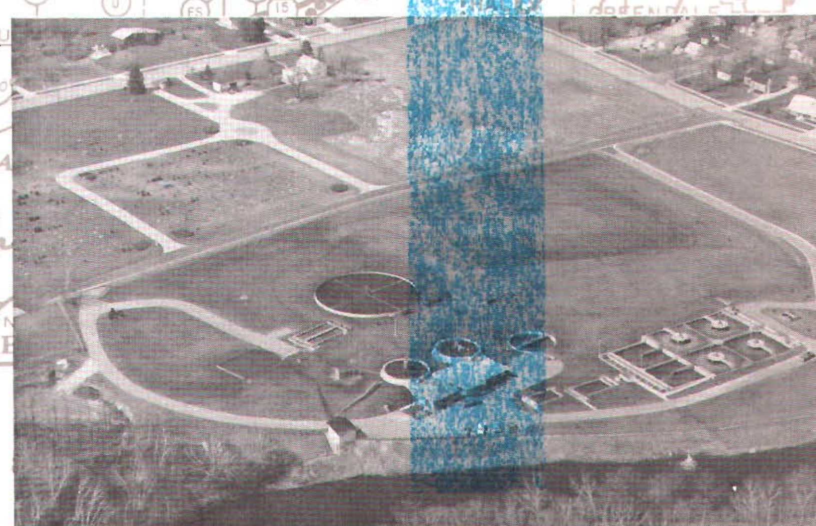
TECHNICAL REPORT NUMBER 18

STATE OF THE ART OF WATER POLLUTION CONTROL IN SOUTHEASTERN WISCONSIN



volume one

POINT SOURCES

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Special acknowledgement is due Lyman F. Wible, P.E., SEWRPC Water Quality Program Coordinator, and Robert P. Biebel, P.E., SEWRPC Sanitary Engineer, for their contributions to this report.

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TECHNICAL REPORT
NUMBER 18

STATE OF THE ART OF WATER POLLUTION CONTROL IN SOUTHEASTERN WISCONSIN

Volume One

POINT SOURCES

Prepared by Stanley Consultants, Inc.,
for the
Southeastern Wisconsin Regional Planning Commission
P. O. Box 769
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916 N. East Avenue
Waukesha, Wisconsin 53186

The preparation of this report was financed through a planning grant from the U. S. Environmental Protection Agency in cooperation with the Wisconsin Department of Natural Resources under the provisions of Section 208 of the Federal Water Pollution Control Act.

July 1977

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July 5, 1977

STATEMENT OF THE EXECUTIVE DIRECTOR

Pursuant to the provisions of Section 208 of the Federal Water Pollution Control Act, the Southeastern Wisconsin Regional Planning Commission on July 1, 1975, undertook an areawide water quality management planning program. The objectives of this program are: to determine current stream and lake water quality conditions within the Region; to compare these conditions against established water use objectives and supporting water quality standards; to explore alternative means of meeting those objectives and standards through the abatement, as necessary, of both point and diffuse sources of water pollution; and to recommend the most cost-effective means of meeting the established objectives and standards over time. The formulation of sound recommendations for the abatement of water pollution and attainment of water use objectives requires, among other things, definitive knowledge of the state of the art of the technology of wastewater treatment and disposal. If the areawide water quality management plan is to be sound and practical, it must seek to properly apply, as necessary, the best available wastewater treatment technology and avoid the proposed application of outmoded as well as of unsound, unreliable, or unsafe practices.

In order to assure that the areawide water quality management plan would be founded on a sound technical basis, the Commission retained a consulting engineering firm—Stanley Consultants, Inc.—to conduct a review of the state of the art of water quality management. The study was intended to provide definitive data on the applicability, effectiveness, reliability, and cost of the various techniques currently available for the treatment of sanitary and industrial wastewaters, urban storm water runoff, rural storm water runoff, and the residual solids—or sludges—resulting from the treatment of these wastewaters. The findings of this review of the state of the art are presented in a four-volume report. This, the first volume, presents the state of the art of the control of point source pollution. More specifically, this report presents in a concise manner information on the cost and effectiveness of the various techniques that are available for municipal sanitary wastewater treatment; small area onsite sewage treatment; and industrial wastewater pretreatment; as well as for discharge or reuse after treatment and for land application of the wastewaters. It is important to note that the experienced and knowledgeable members of the Commission Technical Advisory Committee for Areawide Water Quality Management Planning in Southeastern Wisconsin have found the information presented in this report to be accurate and acceptable for use in the areawide water quality management planning effort.

It is the hope of the Commission staff that, in addition to properly reflecting the current state of the art of wastewater management, this volume and its three companion volumes will contribute to that state of the art by providing a concise presentation of the techniques involved, evaluating their application to water quality management within southeastern Wisconsin, and presenting the technical information in a format which permits consideration of the cost of alternative means of meeting the water use objectives for the lakes and streams of the Region.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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November 5, 1976

Southeastern Wisconsin Regional
Planning Commission
916 N. East Avenue
Old Court House
Waukesha, Wisconsin 53186

Attention Mr. Kurt W. Bauer, Executive Director

Gentlemen:

Re: State-of-the-Art
208 Water Quality Management
Planning Program

We are pleased to submit our final draft report entitled "Point Source Wastewater Control Alternatives and Cost Information." We trust that you will find the information provided representative of existing and emerging state-of-the-art practice applicable to southeastern Wisconsin, and that it will prove useful in your development and analysis of alternatives for your region.

Should you have any questions during your review of this report, please feel free to call us.

Sincerely,

STANLEY CONSULTANTS, INC.

R G Fritchie

R. G. Fritchie, P.E.
Project Manager

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Chapter I

INTRODUCTION

GENERAL

This report presents options for treating point sources of pollution to specified effluent quality objectives. Cost and performance data for the unit operations involved in wastewater treatment are included. Control alternatives include flow or load reduction at the point source and/or treatment for discharge or reuse. Factors other than cost involved in unit process selection are examined. Information is presented in sufficient detail to be useful for subsequent development and evaluation of alternative wastewater treatment plans in the Region. The application of the cost curve information should only be used for general planning purposes for comparing alternatives either on a regional basis or for a given location. More detailed analysis under 201 facilities planning studies will determine the most cost-effective solution for a specific wastewater treatment facility.

SCOPE

The specific scope of this investigation includes:

1. Evaluation and description of industrial pretreatment, municipal, and small area wastewater treatment processes applicable to categories of wastewater sources occurring in the Region including alternatives for treatment and discharge, treatment and reuse, and land application.

2. For each of the processes identified, development of:

   a. Cost curves relating construction and operating costs to appropriate design parameters.

   b. Information on energy, chemical, and manpower requirements of the processes.

   c. Data on removal efficiencies of the processes for relevant wastewater characteristics.

   d. Estimated residual waste quantities and characteristics generated by application of the processes.

   e. General land requirements of the processes.

   f. Information on the reliability, economic life, and other noncost selection factors.

   g. Major constraints to the use of the processes as a result of law and other considerations.

3. Provision of brief descriptions of treatment processes which do not appear appropriate for utilization at the present time for reasons of technology, economics, or environmental factors.

4. Development of typical treatment schematics suitable for application in the Region defining the range of influent characteristics which can be accommodated and range of effluent values which can be expected.

5. Evaluation of alternative techniques to reduce the flow and/or load reaching municipal wastewater treatment facilities including guidelines on industrial waste pretreatment.

6. Evaluation of the general feasibility of alternative methods and costs for conveying wastewater from the point of generation to the point of treatment.

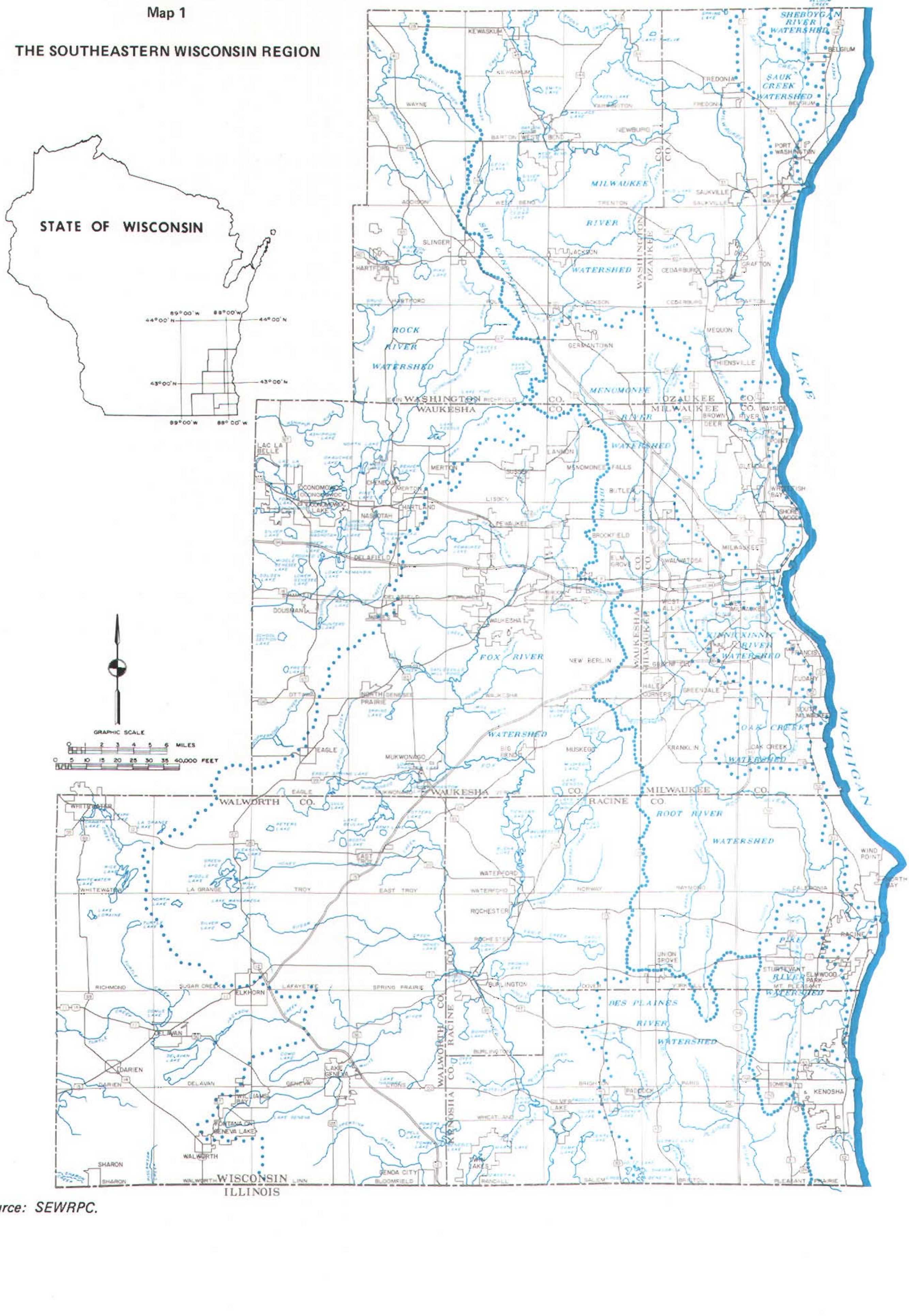
7. Evaluation of the general feasibility of instream modification of water quality through post-plant processes.

STUDY AREA

Treatment processes, schematics, and cost have been developed for application in the Southeastern Wisconsin Region which consists of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties (see Map 1).

Map 1

THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

Chapter II

REVIEW OF EXISTING FACILITIES

INTRODUCTION

In the Region, wastewater discharges from municipal water and wastewater treatment facilities, industrial facilities, power plants, and semipublic and private facilities are recognized as point sources of pollution. Information on flow quantities, influent and effluent wastewater characteristics, and treatment processes used is presented in this chapter for these point sources to provide a basis for evaluation of the applicability of certain wastewater management techniques in southeastern Wisconsin. It should be noted that the information regarding point sources is continually being reviewed and refined by the Commission (SEWRPC). The following sources contain information on existing point source facilities used in compiling data presented in this chapter:

1. A Regional Sanitary Sewerage Plan for Southeastern Wisconsin, Planning Report 16, issued by the Southeastern Wisconsin Regional Planning Commission, 1974.

2. Water Quality Management Basin Plan for the Rivers of Southeastern Wisconsin, issued by the Wisconsin Department of Natural Resources, 1975.

3. Wisconsin Pollutant Discharge Elimination System (WPDES) permits for specific sources, Wisconsin Department of Natural Resources, July 1975.

4. Individual engineering reports and facility plans for specific point sources.

MUNICIPAL WASTEWATER CHARACTERISTICS

The raw wastewater quality and quantity for municipal facilities in the Region varies significantly from treatment facility to treatment facility as shown in Table 1. Because of this wide variety of wastewater characteristics, a distribution analysis was performed for the various raw wastewater parameters as reported in Table 1. Figure 1 presents the results of the distribution analysis. To develop representative treatment schematics (unit process arrangements) to meet specified effluent quality objectives for the Region, three values of raw wastewater characteristics were selected from Figure 1 in concert with Commission staff to typify the wastewater of the Region. These values are shown in Table 2. The wastewater treatment schematics in Chapter V were developed using these raw wastewater characteristics. In this manner, proposed treatment facilities for the Region are based on raw wastewater values experienced in the Region, and not "typical" literature values.

To obtain the raw wastewater values in Table 2, the information used and assumptions made are as follows:

1. BOD_5 and TSS values are 1975 data obtained from SEWRPC[1] as presented in Table 1 and analyzed in Figure 1.

2. Nitrogen and phosphorus values are based upon sampling survey results summarized in Table 70 from Planning Report 16[2] and analyzed in Figure 1. Survey data obtained by the Wisconsin Department of Natural Resources at 22 wastewater treatment plants during 1974, 1975, and 1976 indicated an average phosphorus value which was approximately 17 percent lower than the data included in Planning Report 16 while ammonia nitrogen and organic nitrogen average values were approximately 4 percent and 15 percent higher than the average values indicated in Planning Report 16. It should be noted that the pattern of higher raw wastewater phosphorus and nitrogen concentrations associated with the higher BOD_5 and suspended solids concentration levels can vary at specific treatment facilities. As an example, the Milwaukee-Metropolitan Sewerage District's South Shore wastewater treatment plant reported a 1975 raw wastewater annual average BOD_5 and suspended solids concentrations of 308 mg/l and 437 mg/l, respectively, indicating the influent approximated the BOD and suspended solids influent III level concentrations noted in Table 2. However, the raw wastewater average phosphorus concentration during 1975 for that plant was reported to be 13.3 mg/l indicating a value slightly lower than the phosphorus concentration indicated for influent level II, while the raw wastewater average total Kjeldahl nitrogen concentration was reported to be 47.6 mg/l indicating a higher nitrogen concentration in the influent than indicated for influent level III.

3. Approximately 51 percent of the raw total Kjeldahl nitrogen (TKN) is ammonia nitrogen (NH_3-N) based upon 1970 data from Planning

[1] *Wisconsin Department of Natural Resources, computer printouts on Municipal and Industrial Treatment Facilities, July 1975.*

[2] *Southeastern Wisconsin Regional Planning Commission, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, 1974.*

Table 1

MUNICIPAL TREATMENT FACILITIES IN SOUTHEASTERN WISCONSIN: 1972 and 1975

Facility	Flow: Actual (mgd) (Minimum)	Flow: Actual (mgd) (Average)	Flow: Actual (mgd) (Maximum)	Flow: Design (mgd) (Average)	Raw Waste Characteristics: BOD_5 (mg/l) (Minimum)	Raw Waste Characteristics: BOD_5 (mg/l) (Average)	Raw Waste Characteristics: BOD_5 (mg/l) (Maximum)	Raw Waste Characteristics: TSS (mg/l) (Minimum)	Raw Waste Characteristics: TSS (mg/l) (Average)	Raw Waste Characteristics: TSS (mg/l) (Maximum)	Effluent Characteristics: BOD_5 (mg/l) (Minimum)	Effluent Characteristics: BOD_5 (mg/l) (Average)	Effluent Characteristics: BOD_5 (mg/l) (Maximum)	Effluent Characteristics: TSS (mg/l) (Minimum)	Effluent Characteristics: TSS (mg/l) (Average)	Effluent Characteristics: TSS (mg/l) (Maximum)	Effluent Characteristics: P (mg/l) (Minimum)	Effluent Characteristics: P (mg/l) (Average)	Effluent Characteristics: P (mg/l) (Maximum)	Effluent Characteristics: pH (Average)	Effluent Characteristics: Fecal Coliform (Number of 100 ml) (Average)	Existing Treatment: Liquid	Existing Treatment: Sludge
Kenosha County																							
Kenosha	15.40	18.44	20.87	18.00	75	117	231	102	203	553	4	9	28	9	21	34	0.84	1.36	1.98	7.7	33	PC-C-AS-FC-D	AN-FP-LS
Kenosha[a]	1.80	4.01	7.56	20.00	--	102	--	--	314	--	--	18	--	--	26	--	--	--	--	--	--	CS-FC-D	--
Twin Lakes	0.32	0.41	0.49	0.82	116	137	176	122	319	491	11	14	18	16	171	789	--	--	--	7.9	--	PC-TF-C-FC/AS-FC-D	AD-AN-DB-LF
Silver Lake	0.13	0.15	0.18	0.30	45	47	50	61	74	100	1	2	4	2	2	3	--	--	--	7.3	--	CS-FC-D-C	AD-LC-LS
Pleasant Prairie Utility District D	0.07	0.10	0.17	0.13	58	124	182	--	--	--	5	8	12	--	--	--	--	--	--	7.0	--	CS-FC-D-P	AD-Kenosha
Salem Sewer Utility District No. 1	0.06	0.08	0.13	0.30	50	118	158	77	157	228	5	10	18	5	12	23	--	--	--	7.4	--	AS-FC-D-P	AD-Kenosha
Bristol Utility District No. 1	0.03	0.07	0.11	0.08	--	--	--	--	--	--	--	8	--	--	--	--	--	--	--	--	--	AS-FC-D	AD-LC-LS
Somers Sanitary District No. 2	0.04	0.06	0.09	0.03	109	209	342	96	164	328	26	59	91	17	67	171	--	--	--	7.7	791	EA-FC-D	S-Kenosha
Paddock Lake	--	0.17	--	0.40	--	97	--	--	--	--	--	13	18	--	20	31	--	--	--	7.6	--	PC-AS-FC-D	AN-LS
Pleasant Park Utility Company	--	--	--	0.06	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-SF-D	AD-Kenosha
Pleasant Prairie Utility District 73-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-D-C-SF	AD-Kenosha
Milwaukee County																							
Milwaukee-Metropolitan Sewerage District																							
Jones Island	123.00	137.10	151.40	200.00	345	426	511	276	377	501	17	29	55	14	50	122	0.25	0.76	1.70	7.6	380	PS-AS-C-FC-D	VF-Milorganite
South Shore	58.10	73.70	93.90	120.00	221	308	422	314	437	569	13	28	51	25	71	129	2.30	3.90	6.10	7.0	80	PC-AS-C-FC-D	AN-LC-LF-LS
Hales Corners	0.36	0.52	0.69	0.60	118	174	248	116	174	268	20	35	42	29	53	66	--	--	--	7.4	50	PC-TF-C-FC-D	AN-DB-LS
South Milwaukee	2.04	2.67	3.54	6.00	125	161	202	124	166	209	7	12	27	7	11	18	--	--	--	--	--	PC-AS-C-FC-D	AN-Zimpro-DB-LC-LF-LS
Rawson Homes Sewer and Water Trust	--	--	--	0.04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-D	
Ozaukee County																							
Port Washington	1.37	1.70	2.11	1.25	85	123	168	127	170	253	9	12	18	8	14	21	0.61	0.98	2.17	7.2	--	PC-AS-C-FC-D	AN-AD-LS
Cedarburg	0.97	1.41	2.10	3.00	65	121	176	70	154	315	3	11	29	12	24	82	1.60	2.60	3.30	7.5	66.7	PC-TF/AS-C-FC-D	AN-DB-S-LS
Grafton	0.77	0.88	1.05	1.00	100	138	174	146	258	333	5	9	15	12	16	20	--	--	--	7.3	--	PC-AS-C-FC-D	AD-AN-LS
Thiensville	0.37	0.57	1.02	0.24	50	70	97	60	83	104	8	20	28	8	15	27	0.30	0.50	0.82	7.3	--	PA-PC-AS-C-FC-D	AD-AN-DB-LS
Saukville	0.21	0.29	0.43	0.30	81	129	169	92	139	206	23	36	55	28	39	54	--	--	--	7.5	--	PC-TF-FC-D	AN-DB-LS
Fredonia	0.12	0.28	0.37	0.12	85	132	175	90	141	212	10	35	54	31	43	57	--	--	--	7.3	--	PA-PC-AS-FC-D	AN-DB-LS
Belgium	0.05	0.07	0.10	0.07	164	209	254	179	205	253	22	30	38	40	54	66	--	--	--	7.4	--	PC-AS-FC-D	AN-DB-LS
Racine County																							
Racine	16.84	19.69	24.65	30.00	82	99	119	112	121	136	30	35	41	60	78	111	3.13	4.37	6.15	7.3	260	PC-AS-C-FC-D	AN-VF-LF-LS
Racine[a]	--	--	--	14.13	--	*80*	--	--	233	--	--	40	--	--	94	--	--	1.66	--	--	500	M-CA-AF-D	--
Racine[a]	--	--	--	44.40	--	61	--	--	333	--	--	24	--	--	113	--	--	0.87	--	--	700	M-CA-AF-D	--
Burlington	1.20	1.48	1.75	2.50	133	214	353	87	142	178	6	8	10	4	7	10	0.90	4.33	6.60	7.8	100	AS-C-FC-D	*AD-C-LS*
North Park Sanitary District	0.99	1.13	1.30	2.00	90	97	104	155	179	209	12	15	20	21	24	29	0.70	0.84	0.96	7.9	--	AS-FC-D	AN-DB-LS
Sturtevant	0.38	0.53	0.83	0.25	71	139	200	97	146	238	17	33	48	15	40	63	0.84	2.30	5.90	7.2	180,000	PC-TF-C-FC-D	AN-DB-LC-LS-LF
Union Grove	0.36	0.43	0.59	0.30	130	212	307	149	203	320	22	43	75	12	24	52	--	--	--	7.7	--	PC-AS-C-FC-D	AN-DB-S-LS
Western Racine County Sewerage District	0.22	0.24	0.31	0.50	115	162	200	166	198	233	4	8	11	4	6	10	--	--	--	7.5	--	AS-FC-D-C	AD-DB-LS
Caddy Vista Sanitary District	0.06	0.09	0.12	0.25	131	215	270	91	163	219	21	62	80	13	19	26	--	--	--	7.7	--	PC-TF-FC	AN-DB-LS

Table 1 (continued)

Facility	Flow: Actual (mgd) (Minimum)	Flow: Actual (mgd) (Average)	Flow: Actual (mgd) (Maximum)	Flow: Design (mgd) (Average)	Raw Waste Characteristics: BOD_5 (mg/l) (Minimum)	Raw BOD_5 (Average)	Raw BOD_5 (Maximum)	Raw Waste: TSS (mg/l) (Minimum)	Raw TSS (Average)	Raw TSS (Maximum)	Effluent Characteristics: BOD_5 (mg/l) (Minimum)	Effluent BOD_5 (Average)	Effluent BOD_5 (Maximum)	Effluent: TSS (mg/l) (Minimum)	Effluent TSS (Average)	Effluent TSS (Maximum)	Effluent: P (mg/l) (Minimum)	Effluent P (Average)	Effluent P (Maximum)	Effluent: pH (Average)	Effluent: Fecal Coliform (Number of 100 ml) (Average)	Existing Treatment: Liquid	Existing Treatment: Sludge
Walworth County																							
Walworth	--	--	--	0.15	113	158	223	88	151	212	10	24	40	15	51	86	--	--	--	8.6	--	Imhoff-TF-FC-D-P	AN-DB-LC-LS
Whitewater	0.91	1.14	1.47	2.50	379	461	559	201	281	393	32	50	74	48	81	141	--	--	--	7.0	--	PC-TF-FC/PC-AS-FC-D	AN-DB-LS
Lake Geneva	0.60	0.74	0.87	1.10	89	127	155	120	149	183	18	26	42	29	40	50	5.00	7.20	9.00	7.7	--	PC-TF-C-FC-D	AD-LF
Elkhorn	0.37	0.69	1.37	0.50	77	152	241	62	113	186	5	13	24	8	10	16	--	--	--	7.5	--	PC-TF-FC-TF-FC-C-D	AN-DB-LF-LS
Delavan	0.47	0.59	0.91	1.00	63	101	193	87	160	242	11	19	52	8	18	24	--	--	--	7.6	--	PC-TF-FC-D	AN-DB-LC-LS
Fontana	--	0.52	--	0.40	--	67	--	--	82	--	--	11	--	--	10	--	--	--	--	--	--	PC-TF-FC-P-D	AN-LS
East Troy	0.21	0.25	0.27	0.32	69	105	145	39	64	109	9	28	53	7	16	24	--	--	--	7.5	9,500	PC-TF-FC	AN-DB-LS
Williams Bay	--	0.20	--	0.80	--	126	--	--	57	--	--	32	--	--	5	--	--	--	--	--	--	PC-AS-FC-P-D	AN-LS
Darien	0.09	0.14	0.19	0.15	94	122	210	73	119	165	5	8	17	4	7	11	--	--	--	7.6	--	AS-FC-D-P	AD-LS
Sharon	0.06	0.08	0.13	0.15	57	73	161	--	54	203	15	26	38	1	8	29	--	--	--	7.5	--	PC-TF-FC-D	AN-LC-LS
Genoa	0.06	0.07	0.10	0.12	46	132	179	27	110	261	8	19	28	6	17	36	--	--	--	7.6	--	PC-TF-FC-D	AN-DB-LS
Washington County																							
West Bend	3.20	3.70	4.20	2.50	80	106	126	114	259	336	5	9	15	12	17	22	0.87	1.24	1.80	7.8	--	PC-AS-C-FC-D	AN-LS
Hartford	0.71	1.37	1.80	2.00	150	190	280	124	246	545	1	6	10	3	9	22	0.80	1.03	1.80	7.5	--	AS-C-FC-P-M-D	AD-DB-LS
Germantown	0.60	0.80	1.06	1.00	8	29	150	6	28	118	4	10	14	1	8	27	1.70	2.30	4.70	7.9	--	AS-C-FC-D-P	AD-LC-LF-LS
Kewaskum	0.22	0.32	0.47	0.50	274	362	507	245	454	668	2	9	20	5	8	19	0.21	1.77	3.70	7.8	--	PA-PC-AS-C-FC-P-M-D	AD-VF-LS-LF
Jackson	0.22	0.26	0.28	0.03	--	--	--	--	--	--	89	140	215	65	91	110	--	--	--	7.3	4.8×10^6	PC-TF-FC-D	AN-DB-LS
Slinger	0.07	0.15	0.29	0.15	65	127	192	100	169	268	12	24	46	18	37	54	--	--	--	7.5	--	PA-PC-TF-PA-FC-D	AN-DB-LS
Allenton Sanitary District	0.04	0.08	0.11	0.10	322	424	644	300	479	668	5	17	26	12	37	82	--	--	--	7.6	--	PC-AS-FC-D	AN-DB-LS
Village of Newburg	--	0.07	--	0.08	224	246	258	337	372	417	46	75	117	43	54	67	--	--	--	7.3	--	AS-FC-D	AD-LS
Waukesha County																							
Waukesha	7.08	9.92	11.98	8.50	121	162	197	131	153	172	6	8	14	16	20	26	2.60	2.90	3.60	7.7	--	PC-TF-FC-TF-C-FC-D	AN-S-LS
Brookfield	1.41	2.48	3.90	5.00	78	110	160	79	195	282	3	20	44	11	26	46	1.50	2.40	2.90	7.9	1,000	PC-AS-C-FC-D-P	AD-FP-Incineration-LF
Oconomowoc	1.54	1.90	2.33	1.50	158	231	311	116	180	223	28	41	69	50	68	78	--	--	--	7.4	--	PC-TF-FC-D	AN-DB-LS
Menomonee Falls—Pilgrim Road Plant	1.16	1.40	1.79	1.90	48	71	96	100	146	241	6	13	17	12	23	33	2.20	3.80	6.00	7.6	--	PA-PC-TF-C-FC/AS-C-FC	AD-AN-DB-LF-LS
Menomonee Falls—Lilly Road Plant	0.60	0.70	1.0	1.00	55	99	184	168	247	474	3	8	18	3	20	86	0.60	2.50	10.40	7.3	--	AS-FC-C-D	AD-DB-LF-LS
Muskego-Big Muskego Plant	0.37	0.58	0.88	0.70	90	110	131	64	122	181	3	9	19	11	21	43	4.30	6.50	9.60	7.4	--	P-D	LS
Sussex	0.35	0.47	0.62	0.30	107	142	184	128	191	237	17	32	43	21	35	50	1.60	4.50	8.40	7.7	--	PC-TF-C-FC-D	AD-DB-LS
Mukwonago	0.36	0.44	0.55	0.22	74	121	151	47	127	165	19	29	46	15	25	44	0.70	0.83	0.97	7.4	--	PC-TF-C-FC-D	AN-DB-LS
Hartland	0.34	0.43	0.50	0.35	69	95	115	130	157	189	7	11	17	18	29	50	2.20	3.00	3.90	7.4	--	PC-AS-FC-D	AN-DB-LS
Muskego-Northeast Plant	0.23	0.34	0.51	0.50	116	153	228	85	136	188	6	11	14	8	20	28	1.7	3.1	4.70	7.5	--	CS-C-FC-P-D	AD-DB-LS
Pewaukee	0.22	0.30	0.40	0.75	79	203	374	106	276	655	19	30	42	18	37	55	--	--	--	7.4	--	PC-TF/RBC/FC-D	AD-AN-LF-LS AN-DB-L
Dousman	0.10	0.11	0.13	0.12	61	94	126	109	135	182	18	23	27	10	31	48	--	--	--	7.4	--	PC-AS-FC-D	AD-LS
City of New Berlin																							
Regal Manor	0.12	0.13	0.14	0.35	136	209	282	78	160	260	20	83	145	9	39	96	--	--	--	7.0	--	CS-FC-D-P	AD-DB-LS-Brookfield
Greenridge (Taken Out of Service During 1975)	0.07	0.08	0.09	0.10	140	202	246	76	175	350	19	74	126	36	63	90	--	--	--	7.6	--	CS-FC-D-P	AD-LS-Brookfield

[a] *Facility treats only combined sewer overflows. 1972 data is given.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

TREATMENT KEY: Liquid

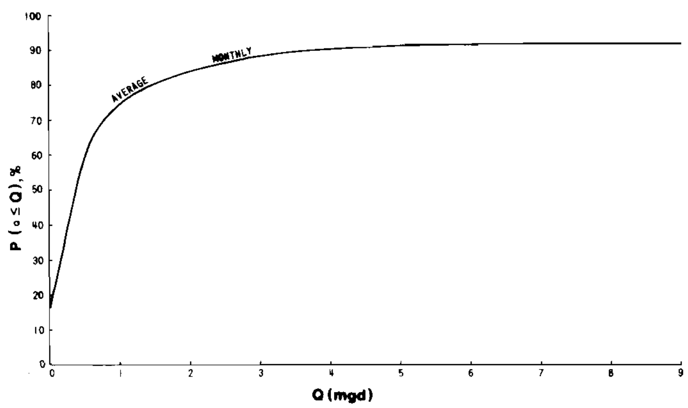
PC - Primary Clarifier
PS - Primary Screens
FC - Final Clarifier
D - Disinfection
AS - Activated Sludge
CS - Contact Stabilization
EA - Extended Aeration
RBC - Bio-disc
CA - Chemical Addition
C - Chemical Addition (Phosphorus Control)
TF - Trickling Filter
PA - Pre-aeration
AF - Air Flotation
P - Lagoon
M - Microstrainer
SF - Sand Filter

Sludge

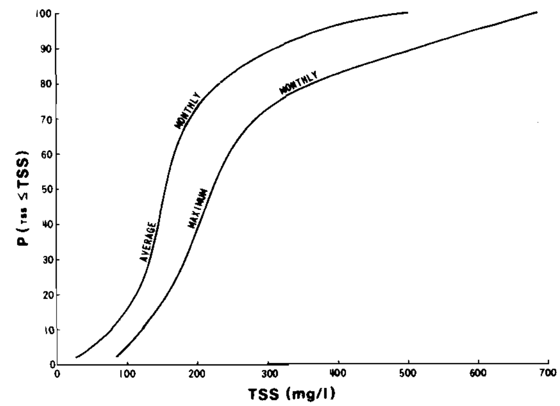
AN - Anaerobic Digestion
AD - Aerobic Digestion
DB - Drying Bed
VF - Vacuum Filter
FP - Filter Press
C - Centrifuge
S - Storage
LS - Land Spreading
LF - Landfill
LC - Contract Disposal

Figure 1

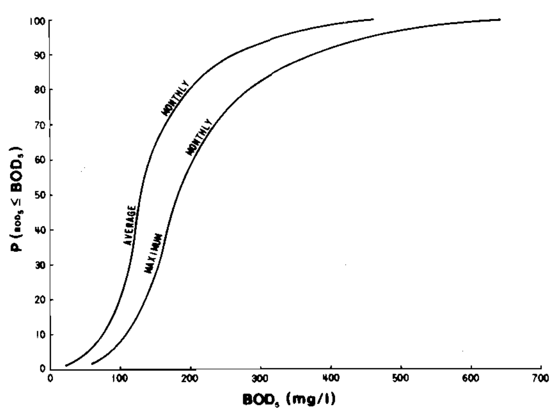
DISTRIBUTION ANALYSIS RESULTS FOR RAW WASTEWATER PARAMETERS



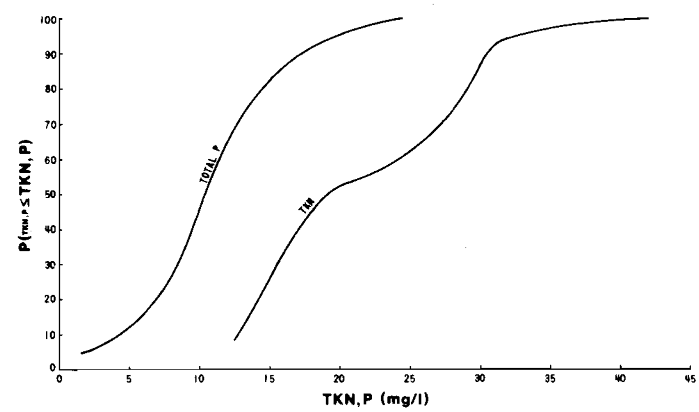
FLOW (Q)



TOTAL SUSPENDED SOLIDS (TSS)



BIOCHEMICAL OXYGEN DEMAND (BOD_5)



TOTAL KJELDAHL NITROGEN (TKN)
AND TOTAL PHOSPHORUS (P)

NOTE: CURVES REPRESENT THE PROBABILITY THAT A GIVEN WASTEWATER TREATMENT FACILITY WILL HAVE A GIVEN RAW WASTEWATER FLOW OR QUALITY. FOR EXAMPLE, 50 PERCENT OF THE FACILITIES IN THE REGION WILL HAVE AN AVERAGE RAW WASTEWATER BOD_5 EQUAL TO OR LESS THAN 130 mg/l

Source: Stanley Consultants.

Report 16[3] and analyzed in Figure 2. Survey data obtained by the Wisconsin Department of Natural Resources at 22 wastewater treatment plants during 1974, 1975, and 1976 indicated that approximately 59 percent of the raw wastewater TKN concentration is NH_3-N.

4. The total nitrite and nitrate nitrogen were assumed to be 2 percent of total nitrogen.

[3] *Ibid.*

Table 2

RAW WASTEWATER CHARACTERISTICS USED IN SCHEMATIC DEVELOPMENT

Parameter	Concentrations (mg/l)		
	Influent I (in Percent)	Influent II (in Percent)	Influent III (in Percent)
Distribution of Parameters[a]	50	80	95
Average Annual Biochemical Oxygen Demand (BOD_5)	130	200	325
Maximum Monthly Biochemical Oxygen Demand (BOD_5)	185	285	460
Average Annual Suspended Solids (TSS)	155	230	370
Maximum Monthly Suspended Solids (TSS)	225	360	600
Ammonia Nitrogen (NH_3-N)	10	15	17
Organic Nitrogen (Org-N)	9	14	16
Nitrate and Nitrite–Nitrogen ($NO_3 + NO_2$)	0.5	0.5	0.5
Total Phosphorus (TP)	10.5	14.5	19.5

[a] *The identified value represents the percent of plants which have values less than or equal to stated value, as shown in Figure 2.*

Source: Stanley Consultants.

The values represent three different raw waste loads representative of the characteristics of the raw waste experienced at facilities in the Region. Values at a particular facility can be expected to vary from these values. Data on influent wastewater values of other parameters in the Region are generally limited as are removals that are obtained in existing facilities.

Average monthly flows range from 0.06 to 137.1 mgd. The average monthly median flow for the treatment facilities in the Region is approximately 0.4 mgd.

As noted from the distribution curves in Figure 1, 50 percent of the communities have wastewaters of lesser strength than those listed in Table 2. If infiltration and inflow can be reduced in many of these areas, as has been found to be the case in many of the Region's sewerage systems that have been studied for infiltration/inflow reduction, it is believed that influent wastewater characteristics will approximate the range of values selected. Accordingly, the wastewater management alternatives for the Region are based on these influent characteristics.

To meet specified effluent quality objectives, unit processes were selected to treat the maximum monthy BOD_5 and TSS values shown in Table 2. Capital costs for liquid waste treatment processes should be based on these values. The average annual values should be used to estimate sludge production and operation and maintenance costs.

For large facilities, special investigations usually are made to determine influent design parameters in 201 facilities planning studies. Smaller facilities are often designed based on generally accepted design values. Existing quality data for any treatment facility can be misleading, as it may reflect unchecked water usage in unmetered communities, infiltration and inflow which dilute the sewage, various levels of industrial contribution, and other factors. Under the regional sanitary sewage planning program, investigations were made, for planning purposes, to determine the regional flow and strength characteristics.[4] The investigations indicated the following average sewage flow conditions for the Region:

1. Average amount of domestic sewage flow contributed by all urban land uses except major industrial and commercial concentrations and based upon water delivery records: 88 gallons per capita per day, ranging from a low of 78 to a high of 103 gpcd.

