	Chemical Floc. DAF Act. Sludge Pol. Pond
039		052	Stab. Pond Pol. Pond
040	Chemical Floc. DAF Act. Sludge Others Org. Rem.	053	Filtration

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations
054	
055	Corr. Plate Sep. Stab. Pond Pol. Pond Evap. or Perc. Pond
056	DAF Aerated Lag. Pol. Pond Evap. or Perc. Pond
057	Aerated Lag. Pol. Pond
058	DAF
059	DAF Act. Sludge
060	Chemical Floc. DAF Act. Sludge Filtration
061	Chemical Floc. DAF Act. Sludge Pol. Pond
062	Trick. Filter Aerated Lag. Pol. Pond
063	Aerated Lag. Pol. Pond
064	DAF Act. Sludge
065	Act. Sludge Pol. Pond
066	Evap. or Perc. Pond
067	Chemical Floc. DAF Aerated Lag.
068	Act. Sludge
070	None
071	Chemical Floc. DAF Aerated Lag. Pol. Pond
072	Chemical Floc. Aerated Lag. Pol. Pond
073	Chemical Floc. Aerated Lag. Pol. Pond
074	Aerated Lag. Pol. Pond
075	
076	Chemical Floc. Aerated Lag. Pol. Pond
077	Act. Sludge Pol. Pond Evap. or Perc. Pond
078	Chemical Floc.
079	
080	Stab. Pond

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations
081	Aerated Lag. Pol. Pond
082	Evap. or Perc. Pond
083	DAF
084	DAF Act. Sludge Pol. Pond
085	Chemical Floc. OAF Act. Sludge
086	Chemical Floc. DAF
087	Evap. or Perc. Pond
088	Stab. Pond
089	Evap. or Perc. Pond
090	Aerated Lag.
091	None
092	DAF Act. Sludge Aerated Lag. Pol. Pond
093	None
094	Corr. Plate Sep. DAF Act. Sludge Pol. Pond
095	Stab. Pond Pol. Pond
096	Corr Plate Sep. Chemical Floc. DAF Act. Sludge
097	None
098	OAF DAF Aerated Lag. Stab Pond
099	DAF Aerated Lag. Pol. Pond
100	Filtration
101	
102	Aerated Lag.
103	Aerated Lag.
104	Corr. Plate Sep. Aerated Lag. Stab. Pond
105	Chemical Floc. OAF Aerated Lag.
106	Aerated Lag. Pol. Pond

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations
107	Filtration
108	OAF
109	Chemical Floc. DAF Act. Sludge Trick. Filter Pol. Pond
110	
111	Chemical Floc. DAF
112	Aerated Lag.
113	Aerated Lag. Pol. Pond
114	Aerated Lag. Pol. Pond
115	Pre-Filtration Act. Sludge Pol. Pond
116	Stab. Pond
117	OAF Aerated Lag. Pol. Pond
118	Aerated Lag. Filtration
119	Aerated Lag. Filtration
120	Aerated Lag. Filtration
121	Corr. Plate Sep. DAF Aerated Lag. Other Org. Rem Pol. Pond
122	Aerated Lag.
124	Chemical Floc. DAF Stab. Pond
125	Aerated Lag. Other Org. Rem. Pol. Pond
126	Aerated Lag. Pol. Pond
127	Chemical Floc. DAF Aerated Lag. Pol. Pond
128	Evap. or Perc Pond
129	Aerated Lag. Evap. or Perc. Pond Pol. Pond
130	None
131	OAF RBC
132	OAF Activated Sludge
133	DAF Act. Sludge Trick. Filter Filtration
134	Act. Sludge Filtration

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations
135	
136	Corr. Plate Sep.
137	None
138	Evap. or Perc. Pond
139	Evap. or Perc. Pond
140	Evap. or Perc. Pond
141	Evap. or Perc. Pond
142	Chemical Floc. DAF
143	Chemical Floc. DAF
144	Aerated Lag. Pol. Pond
145	None
146	Stab. Pond
147	Chemical Floc. DAF Act. Sludge
148	DAF
149	Corr. Plate Sep. Aerated Lag.
150	Corr. Plate Sep. Act. Sludge
151	Chemical Floc. DAF Aerated Lag. Pol. Pond
152	DAF Act. Sludge
153	Other Organics Rem. Filtration
154	Stab. Pond Pol. Pond
155	Stab. Pond Pol. Pond
156	Chemical Floc. DAF Aerated Lag. Pol. Pond
157	Act. Sludge Aerated Lag. Other Organics Rem.
158	Act. Sludge Pol. Pond
159	Stab. Pond Pol. Pond
160	Checical Floc. OAF Act. Sludge Stab. Pond Pol. Pond Evap. or Perc. Pond

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations	Ref. No.	Treatment Operations
161	Aerated Lag. Other Organics Rem. Pol. Pond	175	Corr. Plate Sep.
162	DAF Act. Sludge	176	Aerated Lag.
163	Aerated Lag. Pol. Pond	177	None
164	Evap. or Perc. Pond	178	
165	Chemical Floc. DAF Stab. Pond Pol. Pond	179	Chemical Floc. Aerated Lag. Stab. Pond Pol. Pond
166	None	180	DAF Act. Sludge
167	Chemical Floc. DAF Act. Sludge	181	Pre-Filtration Act. Sludge Filtration
168	Pre-Filtration Act. Carbon	182	Act. Sludge
169	Act. Sludge Trick. Filter	183	Chemical Floc. DAF Aerated Lag. Pol.Pond
170		184	Chemical Floc. Act. Sludge
172	None	185	Evap. or Perc. Pond
173	None	186	DAF Act. Sludge Stab.. Pond
174	Aerated Lag.	187	Filtration Evap. or Perc. Pond

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations	Ref. No.	Treatment Operations
188	Corr. Plate Sep.	201	Chemical Floc. DAF Act. Sludge Filtration
189	Aerated Lag. Pol. Pond	202	
190	Aerated Lag. Pol. Pond	203	Chemical Floc. DAF
191		204	Chemical Floc. DAF Act. Sludge Pol. Pond
192	Evap. or Perc. Pond	205	DAF Aerated Lag. Pol. Pond
193	None	206	
194	Aerated Lag. Pol. Pond	207	None
195	None	208	Corr. Plate Sep. Act. Sludge Trick. Filter Stab. Pond
196	Corr. Plated Sep. Chemical Floc. DAF Act. Sludge Stab. Pond	209	DAF Stab. Pond Pol. Pond Evap. or Perc. Pond
197	Aerated Lag. Pol. Pond	210	None
198		211	Chemical Floc. DAF Act. Sludge Aerated Lag. Filtration
199	Pre-Filtration Aerated Lag. Filtration	212	DAF Act. Sludge
200	None	213	OAF Aerated Lag. Stab. Pond Pol. Pond

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations
214	Evap. or Perc. Pond
215	Evap. or Perc. Pond
216	Chemical Floc. Act. Sludge Aerated Lag.
218	
219	Aerated Lag. Pol. Pond Filtration
220	
221	Other Organics Rem.
222	Aerated Lag. Pol. Pond
223	None
224	Chemical Floc. DAF
225	DAF Filtration
226	Stab. Pond Pol. Pond
227	OAF Aerated Lag. RBC Pol. Pond Filtration
228	Stab. Pond Pol. Pond
229	Evap. or Perc. Pond
230	Stab. Pond
231	
232	Chemical Floc. Filtration
233	Act. Sludge Trick, Filter Pol. Pond
234	DAF Act. Sludge Trick. Filter Pol. Pond
235	Act. Sludge Trick. Filter Pol. Pond
236	
237	Corr. Plate Sep. OAF Act. Carbon
238	Act. Sludge Trick. Filter Aerated Lag. Stab. Pond Pol. Pond
239	Corr Plate Sep. RBC Pol. Pond

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations
240	
241	Act. Sludge Pol. Pond
242	None
243	Aerated Lag. Pol. Pond
244	Evap. or Perc. Pond
245	Corr. Plate Sep. Aerated Lag. Pol. Pond Evap. or Perc. Pond
246	Aerated Lag. Evap. or Perc. Pond Pol. Pond
247	Evap. or Perc. Pond
248	Evap. or Perc. Pond
249	DAF Evap. or Perc Pond
250	
251	
252	Stab. Pond
253	Evap. or Perc. Pond
254	None
255	Pre-Filtration Aerated Lag. Pol. Pond
256	Corr. Plate Sep. Stab. Pond
257	Stab. Pond
258	DAF Act. Sludge Pol. Pond
259	OAF Act. Sludge
260	Aerated Lag.
261	DAF Trick. Filter RBC Evap. or Perc. Pond
264	
265	Corr. Plate Sep. DAF Act. Sludge Stab. Pond Pol. Pond
266	None

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations	Ref. No.	Treatment Operations
275		295	
278	None	296	
282		297	
283		298	
284		299	
287		300	
288		301	
289		302	Evap. or Perc. Pond
290		303	
291		304	
292		305	
293		306	
294		307	

TABLE 7

Wastewater Treatment Operations

Ref. No.	Treatment Operations
308	Evap. or Perc. Pond
309	Chemical Floc. Act. Sludge Aerated Lag.
310	Evap. or Perc. Pond

TABLE 8

Refineries that Utilize, or Plan to Utilize Filtration Systems

Presently Installed	
12	134
23	153
44	168
50	181
53	187
60	199
92	201
100	211
107	219
115	225
118	227
119	232
120	255
133	

Future Installations	
11	105
32	122
42	132
44	152
57	168
67	204
70	212
102	232

TABLE 9

REFINERIES THAT UTILIZE, OR PLAN TO UTILIZE EQUALIZATION SYSTEMS*

PRESENTLY INSTALLED

009	102	187
020	105	188
024	106	190
038	110	196
040	113	197
041	114	200
043	115	204
044	126	208
051	130	210
060	131	211
062	147	212
063	153	216
064	156	219
065	160	227
072	161	230
074	162	232
081	175	243
085	180	256
088	181	258
094	182	301
096	183	
099	184	

FUTURE INSTALLATIONS

76	163	221
77	168	222
83	172	242
104	173	
132	174	

*Note - Minimum Detention 3.0 hours

TABLE 10

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
3	Steam stripper to be added
10	DAF unit to be installed
11	Sour waters to be stripped; Separator effluent to equalization, pH adjustment, flocculation, DAF, bio-reactors, clarification and filtering
15	API effluent to CPI and then to detention pond
16	DAF unit to be installed
25	API sludge handling system to be installed
32	Replace stabilization with bio-disc, and effluent to pass through clarifier carbon and filtration
37	DAF sludge thickener to be installed
38	Chemical floculation and DAF unit to be added
39	Final effluent to be used as boiler feed water
40	DAF effluent to equalization, activated sludge, and clarification
42	Detention pond effluent to oxidation pond, then percolation ponds; Clarifier effluent to filter before recycle to cooling tower
44	Desalter effluent to separate separators; Two CPI and sand filter at deep well; two stage sour water stripper; Warm lime treatment for boiler and cooling water; Equipment for SS removal or wet scrubbers blowdown
46	Segregated streams to trickling filter where effluent to combine with DAF effluent to activated sludge and clarifier
50	Separate stabilization pond for sludge recirculation
51	Additional foul water stripping; IAF for ballast water
57	Activated sludge unit with pre-and post-filtration to be added along with surge pond
62	DAF units being added

TABLE 10 Cont'd.

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
67	Activated sludge plant to be added
70	Segregate process and non-process wastewater and add oil to skimmer and filter
71	Segregate storm water; New API units and equalization pond; Increase lagoon aeration
72	Total renovation of barometric recycle water system
74	Possible addition of pH adjustment, chemical flocculation, and DAF
76	Equalization after API; Two new DAF units; Activated sludge unit; Final clarifier
77	Adding DAF, equalization, pH adjustment, activated sludge unit, and clarification
78	Add sour water stripper effluent and coker effluent to desalter
83	New equalization, bio-discs, and clarifiers after DAF, and sludge to be treated and digested
86	Storm water surge basin
87	All sour water to be evaporated
88	Adding two additional oil separators, and by-passing off-property water
90	Segregation of storm sewers and boiler blowdowns, and installation of bio-discs
92	Aerated lagoons to be converted to activated sludge; Biological treatment of storm runoff and ballast water; Cooling towers will be replaced by once-thru cooling water
95	Adding API separator
97	Adding activated sludge plant
98	Storm water segregation and overall plant modifications
102	New activated sludge plant including pH adjustment, chemical flocculation and settling, DAF unit, two parallel sludge reactor tanks and clarifiers, and final dual media filters; Also partial effluent recycle

TABLE 10 Cont'd.