2. Average amount of sewage flow contributed by major concentrations of industrial land uses: 12,270 gallons per acre per day, ranging from a low of 1,430 to a high of 24,660 gpad.

3. Average amount of sewage flow contributed by major concentrations of commercial land uses: 7,640 gallons per acre per day, ranging from a low of 2,580 to a high of 13,620 gpad.

4. Average infiltration rate: 0.24 gallons per minute per gross developed acre, ranging from a low of 0.09 to a high of 0.73 gpad.

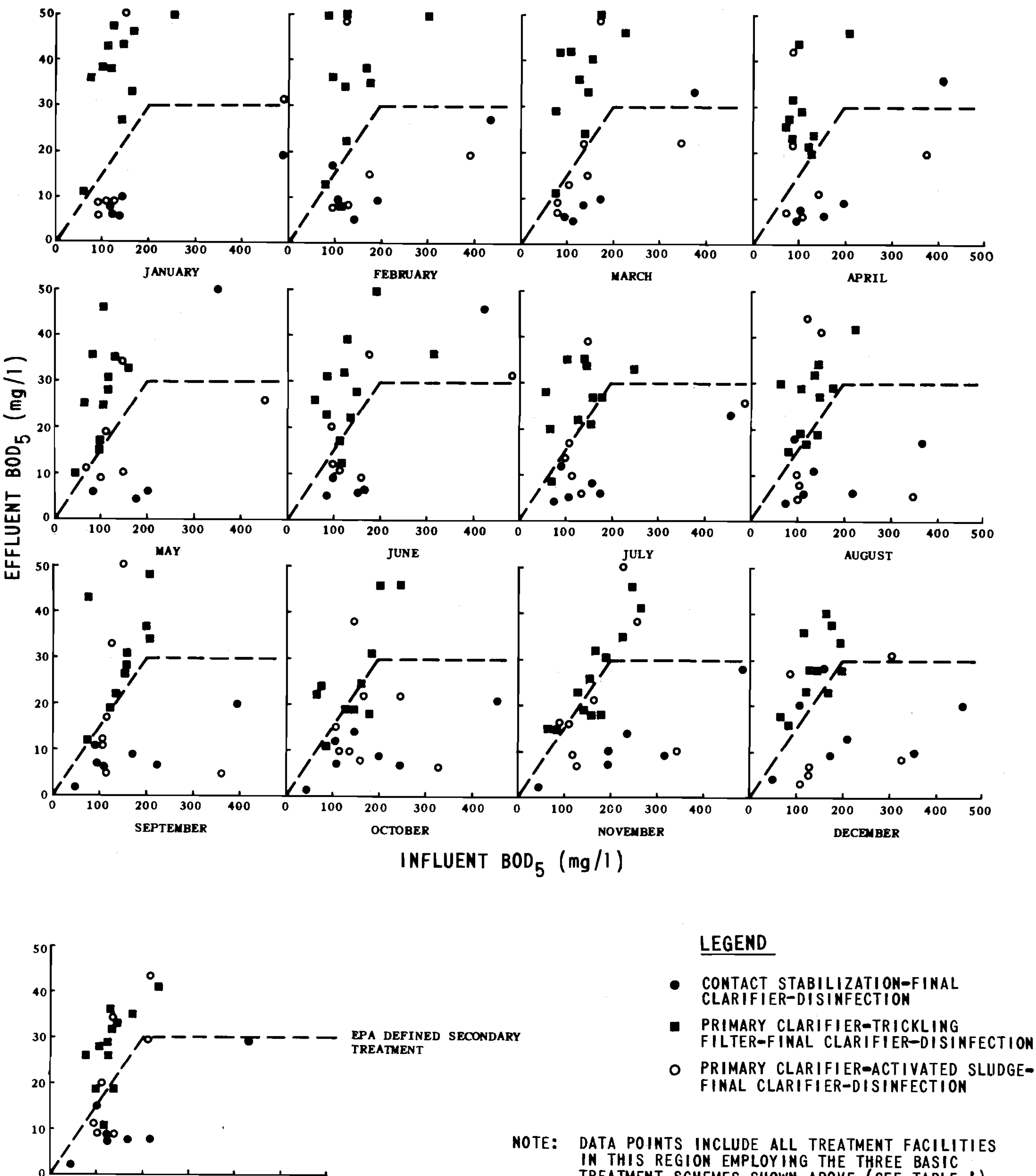
5. Average storm water inflow rate: 0.57 gallons per minute per gross developed acre, ranging from a low of 0.26 to a high of 1.68 gpad.

[4] *Ibid.*

RETURN TO SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION PLANNING LIBRARY

Figure 2

ANALYSIS OF PERFORMANCE OF REGIONAL TREATMENT FACILITIES FOR BOD_5



NOTE: DATA POINTS INCLUDE ALL TREATMENT FACILITIES IN THIS REGION EMPLOYING THE THREE BASIC TREATMENT SCHEMES SHOWN ABOVE (SEE TABLE I).

Source: Stanley Consultants.

6. Peak-to-average flow rates: 3.72 to one for trunk sewers, ranging from a low of 2.83 to one to a high of 4.61 to one; and 1.87 to one for sewage treatment plants, ranging from a low of 1.34 to one to a high of 2.66 to one.

The same analyses also indicated the following average sewage strength contributions for the Region, based on data from 30 treatment facilities:

1. Average five-day carbonaceous biochemical oxygen demand value: 0.259 pound per capita per day, ranging from a low of 0.0627 to a high of 1.523 pounds per capita per day.

2. Average suspended solids value: 0.219 pound per capita per day, ranging from a low of 0.0656 to a high of 0.676 pound per capita per day.

3. Average total phosphorus value: 0.0138 pound per capita per day, ranging from a low of 0.0055 to a high of 0.0535 pound per capita per day.

4. Average organic nitrogen value: 0.0111 pound per capita per day, ranging from a low of 0.0061 to a high of 0.0208 pound per capita per day.

5. Average ammonia nitrogen value: 0.0143 pound per capita per day, ranging from a low of 0.0063 to a high of 0.0233 pound per capita per day.

Values utilized in Planning Report 16 to typify regional wastewater for alternative analysis were 125 gallons/capita/day containing 0.21 pound of BOD_5 and TSS/capita/day. An infiltration allowance of 85 gallons/capita/day was added to this value to produce a design average flow value of 210 gallons/capita/day. Similar analysis and selection of loading factors will be made in ongoing 208 planning efforts.

MUNICIPAL WASTEWATER TREATMENT FACILITIES

In 1970, 81 of the 146 cities, villages, and towns in the SEWRPC area were served by municipal wastewater treatment facilities. Between 21 and 23 percent of the urbanized area, or about 8 percent of the population, was without public sanitary sewer service. Preparations had been made at the local level to extend sanitary sewer service to an additional 447 square miles not currently served by such facilities.

Municipal wastewater treatment plants were considered the major source of surface water pollution in the Region in 1970.[5] Currently, 65 wastewater treatment plants are in operation. Information on these facilities is presented in Table 1.

There are three facilities listed in Table 1 that treat only combined sewer overflows. These facilities are located in the Cities of Kenosha and Racine. Many communities in the Region are served by contract with the Milwaukee-Metropolitan Sewerage District, Racine, Kenosha, or other systems.

[5] *Ibid.*

The hydraulic design capacity range of the treatment facilities in the Region is as follows:

	Number of Plants
Less than 0.1 mgd	7
Between 0.1 and 0.5 mgd	24
Between 0.5 and 1.0 mgd	10
Between 1.0 and 5.0 mgd	14
Between 5.0 and 10.0 mgd	3
Between 10.0 and 100.0 mgd	5
Greater than 100.0 mgd	2

The breakdown of the basic treatment process used by the facilities is presented below:

	Number of Plants
Primary clarification plus:	
Trickling filter	22
Activated sludge	21
Rotating biological contactor	1
Primary mechanical clarification plus activated sludge	1
Contact stabilization	6
Activated sludge	13
Extended aeration	1
Lagoons	1
Physical-chemical	2

There are five facilities in the Region that have two different basic treatment processes in use concurrently. The only advanced wastewater treatment process presently employed is chemical addition for phosphorus removal. Chemical addition is employed at 30 of the treatment facilities. Effluent polishing ponds, which are intended to upgrade effluent quality, are used at 13 facilities.

Sludge produced from the above treatment systems is processed by the following unit operations:

	Number of Unit Operations
Aerobic digestion	27
Anaerobic digestion	38
Drying beds	32

	Number of Unit Operations
Vacuum filters	3
Centrifuges	1
Filter presses	2

Ultimate disposal of sludges in the Region is generally accomplished by landfill, by landspreading, or by product recovery (Milorganite).

The three most commonly used regional basic wastewater treatment processes are primary clarification plus trickling filter, primary clarification plus activated sludge, and contact stabilization. An investigation was made to see if these processes were meeting secondary treatment requirements as defined by the U. S. Environmental Protection Agency (EPA) (at least 85 percent reduction in BOD_5 and TSS concentrations or an effluent level of 30 mg/l BOD_5 and 30 mg/l TSS on a monthly average basis). Processes that are currently being used to upgrade the effluent of these three basic treatment processes were also investigated.

Figure 2 shows the monthly average and annual average of BOD_5 reduction for the treatment facilities employing the three basic treatment processes. The figure shows that many of the facilities are not meeting secondary requirements, especially the trickling filters. Seasonal variations are not readily apparent for the processes. Many of the violations can be attributed to inadequate operations, overload of design capacity, and similar factors. However, a study of the trickling filter data revealed that the high BOD_5 concentration in the effluent could be attributed to the high soluble BOD_5 level in the effluent (approximately 30 to 40 percent of the total BOD_5) and to carry-over of suspended solids.

A survey of current regional practices used to upgrade effluent quality was performed. Trickling filters were upgraded with activated sludge processes, chemical addition for phosphorus removal; polishing ponds, and second stage trickling filters. When using activated sludge along with chemical addition in conjunction with trickling filters, overall raw wastewater BOD_5 and TSS concentrations were reduced by 91 and 84 percent, respectively. Polishing ponds reduced overall BOD_5 concentration by 84 to 85 percent and TSS concentration by 66 to 88 percent. Overall BOD_5 and TSS concentrations were reduced by 91 to 95 percent and 87 to 90 percent, respectively, with second stage trickling filters.

Activated sludge processes in the Region have been upgraded with chemical addition for phosphorus removal. Overall BOD_5 and TSS removals of 90 and 92 percent, respectively, were obtained by facilities in the Region.

Polishing ponds and chemical addition for phosphorus removal are used to improve the effluent quality of contact stabilization processes. Polishing ponds have reduced overall BOD_5 levels 58 to 94 percent and TSS levels by 64 to 85 percent. Overall BOD_5 and TSS reduction of 93 percent and 85 percent, respectively, have occurred with chemical addition.

SEMIPUBLIC AND PRIVATE FACILITIES

There are 67 semipublic and private wastewater treatment facilities in the Region as shown in Table 3. The facilities listed are primarily institutions, mobile home parks, or isolated residential subdivisions. Most of these facilities are served by package treatment plants with design flows less than 0.5 mgd. Some will be abandoned as centralized sewerage systems are extended if the recommendations in Planning Report 16 are followed. Treatment concepts and costs for small areas are discussed in Chapter VI.

INDUSTRIAL FACILITIES

An attempt has been made to identify the industrial enterprises in the study area. The results of the investigation are presented in Appendix B. Approximately 430 industries are listed. The industries are classified by two and three digit standard industrial classification codes (SIC). Included in the table is information describing the enterprise location, product, wastewater flows (cooling and process), and wastewater characteristics, and discharge location. All facilities are listed whether they have a separate discharge or discharge through a municipal facility.

Effluent quality standards have been established by federal regulations for various industrial classes. Effluent standards are administered to the industries through WPDES permits. These permits specify the maximum allowable mass of pollutants that can be discharged per day and are arrived at through the permit issuance process which includes discussion with industries as well as public hearings and notices and technical evaluation of the facilities waste reduction.

Food and kindred product is one of the largest category of industrial types in the Region. BOD_5 and TSS are the primary pollutants associated with these industries. Process wastewater is usually treated by biological methods at the facility or by municipalities at central systems.

Industries which produce sand, gravel, stone, clay, glass, and allied products generally have WPDES permits limiting the amount of TSS, COD, and total phosphorus amounts that can be discharged. Processes used for wastewater treatment include sedimentation (with or without chemical addition), neutralization, and chemical addition for phosphorus removal.

For the paper and allied product industries, effluent limitations on BOD_5 and TSS are required. Process wastewater is usually treated by biological methods.

In the metal casting and product category, there are many parameters for which effluent limitations are specified. These parameters include pH, ammonia, cyanide, phenol, TSS, oil and grease, chlorides, sulfates, fluorides, phosphates, chromium, tin, zinc, and other numerous heavy metals. Wastewater treatment methods practiced by these industries are phenol removal, solvent extraction, biological treatment, recycle and blowdown, neutralization, precipitation, chemical treatment, sedimentation, emulsion breaking, air flotation, and ion exchange. A full discussion of the application of these processes to industrial waste treatment is beyond the scope of this investigation.

Table 3

SELECTED CHARACTERISTICS OF SEMIPUBLIC AND PRIVATE TREATMENT FACILITIES IN SOUTHEASTERN WISCONSIN: 1975

	Actual Flow (mgd)			Raw Waste Characteristics: BOD5 (mg/l)			Raw Waste Characteristics: TSS (mg/l)			Effluent Characteristics: BOD5 (mg/l)			Effluent Characteristics: TSS (mg/l)			Effluent Characteristics: pH	Effluent Characteristics: Fecal Coliform (Number Per 100 ml)	Existing Treatment	
Facility	(Minimum)	(Average)	(Maximum)	(Minimum)	(Average)	(Maximum)	(Minimum)	(Average)	(Maximum)	(Minimum)	(Average)	(Maximum)	(Minimum)	(Average)	(Maximum)	pH		Liquid	Sludge
Kenosha County																			
Paramski Mobile Home Park	--	--	--	101	178	218	404	734	940	--	--	--	--	--	--	--	--	EA-FC-D	S-L
Howard Johnson Motor Lodge and Restaurant	0.023	0.049	0.077	44	98	152	79	121	207	10	38	57	21	111	187	6.6	4,270	AS-FC-D-P	S-L
Brightondale County Park	--	0.002	--	--	71	--	--	20	--	--	4	--	--	3	--	8.3	--	AS-FC-P	AN-L
American Motors Corporation—Truck Service Facility	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-SF-D	S-L
Wheatland Mobile Home Park	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	CS-FC-D-P	S-L
Wisconsin Department of Transportation—Tourist Information Center	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-D-P	S-L
Sienadale Motherhouse	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-D-P	S-L
George Connolly Development (Under Construction)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-SF-D	S-L
Kenosha Packing Company, Inc.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	RF	--
Milwaukee County																			
Highway 100 Drive In Theater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-SF-P	S-L
Union Oil Highway 100 Truck Stop	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-D	--
Wisconsin Electric Power Company (Oak Creek)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-D	--
Ozaukee County																			
Sisters of Notre Dame School	0.130	0.160	0.210	--	--	--	--	--	--	1	2	2	1	2	3	7.5	--	AS-FC-D	S-L
Port Country Club	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-SF	S-L
Chalet on the Lake	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	PC-D	AN-L
Cedar Valley Cheese Factory	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SI-RF	--
Justo Foods Company (not in operation)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SA	--
Krier Preserving Company	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-P-SI	--
S & R Cheese Corporation	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-P-JA	--
Federal Foods, Inc.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-SA	--
Racine County																			
Wisconsin Southern Colony Training School	0.150	0.180	0.210	--	450	--	186	202	213	--	48	--	29	33	37	7.3	--	PC-CS-FC-D-P	AN-DB-L
Holy Redeemer College	0.002	0.008	0.013	45	93	144	47	135	320	3	8	32	3	6	8	7.0	--	EA-FC-D-P	S-L
St. Bonaventure Prep School	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	CS-FC-D-P	S
C & D Foods, Inc.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-P-D	--
Fonk's Mobile Home Park No. 1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-D-P	S
Fonk's Mobile Home Park No. 2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-D-P	S
Franks Pure Food Company	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P	--
Grove Duck Farm	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-P-D	--
J. I. Case Company	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	CH-FC	--
Meeter Brothers Company	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P	--
Packaging Corporation of America	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-D-P	--
Pekin Duck Company	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SI	--
Racine County Highway and Park Commission	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-D-P	--
Downy Duck Company, Inc.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-SI	--
Walworth County																			
Lakeland Nursing Home (Walworth County Institutions)	0.050	0.070	0.080	137	149	171	75	112	137	11	22	59	17	28	47	7.8	--	PC-AS-FC-D	S-L
Country Estates	0.018	0.015	0.023	109	155	270	40	108	170	12	29	46	13	26	56	7.2	--	EA-FC-D-P	S-L
Playboy Club Hotel	--	--	--	117	123	131	--	--	--	--	--	--	--	--	--	7.3	--	CS-FC-D-P-P	AD-S-L
Slovak Sokol Camp	--	--	--	--	81	--	--	94	--	--	10	--	--	12	--	--	--	AS	--
Alpine Valley Resort, Inc.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-P	S-L
Kikkomen Foods, Inc.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Aerobic Digester-P	--
Lake Lawn Lodge	0.05	0.070	0.10	31	81	128	60	82	103	31	38	44	51	69	98	7.0	--	PC-AS-FC-D	AN-S-L
Libby, McNeill & Libby—Darien	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-SI	--
Paiser Produce Company (not in operation)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-SA	--
Lake Geneva Interlaken Resort Village	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	CS-FC-SF-P-SA	S-L
Walworth County Correctional Center (not in operation)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-SA	--
Wisconsin Dairies Cooperative—Genoa City	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS	--
Wisconsin Department of Transportation—East Troy Rest Area	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	CS-FC-SF-D	AD-Contract Pickup
Washington County																			
Cedar Lake Rest Home	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	CS-FC-D-P	S-L
Level Valley Dairy	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-P	S-L
Libby, McNeill & Libby—Jackson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-P-SI	--
Libby, McNeill & Libby—Hartford	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-Hartford STP	--
National Farmers Association—Slinger Transfer Station	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	RF	--
Pike Lake State Park	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-SA	--
Waukesha County																			
New Berlin Memorial Hospital	0.210	0.260	0.370	175	230	276	85	116	149	8	21	30	9	32	79	7.0	--	AS-FC-D-P	S-L
Cleveland Heights School—New Berlin	0.002	0.005	0.007	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-SF-P	S-L
New Berlin High School	0.010	0.018	0.022	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-SF-P	L
Highway 24 Outdoor Theater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-SA	--
Wisconsin School for Boys—Wales	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	CS-FC-D-P	AD-DB
Steeplechase Inn	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	EA-FC-D-P	S-L
Gigas-Hillside Apartments	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-D	--
Oakton Manor—Tumblebrook Golf Course	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	PC-AS-FC	--
Rainbow Springs Resort (not in operation)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	AS-FC-D	AD-DB
St. John's Military Academy—Delafield	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-P	S-L
Willow Springs Mobile Home Park	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SA	--
Muskego Rendering Company	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	P-SA	--
Mammoth Springs Canning Company	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SI	--
Brookfield Central High School	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	SP-SF-P	--

TREATMENT KEY: Liquid

- PC - Primary Clarifier
- FC - Final Clarifier
- D - Disinfection
- SP - Septic Tank
- I - Imhoff Tank
- SF - Sand Filter
- AS - Activated Sludge
- EA - Extended Aeration
- CS - Contact Stabilization
- P - Lagoon
- TF - Trickling Filter
- CH - Chemical Treatment
- SI - Spray Irrigation
- SA - Soil Absorption
- SP - Septic Tank
- RF - Ridge and Furrow

Sludge

- L - Land
- S - Storage
- AN - Anaerobic Digestion
- AD - Aerobic Digestion
- DB - Drying Beds

Source: Wisconsin Department of Natural Resources and SEWRPC.

The majority of the industries in the area discharge their wastewater to municipal wastewater treatment plants. The Milwaukee-Metropolitan Sewerage District receives by far the largest amount of the Region's industrial flow. Pretreatment requirements for industries discharging wastes to a municipal treatment facility are discussed in Chapter VII. Application of schematics and costs to industrial facilities is discussed in Chapter V.

Solutions for a particular industrial facility are best made on a case-by-case basis because of the varied and complex nature of each industry and its process wastewater. Industrial treatment facilities discharging basically biodegradable organic matter can be assessed using the treatment schematics and costs developed in this report with minor adjustment of design parameters. Treatment options including oil and grease removal, heavy metal precipitation, neutralization, and cooling are discussed in this report and costs for the options are presented. Utilizing the cost and performance data provided, logical decisions can be reached on joint treatment, pretreatment, and separate treatment costs and benefits for most of the industrial enterprises in the Region.

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Chapter III

POINT SOURCE CONTROL REQUIREMENTS

INTRODUCTION

The overall objective in this report is to provide treatment processes and schematics that can be applied to regional raw wastewater of a given quality to produce desired effluent qualities. Effluent qualities are those which can protect instream water quality for beneficial uses. Regional raw wastewater qualities are reviewed in Chapter II. This chapter examines desired effluent quality objectives. Chapters II and V examine processes and schematics that can be applied in the Region to meet these effluent quality objectives.

EFFLUENT QUALITY OBJECTIVES

Municipal Wastewater Treatment

In Planning Report No. 16, 1990 effluent limitations for facilities in the Region were recommended.[1] The Wisconsin Department of Natural Resources (DNR) has not yet established limitations for 1990, and does not necessarily concur with all the 1990 recommendations made in that report.[2] At present, DNR requires all wastewater dischargers to provide a degree of treatment so that stream water quality standards are continually met for streamflows equal to or in excess of the seven day average low flow based on an average recurrence interval of 10 years. Effluent restrictions on publicly owned treatment facilities may apply to BOD_5, suspended solids, ammonia nitrogen, phosphorus, dissolved oxygen, and fecal coliforms (or chlorine residual). Where water quality standards are expected to be met, existing treatment facilities must remove at least 85 percent of BOD_5 and suspended solids and produce an effluent quality of at least 30 mg/l BOD_5 and 30 mg/l suspended solids, even if this requires greater than 85 percent removal. For new treatment facilities, the minimum allowable level of treatment is 90 percent BOD_5 removal and 90 percent suspended solids removal. These treatment requirements have been defined by DNR as secondary treatment. Where water quality standards are not expected to be met with secondary treatment levels, more stringent effluent limitations are specified in WPDES permits issued by DNR under the authority delegated by the federal government. The EPA has proposed that suspended solids levels for waste stabilization ponds with design flows less than 1.0 mgd be revised. The status of this proposed revision and its impact on the Region should be explored prior to alternative plan development.

Disinfection to a fecal coliform level of 200 per 100 ml is also required by DNR for all but stabilization pond effluents. Just recently, the EPA has amended its regulation governing disinfection of municipal wastewater in an effort to guard against excessive or unnecessary use of disinfectants in the treatment process.[3] Under the amendment, disinfection requirements for publicly owned wastewater treatment plants will be set in accordance with specific water quality standards and public health needs. Thus, it is expected that DNR in the future will establish new disinfection requirements for study area municipal treatment facilities.

Phosphorus control is required when the population equivalent of a treatment facility is greater than 2,500 and that facility discharges its effluent to the Great Lakes Basin or within the Fox River watershed in southeastern Wisconsin. Phosphorus control also is required of a facility of any size that discharges directly to a lake, or where phosphorus is determined the limiting factor in attaining water quality standards. When phosphorus control is needed, the specified monthly average level is generally 1.0 mg/l.

When ammonia toxicity to fish and aquatic life is suspected, effluent limitations for ammonia nitrogen are established. Effluent limitations for ammonia nitrogen also are set when stream oxidation of ammonia results in violation of dissolved oxygen standards.[4] Established ammonia nitrogen limitations usually differ between summer and winter months.

The degree of treatment to be provided at existing and proposed facilities is not finalized for many systems in the Region. Effluent requirements which may be necessary for the attainment of applicable water use objectives and supporting water quality standards in the Region have been identified by SEWRPC and are shown in Table 4. It is anticipated that water quality modeling will be performed to identify which specific effluent qualities are required for a particular facility to achieve stream water quality standards in subsequent regional 208 water quality management planning program efforts.

The effluent levels noted in Table 4 were established by SEWRPC and were intended to provide a relatively continuous range of potential effluent quality levels which could be practically met by applying various degrees of

[1] *Southeastern Wisconsin Regional Planning Commission, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, 1974.*

[2] *Wisconsin Department of Natural Resources, Water Quality Management Basin Plan for the Rivers of Southeastern Wisconsin, July 1975.*

[3] *See Federal Register of July 26, 1976.*

[4] *Wisconsin Department of Natural Resources, Water Quality Management Basin Plan for the Rivers of Southeastern Wisconsin.*

proven wastewater treatment technology. Effluent levels 1 and 2 were established as meeting secondary treatment requirements for influent wastewaters with 200 mg/l of BOD or more, with and without phosphorus removal requirements. Levels 4, 5, 6, and 7 were established based upon a review of the recommended effluent quality levels set forth in Planning Report No. 16.[5] These four levels were determined as necessary to meet the adopted water use objectives and supporting water quality standards established in that planning report. Level 3 was established to provide continuity from Levels 1 and 2 to Levels 4, 5, 6, and 7, as well as to cover instances where effluent BOD levels below 30 mg/l are needed to achieve 85 to 90 percent removal due to a low influent wastewater strength.

Effluent BOD_5 restrictions of 20 and 15 mg/l fall into the variance treatment categories developed by DNR. These categories—intermediate aquatic life and marginal uses—permit a variance for those surface waters which can only support some aquatic life because of low stream flow and natural background levels of water quality. The intermediate aquatic life category is designed to support a variety of insect life and forage fishes.

Levels 8 and 9 were established as further logical treatment steps which could be accomplished with continued application of proven treatment technology and which may be considered in some areawide water quality management alternatives for those treatment facilities which discharge to environmentally sensitive and significant streams or to surface waters where water use objectives and standards to be developed require a very high quality effluent.

Table 4

POTENTIAL EFFLUENT QUALITY OBJECTIVES

Effluent Characteristic Level	BOD_5 (mg/l)	TSS (mg/l)	Total P (mg/l)	NH_3-N (mg/l)	DO (mg/l)
1	30	30[a]			
2	30	25[a]	1		
3	20	20[a]			
4	15	15[a]			
5	15	15[a]	1		
6	15	20[a]	1	1.5[b]	
7[c]	15	15[a]		1.5[b]	
8	10	10[a]	1	1.5[b]	6
9	5	5[a]	1	1.5[b]	6

[a] *Effluent suspended solids concentrations specified are for general description purposes and are expected to correlate closely with effluent BOD_5 concentrations. Suspended solids concentrations are not presented as design requirements, however, since the design BOD_5 level is considered the primary design parameter.*

[b] *During winter months, NH_3-N effluent limit of 3 mg/l is specified.*

[c] *For communities which have 0.5 mgd or less daily average flow.*

Source: SEWRPC.

Although no suspended solids parameter restriction is specified, concentrations are expected to correlate closely with the effluent BOD_5 concentration. All wastewater discharges are to be in the pH range of 6.0 to 9.0 standard units with a desired range of 7.2 to 7.6 standard units. All effluents are to be disinfected, but chlorine residual should not exceed 0.50 mg/l at any point in the receiving water. Values for phosphorus, nitrogen, and dissolved oxygen are indicative of decisions that may be reached to require nitrification, phosphorus removal, or effluent aeration at certain facilities to meet water quality objectives.

One further level of treatment relating to the concept of zero discharge has been given consideration and is discussed in Appendix E. This is particularly important since the 1972 Amendments to the Federal Water Pollution Control Act call for the achievement of a national goal of zero discharge by 1985. The processes considered are applicable to an assumed effluent requirement of 5.0 mg/l BOD_5, 5 mg/l TSS, 0.5 mg/l NH_3-N, 0.1 mg/l total phosphorus, and fecal coliform levels less than 200/100 ml for all influent levels discussed in Chapter II. It is necessary to assume levels since the Federal definitions of zero discharge have yet to be established.

Industrial Wastewater Treatment

Many of the treatment schematics developed later in this report for municipal wastewater treatment are directly applicable to industrial wastes that primarily contain biodegradable organics. Some adjustment of design parameters is normally required. However, many industrial processes do not generate significant biodegradable organic material; therefore, different treatment approaches must be taken.

Effluent limitations for industry are determined either by effluent guidelines (WPDES permits) or instream water quality standards (waste load allocations). The WPDES system, which has been implemented since the passage of the Federal Water Pollution Control Act Amendments of 1972, requires each significant industrial point source to obtain a permit to discharge. These permits are usually written to express discharge criteria in terms of the maximum allowable mass of pollutants that can be discharged per day. The effluent limitations are "loosely" based on EPA "development documents" for point source categories or waste load allocations where water quality standards dictate more stringent effluent requirements. Two minimum effluent levels are specified by EPA: "Best Practicable Control Technology Currently Achievable" (BPCTCA) which must be met by July 1, 1977, and "Best Available Technology Economically Achievable" (BATEA) which is to be satisfied by July 1, 1983. Summaries of treatment processes or schematics that other investigators have perceived for meeting BPCTCA or BATEA criteria are presented in Appendix C. This listing has been extracted from various Federal Register publications on effluent limitation guidelines.

[5] *Southeastern Wisconsin Regional Planning Commission, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, 1974.*

If water quality standards are expected to be violated when wastes are discharged at the BPCTCA or BATEA levels, more stringent effluent limitations may be placed on an industry. These limitations will be developed through a waste load allocation analysis similar to that utilized for development of limitations for municipal facilities.

Because of the specific nature of each permit, the various processes that can be used at each facility, and limitations of scope, no schematics for industrial point sources are detailed in this report. Along with the schematics developed for municipal waste treatment, a discussion of industrial wastewaters is also presented in Chapter V.

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Chapter IV

WASTEWATER MANAGEMENT ALTERNATIVES

INTRODUCTION

This chapter presents background information on options available to meet water quality objectives in surface waters of the Region. Included are the following options:

1. Collection of wastewaters for treatment.

2. Treatment and discharge to meet specified effluent quality objectives.

3. Application of wastewater to land.

4. Treatment of surface waters.

Application of the options to various categories of wastewater sources occurring in the Region are detailed in subsequent chapters of this report.

WASTEWATER COLLECTION

All treatment systems include some transport of wastewaters from their point of generation to the point of treatment.

Onsite Collection and Holding Systems

Homes, businesses, and industries not served by central wastewater collection and treatment systems must provide their own treatment and disposal system or hold the wastewater until it may be transported to treatment and disposal facilities. If onsite treatment and disposal facilities are not feasible, a holding tank system is indicated. The flow is generally transported to the holding tank by gravity, but a vacuum system may be used to reduce the water flow needed to transport the wastewater solids. Vacuum systems are most successfully used to transport toilet wastes only, and are considered most economical when used for apartment houses or small groups of homes. The vacuum-transported waste must still be periodically removed from the vacuum receiving tank and transported to a disposal facility. Treatment facilities for small areas are discussed in Chapter VI.

Central Collection System

The vast majority of the residential population in the Region is served by central collection systems.

Gravity Collection Systems: The vast majority of existing collection systems utilize single pipe, gravity flow to transport wastewater to treatment facilities. This has been the historic method of constructing collection systems and will continue to be the predominant system for the foreseeable future.

Two major advances in gravity sewer design have recently emerged and involve the use of new piping materials and computer techniques to arrive at the least-cost combination of pipe size, slope, and depth. In the past two years, plastic pipe usage has increased from only about 2 percent of sewer main pipe installed to about 19 percent.[1] The advantages of plastic pipe include fewer joints, fewer corrosion problems, and easier installation than conventional pipe materials. Table 5 presents current usage estimates for various pipe materials in the United States.

Computer programs have been developed which optimize gravity collection system design. The programs generally consider minimum sewer grade, ground cover, critical invert elevation, and minimum maximum velocities to arrive at the least-cost design of pipe sizes, slopes, and depths. Gravity collection system cost curves are presented in Appendix D.

Force Mains: Pumping is more frequently being used in wastewater collection and transmission systems. Regionalization of treatment facilities often results in greater distances between the wastewater producer and the treatment facilities. Gravity systems may not be the most economical way to convey the wastewater the added distances. Housing developments may utilize pumping systems to convey wastewater to a noncontiguous sewer collection system until truck sewers are extended at a later time to serve the developments by gravity flow.

Wastewater pumping requires pumping (lift) stations to discharge the wastewater through the piping system. The piping system is generally constructed of ductile iron or polyethylene, which is usually more expensive than the reinforced concrete or vitrified clay piping normally used in gravity collection systems. Pumping station costs may be taken from the cost curve developed for raw waste pumping in Appendix D.

Grinder Pump/Pressure Sewer System: Wastewater collection in areas of rocky, hilly terrain, or high groundwater table is especially difficult and expensive. An alternate collection system which may be more economical than a gravity sewer-lift station system makes use of individual home grinder pumps which discharge into a common force main. The force main is laid in a narrow trench only deep enough to prevent freezing and follows the contours of the ground areas through which it passes. The use of plastic piping for the force main allows fast and easy installation while excluding ground water infiltration.

The force main for these systems must be carefully designed. The piping must be large enough to avoid excessive friction losses, which could overload the grinder pumps, but small enough to attain a velocity of two fps,

[1] *"Plastic Pipe Use Grows for Sewer Main Installations," American City and County, 90, September 1975.*

Table 5

MATERIALS USED IN SEWER CONSTRUCTION IN THE UNITED STATES

Current Sewer Pipe Mileage

Type	Mileage	Percent of Total
Vitrified clay	306,435	66.8
Reinforced concrete	74,359	16.2
Asbestos cement	24,767	5.4
Nonreinforced concrete	20,529	4.5
Cast iron	15,097	3.3
Plastic	9,392	2.1
Other	7,843	1.7
Total	458,422	100.0

Current Pipe Mileage by Size Range[a]

Type	Mileage	Percent of Total
Under 8 inches	73,286	16.0
8 inches to 14 inches	287,333	62.7
15 inches to 24 inches	60,914	13.3
Over 24 inches	36,889	8.0
Total	458,422	100.0

1974 Installations

Type	Mileage	Percent of Total
Vitrified clay	8,746	52.9
Reinforced concrete	2,487	15.0
Asbestos cement	1,156	7.0
Nonreinforced concrete	522	3.1
Cast iron	321	1.9
Plastic	3,168	19.3
Other	132	0.8
Total	16,532	100.0

1975 Installations

Type	Mileage	Percent of Total
Vitrified clay	7,354	43.7
Reinforced concrete	2,508	14.9
Asbestos cement	2,556	15.2
Nonreinforced concrete	209	1.2
Cast iron	988	5.9
Plastic	3,027	18.0
Other	181	1.1
Total	16,823	100.0

[a] *Size ranges, of course, vary among the major pipe materials. Approximately 55 percent of all reinforced concrete pipe is over 14 inches in diameter and almost one-third is larger than 24 inches. On the other hand, over 90 percent of all plastic in place is less than 15 inches in diameter. The majority of vitrified clay, asbestos cement, and cast iron pipe lie within the 8-inch to 14-inch range.*

Source: American City and County, September 1975.

frequently enough to avoid solids deposition. The design flow is dependent on the number of pumps operating simultaneously. Design curves have been established which relate the design flow to the number of grinder pumps connected to the force main.[2]

Costs for components of a grinder pump system are presented in Table 6. EPA demonstration projects in Albany, New York; Phoenixville, Pennsylvania; and Columbus, Indiana, and a municipally-financed system in Saratoga, New York, indicate savings of 50 to 80 percent when compared to the installation cost of a gravity collection system in difficult terrain.

[2] *I. G. Carcich et al, "The Pressure Sewer: A New Alternative to Gravity Sewers," Civil Engineering, May 1974, and R. L. Sanson, "Design Procedure for a Rural Pressure Sewer System," Public Works, 104, September 1973.*

TREATMENT AND DISCHARGE

Varying levels of constituent control are required of the municipal wastewater treatment facilities with surface water discharges as discussed in Chapter III. Ammonia, phosphorus, and increased organic and solids removal may be needed. Numerous unit processes are available for various constituent removal from domestic wastewaters. A summary of conventional and additional wastewater treatment processes which are commonly used is presented in Figure 3. A discussion of these processes and their applicability to the SEWRPC area follows:

Organic and Solids Removal

By July 1, 1977, an effluent quality equivalent to secondary treatment requirements must be obtained by all municipal facilities. Because of their familiarity, secondary treatment processes are only briefly discussed.

Primary sedimentation removes readily settleable solids and floating material, thus reducing the suspended solids content in the wastewater. Efficiently designed and

Table 6

PRESSURE SEWER SYSTEM COMPONENT COSTS

Component	Cost (in Dollars)
Grinder Pump.	1,000-2,000
Outside Installation (Includes excavation, manhole, cover, frame, electrical connection)	300-700
Inside Installation (Includes electrical connection and plumbing).	100-300
Clean-outs (concrete box)	200-400
Pipe Installation per Lineal Foot (including material) to a 5-foot depth	
a. Use of power trencher in new area being developed.	2-5
b. Use of power trencher in area already developed	5-10
c. Use of backhoe in new area being developed.	4-6
d. Use of backhoe in area already developed	7-15
Pressure Sewer Appurtenances per Lineal Foot (Includes check valves, curb stops, pressure main shut-off, and valves)	2

Source: Journal, Environmental Engineering Division, ASCE, February 1974.

operated, primary clarifiers generally remove from 50 to 65 percent of the suspended solids and 25 to 40 percent of the BOD_5.[3] When chemicals (salts of iron or aluminum) are mixed with the influent wastewater, removal efficiencies of 60 to 75 percent of suspended solids and 40 to 50 percent of BOD_5 have been obtained.[4] Fine screens have been used in place of clarifiers at several locations (such as Jones Island).

Trickling filters have been widely used for wastewater treatment in the United States. Under normal operation, trickling filter plants preceded by primary sedimentation usually remove 75 to 85 percent of the BOD_5.[5] Data from the monthly operation reports of municipal facilities on the Lower Peninsula of Michigan showed the median BOD_5 removal around 83 percent.[6]

As mentioned in Chapter II, the majority of the trickling filter plants in the study area are not removing 85 percent of the BOD_5, the secondary treatment requirements. Since approximately 60 to 70 percent of the effluent BOD_5 appears to be due to suspended solids, secondary treatment effluent limitations would probably be met with increased suspended solids removal. An effluent containing 30 mg/l BOD_5 could be achieved by a trickling filter when treating low strength wastewaters (although this may not represent secondary treatment as defined as 85 percent removal).

Rotating biological contactors (bio-discs) are a relatively new wastewater treatment process in the United States. Although bio-discs operate much on the same principle as trickling filters (attached growth systems), much higher BOD_5 removals (85 to 90 percent) have been obtained.[7]

The activated sludge process is very flexible and can be adapted to treat almost any type of raw wastewater. There are many modifications of the activated sludge process in practice today. Each modification has its advantages and disadvantages: some achieve better BOD_5 and suspended solids removal than others, some cost less to construct, others cost less to operate, some produce less sludge, and some obtain better nutrient removal. No attempt is made in this report to analyze the applicability of each type of activated sludge process to the treatment needs of the study area. Instead, the activated sludge process is generally discussed with the exceptions of the contact stabilization and extended aeration processes which are now commonly used in the Region.

The activated sludge process generally achieves 85 to 95 percent overall BOD_5 reduction with proper operation.[8] Solids retention times (SRT) are normally between five and 15 days. Plants operating at the higher SRTs generally achieve higher removal efficiencies. However, operational constraints (mixing difficulties, oxygen mass transfer limitations, nutrient depletion, and clarification of biological floc) limit the use of high SRT values.

[3] *Metcalf and Eddy, Inc., Wastewater Engineering, McGraw-Hill, New York, New York, 1972.*

[4] *Metcalf and Eddy, Inc., for U. S. Environmental Protection Agency, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, October 1974, and Black and Veatch and Shimik, Roming, Jacobs, and Finklea for the U. S. Environmental Protection Agency, Process Design Manual for Phosphorus Manual, April 1976.*

[5] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants.*

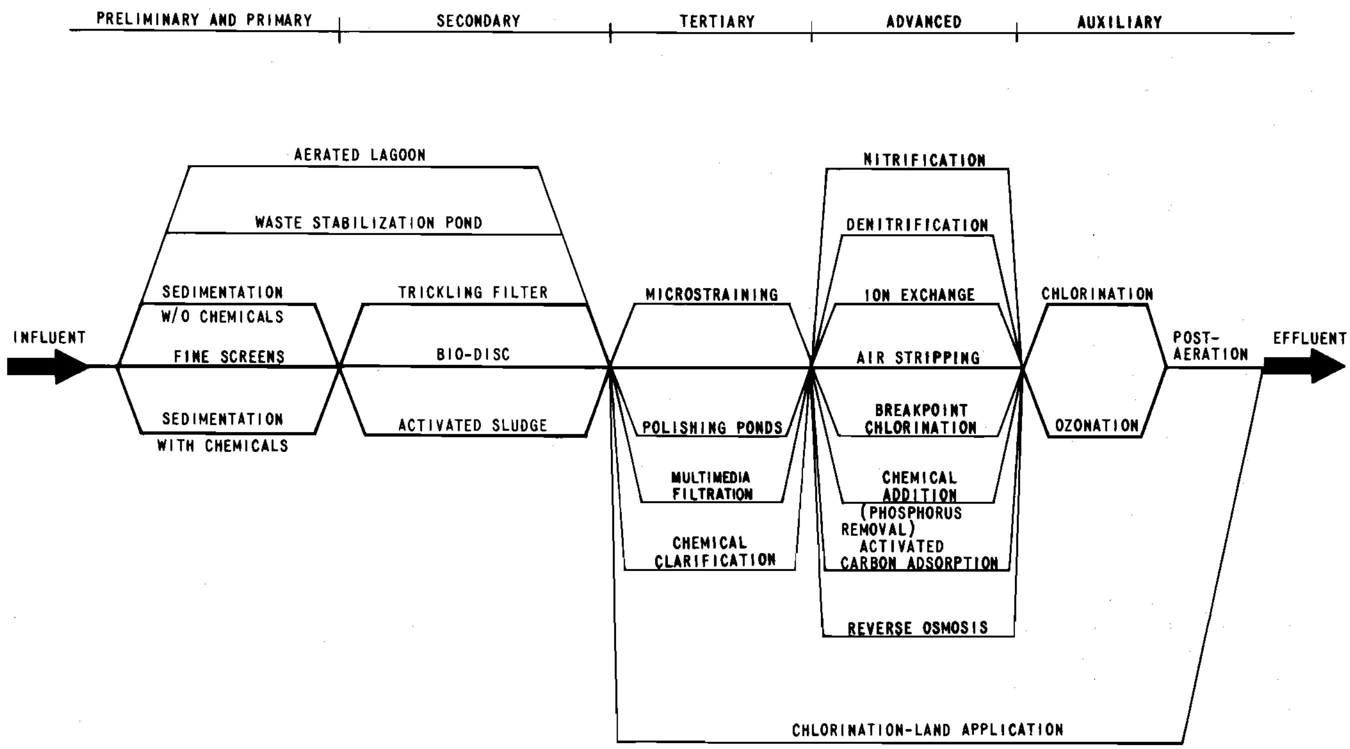
[6] *Clark, Viessman, and Hammer, Water Supply and Pollution Control, International Textbook Company, Scranton, Pennsylvania, 1971.*

[7] *Autotrol Corporation; H. Oliver and E. P. Leary.*

[8] *Metcalf and Eddy, Inc., Process Design Manual for Upgrading Existing Wastewater Treatment Plants, and Metcalf and Eddy, Inc., Wastewater Engineering.*

Figure 3

WASTEWATER TREATMENT ALTERNATIVE PROCESSES



Source: Stanley Consultants.

The advantage of the contact stabilization process is a smaller total aeration tank volume because of the use of contact and sludge reaeration tanks. This process is only applicable for wastes with limited soluble BOD_5. Efficiency ranges from 80 to 90 percent of the BOD_5.[9]

The extended aeration process is generally used in small communities for wastewater treatment in the form of package treatment plants. The hydraulic retention time of this process is 24 hours or greater which makes the process operate in the endogenous growth phase, which results in very low sludge production. This may reduce the requirements for separate sludge handling treatment processes. Primary sedimentation is not generally needed. BOD_5 removal efficiency ranges from 75 to 95 percent.[10]

Recently, there has been a great deal of interest in the use of pure oxygen as a substitute for air in the activated sludge process. The advantages of using pure oxygen include reduction in aeration tank volume, decreased sludge volume, and improved sludge settling characteristics. The system is most advantageous and has been most widely used on high strength wastes. Detailed investigations during subsequent 201 facilities planning studies in the Region will determine if the system is cost-effective for a particular facility.

An aerated lagoon system is similar to the complete mix activated sludge process with the exception that solids are not recycled to the lagoon. Up to 90 to 95 percent BOD_5 removals are obtainable, depending on detention time and the degree of solids removed.[11] Large land requirements and decreased treatment efficiency in cold weather are the principal disadvantages of aerated lagoons.

Waste stabilization ponds have been widely used throughout the United States because of their relatively low construction costs and minimal operation and maintenance requirements. High solids carryover (primarily algae) and seasonal changes (spring turnover after winter ice cover) are a few of the problems which make secondary effluent standards very difficult to achieve with this process. However, because of the cost advantages for small communities, EPA has issued a draft regulation

[9] *Clark, Viessman, and Hammer, Water Supply and Pollution Control, International Textbook Company, Scranton, Pennsylvania, 1971, and Metcalf and Eddy, Inc., Wastewater Engineering.*

[10] *Clark, Viessman, and Hammer, Water Supply and Pollution Control, and Metcalf and Eddy, Wastewater Engineering.*

[11] *Brown and Caldwell for the U. S. Environmental Protection Agency, Upgrading Lagoons, August 1973.*

revising the definition of secondary treatment to allow the use of stabilization ponds for communities with wastewater flows less than 1 mgd.

Nitrogen Control:[12] Wastewaters containing nitrogen can cause several deletrious effects when discharged to receiving waters. Among the most notable are biostimulation of receiving waters, toxicity to aquatic life, and dissolved oxygen depletion in surface waters.

Currently, ammonia nitrogen is the major form of nitrogen restricted by regulatory agencies in municipal wastewater discharges in the Region. Therefore, the following discussion is centered around ammonia conversion to nitrate nitrogen, even though other forms of nitrogen may be reduced concurrently. Processes to remove nitrogen from wastewater (biological nitrification-denitrification, ion exchange, ammonia stripping, and breakpoint chlorination) are generally not required to meet the specified effluent quality objectives in Chapter III.

Nitrogen control can be accomplished by physical, chemical, and biological techniques. Nitrogen concentrations in raw municipal wastewater generally range from 15 to 50 mg/l. Nitrogen is principally in the form of organic nitrogen, both soluble and suspended, and ammonia. The soluble organic nitrogen is mainly in the form of urea and amino acids.

Primary sedimentation removes a portion of the suspended organic nitrogen (less than 10 percent of the total nitrogen). Where chemical addition for phosphorus control occurs in the primary clarifier, additional nitrogen reduction can be expected. Overall total nitrogen reduction of less than 30 percent can be expected with chemical addition.

Suspended organic nitrogen is removed and also transformed to ammonia and other inorganic forms in biological treatment. In addition, some of the ammonia is taken up to form new cell material. Overall, 10 to 20 percent of the total nitrogen is removed with biological treatment and secondary sedimentation. For a conventional primary-secondary biological treatment facility, total nitrogen removal is usually less than 30 percent.

Other advanced wastewater treatment processes used to remove constituents other than nitrogen often provide some form of total nitrogen reduction. Nitrogen removed is usually in the particulate form, and overall removal efficiency is generally not too high. These processes and the nitrogen form commonly removed by them are listed below:

1. Filtration—organic nitrogen.
2. Carbon adsorption—organic nitrogen.
3. Reverse osmosis—ammonia and nitrate.
4. Electrodialysis—ammonia and nitrate.
5. Land disposal—all forms of nitrogen.

Processes that are currently applicable for nitrogen removal include biological nitrification-denitrification, breakpoint chlorination, selective ion exchange, and air stripping. There are other methods of nitrogen removal available, but most are in the experimental stage of development or occur coincidentally with another process.

The above mentioned nitrogen removal processes remove various forms of nitrogen to various degrees. Biological nitrification transforms ammonia to nitrate by biological oxidation. Nitrification can be carried out in conjunction with secondary treatment (combined carbon oxidation-nitrification system) or in a separate stage. Both suspended growth (activated sludge) and attached growth reactors (trickling filters and bio-discs) have been used and can oxidize up to 98 percent of the ammonia to nitrate.

In breakpoint chlorination, chlorine is added in sufficient amounts to chemically oxidize ammonia to nitrous oxide and nitrogen gas. In practice, approximately 10 mg/l of chlorine is added for every one mg/l of ammonia. With this method, ammonia concentrations can be reduced to near zero. However, pH adjustment and dechlorination are sometimes necessary.

Ammonia removal in the 90 to 97 percent range can be expected in a clinoptilolite ion exchange system. Filtration is usually required prior to ion exchange to prevent fouling of the resins. In the air stripping process, ammonium ions are converted to molecular ammonia at high pH. The wastewater then passes through a stripping tower where ammonia is transferred to the adjacent air. Table 7 summarizes expected nitrogen removal efficiencies that are attained by various wastewater treatment processes.

Although it has the advantages of high efficiency and insensitivity to temperature fluctuations, selective ion exchange with filtration is not cost-effective when compared to other methods. Air stripping is not applicable to the study area principally because of its inefficiency in cold weather and required shutdown during freezing conditions. Due to the high operating costs and resulting increase in total dissolved solids concentration, breakpoint chlorination is only desirable as an effluent polishing technique. For the region, biological nitrification appears to be the best selection for ammonia conversion.

There are many alternatives in the selection of biological nitrification systems. Both combined carbon oxidation-nitrification (single-stage) and separate stage nitrification processes are used. These processes can be further subdivided into suspended growth and attached growth processes.

The BOD_5:TKN ratio of the wastewater influent to the nitrification process is usually less than 3.0 for separate stage nitrification. For single-stage nitrification, an

[12] *Brown and Caldwell for the U. S. Environmental Protection Agency, Process Design Manual for Nitrogen Control, October 1975.*

Table 7

EFFECTS OF VARIOUS TREATMENT PROCESSES ON NITROGEN COMPOUNDS

Treatment Process	Effect on Constituent: Organic N	Effect on Constituent: NH_3/NH_4^+	Effect on Constituent: NO_3^-	Removal of Total Nitrogen Entering Process (percent[a])
Conventional Treatment Processes				
Primary	10-20 percent removed	No effect	No effect	5-10
Secondary	15-25 percent removed[b] Urea → NH_3/NH_4^+	< 10 percent removed	Nil	10-20
Advanced Wastewater Treatment Processes				
Filtration[c]	30-95 percent removed	Nil	Nil	20-40
Carbon adsorption	30-50 percent removed	Nil	Nil	10-20
Electrodialysis	100 percent of suspended organic N removed	40 percent removed	40 percent removed	35-45
Reverse osmosis	100 percent of suspended organic N removed	85 percent removed	85 percent removed	80-90
Chemical coagulation[c]	50-70 percent removed	Nil	Nil	20-30
Land Application				
Irrigation	→ NH_3/NH_4^+	→ NO_3^- → plant N	→ plant N	40-90
Infiltration/percolation	→ NH_3/NH_4^+	→ NO_3^-	→ N_2	0-50
Major Nitrogen Removal Processes				
Nitrification	Limited effect	→ NO_3^-	No effect	5-10
Denitrification	No effect	No effect	80-98 percent removed	70-95
Breakpoint chlorination	Uncertain	90-100 percent removed	No effect	80-95
Selective ion exchange for ammonium	Some removal, uncertain	90-97 percent removed	No effect	80-95
Ammonia stripping	No effect	60-95 percent removed	No effect	50-90
Other Nitrogen Removal Processes				
Selective ion exchange for nitrate	Nil	Nil	75-90 percent removed	70-90
Oxidation ponds	Partial transformation to NH_3-NH_4^+	Partial removal by stripping	Partial removal by nitrification-denitrification	20-90
Algae stripping	Partial transformation to NH_3/NH_4^+	→ cells	→ cells	50-80
Bacterial assimilation	No effect	40-70 percent removed	Limited effect	30-70

[a] *Will depend on the fraction of influent nitrogen for which the process is effective, which may depend on other processes in the treatment plant.*

[b] *Soluble organic nitrogen, in the form of urea and amino acids, is substantially reduced by secondary treatment.*

[c] *May be used to remove particulate organic carbon in plants where ammonia or nitrate are removed by other processes.*

Source: Brown and Caldwell for U. S. Environmental Protection Agency, Process Design Manual for Nitrogen Control, October 1975.

influent BOD_5:TKN ratio greather than 5.0 is generally required. The main advantage of a combined carbon oxidation-nitrification system is that carbonaceous material and ammonia are treated in a single reactor eliminating the need for a separate aeration basin and an additional clarifier. Due to the high influent BOD_5:TKN ratio, careful control of sludge inventory is not required. A disadvantage is the moderate stability of operation. Separate stage nitrification systems are very stable in operation, but require careful control of sludge inventory. A single-stage suspended growth system also produces lower sludge quantities than a two-stage system. Since combined carbon oxidation-nitrification systems have performed well in the cold climates of the United States and represent cost savings, single-stage nitrification is proposed for new treatment facilities and where existing facilities can be modified.[13] Separate stage systems may be more appropriate in existing facility upgrading.

In the past, nitrification has usually been provided by suspended growth systems. In recent years, attached growth systems, primarily bio-discs, have been considered.

[13] *Ibid.; The Metropolitan Sanitary District of Greater Chicago, Department of Research and Development, Report No. 76-2, Single Stage Nitrification Study at the West-Southwest Treatment Plant, November 1975, and Report No. 76-8, Report on the Single Stage Biological Nitrification of Calumet Sewage, March 1976.*

In general, attached growth reactors do not normally achieve as high ammonia removals as suspended growth, but bio-discs have been reported to be able to achieve ammonia levels of 1.5 mg/l or less in separate stage systems.[14] Performance data for bio-discs in combined carbon oxidation-nitrification is limited. No installation of this type is known at this time. Therefore, bio-discs are recommended for separate stage nitrification with existing trickling filters, because the process is similar to trickling filters and, therefore, familiar to operating personnel. Because of ease of operation, bio-discs may also be desirable for nitrification when following activated sludge processes. However, at large capacity treatment facilities, suspended growth systems are generally more cost-effective. Bio-discs are not recommended for combined carbon oxidation-nitrification system due to lack of data demonstrating adequate removals. Two-stage trickling filters for nitrification are limited by NR 110.19 provisions restricting their use.

Phosphorus Removal:[15] The Wisconsin DNR requires many of the treatment facilities in the study area to remove phosphorus. Phosphorus can be removed at the treatment facility or from the wastewater at the source. Human wastes, detergents containing phosphate builders, scale and corrosion inhibitors used in water treatment, and industrial wastewater discharges are the major sources of phosphorus in municipal wastewater. The incoming concentration of phosphorus at a particular treatment facility is determined by the overall contribution of these sources. Options for phosphorus control include:

1. Reduction in the use of phosphate-containing detergents.

2. Pretreatment or internal reuse of high-phosphorus level industrial wastes.

3. Reduced use of phosphates in water supplies.

4. Removal at the wastewater treatment facility.

5. Combined treatment of phosphorus deficient wastewaters (i.e., paper and pulp, canning, and starch) with municipal wastewaters.

Municipal wastewaters contain on the average approximately 10 mg/l of total phosphorus which may be present in three principal forms: orthophosphate, polyphosphates, and organic phosphates. Orthophosphate makes up about 25 to 30 percent of the total phosphates in settled raw domestic wastewaters. In biological treatment, polyphosphates are converted to soluble orthophosphates through hydrolysis. Thus, the orthophosphate concentration in the final secondary influent is a large fraction of the total phosphorus present. Primary treatment alone removes 5 to 10 percent of the total phosphorus concentration. Approximately 5 to 10 percent of the influent phosphorus is removed via cell growth during secondary treatment.

Chemical precipitation appears to be the most widely accepted method available for phosphorus removal. The orthophosphate form of phosphorus is the easiest to precipitate. Chemicals commonly used as coagulants include: iron salts (ferric chloride, ferric sulfate, ferrous chloride, ferrous sulfate, and pickle liquor), aluminum salts (alum and sodium aluminate), and lime. The theoretical requirement for precipitation with aluminum salts is 0.87 pounds A1 per pound P, 1.8 pounds Fe per pound P with iron salts, or 2.2 pounds Ca per pound P with lime. In actual practice, higher chemical dosages are necessary in order to overcome competing reactions.

Waste pickle liquor (ferrous sulfate) as an iron source is successfully utilized to precipitate phosphorus at the City of Milwaukee Sewerage Commission Jones Island activated sludges treatment facility. Results of one study[16] indicated that the plant effluent phosphorus concentration averaged 0.72 mg/l of phosphorus when the plant screened influent total phosphorus concentration was 7.3 mg/l. Total soluble phosphorus concentration in the plant effluent averaged 0.25 mg/l while the plant screened influent total soluble phosphorus concentration was 2.7 mg/l. It was noted that no minimum iron dosage was established but that the minimum would be below 8.8 mg/l.

Chemical addition for phosphorus precipitation can be made at several locations in a wastewater treatment system. Chemicals can be added before the primary clarifier, in the secondary treatment process, or to the final effluent.

In the primary clarifier, aluminum or iron salts are primarily used instead of lime to minimize adverse pH affects on subsequent biological processes. An anionic polymer is often used to enhance flocculation. A disadvantage of this chemical application point is that a significant amount of the phosphorus may not be in the ortho form and may not be easily precipitated. Phosphorus removal can be increased if chemicals are also added at other points. Even so, 70 to 90 percent of the phosphorus can be removed in primary sedimentation with chemical addition. An additional 10 to 15 percent phosphorus reduction can be expected in the secondary biological treatment units. An advantage of chemical addition to the primary clarifier is the increase in BOD_5 and suspended solids removal which

[14] *Autotrol Corporation, manufacturer's literature describing performance of Bio-surf process, and Brown and Caldwell, Process Design Manual for Nitrogen Control.*

[15] *Black and Veatch, and Shemik, Roming, Jacobs, and Finklea for the U. S. Environmental Protection Agency, Process Design Manual for Phosphorus Manual.*

[16] *R. P. Leary et al, "Phosphorus Removal Using Waste Pickle Liquor," Journal Water Pollution Control Federation 46, No. 2, February 1974.*

reduces loads on subsequent biological processes. The concept cannot be applied to facilities not equipped with primary clarifiers. Contact stabilization processes limit time available for orthophosphate formation, and facilities without primary clarifiers may have difficulty in consistently meeting a 1.0 mg/l effluent criteria.

Mineral addition (aluminum or iron salts) to the secondary treatment process is usually added just prior to entering the final clarifier. Direct chemical addition to the tail end of the aeration tank is sometimes employed with the activated sludge process. At these points, the phosphorus is primarily in the ortho form which lowers the iron or aluminum dosages required as compared with addition to primary units. When chemicals are added at both the primary and secondary units of the treatment facility, high phosphorus removals (greater than 90 percent) can be obtained. Residual phosphorus levels of approximately 1.0 mg/l can usually be obtained.

Phosphorus can also be removed by addition of lime and other chemicals to the final effluent of the treatment facility in either a single or two-stage process called lime clarification. Lime clarification of final effluents followed by filtration can usually achieve phosphorus levels to about 0.1 mg/l. Capital costs are much greater than chemical addition in the secondary treatment plant because of the cost of lime clarification units and filters.

To achieve an effluent standard of 1.0 mg/l P, mineral addition (aluminum or iron salts) to the primary and secondary units of the treatment facility is proposed. Lime treatment has the disadvantage of increasing hardness and alkalinity (raises pH). Also, storage and handling of lime create more problems than the iron or aluminum salts. In addition, lime sludges require separate treatment, where aluminum and iron sludges can be incorporated in biological sludge digestion processes. If lower residual phosphorus levels must be achieved, lime clarification and effluent filtration are required.

Addition of alum or iron salts lowers wastewater pH by precipitating metal hydroxide. Most wastewaters contain sufficient alkalinity to limit the pH reduction. When insufficient alkalinity is present, sodium hydroxide or other bases are needed. Sodium aluminate can also be used to reduce adverse pH affects on low alkalinity wastewaters.

Sludges produced with iron or aluminum salts have a significantly different character than conventional biological sludges. Quantities are greater and handling and dewatering properties are different. They can usually be handled effectively by conventional biological sludge treatment processes.

Additional Organic and Solids Reduction

In order to maintain water quality standards, higher BOD_5 and suspended solids removals may be required than can be obtained with secondary treatment processes. Most of the treatment processes used for phosphorus and nitrogen removal remove additional BOD_5 and suspended solids. Biological nitrification combined with secondary treatment has been reported to remove 95 to 97 percent BOD_5 and suspended solids.[17] When chemicals have been applied for phosphorus control, over 95 percent removals of overall BOD_5 and suspended solids have been recorded.[18]

In many cases, lower BOD_5 levels can be achieved by simply reducing the suspended solids in the effluent. Filtration and microscreening are processes commonly employed for suspended solids reduction. Microscreens are capable of removing 45 to 80 percent of the incoming suspended solids.[19] However, even under best operation, 5 to 10 mg/l of suspended solids will pass through the microscreen unit. The units are not as effective as filters in removing chemical floc which may be present following phosphorus precipitation. It is estimated that a 30 to 70 percent reduction of BOD_5 can be obtained by microstrainers.[20] The effectiveness is a function of the soluble BOD_5 in the effluent. Activated sludge and extended aeration soluble BOD_5 will usually be about 10 to 20 percent. Effluents from contact stabilization and trickling filters may have 30 to 50 percent of the BOD_5 in the soluble form. Soluble BOD_5 is not effectively removed by screening or filtration.

Although more expensive than sand filters, multimedia filters are sometimes preferred over sand filters because of higher application rates, lower head losses, and lower backwashing frequency which are sometimes associated with the multimedia fulters. For small wastewater flows, sand filters are usually employed. Past filter performance indicates 50 to 90 percent of the incoming suspended solids can be removed along with 50 to 80 percent of the BOD_5.[21]

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[17] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, and Brown and Caldwell, Process Design Manual for Nitrogen Control.*

[18] *Black and Veatch, Process Design Manual for Phosphorus Manual, and Richard W. Ockershausen, "In-plant Usage Works and Works," Environmental Science and Technology, 8, May 1974.*

[19] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, and Hazen and Sawyer for the U. S. Environmental Protection Agency, Design Manual for Suspended Solids Removal, October 1971.*

[20] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, and E. P. Saffran and R. A. Kormanik, "Designing Microscreens: Here's Some Help," Water and Wastes Engineering, April 1976.*

[21] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, and Hazen and Sawyer for the U. S. Environmental Protection Agency, Design Manual for Suspended Solids Removal, October 1971.*

To obtain BOD_5 removals below 10 mg/l, carbon adsorption is usually employed, except for low strength wastewaters.[22] Carbon adsorption is generally preceded by filters. Because of the possibility for economical regeneration, the granular form of activated carbon is often preferred over powder.

For the present, reverse osmosis and ion exchange processes are not cost-effective for practical advanced wastewater treatment. Rapid advances are being made in ion exchange technology for wastewater treatment and practical systems may be available in the next few years.

Polishing ponds have been used to upgrade existing secondary biological treatment facilities in the study area. Effluent holding ponds are required by NR 110.28 after extended aeration systems. Data has indicated that significant BOD_5 removal is obtained, but effluent suspended solids data show that a net increase in solids concentration sometimes occurs.[23] This increase is due to algae production in the lagoon, particularly in the summer months. In some cases, polishing ponds followed by sand filters can resolve the solids carryover. There is some doubt on whether the high algae induced solids loadings are harmful to receiving waters.

Disinfection

Wastewaters can be disinfected by chlorination or ozonation if receiving stream quality is such to require disinfection. Currently, chlorination is by far the most economical method. Ozonation provides a degree of advanced treatment, precludes the need for effluent aeration, and does not introduce known harmful byproducts in its use. Consideration of these factors and further developments to reduce the cost of ozonation may make the process more usable in the future.

LAND APPLICATION

Development of systems to meet high degrees of treatment in the past several years has resulted in consideration of land application approaches as an alternative to treatment and direct return to surface waters. The concept of land disposal of wastewaters was considered in SEWRPC Planning Report 16. Conclusions reached included:

1. Land application appears to be suitable within the Region only for rather small, isolated communities located in rural, agricultural areas.

2. The long period of potential below-freezing temperatures (November 1 to April 1) precludes the possibility of using spray irrigation systems (most effective application system) without large storage reservoirs.

3. The low permeability of the soil restricts application rates to one inch per week requiring 300 acres per mgd of wastewater (for 30-week growing season).

4. Only a relatively small portion of the Region has soils suitable for land application (Note: Based primarily on suitability interpretations for onsite septic systems.) The neutral or mildly alkaline soils may lead to toxic conditions in the soils when wastewaters are applied.

5. The costs of land application were higher than costs for advanced wastewater treatment.

6. The biggest constraint on the concept was determined to be the large areas of land required. An area equal to the area of Racine County would be required to treat all the wastewaters from the Region.

7. Land application on a small individual community scale is within the realm of possibility and should be considered by design engineers during plan implementation.

Considerations for potential land application in the Region are discussed herein. Considerable literature is available and reported elsewhere on most other treatment and discharge controls. Information on land treatment systems is not extensively available, so this part summarizes some of the background for potential application to the 208 study area. A recent report on land application in Wisconsin has been issued and should be consulted for additional information on the topic.[24] A relatively large land application system is located in Muskegon County, Michigan, which contemplates utilizing about 5,600 acres to eventually treat up to 43 mgd.[25]

Concepts

Land application of wastewater consists of the transport of municipal and industrial wastewaters from an urban area to suitable rural areas for secondary treatment followed by disposal on the land. For existing facilities, the secondary treatment will usually be provided in the urban area and the effluent will be transported to rural areas. For new operations, the treatment facilities will likely be more economically located adjacent to the land application area.

Transmission facilities required to convey wastewater to the land application locations consist of conventional gravity sewers, force mains, and pumping stations. For new facilities, aerated lagoons will provide biological treatment and the effluent will discharge to storage

[22] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, and CH_2M/Hill for the U. S. Environmental Protection Agency, Process Design Manual for Carbon Adsorption, October 1973.*

[23] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants.*

[24] *Wisconsin Department of Natural Resources, Guideline Document for the Design, Construction, and Operation of Land Disposal Systems for Liquid Wastes, draft, November 1975.*

[25] *R. L. Lappo, "Living Filter Perks Up Regional System," Water and Wastes Engineering, June 1976.*

Table 8

COMPARATIVE CHARACTERISTICS OF LAND APPLICATION OF WASTEWATER

Factor	Irrigation	Overland Flow	Infiltration-Percolation
Waste Loading Rate	0.5 to 4 inch/week	2 to 5.5 inch/week	4 to 120 inch/week
Annual Application	2 to 8 feet/year	8 to 24 feet/year	18 to 500 feet/year
Land Required for 1 mgd Flow	140 to 560 wet acres	46 to 140 wet acres	2 to 62 wet acres
Application	Spray or surface	Spray	Surface
Soils Needed	Moderate permeability	Slow permeability	Rapid permeability
Soil Depth Needed	5 feet	Undetermined	15 feet
Desirable Slope	0 to 15 percent	2 to 6 percent	0 to 2 percent
Removal Expected[a]			
BOD	98 percent	92 percent	85 to 99 percent
COD	95 percent	85 percent	60 percent
Suspended Solids	99 percent	92 percent	85 to 99 percent
Metals	95 percent	50 percent	50 to 60 percent
Nitrogen	85 percent	70 to 90 percent	0 to 50 percent
Phosphorus	80 to 99 percent	40 to 80 percent	60 to 95 percent
Water to Groundwater	0 to 70 percent	0 to 10 percent	70 to 99 percent
Use for Crop Growth	Excellent	Fair	Poor
General Use	Common	Rare	Rare
Treatment Reliability	Excellent	Fair	Fair
Failure Correction	Fair	Excellent	Poor

[a] *Depends upon crop grown.*

Source: U. S. Environmental Protection Agency and U. S. Army Corps of Engineers.

lagoons capable of retaining flows when land application treatment is not practicable. Disinfection of the storage lagoon effluent is required.

Application Methods

The three most common approaches for applying wastewater to the land are presented in Table 8 and summarized below:

1. Irrigation—Land application where wastewater is applied to enhance the growth of plants. Moderate amounts of wastewater infiltrate the surface and percolate to the groundwater. Water applied either evapotranspirates or infiltrates to the ground water.

2. Overland Flow—Land application by spray runoff is the process of spraying wastewater on to gently sloping, relatively impermeable soil which has been planted with vegetation. A large portion of the applied water appears as runoff.

3. Infiltration-Percolation—An approach to land application where large volumes of wastewater are applied to the land, infiltrate the surface, and percolate through the soil pores. Most applied water appears as ground water.

The irrigation method is generally most applicable for the study area because it provides a higher level of treatment and is generally more reliable than overland flow or infiltration-percolation. All have been used in Wisconsin for small facilities.[26]

The vegetative cover on the land, the biological organisms in the soil, the filtering capacity of the soil, and the chemical fixation properties of the soil are all used to remove constituents from wastewater. The degree of treatment provided depends upon a number of factors, including:

1. The characteristics and application rate of the wastewater.

2. The climate of the area and the resultant influence upon water use by plants, and application rates and schedules.

3. The plants growing in the application area since they influence water use, nutrient use, and tolerance to various wastewater characteristics.

[26] *Wisconsin Department of Natural Resources, Guideline Document.*

Table 9

REQUIRED WASTEWATER CHARACTERISTICS IN LAND APPLICATION

Constituent	Quality Applied to Land Range (mg/l)	Quality Applied to Land Average (mg/l)	Waste Load in 1-Inch Average Application (lb/acre)
BOD_5	10 to 42	25	5.65
Suspended Solids	10 to 100	25	5.65
Total Phosphorus	8 to 25	10	2.26
Total Potassium	10 to 40	15	3.39
Total Nitrogen	10 to 60	20	4.52
Ammonia Nitrogen	1 to 40	10	2.26
Organic Nitrogen	0 to 4	2	0.46
Nitrate Nitrogen	0 to 10	8	1.81
Zinc	0.02 to 20	0.15	0.0339
Copper	0.02 to 5.9	0.10	0.0226
Nickel	0.02 to 5.4	0.02	0.0045
Boron	0.5 to 1.0	0.60	0.136
Cadmium	0.011 to 0.021	0.014	0.003
Mercury	0.0004 to 0.0012	0.0005	0.0001
Lead	0.05 to 0.13	0.01	0.0023
Chromium	0 to 0.50	0.10	0.0226

Source: U. S. Environmental Protection Agency, U. S. Army Corps of Engineers, and U. S. Department of Agriculture.

4. The surface soils of the area because they influence the infiltration rate of the water, plant growth, and chemical content of the percolated water.

5. The subsurface soils and geology of the area because they constrain the quality and quantity of treated wastewater reaching the groundwater.

Required Wastewater Characteristics

The estimated quality of applied wastewater necessary to obtain removals given in Table 8 are shown in Table 9. Pretreatment to these levels by methods discussed elsewhere are necessary prior to land application. The average waste load contained in a one-inch application of wastewater is also presented.

Climate

Climatic information for the study area is summarized in Table 10. Climatic information is necessary to calculate water balances, design storage volumes, and predict days of system operation. The water balance in Table 10 indicates up to 60 inches/year can be applied. Wastewater should not be applied on days when the ground is frozen or snow covered, when rainfall is excessive, or when surface runoff will occur.

The growing season usually starts near the first day of May and lasts until early October. The growing season for frost damaged crops is:

Near Lake Michigan	190 days
Average for Region	170 days
Northern Areas	150 days

On the basis of climatic factors, year-round irrigation is not practicable. Vegetation is important in nutrient removal from application areas; therefore, land should only be irrigated during the growing season. The equivalent of 23 weeks of application is used in this report, but may be optimistic in northern areas of the Region. No wastewater is assumed to be applied in October, November, December, January, February, or March due to potential snow problems, wetness of fields during winter and spring, potential for frozen ground, and to avoid interfering with harvesting operations.

Soils

Soil characteristics are usually the most important factor for selecting both a site and land application method. Soils of the study area have been rated for suitability for land application systems based primarily on permeability and depth to seasonal high water table. Ratings and characteristics of the predominant soils in the study area are given in Table 11. Restricting application to periods of low water table may remove some of the constraints for soils of the Region.

The highest hydraulic loading rate for spray irrigation that can be consistently achieved without system failure in Wisconsin is reported to be 2.6 inches/week.[27] Many systems operate at less than 1.0 inches/week.

[27] *Ibid.*

Table 10

CLIMATIC DATA AND WASTEWATER IRRIGATION WATER BALANCE FOR SOUTHEASTERN WISCONSIN

Month	Precipitation (inches)[a]			Average Temperature (°F)	Evapo-transpiration[c] (inches)	Design Percolation[d] (inches)	Potential Application[e] (inches)
	Average Annual	Wettest Year in 10 Years[b]	Dryest Year in 10 Years[b]				
January	1.69	2.18	1.41	21	0.00	No Application	No Application
February . . .	1.32	1.71	1.10	24	0.11	No Application	No Application
March	2.26	2.92	1.89	32	0.67	No Application	No Application
April	2.79	3.61	2.33	45	1.80	10	8.2
May	3.36	4.34	2.80	55	3.15	11	9.8
June	2.86	4.99	3.22	66	4.16	12	11.2
July	3.30	4.27	2.75	71	4.50	12	12.2
August	3.10	4.00	2.59	70	3.94	11	10.9
September . .	2.70	3.49	2.25	62	2.70	10	7.2
October. . . .	2.11	2.73	1.76	52	1.24	No Application	No Application
November . .	2.13	2.75	1.77	37	0.23	No Application	No Application
December . .	1.71	2.21	1.43	25	0.00	No Application	No Application
Annual	30.33	39.20	25.30	47	22.50	66	59.5

[a] Based on regional data in SEWRPC Planning Report No. 16.

[b] Based on annual precipitation distributed throughout the year proportional to average monthly rainfall and thus does not reflect monthly average extremes.

[c] Based on data in SEWRPC Planning Report No. 13.

[d] Based on soil with permeability greater than 0.20 inches/hour in limiting layer.

[e] Evapotranspiration + Design Percolation - Precipitation (wettest year in ten).

Source: SEWRPC Planning Reports No. 13 and No. 16 and Stanley Consultants.

Loading Rates

Loading rates are difficult to develop for regional analysis purposes since investigation of a specific site is required. Two loading rates are utilized herein for the preparation of cost information. The first is 60 inches/year (equivalent to 2.6 inches/week for the 23-week growing season) which represents the optimum potential loading based on water balance and operating experience in Wisconsin. A lower rate of 46 inches/year (equivalent to 2.0 inches/week for the 23-week growing season) may be a more typical value for soils that are fair to good for spray irrigation as listed in Table 11. The application rate of 2.0 inches/week is commonly referenced in the literature primarily since the rate has been successfully used in investigations at Pennsylvania State University,[28] and performance information is available.

[28] *W. E. Sopper and L. T. Kardos, Recycling Treated Municipal Wastewater and Sludge Through Forest and Cropland, Pennsylvania State University Press, University Park, Pennsylvania, 1973, and L. T. Kardos et al for U. S. Environmental Protection Agency, Renovation of Secondary Effluent for Reuse as a Water Resource, Office of Research and Development, EPA 660-2-74-016, February 1974.*

Crop Considerations

Effluent has been applied to corn, hay, reed canary grass, and other perennial grasses in Wisconsin. The final use of the crop is important. Guidelines that limit final use include:[29]

1. No application in a year in which soil is used to grow root vegetables or vegetables that are consumed uncooked.

2. Milk cows cannot graze pasture land for two months after application (other animals two weeks).

3. Harvested crops cannot be fed to milk cows for two months after harvest (other animals two weeks).

4. Application to small grains (oats) can cause lodging and should be avoided.

With these limitations, both corn and grass can be used as cattle feed.