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
104	New impounding basin before aerated lagoon
105	Areated lagoon to be converted to activated sludge basins and to be followed by sand filters
106	Storm water segregation
107	Tie in to POTW
110	Boiler blowdown, sour water, desalter condensate, water treatment system blowdown, and spent caustic to be routed to new separator and into POTW
114	Tie in to POTW
115	Storm water segregation; Separator effluent to pH adjustment, equalization, chemical floculation, DAF unit, activated sludge and clarification
120	Additional API separators and enlargement of aeration ponds; Activated carbon to be added if necessary
121	Plant source control programs
122	Stormwater segregation; Extra aerators to aeration basins; Mixed media filter for final effluent; Some recycle of final effluent to cooling water
124	Storm water retention pond
125	DAF unit to be installed
127	Baffles added to final polishing pond
132	Water treatment systems blowdown to clarifier; Segregate once-thru cooling water and un-contaminated runoff; Additional sour water stripper to allow reuse of stripped sour water; Effluent from separator, stripper, and clarifier to go to equalization, activated sludge, and filtration
142	Tie in to POTW
143	Tie in to POTW
150	Bio-discs to be added
151	Additional ammonia removal facilities; Bio-discs studies on aerated lagoon effluent

TABLE 10 Cont'd.

FUTURE WASTEWATER TREATMENT MODIFICATIONS

Refinery No.	Modifications
152	Downflow sand filter to be added prior to final discharge
154	API separator to be added with new holding pond
163	API effluent to equalization pond with skimmer, four stage bio-disc unit, two parallel clarifiers, and final ponding with skimmers
165	Storm water runoff retention basin
168	Oily process wastewater, stripped sour water, and contaminated runoff to receive pH adjustment, oil water separation, sand filtration , equalization, nutrient addition, bio-disc treatment, and final clarification; ballast water to be held, fed to an IAF unit, passed through cooling water guard basin and discharged
172	Adding IAF, equalization, bio-discs, and clarification
173	API effluent to equalization, chemical addition, DAF, activated sludge, and clarification
175	To join regional POTW
177	Installation of bio-discs and clarifiers
181	API effluent to primary clarifiers before equalization
182	Expanded reuse of stripped sour water; Increased rainfall collection and retention facilities
184	Addition of chemical flocculation, DAF units, and cooling towers, and modification of aeration basin and clarifier
185	Add secondary treatment, effluent reuse, and, in 1981, solar evaporation
187	Larger API separator
190	Increase lagoon size
194	Improve API and polishing pond
199	Additional API separator
204	Modify DAF for recycle pressurization; Aerators in equalization pond; Dual media filters for bio-treator effluent; Improve chlorination; Better storm water segregation

TABLE 10 Cont'd.

FUTURE WASTEWATER TREATMENT MODIFICATION

Refinery No.	Modifications
205	Sour water stripping systems; Larger API separator; Ponding or biological systems
208	Existing two parallel plate interceptors and three API separators to be replaced by five CPI units
212	Sand filtration for plant effluent
216	Aerated lagoon to be converted to activated sludge; New contaminated runoff impoundment facilities; Sour water oxidizer to be replaced by single stage stripper
219	Storm sewer effluent treatment to be improved; New CPI and equalization basin to be installed; Filter backwash to be dewatered in settling ponds and supernatant sent back to treatment plant intake
221	Equalization before aeration, and storm water segregation
222	Increase surge pond size; Chemical Floculation and clarification to be added; Effluent recycle facilities installed
230	IAF provided for API separator and equalization basin enlarged for grit removal
231	Tie in to POTW
232	Storm water retention, activated sludge, and filtration under construction
236	New system to include API separator, holding tank, CPI, aerated equalization basin, four stage bio-disc unit, and final clarifier
240	New oil-water separator and existing pond to be subdivided into primary settling, aeration, and final settling
241	New parallel separator to combine with old separator and go to two parallel DAF units, activated sludge pond, clarifier, and final chlorination
242	Adding equalization basin after API separators, then chemical floculation, DAF, activated sludge, and final clarification
246	Total impoundment for all but once-thru cooling water
225	New API separator, additional treatment pond, DAF, new aeration basin, and phenolic treatment

TABLE 10 Cont'd.

FUTURE WASTEWATER TREATMENT MODIFICATION

Refinery No.	Modification
256	Additional CPI to operate in parallel with existing one; Continuous solids removal to be added prior to API separator; Equalization basin capacity to be increased
257	Additional API separator, air flotation unit, and aerated lagoon
298	New system including primary separator, DAF, and secondary separator

TABLE 11

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
3	-	1978	Upgrade piping and installing air coolers.
7	0.115	1977	Stripping steam to crude unit.
9	0.023	-	In plant modifications.
11	0.72	1977	Better cooling tower controls and wastewater supervision.
12	0.0014	1977	Recycle.
13	-	-	Cascading of sour water.
18	0.0462	1977	Sour water stripper effluent to desalter and cooling towers.
22	0.021	1978	Recycle.
31	-	-	Wastewater to cooling tower.
35	0.00189	1977	Replace once-thru condensers with recycled water.
39	-	-	Reuse; final effluent to be used for boiler feedwater.
40	1.2	1978	Discontinue selected quench streams.
42	0.005	-	Recycle treated effluent to cooling tower.
44	0.230	1979	Recycle cooling tower water and boiler blowdown.
45	0.13	1977	Stripped sour water to desalter.
46	0.450	1977	Stripped sour water to cooling towers and recycle cooling water and desalter water.
50	0.052	1977	Sour water used for desalting.
53	0.100	1978	Reuse and increase cooling water cycles

TABLE 11 (continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
57	4.3	1977	Recycle cooling water and control blowdowns.
59	0.11	1980	Water management within refinery.
63	0.125	1977	Reroute cooling tower blowdown out of end-of-pipe treatment system.
64	2.37	1983	Closed system for pump cooling; once-thru cooling eliminated; cooling cycles increased via acid injection.
67	-	-	Recycle and make-up for firewater.
72	0.020	1977	Larger cooling capacity for lower blowdown rates; total rennovation of barometric recycle water systems.
74	-	1977	Improved condensate recovery.
76	0.5	1978	Fin fan air condensing.
77	-	1977	Stripped sour water used as desalter make-up.
78	0.063	-	Treated sour water to desalter.
82	-	1982	Switch to fin fan cooling.
87	-	1977	Reuse of wastewater in gas handling system; all sour water to be evaporated.
90	0.002	1978	Closed cooling system and some recycle.
92	0.270	1978	Cooling towers replacing once-thru cooling.
96	2.1	1977	Treated wastewater for firewater system.
102	0.417	-	Recycle treated wastewater.
113	0.072	1977	Reduce once-thru cooling and tower blowdown.

TABLE 11 (continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
115	0.08	1978	Recycle process wastewater to coker cooling.
117	0.200	1977	Pump gland cooling to cooling towers.
122	0.700	1977	Coker recycle water system; some recycle of final effluent to cooling system.
132	0.7	1978	Process wastewater reductions to end-of-pipe treatment; reuse of stripper sour water.
138	0.538	-	Recycle to cooling towers.
144	0.08	1977	Two series desalter.
150	0.072	1978	Segregated once-thru pump gland cooling and plant wastewater conservation program.
152	0.4	1978	Firewater use reduction and mechanical pump seal replacement.
153	1.0	1977	Recycle treated wastewater to cooling towers.
156	0.216	1977	Increase cooling tower cycle, decreasing blowdown.
162	1.0	1977	Recycle wastewater to process units.
169	1.55	1977	Reuse of process water
172	0.156	1977	Replace barometric condenser with surface condensers and recycle treated sour water to desalter.
173	0.180	1977	Replace barometric condenser with non-contact condensing system.

TABLE 11 (continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
181	3.0	1978	Reduce boiler blowdown via better control; increase cooling tower cycles; cascade boiler blowdown from high pressure boilers to low pressure boilers; use boiler blowdown as desalter water; use clarifier overflow and regeneration water from condensate polisher as cooling tower make-up; recycle filter backwash to clarifier; reuse coke cutting water and coke drum cool-water in delayed coking units; reuse treated wastewater in firewater system.
182	0.94	1977	Treated wastewater used as utility water and greater reuse of stripper bottoms.
183	0.080	1977	Recycle desalter effluent.
184	0.144	1978	Steam condensate collection and reuse.
185	0.837	1981	Effluent reuse and evaporation.
187	0.72	1977	Recycle effluent to cooling towers.
191	0.140	1979	Sour water stripper.
194	3.0	1977	Replace barometric condenser; use recycled fire water in wet gas scrubbers on cat cracker; automate cooling tower blowdown.
196	4.	1983	Recycle treated effluent to cooling tower.
200	0.022	1977	Stripped sour water to desalter.
202	0.0001	1977	Total recycle.
207	0.0005	1977	Increase heat recovery at reformer to reduce cooling requirements.

TABLE 11 (continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
208	-	1980	Increase cooling tower cycles; reuse boiler blowdown; recover condensate; recycle demineralizing regenerants to fire system; reuse appropriate water for cooling.
210	0.003	-	Boiler blowdown and stripped sour water to be used in desalter.
216	4.56	1977	Reuse treated effluent and sludge blowdown decant as intake water sources.
220	0.001	1977	Condensate from tower overheads to desalter feed.
222	-	-	Recycle some treated effluent.
227	0.0432	1978	Sour water treatment to reduce volume requiring stripping.
229	0.0125	1978	Strip ammonia from cat cracking condensate to release water for desalter.
236	0.026	1977	Contact cooling to non-contact cooling.
240	0.37	1977	Contact cooling to non-contact cooling.
242	0.36	1977	Non-contact cooling water segregation.
247	0.000652	-	Find market for spent phenolic caustic.
249	0.0144	1977	Reroute cooling tower blowdown to spray pond.
252	0.016	1977	Additional wastewater evaporation.
259	0.072	1977	Recycle boiler blowdown.
265	0.537	-	Desalter water and zealite regeneration brine to disposal well.

TABLE 11 (continued)

PLANNED WASTEWATER FLOW REDUCTIONS

Refinery No.	Expected Flow Reduction (MGD)	Effective Date	Reduction Technique
298	-	-	Install water softeners to reduce cooling tower blowdown.
309	0.15	1978	Replace two vacuum jet ejecters on solfolane unit with vacuum pump.

TABLE 12

REFINERIES WITH FLOW REDUCTION COSTS

30	105	173
40	112	174
51	117	177
56	122	180
57	126	183
64	129	194
65	132	196
67	133	199
68	134	204
70	146	205
76	149	221
81	151	222
87	152	238
92	167	261
94	169	266
102	172	309

TABLE 13

PLANTS MEETING BOD AND TSS LIMITATIONS

PLANTS MEETING BOTH BOD AND TSS FOR LEVEL 1

REFINERY NO.	
1	119
2	120
37	121
49	125
50	126
53	127
54	147
59	167
63	179
72	211
80	213
90	227
99	233
107	235
108	239
113	243

Total: 32

PLANTS MEETING BOTH BOD AND TSS FOR LEVELS 1 AND 2

REFINERY NO.	
1	120
2	121
50	125
53	126
54	147
59	179
72	211
80	213
90	235
99	239
119	243

Total: 22

TABLE 14

WASTEWATER FLOW RATE

TO

END-OF-PIPE TREATMENT

REFINERY NO.	FLOW RATE (MGD)	REFINERY NO.	FLOW RATE (MGD)
1	0.19	49	0.132
2	0.054	50	0.768
3	0.014	51	9.9
6	0.075	52	0.3
7	0.05	53	0.15
9	0.013	54	0.017
10	0.05	56	1.306
11	0.779	57	6.0
12	0.59	59	0.99
13	*	60	1.944
19	INSIGNIFICANT	61	2.64
20	1.91	62	4.80
24	0.30	63	2.605
30	0.237	64	2.43
32	5.9	65	3.60
37	2.36	67	21.0
38	*	68	4.86
40	6.6	70	0.150
41	9.38	71	0.240
43	2.869	72	0.132
46	0.86	73	*

TABLE 14 (continued)

REFINERY NO.	FLOW RATE (MGD)	REFINERY NO.	FLOW RATE (MGD)
74	0.19975	106	1.583
76	1.78	107	**
77	0.276	108	0.044
80	0.08	109	0.24
81	1.21	110	**
83	2.44	112	0.203
84	1.69	113	0.428
85	3.29	114	**
87	0.09	115	2.72
88	0.212	116	1.2
89	0.0576	117	0.81
90	0.03	118	0.026
91	0.012	119	0.125
92	10.42	120	0.100
93	0.024	121	4.5
94	1.836	122	6.4
96	11.82	124	0.475
97	0.0712	125	0.444
98	2.34	126	6.48
99	0.07	127	0.173
100	0.0518	129	0.10
102	1.584	131	2.88
103	0.063	132	10.13
104	6.01	133	7.93
105	2.381	134	4.15

TABLE 14 (continued)

REFINERY NO.	FLOW RATE (MGD)	REFINERY NO.	FLOW RATE (MGD)
142	**	173	0.472
143	**	174	0.576
144	0.119	175	**
146	0.093	176	0.3684
147	0.576	177	0.765
149	1.179	179	0.282
150	0.968	180	2.764
151	3.974	181	12.57
152	7.98	183	0.559
153	3.89	184	1.216
154	1.0	186	1.815
155	0.0936	189	0.015
156	0.634	190	0.0332
157	2.01	194	13.76
158	0.548	196	18.5
159	0.277	197	0.008
160	0.175	199	0.0492
161	0.35	201	0.95
162	2.45	204	3.366
163	1.037	205	2.424
165	0.29	208	4.98
167	5.1	210	0.016
168	2.88	211	0.8135
169	8.67	212	0.703
172	0.764	213	0.051

TABLE 14 (continued)

REFINERY NO.	FLOW RATE (MGD)	REFINERY NO.	FLOW RATE (MGD)
216	20.5	259	2.127
219	1.2	260	0.025
221	3.312	261	0.43
222	0.35	265	0.571
226	0.036	266	0.067
227	1.2268	292	INSIGNIFICANT
230	0.7	295	0.2376
231	**	309	0.432
232	1.09		
233	1.00		
234	1.0		
235	1.499		
236	0.094		
237	0.028		
238	1.914		
239	0.126		
240	0.23		
241	0.432		
242	0.28		
243	0.168		
252	0.123		
255	0.125		
256	0.365		
257	2.03		
258	1.0		

* Consider present indirect discharge only.

** Will be discharging to POTW in future.

TABLE 15

CAPITAL AND OPERATING COSTS BY REFINERY NUMBER
ECONOMIC COSTS, DOLLARS

REFINERY NUMBER	OPTION 2 LEVEL 1		OPTION 2 LEVEL 2	
	CAPITAL COSTS	ANNUAL OPERATING COSTS	CAPITAL COSTS	ANNUAL OPERATING COSTS
1	131,000	8,600	181,000	30,100
2	76,000	5,900	126,000	14,900
3	50,000	4,700	85,000	9,700
6	86,000	6,700	171,000	14,700
7	70,000	5,600	140,000	12,600
9	15,000	3,200	67,000	9,400
10	70,000	5,600	140,000	12,600
11	178,000	6,500	238,000	73,500
12	145,000	5,200	586,000	32,200
13	No cost - considered presently indirect discharger only.			
19	No cost - insignificant flow.			
20	200,000	15,000	275,000	165,000
24	73,000	6,900	313,000	22,900
30	325,000	19,800	375,000	43,800
32	750,000	29,300	4,750,000	122,000
37	610,000	32,300	2,210,000	117,000
38	No cost - considered presently indirect discharger only			
40	935,000	47,300	1,060,000	558,000
41	550,000	37,500	6,950,000	328,000
43	300,000	17,500	2,400,000	120,000
46	338,000	17,500	398,000	90,500
49	110,000	7,800	230,000	17,800
50	180,000	6,600	745,000	40,600
51	1,420,000	606,000	3,690,000	942,000
52	166,000	10,100	406,000	26,100
53	65,000	2,200	100,000	20,200
54	53,000	4,000	88,000	15,000
56	645,000	35,800	1,550,000	83,800
57	1,280,000	121,000	1,380,000	683,000
59	385,000	19,100	460,000	104,000
60	0	0	75,000	145,000
61	650,000	33,800	730,000	238,000
62	400,000	24,500	500,000	397,000
63	250,000	18,000	2,150,000	108,000
64	485,000	32,500	560,000	225,000
65	720,000	47,600	820,000	330,000
67	4,510,000	360,000	7,760,000	720,000
68	1,385,000	88,000	1,490,000	464,000
70	190,000	10,700	225,000	28,700

TABLE 15 (continued)

CAPITAL AND OPERATING COSTS BY REFINERY NUMBER
ECONOMIC COSTS, DOLLARS

REFINERY NUMBER	OPTION 2 LEVEL 1		OPTION 2 LEVEL 2	
	CAPITAL COSTS	ANNUAL OPERATING COSTS	CAPITAL COSTS	ANNUAL OPERATING COSTS
71	145,000	9,300	345,000	24,300
72	50,000	5,700	85,000	22,700
73	No cost - considered presently indirect discharger only.			
74	72,000	2,500	242,000	15,500
76	380,000	26,400	1,630,000	92,400
77	70,000	6,700	110,000	34,700
80	91,000	6,800	181,000	15,800
81	270,000	21,100	1,150,000	69,100
83	210,000	17,000	295,000	209,000
84	520,000	25,400	595,000	164,000
85	300,000	22,000	395,000	286,000
87	220,000	15,400	315,000	24,400
88	60,000	6,200	235,000	19,200
89	79,000	6,100	156,000	15,100
90	58,000	4,700	118,000	11,700
91	45,000	3,400	80,000	7,400
92	1,680,000	78,100	4,010,000	415,000
93	51,000	4,000	86,000	10,000
94	428,000	27,400	503,000	172,000
96	600,000	44,300	3,080,000	387,000
97	85,000	6,500	120,000	17,500
98	650,000	30,800	2,250,000	111,000
99	45,000	5,000	128,000	13,000
100	30,000	1,100	65,000	10,600
102	230,000	13,600	305,000	32,600
103	48,000	6,100	157,000	14,100
104	500,000	28,000	4,600,000	208,000
105	305,000	22,200	380,000	203,000
106	200,000	13,000	1,300,000	73,000
107	No cost - will discharge to POTW in future.			
108	70,000	5,400	105,000	13,400
109	145,000	9,300	185,000	118,000
110	No cost - will discharge to POTW in future.			
112	295,000	184,000	465,000	31,400
113	90,000	7,800	420,000	28,800
114	No cost - will discharge to POTW in future.			
115	0	0	90,000	216,000
116	400,000	21,000	1,300,000	69,000
117	677,000	25,300	1,270,000	59,300

TABLE 15 (continued)

CAPITAL AND OPERATING COSTS BY REFINERY NUMBER
ECONOMIC COSTS, DOLLARS

REFINERY NUMBER	OPTION 2 LEVEL 1		OPTION 2 LEVEL 2	
	CAPITAL COSTS	ANNUAL OPERATING COSTS	CAPITAL COSTS	ANNUAL OPERATING COSTS
118	20,000	900	75,000	7,400
119	60,000	2,000	175,000	12,000
120	55,000	1,800	155,000	10,800
121	1,000,000	47,500	4,100,000	197,500
122	1,320,000	115,000	5,720,000	319,000
124	220,000	12,400	585,000	35,400
125	210,000	12,000	550,000	33,500
126	760,000	54,500	5,160,000	265,000
127	126,000	8,400	276,000	20,400
129	221,000	15,600	521,000	24,600
131	300,000	17,500	390,000	254,000
132	740,000	108,000	3,070,000	454,000
133	1,560,000	172,000	1,690,000	772,000
134	940,000	56,500	1,040,000	381,000
142	No cost - will discharge to POTW in future.			
143	No cost - will discharge to POTW in future.			
144	110,000	7,700	223,000	17,700
146	220,000	15,300	315,000	24,300
147	109,000	8,700	149,000	59,700
149	570,000	31,700	1,370,000	73,700
150	372,000	18,900	424,000	99,900
151	1,230,000	62,000	3,930,000	94,000
152	1,530,000	155,000	1,650,000	67,000
153	0	0	100,000	00,000
154	310,000	19,400	1,010,000	59,400
155	95,000	7,000	190,000	16,000
156	115,000	9,000	590,000	37,500
157	580,000	28,500	655,000	189,000
158	243,000	13,400	283,000	62,400
159	158,000	10,200	383,000	25,700
160	56,000	6,500	91,000	27,000
161	80,000	7,200	355,000	25,200
162	220,000	17,000	295,000	215,000
163	165,000	11,400	865,000	53,400
165	162,000	10,000	396,000	26,000
167	1,680,000	111,000	1,780,000	507,000
168	0	0	80,000	228,000
169	2,220,000	172,000	2,340,000	840,000
172	320,000	24,000	370,000	89,000
173	255,000	17,700	295,000	60,700

TABLE 15 (continued)

CAPITAL AND OPERATING COSTS BY REFINERY NUMBER
ECONOMIC COSTS, DOLLARS

REFINERY NUMBER	OPTION 2 LEVEL 1		OPTION 2 LEVEL 2	
	CAPITAL COSTS	ANNUAL OPERATING COSTS	CAPITAL COSTS	ANNUAL OPERATING COSTS
174	244,000	16,900	674,000	42,900
175	No cost - will discharge to POTW in future.			
176	185,000	11,000	470,000	30,000
177	485,000	28,500	535,000	93,500
179	158,000	9,800	383,000	25,600
180	565,000	46,100	640,000	263,000
181	980,000	106,000	3,540,000	448,000
183	106,000	8,500	526,000	33,400
184	150,000	12,000	225,000	112,000
186	580,000	26,500	655,000	171,500
189	50,000	3,700	103,000	9,900
190	38,000	3,800	60,000	6,400
194	2,870,000	154,000	12,200,000	650,000
196	2,230,000	255,000	5,330,000	611,000
197	35,000	3,000	85,000	9,000
199	155,000	9,500	227,000	16,500
201	209,000	7,700	269,000	87,700
204	268,000	18,700	358,000	283,000
205	890,000	48,400	2,590,000	133,000
208	420,000	25,000	520,000	415,000
210	35,000	3,200	70,000	8,200
211	0	0	60,000	69,000
212	0	0	50,000	61,000
213	71,000	5,700	144,000	12,700
216	1,000,000	66,800	4,250,000	424,000
219	0	0	850,000	48,000
221	600,000	423,000	690,000	301,000
222	235,000	17,000	510,000	35,000
226	63,000	5,000	128,000	12,000
227	0	0	60,000	96,000
230	125,000	9,400	645,000	40,400
231	No cost - will discharge to POTW in future.			
232	0	0	60,000	90,000
233	385,000	19,400	445,000	103,400
234	385,000	19,400	445,000	103,400
235	400,000	24,000	475,000	144,000
236	100,000	7,100	135,000	20,100
237	55,000	4,500	90,000	10,500
238	793,000	45,100	868,000	196,000

TABLE 15 (continued)

CAPITAL AND OPERATING COSTS BY REFINERY NUMBER
ECONOMIC COSTS, DOLLARS

REFINERY NUMBER	OPTION 2 LEVEL 1		OPTION 2 LEVEL 2	
	CAPITAL COSTS	ANNUAL OPERATING COSTS	CAPITAL COSTS	ANNUAL OPERATING COSTS
239	110,000	7,700	145,000	24,200
240	145,000	9,100	185,000	33,600
241	205,000	11,800	250,000	51,800
242	70,000	6,700	110,000	34,700
243	55,000	6,000	200,000	17,500
252	110,000	7,700	225,000	17,700
255	60,000	2,000	175,000	12,000
256	80,000	7,300	365,000	26,300
257	590,000	29,000	990,000	101,000
258	165,000	11,400	225,000	95,400
259	590,000	29,300	665,000	198,000
260	58,000	4,400	116,000	10,700
261	385,000	22,100	433,000	261,000
265	248,000	13,700	296,000	64,700
266	410,000	23,200	470,000	81,200
292	No cost - insignificant flow.			
295	315,000	20,100	355,000	45,100
309	425,000	59,100	470,000	99,100