[29] *Wisconsin Department of Natural Resources, Guideline Document.*

Table 11

PREDOMINANT SOILS IN THE SOUTHEASTERN WISCONSIN REGION AND THEIR CHARACTERISTICS

Soil Type	Acreage in County							Depth to Seasonal High Groundwater (feet)	Surface Texture	Permeability of Limiting Layer (inch/hour)	Suitability for Land Application[a]			Limits[c]
	Kenosha	Milwaukee[b]	Ozaukee	Racine	Walworth	Washington	Waukesha				Infiltration-Percolation (Absorption Ponds)	Ridge and Furrow Irrigation	Spray Irrigation	
Ashkum.	16,180	--	--	16,014	--	--	--	0-1	Silty Clay Loam	0.20-0.63	Poor	Poor	Poor	1,3
Aztalan	4,186	--	--	5,453	--	--	--	1-3	Loam	0.20-0.63	Poor	Poor	Poor	1,2
Blount.	--	11,860	--	5,187	--	--	3,395	1-3	Silt Loam	0.20-0.63	Poor	Poor	Poor	1,2
Boyer	--	--	--	--	--	6,963	--	>5	Loamy Sand	2.00-6.30	Fair	Fair	Fair	4
Brookston	--	--	--	--	--	11,239	--	0-1	Silt Loam	0.63-2.00	Poor	Poor	Poor	1
Casco	7,708	--	6,238	11,817	22,768	29,947	38,452	>5	Alkaline Loam	0.63-2.00	Poor	Fair	Fair	4
Dodge.	--	--	--	--	12,891	--	--	>5	Silt Loam	0.63-2.00	Good	Good	Good	4
Drummer.	--	--	--	--	6,423	--	--	0-1	Silt Loam	0.06-0.20	Poor	Poor	Poor	1
Elburn.	--	--	--	--	6,020	--	--	1-3	Silt Loam	0.20-0.63	Poor	Poor	Poor	1
Elliot	15,244	--	--	11,888	--	--	--	1-3	Silty Clay Loam	0.20-0.63	Poor	Poor	Poor	1
Flagg.	--	--	--	--	6,294	--	--	>5	Silt Loam	0.20-0.63	Good	Good	Good	4
Fox	11,045	--	3,298	12,011	15,910	--	49,475	>5	Neutral Loam	0.63-2.00	Poor	Fair	Good	4
Griswold	--	--	--	--	4,204	--	--	>5	Silt Loam	0.20-0.63	Good	Good	Good	4
Hochheim	--	--	22,836	--	--	42,254	51,115	>5	Loam	0.20-0.63	Good	Good	Good	4
Houghton	4,471	--	--	13,603	14,538	17,840	--	0-1	Mucky Peat	2.00-6.30	Poor	Poor	Poor	1
Kendall	--	--	--	--	4,131	--	--	1-3	Silt Loam	0.20-0.63	Poor	Poor	Poor	1
Kewaunee	--	--	48,412	--	--	--	--	1-3	Silty Clay Loam	0.06-0.20	Poor	Fair	Fair	3,4
Lamartine	--	--	--	--	--	4,962	--	1-3	Silt Loam	0.63-2.00	Poor	Poor	Poor	1
McHenry	--	--	--	--	28,184	--	--	>5	Silt Loam	0.63-2.00	Good	Good	Good	4
Manawa.	--	--	9,430	--	--	--	--	>5	Silt Loam	0.06-0.20	Poor	Poor	Poor	1
Markham	19,404	--	--	13,166	--	--	--	3-5	Silt Loam	0.20-0.63	Poor	Fair	Fair	3,4
Mayville.	--	--	--	--	--	8,758	--	3-5	Silt Loam	0.63-2.00	Poor	Fair	Fair	1,4
Mequon.	--	7,229	--	--	--	--	9,388	1-3	Silt Loam	0.20-0.63	Poor	Poor	Poor	1,2
Miami	7,200	--	--	6,375	71,186	--	10,371	>5	Loam	0.63-2.00	Good	Good	Good	4
Montgomery. . . .	6,459	--	--	3,776	--	--	--	0-1	Silty Clay	0.06-0.20	Poor	Poor	Poor	1,3
Morley	15,709	20,341	--	52,946	--	--	6,812	>5	Silt Loam	0.20-0.63	Poor	Fair	Fair	3,4
Ozaukee	--	14,266	13,435	--	--	11,996	18,599	>5	Acid Silt Loam	0.20-0.63	Poor	Fair	Fair	3,4
Palms	--	--	--	--	--	8,764	--	0-1	Mucky Peat	0.63-2.00	Poor	Poor	Poor	1
Pella	--	--	--	--	24,130	6,934	8,213	0-1	Silt Loam	0.20-0.63	Poor	Poor	Poor	1
Plano	--	--	--	--	56,975	--	--	>5	Silt Loam	0.63-2.00	Good	Good	Good	4
St. Charles	--	--	--	--	22,505	5,656	--	>5	Silt Loam	0.63-2.00	Good	Good	Good	4
Sisson	--	--	--	--	--	11,335	--	>5	Sandy Loam	0.63-2.00	Fair	Good	Good	4
Theresa	--	--	--	--	--	34,927	17,093	>5	Silt Loam	0.63-2.00	Good	Good	Good	4
Varna	13,469	--	--	7,982	--	--	--	3-5	Silt Loam	0.20-0.63	Poor	Fair	Fair	3
Warsaw	--	--	--	--	8,354	--	--	>5	Silt Loam	0.20-0.63	Poor	Good	Good	4
Zurich.	--	--	--	--	--	4,390	--	>5	Silt Loam	0.63-2.00	Fair	Good	Good	4
Total[d]	121,075	53,696	103,649	160,218	304,513	205,965	212,913							
Acres in County	174,720	94,610	150,400	215,680	358,400	273,920	355,840							

[a] *From Wisconsin Department of Natural Resources, Guideline Document for the Design, Construction, and Operation of Land Disposal Systems for Liquid Wastes, draft, November 1975.*

[b] *58,330 acres in Milwaukee County not surveyed.*

[c] *Limit Code 1 = high water table, 2 = moderate slow permeability, 3 = slow permeability, and 4 = slope.*

[d] *Excludes soils comprising less than 3,000 acres in any county.*

Source: Wisconsin Department of Natural Resources and U. S. Department of Agriculture.

Nitrogen Considerations

Nitrogen is added to the soil from rainfall (three to six pounds ammonia and one to two pounds nitrate per acre per year), from wastewater application (4.52 pounds per acre per inch application at 20 mg/l total-N), and from decaying vegetation. The total nitrogen balance is important since nitrate ions are mobile in the soil and can affect the quality of the ground water. The balance is a function of the nitrogen applied, the nitrogen removed from the area by plants, the nitrogen lost by denitrification and volatilization, and the nitrogen lost to the groundwater. The concentration of nitrate nitrogen in groundwater should not limit application rates in the study area for spray irrigation systems.

Basically, when nitrogen is applied to soil, the ammonia and organic nitrogen portions are adsorbed or incorporated in the soil matrix. Nitrate is free to move within the soil. As wastewater is applied, the nitrogen level will increase through growth of aerobic microbes and conversion of plant material to nonbiodegradable organic matter. At some point in time, a maximum organic balance will be reached so that effective nitrogen removal is due only to plant harvest and denitrification. During initial utilization of a site, much more nitrogen can be removed than that utilized by crops.

The nitrogen uptake of most plants has been determined from greenhouse or field studies using fresh water containing supplemental nitrogen for irrigation. The total nitrogen uptake by plants is a function of the plant type and yield of the plant. Typical nutrient uptake by crops is one pound per acre per bushel for corn and 50 to 60 pounds per acre per ton of hay or grass. Crops remove nitrogen at rates paralleling the evapotranspiration demand.

Crop yield is a function of the quantity of nitrogen and water applied. Experience with hayland indicates increased production with increased nitrogen applied until about 400 pounds per acre of nitrogen are applied.[30] Continuous wet soil conditions can reduce yields, however, and cycles of application must be used to prevent this from occurring.

The denitrification rate is highest for stratified soils and the lowest rates occur in uniform soils with moderate to rapid permeabilities. Because the root zone must be aerated for most agricultural crops, high rates of denitrification are not likely to occur within the active root zone. Denitrification has been shown to vary considerably for water moving below the root zone. However, an assumption of 25 percent denitrification of the nitrogen moving below the root zone may be reasonably made.[31]

The annual nitrogen balance under steady-state conditions for two crops is presented in Table 12. The previously developed water balance was used to establish an upper loading rate of 60 inches per year for hayland. Cropland has been limited to an annual application rate of 46 inches based upon compatibility with farming operations.

Phosphorus Limitations

Most phosphorus applied to the soil is retained in the soil matrix or utilized by plants.[32] Phosphorus from wastewater is added to the soil at a higher rate than the crops can utilize. Over a period of years, the phosphorus adsorption capacity of the soil may be reached and exceeded. Phosphorus uptake values developed for the study area are:

Land Use	Phosphorus Removal Rates (pound/acre/year)
Cropland	40
Pasture	35

With these removals and a typical soil phosphorus adsorption capacity of 1,000 pounds per acre per foot,[33] the top 40 inches of soil allow wastewater application for the following periods:

Table 12

ANNUAL NITROGEN BALANCE IN LAND APPLICATION OF WASTEWATER

Land Use	Cropland	Pasture
Crop	Corn	Reed Canary Grass
Wastewater Applied (in/yr)	46	60
Nitrogen Applied (lb/acre)	208	271
Crop Uptake (lb/acre)	120	200
Denitrification (lb/acre)	22	18
Nitrogen Remaining (lb/acre)	66	53
Flow to Groundwater (in/yr)	54	68
Nitrogen to Groundwater (mg/l)	5.4	3.5

Source: Stanley Consultants.

Land Use	Application Rate 46 in/yr	60 in/yr
Cropland	47 years	32 years
Pasture	44 years	30 years

Heavy Metal Considerations

Most heavy metals remain in the soil if the pH stays above 6.5.[34] Soils in the study area are mostly neutral to alkaline. The pH will increase with continued wastewater application. Lime treatment may be required to avoid initial heavy metal leaching on acid soils. Plants will remove about one pound per acre per year of heavy metals. One reference[35] indicated that the zinc equivalent should be limited to 500 pounds per acre to avoid toxicity to plants. That reference utilized a formula which set the zinc equivalent equal to the zinc concentration plus twice the copper level plus eight times the nickel concentration.[36] About 5.5 pounds of zinc equivalent at a 46 inch per year application rate and 7.3 pounds at 60 inches per year application rate can be expected. Using influent wastewater characteristics given in Table 9, a site life of 50 to 100 years is determined based upon metal accumulation. Zinc equivalent has been developed as an expression for potential plant phytotoxicity. Zinc equivalent formula expresses the toxicity of zinc, copper, and nickel to typical plants grown on wastewater or sludge applied soil. Initial drafts of the U. S. EPA Technical bulletin on municipal sludge management environmental factors used incorporated the zinc equivalent formula as one determination of the amount of sludge which could be applied over the life of a project. Controversy over use of the formula developed and it was dropped from the June 1976 draft of that same technical bulletin.

[30] *U. S. Department of Agriculture, Soil Conservation Service, Agricultural Waste Management Field Manual, U. S. Government Printing Office, Washington, D. C., August 1975.*

[31] *Culp, Wesner, and Culp, 1974 Lake Tahoe Advanced Wastewater Treatment Seminar Manual, Clean Water Consultants, El Dorado Hills, California, 1975.*

[32] *H. O. Buckman and N. C. Brady, The Nature and Property of Soils, Seventh edition, McMillan Company, London, England, 1969.*

[33] *Ibid.*

[34] *U. S. Department of Agriculture, Factors Involved in Land Application of Agricultural and Municipal Wastes, Agricultural Research Service, Beltsville, Maryland, July 1974.*

[35] *Ibid.*

[36] *Ibid.*

Organic Loading

Organic loadings on the soil are expected to be less than two pounds per acre per day from the addition of treated wastewater. Loadings in this range are well below the capacity of the soil to utilize organic matter. Resting periods in the irrigation schedule are important to give soil bacteria time to break down organic matter and allow the water to drain from the top few inches. Aerobic conditions are restored as air penetrates the soil. The length of the resting period will depend upon the crop type, the number of acres in the rotation cycle, and management considerations. Typical resting periods range from five to 10 days.

Land Requirements

Land will be required for aerated lagoons, storage lagoons, wastewater application areas, buffer zones, buildings, roads, and other miscellaneous items. Due to the topography of the land and the relatively large sites required, additional amounts of land may be needed for valleys and hilltops where slopes are too steep or soils are unsuitable for land application.

The term "wetted area" refers to the area receiving direct application of liquid. The wetted area is directly related to the annual wastewater application rate. Where an application rate of 46 inches per year is used, a wet area of 292 acres/mgd of design capacity is required; at 60 inches per year, 224 acres/mgd is needed. Setback distances (500 feet to 1,000 feet) and unusable areas will increase requirements by 30 to 50 percent.

Storage Requirements

Following secondary treatment, storage volume is required to maintain the desired irrigation schedule, retain flow during periods of inclement weather, and hold surface runoff collected from the application areas. The amount of storage required to maintain a desired irrigation schedule depends upon the variation in application rate throughout the year. For the study area, lagoons (built in accordance with NR 110.28) are sized to store 200 days of wastewater flow. (Capacities of up to 210 days have been used in Wisconsin.) This volume is sufficient to store all wastewater if application is discontinued for a period up to 30 continuous days during the spring (most critical period), and to store runoff from the irrigated area from a storm with a two-year (1-in-2 year) return frequency.

Costs

Cost curves for certain unit operations for land application systems are presented in Appendix D.

1. Various curves for pretreatment, transmission, and pumping to reach the application site.

2. Curves for storage at the site.

3. Curves for land requirements and costs.

4. Curves for three methods of application of wastewater.

5. Curves for underdraining an area.

6. A curve which assumes values for 3, 4, and 5 above which may be used as a guide for total application costs.

EFFLUENT POLISHING AND RECEIVING WATER TREATMENT

Various systems have been considered to minimize the impact of wastewater discharges on receiving waters after the previously described treatment and discharge options have been applied. Relevant processes are summarized in Table 13. The costs and effectiveness of the options are difficult to predict since many are site specific and few have had extensive large scale testing. Combinations of options may prove most effective in restoring the quality of lake or other surface waters.

Effluent Polishing

Techniques not described previously for upgrading or minimizing the impact of discharges on surface waters include postaeration, algal harvesting, aquiculture, and controlled discharge.

Postaeration: The dissolved oxygen content of biological treatment processes is usually 0 to 2 mg/l. In instances where receiving water flow is inadequate to dilute the wastewater, an oxygen deficit can result regardless of the remaining BOD_5 or ammonia oxygen demands in the effluent. Effluent aeration can be accomplished using diffused air, mechanical aerators, cascade systems, or U-tube systems.[37] A cost curve for diffused air systems

Table 13

PROCESSES FOR EFFLUENT POLISHING AND RECEIVING WATER TREATMENT

Effluent Polishing
Postaeration
Algal Harvesting
Aquiculture
Controlled Discharge
Lake Treatment[a]
Destratification
Sediment Removal
Sediment Encasement
Chemical Addition
Biological Controls
Plant Harvesting
Stream Treatment
Sediment Removal
Instream Aeration
Low-Flow Augmentation

[a] *Wisconsin Department of Natural Resources, Survey of Lake Rehabilitation Techniques and Experiences, 1975.*

Source: Stanley Consultants.

[37] *Metcalf and Eddy, Process Design Manual for Upgrading Existing Wastewater Treatment Plants.*

for post-aeration is included in Appendix D. Effluent dissolved oxygen levels for this system are expected to range from 6 to 9.5 mg/l, higher than cascade systems can dependably provide.[38] U-tube aerators have not been used as postaeration devices, and mechanical surface aerators would induce icing problems in the winter.

Algal Harvesting: The principal reason for removing phosphorus from wastewater treatment plant effluents is to reduce the potential for nuisance algal growths in streams and lakes. The most prevalent system in use today for phosphorus removal is chemical precipitation as discussed earlier. An alternative to this strategy is to encourage algal growth as part of the wastewater treatment process and to remove the nutrient containing algae. A typical system would consist of a shallow lagoon followed by an algal removal device. Centrifuges, microscreens, sedimentation with chemicals, and sand filters have been used for algal removal,[39] with sand filters tending to be the most dependable process. This concept has been applied in small areas. A one-acre pond (18 inches deep, detention time = 24 hours) with a flow rate of 0.5 mgd produced 100,000 pounds of algae/year which was harvested at a rate of 400 lbs/acre/day.[40] The large land areas required and reduced effectiveness in cold periods limit application of this option. The algal harvest has been suggested for use as cattle feed. Oily wastes and wastewaters containing toxic metals may inhibit algal growth in the ponds. This leads to poor phosphorus removal and continued opportunities for eutrophication when inhibiting effects are reduced as the discharge is diluted by the receiving water.

Aquiculture: A system currently under development which is similar to algae harvesting for controlling nitrogen and phosphorus is aquiculture, the controlled growth of aquatic organisms.[41] Aquiculture systems can be either single or multistage configurations which culture phytoplankton, shellfish, red algae, water hyacinths, and duckweed. Some systems using yeasts have been applied to wastewaters. Nitrogen and phosphorus removals of over 90 percent have been reported. The major drawback of any aquiculture system is the land requirement. Approximately 6 to 60 acres per million gallons per day of wastewater flow are required for summer operation in the northern United States. Under northern winter conditions, area requirements may be over 10 times as great, and necessary precautions must be taken to preserve aquatic species, such as water hyacinths and shellfish.[42] At present, the effects of toxic materials and pathogens have not been investigated. Also, the overall cost-effectiveness of the aquiculture systems has not been demonstrated.[43]

Aquiculture techniques offer a degree of promise for control of discharges. Future systems may employ the more dependable mechanical systems previously described in adverse winter conditions, and use aquiculture techniques in favorable summertime conditions to reduce overall annual operating costs, energy use, and process upsets. Investigations into the concept are certain to expand in future years with various types of organisms, loading rates, and process configurations being studied. The present state of the art would limit application only to smaller facilities in the Region. Effluent discharges to aquiculture systems may be suitably incorporated into wildlife refuges and wildlife/recreational parks in future years.

Controlled Discharge: Stream water quality standards are usually based on impacts that discharges would have at low flow, usually the 7 day-10 year low flow event. One method of reducing impact is to prohibit discharge during these periods. This can be accomplished in one of two ways. An adjustable effluent weir on lagoons with sufficient freeboard would allow storage. Alternatively for most of the Region's treatment facilities, a separate low flow storage basin would need to be built to contain the flow. Controlled discharge would reduce stream flows downstream of the treatment facility and may have a cumulative negative effect on a watershed. The concept is accepted as a pollution control practice in Iowa.

Lake Treatment

In addition to the techniques for water quality control in flowing streams as presented below, numerous methods for modifying water quality in impoundments and in natural lakes are available.[44] Although the major emphasis of this report has been on the evaluation and description of wastewater treatment processes, a brief review of these lake treatment processes has been included herein to demonstrate these as potential alternative water quality management processes, since in situ treatment and management techniques have been found to be cost-effective in a few such circumstances in the Region. It may also be important to recognize the need to consider such techniques when considering meeting water quality objectives which are more stringent than can be met by the direct control of point sources.

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[38] *Ibid.*

[39] *E. J. Middlebrooks et al, "Technique for Algal Removal from Wastewater Stabilization Ponds," Journal Water Pollution Control Federation, 46, December 1974.*

[40] *M. G. McGarry and C. Tongkasame, "Water Reclamation and Algae Harvesting," Journal Water Pollution Control Federation, 43, May 1971.*

[41] *D. Walrath and A. S. Nattes, "Aquiculture—New Broom Cleans Up Wastewater," Water and Wastes Engineering, 13, February 1976.*

[42] *Ibid.*

[43] *Ibid.*

[44] *Wisconsin Department of Natural Resources, Survey of Lake Rehabilitation Techniques and Experiences, Technical Bulletin 75, Madison, Wisconsin, 1975.*

Destratification: Mixing can be utilized to destratify lakes and impoundments or to prevent stratification from occurring. The continuous mixing provides oxygen in the deep portions of the lake which generally contain little or no oxygen during stratified conditions. By providing oxygen to the lower depths of a lake, anaerobic conditions, which sometimes bring nutrients into solutions from the bottom muds, are limited. Continuous mixing also lowers surface water temperatures. The concept is limited to rather small lakes.

The effects of continuous mixing on overall lake water quality are not well known. Algal growth may be limited by lowered water temperatures and by dispersion of algae cells out of photosynthetic activity zones. However, mixing may resuspend nutrients from the lower depths and cause an increase in algal growth.

Sediment Removal: Dredging or draglining of the bottom sediments of a lake or stream may remove large quantities of nutrients. Exact quantities of nutrient removal are hard to predict and vary among water bodies. Sediment removal also increases the volume or flow capacity of a lake or stream. In addition, benthal demands which contribute to dissolved oxygen depletion are reduced. The unit cost of sediment removal can range from $0.75 to $5.00 per cubic yard, depending on the method of sediment removal, the volume of sediment removed, the distance to a disposal site, and other factors. Adverse effects on existing aquatic life and suitable disposal sites may limit the use of sediment removal as a method of water quality control. It will prove to be a short-term solution unless the cause of the sediment load is found and corrected. Removal in that case can increase the lake recovery rate.

Sediment Encasement: The encasement of the bottom sediments of a lake or impoundment can delay eutrophication by preventing nutrient transfer from bottom sediments to the water column. Layers of sand or sheets of polyethylene could be used to cover the bottom sediments.

Chemical Addition: Algae growth can be controlled by the use of algicidal chemicals. Chemicals used for the control of algae include copper sulfate, chlorine, and potassium permanganate. Copper sulfate is most commonly used and is the only algicide presently permitted by DNR. Permits are required from DNR for any chemical spraying operations on a lake. Copper sulfate can be toxic to fish and other aquatic life if use is excessive. Table 14 lists approximate concentrations that kill common varieties of fish and limiting safe dosages in soft water. Fatal concentrations are higher in hard waters. Although an algicide controls nuisance blooms of algal, no nutrient removal from the lake occurs since dead algae, upon decay, release nutrients back into the water.

Cost estimates for algae control using chemicals are usually based upon two control operations per lake per year and vary with the size of lake to be treated and with chemical dosage.[45] Cost estimates include the cost

[45] *SEWRPC, A Comprehensive Plan for the Milwaukee River Watershed, Volumes I and II, 1971.*

Table 14

APPROXIMATE TOXIC AND SAFE COPPER SULFATE DOSAGES FOR VARIOUS FISH SPECIES

Species	Toxic Concentrations (mg/l)	Limiting Safe Dosage (mg/l)	Limiting Safe Dosage (lbs/million gallons)
Trout.	1.2	0.14	1.17
Catfish	2.5	0.40	3.34
Suckers. . . .	2.5	0.33	2.75
Carp	2.5	0.33	2.75
Pickerel. . . .	3.5	0.40	3.34
Black Bass . .	17.0	2.00	16.68
Perch	6.0	0.67	5.59

Source: Stanley Consultants.

of chemicals, at $2.00 per acre treated; a boat or barge and spray apparatus, at an initial cost of $2,500; operation and maintenance costs of $100 per day; and state supervision and inspection costs of approximately $200 per day.[46]

On an average, it is estimated to take about 30 minutes to treat one acre of growth. The time is somewhat dependent, however, upon the type of chemical, operator experience, and density of growth. Prices quoted by commercial chemical applicators indicate that the cost for chemical treatment ranges from $0.30 to $0.90 per lineal foot of lake shoreline with the average cost about $0.60 to $0.65 per lineal foot of shoreline. Application area generally covers about 250 feet out from the shoreline.

Biological Control: Biological control is a possible solution for nutrient removal. Herbivorous fish, such as grass carp and silver carp, can be used to control aquatic plant growth. Since fish tend to concentrate nutrients in their bodies, fish removal also will remove some nutrients contained in the fish protoplasm. However, in relation to the total quantity of nutrients in a lake, nutrient removal by biological control is relatively small.

Plant Harvesting: Aquatic plant harvesting is another method of receiving water treatment. Periodic cutting and removal of aquatic weeds will remove a small amount of nutrients fixed in plant tissue. In one study, the harvesting of macrophytes was found to remove only 1.37 percent of the total nitrogen.[47] Although aquatic plant harvesting does little to reduce the rate of eutrophication in some lakes, nuisances which accompany eutrophication are temporarily reduced.

[46] *Ibid.*

[47] *S. A. Petersen et al, "Harvesting of Aquatic Plants; Nutrient Removal in an Artificially Enriched Lake," Journal Water Pollution Control Federation, 46, April 1974.*

Harvesting machines exist which are able to cut aquatic weeds to a maximum depth of seven feet. Barges are used to transport the weeds to suitable land areas nearby. Cost estimates are based on two harvesting operations per year, removal of aquatic plants to a depth of seven feet, and disposal of weeds on suitable nearby land areas.[48] The initial cost of a large weed harvesting machine is approximately $90,000, and operation and maintenance costs are estimated to be $300 per day.[49] It is estimated that aquatic weeds can be harvested from areas at a rate of three-quarters of an acre to one acre per hour. Harvesting machines can also be rented, or an areawide harvesting program can be organized to split the cost of purchasing and operating the machines.

Stream Treatment

Methods for stream treatment include sediment removal, instream aeration, and low-flow augmentation. Sediment removal has been discussed in the lake treatment portion of this chapter.

Instream Aeration: Little natural reaeration occurs in winter when surface waters are covered with ice. Also, during low-flow periods, wastewater discharges from treatment plants may comprise the major portion of stream flow. During these conditions, stream dissolved oxygen standards may be violated with secondary treatment effluent discharges. Rather than require additional treatment, artificial reaeration of the receiving water can be used as a supplement to secondary treatment to satisfy dissolved oxygen criteria. In effect, instream aeration uses a stream or lake as a separate stage of wastewater treatment, supplying oxygen only at the locations where it is needed.

An economic and technological study of instream river aeration was performed by Rutgers University.[50] Two basic types of aeration devices were tested, surface mechanical aerators and diffusion aerators. Based upon test results, the oxygen transfer rate of the diffusion aerator was only about 60 percent that of the mechanical aerator under comparable stream conditions. The average oxygen transfer rates under standard conditions over the observed flow range (85 to 1,670 cfs) were approximately 2.1 pounds 0_2 per hp-hr for the mechanical aerator and 1.2 pounds 0_2 per hp-hr for the diffused aerator.

Cost estimates for the aeration systems were also presented in the study. Construction costs for a 75-horsepower mechanical aerator were approximately $64,000, and $56,000 for a 50-horsepower aerator. Annual operation and maintenance costs ranged from $175 to $275 per horsepower. An 80-horsepower diffused aeration system was estimated to have a construction cost of about $74,000. Annual operation and maintenance costs were expected to be between $175 and $200 per horsepower (costs adjusted to August 1976).[51]

From the test results and a cost analysis performed in the study, the mechanical aerator was found to be more cost-effective by a wide margin. However, these aerators have certain disadvantages. They are subject to damage from ice and debris, restrict passage in a waterway, and have to be adjusted or removed during flooding.

Low-Flow Augmentation: During low flow periods, instream water quality conditions can be improved by low-flow augmentation. The most common form of low-flow augmentation is by controlled releases from reservoir storage. Flow can also be increased by withdrawing water from groundwater sources and releasing it into surface watercourses.

The flushing tunnels in use in the Milwaukee area since 1888 are a unique low-flow augmentation system which has proved and may continue to be a successful water quality improvement method.[52] The operating cost of the system ($9,000 for all of 1975) is low and the system is known to have resulted in improvement in stream quality.

Most regulatory agencies do not encourage instream aeration or low-flow augmentation as substitutes for adequate point source treatment, though the increasing emphasis on the resource utilization of advanced wastewater treatment may tend to change such policies in future years.

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[48] *SEWRPC, A Comprehensive Plan for the Milwaukee River Watershed.*

[49] *Ibid.*

[50] *W. J. Whipple et al, Instream Aeration of Polluted Waters, Water Resources Research, Rutgers University, August 1969.*

[51] *Ibid.*

[52] *SEWRPC, A Comprehensive Plan for the Milwaukee River Watershed.*

Chapter V

WASTEWATER TREATMENT SCHEMATICS

INTRODUCTION

This chapter presents point source structural control schematics necessary to meet the nine levels of effluent criteria summarized in Chapter III when treating raw waste influents summarized in Chapter II. The treatment schematics are composed of the unit processes discussed in Chapter IV. The schematics are developed to satisfy the indicated level of effluent criteria for the maximum monthly average condition. In each schematic, three different levels of influent characteristics are considered.

If properly designed and operated, the schematics should satisfy the various levels of effluent requirements presented in Table 4. The schematics presented are to be used for planning new treatment facilities or for upgrading an existing treatment system. Most treatment upgrading consists of a combination of both biological and physical-chemical processes.

Each schematic is developed to satisfy a particular level of effluent quality. In many cases, a treatment schematic used to satisfy one level of effluent criteria can be used to meet a stricter level of effluent criteria by adjusting design or operation parameters. This is assumed in certain treatment schematics which are shown for the different levels of effluent criteria.

All the schematics shown can be preceded by a flow equalization basin. Equalization basins are discussed in Chapter VII.

LEVEL I SCHEMATICS

Four schematics are presented in Figure 4 to meet an effluent criteria of 30 mg/l BOD_5 (the Wisconsin DNR definition of secondary treatment for medium strength wastewaters). The activated sludge and bio-disc processes should satisfy the effluent limitations. For the contact stabilization process, a microstrainer is needed when treating high strength domestic wastes such as Influent III. As discussed in Chapter II, the majority of the trickling filters in the Region are not currently meeting secondary requirements (85 percent BOD_5 removal). For a low strength domestic wastewater, like Influent I, a 30 mg/l BOD_5 effluent (not necessarily secondary treatment) is achievable from a well-operated facility, but higher strength wastes will probably require a microstrainer to meet this effluent criteria. A two-stage trickling filter could be used without microstrainers, but may be more expensive. Further determination and refinement of which biological process is most cost-effective should be done during 201 facilities planning studies. Chlorination is used for disinfection in this and other schematics in lieu of ozonation.

LEVEL 2 SCHEMATICS

Level 2 schematics to meet an effluent criteria of 30 mg/l BOD_5 and 1.0 mg/l total phosphorus are shown in Figure 5. Chemical precipitation for phosphorus removal is used. Phosphorus removal to 1.0 mg/l demands 90 to 95 percent removals for the influent phosphorus concentrations considered in the study area. To ensure an effluent of 1.0 mg/l phosphorus, aluminum or iron salts are applied before the primary and final clarifiers. Full scale plant operations have indicated this is possible.[1]

Chemical addition prior to the primary clarifier reduces the organic load on the secondary biological process. Hence, better BOD_5 removals are achieved. Also, chemical addition prior to the final clarifier improves effluent quality. Providing chemical addition at both locations improves process reliability and increases operational flexibility.

Level 2(A) schematic requires multimedia filtration to satisfy BOD_5 requirements when treating a wastewater with characteristics like Influent III. Multimedia filters are proposed because microstrainers do not perform well on weak chemical flocs. A lower phosphorus level than 1.0 mg/l may be obtained with filtration.

Where existing facilities employ the contact stabilization process [Level 2(C)], an installation of a primary clarifier may be necessary for consistent phosphorus removal. For an Influent I phosphorus level using this process, a pilot plant study may indicate that chemical addition to the aeration basin or prior to the final clarifier will achieve the required phosphorus residual.

LEVEL 3 SCHEMATICS

Higher BOD_5 removals are provided with Level 3 Schematics (see Figure 6). To achieve the 20 mg/l BOD_5 effluent criteria, Level 3(A) requires microscreening of the trickling filter effluent. This schematic does not satisfy the effluent requirements for this level when the influent wastewater characteristics resemble Influent III. To satisfy effluent requirements, an additional biological process or chemical precipitation is required to lower the soluble BOD_5 portion of the effluent.

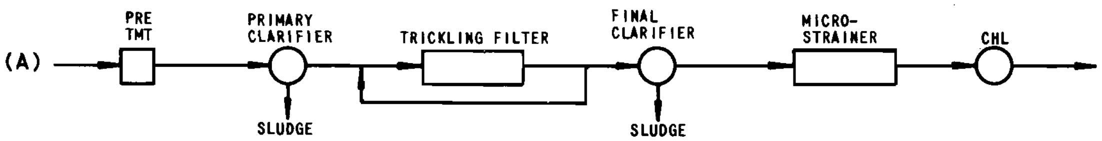
---

[1] *Black and Veatch, and Shemik, Roming, Jacobs, and Finklea for the U. S. Environmental Protection Agency, Process Design Manual for Phosphorus Removal, April 1976, and Richard W. Ockershausen, "In-plant Usage Works and Works," Environmental Science and Technology, 8, May 1974.*

Figure 4

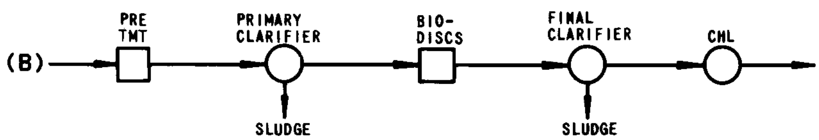
LEVEL 1 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 30 mg/l BOD_5



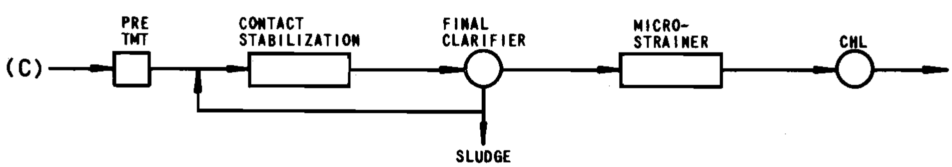
EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	30	35	9	9
INFLUENT II	20	20	11	13
INFLUENT III	30	20	15	15



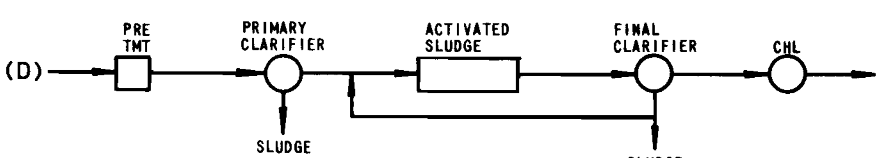
EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	30	30	9	9
INFLUENT II	30	30	12	13
INFLUENT III	30	30	16	15



EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	30	30	9	9
INFLUENT II[b]	30	30	12	13
INFLUENT III	20	15	15	15



EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	30	30	9	9
INFLUENT II	30	30	12	13
INFLUENT III[c]	30	30	16	15

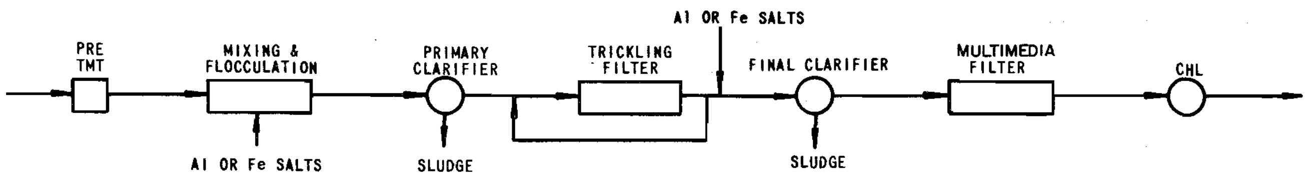
[a] MAXIMUM MONTHLY AVERAGE
[b] MICROSTRAINER NOT REQUIRED
[c] SRT $\geq$ 15 DAYS

Source: Stanley Consultants.

Figure 5

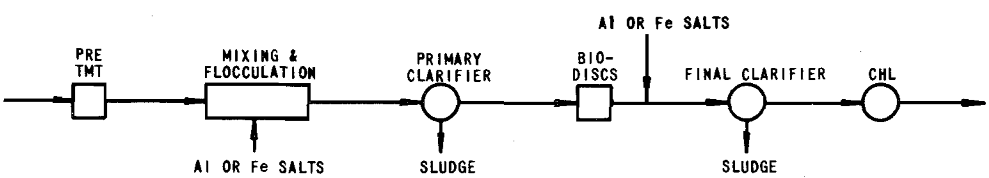
LEVEL 2 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 30 mg/l BOD_5, 1.0 mg/l Total P

(A)


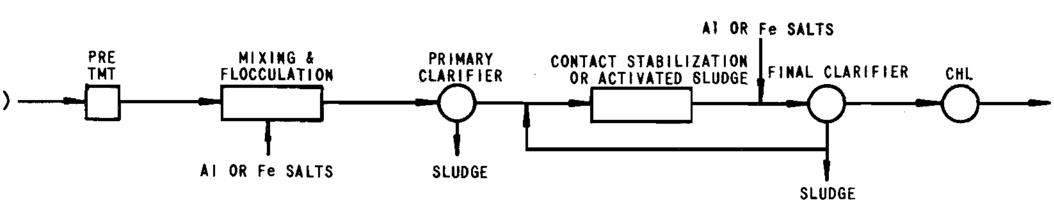
EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	20	20	1	9
INFLUENT II[b]	30	25	1	13
INFLUENT III	20	15	1	15

(B)


EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	20	20	1	9
INFLUENT II	25	25	1	13
INFLUENT III	30	30	1	15

(C)


EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	15	15	1	9
INFLUENT II	25	25	1	13
INFLUENT III	30	30	1	15

[a] MAXIMUMUM MONTHLY AVERAGE

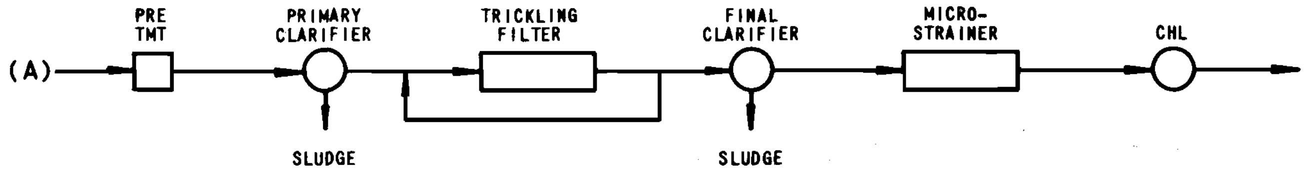
[b] MULTIMEDIA FILTER NOT REQUIRED

Source: Stanley Consultants.

Figure 6

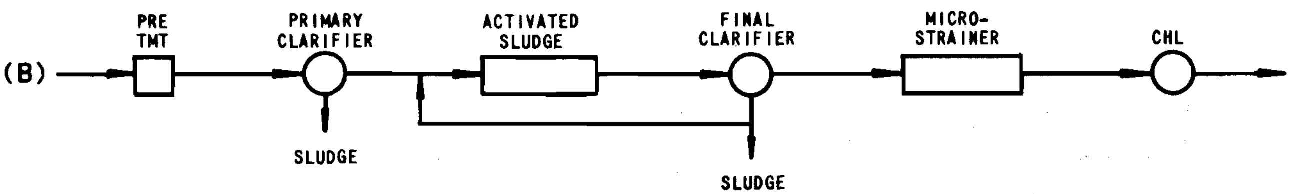
LEVEL 3 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 20 mg/l BOD_5



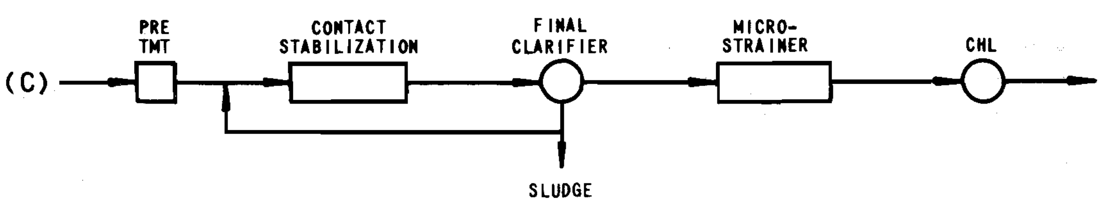
EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	15	15	8	9
INFLUENT II	20	20	11	13
INFLUENT III	EFFLUENT REQUIREMENTS NOT SATISIFED WITH TREATMENT SCHEME.			



EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	20	25	9	9
INFLUENT II[b,c]	20	25	12	13
INFLUENT III[c]	15	12	15	15



EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	20	25	9	9
INFLUENT II	15	12	11	13
INFLUENT III	20	15	15	15

[a] MAXIMUM MONTHLY AVERAGE

[b] MICROSTRAINER NOT REQUIRED

[c] SRT $\geq$ 15 DAYS

Source: Stanley Consultants.

For Level 3(B), the activated sludge process can be modified so that microstrainers are not needed for Influents I and II. For Influents II and III, solids retention time (SRT) must be adjusted to 15 days or longer to achieve necessary BOD_5 removals. For an SRT of 15 days or greater, complete nitrification will probably occur in the summer months, but nitrification will be suppressed during the winter since the facility is not designed for year-round nitrification.

In Level 3(C), the contact stabilization process can meet the effluent requirements alone for Influent I. Microstrainers are needed for the other influents.

Bio-discs are not shown for this level of effluent quality or the other more stringent levels for primary organic removal due to lack of performance data from permanent installations, other than manufacturer's data. If proven as reliable as this limited data indicates, bio-discs can be expected to perform as well as the activated sludge process in the proposed schematics. The process should be considered in proposed designs for new facilities in the Region in 201 facilities planning investigations.

LEVEL 4 SCHEMATICS

Figure 7 displays the Level 4 schematics to meet an effluent criteria of 15 mg/l BOD_5. The activated sludge process with a SRT of 15 days or greater, is used in Level 4(A). A microstrainer is not required to meet effluent requirements with Influent I. Complete nitrification will probably occur during the summer months.

Level 4(B) utilizes the contact stabilization process. Microstrainers are needed with Influents I and II. With Influent III waste characteristics, a multimedia filter is required for higher suspended solids removals to obtain the effluent BOD_5 limit.

A schematic utilizing a trickling filter is not shown for this level. As shown in Level 3(A), this schematic will satisfy Level 4 effluent criteria for treating a wastewater with Influent I characteristics. For the other influents, this schematic, even if a multimedia filter is used instead of a microstrainer, will not satisfy Level 4 criteria because of the high effluent soluble BOD_5. A biological process following the trickling filter is needed to reduce the soluble BOD_5.

LEVEL 5 SCHEMATICS

The same principles and processes used for phosphorus removal in Level 2 schematics also apply to Level 5 as shown in Figure 8. Effluent criteria are 15 mg/l BOD_5 and 1.0 mg/l phosphorus.

A modification in the activated sludge or contact stabilization process allows effluent criteria to be achieved without filtration for Influents I and II in Level 5(A). As discussed in Level 2 schematics, a primary clarifier may be required to achieve low effluent phosphorus requirements when the contact stabilization process is used.

Level 5(B) uses a trickling filter and a multimedia filter to meet effluent criteria for Influents I and II. Because of the high effluent soluble BOD_5 level, this schematic cannot be used for Influent III.

LEVEL 6 SCHEMATICS

Level 6 schematics are presented in Figure 9 for effluent criteria of 15 mg/l BOD_5, 1.0 mg/l phosphorus, and 1.5 mg/l ammonia nitrogen. The schematics are similar to those for Levels 2 and 5 except that nitrification is required and multimedia filtration is not. Expected effluent quality for Levels 6(A) and (B) is approximately the same.[2] Chlorination can provide a backup for nitrification as well as disinfection for these schematics, but chlorinators must be sized to provide chlorine dosages adequate for breakpoint to remove trace ammonia concentrations.

With separate stage nitrification, higher overall organic removals are obtained due to the additional reduction of carbonaceous material in the nitrification basins. Levels 6(A) and (B) have been employed at several locations.[3] Bio-discs are currently being utilized for separate stage nitrification.[4] In a few instances, trickling filters have been used for nitrification facilities,[5] but DNR does not consider trickling filters suitable for such wastewater treatment in Wisconsin and discourages the construction of new facilities (NR 110) using this process.

Combined carbon oxidation-nitrification wastewater treatment facilities are beginning to be used in the United States and are alternatives to the schematics shown.[6] The

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[2] *Brown and Caldwell for the U. S. Environmental Protection Agency, Process Design Manual for Nitrogen Control, October 1975.*

[3] *Brown and Caldwell for the U. S. Environmental Protection Agency, Process Design Manual for Nitrogen Control, October 1975; Metcalf and Eddy, Inc., "Largest Advanced Wastewater Treatment Plant in the U. S. and in the World," Environmental Science and Technology, October 1974; and Metcalf and Eddy, Inc., "First Year Performance of the Marborough, Massachusetts, Advanced Wastewater Treatment Plant," paper presented at the joint meeting of the New York and New England Water Pollution Control Federation, June 9, 1975.*

[4] *Greely and Hansen, "Process Designs for Nitrogen Control: NSSD, Peoria, Tampa," paper presented at the U. S. Environmental Protection Agency Technology Transfer, National Conference on Nitrogen Control, July 29, 1976, and A. K. Singhal, "AWT Plant Cuts Nutrients Economically," Water and Wastes Engineering, November 1975.*

[5] *Brown and Caldwell, Process Design Manual.*

[6] *Ibid.; The Metropolitan Sanitary District of Greater Chicago, Department of Research and Development, Report No. 76-2, Single Stage Nitrification Study at the West-Southwest Treatment Plant, November 1975, and Report No. 76-8, Report on the Single Stage Biological Nitrification of Calumet Sewage, March 1976.*

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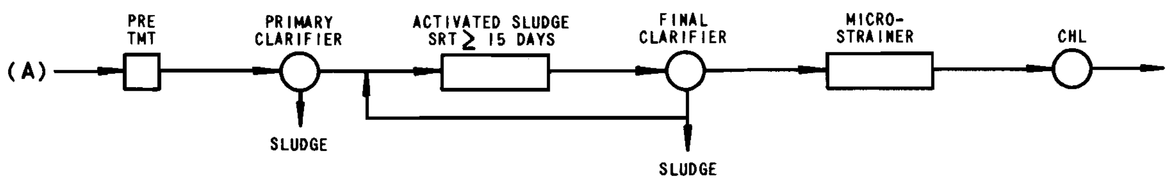
Figure 7

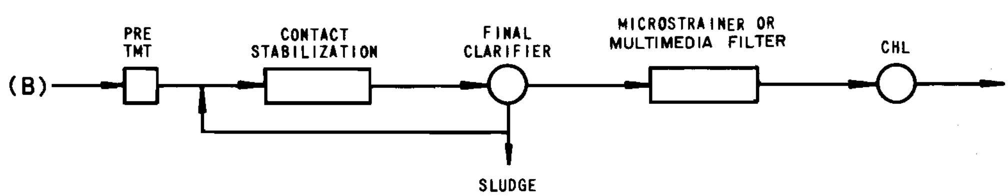
LEVEL 4 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 15 mg/l BOD_5



EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	15	20	9	9
INFLUENT II	15	12	11	13
INFLUENT III	15	12	15	15



EXPECTED EFFLUENT QUALITY[a]

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	15	12	9	9
INFLUENT II	15	12	12	13
INFLUENT III[c]	15	10	15	15

a MAXIMUM MONTHLY AVERAGE

b MICROSTRAINER NOT REQUIRED

c MULTIMEDIA FILTER REQUIRED

Source: Stanley Consultants.

effluent from a single-stage facility, when combined with chemical addition for phosphorus removal, should attain the effluent quality specified in Level 6. A single-stage facility is recommended for nitrification where existing treatment facilities can be modified or when planning a new wastewater treatment facility, providing it proves cost-effective and influent wastewater characteristics are suitable. The process is generally less reliable than separate stage systems.

Level 6(C) utilizes land disposal of wastewater after treatment at a secondary biological facility. A storage lagoon is necessary for retention when soil conditions do not allow wastewater application. Overall constituent removals will depend on soil type and cropping practice (see Chapter IV).

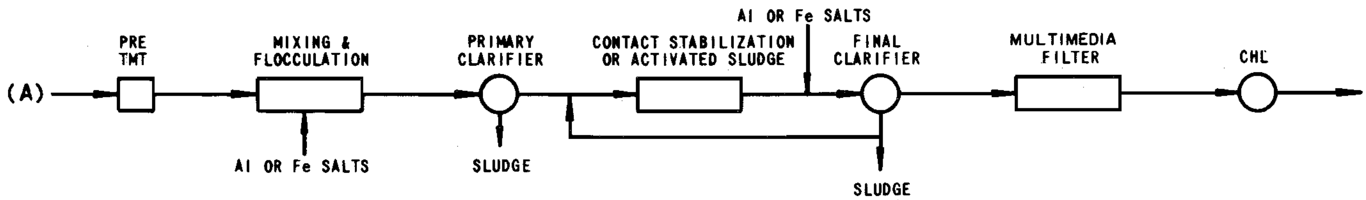
LEVEL 7 SCHEMATICS

Level 7 schematics apply to small communities which have wastewater flows of 0.5 mgd or less. This is the maximum population equivalent flow for which the Wisconsin DNR does not require phosphorus removal. Schematics developed are shown in Figure 10. Level 7(A) uses the extended aeration process for organic removal and nitrification to effluent criteria levels of 15 mg/l

Figure 8

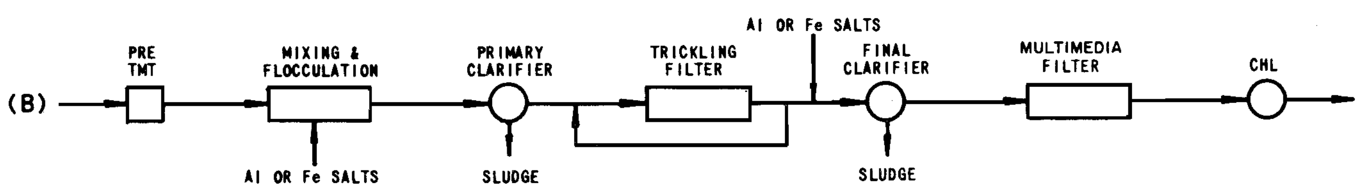
LEVEL 5 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 15 mg/l BOD_5, 1.0 mg/l Total P



EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	12	12	1	9
INFLUENT II[b]	15	15	1	13
INFLUENT III	15	10	1	15



EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	12	5	1	9
INFLUENT II	15	8	1	13
INFLUENT III	- EFFLUENT REQUIREMENTS NOT SATISFIED WITH TREATMENT SCHEME.			

[a] MAXIMUM MONTHLY AVERAGE

[b] MULTIMEDIA FILTER NOT REQUIRED

Source: Stanley Consultants.

BOD_5 and 1.5 mg/l ammonia nitrogen. Influent III requires a sand filter or microstrainer to meet effluent criteria. Most package treatment plants employ the extended aeration process, using a 24-hour hydraulic retention time and continuous solids recycle. To operate efficiently, solids must be wasted periodically from the system.

Other activated sludge processes combined with nitrification will provide the same effluent quality. Bio-discs, if proven reliable, can be used as a combined carbon oxidation-nitrification system in new systems.

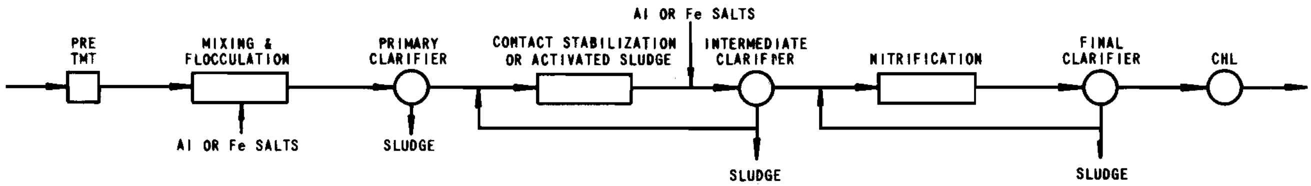
Levels 7(B) and (C) utilize land application following secondary treatment. During summer months, the aerated

Figure 9

LEVEL 6 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 15 mg/l BOD_5, 1.0 mg/l Total P, 1.5 mg/l NH_3-N

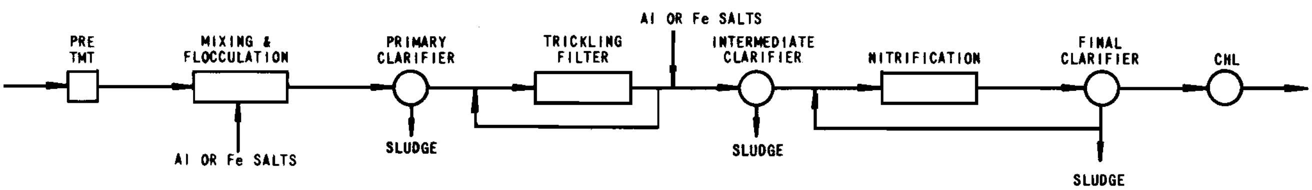
(A)



EXPECTED EFFLUENT QUALITY [a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	10	12	1	1.5
INFLUENT II	15	20	1	1.5
INFLUENT III	15	20	1	1.5

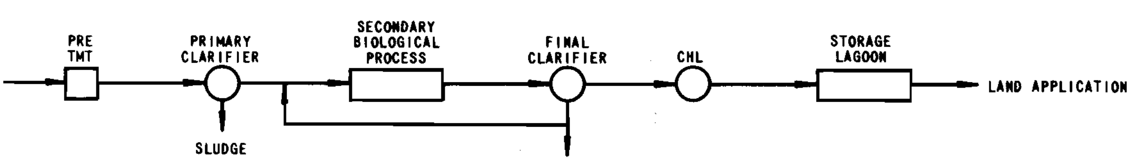
(B)



EXPECTED EFFLUENT QUALITY [a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I	10	12	1	1.5
INFLUENT II	15	20	1	1.5
INFLUENT III	15	20	1	1.5

(C)



EXPECTED EFFLUENT QUALITY [a]:

ALL INFLUENTS: REMOVALS DEPEND ON SOIL TYPE AND CROPPING PRACTICE - SEE TEXT

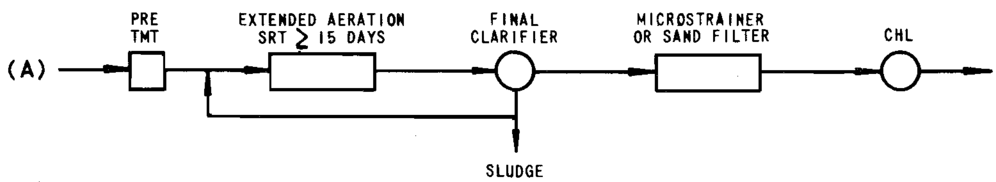
[a] MAXIMUM MONTHLY AVERAGE

Source: Stanley Consultants.

Figure 10

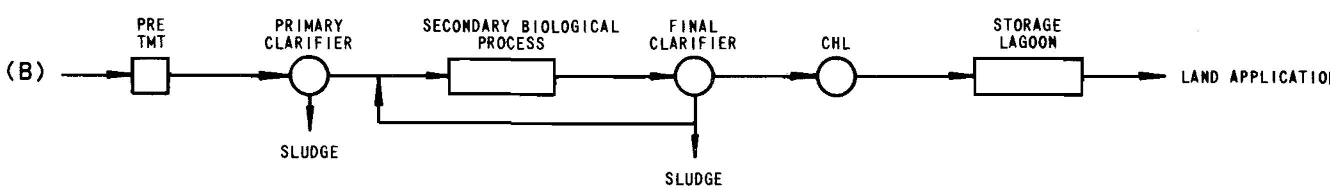
LEVEL 7 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 15 mg/l BOD_5, NH_3-N = 1.5 mg/l   Q ≤ 0.5 mgd

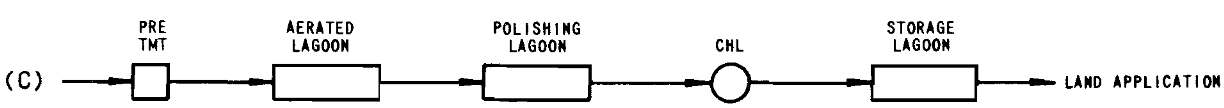


EXPECTED EFFLUENT QUALITY[a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)
INFLUENT I[b]	10	12	9	1.5
INFLUENT II[b]	15	20	12	1.5
INFLUENT III	15	12	15	1.5



EXPECTED EFFLUENT QUALITY[a]:
ALL INFLUENTS: REMOVALS DEPEND ON SOIL TYPE AND CROPPING PRACTICE - SEE TEXT



EXPECTED EFFLUENT QUALITY[a]:
ALL INFLUENTS: REMOVALS DEPEND ON SOIL TYPE AND CROPPING PRACTICE - SEE TEXT

a MAXIMUM MONTHLY AVERAGE

b MICROSTRAINER OR SAND FILTER NOT REQUIRED

Source: Stanley Consultants.

lagoon alone would probably satisfy effluent requirements, but organic and ammonia levels would violate effluent criteria for colder temperatures.

Treatment alternatives for small areas using other concepts are fully detailed in Chapter VI.

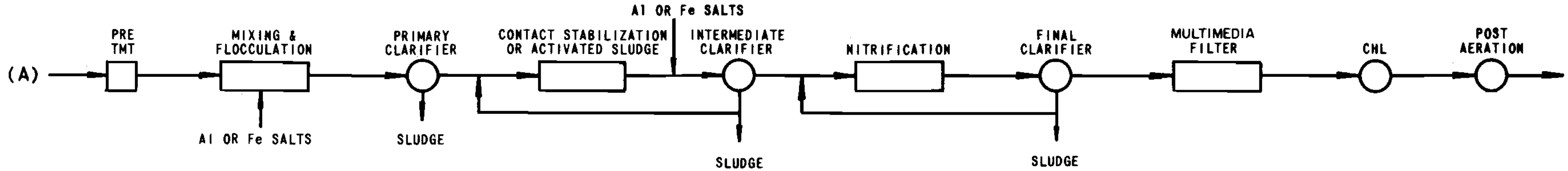
LEVEL 8 SCHEMATICS

Figure 11 displays the Level 8 schematics. These schematics are essentially the same as those for Level 6 except that a multimedia filter is necessary for Influents II and III in Levels 8(A) and (B) to ensure meeting the 10 mg/l

Figure 11

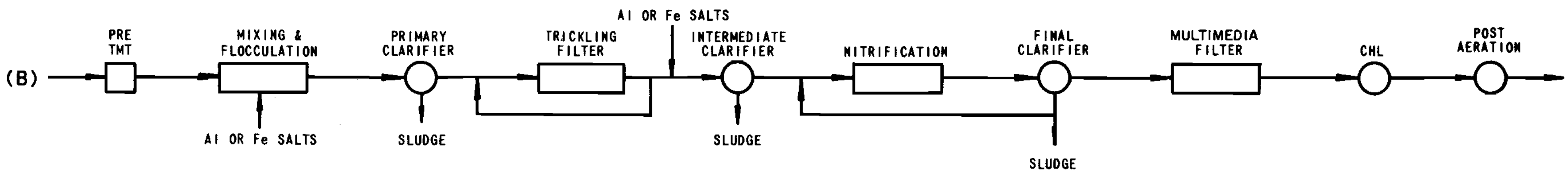
LEVEL 8 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 10 mg/l BOD_5, 1.0 mg/l Total P, 1.5 mg/l NH_3-N, 6.0 mg/l DO



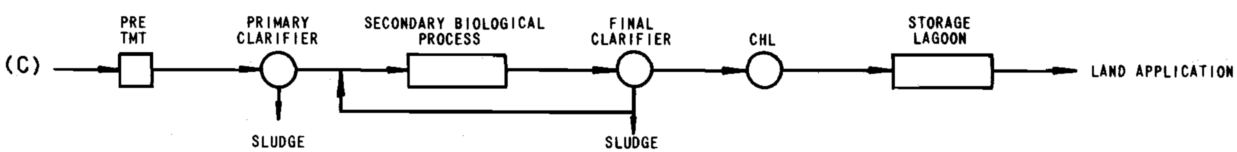
EXPECTED EFFLUENT QUALITY [a]

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)	DO(mg/l)
INFLUENT I [b]	10	12	1	1.5	6
INFLUENT II	8	5	1	1.5	6
INFLUENT III	10	8	1	1.5	6



EXPECTED EFFLUENT QUALITY [a]

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)	DO(mg/l)
INFLUENT I [b]	10	12	1	1.5	6
INFLUENT II	8	5	1	1.5	6
INFLUENT III	10	8	1	1.5	6



EXPECTED EFFLUENT QUALITY [a]

ALL INFLUENTS: REMOVALS DEPEND ON SOIL TYPE AND CROPPING PRACTICE - SEE TEXT

[a] MAXIMUM MONTHLY AVERAGE

[b] MULTIMEDIA FILTER NOT REQUIRED

Source: Stanley Consultants.

BOD_5 criteria. Where multimedia filters are used, phosphorus residuals lower than 1.0 mg/l may be achieved. An alternative to the schematics shown for new systems is single-stage nitrification. Postaeration is added to increase effluent dissolved oxygen from the 1 to 2 mg/l that can be expected in Schematics 1 through 7 to the 6 mg/l specified for this treatment level. Use of ozonation in lieu of chlorination would preclude the need for postaeration, but ozonation is not cost-effective when compared to chlorination plus postaeration.[7]

LEVEL 9 SCHEMATICS

Level 9 schematics are developed to meet the most stringent criteria of all the levels specified by SEWRPC (see Figure 12). The schematics are similar to those for Level 8 except that a carbon adsorption step is required for Levels 9(A) and (B). No additional removal of suspended solids is expected with an upflow contactor unit. Carbon adsorption has been used at several locations to achieve a BOD_5 level of 5 mg/l or lower.[8]

Treatment of a wastewater with Influent I wastewater characteristics may not require carbon adsorption, depending on the soluble BOD_5 in the effluent. Pilot plant studies can determine if this is feasible.

Level 9(C) proposes land application after secondary treatment. Constituent removal will depend on soil type and cropping practice.

Ozonation at high dosages (100 mg/l) has been proposed by some as a replacement for carbon adsorption, chlorine disinfection, and postaeration, but the system is not currently cost-effective and has not been demonstrated.[9]

CONSTITUENT REMOVAL AND SLUDGE PRODUCTION FROM SCHEMATICS

To estimate the quantity of solids that is produced from a given treatment system, expected removal of suspended solids and organic matter from each unit process must be assumed. The addition of chemicals for phosphorus removal increases the quantity of sludge produced. The significant quantities of sludge that result from the proposed wastewater treatment schematics come from the primary clarifier, secondary biological processes, nitrification processes, and addition of chemicals for phosphorus control.

The primary clarifier is estimated to remove 60 percent of the influent suspended solids and 35 percent of the influent BOD_5. The amount of suspended solids removed is the quantity of sludge produced. When aluminum or iron salts are applied for phosphorus control to the primary clarifier, it is assumed that 70 percent of the suspended solids, 45 percent of the BOD_5, and 80 percent of the phosphorus are removed. In addition to the suspended solids removed, it is estimated that approximately 14 pounds of chemical sludge are produced per pound of phosphorus removed. Solids content of the above sludges can range from 2 to 6 percent.

Trickling filters with primary clarifiers are assumed to remove 70 percent of the applied BOD_5. It is estimated that approximately 0.5 pound of sludge requiring sludge handling is produced per pound of BOD_5 removed. The solids are removed in the final clarifier. Solids content usually ranges from 3 to 6 percent. Chemical sludge produced from phosphorus removal can be estimated in the same manner as in the primary clarifier. Often the solids removed in the secondary clarifier are directed to the primary clarifier before being pumped to sludge handling facilities.

It is estimated that the activated sludge process will produce approximately 0.8 pound of sludge requiring sludge handling per pound of BOD_5 removed. Overall BOD_5 removals with the activated sludge process range from 85 to 95 percent. Solids content varies from 0.5 to 1.5 percent. Chemical sludge production can be estimated by the previously discussed method. Waste solids are removed from the final clarifier or return sludge lines and are commonly directed to thickeners prior to being directed to other sludge handling equipment.

Sludges produced by a separate stage suspended growth nitrification system are primarily due to carbonaceous material that is removed. Theoretically, 0.17 pound of nitrifiers is produced per pound of ammonia removed. Table 7 lists various ammonia removal efficiencies for different treatment processes. The quantity of solids produced due to carbonaceous material removal can be estimated in the same manner as that for activated sludge. Excess solids are usually removed from the primary biological treatment system which is used to control sludge inventories in the second stage system. Sludge production from bio-discs can be estimated by the method presented for trickling filters.

A combined carbon oxidation-nitrification system produces less solids than a two-stage system. It is assumed that approximately 0.7 pound of sludge requiring sludge handling is produced per pound of BOD_5 removed.[10] Solids content range from 0.5 to 1.5 percent.

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[7] *Culp, Wesner, and Culp, 1974 Lake Tahoe Advanced Wastewater Treatment Seminar Manual, Clean Water Consultants, El Dorado Hills, California, 1975.*

[8] *Metcalf and Eddy, Inc., for the U. S. Environmental Protection Agency, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, October 1974.*

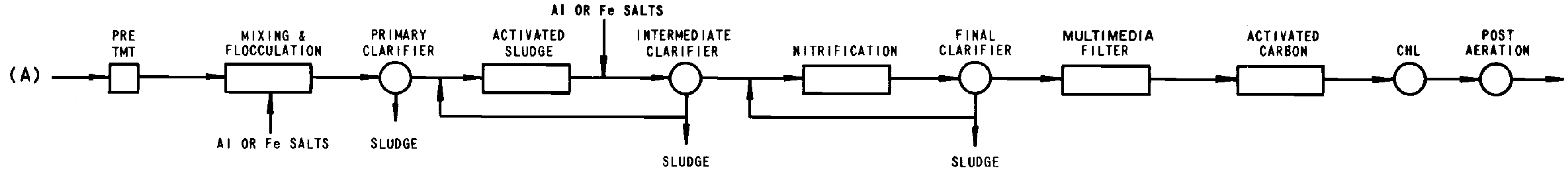
[9] *Culp, Wesner, and Culp, 1974 Lake Tahoe Advanced Wastewater Treatment Seminar Manual.*

[10] *D. F. Bishop et al, "Single Stage Nitrification-Denitrification," Journal Water Pollution Control Federation, 48, March 1976.*

Figure 12

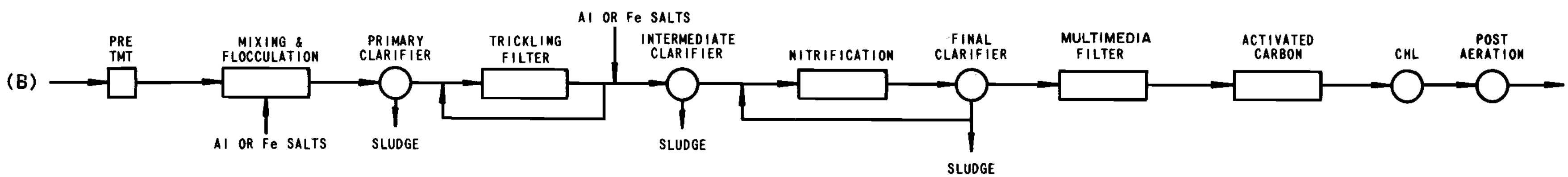
LEVEL 9 TREATMENT SCHEMATICS

EFFLUENT REQUIREMENTS[a]: 5 mg/l BOD_5, 1.0 mg/l Total P, 1.5 mg/l NH_3- N, 6.0 mg/l DO



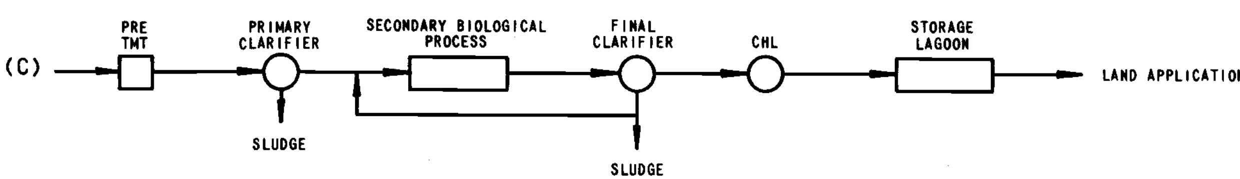
EXPECTED EFFLUENT QUALITY [a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)	DO(mg/l)
INFLUENT I	3	4	1	1.5	6
INFLUENT II	4	5	1	1.5	6
INFLUENT III	5	8	1	1.5	6



EXPECTED EFFLUENT QUALITY [a]:

	BOD_5(mg/l)	TSS(mg/l)	TOTAL P(mg/l)	NH_3-N(mg/l)	DO(mg/l)
INFLUENT I	3	4	1	1.5	6
INFLUENT II	4	5	1	1.5	6
INFLUENT III	5	8	1	1.5	6



EXPECTED EFFLUENT QUALITY [a]:

ALL INFLUENTS: REMOVALS DEPEND ON SOIL TYPE AND CROPPING PRACTICE - SEE TEXT

[a] MAXIMUM MONTHLY AVERAGE

Source: Stanley Consultants.

The sludge production factors can be used to estimate sludge quantities from the various treatment processes using constituents removals contained therein. The factors indicate solids to be handled by sludge handling facilities. More solids are usually produced, but solids lost in the effluent reduce quantities requiring handling. This 5 to 10 percent loss must be accounted for where effluent screening or filtration is employed. Sludge characteristics and sludge handling processes are detailed in a separate report.

MUNICIPAL STRUCTURAL CONTROL SUMMARY

As shown by the previous treatment schematics, several unit processes are involved in the treatment of municipal wastewaters. The treatment schemes involve physical, chemical, and/or biological processes. Design criteria and performance of the unit operations involved in the schematics are documented in a number of literature references.[11] The structural controls proposed for municipal wastewater are summarized below. Cost curves for these processes are presented in Appendix D. A further discussion on the development and application of these curves is covered in Chapter VIII. Processes include:

1. Pretreatment.
2. Raw waste pumping.
3. Primary clarification.
4. Primary clarification with aluminum or iron salt addition.
5. Aeration tanks for activated sludge.
6. Trickling filters.
7. Final clarifiers (or intermediate clarifiers).
8. Final clarifiers with aluminum or iron salt addition.
9. Aerated lagoons.
10. Polishing lagoons.
11. Chlorination facilities.
12. Postaeration facilities.
13. Sand filters.
14. Multimedia filters.
15. Microstrainers (microscreens).
16. Rotating biological contactors (bio-discs).
17. Activated sludge nitrification tanks.
18. Breakpoint chlorination.
19. Carbon adsorption and carbon regeneration.
20. Land application of secondary effluent.
21. Ozonation.

Structural controls for sludge processing and disposal are addressed in a separate report.

Commonly discussed advanced wastewater treatment processes (lime clarification, clinoptilolite or other ion exchange, biological denitrification) are not required to meet specified effluent objectives. Other processes (air stripping, reverse osmosis, solvent extraction, foam fractionation, electrodialysis, and desalination) are either not required, do not operate well in the area's climate, or are not sufficiently developed to be economically competitive for municipal wastewater treatment or for larger installations.

SPECIAL INDUSTRIAL WASTE CONSIDERATIONS

Common industrial waste problems in the Region include heat removal, neutralization, oil and grease removal, and metals control (see Chapter II and Appendix B).

Heat Removal

Basic alternatives in heat reduction include cooling towers and cooling lagoons or ponds. Cooling can also be accomplished using air instead of water as the cooling medium.

Cooling towers are often used in recirculating water systems. The circulated water is treated for scale and biological growth control. As the water is cooled, approximately 1 percent is evaporated for each $10^{o}F$ cooling, resulting in concentrating dissolved material in the

[11] *Metcalf and Eddy, Process Design Manual; Clark, Viessman, and Hammer, Water Supply and Pollution Control, International Textbook Company, Scranton, Pennsylvania, 1971; Metcalf and Eddy, Inc., Wastewater Engineering, McGraw-Hill, New York, New York, 1972; Black and Veatch, and Shemik, Roming, Jacobs, and Finklea for the U. S. Environmental Protection Agency, Process Design Manual for Phosphorus Removal, April 1976; Brown and Caldwell for the U. S. Environmental Protection Agency, Process Design Manual for Nitrogen Control, October 1975; Hazen and Sawyer for the U. S. Environmental Protection Agency, Design Manual for Suspended Solids Removal, October 1971; CH_2M/ Hill for the U. S. Environmental Protection Agency, Process Design Manual for Carbon Adsorption, October 1973; Gordon M. Fair et al, Water and Wastewater Engineering, Volume 2, John Wiley, New York, 1958; and R. L. Culp and G. L. Culp, Advanced Wastewater Treatment, Van Nostrand Reinhold Company, New York, New York, 1971.*

circulating water. The dissolved material is controlled by incorporating a blowdown stream (5 to 10 pèrcent) of circulating flow. A cost curve for cooling towers is presented in Appendix D.

Cooling ponds or spray ponds require large land areas which generally are not available in urban centers. The required size of the pond depends on the heat load and type of spray system.

Neutralization

Certain industrial wastes can have wide ranges of pH which can violate discharge criteria. Neutralization consists of constructing basins with mixers and chemical feed equipment for sulfuric acid or carbon dioxide (basic wastes) or caustic, soda ash, or lime (acid wastes). Often two waste streams can be combined to effect neutralization in a cost-effective manner. (Treatment processes to destroy cyanide, reduce chromium, or to precipitate heavy metals also require pH control.) Cost curves for neutralization are presented in Appendix D.

Oil and Grease Removal

Metal-working operations may contain large quantities of oils in any of three forms: free floating oil, emulsified oil, or soluble oil. Physical, chemical, and biological treatment steps may be used in various combinations to reduce oil concentrations to levels required by water usage or regulatory criteria.

Free oils readily float to the surface for removal by a gravity separator such as conventional primary clarifiers with surface skimming devices or API separators.

Emulsified oils can be oil-in-water or water-in-oil types. Oil-in-water emulsions are most common. Soaps, alcohols, or suspended matter can act to stabilize the small oil droplets. It is necessary to first break the emulsion and then remove the oil as free oil. Cracking using heat, chemicals, and settling can be used for large oil quantities. Iron or aluminum salts are used to break emulsions on wastewaters containing less than 1,000 mg/l of emulsified oil. Soluble oils can be removed by conventional biological treatment processes.

The effectiveness of oil separation depends on the type of oil, temperature of the waste, and other factors. Some generalizations on removals expected are as follows:[12]

Method of Oil Removal	Effluent
Gravity separators	150 to 200 mg/l
Dissolved air flotation (DAF)	50 to 100 mg/l
Separators plus filters	10 to 20 mg/l
DAF plus filters	10 to 20 mg/l
Chemical precipitation plus DAF	5 to 10 mg/l
Chemical precipitation plus separators	5 to 10 mg/l

Metals Removal

The most commonly used heavy metal removal techniques are chemical precipitation, metallic replacement, electrodeposition, ion exchange, evaporation, and reverse osmosis; solvent extraction, activated carbon adsorption, and ion flotation are being developed and are applicable in some situations.[13]

Chemical precipitation is the most commonly used removal method, particularly when metal recovery is not a consideration. This process is based on the fact that most metal hydroxides and some metal carbonates and sulfides are only sparingly soluble in water. The typical precipitation process using caustic or lime as a reactant is applicable to copper, zinc, iron, or nickel removal.[14]

Chromium exists in wastewaters in the highly toxic hexavalent and less toxic trivalent forms. The hexavalent form is converted to the trivalent form using sulfur dioxide, ferrous sulfate, metallic iron, or sodium bisulfite reducing agents at a pH of 2 to 3. The trivalent chromium is then precipitated using lime or caustic.[15] Soda ash needs to be used to precipitate lead or mercury. Cyanide removal using sodium sulfide[16] needs to be accomplished prior to cadmium precipitation. Metallic replacement or electrodeposition is primarily used for recovery of valuable metals. A cost curve for metal precipitation using lime clarification is included in Appendix D.

Although these methods are currently considered to be effective applications of the state of the art of wastewater treatment, it is noteworthy that the 1976 passage of the Federal Hazardous Waste Management Act may result in a series of official USEPA definitions of "hazardous wastes" and an ensuing series of definitions of cost-effective treatment techniques.