TABLE 16

RAW WASTEWATER EQUALIZATION SYSTEMS
CAPITAL AND OPERATING COSTS

Description	380 M^3/day (0.1×10^6 gal/day)	3800 M^3/day (1.0×10^6 gal/day)	19,000 M^3/day (5×10^6 gal/day)	38,000 M^3/day (10×10^6 gal/day)	76,000 M^3/day (20×10^6 gal/day)
Capital Cost, Dollars					
Detention tank, 12 hours detention, steel shell on concrete pad	$ 30,000	$ 116,000	$ 346,000	$ 595,000	$1,020,000
Pumps, and associated controls, installed	8,000	30,000	87,000	149,000	255,000
Subtotal	$ 38,000	$ 146,000	$ 433,000	$ 744,000	$1,275,000
Piping, installed (15%)	5,700	22,000	65,000	117,000	192,000
Total Installed Cost	$ 43,700	$ 168,000	$ 498,000	$ 861,000	$1,467,000
Engineering	6,650	26,000	75,000	129,500	221,500
Contingency	6,650	26,000	75,000	129,500	221,500
Total Capital Cost	$ 57,000	$ 220,000	$ 648,000	$1,120,000	$1,910,000
Land Requirements, Ft^2	585	5,780	28,200	57,600	113,000
Annual Operating Costs, Dollars					
Pumping	$ 140	$ 1,400	$ 7,000	$ 14,000	$ 28,000
Maintenance (3% of Capital Cost)	1,700	6,600	19,500	33,600	57,300
Total Annual Cost	$ 1,840	$ 8,000	$ 26,500	$ 47,600	$ 85,300

Note: The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE 17

ROTATING BIOLOGICAL CONTACTORS (RBC's)
AS ROUGHING SYSTEMS
EQUIPMENT COST BASIS
AND ENERGY REQUIREMENTS

Description	Equipment Size				
	380 M^3/day (0.1×10^6 gal/day	3800 M^3/day (1.0×10^6 gal/day	19,000 M^3/day (5×10^6 gal/day	38,000 M^3/day (10×10^6 gal/day	76,000 M^3/day (20×10^6 gal/day
Design Percent Removal of BOD	50	50	50	50	50
Number of Units	1	6	24	48	96
Shaft Lengths, each	15	20	25	25	25
Total Square Feet of Surface Area	75,000	630,000	3,200,000	6,400,000	12,800,000
	Annual Operating and Energy Requirements				
Manpower Requirements, hours	500	750	1,000	1,500	2,000
Power Requirements, kwh/year	33,000	294,000	1,180,000	2,360,000	4,720,000

TABLE 18

ROTATING BIOLOGICAL CONTACTORS (RBC's)
AS ROUGHING FILTERS
CAPITAL AND OPERATING COSTS

Description	380 M^3/day (0.1×10^6 gal/day	3800 M^3/day (1.0×10^6 gal/day	19,000 M^3/day (5×10^6 gal/day	38,000 M^3/day (10×10^6 gal/day	76,000 M^3/day (20×10^6 gal/day
	Capital Cost, Dollars				
RBC Units, Steel Shell, Fiberglass Cover	$ 46,000	$340,000	$1,590,000	$3,170,000	$6,340,000
Piping	5,000	35,000	160,000	317,000	634,000
Total Equipment Cost	51,000	375,000	1,750,000	3,487,000	6,974,000
Installation (50%)	25,500	187,500	875,000	1,744,000	3,487,000
Total Constructed Cost	76,500	562,500	2,625,000	5,231,000	10,461,000
Engineering	11,750	84,750	397,500	784,500	1,569,500
Contingency	11,750	84,750	397,500	784,500	1,569,500
Total Capital Cost	$100,000	$732,000	$3,420,000	$6,800,000	$13,600,000
Land Required, Ft^2	420	2,800	13,500	27,000	54,000
	Annual Operating Costs*				
Power	$ 1,500	$ 12,000	$ 48,000	$ 95,000	$ 190,000
Labor	5,000	7,500	10,000	15,000	20,000
Maintenance (3% of Total Capital Cost)	3,000	22,000	103,000	204,000	408,000
Total Annual Cost	$ 9,500	$ 41,500	$ 161,000	$ 314,000	$ 798,000

Note: The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE 19

POWDERED ACTIVATED CARBON
EQUIPMENT COST BASIS
AND ENERGY REQUIREMENTS
INCLUDING COSTS FOR SLUDGE DISPOSAL
80 mg/l DOSAGE RATE

Description	Equipment Size				
	380 M^3/day (0.1×10^6 gal/day	3800 M^3/day (1.0×10^6 gal/day	19,000 M^3/day (5×10^6 gal/day	38,000 M^3/day (10×10^6 gal/day	76,000 M^3/day (20×10^6 gal/day
Powdered Carbon Feed Tanks (2 each) Capacity, gallons (Based on feed concentration of one pound carbon/gallon water)	700	7,000	35,000	70,000	140,000
Feed Rate pounds/day	67	670	3,350	6,700	13,400
Sludge handling and/or regeneration system, lbs/day dry solids	290	2,900	14,600	29,000	58,000
	Annual Operating and Energy Requirements				
Carbon make-up lbs/day	67	670	3,350	2,000	4,000
Furnace power requirements					
Fuel, BTU/hr	N.A.	N.A.	N.A.	2,500,000	4,500,000
Connected hp	N.A.	N.A.	N.A.	100	140
Manpower requirement, hours	400	540	940	10,000	10,700

TABLE 20

POWDERED ACTIVATED CARBON
CAPITAL COSTS
INCLUDING COSTS FOR SLUDGE DISPOSAL

Description	Capital Costs, Dollars				
	380 M^3/day (0.1×10^6 gal/day	3800 M^3/day (1.0×10^6 gal/day	19,000 M^3/day (5×10^6 gal/day	38,000 M^3/day (10×10^6 gal/day	76,000 M^3/day (20×10^6 gal/day
Powdered Carbon Feed System	$10,000	$30,000	$45,000	$60,000	$100,000
Solids Dewatering System	---	---	---	397,000	585,000
Regenerated Carbon Acid Wash System	---	---	---	40,000	60,000
Subtotal	10,000	30,000	45,000	497,000	745,000
Piping (10%)	1,000	3,000	4,500	49,700	74,500
Total Equipment Cost	11,000	33,000	49,500	546,700	819,500
Installation (50%)	6,000	16,500	24,800	273,400	410,000
Total Constructed Cost	17,000	49,500	74,300	820,100	1,229,500
Engineering	9,000	7,750	11,350	119,950	185,250
Contingency	9,000	7,750	11,350	119,950	185,250
Subtotal	35,000	65,000	97,000	1,060,000	1,600,000
Activated Carbon Regeneration System (installed)	---	---	---	900,000	1,200,000
Contingency (For utility hook-up etc.)	---	---	---	190,000	250,000
Engineering for Carbon Regeneration System	---	---	---	150,000	200,000
Total Capital Cost	$35,000	$65,000	$97,000	$2,300,000	$3,250,000
Land Requirements, $Ft.^2$	100	200	900	3,000	4,500

TABLE 21

POWDERED ACTIVATED CARBON
ANNUAL OPERATING COSTS
INCLUDING CREDIT FOR SLUDGE DISPOSAL
80 mg/l DOSAGE RATE

Description	Annual Cost, Dollars				
	380 M^3/day (0.1×10^6 gal/day	3800 M^3/day (1.0×10^6 gal/day	19,000 M^3/day (5×10^6 gal/day	38,000 M^3/day (10×10^6 gal/day	76,000 M^3/day (20×10^6 gal/day
Carbon Make-Up	$7,400	$74,000	$370,000	$220,000	$440,000
Furnace Power	---	---	---	76,000	132,000
Miscellaneous Power Requirements	1,000	2,000	5,000	8,000	15,000
Labor ($10/manhour)	4,000	5,400	9,400	100,000	108,000
Sludge Disposal Credit	---	---	---	(-)400,000	(-)800,000
Maintenance	1,000	2,000	3,000	332,000	461,600
Total Annual Cost	$13,400	$ 83,400	$387,000	$336,000	$ 356,000

Note:
The depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE 22

TERTIARY FILTRATION
EQUIPMENT COST BASIS AND ENERGY REQUIREMENTS

Description	Equipment Cost Basis				
	380 M^3/ day	3800 M^3/day	19,000 M^3/day	38,000 M^3/day	76,000 M^3/day
	(0.1 X 10^6gal/day)	(1 X 10^6gal/day)	(5 X 10^6gal/day)	(10 X 10^6gal/day	(20 X 10^6gal/day)
Filter Description (all units are automatic and air scoured)	2 units 5' diam.,steel	2 units 11' diam.,steel	1 unit, 4-35'square cells, concrete	1 unit,4-47'square cells, concrete	2 units, 47' square cells, concrete
Bed depth, ft.	4	4	4	4	4
Operation type	Gravity	Gravity	Gravity	Gravity	Gravity
Media type	Dual media	Dual media	Dual media	Dual media	Dual media
	Annual Operating and Energy Requirements				
Pumping, KWH/year	3,440	34,400	172,000	344,000	688,000
Labor, Manhours/year	400	500	600	700	800

TABLE 23

TERTIARY FILTRATION
CAPITAL AND OPERATING COSTS

Description	380 M^3/day (0.1×10^6 gal/day	3800 M^3/day (1.0×10^6 gal/day	19,000 M^3/day (5×10^6 gal/day	38,000 M^3/day (10×10^6 gal/day	76,000 M^3/day (20×10^6 gal/day
	Capital Cost, Dollars				
Filtration Units Installed	$ 25,000	$100,000	$250,000	$350,000	$600,000
Interconnecting Piping, Installed	3,000	10,000	25,000	35,000	60,000
Pumps, Installed	5,000	15,000	42,000	60,000	100,000
Total Installed Cost	33,000	125,000	317,000	451,000	770,000
Engineering	6,000	20,000	49,000	69,500	115,000
Contingency	6,000	20,000	49,000	69,500	115,000
Total Capital Cost	$ 48,000	$165,000	$415,000	$590,000	$1,000,000
Land Requirement, Ft^2	200	700	5,000	9,000	18,000
	Annual Operating Cost, Dollars				
Pumping	$ 140	$ 1,400	$ 7,000	$ 14,000	$ 28,000
Labor	4,000	5,000	6,000	7,000	8,000
Maintenance (3% of Capital Cost)	1,400	5,000	12,500	18,000	30,000
Total Annual Cost	$ 5,540	$ 11,400	$ 25,500	$ 39,000	$ 66,000

Note: The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Impact Analysis Supplement.

TABLE 24

SUPPLEMENTAL ECONOMIC COST INFORMATION
CAPITAL AND OPERATING COSTS
FOR 10,000 GALLON PER DAY TREATMENT SYSTEMS

Treatment System	Capital Cost, Dollars	Annual Operating Cost Dollars*
Equalization	$ 12,000	$ 400
Rotating Biological Contactors	50,000	6,100
Filtration	35,000	3,000
Powdered Activated Carbon	35,000	4,300
Granular Carbon	60,000	10,000

TABLE 25

Wastewater Recycle - Capital and Operating Costs

Description	2.3 m^3/hr (10 gpm)	16 m^3/hr (70 gpm)	80 m^3/hr (350 gpm)	160 m^3/hr (700 gpm)	320 m^3/hr (1400 gpm)	800 m^3/hr (3500 gpm)
	Capital Costs, Dollars - Per Mile					
Piping:						
Piping, installed, per mile	$32,000	$53,000	$100,000	$135,000	$175,000	$243,000
Misc. Costs (15%)	5,000	8,000	15,000	20,000	26,000	36,000
Total Constructed cost, per mile	37,000	61,000	115,000	155,000	201,000	279,000
Engineering (15%)	6,000	9,000	18,000	23,000	30,000	42,000
Contingency	7,000	10,000	17,000	22,000	29,000	42,000
Piping-total capital costs per mile	$50,000	$80,000	$150,000	$200,000	$260,000	$363,000
Pumps:						
Pumps and associated equipment installed (10% of piping cost)	5,000	8,000	15,000	20,000	26,000	37,000
Total capital costs per mile	$55,000	$88,000	$165,000	$220,000	$286,000	$400,000
(Minimum pumping costs regardless of distance)	5,000	6,000	12,000	18,000	24,000	40,000
	Annual Operating Costs, Dollars - Per Mile					
Pumping costs per mile, per year	$100	$ 700	$2600	$4500	$ 9200	$24,300
Maintenance (1.5% of capital costs) per mile, per year	800	1300	2500	3300	4300	6,000
Total Annual operating cost	$900	$2000	$5100	$7800	$13,500	$30,300

Note: The Depreciation factor has been omitted from this analysis due to the fact that it will be included separately in the Economic Input Analysis Supplement.