[12] *Y. H. Lin and J. R. Lawson, "Treatment of Oily and Metal-Containing Wastewater," Pollution Engineering, 5, November 1973, and H. F. Lund, Industrial Pollution Control Handbook, McGraw-Hill, New York, New York, 1971.*

[13] *Battelle Memorial Institute for the U. S. Environmental Protection Agency, A State-of-the-Art Review of Metal Finishing Waste Treatment, November 1968; J. G. Dean et al "Removing Heavy Metals from Wastewater," Environmental Science and Technology, 6, June 1972; and M. Sittig, Pollutant Removal Handbook, Noyes Data Corporation, 1973.*

[14] *J. G. Dean, Environmental Science and Technology.*

[15] *Battelle Memorial Institute, A State-of-the-Art Review.*

[16] *M. Sittig, Pollutant Removal Handbook, Noyes Data Corporation, 1973.*

Chapter VI

SMALL AREA WASTE TREATMENT SYSTEMS

INTRODUCTION

Wastewater treatment systems, schematics, and costs discussed in prior chapters focused on treatment facilities for centralized sewerage systems. Planning Report 16[1] estimated that approximately 268,000 people (241,000 in urban areas) in the Region rely on other systems for wastewater handling. The most common system used is the familiar septic tank followed by leaching fields. Some homes rely on holding tanks which are emptied weekly. Septage from these systems is usually transported to centralized systems. Increased reisistance to acceptance of septage at centralized systems and the fact that most of the soils in the study area are not suitable for leaching fields indicates special attention needs to be focused on practical alternatives for these areas.

Although connection to a central sewerage system is not always practical or economical for some areas, the Commission does not necessarily encourage small area waste treatment systems. In Planning Report 16 the need for a regional sanitary sewerage system planning program was recognized for the Southeastern Wisconsin Region in order to maximize the proportion of residential houses which can be served by central sewerage facilities. This need was considered desirable by the Commission because the widespread use of onsite private sewage disposal systems can potentially result in groundwater or surface water pollution, and public health hazards, and may create a demand for urban services to areas of such low densities as to make the cost of such service unduly expensive.

TREATMENT OPTIONS FOR THE INDIVIDUAL HOME

Characterization of Household Wastewater

Wastewater from individual homes or small groups of homes has volume and constituent characteristics which are quite variable. Typical values are summarized in Tables 15 and 16. (Planning Report 16 reported an average flow of 88 gallons per capita per day for the Region, but this was for centralized sewerage systems.) Assuming an average family of four, wastewater volume is approximately 200 gallons per residence per day in rural homes. The greatest single producer of wastewater flow in the household is toilet flushing, which accounts for about 36 percent of total wastewater volume. This source also accounts for approximately one-fourth of the BOD_5 and three-quarters of the total nitrogen.

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[1] *Southeastern Wisconsin Regional Planning Commission, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, 1974.*

Reduction of Household Wastewater Load

Household wastewater is usually not significantly reducible in strength, except for reduced use of garbage grinders or phosphate detergents. The volume of wastewater may be decreased by a number of methods discussed below. Less wastewater volume can result in smaller liquid handling facilities at the waste treatment facility, as well as conserving water and energy for pumping and treatment. Some of these methods have equal benefit in larger systems. Sludge quantities and sludge handling requirements will not be diminished by reducing the wastewater flow quantity alone.

The quantity of household wastewater may be reduced by decreasing the volume of water used in the home. Water use may be lessened by:

1. Water conservation practices in the home. Consumer education should make residents aware of the benefits of water conservation.

Table 15

PER CAPITA WASTEWATER QUANTITIES FROM INDIVIDUAL HOUSEHOLDS

Source	Quantity (gallons/capita/day)	
	Range	Average
Toilet	9-25	18
Bath or Shower.	9-20	13
Laundry	8-12	10
Dishwashing	1- 5	2.5
Sink or Lavatory	3- 8	4.5
Other	1- 7	2
Total	43-64	50

[a] *Values shown on this table are for a rural home not connected to a centralized water or sewerage system. Values for homes served by centralized facilities are expected to be higher as shown in Planning Report 16.*

Source: Journal, Environmental Engineering Division, ASCE, June 1976; Journal, Environmental Engineering Division, ASCE, February 1974; Pennsylvania State University Information Report 74, Proceedings of Conference on Water Conservation and Sewage Flow Reduction with Water-Saving Devices, July 1975; and General Dynamics.

Table 16

PER CAPITA WASTEWATER CHARACTERISTICS FROM INDIVIDUAL HOUSEHOLDS

Facility	Characteristics (pounds/capita/day)							
	BOD_5	COD	TS	TSS	TVS	TVSS	Total N	Total P
Toilet								
(Average)	0.030	0.159	0.163	0.059	0.113	0.050	0.028	0.002
(Range)	0.015-0.052	--	0.063-0.214	0.028-0.080	0.043-0.184	0.022-0.078	0.009-0.037	0.001-0.003
Bath or Shower								
(Average)	0.011	0.016	0.027	0.006	0.008	0.003	0.001	--
(Range)	0.007-0.020	--	0.010-0.046	0.002-0.012	0.007-0.008	0.002-0.003	--	--
Laundry								
(Average)	0.024	0.053	0.089	0.016	0.029	0.011	0.002	0.004
(Range)	0.019-0.033	--	0.073-0.106	0.008-0.024	0.014-0.043	0.008-0.014	--	0.001-0.005
Dishwashing								
(Average)	0.020	0.002	0.015	0.014	0.001	--	--	0.002
(Range)	0.001-0.046	--	0.008-0.022	0.006-0.021	--	--	--	0.001-0.003
Total								
(Average)	0.108	0.350	0.410	0.110	0.200	0.150	0.032	0.008
(Range)	0.106-0.110	--	0.370-0.450	0.077-0.150	--	--	0.013-0.050	0.005-0.009
Total with Garbage Disposal								
(Average)	0.174	--	0.505	0.198	--	--	--	0.009

Source: *Journal, Environmental Engineering Division, ASCE, June 1976; Journal, Environmental Engineering Division, ASCE, February 1974; Pennsylvania State University Information Report 74, Proceedings of Conference on Water Conservation and Sewage Flow Reduction with Water-Saving Devices, July 1975.*

2. Plumbing code changes. Plumbing codes may be amended to require use of water-saving devices in all new construction, although requirements for adhering to national codes may restrict this method of wastewater flow reduction in some communities.

3. Installation of pressure-reducing valves in the distribution system. Generally, areas with pressures greater than 60 psi should be provided with pressure-reducing valves. Considerations must be given to adequate fire protection prior to adopting such a system.

4. Metering water and charging for actual water used.

5. Use of water-saving devices. These devices range from simple faucet aerators to recycling toilets and are discussed in more detail in following paragraphs.

6. Reuse of wastewater within the home. This most often involves a cascade system in which wastewater from laundry, lavatory, and/or tub or shower is used for toilet flushing.

Public opinion is generally favorable to the installation of water-saving devices, but opposed to water price increases. Low contact reuse of treated wastewater (i.e., lawn sprinkling) is marginally acceptable, but direct contact reuse (bathing) is not generally acceptable.[2] Public education programs can play an important role in improving consumer attitudes toward water conservation and reuse.

The reduction of wastewater flows from homes can be negated by infiltration and inflow of water into the collection system between the homes and the wastewater treatment system. This is not so much of a problem for homes with individual onsite systems as it is for those homes served by a central collection and treatment system.

Water-Saving Devices in the Home

It is estimated that 60 percent of bathing done in homes with showers and tubs is done in the shower. The typical shower uses 5 to 10 gpm of water. Flow limiting showerheads are available that use only 3 gpm. In addition to water savings, energy required to heat the water is correspondingly reduced.

[2] *Proceedings of Conference on Water Conservation and Sewage Flow Reduction with Water-Saving Devices, Pennsylvania State University Information Report Number 74, July 1975.*

Water used at lavatories and sinks may also be reduced by flow restriction devices. These devices reduce the maximum flow from about 4.5 gpm to about 2.5 gpm. In addition, faucet aerators provide a small degree of water savings.

Front loading clothes washers use approximately 33 percent less water than do top loading machines. Some models reduce water usage by means of level controls which allow selection of water level based on the size of load being washed.

Toilet flushing water requirements can be significantly decreased by use of water-saving devices. The average toilet uses 5 to 6 gallons per flush. Virtually all manufacturers now offer a 3.5 gallon per flush shallow-trap toilet meeting the requirements of federal specification WW-P-541/A for water-saving toilets.[3] This specification is often cited in modification of local codes to accommodate water conservation devices.

Other toilet modifications include the dual-flush toilet and the vacuum toilet system. The dual-flush toilet uses approximately 2.5 gallons for a full flush when solid matter is present. Tripping the tank handle the opposite direction produces a half-flush of 1.25 gallons which is used when solid matter is not present. Vacuum toilet systems use a vacuum to pull wastes to a central collection point. Air is the primary transporting fluid, and the 0.5 gallon of water required per flush is used primarily to rinse the toilet bowl. This system is not considered economical for single residences, but may be attractive for apartment buildings or a group of homes. A vacuum pump, receiving tank, and special toilets are required for the vacuum system. In addition, the receiving tank must be emptied and the contents discharged to a sewer, transported to a sewage treatment facility, or treated onsite.

Existing home toilets may be retrofitted with water-saving devices. Bricks, water-filled plastic bottles, and partitions are just some of the devices that can be used to displace water in the tank, reducing water volume per flush. Regional programs in the Washington, D. C. area [4] indicate that increased maintenance caused by placing objects in toilets led many residents to remove them. Results were mixed with some programs being successful in reducing wastewater flow, while others failed.

Most home sewer lines are designed to carry the flow and solids from a standard 5 to 6 gallon/flush toilet. These lines can adequately transport solids for toilet flushes down to approximately 2 gallon/flush. New houses using water-saving toilets should consider the use of 4-inch sewer house connections, rather than the 6-inch connections used in many localities.

Several toilet systems require little or no water. Among these are incinerating toilets, composting toilets, chemical toilets, and recirculating toilets. These systems allow reduction of the total water used in the home by over one-third and allow segregation of toilet wastes from other household wastewater. The wastewater from the toilet is the major contributor of BOD, COD, nitrogen, suspended solids, bacteria, and viruses. Gray water wastes (laundry, bath/shower, etc.) account for approximately two-thirds of the household wastewater volume. The reduced flow volume and strength of the gray water wastes may allow usage of a smaller septic tank adsorption field or an alternate treatment method than that required to treat all household wastewater.

Incinerating toilets use electricity or propane gas to burn the solid waste and evaporate the liquids, leaving a sterile, inert ash. Blowers are used to remove vapors, odors, and heat. Some models have a cycle time of 20 to 30 minutes, during which time the toilet cannot be used.

Composting toilets provide sufficient air to biologically decompose the waste under aerobic conditions. Odors are vented away and the compost is periodically removed. Garbage as well as human wastes may be treated by this system. Results from installed systems in the United States indicate varied performance and some operational problems.[5]

Chemical toilets are usually suitable for occasional usage only. A liftout bucket containing a bactericide and deodorant hold the waste until it may be disposed by some other means.

Recirculating toilets use a chemical-water mixture or mineral oil to transport the waste material. The chemical-water system has a holding tank and is suitable for about 50 flushes before the entire contents must be removed and the system refilled. The mineral oil system has a holding tank where solids may settle before the mineral oil is filtered, disinfected, and returned for reuse. The mineral oil system requires electricity and is often difficult to maintain. Both systems require further treatment and disposal of the waste material.

Many regulatory agencies consider all four toilet systems discussed above as holding tanks only. Their primary benefit is considered to result from flow reduction, not from any associated treatment.

Table 17 lists cost of installation and annual savings resulting from the use of water-saving devices for a typical residence.

Wastewater Reuse in the Home

At present cost levels for water and sewage treatment, the advanced treatment of household waste flows for direct reuse in the home cannot be economically justified. Two reuse schemes which do appear to have economic merit, however, are the reuse of wash waters for toilet flushing and the reuse of aerobic treatment unit effluent for toilet flushing and/or lawn irrigation. The public health impacts and questions of reliability of systems are significant drawbacks to widespread use.

[3] *Ibid.*

[4] *Ibid.*

[5] *Ibid.*

Table 17

WATER USE REDUCTION SAVINGS FOR A TYPICAL RESIDENCE

Water Use	Base Use (gpd)	Water Reduction Device	Water Savings (gpd)	Installation Cost (in Dollars)	Annual Savings (in Dollars)
Shower	52	Flow Limiting Valve	26	87	22.90
Water Taps	28	Aerators	2	3.50/tap	2.10
		Flow Limiting Valve	4	118/tap	3.50
Washing Machine	40	Level Control	5	60	6.90
Toilet	72	Shallow Trap Water Closet	30	190	25.70
		Dual Flush Water Closet	50	225	43.40
		Vacuum Flush	66	2,600	- 175.00[a]
		Oil Recycle Toilet	72	4,000	- 260.00[a]
		Reuse of Wash Waters for Toilet Flushing	70	560	- 44.50[a]

[a]*Negative sign indicates annual cost, rather than savings.*

Source: Proceedings of Conference on Water Conservation and Sewage Flow Reduction with Water-Saving Devices, July 1975, and General Dynamics.

Reuse of laundry and tub and shower wastes requires a storage tank, filter, pump, pressure tank, and chlorination equipment. The wastewater flows into the storage tank where a chlorinating agent is added either manually or automatically. The water is pumped through a filter to a pressure tank. As the toilet tank empties, water is automatically bled from the pressure tank to the toilet. Surplus water received at the storage tank is routed directly to the sewer.

The use of aerobic treatment unit effluent for toilet flushing requires equipment similar to that described above. Lawn irrigation requires additional piping and spray nozzles.

The two systems described above cannot generally be justified on an economic basis alone. They do allow use of lesser amounts of fresh water and, therefore, reduce the total volume of wastewater to be treated.

Onsite Sewage Treatment and Disposal Methods for Households

The predominant form of onsite household wastewater treatment is the septic tank followed by a soil absorption (leaching) field. The efficiency of the system is dependent on the characteristics of the applied wastewater, tank and leaching field size, characteristics of the soil, and depth of groundwater in the area of the leaching field. The tank must be of adequate size to provide adequate settling time for solids, as well as providing surge capacity for laundry and bathing flows. The solids are settled out in the tank and undergo anaerobic decomposition. The effluent from the tank is discharged to the soil absorption system where the remaining nutrients, suspended solids, and microorganisms are potentially removed. The soil absorption system must be of large enough size and have the proper characteristics to absorb the liquid waste at the rate it is discharged from the tank. When the solids in the tank reach a certain level, incoming solids cannot settle properly and are discharged to the soil bed, resulting in anaerobic conditions in the bed, plugging of soil pores, and eventual failure. For this reason, the solids level in the septic tank must be checked periodically, and the septage removed as required. The average period between septic tank cleanings is two to three years. Removed septage must be adequately handled after removal. It is important to leave approximately one-third of the tank contents in the tank to provide the organisms to continue the anerobic decomposition process immediately after pumping.

The major pollutional problems associated with septic tank usage are transfer of nitrogen and pathogens to the adjacent groundwater (sometimes to surface waters). Nitrogen and pathogens from septic tank effluent can pollute nearby shallow wells, and the nitrogen can contribute to eutrophication of nearby lakes. Characteristics of typical septic tank effluent are shown in Table 18.

In those areas with soils which are not completely suitable for absorption of septic tank effluent, alternative methods of treatment and/or disposal must be utilized. The preferable method, not always available, is connection to a centralized sewerage system.

If the groundwater table is not too high, but existing soil absorption characteristics are unsuitable, fill material may be hauled in to replace existing soil in the area of soil absorption bed construction.

Table 18

ONSITE SEWAGE TREATMENT SYSTEM EFFLUENT CHARACTERISTICS

Effluent Type	BOD_5 (mg/l)	COD (mg/l)	TSS (mg/l)	BSS (mg/l)	NH_3-N (mg/l)	NO_2^-, NO_3-N (mg/l)	Ortho-phosphate (mg/l)	Fecal Coliform (Number/100 ml)	Total Coliform (Number/100 ml)
Septic Tank Effluent	123	280	48	37	19.2	0.3	8.7	5.9×10^5	9×10^5
After intermittent sand filtration[a];	9	52	7	5	1.0	20.0	6.9	0.65×10^3	1.3×10^3
and chlorine disinfection . .	3	32	6	4	1.6	18.9	7.9	2	3
Aerobic Unit Effluent	26	82	48	33	0.4	33.8	28.1	1.9×10^4	1.5×10^5
After intermittent sand filtration[b];	4	29	11	6	0.3	36.8	22.6	1.3×10^3	1.3×10^4
and chlorine disinfection . .	4	26	7	4	0.4	37.6	23.4	8	35

[a] *Sand filter loaded at rate of 5 gal/day/ft²*.

[b] *Sand filter loaded at rate of 3.8 gal/day/ft²*.

Source: Journal, Environmental Engineering Division, ASCE, August 1976.

Another alternative soil absorption system is the experimental "mound system."[6] This system uses sand placed in a mound on top of the existing soil to absorb the septic tank effluent which is discharged inside the mounded bed. The effluent infiltrates the adjacent soil after undergoing some purification in the mound. Treatment results may be adversely affected in climates with rainfall considerably in excess of evaporation (the case in the Region). At this time, the use of the mound system is restricted in the State of Wisconsin but can be utilized if special county and State authorizations are obtained.

The use of mound systems where other soil absorption systems are not allowed may significantly alter growth patterns in the study area. Some sites not previously suitable for building due to lack of service by existing sewerage systems, poor soil absorption rates, or a high groundwater table could be developed where mound systems are allowed. Zoning or subdivision restraints may need to be adjusted to control and guide this growth to prevent rural sprawl.

Aerobic treatment units are also utilized for individual onsite sewage treatment, although their cost is greater than that of a septic system and they require more maintenance. Aerobic units, like septic tanks, are generally followed by additional treatment and/or disposal processes such as soil absorption beds, filtration, etc. The effluent from aerobic units is generally lower in BOD_5 than that from septic tanks, but suspended solids levels may be comparable. Soil absorption area requirements are generally less for aerobic effluent than for septic tank effluent. Septic tanks are less likely to be upset by flow surges than are aerobic units.[7]

Aerobic units utilize compressed air and mixing to biologically decompose the wastewater. They operate similar to larger extended aeration package plants. Many units are poorly designed, with poor sludge return and weir lengths insufficient to accommodate surge flows.[8] Solids often build up because most units do not have sludge removal facilities or homeowners fail to pump out the solids on a periodic basis. As a result, suspended solids are lost over the effluent weir, accounting in great part for the relatively poor effluent characteristics from these units. Lack of homeowner attention and maintenance is a great problem that remains to be solved. Table 18 lists characteristics of a well-designed and operated onsite aerobic treatment unit effluent.

Intermittent sand filtration of septic tank and aerobic unit effluent may offer advantages in areas where soil absorption systems are not adequate. Experimental work has indicated that intermittent sand filtration of aerobically treated effluent produces a high quality product that is suitable for discharge to surface waters in terms of

[6] *State of Wisconsin, Department of Health and Social Services, Alternate Sewage Manual, June 1975.*

[7] *General Dynamics for the Federal Water Quality Administration, A Study of Flow Reduction and Treatment of Wastewater from Households, 11050, FKE, December 1969.*

[8] *R. J. Otis and W. C. Boyle, "Performance of Single Household Treatment Units," Journal, Environmental Engineering Division, ASCE, 102, February 1976.*

BOD_5 and TSS.[9] Chlorination can reduce the total and fecal coliform levels to acceptable levels, but high chlorine residuals usually result. Table 18 summarizes sand filter performance with septic tank and aerobic treatment unit effluents.

In some areas, onsite treatment facilities are not acceptable and holding tanks are required. The cost of pumping and transporting the wastes from the holding tanks can be quite expensive. The use of water-saving devices will help to minimize the volume of wastes to be hauled. An alternative method involves segregation of the waste streams, with only toilet and garbage wastes going to the holding tank. Gray water wastes may be treated aerobically, followed by disinfection, and the resulting treated wastewater used for lawn irrigation or toilet flushing.

Table 19 summarizes costs for onsite sewage treatment systems.

TREATMENT OPTIONS FOR SMALL AREAS

Biological Package Plants

Housing subdivisions, trailer courts, apartment complexes, or very small communities most commonly rely on biological "package plants" for wastewater treatment. These plants are factory assembled and shipped to the user's site, where final field assembly and connection of piping and electrical wiring are completed. Extended aeration, contact stabilization, and complete mix variations of the activated sludge process comprise a majority of the existing package installations. The activated sludge process will remove approximately 90 to 95 percent of the influent BOD and suspended solids.

Table 19

ONSITE SEWAGE TREATMENT SYSTEMS: COST PER HOME

System	Construction Cost (in Dollars)	Operating and Maintenance Cost (in Dollars/Year)
Holding Tank Pumping and Waste Transportation	--	600-1,800
Septic Tank	445	15
With Soil Absorption Field[a]	1,100-2,500	30
With Evapotranspiration Bed	2,400-4,500	30
With Intermittent Sand Filters	2,500	65
Plus Disinfection	3,500	105
Aerobic Treatment	1,000-2,000	80- 135
With Soil Absorption Field[a]	1,700-4,100	95- 150
With Intermittent Sand Filtration	3,100-4,100	130- 185
Plus Disinfection	4,100-5,100	170- 225

[a] *Assuming poor soil absorption characteristics.*

Source: Proceedings of Conference on Water Conservation and Sewage Flow Reduction with Water-Saving Devices, July 1975; General Dynamics; Journal, Environmental Engineering Division, ASCE, August 1976; Journal, Environmental Engineering Division, ASCE, February 1976; and Water Pollution Control in Low Density Areas: Proceedings of a Rural Environmental Engineering Conference, 1975.

Small plants (below 50,000 gpd) use the extended aeration process almost exclusively, while plants of larger capacity often employ contact stabilization. Experience has shown that careful operation and fairly constant influent wastewater flow are required to attain the best treatment from contact stabilization plants.[10] Aerated flow equalization basins preceding these units can improve performance of most systems.

Contact stabilization activated sludge package plants generally employ an aerobic digestion chamber to further oxidize waste activated sludge. The aerobically digested solids must be periodically removed and disposed. Sludge drying beds and landfilling are the usual disposal method. Extended aeration systems may have no onsite sludge handling facilities, relying on periodic pumpout to control solids accumulation.

Pure oxygen activated sludge package plants have recently been introduced. These plants utilize pure oxygen, rather than air alone, to provide dissolved oxygen for the microorganisms in the treatment system. Smaller aeration tank volumes, better solids settling in the final settling chamber, and maintenance of high dissolved oxygen levels are benefits of the system. Domestic wastewater, however, does not usually require the high oxygen demands this system is capable of supplying. The oxygen must be produced onsite or purchased and hauled to the treatment plant. Economics of the system depend primarily on existing power costs and the availability of liquid oxygen from outside sources. The relatively high energy use of oxygen systems may limit their application in future years.

Another aerobic biological process available in package plant form is the rotating biological contactor, more commonly known as the bio-disc. This system consists of large diameter discs mounted on a shaft which are half submerged in wastewater. The discs are slowly rotated in the wastewater, exposing the attached biological growth alternately to air and wastewater. Approximately 90 percent of the BOD may be removed by this process following primary treatment.

Primary treatment and secondary sludge treatment for small bio-disc installations may be accomplished by the use of a two-compartment septic tank. The first compartment receives the influent wastewater, allowing solids to settle and provides some flow equalization. The liquid waste is pumped to the bio-disc, from which it flows to a clarifier. The secondary sludge is routed to the second compartment of the septic tank for storage and stabilization before ultimate treatment and disposal.

[9] *D. K. Sauer, W. C. Boyle, and R. J. Otis, "Intermittent Sand Filtration of Household Wastewater," Journal, Environmental Engineering Division, ASCE, 102, August 1976.*

[10] *R. Dresnack and W. Miller, "Current Trends in Packaged Wastewater Treatment Facilities," Water and Sewage Works, August 1975.*

The rotating discs require enclosures to work effectively during cold weather. A building may be used to house the equipment, or a cover may be supplied which encloses the discs.

A modification of the trickling filter process is offered in package plant form by at least one manufacturer. The modified system uses forced-air ventilation and recirculated effluent to achieve approximately 90 percent BOD removal.

Physical-Chemical Package Plants

A typical physical-chemical package plant uses alum or lime to coagulate suspended solids and powered activated carbon to adsorb organic materials. The flocculated solids and adsorbed organics are settled in tube settlers or other clarification devices before filtration and disinfection. BOD and COD reduction by this process is typically about 85 percent. Suspended solids will generally be less than 5 mg/l and phosphorus less than 1 mg/l.

Additional reduction in wastewater constituents can be achieved by incorporating a high rate activated sludge process before the physical-chemical treatment step. The biological process converts biodegradable soluble organic matter into particulate matter which can be removed in the physical-chemical treatment process. Activated granular carbon columns may also be utilized to adsorb additional organic matter.

The system is best applied to intermittent flows or other applications where biological treatment alone is not suitable. The volume of sludge to be handled is greater with this system than with biological systems. In addition, tanks for containing the raw waste, backwash storage, backwash waste, and sludge are not usually furnished with the package plant equipment, requiring separate onsite construction.

Oxidation Ponds

Oxidation or stabilization ponds are generally not suitable for treatment of domestic wastewater since the effluent quality is quite variable. The addition of mechanical surface aerators or plastic tube aerators on the bottom of the pond can significantly increase the degree of treatment obtainable. Even aerated lagoons, however, are adversely affected by cold winter temperatures. Oxidation ponds can be used as a pretreatment step for land disposal of wastewaters.

Land Disposal

Land disposal of wastewater has been practiced successfully by some small communities, but may not be practical for small groups of homes. Suitable land application areas may not be near, and pretreatment requirements may offset the high degree of treatment achievable with this process. Chapter IV of this report presents more details on application of land disposal methods and their related costs. Land application of wastewaters may be a viable alternative to treatment and discharge where stringent effluent criteria are specified for small communities.

Phosphorus Removal

Those wastewater treatment systems which discharge effluents to lakes in Wisconsin must remove phosphorus to a level less than or equal to 1 mg/l. The package plant processes discussed previously can all achieve this level of phosphorus removal with the addition of coagulation chemicals. The chemicals most commonly used to remove phosphorus are aluminum and iron salts and lime. Most package plant manufacturers can supply the necessary chemical holding tanks, mixers, and chemical feeders with their basic equipment. Quantities of sludge will be increased by the chemical additions.

Effluent Polishing

A high quality effluent containing less than 10 mg/l BOD_5 and 5 mg/l suspended solids can be achieved by sand filtration of secondary effluent from the extended aeration package plants described previously. These "tertiary" filters are also available in package plant form and come from the factory complete with backwash supply tank, backwash pumps, and backwash waste storage.

Costs

The installed cost of "package" treatment systems is quite variable and not subject to precise definition or cost curve development. This is generally due to the inherent variability of site preparation and erection costs which make up a larger percentage of total costs in small facilities. Costs for "package" plants of various sizes are presented in Table 20. Adequate data are available in the literature,[11] and from manufacturers[12] to represent extended aeration and tertiary filtration costs. Costs for bio-disc package plants could not be obtained, and the cost in Table 20 for this treatment option is based on a built-in place system. Costs for other built-in place systems (lagoons, physical-chemical, biological/physical-chemical) can be derived from the cost curves in Appendix D for flows greater than 0.1 mgd, generally the size range where they are employed.

Although their long-term serviceability varies, wastewater treatment systems are available both for individual homes, and for small residential areas. Because of the difficulties of maintaining and operating such small facilities and the resultant potential health hazards associated with malfunctions of such systems, and because of the potential for pollution of groundwater and surface water systems, they are generally considered less desirable than centralized sanitary sewage systems.

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[11] *R. Dresnack and W. Miller, Water and Sewage Works; G. Tchobanoglous, "Wastewater Treatment for Small Communities," Public Works, July and August 1974; G. E. Lamp, Jr., "Package Treatment Plant Prices," Journal Water Pollution Control Federation, 46, November 1974; Wisconsin Department of Natural Resources, Cost Estimates for Small Wastewater Treatment Plants, 1975; Qasim and Shah, "Cost Analysis of Package Wastewater Treatment Plants," Water and Sewage Works, February 1975; and Illinois State Water Survey, Cost of Municipal Sewage Treatment Plants in Illinois, Circular 99, 1970.*

[12] *Cost data provided by Clow Company, Can-Tex Company, and Neptune Micro-Floc, August 1976.*

Table 20

COSTS FOR TREATMENT OPTIONS FOR SMALL AREAS

Type of Plant	Installed Cost (thousands of dollars)[a] Plant Size (mgd) 0.01	0.05	0.10	0.50
Package Plants				
Extended Aeration[b]				
Range	29-79	61- 92	90-162	140-405
Typical	45	80	120	260
Tertiary Filtration[c]				
Range	22-25	32- 39	43- 53	124-154
Typical	24	35	48	135
Erected Onsite Plants				
Bio Discs[d]				
Range	52-75	140-200	216-308	584-835
Typical	64	171	263	711
Others	Use Cost Curves for Unit Processes in Appendix D			

Type of Plant	Annual Operating Costs (thousands of dollars)[e]			
Biological Package Plants				
Range	1- 4	3- 8	5- 11	9- 20
Typical	2.5	5.5	7.5	15
Tertiary Filter Package Plants				
Range	--	--	--	--
Typical	--	--	5	12

[a] *ENRCCI = 2,445 (August 1976).*

[b] *Includes cost of treatment plant, shipping, site preparation, erection and installation, and package lift station. Cost excludes sludge handling facilities, standby power, and lab or storage building. Water and Sewage Works, August 1975; Public Works, July and August 1974; Journal, Water Pollution Control Federation, November 1974; Wisconsin Department of Natural Resources; Water and Sewage Works, February 1975; and cost data provided by Clow Company, Can-Tex Company, and Neptune Micro-Floc, August 1976.*

[c] *Design flow of 1.0 gpm/ft ^{2}, includes backwash storage and pumps, clean water storage, and air scour system. Wisconsin Department of Natural Resources and cost data provided by Clow Company, Can-Tex Company, and Neptune Micro-Floc, August 1976.*

[d] *Complete plant installed. Public Works, July and August 1974.*

[e] *References. Public Works, July and August 1974; Wisconsin Department of Natural Resources; and Cost of Municipal Sewage Treatment Plants in Illinois, 1970.*

Source: Adopted from footnoted references.

Chapter VII

WASTEWATER FLOW AND LOAD REDUCTION

INTRODUCTION

Reduction of flow and/or pollutants received at existing wastewater treatment plants would allow those plants to operate for a longer period of time at or below design conditions, providing increased treatment and eliminating or delaying the need for present facility expansion. Lower flows and loads also would mean lower plant operation and maintenance costs. Increased treatment would result in improved stream water quality. Conversely, flow reduction might also lower base flows in receiving streams or cause sewer odors due to lower sewer flows. Opportunities for municipal and industrial flow and load reduction are discussed in this section.

MUNICIPAL FLOW REDUCTION

Infiltration and Inflow

Extraneous water enters sewer systems and sewer service connections underground through defective pipe, joints, and manhole walls in a process termed "infiltration." "Inflow" results from roof leaders, sump and yard drains, manhole covers, storm water, surface runoff, and drainage discharging water into the sewer system. Infiltration can cause continual hydraulic overloading of a sewage treatment facility, thereby reducing the ability of the facility to perform adequately. Inflow may result in severe short-term overloading of the sewer system and treatment facility, resulting in surcharged sewers, flooding of homes and businesses, and diversion of raw wastewater.

A written legal commitment to stop excessive infiltration/inflow into sewers is required before federal grant monies can be made available to expand or construct municipal wastewater treatment facilities.[1] Excessive infiltration/inflow is defined as the quantity of infiltration/inflow that can be economically eliminated from the sewer system by rehabilitation. The quantity of excessive infiltration/inflow is determined by a cost-effective analysis comparing the cost of correcting the problem with the cost of providing additional treatment capacity to handle the increase flow. This cost-effective analysis is conducted as a part of 201 facility planning studies.

Methods of evaluating the condition of the sewer system include smoke testing and viewing the interior with a television camera pulled along the inside of the pipe. After sources of infiltration and inflow are located, a grouting machine may be used to seal cracks or defective joints. The cost of television inspection is about $0.15-$0.25 per foot of pipe.[2] Grouting of a typical infiltration source inside the sewer costs approximately $50.[3] Correcting inflow around manhole curbs costs $50-$75 for each repair.[4]

Ordinances should be adopted and enforced to prevent discharge of clear water into the sewer system. The cost of rehabilitating existing house roof leaders has been estimated at $60-$90, while rehabilitating foundation drains has been estimated to cost $350-$1,450 per home.[5]

Insertion of plastic piping inside an existing sewer is another method used to reduce infiltration. The slightly smaller diameter plastic pipe will usually carry as much or more flow than the existing pipe due to the plastic pipe's low friction resistance to flow. Plastic lining of house sewer connections can reduce a substantial amount of all infiltration and is estimated to cost $1-$3 per foot of drain.[6]

Water Conservation

Public education programs may be helpful in improving consumer attitudes toward the use of water conservation practices and devices.

Water-saving devices available for use in residential construction include:

1. Flow limiting valves for showers and faucets.
2. Faucet aerators.
3. Shallow-trap water closets.
4. Dual-flush water closet.
5. Washing machine level controls.

The applicability and economics of using these devices is discussed in Chapter VI.

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[1] *U. S. Environmental Protection Agency, Handbook for Sewer System Evaluation and Rehabilitation, EPA 430/0-75-021, December 1975.*

[2] *H. Farmer, "Sewer System Evaluation and Rehabilitation Cost Estimates," Water and Sewage Works, Reference Issue, 1975.*

[3] *D. J. Caesares and R. Field, "Infiltration Flow Analysis," Journal, Environmental Engineering Division, ASCE, 101, October 1975.*

[4] *Farmer, Water and Sewage Works, 1975.*

[5] *Caesares and Field, Journal, Environmental Engineering Division, 1975.*

[6] *Stanley Consultants for the Miami Conservancy District, Point Source Wastewater Controls, January 1976.*

Water saving measures for public facilities include:

1. Elimination or control of urinals with flush tanks.

2. Time release or self-closing faucets.

Other measures which result in the reduction of water usage are:

1. Lowering pressures in the water distribution system.

2. Metering water usage and charging for actual water used.

3. Water reuse.

Municipal flow reduction by the use of water conservation devices and elimination of excessive infiltration/inflow will result in less flow volume being received at the wastewater treatment plant. This reduced flow volume will still be carrying nearly the same loading of pollutants, however. Liquid treatment system requirements will be lessened, while sludge handling and treatment system requirements will remain the same.

Water Reuse

The reuse of wastewater generally requires that some form of treatment precede second or subsequent usage. Therefore, flow reduction to treatment facilities does not usually result from municipal reuse of wastewater. Reuse often requires more extensive treatment of wastes than practiced without reuse.

The main advantage of water reuse is the overall conservation of water resources in the Region. Over 350 U. S. locations reuse municipal wastewater for irrigation, industrial cooling and process water, and recreational lakes.[7] In addition, effluent from advanced wastewater treatment facilities can be spread on infiltration basins for groundwater recharge if nitrogen buildup in the groundwater is controlled.

Colorado Springs, Colorado, uses a dual-water system in new residential developments to provide nonpotable water uses with municipal effluent.[8]

Direct potable reuse of renovated wastewater is not considered to be a desirable practice except on an emergency basis. Further research into the health effects of ingesting treated wastewater is needed.

Table 21 lists various uses of renovated wastewater.

Equalization Basins

Flow equalization will allow use of smaller hydraulic units in a wastewater treatment facility, as well as improving plant performance by eliminating large flow variations and reducing the variations in levels of raw wastewater constituents. Equalization basins to accomplish these purposes might be located in the sewage collection system or at the head end of a treatment facility. In some cases, the storage capacity of interceptor sewers can be used as equalization facilities. The use of flow equalization basins is becoming more common for facility upgrading or as a component of new facility designs. The basic concept involves storing maximum flow or loads for later release during periods of minimum flow or loads.

A desirable location for an equalization facility is at the head end of the treatment facility where it can be used not only to reduce variations in raw wastewater characteristics, but also to equalize treatment facility return streams (centrate, filtrate, thickener overflow, etc.). Basins must normally be aerated (1.5 to 2 cfm air/1,000 gallons volume) and mixed (0.02-0.04 HP/1,000 gallons volume) to prevent anaerobic conditions and solids deposition.[9]

Benefits gained in using equalization basins have been reported to include:[10]

1. A 10 percent or more reduction in raw wastewater BOD_5.

2. An increase in overall removal efficiency of primary clarifiers and activated sludge systems by minimizing the carryover of solids in clarifiers caused by surge flows and high overflow rates during certain periods of the day.

3. A decrease in the cost of chemical feed where chemicals are added as a part of the wastewater treatment system.

Typical basin sizes are volumes of 15 to 25 percent of the average daily flow. Peak flow using a basin of this volume will be reduced by 30 to 40 percent with waste constituent peak concentrations similarly reduced by 20 to 30 percent. Because of head requirements needed to obtain storage volume, most basins will have to be emptied by pumping, a disadvantage where gravity flow would otherwise suffice.

Costs for equalization basins are estimated below:

Basin Storage Volume (mg)	Capital Cost[a] (million dollars)	Operating and Maintenance Cost[b] (dollars/year)
0.1	0.10	8,000
1	0.26	22,000
10	1.75	75,000
25	5.00	130,000

[a] *August 1976 values include lined earthen basin, floating aerators, and pumping.*

[b] *Includes aerators and pumping.*

[7] *C. J. Schmidt et al, "Municipal Wastewater Reuse in the U. S.," Journal Water Pollution Control Federation, 47, September 1975.*

[8] *D. A. Okun, "Planning for Water Reuse," Journal American Water Works Association, 65, October 1973.*

[9] *Metcalf and Eddy, Inc., for U. S. Environmental Protection Agency, Process Design Manual for Upgrading Existing Wastewater Treatment Plants, October 1974.*

[10] *Ibid.*

Table 21

USES OF RENOVATED WASTEWATER

Use	Direct	Indirect
Municipal.	Park or golf course watering Lawn watering with separate distribution system Potential source for municipal water supply	Groundwater recharge to reduce aquifer overdrafts
Industrial.	Cooling tower water Boiler feedwater Process water	Replenish groundwater supply for industrial use
Agricultural	Irrigation of certain agricultural lands, crops, orchards, pastures, and forests Leaching of soils	Replenish groundwater supply for agricultural overdrafts
Recreational.	Forming artificial lakes for boating, swimming, and related activities Swimming pools	Develop fish and waterfowl areas
Other	Groundwater recharge to control saltwater intrusion Salt balance control in groundwater Wetting agent-refuse compaction	Groundwater recharge to control land subsidence problems Oil-well repressurizing Soil compaction

Source: Metcalf and Eddy, Inc.