TABLE 26

Water Softening of Recycled Wastewater

Capital Costs

Description	2.3 m^3/hr (10 gpm)	16 m^3/hr (70 gpm)	80 m^3/hr (350 gpm)	160 m^3/hr (700 gpm)	320 m^3/hr (1400 gpm)	800 m^3/hr (3500 gpm)
	Capital Costs, Dollars					
Solids Contact Clarifier (Diameter, ft)	$ 25,000 (8)	$ 30,000 (11)	$ 45,000 (23)	$ 65,000 (32)	$ 80,000 (45)	$125,000 (72)
Chemical Feed System(s)	5,000	7,000	10,000	15,000	25,000	50,000
Filter Unit (Diameter, ft)	15,000 (3)	25,000 (8)	30,000 (11)	40,000 (15)	80,000 (two-15' units)	150,000 (three-20' units)
Subtotal	45,000	62,000	85,000	120,000	185,000	325,000
Auxiliary Equipment	5,000	8,000	10,000	15,000	20,000	35,000
Total Capital Cost	50,000	70,000	95,000	135,000	205,000	360,000
Installation(50%)	25,000	35,000	50,000	70,000	100,000	180,000
Total Constructed Cost	75,000	105,000	145,000	205,000	305,000	540,000
Engineering	15,000	20,000	25,000	30,000	45,000	80,000
Contingency	15,000	20,000	25,000	30,000	45,000	80,000
Total Capital Costs	$105,000	$145,000	$195,000	$265,000	$395,000	$700,000

TABLE 27

WATER SOFTENING OF RECYCLED WASTEWATER

ANNUAL OPERATING COSTS, DOLLARS

Description	2.3 m^3/hr (10 gpm)	16 m^3/hr (70 gpm)	80 m^3/hr (350 gpm)	160 m^3/hr (700 gpm)	320 m^3/hr (1400 gpm)	800 m^3/hr (3500 gpm)
Lime and Caustic Feed (Based on 500 mg/l Hardness)	$1,000	$ 7,000	$35,000	$70,000	$140,000	$350,000
Misc. Power	100	700	3,500	7,000	14,000	35,000
Labor ($10/Manhour)	4,000	5,000	6,000	7,000	8,000	9,000
Maintenance (3% of Total Capital Cost)	3,200	4,400	5,900	8,000	12,000	21,000
TOTAL ANNUAL COST	$8,300	$17,100	$50,400	$92,000	$174,000	$415,000