The added cost of the facilities must be balanced against savings in downstream units (usually minor except for advanced waste treatment systems) and increased reliability that can usually be expected. The use of equalization basins should be explored further in subsequent 201 facilities planning investigations.

MUNICIPAL LOAD REDUCTION

General

The pollution load from domestic sources may be reduced by curtailing the use of home garbage grinders and banning phosphate detergents. Application of wastewater to the land usually requires pretreatment but results in a total reduction in pollutants to be handled at a treatment facility. Nutrients are used by the land rather than being discharged directly to receiving waters.

Phosphate Detergent Bans

Detergents contribute only 35 to 50 percent of the domestic phosphorus load to the wastewater treatment plant. Banning of phosphate detergent alone usually is not sufficient to prevent eutrophication of receiving waters. An exception could be the case of a phosphorus limited lake whose principal source of influent phosphorus is wastewater.[11]

[11] *D. Jenkins et al, "Environmental Impact of Detergent Builders in California Waters," Water Res. (G.B.), 7, 1973; D. E. Francisco and C. M. Weiss, "Algal Response to Detergent Phosphate Levels," Journal Water Pollution Control Federation, 45, March 1973; and J. E. Etzel et al, "Detergent Phosphate Ban Yields Little Phosphorus Reduction," Water and Sewage Works, 122, September, November, December 1975.*

Phosphorus removal by chemical addition appears to be the most practical method of limiting the quantity of phosphorus discharged from a wastewater treatment facility. Banning phosphate detergents would result in chemical cost savings for phosphorus removal and result in sludge handling savings.

Garbage Grinders

Some states require higher solids loading design factors in areas where garbage grinders are used (values of 0.22-0.28 pound/capita/day are used versus 0.2 pound/capita/day used in conventional practice). Solids and organic loads induced by garbage grinders can be reduced by banning their use, although this would not be popular with the general public and the load induced at solid waste handling facilities would be increased.

Onsite Treatment of Residential Wastewater

Treatment of residential wastewater onsite with the use of septic tank or aerobic treatment units may be more economical than providing a sewer system and treatment capacity at a central plant. The main objections to onsite treatment are health and aesthetic related. The majority of the Southeastern Wisconsin Region is unsuited for septic tanks or aerobic treatment units because of soil conditions, high water table, and increasing population density. Poor treatment due to lack of proper operation and maintenance can result in contamination of water supplies. Because of these constraints and adopted land use objectives, SEWRPC does not encourage development in areas where public sanitary sewerage system services are not available.

Costs and characteristics of onsite and small area treatment systems are presented in Chapter VI.

Table 22

RENOVATION OF MUNICIPAL WASTEWATER EXPECTED EFFLUENT VALUES AFTER TREATMENT

Parameter	Biological/Chemical/Physical Treatment								
	Raw Wastewater	Primary Effluent	Activated Sludge	Filtered Activated Sludge	Bio-Physical Effluent[a]	Chemical Treatment	Filtered Chemical Treatment Effluent	Activated Carbon Adsorption	Bio-Physio-Chemical Effluent[b]
Fe (mg/l)	1.04	1.04	0.29	0.12	0.12	0.33	0.12	0.05	0.05
Mn (mg/l)	0.07	0.07	0.05	0.04	0.04	0.013	0.007	0.007	0.006
Ca (mg/l)	41	41	38	38	38	151	146	137	123
Mg (mg/l)	5.2	5.2	4.9	4.9	4.9	0.82	0.53	0.26	0.26
SiO_2 (mg/l)	23	23	--	--	--	--	--	--	--
SO_4 (mg/l)	--	86	111	108	108	110	110	110	110
NH_3-N (mg/l)	22.5	22.1	1.9	1.9	1.9	2.7	3.4	3.6	3.6
Organic N (mg/l)	15.1	9.9	3.7	2.8	2.8	3.9	2.4	1.8	1.8
$NO_{2,3}$-N (mg/l)	0.2	0.2	12.1	11.6	11.6	12.6	12.6	11.7	11.7
Total N (mg/l)	37.8	32.2	17.3	16.3	16.3	18.8	18.5	17.1	17.1
Total P (mg/l)	13.8	13.6	12	9.1	9.1	0.5	0.2	0.1	0.1
Hardness ($CaCO_3$) (mg/l)	165	165	165	--	--	--	--	--	--
Alkalinity ($CaCO_3$) (mg/l)	--	211	235	82	82	--	--	--	--
TDS (mg/l)	--	625	--	--	--	--	--	--	--
TSS (mg/l)	284	86	15	4	4	11	8	4	4
BOD (mg/l)	239	155	8	2	2	2	2	2	2
COD (mg/l)	588	331	51	33	33	25	27	14	14
TOC (mg/l)	211	100	16	16	16	13	11	6	6
Turbidity (JTU)	--	--	3.3	1.6	1.6	2	1	0.3	0.23
pH	--	--	--	--	--	--	--	--	--
Total Coliforms/100 ml	--	118×10^6	12×10^5	34×10^4	0	7	0.3	0.1	0
Fecal Coliforms/100 ml	--	11×10^6	8×10^4	48×10^3	0	0	0	0	0
Total Bacteria Count/ml	--	95×10^5	10×10^4	57×10^3	10	18	18	9	10

[a] *Includes following unit operations (in series): screening and degritting, primary sedimentation, completely mixed activated sludge, multimedia filtration, and disinfection.*

[b] *Includes following unit processes (in series): screening and degritting, primary sedimentation, completely mixed activated sludge chemical treatment, multimedia filtration, carbon adsorption, and disinfection.*

Source: Industrial Water Engineering, July-August 1973.

INDUSTRIAL FLOW REDUCTION

Water Reuse or Recycle

Water reuse and recycle are common industrial practices. Reuse involves using water more than once prior to discharge, while recycle systems recirculate the water continuously.

Water reuse systems may use the water from one process to supply another process. This type of cascade system does not usually require chemical treatment or cooling to maintain water quality between processes since the entire stream is discharged at the end of the last process usage. Reuse systems may, however, be part of an overall plant water recycle system.

Water recycle systems continuously recirculate water in a closed loop. Cooling by means of evaporative cooling towers usually is required, and process water treatment by clarification or filtration is often used to remove suspended solids. Blowdown of a certain portion of the recirculating water and corresponding makeup from good quality water are required to maintain the dissolved solids concentration at acceptable levels. Chemical treatment is utilized to maintain water quality. Chemical inhibitors and/or dispersants are used to help control corrosion and/or scaling, while chlorine or other biocides are utilized to control microorganism growth in the cooling tower, piping, and process equipment. Chemical addition is also used to control the recycle system water pH.

Reuse of Municipal Effluent

At present, industrial plants use approximately 40 percent of the total municipal effluent reused in the United States.[12] Municipal effluent often is readily available and usually is of sufficient quality for many industrial cooling and process applications. Table 22 lists characteristics of effluents expected from various treatment processes, while Table 23 presents water quality requirements for various industrial uses. The information can be used as a guide in determining suitability of municipal wastewater for industrial use.

[12] *Schmidt, Journal Water Pollution Control Federation.*

Table 23

WATER QUALITY REQUIREMENTS FOR INDUSTRIAL WATER USES

	Constituent (mg/l)																								
Process	Al	Cu	Fe	Mn	Zn	Ca	Mg	Cl	F	NH_4	HCO_3	NO_2	NO_3	SO_4	SiO_2	Hardness	Alkalinity	TDS	TSS	COD	Color	pH	Coliform[a]	CCE[b]	Taste and Odor
Cooling Water																									
Once Through	--[c]	--	--[c]	--[c]	--	200	--[c]	600	--	--	600	--	--	680	50.00	850	500	1,000.0	5,000	75.0	--	5.0- 8.3	--	--	--
Makup (recycle)	0.10	--	0.50	0.50	--	50	--[c]	500	--	--	24	--	--	200	50.00	130	20	500.0	100	75.0	--	--[c]	--	--	--
Boiler Feedwater																									
Operating Pressures, psig:																									
0-150	5.00	0.50	1.00	0.30	--[c]	--[c]	--[c]	--[c]	--	0.1	170	--	--	--[c]	30.00	20	140	700.0	10	5.0	--[c]	8.0-10.0	--	--	--
150-700	0.10	0.05	0.30	0.10	0	0	0	--[c]	--	0.1	120	--	--	--[c]	10.00	0	100	500.0	5	5.0	--[c]	8.0-10.0	--	--	--
700-1,500	0.01	0.05	0.05	0.01	0	0	0	--[c]	--	0.1	48	--	--	--[c]	0.70	0	40	200.0	0	0.5	--[c]	8.0-10.0	--	--	--
1,500-5,000	0.01	0.01	0.01	--[d]	--[d]	--[d]	--[d]	--[d]	--	0.7	--[d]	--	--	--[d]	0.01	0	0	0.5	0	0.0	--[c]	8.8- 9.2	--	--	--
Boiler Makeup (raw water)																									
0-1,500 psig	3.00	--	80.00	10.00	--	--	--[c]	19,000	--	--	600	--	--	1,400	150.00	5,000	500	35,000.0	15,000	100-500	1,200	--	--	--	--
Pulp and Paper[e]																									
Mechanical Pulping	--[c]	--	0.30	0.10	--	--[c]	--[c]	1,000	--	--	--	--	--	--	--[c]	--[c]	--	--[c]	--[c]	--	30	6.0-10.0	--	--	--
Chemical, Unbleached	--[c]	--	1.00	0.50	--	20	12	200	--	--	--	--	--	--	50.00	100	--	--[c]	10	--	30	6.0-10.0	--	--	--
Pulp and Paper, Bleached	--[c]	--	0.10	0.05	--	20	12	200	--	--	--	--	--	--	50.00	100	--	--[c]	10	--	10	6.0-10.0	--	--	--
Chemical[f]	--	--	0.10	0.10	--	68	19	500	--	--	128	--	5	100	50.00	250	125	1,000.0	5	--	20	6.2- 8.3	--	--	--
Petrochemical and Coal	--	--	1.00	--	--	75	30	300	--	--	--[c]	--	--	--[c]	--[c]	350	--	1,000.0	10	--	--[c]	6.0- 9.0	--	--	--
Textile Products[g]																									
Sizing Suspension	--	0.05	0.30	0.05	--	--	--	--	--	--	--	--	--	--	--	25	--	100.0	5	--	5	--	--	--	--
Scouring, Bleaching, Dyeing	--	0.01	0.10	0.01	--	--	--	--	--	--	--	--	--	--	--	25	--	100.0	5	--	5	--	--	--	--
Primary Metals[h]																									
Quenching, Hot Rolling	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--[d]	--[d]	--[c]	--[c]	--	--	5.0- 9.0	--	--	--
Cold Rolling	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--[d]	--[d]	--[c]	10	--	--	5.0- 9.0	--	--	--
Rinse (soft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	100	--[d]	--[c]	0	--	--	6.0- 9.0	--	--	--
Tanning																									
Tanning	--	--	50.00	--	--	60	--	250	--	--	--	--	--	250	--	150	--[c]	--	--	--	5	6.0- 8.0	--[i]	--	--
Finishing	--	--	0.30	0.20	--	Lime Softening	--	250	--	--	--	--	--	250	--	Lime Softening	--[c]	--	--	--	5	6.0- 8.0	--[i]	--	--
Coloring	--	--	0.10	0.01	--	0	--	--	--	--	--	--	--	--	--	0	--[c]	--	--	--	5	6.0- 8.0	--[i]	--	--
Cement	--	--	2.50	0.50	--	--	--	250	--	--	--	--	--	250	35.00	--[c]	400	600.0	500	--	--[c]	6.5- 8.5	--[c]	1.0	--
Food (canning)	--	--	0.20	0.20	--	100	--	250	1.0	--	--	0	0	250	50.00	250	250	500.0	10	--	5	6.5- 8.5	--[i]	--	0
Soft Drinks	--	--	0.30	0.05	--	--	--	500	1.7	--	--	--	--	500	--	--[d]	85	--[d]	--	--	10	--[d]	--[i]	0.2	0

[a] *Total coliform counts per 100 ml, including fecal coliform count.*

[b] *Carbon chloroform extract.*

[c] *Accepted as received.*

[d] *Determined by treatment of other constituents.*

[e] *Water quality requirements are variable, depending on process involved and desired quality of finished product.*

[f] *Water quality requirements vary widely; criteria above are stringent.*

[g] *Nonstaining water usually required.*

[h] *Water quality requirements are variable.*

[i] *U. S. Drinking Water Standards.*

Source: Industrial Water Engineering and Water Quality Treatment.

A potential problem of reuse of municipal effluent by industry is the legal responsibility of final disposal after reuse and whether the industry reusing the wastewater is responsible for the gross amounts of pollutants discharged, or only for the net amounts contributed during the reuse process. An agreement is necessary between the municipality and industry to determine a feasible arrangement of wastewater disposal after reuse (i.e., should industry pay the whole cost of disposal or should the municipality share the cost burden?).

INDUSTRIAL LOAD REDUCTION

Industries discharging wastes to a publicly-owned treatment works must pretreat those wastes which would interfere with the operation or performance of the treatment works. The performance of biological treatment processes is adversely affected by certain materials. Table 24 presents concentrations of these inhibiting materials. These values may be used as a guide in establishing pretreatment levels which will result in safe concentrations at the treatment facility. Table 25 lists hazardous substances which may be present in industrial waste discharges to a treatment facility. The following wastes cannot be discharged to publicly owned treatment works in Wisconsin:

1. Wastes which create a fire or explosion hazard.
2. Wastes with pH lower than 5, unless the treatment facility is specifically designed to handle low pH wastes.
3. Wastes which obstruct sewer flows.
4. Wastes at excessive flow rates and/or pollutant discharge rates over a short period of time.
5. New wastes or increased volumes or quantities of wastes which overload the treatment facility or cause loss of treatment efficiency.

Municipal sewage treatment facilities are designed to remove BOD, suspended solids, and fecal coliform. Other additional pollutants which may be removed by the treatment process include COD, TOC, phosphorus, and nitrogen. Industrial pollutants which the plant is incapable of removing or which interfere with plant operation or efficiency require pretreatment. Pretreatment requirements are based on effluent limitations which define the best practicable control technology currently available (BPCTCA). Pretreatment to this level is required for industries discharging to municipal facilities in 1983 under current regulations. Industries which have direct discharge would be required to meet the generally more stringent criteria of best available treatment technology economically achievable (BATEA). Pretreatment pro-

Table 24

CONCENTRATIONS OF MATERIALS WHICH INHIBIT BIOLOGICAL TREATMENT PROCESSES

Pollutant	Inhibiting Concentration[a], mg/l	
	Aerobic Processes	Anaerobic Digestion
Copper	1.00	1.00
Zinc	5.00	5.00
Chromium (Hexavalent)	2.00	5.00
Chromium (Trivalent)	2.00	2,000.00[b]
Total Chromium	5.00	5.00
Nickel	1.00	2.00
Lead	0.10	--[c]
Boron	1.00	--[c]
Cadmium	--[c]	0.02[b]
Silver	0.03	--[c]
Vanadium	10.00	--[c]
Sulfides (S)	--[c]	100.00[b]
Sulfates (SO_4)	--[c]	500.00
Ammonia	--[c]	1,500.00[b]
Sodium (Na)	--[c]	3,500.00
Potassium (K)	--[c]	2,500.00
Calcium (Ca)	--[c]	2,500.00
Magnesium (Mg)	--[c]	1,000.00
Acrylonitrite	--[c]	5.00[b]
Benzene	--[c]	50.00[b]
Carbon Tetrachloride	--[c]	10.00[b]
Chloroform	18.00	0.10[b]
Methylene Chloride	--[c]	1.00
Pentachlorophenol	--[c]	0.40
1, 1, 1-Trichloroethane	--[c]	1.00[b]
Trichlorofluoromethane	--[c]	0.70
Trichlorotrifluoroethane	--[c]	5.00[b]
Cyanide (HCN)	--[c]	1.00
Total Oil (Petroleum Origin)	50.00	50.00

[a] *Concentrations refer to those present in raw wastewater unless otherwise indicated.*

[b] *Concentrations apply to the digester influent only. Lower values may be required for protection of other treatment process units.*

[c] *Insufficient data.*

Source: U. S. Environmental Protection Agency.

cesses for various industry point source categories are presented at the end of this chapter in Table 27. Current BPCTCA and BATEA criteria for industrial point sources are presented in Appendix C.

If the publicly-owned treatment facility is committed to remove pollutants (per WPDES permit) of a type present in an industrial user's waste, the pretreatment standard for those pollutants will be correspondingly reduced. In the case of BOD, suspended solids, and fecal coliform, pretreatment may not be necessary unless industrial waste strength or volume are excessive.

If several industries discharge the same type of incompatible pollutant to a publicly owned treatment system, it may be necessary for the municipality to allocate waste loads. Pretreatment criteria for each industry would then be based on these waste load allocations.

In some cases, a beneficial use can be made of an incompatible pollutant. For instance, nutrient deficient paper mill wastewater requires nitrogen and phosphorus which can be supplied by a nutrient rich wastewater. "Milorganite" fertilizer produced by the Milwaukee-Metropolitan Sewage District relies on the unique combination of various constituents from domestic, commercial, and industrial wastewaters. Pickle liquor from a steel mill or other metal processing operations can provide a source of iron for coagulation, phosphorus removal, and sludge conditioning at the joint treatment facility. Pretreatment to reduce these pollutants could actually result in lower plant efficiency and increased costs.

Federal guidelines on pretreatment of discharges to publicly owned treatment works[13] indicate the following unit operations for industries:

1. Coarse solids separation.
2. Neutralization.
3. Equalization.
4. Chemical precipitation for heavy metals.
5. Grease and oil removal.
6. Cyanide oxidation or removal.
7. Chromium reduction.

These operations are discussed in Chapter V and cost information for unit processes involved is presented in Appendix D.

Industries discharging wastes requiring pretreatment will choose the more advantageous of the following two alternatives:

1. Build and operate facilities required to meet pretreatment standards.
2. Eliminate the pollutant from the discharge by process change, recycle, or other process.

[13] *U. S. Environmental Protection Agency, Pretreatment of Discharges to Publicly Owned Treatment Works, U. S. Government Printing Office, EPA 546-308-30, 1973.*

Table 25

HAZARDOUS SUBSTANCES WITHIN INDUSTRIAL WASTE STREAMS

Industry	As	Cd	Chlorinated Hydrocarbons[a]	Cr	Cu	Cyanides	Pb	Hg	Miscellaneous Organics[b]	Se	Zn
Mining and Metallurgy	X	X		X	X	X	X	X		X	X
Paint and Dye.		X		X	X	X	X	X	X	X	
Pesticide	X		X			X	X	X	X		X
Electrical and Electronic.			X		X	X	X	X		X	
Printing and Duplicating.	X			X	X		X		X	X	
Electroplating and Metal Finishing . .		X		X	X	X					X
Chemical Manufacturing.			X	X	X			X	X		
Explosives	X				X		X	X	X		
Rubber and Plastics		X	X			X		X	X		X
Battery		X					X	X			X
Pharmaceutical	X							X	X		
Textile				X	X				X		
Petroleum and Coal	X		X				X				
Pulp and Paper								X	X		
Leather				X					X		

[a] *Including polychlorinated biphenyls.*

[b] *For example, acrolein, chloropicrin, dimethyl sulfate, dinitrobenzene, dinitrophenol, nitroaniline, and pentachlorophenol.*

Source: U. S. Environmental Protection Agency.

Appendix B presents wastewater flow quantity and quality characteristics for various industries located in southeastern Wisconsin. Industry name, type, location, and cooling and process effluent discharge location also are presented. A review of WPDES permits for these industries indicates that discharge limitations apply primarily to total suspended solids and oil and grease. Approximately 25 percent of the industries listed in Appendix B have TSS limitations with the range of allowable discharge concentrations being 10 to 60 mg/l. Less than 10 percent have oil and grease limitations with the usual allowable concentration being 10 mg/l. Only about 5 percent of the industries have BOD limitations, while about 3 percent require metals control. Nutrient removal from industrial discharges is generally not required under present WPDES permits.

Table 26 summarizes the quantities of cooling and process flow discharged by industries listed in Appendix B. The major industrial classes discharging flow to sewage treatment plants in the study area are malt beverages, fabricated metal products, electrical and electronic machinery, and transportation equipment.

Table 26

FLOW QUANTITIES FROM AREA INDUSTRIES BY INDUSTRIAL CLASS

SIC Series	Description	Industries		Reported Flow[a] (mgd)			
				Cooling		Process	
		Number[b]	Number Reported	To Treatment	Surface Water Discharge	To Treatment	Surface Water Discharge
2010 and 0250	Meat and Poultry Products, Poultry and Egg Production	20	19	0.267	0.1060	3.320	0.3200
2020	Dairy Products	13	9	0.932	0.437	0.8200	0.3130
2030	Canned and Preserved Fruits and Vegetables	12	10	0.803	0.182	0.4030	1.752
2040, 2050, and 0700	Grain Milling and Bakeries, Grain Preparation	3	2	--	0.087	0.0212	0.0050
2060	Sugar and Confectionaries	4	2	0.096	0.875	0.3090	--
2070	Fats and Oils	1	1	--	--	0.1160	--
2080	Beverages:						
	Malt and Malt Beverages	7	7	9.124	16.351	9.0660	--
	Other Beverages	8	8	0.024	--	0.3770	0.0280
2090	Fish, Seafood, and Food Preparation	6	5	1.819	1.500	0.6670	--
2200 and 2300	Textiles	4	3	0.001	--	0.1430	--
2400 and 2500	Wood and Wood Products, Furniture and Fixtures	2	1	0.005	--	0.0020	--
2600	Paper and Paper Products	15	12	0.365	0.617	5.2340	0.0536
2700	Printing, Publishing, and Allied Industries	7	7	0.418	0.277	0.6960	0.0100
2800	Chemicals and Allied Products	13	11	0.561	6.792	4.7450	0.0410
2900	Petroleum, Refining, and Related Industries	3	1	--	0.004	--	--
3000	Rubber and Plastics Products	11	6	--	0.485	0.0056	0.0070
3100	Leather and Leather Products	18	17	0.050	0.005	5.1450	--
3200 and 1400	Stone, Clay, Glass, and Concrete Products; Nonmetallic Minerals	19	9	--	0.875	0.2235	3.9405
3300	Primary Metals Industry	45	34	2.391	12.247	1.5730	1.3180
3400	Fabricated Metal Products, except Machinery and Transportation Equipment	51	43	2.260	1.268	8.4780	0.9361
3500	Machinery, except Electrical	43	35	2.127	4.189	3.5030	3.2010
3600	Electrical and Electronic Machinery	31	23	1.729	1.286	7.2550	0.2180
3700	Transportation Equipment	19	13	2.817	6.895	4.5450	0.0530
3800	Measurements, Analytical, and Control Instruments; Photo, Medical and Optical, Watches, etc.	10	9	0.355	0.541	1.5740	0.0610
3900	Miscellaneous Manufacturing Industries	4	3	0.001	0.060	0.0930	--
7200	Laundries	13	12	0.004	--	0.7580	--
7542	Car Washes	11	9	--	--	0.0945	--
4940	Water Treatment Plants	12	--	--	--	--	--
--	Miscellaneous	21	6	--	2.539	0.0140	0.4350
Total		428	318	25.090	57.219	57.4650	10.4950

[a] *Cooling and process water flows discharge to various surface waters and sewage treatment plants in the Region as presented in Appendix B.*

[b] *Number refers to number of industries listed in Appendix B.*

Source: Stanley Consultants.

Table 27

TREATMENT PROCESSES TO MEET PRETREATMENT STANDARDS FOR INDUSTRIAL POINT SOURCE CATEGORIES

Industry	Treatment Processes[a,b,c]
Beverage	
Distilleries	Cooling water recycle; maximum by-product recovery from stillage; improved evaporator entrainment for separation of organics contained in released water vapors in feed recovery operation; elimination of spillage, overflows, dumps, and excess running water; biological oxidation by trickling filters and/or activated sludge.
Wineries	Wine recovery from "lees" and dry handling of waste solids; elimination of spillage, overflows, dumps, and excess running water; elimination of cloth filters; low volume; high pressure cleaning of process tanks; maximum recirculation and reuse of cooling, washup, and process water; biological oxidation by activated sludge or equivalent process; disinfection, if necessary.
Canned and Frozen Fruits and Vegetables	In-plant controls to conserve water and reduce waste loads; dry caustic peeling or equivalent process; maximum by-product recovery; elimination of extraneous drainage from refuse storage areas; flow equalization; biological oxidation using aerated lagoons or activated sludge; secondary clarification; disinfection, if necessary.
Asbestos Products, Flat Glass, Cement, Concrete, Lime, and Gypsum	Flow equalization; sedimentation (with coagulants where required); neutralization; metal precipitation (where required).
Inorganic Chemicals	
Aluminum Chloride	Sedimentation and coagulation.
Aluminum Sulfate	Sedimentation and recycling of clarified effluents.
Caustic-Chlorine	Sedimentation; chemical precipitation; coagulation; filtration; carbon adsorption; neutralization; water recycling; water conservation practices.
Hydrochloric Acid	Cooling water segregation; spill and leak collection for recycle or land disposal.
Hydrofluoric Acid	Lime precipitation; coagulation; flocculation; sedimentation; neutralization.
Hydrogen Peroxide (Organic Method)	Biological oxidation of organic solvents, sedimentation.
Lime	Dry collection of dust.
Nitric Acid	Cooling water segregation; spill and leak collection for recycle or land disposal.
Phosphorus	Sedimentation and recycle.
Sulfuric Acid	Cooling water segregation; spill and leak collection for recycle or land disposal.
Fertilizer	
Phosphate	Impoundment followed by two-stage double liming process. Heavy metal removal (if required) by precipitation and sedimentation.
Ammonia Nitrogen	Biological denitrification, air stripping, or steam stripping.
Nitrate Nitrogen (Ammonium Nitrate Waste)	Recycling and in-plant modifications; may require filtration followed by contact with strong acid cation exchange resin.
Organic Nitrogen (Urea Waste)	Urea hydrolysis and steam stripping.
Dairy Products	Whey and by-products recovery; biological oxidation using trickling filter or modifications of activated sludge; secondary clarification; disinfection, if necessary.
Iron and Steel	
Coke Manufacturing	Dephenolizer; solvent extraction; biological treatment.
Iron Manufacturing	Recycle and blowdown treatment.
Steel Manufacturing	Recycle and blowdown treatment.
Pickling	Neutralization; precipitation; chemical treatment; flocculation; clarification; acid regeneration.
Cold Rolling	
Recirculating Oil	Recirculation; skimming; air flotation; magnetic separation; biological treatment.
Direct Application	Emulsion breaking; air flotation; chemical treatment; skimming.
Tinplate and Chromium Plating	Ion exchange for chromium; air flotation; chemical treatment; flocculation; settling basin.
Other Coatings	Segregation and separate treatment.
Meat and Poultry Products	
Meat Packing	Blood collection; dry handling of paunch; dry cleanup prior to washdown; high pressure spray system for washdown; screening and grit removal; dissolved air flotation; anaerobic lagoons followed by aerated lagoons or activated sludge; disinfection.
Poultry Processing	Blood collection; dry cleanup prior to washdown; high pressure spray system for washdown; reuse of chiller water; grease removal; biological oxidation by activated sludge or aerated lagoon; disinfection.

Table 27 (continued)

Industry	Treatment Processes[a,b,c]
Metal Finishing and Electroplating	Metal precipitation by coagulation, sedimentation, flotation, and filtration; evaporative recovery and ion exchange; chemical oxidation for cyanides; chemical reduction for chromium.
Mining and Milling Ores	
Mine Discharge	Reduce flow of water to mines; reduce exposure of sulfide minerals to the atmosphere; neutralization, sedimentation, and precipitation of remaining metals as metal sulfide.
Milling Discharge	Slurry discharge to tailing pond, decant from pond is neutralized and metals removed by sulfide precipitation; alkaline chlorination destruction of cyanides, if required; recycle as mill process water.
Motor Vehicle	Cooling water separation from contaminated wastewaters; soluble oil separation from other plant wastewaters; recirculation in emulsified oil system; electrostatic painting; use of non-phenol paint strippers; reduced dragin to rinsing circuits; water usage curtailment procedures; toxic wastewater segregation; spill, overflow, and leak prevention.
Nonferrous Metals	
Bauxite Refining	Impoundments and evaporation of mud slurry in lagoons.
Primary Smelting	Washwater recycle and treatment by lime addition, clarification, and adequate detention time.
Ingot Casting and Foundry Operations	Skimming; clarification; recycle; blowdown treatment by clarification and air flotation or filtration.
Plate and Sheet Rolling	Line addition; emulsion breaking; skimming; air flotation; clarification; recycle.
Foil Rolling	Emulsion breaking; skimming; clarification; recycle.
Rolling and Drawing of Rod, Bar, Structural Shapes	Emulsion breaking; skimming; clarification; recycle.
Extrusion of Tube Shapes	Emulsion breaking; skimming; clarification; recycle.
Petroleum Refining	(a) Biological System: API oil separators; equalization; sour water stripping; dissolved air flotation; biological oxidation using aerated lagoons or activated sludge; secondary clarification; chromate removal; sand or dual media filters. (b) Physical-Chemical System: API oil separators; chemical coagulation and clarification; pH control; sand or dual media filters; chromate removal system; ammonia stripper or ion exchange; carbon adsorption; carbon reactivation.
Plastic and Synthetic Material	Chemical coagulation; settling; biological treatment (usually completely mixed activated sludge); flow equalization (when required); nutrient addition; heavy metal, oil, and grease removal (when required); cyanide removal by chlorination (when required); urea hydrolysis (when required); fluidized-bed incineration of wastes with constituents which interfere with biological treatment.
Pulp and Paper	Heat and/or chemical recovery; water reuse; primary clarification; biological oxidation using aerated lagoons or activated sludge; secondary clarification; disinfection (if necessary); tissue mills using purchased pulp will require physical or physical-chemical treatment rather than biological treatment.
Textiles	
Wool Processing	Solvent extraction of grease and suint; screening; dissolved air flotation; pH adjustment; equalization; chemical coagulation; settling; aerated lagoon.
Cotton-Synthetics Integrated Mill	Caustic recovery and reuse; equalizing pond; pH adjustment; bar and fine screens; chemical coagulation and sedimentation; carbon adsorption; biological oxidation.
Carpet Integrated Mill	Equalization; fine screening; chemical coagulation and sedimentation; carbon adsorption; biological oxidation; heat recovery.

[a] *Based on best practicable treatment technology for purposes of establishing interim effluent limitations; Wisconsin Department of Natural Resources as published in Register, March 1974, No. 219, Environmental Protection.*

[b] *Treatment processes given illustrate type of treatment required. Other treatment technology may be acceptable.*

[c] *Treatment processes for other categories and classes of point sources (as listed in Chapter NR 220 of Wisconsin Department of Natural Resources and published in Register, March 1974, No. 219, Environmental Protection) are based on best practicable control technology currently available. BPCTCA requirements for industries, as described by the U. S. Environmental Protection Agency, are summarized in Appendix C.*

Source: Wisconsin Department of Natural Resources.

Chapter VIII

APPLICATION OF SCHEMATICS AND COST

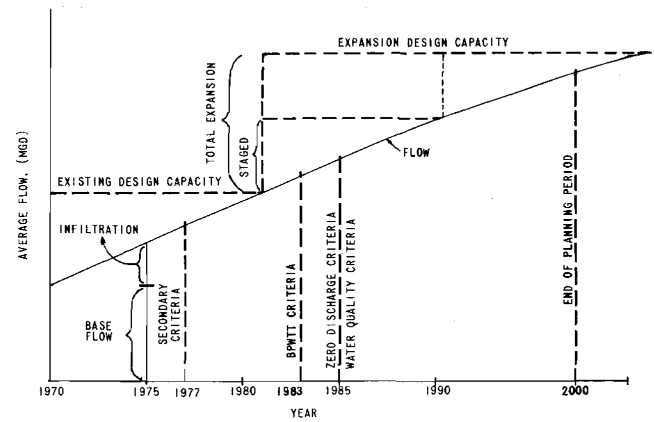
INTRODUCTION

This report has presented detailed considerations in treatment of wastewaters from point sources of pollution. The information provided can be used to determine the cost of various levels of treatment. The level required at a given location will depend on the effect of the discharge on water quality. Various methods of reducing waste load and/or flow to a location are itemized. Alternative schemes for groundwater recharge via land application or direct recharge are presented which may eliminate a direct discharge to surface waters. On a regional basis, direct discharge to surface waters from point sourcess after treatment will continue to predominate for a number of years. The schematics and cost data can be used as a guide for selecting economical treatment to required levels to avoid water quality problems from these discharges.

The application of treatment schematics and cost curves to specific point sources in the study requires that basic design criteria, growth and flow projections, wastewater quality information, and effluent criteria be known. The situation which a hypothetical community in the 208 study region may face at the present time is depicted in the concept model shown in Figure 13. The components of this model and considerations in process selection are described in this section.

Figure 13

RELATIONSHIP BETWEEN WASTEWATER FLOWS, EFFLUENT CRITERIA, WASTEWATER TREATMENT PLANT DESIGN CRITERIA AND EXPANSION: 1975-2000



A COMMUNITY LOOKING TO THE FUTURE FROM 1975 MUST CONSIDER THE FOLLOWING FACTORS:

(1) WHETHER TO REDUCE INFILTRATION TO EXTEND THE LIFE OF EXISTING FACILITIES.

(2) IF FUTURE FLOW PROJECTIONS INDICATE THE NEED FOR EXPANSION, WILL THE EXPANSION BE STAGED OR NOT.

(3) WHAT DEGREE OF TREATMENT IS REQUIRED (SECONDARY, BPT, ZERO DISCHARGE, ANOTHER LEVEL DEPENDING ON WATER QUALITY IMPACT) AND WHEN IS IT REQUIRED (1977, 1983, 1985, OR 2000).

(4) WHAT UNIT PROCESSES ARE REQUIRED AND WHEN MUST THEY BE INSTALLED TO MEET REQUIRED DEGREE OF TREATMENT.

Source: Stanley Consultants.

CONSIDERATIONS IN SCHEMATIC SELECTION

Wastewater Characteristics

Selection of wastewater treatment processes begins with an analysis of wastewater flow and characteristic data from historic plant records, followed by projections of changes that may occur during the planning period. In a regional study, detailed analysis of the daily records of each existing treatment facility is not practicable. More detailed analyses are made in 201 facilities planning investigations and in final plant design. For a particular facility in the regional planning program, a raw waste influent value that is represented by one of the influent levels provided herein would be chosen, and the appropriate schematic to provide a required degree of treatment would be selected.

Average Flow and Load: Various methods have been previously used to predict flow and load in the Region as discussed in Chapter II.

Where flow and quality records exist for an entity, they should be used to characterize the existing wastewater flow and load. As new homes and businesses are constructed, more flow will occur. Industries have to be reviewed individually as to load changes or expansion plans.

Several factors will influence future wastewater flows. Among them are:

1. Reduction of inflow and infiltration as a result of sewer system evaluations and rehabilitation efforts resulting from 201 plans.

2. Increasing costs for water resulting in a probable trend toward reduced water use.

3. Increasing trends toward use of home garbage grinders, automatic dishwashers, and similar appliances. In new residential construction leading to higher loads at treatment facilities.

4. Increasing attention to industrial discharges to municipal sewerage systems resulting in higher levels of pretreatment, increased water conservation by industry, and some trends toward separate treatment and discharge.

Each of these identified factors will affect the flow or strength of the wastewaters reaching existing facilities in the Region.

Peak Flows: Peak (and minimum) flows may be computed using various procedures.[1] These will yield peak dry weather flow information. The peak flow from domestic discharges will seldom exceed 2.5 times the average flow. The discharges of industries must be evaluated separately. The contribution of infiltration/inflow must be assessed to develop design peak flows for the treatment facility.

Peak flows will determine the needed hydraulic capacity of treatment facilities and must be considered in final plant design. Final clarifier overflow rates of 1,000 gallons per day per square foot (gpd/ft^2) at peak flow should not be exceeded.

Infiltration/Inflow: The State of Wisconsin has set a maximum allowable infiltration/inflow limit of 200 gallons per inch of pipe diameter per mile per day (gal/in dia/mile/day) for installation of new sanitary sewers [NR 110.13 (6)(e)]. For residential construction in areas with 10 to 15 people/acre, this would correspond to about 100 to 130 gal/acre/day. (Based on 240 to 260 feet of 8-inch collectors and 200 to 300 feet of 4-inch to 6-inch house drains per developed acre.) This averages about 10 gpcd. No direct sources of inflow (from roof drains, sump pumps, or similar sources) are allowed.

Many areas are served by older sewers or have inflow sources. Inflow and infiltration flow estimates and evaluations of the cost-effectiveness of removing extraneous flows are to be developed in 201 plans (Step 1 facility plans). Draft guideline criteria from the U. S. EPA[2] indicate that it is usually cost-effective to eliminate all inflow except foundation drains. However, the draft guideline suggests that only elimination of infiltration in excess of 1,000 gal/in dia/mile/day is generally cost-effective. The draft guideline further indicates it is cost-effective to eliminate infiltration/inflow in excess of 5,000 gal/in dia/mile/day. Hence, a separate detailed study is generally most fruitful for values between 1,000 and 5,000 gal/in dia/mile/day. An infiltration rate considering these factors could be selected for regional analysis purposes, and existing flow data adjusted accordingly. It is important to note the hazard of considering very carefully the application of such general guidelines to specialized cases, most notably those areas served by combined storm and sanitary sewerage systems. Future infiltration from developing areas could be estimated assuming DNR criteria would be met (allowances should be made for system deterioration). It would be necessary to assume that infiltration/inflow reduction programs would be carried out. The cost-effectiveness of these programs could be determined by assessing facility requirements with and without reduction programs.