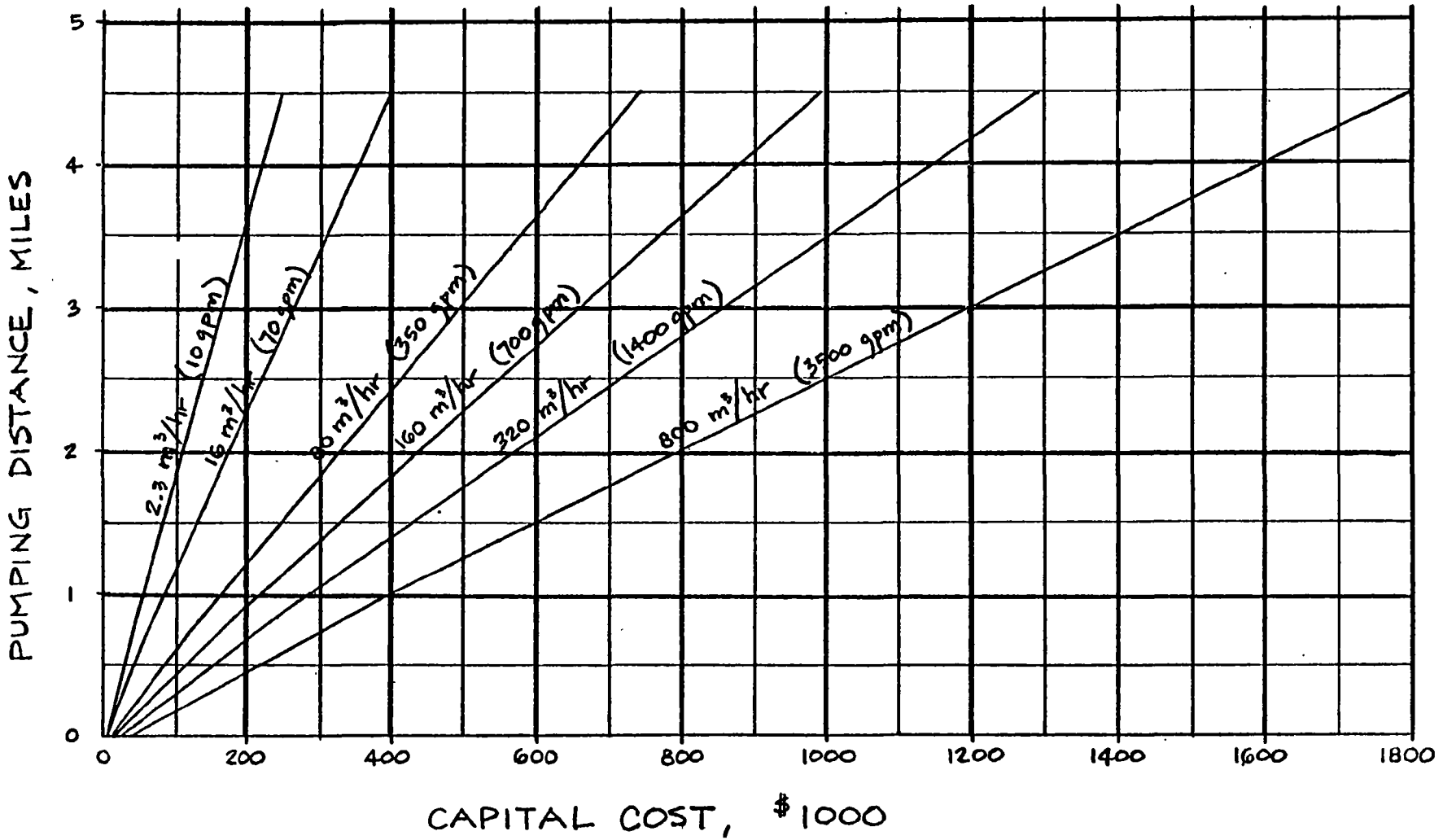

FIGURE 1

Pumping Capital Cost vs. Pumping Distance

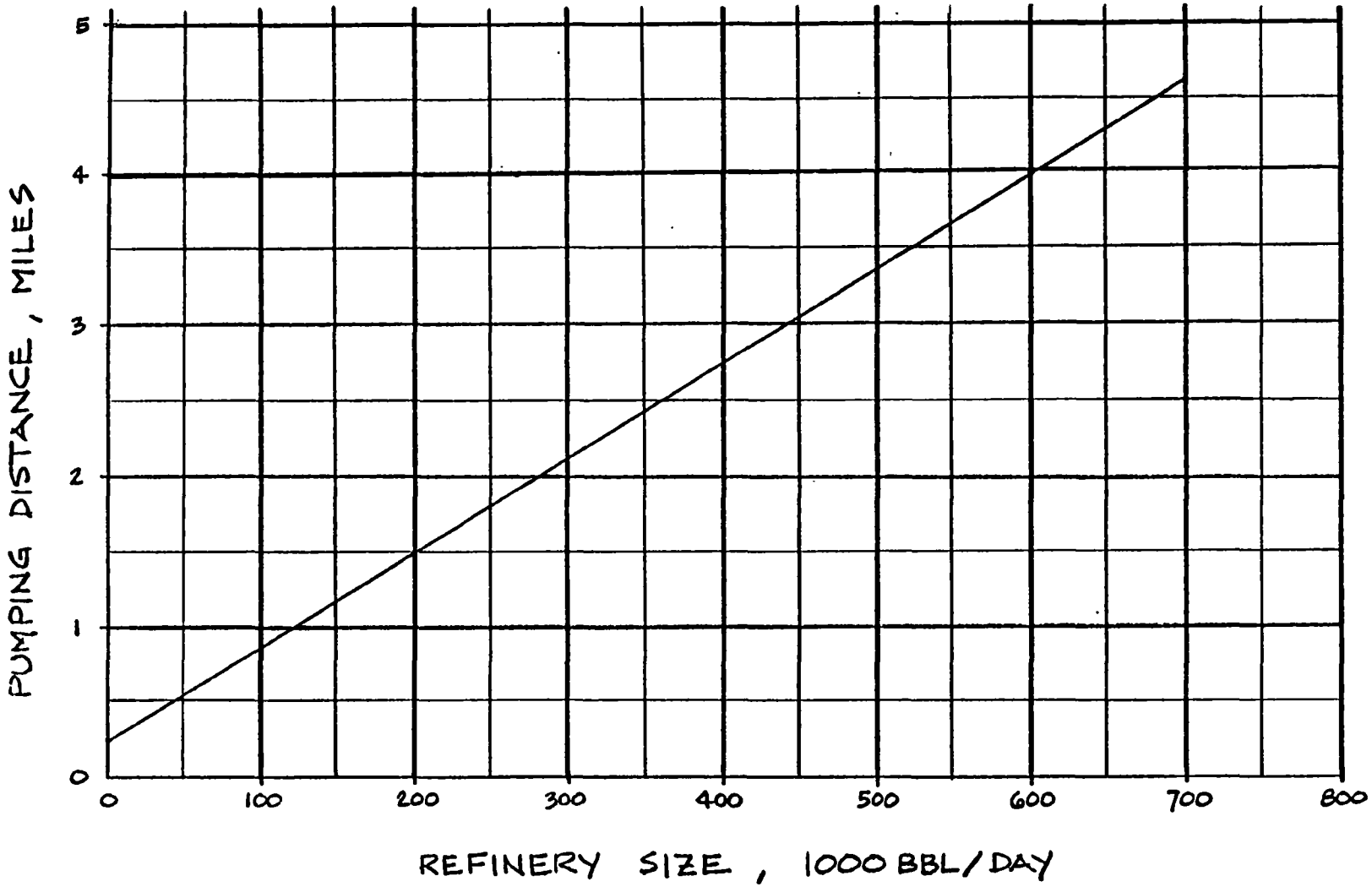

FIGURE 2

Refinery Size vs. Pumping Distance

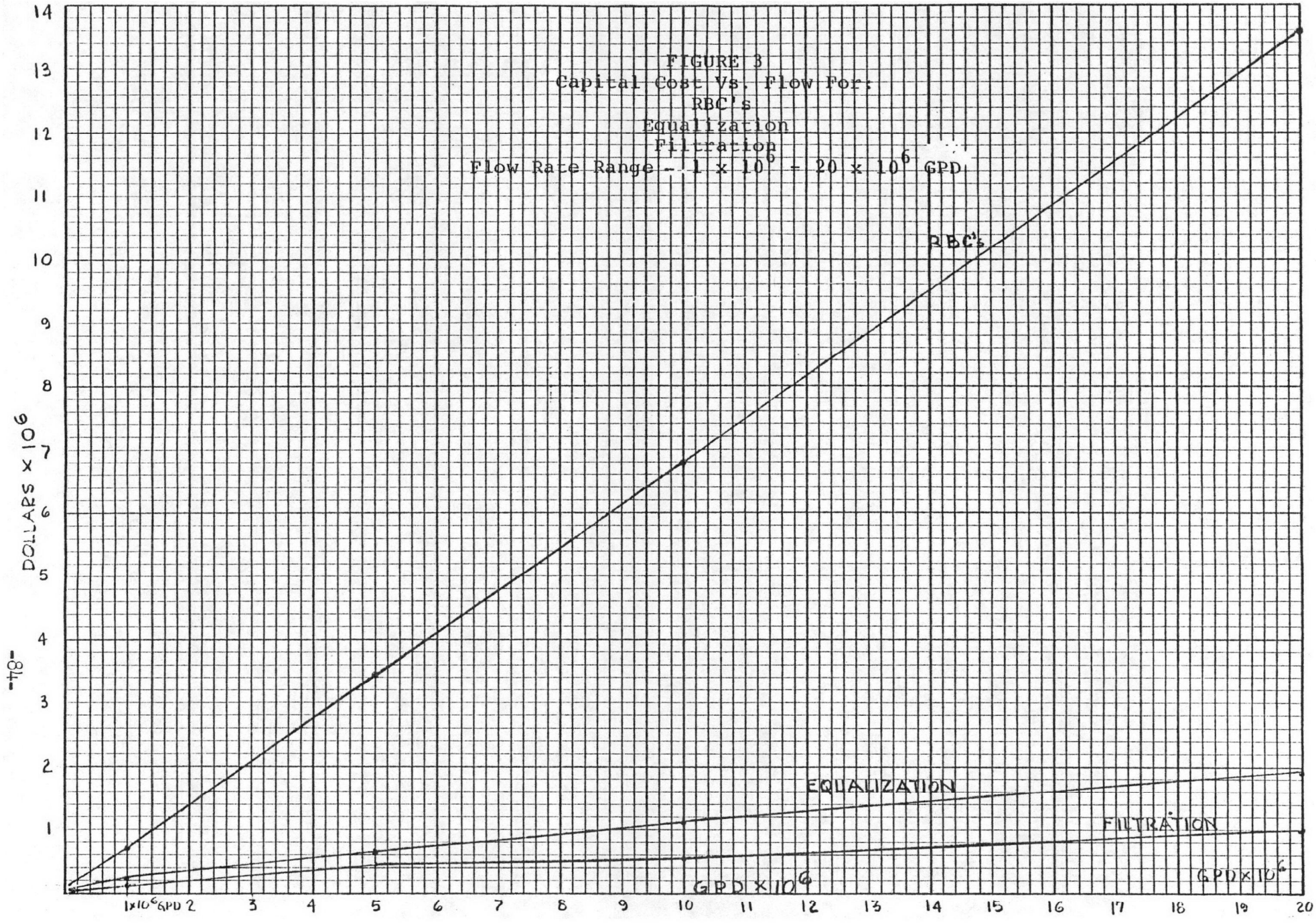
FIGURE 3
Capital Cost Vs. Flow For:
RBC's
Equalization
Filtration
Flow Rate Range - 1 x 10^6 - 20 x 10^6 GPD
RBC's
EQUALIZATION
FILTRATION
DOLLARS x 10^6
GPD x 10^6
1x10^6 GPD
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1
2
3
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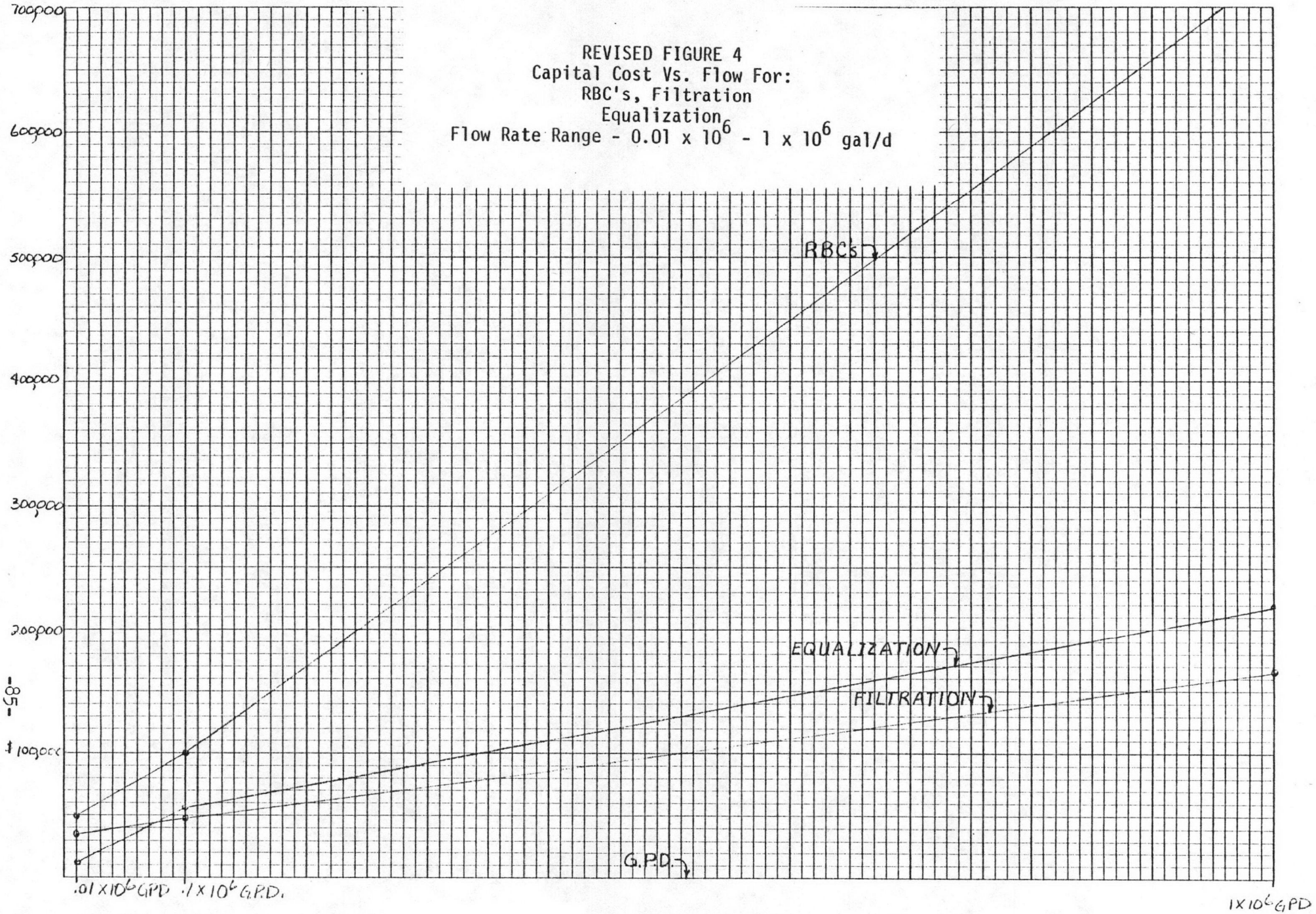
11
12
13
14


REVISED FIGURE 4
Capital Cost Vs. Flow For:
RBC's, Filtration
Equalization
Flow Rate Range - 0.01 x 10^6 - 1 x 10^6 gal/d
700,000
600,000
500,000
400,000
300,000
200,000
100,000
RBCs
EQUALIZATION
FILTRATION
G.P.D.
.01 x 10^6 GPD
.1 x 10^6 G.P.D.
1 x 10^6 GPD

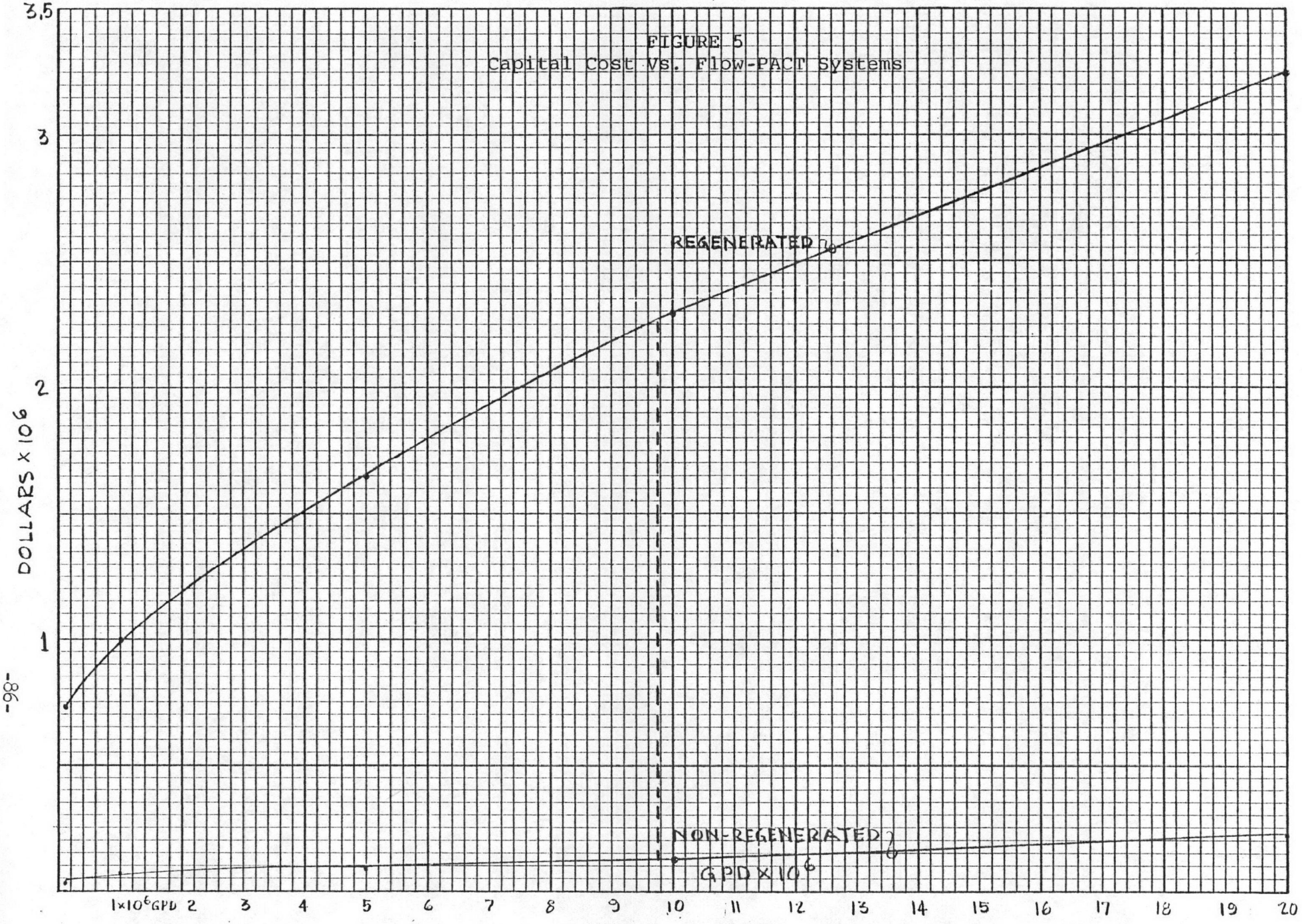


FIGURE 5
Capital Cost Vs. Flow-PACT Systems
3.5
3
2
1
DOLLARS X 10 6
REGENERATED
NON-REGENERATED
GPD X 10 6
1x10 6 GPD
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

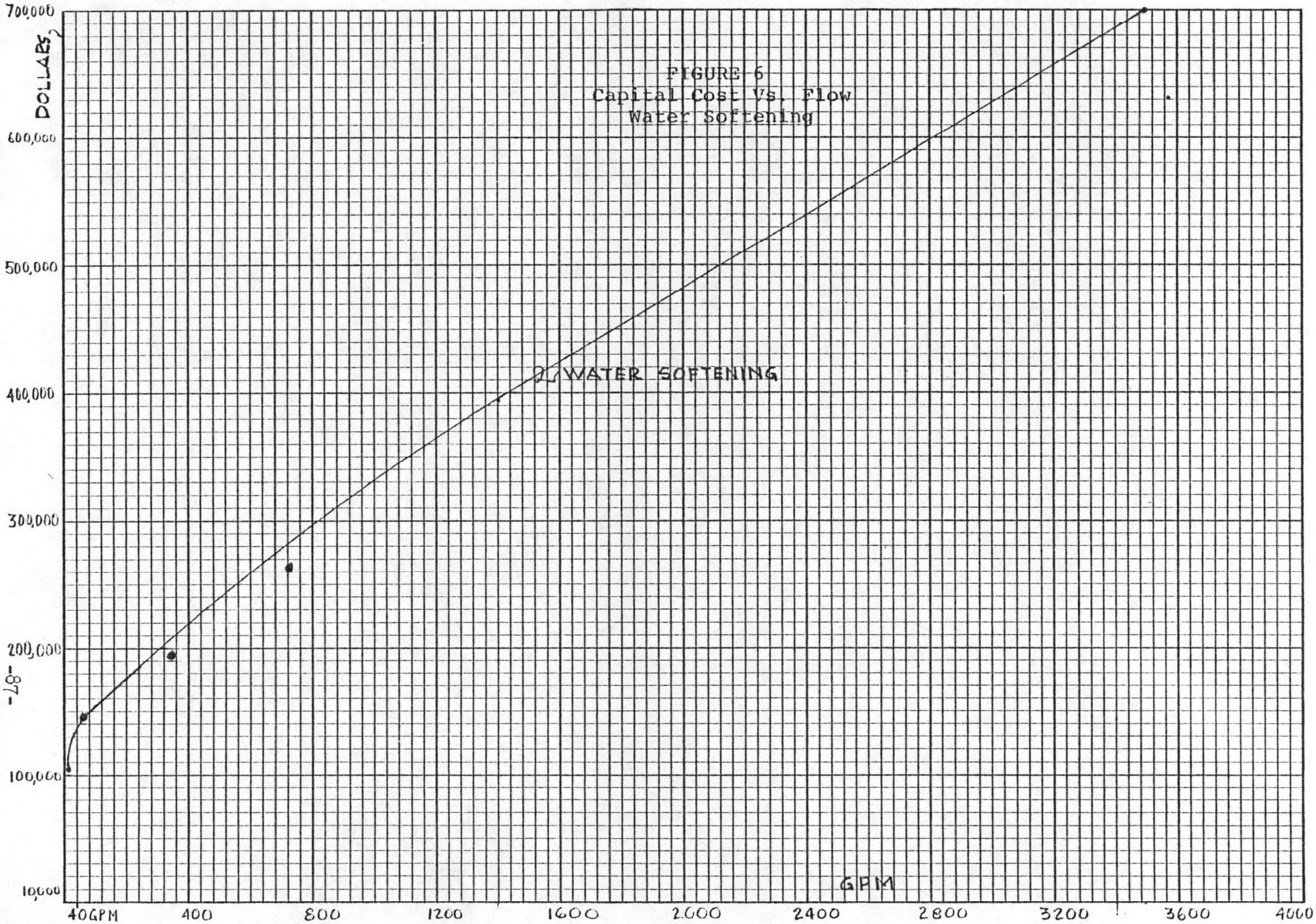


FIGURE-6
Capital Cost Vs. Flow
Water Softening
DOLLARS
700,000
600,000
500,000
400,000
300,000
200,000
100,000
10,000
J/WATER SOFTENING
GPM
40GPM
400
800
1200
1600
2000
2400
2800
3200
3600
4000

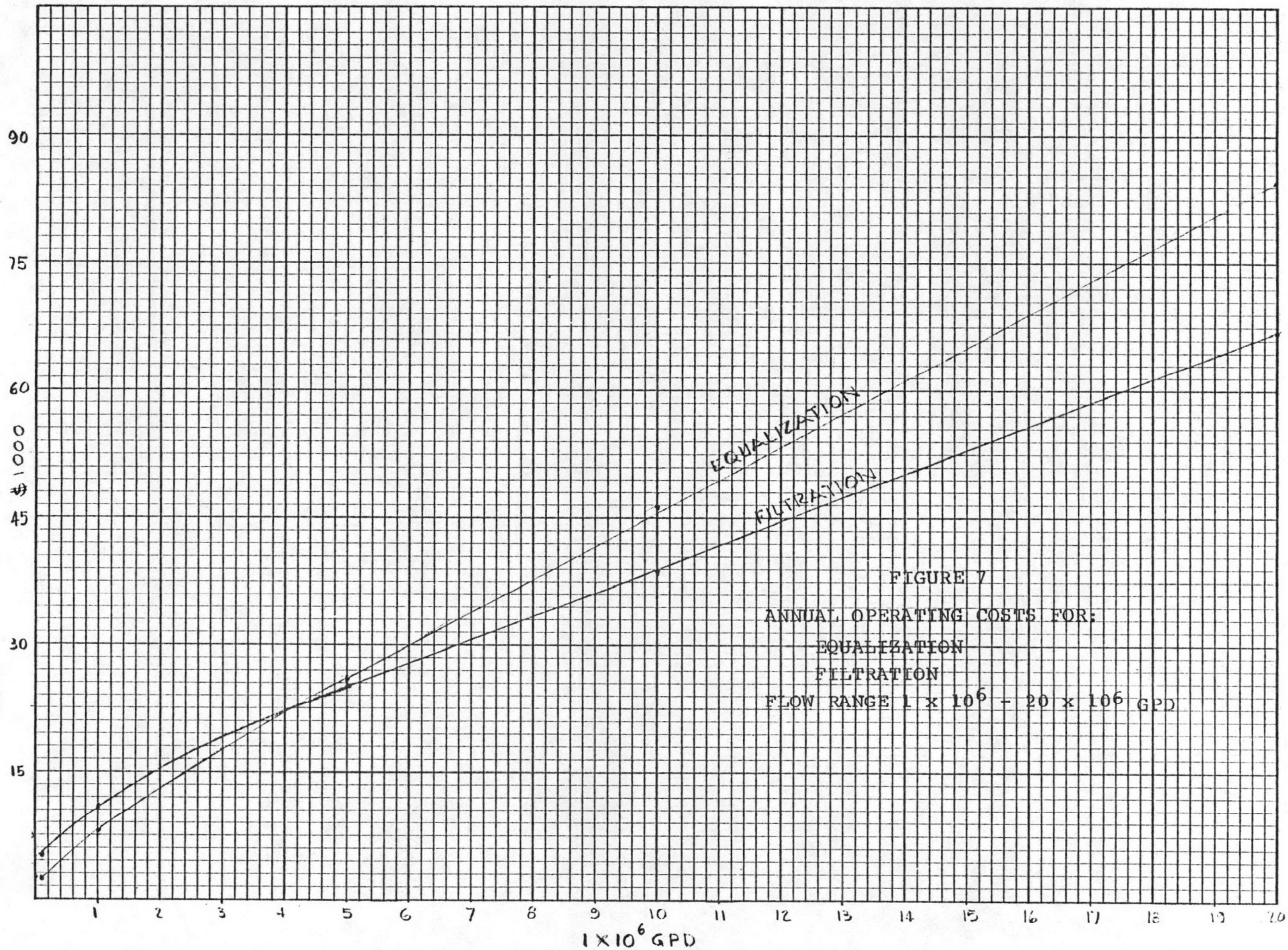


FIGURE 7

ANNUAL OPERATING COSTS FOR:

EQUALIZATION

FILTRATION

FLOW RANGE 1 x 10^6 - 20 x 10^6 GPD

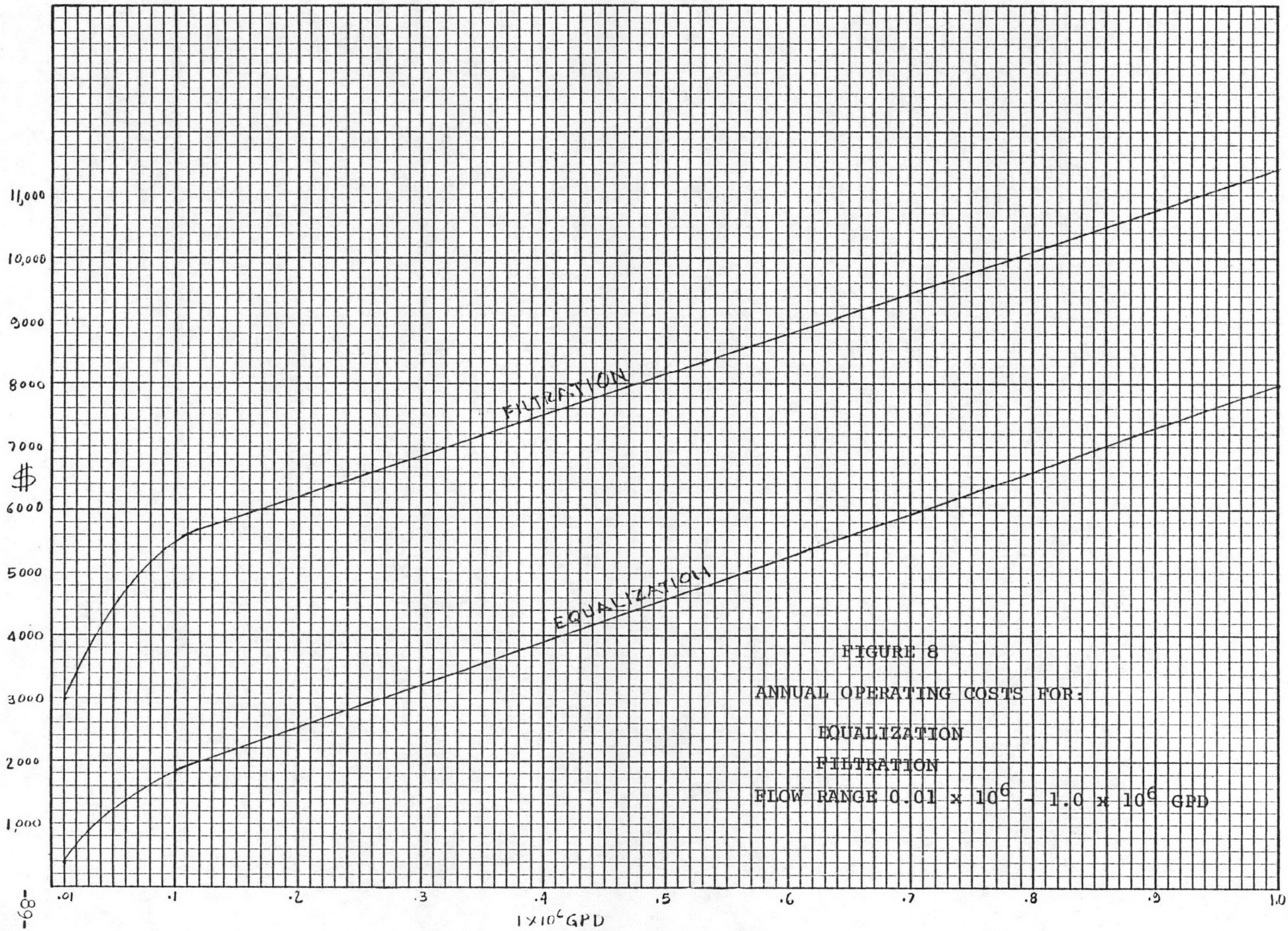


FIGURE 8

ANNUAL OPERATING COSTS FOR:

EQUALIZATION

FILTRATION

FLOW RANGE 0.01×10^6 - 1.0×10^6 GPD

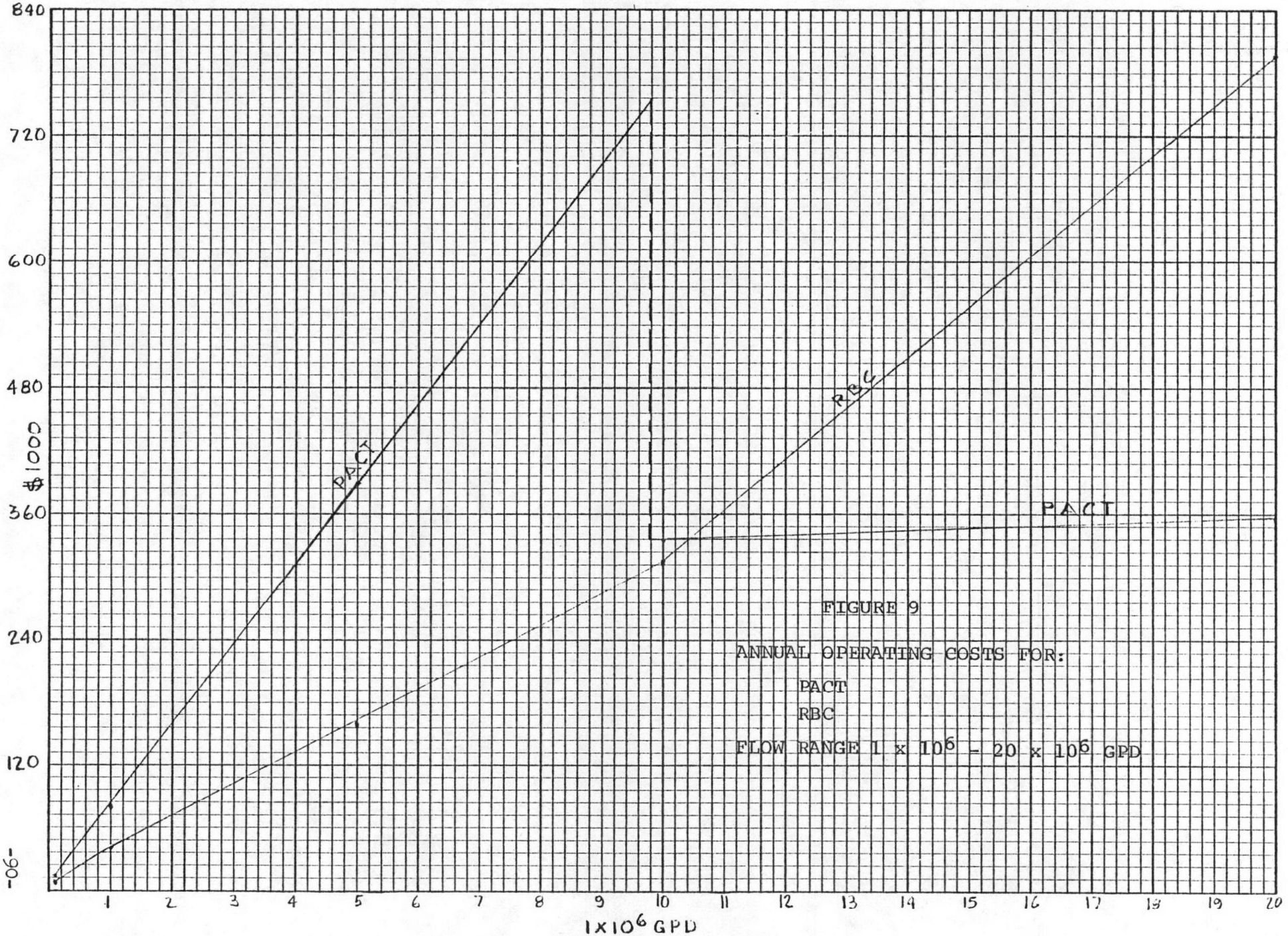


FIGURE 9

ANNUAL OPERATING COSTS FOR:

PACT

RBC

FLOW RANGE 1 x 10^6 - 20 x 10^6 GPD

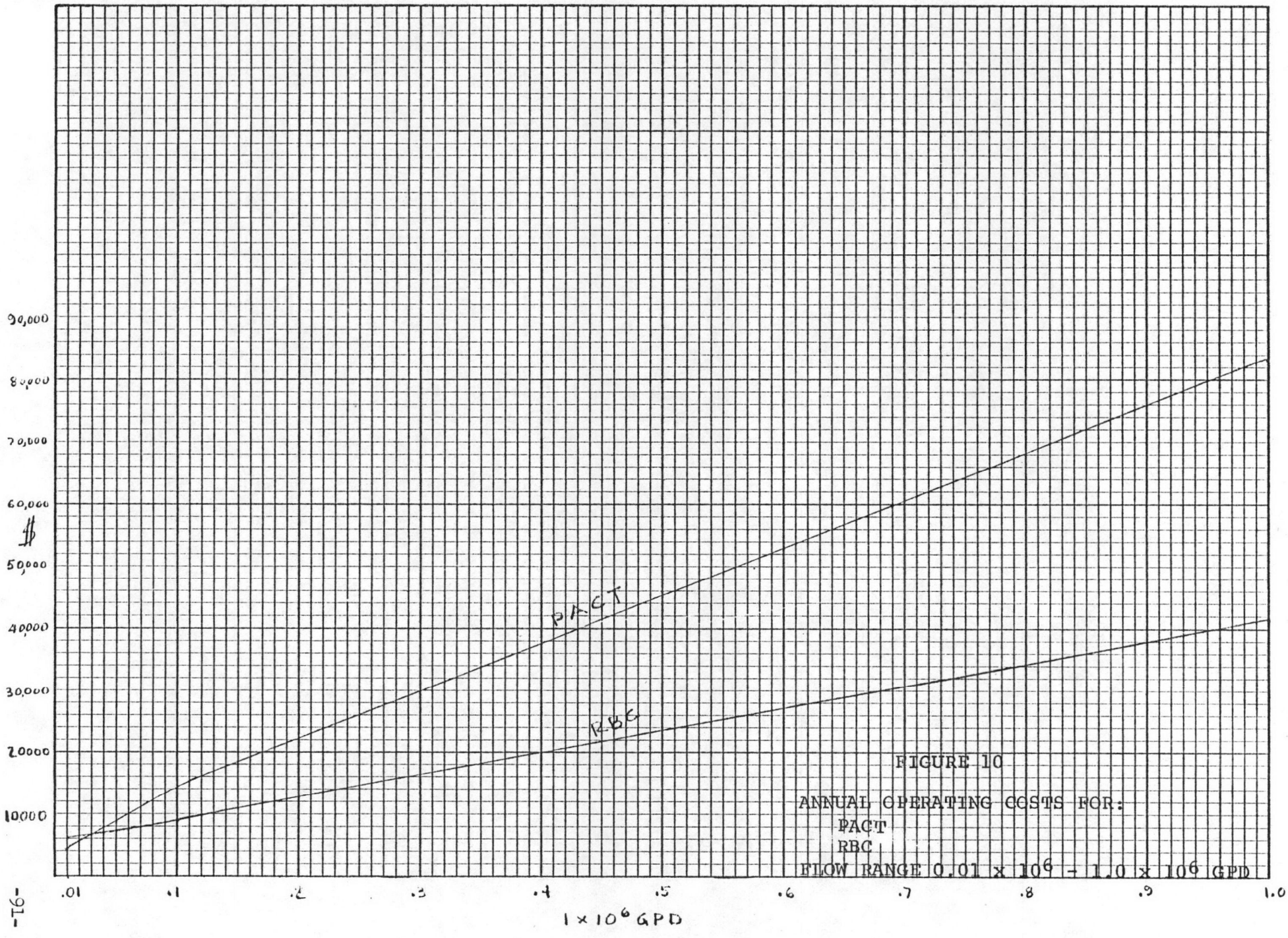


FIGURE 10

ANNUAL OPERATING COSTS FOR:
PACT
RBC
FLOW RANGE 0.01 x 10^6 - 1.0 x 10^6 GPD

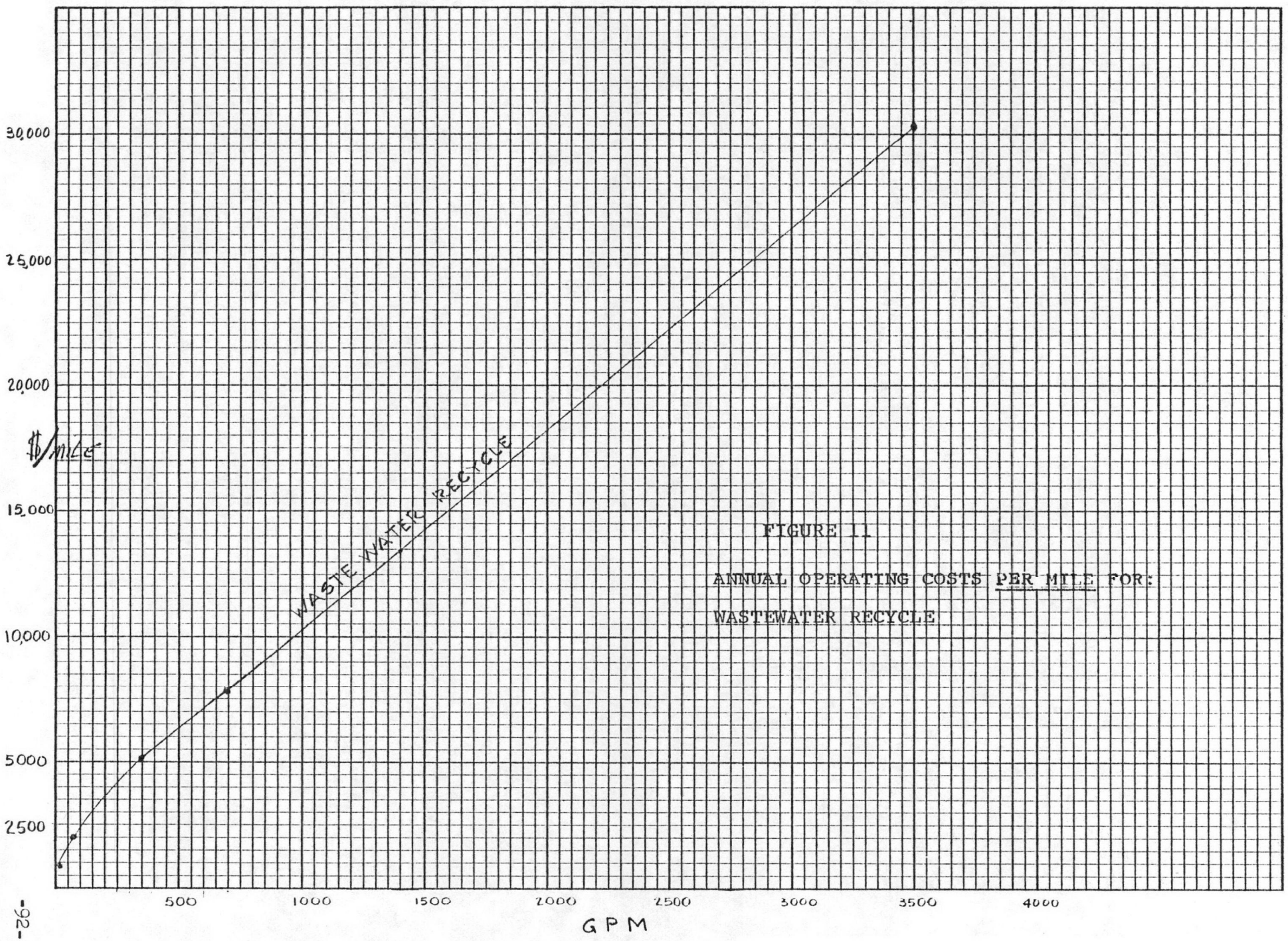


FIGURE 11

ANNUAL OPERATING COSTS PER MILE FOR:

WASTEWATER RECYCLE

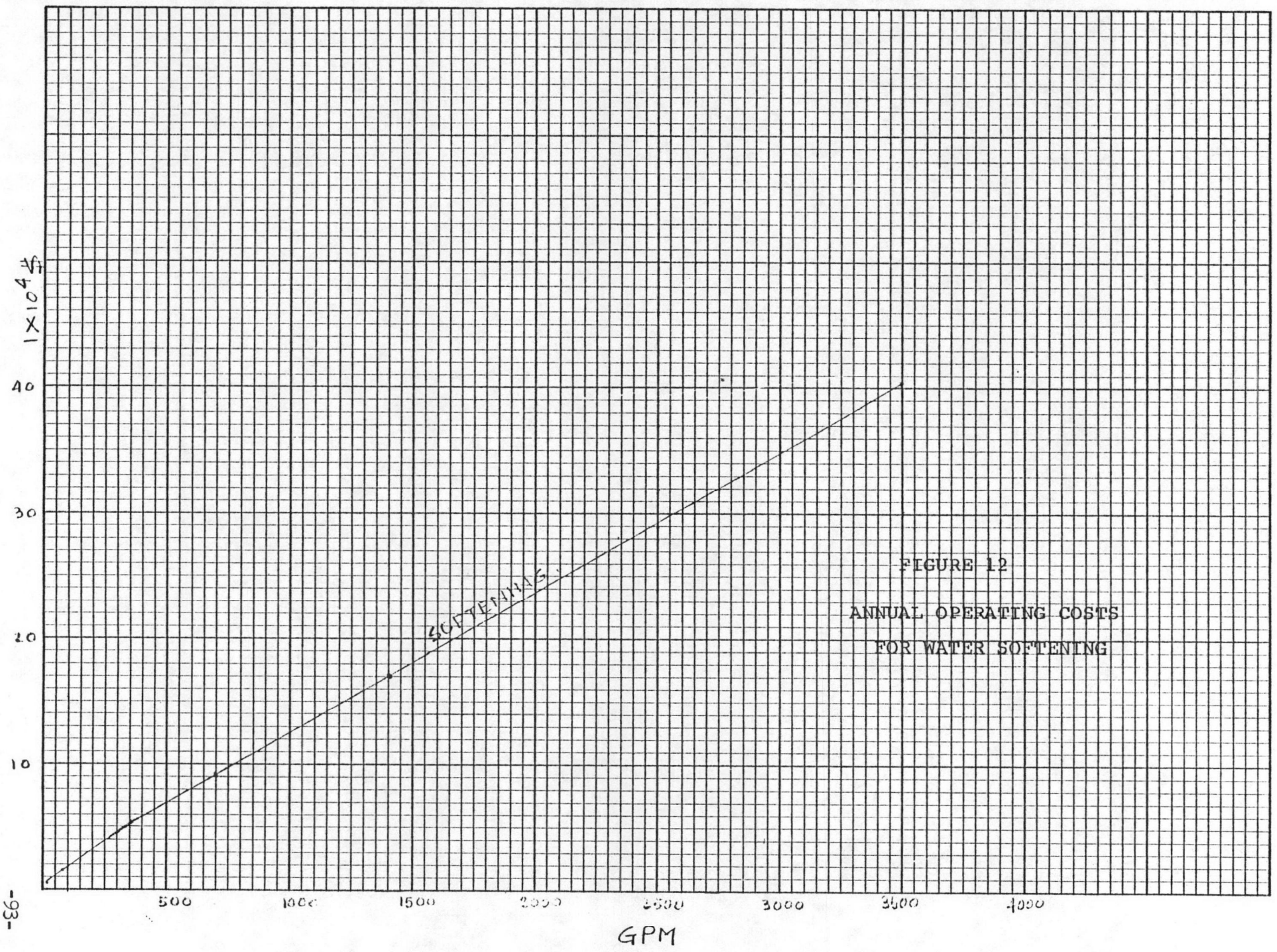


FIGURE 12

ANNUAL OPERATING COSTS

FOR WATER SOFTENING