Existing Design Capacity

Many design criteria are used for sizing the various unit processes, channels, and piping in a wastewater treatment facility. The facility usually is designed to hydraulically handle a peak flow, but sized to obtain certain constituent removal efficiencies at a lower average flow rate. The design capacity is a function of the design criteria. Many criteria are established by DNR based on experience and other standards (NR 110). Design criteria on which the treatment costs are based are presented on the cost curves of Appendix D. Available records can be used to summarize the design basis and major unit process sizes in existence for each facility to determine existing design capacity.

Effluent Criteria

The effluent criteria that a facility must meet are a function of several variables. In the absence of criteria developed to protect water quality in the stream or river, secondary treatment, BPWTT, and zero discharge criteria would become effective on the dates shown in the concept model (see Figure 13). Values used in previous studies[3] for these discharge levels are:

Effluent Criteria	Effluent Concentrations (mg/l)					
	BOD_5	TSS	NH_3-N	P	DO	Total N
Secondary Treatment	30	30	–	–	6	–
BPWTT[a]	20	20	5	–	5	–
Zero Discharge[b]	5	5	0.5	0.1	6	8

[a] *Represents Stanley Consultants' interpretation to meet ultimate oxygen demand limits of 50 mg/l and ultimate BOD of 30 mg/l for best practicable waste treatment technology (BPWTT).* [4]

[b] *Represents U. S. Corps of Engineers' estimate of zero discharge of critical pollutants as used in the Atlanta, Georgia, area.* [5]

Effluent criteria have been developed from water quality modeling efforts by SEWRPC in Planning Report 16. Such criteria, based on stream water quality, override effluent criteria based on BPWTT. The modeling efforts under the 208 program will assess the adequacy of these prior waste load allocations for the planning period beyond 1990.

[1] *Water Pollution Control Federation, WPCF Manual of Practice No. 9, 1971.*

[2] *U. S. Environmental Protection Agency, Program Guidance Memorandum-Infiltration/Inflow Program, draft, July 1975.*

[3] *Stanley Consultants for the Miami Conservancy District, Point Source Wastewater Controls, January 1976.*

[4] *Stanley Consultants, Inc., for U. S. Army Corps of Engineers, Office of the Chief of Engineers, Technical Manual on Criteria for Water Pollution Prevention, Control, and Abatement Report, September 1974.*

[5] *Stanley Consultants, Inc., for the Metropolitan Atlanta Water Resources Study Group, Wastewater Treatment Unit Processes Design and Cost Estimating Data, January 1975.*

For the evaluations presented herein, treatment schematics were developed to represent general effluent levels required to meet varying water quality criteria.

This approach anticipates that "across the board" criteria for BPWTT for municipal point sources will not be developed. In addition, it assumes no effluent criteria will be more stringent than the zero discharge criteria regardless of impact on water quality by an entity. None of the schematics presented in Chapter V were developed for this high quality of effluent, and no facilities in the Region currently have discharge permits requiring this degree of treatment. Additional unit processes than may be involved in meeting this criteria along with cost information is provided in Appendix E.

Facility Expansion

Facilities will need to be expanded when the average flow exceeds the existing design average flow or when the effluent criteria change. For a particular facility, this can amount to several expansion dates. Sometimes additional unit processes will need to be added to meet more stringent effluent criteria, while other times the facility may have to be expanded to add additional treatment capacity. In some cases, obsolete facilities may need to be replaced. A design period of 20 years for treatment works will apply in most cases. Some economy may occur in a few instances by using staged construction.

The required capacity of the unit operations is computed using the design criteria developed for the operation. The capacity of existing unit operations is computed using the same criteria. The needed capacity is the difference. In addition, replacement of equipment that has served its economic service life must be considered. Each of the criteria can and may be modified in subsequent 201 facility planning efforts for a given point source.

Sewerage System Expansion

Major interceptors and facility service areas must be considered in the analysis of regional alternatives. NR 110-13 currently requires that the sewerage facilities be designed for the ultimate tributary population of a service area although this practice has been questioned due to overdesign and induced growth effects. Treatment facilities that may be cost-effective to combine must also be examined for the water quality aspects of dispersed versus concentrated discharges in the Region. A cost curve for sewers is included in Appendix D, but preliminary layout of systems for economic comparisons is preferred due to the wide variation in costs that can be induced in specific locales.

COST CONSIDERATIONS FOR STRUCTURAL CONTROLS

Cost curves for individual treatment processes are presented in Appendix D. The curves depict different application processes and can be combined to obtain a cost for each of the liquid waste treatment schematics presented in Chapter V. A separate report is being prepared to provide information on sludge handling alternatives. Major design criteria are included on each curve. The cost basis for all curves is August 1976. Various references (19, 36, 76, 88, 89, 90, 91, 92, 93, and 94)[6] were used as the basis for system costs. Various indexes and labor rates used to update other curve information for August 1976 are as follows:

Indexes and Labor Rates for August 1976	Index
EPA Sewage Treatment Plant Construction (LCAT) (Third Quarter 1973 = 100)	129 Milwaukee
Engineering News Record Construction Cost	2,445 National
Average Labor Rate—Construction	$10.00/hour
Average Labor Rate—Operations	$ 5.00/hour

Cost curves for liquid waste treatment processes are presented in terms of cost versus flow for the flow range of 0.1 to 100 mgd. The economy of scale has usually been reached at 100 mgd so that the cost of larger facilities can be estimated by direct proportion to the 100 mgd cost (e.g., a 1,000 mgd plant will cost 10 times as much as a 100 mgd plant and have only slightly lower unit operating cost). The cost of field-fabricated small facilities depends on many factors and is not generally subjected to cost curve analysis. The costs for package plants given in Chapter VI can be used to evaluate probable costs for small facilities (design flow less than 0.1 mgd).

[6] *Hazen and Sawyer for the U. S. Environmental Protection Agency, Design Manual for Suspended Solids Removal, October 1971; Culp, Wesner, and Culp, 1974 Lake Tahoe Advanced Wastewater Treatment Seminar Manual, Clean Water Consultants, El Dorado Hills, California, 1975; Stanley Consultants, Point Source Wastewater Controls, January 1976; Stanley Consultants, Technical Manual, September 1974; Stanley Consultants, Wastewater Treatment Unit Processes, Design, and Cost Estimating Data, January 1975; Bechtel Incorporated for the U. S. Environmental Protection Agency, A Guide to the Selection of Cost-Effective Wastewater Treatment Systems, EPA 430-9-75-002, July 1975; Metcalf and Eddy, Inc., for the U. S. Environmental Protection Agency, Costs of Wastewater Treatment by Land Application, EPA 430-9-75-003, June 1975; J. W. Patterson and R. A. Minear, State of Illinois, Institute for Environmental Quality, Wastewater Treatment Technology, IIEQ Document No. 71-4, August 1971; Battelle Memorial Institute for the Council on Environmental Quality, Municipal Sewage Treatment—A Comparison of Alternatives, U. S. Government Printing Office, February 1975; and Black and Veatch Consulting Engineers for the U. S. Environmental Protection Agency, Estimating Costs and Manpower Requirements for Conventional Wastewater Treatment Facilities, October 1971.*

The total cost of a treatment scheme should be obtained by multiplying the total construction cost from the cost curves by 1.27 to include other expenses including engineering, legal, administration, and interest during construction. This total project cost can then be annualized using an interest rate and amortization period.

The monetary costs of alternatives can be evaluated using the cost curves. The U. S. EPA has published cost-effectiveness analysis guidelines (CFR Vol. 39, No. 29, pp 5269-5270, February 11, 1974) which serve to guide analysis procedures. The service life of constructed and existing facilities needs to be defined. Maximum treatment facility life as specified by EPA for planning purposes is:

Item	Service Life
Land	Permanent
Structures	50 Years
Major Process Equipment	30 Years
Auxiliary Equipment	15 Years

Sewers and earthen structures (lagoons) can be assumed to have a 50-year life. Aeration systems, chemical feed equipment, and pumps may have a life of 15 years. An economic life of 30 years can be assumed for all other processes.

The useful economic life of the various wastewater treatment plant components as presented in SEWRPC Planning Report No. 16 is summarized below:

Item	Economic Life
Concrete structures	40
Piping, valves, fittings, miscellaneous iron, and steel	25
Process equipment	15
Excavation and backfill	40
Electrical, heating and ventilating, and piping	25

To select among alternatives, an equivalent basis of comparison is required. A present worth approach gives consideration to the design life of facilities, the time value of money, and the increase in operation and maintenance costs resulting from future higher loads on facilities. SEWRPC has consistently used a 50-year present worth economic analysis, using an interest rate of 6 percent. According to U. S. EPA guidelines, no inflation in construction or operating costs is to be assumed, and an interest rate established by the Water Resources Council (currently 6 3/8 percent) is to be used in cost-effectiveness studies.

The curves can be directly applied for municipal wastewaters with characteristics similar to the wastewaters used to develop the curves. Many unit processes are more flow-dependent than constituent-dependent, and the curves are applicable for reasonable ranges of BOD_5 and nitrogen. Adjustment will need to be made in sludge handling costs for differing suspended solids or chemical requirements for phosphorus precipitation. Costs for the nine effluent class schematics can be obtained by combining processes. The cost curve for administration needs to be included for all schematics. (A facility upgrading may only involve the operation and maintenance costs given.)

It must be thoroughly understood that costs obtained from the cost curves are sufficiently accurate for preliminary planning only. The major application for the cost information is the comparison among alternatives either on a regional basis or for a given location. For these purposes the costs are sufficiently accurate.

NONCOST CONSIDERATIONS FOR STRUCTURAL CONTROLS

The application of a particular treatment process at a given location is a function of more than cost. Table 28 lists some other factors that should be considered in the selection of a process.

Significant operation and maintenance costs are influenced by energy, chemical, and manpower use. Use of energy and chemicals infers secondary environment effects at the point of energy or chemical production. Selection of a process must include considerations of long-range resource commitment. A guide to direct resource utilization is presented in Table 29.

In addition to values listed in Table 29, energy use of pumping is about 5 kwh/day/mgd/ft of pumping head. Pretreatment consisting of bar screens, communutors, grit removal, and flow metering uses about 2.7 kwh/day/mgd. The energy expended in constructing facilities can be approximated by the following:[7]

$$\text{Energy for construction} = \frac{75{,}534\ \text{Btu}}{\text{Dollars Spent}^{8}} \times \left(\frac{901}{\text{ENRCCI}}\right) \times \text{Construction Cost}$$

ENRCCI = 2,445 for August 1976.

The offsite or indirect energy use of various unit operations can be approximated using the data in Table 30 applied to the chemical and energy use in Table 29.

Total direct and indirect energy use increases dramatically as unit processes necessary to achieve more stringent effluent criteria are added.

[7] *R. A. Mills and G. Tchobanoglous, "Energy Consumption in Wastewater Treatment," Energy, Agriculture and Waste Management, Ann Arbor Science Publications, Inc., Ann Arbor, Michigan, 1975.*

[8] *Ibid.*

Table 28

FACTORS OTHER THAN COSTS RELEVANT TO SELECTION OF WASTEWATER TREATMENT AND SLUDGE HANDLING UNIT PROCESSES

Process	Land Requirements	Adverse Climatic Conditions	Ability to Handle Inlet Flow Variations	Ability to Handle Influent Quality Variations	Industrial Pollutants Affecting Process	Reliability of the Process	Ease of Operation and Maintenance	Potential[b] Occupational Hazards	Air Pollution	Waste Products
Preliminary Treatment	Minimum	--	Good	Good	Minimum	Very Good	Fair	Structures Mechanical	Odors	Grit Screenings
Pumping	Minimum	Freezing	Good	Good	Minimum	Very Good	Fair	Structures Mechanical	--	--
Primary Sedimentation:										
Conventional	Moderate	--	Fair	Good	Moderate	Good	Very Good	Structures	Odors	Sludges
With Chemicals	Minimum	--	Good	Very Good	Maximum	Very Good	Good	Chemicals	--	Sludges
Trickling Filters	Maximum	Freezing	Good	Fair	Moderate	Very Good	Very Good	Structures	Odors	Sludges
Activated Sludge:										
Conventional	Moderate	--	Fair	Good	Moderate	Good	Fair	Structures	--	Sludges
With Chemicals	Minimum	--	Good	Very Good	Maximum	Good	Good	Chemicals	--	Sludges
Dual Media Filters	Moderate	--	Good	Good	Minimum	Very Good	Good	Structures Mechanical	--	Backwash Waste
Activated Carbon	Moderate	--	Good	Fair	Maximum	Good	Good	Fires Explosion	Regenerant Gas	Spent Carbon
Two-Stage Lime Treatment	Maximum	--	Good	Good	Minimum	Very Good	Fair	Chemicals	--	Excess Sludge
Biological Nitrification	Maximum	Cold	Fair	Fair	Moderate	Fair	Fair	Structures	--	Sludge
Biological Denitrification	Maximum	Cold	Fair	Fair	Moderate	Fair	Fair	Chemicals Explosions	--	Sludge
Ion Exchange	Minimum	--	Fair	Good	Maximum	Good	Good	Chemicals	Odor NH_3	Waste Regenerant
Breakpoint Chlorination	Moderate	--	Good	Good	Maximum	Very Good	Good	Chemicals	Chlorine Odor	--[a]
Ammonia Stripping	Moderate	Cold	Fair	Fair	Minimum	Good	Fair	Structures	Ammonia	Ammonia
Disinfection	Minimum	--	Good	Good	Maximum	Very Good	Good	Chemicals	Chlorine Odor	--[a]

[a] *Increases effluent total dissolved solids.*

[b] *Generally these hazards can be avoided with proper design, operation, and maintenance.*

Source: Becntel Incorporated.

In alternative analyses, assumptions must be made on potential implementation of nonstructural control procedures which would alter the waste flow or load reaching treatment facilities. Types of assumptions involved may include:

1. The effectiveness of infiltration/inflow programs on reducing flows along with resultant changes in concentrations of wastewater constituents.

2. The extent of implementation of industrial waste pretreatment requirements and the effects this would have on load or compatability of wastes to and from treatment facilities.

3. The extent to which recycle toilets, single home unit treatment, and similar self treatment processes would be used in the Region.

4. The extent to which policies encouraging use of septic systems, mound systems, and small group treatment to serve urban growth areas will be adopted.

5. The extent to which building code requirements for shallow water closets and flow limiting and similar devices, would be adopted for urban areas.

6. The extent to which chemical bans (mercury use, phosphorus detergent) will affect the degree or type of treatment covered if applied.

7. The extent to which water reuse will be practiced. (Water reuse will probably be limited to irrigation, groundwater recharge, or industrial cooling water using effluent from treatment facilities producing little flow or load change to treatment facilities.)

8. The extent to which river treatment may obviate the need for a high degree of treatment at a facility and the extent to which legal commitments to a high degree of treatment can be changed by the implementation of this practice.

USE IN ALTERNATIVE EVALUATIONS

The detailed cost curves allow for refinement of design parameters at specific sites as in the 201 facility planning investigations. Alternative treatment schematics can be developed and compared in order to select a combination of processes to meet criteria for a specific point source. The developed schematics can be used as a guide to the effluent quality expected, but the local raw waste quality and any differences from the assumed raw waste quality should be taken into consideration.

Table 29

ESTIMATED DIRECT ENERGY USE, CHEMICAL PROCESS, AND MANPOWER USE IN SELECTED WASTEWATER TREATMENT PROCESSES

	Energy[a] (kWh/day)				Chemical (lb/day)				Chemical	Manpower[b] (man-yr/yr)			
Plant Size (mgd)	0.1	1	10	100	0.1	1	10	100	--	0.1	1	10	100
PROCESS													
Primary Clarifier[c]	110	250	1,270	4,000	--	--	--	--	--	0.82	2.6	5.5	28.0
Trickling Filter[d]	145	325	1,140	2,790	--	--	--	--	--	0.2	0.5	3.0	24.0
Activated Sludge[e]	165	800	3,100	9,900	--	--	--	--	--	0.5	1.0	7.9	40.0
Final Clarifier	55	125	635	2,000	--	--	--	--	--	0.41	1.3	2.7	14.0
Chlorination	1	8	60	500	8	80	800	8,000	Cl_2	0.1	0.5	1.0	2.0
Ozonation[f]	20	100	950	8,500	--	--	--	--	--	0.12	0.6	1.2	2.5
Alum Precipitation	5	40	350	3,000	126	1,260	12,600	126,000	Alum[g]	0.25	0.5	2.5	15.0
Lagoon	315	650	1,000	3,000	--	--	--	--	--	0.06	0.5	2.0	10.0
Land Disposal	120	800	4,600	18,800	--	--	--	--	--	0.1	1.0	10.0	55.0
Extended Aeration	306	960	--	--	--	--	--	--	--	0.66	2.6	--	--
Nitrification	150	700	2,800	9,000	--	--	--	--	--	0.5	1.5	3.5	8.9
Denitrification	3	10	100	1,000	42	420	4,200	42,000	Methanol	0.5	1.5	3.5	8.9
Lime Clarification	200	1,000	5,000	11,000	210	2,100	21,000	210,000	Lime	1.0	2.0	3.0	20.0
	--	--	--	--	260	2,600	26,500	265,000	CO_2	--	--	--	--
Lime Reclamation	500	4,000	18,000	80,000	--	--	--	--	--	0.5	1.0	1.5	8.0
Filtration	5	50	500	5,000	--	--	--	--	--	0.5	1.0	1.3	9.0
Carbon Treatment[h]	290	2,900	4,200	14,400	35	340	3,400	34,000	Carbon	1.5	3.0	4.5	29.0
Ion Exchange	120	1,200	12,000	45,000	10	90	900	9,000	Zeolite	0.2	0.5	1.2	2.0
	--	--	--	--	10	100	1,000	10,000	Salt	--	--	--	--
Rotating Biological Disks[i]	80	500	2,500	8,000	--	--	--	--	--	0.5	1.0	6.0	20.0
Ammonia Stripping	300	2,000	18,000	80,000	--	--	--	--	--	1.0	2.0	3.0	10.0
Reverse Osmosis	700	7,000	70,000	--	--	--	--	--	--	--	--	--	--
Microscreens	25	100	200	1,500	--	--	--	--	--	0.5	1.0	1.3	9.0

[a] *Values in various references varied significantly for some unit operations.*

[b] *The rapid increase of automation and instrumentation advances are expected to reduce manpower requirements for operations in the future.*

[c] *Includes sludge pumping and pretreatment.*

[d] *Based on intermediate pumping.*

[e] *Mechanical aerators.*

[f] *Ozone produced onsite with dried air feed to ozonator.*

[g] *Alum dosages variable, value given for 150 mg/l.*

[h] *About half for regeneration.*

[i] *Designed for 90 percent removal, if 95 percent removal, design energy use is doubled.*

Source: Based on/data from Batelle Memorial Institute for the Council on Environmental Quality; Black and Veatch Consulting Engineers; Water and Wastes Engineering, July 1976; Energy, Agriculture and Waste Management, 1975; Journal, Environmental Engineering Division, ASCE, June 1975; and Water and Wastes Engineering, May and June 1976.

Table 30

INDIRECT ENERGY USE OF SELECTED UNIT OPERATIONS

Commodity	Energy Required For Production
Alum	2.5 million Btu/ton
Polymer.	2.0 million Btu/ton
Chlorine	42.0 million Btu/ton
Activated Carbon . . .	102.0 million Btu/ton
Lime.	5.5 million Btu/ton
Power	10,500.0 Btu/kwh

Source: Water and Wastes Engineering, May and June 1976.

Special curves are developed for certain industrial waste problems. The unit cost information for municipal facilities can also be applied to organic or suspended solids removal requirements of most industrial operations, with some minor adjustments. Pretreatment processes can also be described using information in Chapter VII.

On a regional analysis scale, however, a cost function can be developed which combines the unit process cost functions into the schematics presented for each of the nine classes of effluent criteria. The cost of alternatives developed by logical combinations of treatment plant locations and treatment requirements can then be assessed as they relate to the cost and the effect on water quality of those alternatives.

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APPENDICES

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Appendix A

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Appendix B

INDUSTRIAL POINT SOURCE LISTING

						Discharge Characteristics							Flow, mgd	
SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Cooling	Process
2010 and 0250	MEAT AND POULTRY PRODUCTS, POULTRY AND EGG PRODUCTION													
	C&D Foods, Inc.	Yorkville	Racine	Poultry	West Branch Root River Canal	--	37.00	14.00	3.10	11.000	--	6.00	--	0.1740
	Downy Duck Company	Kansasville	Racine	Poultry	Land Disposal	--	52.00	56.00	22.00	23.000	--	0.00	--	0.0450
					Goose Lake Branch Canal	--	--	--	--	--	--	--	--	--
	Grove Duck Farm	Raymond	Racine	Poultry	West Branch Root River Canal	--	130.00	120.00	40.00	22.500	--	5.00	--	0.0250
	Pekin Duck Farm	Yorkville	Racine	Pulltry	Land Disposal	--	80.00	157.00	33.00	18.000	--	0.00	--	0.0200
	Northern Packing Company	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	162.00	291.00	--	0.500	--	456.00	--	0.0300
	Patrick Cudahy, Inc.	Cudahy	Milwaukee	Meat products	Cudahy Sewage Treatment Plant	--	264.00	330.00	13.00	13.000	--	160.00	0.1100	2.0900
					Lake Michigan	--	5.00	17.00	--	--	--	--	0.0720	--
	Peck Meat Packing Company	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	2.50	0.00	0.00	0.330	--	7.50	--	0.1000
	Strauss Brothers Packing Company, Inc.	Franklin	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	131.00	70.00	25.00	5.000	--	18.00	--	0.0230
	United Packing Company, Inc.	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	4,505.00	6,816.00	--	1.000	--	5,222.00	--	0.1760
	Wisconsin Packing Company	Butler	Waukesha	Meat products	Milwaukee Sewage Treatment Plant	--	1,350.00	872.00	--	50.000	--	315.00	--	0.0175
	Wisconsin Packing Company	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	1,300.00	760.00	105.00	14.100	--	252.00	--	0.1840
	Armour and Company	New Berlin	Waukesha	Meat products	New Berlin Sewer System	--	2,800.00	600.00	32.00	335.000	--	1,830.00	0.0010	0.0140
	Fred Usinger, Inc.	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	1,492.00	160.00	--	2.000	--	700.00	0.0200	0.1140
					Milwaukee River	72.0	--	--	--	--	--	--	0.0260	--
	Kenosha Packing Company	Kenosha	Kenosha	Meat products	Kenosha Sewage Treatment Plant	--	30.00	56.00	--	0.280	--	144.00	--	0.2880
					Land Disposal	--	800.00	273.00	12.00	6.930	--	430.00	0.0070	0.0420
	Kewaskum Frozen Foods	Kewaskum	Washington	Meat products	Kewaskum Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Milwaukee River	--	--	--	--	--	--	--	--	--
	Klement Sausage Company, Inc.	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	778.00	117.00	2.60	2.800	--	88.00	0.0320	0.0360
	Natural Casing Company	Hartford	Washington	Meat products	Hartford Sewage Treatment Plant	--	2,460.00	236.00	--	21.000	--	150.00	--	0.0220
	Purdy Steak Corporation	St. Francis	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	138.00	57.00	0.10	0.310	--	20.00	0.0010	0.0150
	Uncle August Sausage Company, Inc.	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	119.00	60.00	0.60	4.300	--	66.00	0.0010	0.0430
	Weisel and Company	Milwaukee	Milwaukee	Meat products	Milwaukee Sewage Treatment Plant	--	18.70	0.10	--	8.700	--	2.50	0.1020	0.0150
2020	DAIRY PRODUCTS													
	Level Valley Dairy Company	West Bend	Washington	Dairy products	Cedar Creek	73.0	52.00	48.00	1.07	16.000	--	20.00	0.0850	0.0090
	S&R Cheese Corporation	Fredonia	Ozaukee	Dairy products	Land Disposal	--	--	--	--	--	--	--	--	--
	Cedar Valley Cheese Factory	Belgium	Ozaukee	Dairy products	Land Disposal	--	--	--	--	--	--	--	--	--
	Beecham, Inc. (Horlicks)	Racine	Racine	Dairy products	Racine Sewage Treatment Plant	--	88.00	5.00	--	0.550	X	1.00	0.1740	0.0360
	Foremost Foods Company	Whitewater	Walworth	Dairy products	Whitewater Sewage Treatment Plant	--	427.00	160.00	0.00	48.000	--	38.40	0.0020	0.0430
	Borden, Inc.	West Allis	Milwaukee	Dairy products	Milwaukee Sewage Treatment Plant	--	906.00	203.00	--	26.140	--	71.00	0.0710	0.3490
					Root River	52.0	270.00	57.00	--	2.880	--	8.00	0.0920	0.0020
	Fairmont Foods Company	Kewaskum	Washington	Dairy products	Milwaukee River	55.0	8.00	3.40	1.59	0.620	--	11.60	0.0080	--
					Kewaskum Sewage Treatment Plant	--	830.00	323.00	--	12.600	--	126.00	0.0070	0.0830
	Gehl Guernsey Farms, Inc.	Germantown	Washington	Dairy products	Menomonee River	--	8.50	8.00	1.40	0.170	--	19.00	0.1900	--
					Germantown Sewage Treatment Plant	--	3,950.00	366.00	--	6.900	--	180.00	--	0.0380
	Hawthorn-Mellody Farms	Waukesha	Waukesha	Dairy products	Waukesha Sewage Treatment Plant	--	210.00	137.00	5.00	0.000	--	124.00	0.0200	0.0300
	Hawthorn-Mellody Farms	Whitewater	Walworth	Dairy products	Whitewater Sewage Treatment Plant	47.0	1,421.00	392.00	0.40	83.000	--	210.00	0.6580	0.2410
					Whitewater River	--	--	--	--	--	--	--	--	--
	Pabst Farms, Inc.	Oconomowoc	Waukesha	Dairy products	Land Disposal-Lagoon and Spray Irrigation	--	297.00	111.00	0.18	7.200	--	72.30	0.0620	0.3020
	Borden Food Company	Waukesha	Waukesha	Dairy products	Fox River	--	--	--	--	--	--	--	--	--
	Brookhill Farms	Genesee	Waukesha	Dairy products	Genesee Creek	--	--	--	--	--	--	--	--	--

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics							Flow, mgd	
						T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Cooling	Process
2030	CANNED AND PRESERVED FRUITS AND VEGETABLES													
	Beatrice Foods Company-Pereles Brothers Division	Milwaukee	Milwaukee	Preserved fruits and vegetables	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Milwaukee River	--	--	--	--	--	--	--	--	--
	Frank Pure Food Company	Franksville	Racine	Preserved fruits and vegetables	Land Disposal	--	45.00	135.00	0.80	2.100	--	5.00	--	0.0720
					Hoods Creek	80.0	0.00	1.00	0.00	0.000	--	0.00	0.0170	--
	Kikkoman Foods, Inc.	Walworth	Walworth	Preserved fruits and vegetables	Land Disposal-Lagoon	--	--	--	--	--	--	--	--	--
	Libby, McNeill & Libby	Jackson	Washington	Preserved fruits and vegetables	Cedar Creek	--	12.00	28.00	0.00	0.000	--	0.00	0.0370	0.0870
					Jackson Sewage Treatment Plant	--	1,350.00	205.00	4.70	7.400	--	11.00	--	0.0150
	Libby, McNeill & Libby	Hartford	Washington	Preserved fruits and vegetables	Hartford Sewage Treatment Plant	--	1,993.00	1,228.00	462.00	11.000	--	26.00	0.1970	0.3050
	Mammoth Spring Canning Corporation	Sussex	Waukesha	Preserved fruits and vegetables	Sussex Creek	96.0	4.00	68.00	--	7.800	--	11.00	0.0400	--
					Land Disposal	--	--	--	--	--	--	24.00	--	0.2000
	Meeter Brothers and Company	Union Grove	Racine	Preserved fruits and vegetables	Land Disposal-Soil Absorption	--	160.00	160.00	--	--	--	--	--	0.0010
					Des Plaines River	47.0	40.00	100.00	24.00	4.790	--	3.20	0.0480	0.0620
	Krier Preserving Company	Belgium	Ozaukee	Canned and preserved fruits and vegetables	Onion River	80.0	1.00	15.70	--	0.040	--	8.60	0.0400	--
					Land Disposal-Spray Irrigation	--	30.00	30.00	--	8.330	--	26.00	--	0.5500
	Ocean Spray Cranberries, Inc.	Kenosha	Kenosha	Canned and preserved fruits and vegetables	Kenosha Sewage Treatment Plant	--	317.00	46.70	0.10	0.580	--	3.20	0.5610	0.0300
	Holsum Foods	Waukesha	Waukesha	Canned and preserved fruits and vegetables	Waukesha Sewage Treatment Plant	--	247.00	60.00	--	171.000	--	32.00	0.0450	0.0450
	Splinter Pickle Company, Inc.	Greenfield	Milwaukee	Canned and preserved fruits and vegetables	Milwaukee Sewage Treatment Plant	--	13.20	8.00	--	2.930	--	--	--	0.0080
	Libby, McNeill & Libby	Darien	Walworth	Canned and preserved fruits and vegetables	Land Disposal	--	--	--	--	--	--	12.00	--	0.7300
					Land Disposal-Septic System	--	--	--	--	--	--	12.00	--	0.0500
2040, 2050, and 0700	GRAIN MILLING AND BAKERIES, GRAIN PREPARATION													
	Baker Laboratories	East Troy	Walworth	Grain mill products	Honey Creek	--	21.00	116.00	--	0.800	--	300.00	0.0860	0.0040
					East Troy Sewage Treatment Plant	--	1,350.00	755.00	--	--	--	0.10	--	0.0200
	Murphy Product Company, Inc.	Burlington	Racine	Grain mill products	Burlington Sewage Treatment Plant	--	40.00	43.00	0.77	0.220	--	6.00	--	0.0009
					Fox River	263.0	0.00	27.70	0.17	0.100	X	0.84	0.0010	0.0003
	Krause Milling Company	West Milwaukee	Milwaukee	Crop preparation services for market	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
2060	SUGAR AND CONFECTIONARIES													
	Howard B. Stark Company	Pewaukee	Waukesha	Sugar and confectionary products	Pewaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Pewaukee River	--	--	--	--	--	--	--	--	--
	Nestle Company	Burlington	Racine	Sugar and confectionary products	Burlington Sewage Treatment Plant	--	1,830.00	390.00	0.40	9.800	X	86.00	0.0140	0.1860
	Ambrosia Chocolate Company	Milwaukee	Milwaukee	Chocolate and cocoa products	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Ward-Johnston, Inc.	West Milwaukee	Milwaukee	Chocolate and cocoa products	Milwaukee Sewage Treatment Plant	--	156.00	207.00	--	1.000	--	12.00	0.0820	0.1230
					Storm Sewer	75.0	1.40	0.00	--	0.070	--	--	0.8750	--
2070	FATS AND OILS													
	Milwaukee Tallow Company	Milwaukee	Milwaukee	Animal and marine fats and oils	Milwaukee Sewage Treatment Plant	--	5,152.00	26,800.00	57.00	43.200	--	24,400.00	--	0.1160

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd Cooling	Process
2080	BEVERAGES, MALT AND MALT BEVERAGES, OTHER BEVERAGES													
	Froedtert Malt Corporation	Milwaukee	Milwaukee	Beverages	Milwaukee Sewage Treatment Plant	--	636.00	100.00	1.60	7.000	--	--	--	1.0200
					Kinnickinnic River	60.0	--	--	--	--	--	--	0.1200	--
	Jos. Schlitz Brewing Company	Milwaukee	Milwaukee	Beverages	Milwaukee River	63.5	0.00	4.00	--	0.000	--	11.70	12.9000	--
					Milwaukee Sewage Treatment Plant	--	1,517.00	80.00	0.00	3.500	--	93.00	4.6800	0.5200
	Kurth Malting Corporation-Plant No. 1	West Milwaukee	Milwaukee	Beverages	Milwaukee Sewage Treatment Plant	--	600.00	87.00	--	28.000	--	0.40	--	0.4200
					Kinnickinnic River	60.0	--	--	--	--	--	--	0.1500	--
	Kurth Malting Corporation-Plant No. 2	Milwaukee	Milwaukee	Beverages	Milwaukee River	71.0	--	--	--	--	--	--	1.6200	--
					Milwaukee Sewage Treatment Plant	--	700.00	114.00	--	31.000	--	0.60	--	0.0650
	Miller Brewing	Milwaukee	Milwaukee	Beverages	Menomonee River	62.0	28.00	16.00	0.22	0.200	--	3.10	1.5610	--
					Milwaukee Sewage Treatment Plant	--	792.00	562.00	--	5.930	X	64.00	3.6160	1.8530
	Seven-Up Milwaukee, Inc.	West Allis	Milwaukee	Beverages	Root River	--	2,406.00	1,693.00	0.06	10.500	--	45.00	--	0.0080
					Milwaukee River	--	1,100.00	86.00	0.10	5.300	--	9.00	--	0.0060
	Pabst Brewing Company	Milwaukee	Milwaukee	Malt beverages	Milwaukee Sewage Treatment Plant	--	2,475.00	660.00	--	7.700	X	32.90	0.8280	5.1720
	L. Rosenheimer Malt & Grain Company	Kewaskum	Washington	Malt	Kewaskum Sewage Treatment Plant	--	1,800.00	188.00	--	3.080	--	26.80	--	0.0160
	Coca Cola Bottling Company	Kenosha	Kenosha	Bottled and canned soft drinks	Kenosha Sewage Treatment Plant	--	76.00	31.40	--	1.450	X	16.00	0.0010	0.0110
	Coca Cola Sheridan Spring Bottling	Lake Geneva	Walworth	Beverages	White River	70.0	128.00	77.00	0.83	0.040	--	15.00	--	0.0060
	Coca Cola Bottling Company	Milwaukee	Milwaukee	Bottled and canned soft drinks	Milwaukee Sewage Treatment Plant	--	1,799.00	995.00	--	24.000	--	454.00	0.0220	0.1770
	Graf's Beverages, Inc.	Milwaukee	Milwaukee	Bottled and canned soft drinks	Milwaukee Sewage Treatment Plant	--	1,196.00	89.00	--	3.270	--	--	0.0010	0.1210
	Pepsi Cola Bottling Company	Kenosha	Kenosha	Bottled and canned soft drinks	Kenosha Sewage Treatment Plant	--	797.00	6.60	--	2.400	--	5.60	--	0.0320
	Seven-Up Bottling Company	Racine	Racine	Bottled and canned soft drinks	Racine Sewage Treatment Plant	--	1,300.00	109.00	16.00	4.700	--	19.00	--	0.0300
	Seven-Up Bottling Company	Milwaukee	Milwaukee	Bottled and canned soft drinks	Milwaukee Sewage Treatment Plant	--	1,100.00	86.00	0.63	--	--	--	--	0.0060
					Root River	--	2,406.00	1,093.00	0.11	--	--	--	--	0.0080
2090	FISH, SEAFOOD, AND FOOD PREPARATIONS													
	Carnation Company	Oconomowoc	Waukesha	Food preparations	Oconomowoc River	72.0	0.00	0.00	0.18	0.000	--	0.00	1.5000	--
					Oconomowoc Sewage Treatment Plant	--	405.00	102.00	--	--	--	15.00	--	0.1000
	Geiser's Potato Chip Company	Milwaukee	Milwaukee	Food preparations	Milwaukee Sewage Treatment Plant	--	3,675.00	6,200.00	0.23	11.900	--	3.00	--	0.0680
	Mrs. Howe's Food Products, Inc.	Milwaukee	Milwaukee	Food preparations	Milwaukee Sewage Treatment Plant	--	1,200.00	759.00	--	2.680	--	0.00	--	0.0360
	Pfizer, Inc.	Milwaukee	Milwaukee	Food preparations	Milwaukee Sewage Treatment Plant	--	202.00	96.00	--	1.100	X	16.00	0.0220	0.0047
	Universal Foods Corporation	Milwaukee	Milwaukee	Food preparations	Milwaukee Sewage Treatment Plant	--	1,494.00	380.00	--	3.940	--	276.00	1.7970	0.7030
	Federal Foods	Mequon	Ozaukee	--	Soil Absorption	--	--	--	--	--	--	--	--	--
2200 and 2300	TEXTILES													
	Milwaukee Dye & Bleach Company	Milwaukee	Milwaukee	Textile finishing plant, synthetics	Milwaukee Sewage Treatment Plant	--	678.00	17.50	0.83	9.150	X	99.00	--	0.0950
	Badger Mills	Grafton	Ozaukee	Yarn mill, except wool	Grafton Sewage Treatment Plant	--	42.00	15.00	--	1.260	X	6.20	--	0.0300
	Jockey International	Kenosha	Kenosha	Men's and boys' underwear	Kenosha Sewage Treatment Plant	--	24.00	55.00	--	2.470	X	8.00	0.0010	0.0180
	Florence Eiseman, Inc.	Milwaukee	Milwaukee	Women's and misses outerwear	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Milwaukee River	--	--	--	--	--	--	--	--	--
2400 and 2500	WOOD AND WOOD PRODUCTS, FURNITURE AND FIXTURES													
	Kerr-McGee Chemical Corporation	Milwaukee	Milwaukee	Wood preserving	Milwaukee Sewage Treatment Plant	--	166.00	20.00	3.70	52.200	X	14.00	0.0050	0.0020
	Maysteel Products Corporation	Allenton	Washington	Metal partitions and fixtures	--	--	--	--	--	--	--	--	--	--

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd Cooling	Flow, mgd Process
2600	PAPER AND PAPER PRODUCTS													
	Bermico Company	West Bend	Washington	Miscellaneous converted	West Bend Sewage Treatment Plant	--	175.00	1,080.00	1.55	2.930	X	80.00	--	0.0860
				paper products	Milwaukee River	69.4	0.00	13.50	--	--	--	4.30	0.2890	0.0510
	Horner Waldorf Corporation	Milwaukee	Milwaukee	Paperboard containers	Milwaukee Sewage Treatment Plant	--	2,500.00	6,820.00	--	40.000	X	120.00	0.0090	0.0410
				and boxes	Storm Sewer	80.0	50.00	60.00	0.00	3.850	X	0.00	--	0.0001
	Longview Fiber Company	Milwaukee	Milwaukee	Miscellaneous converted	Milwaukee Sewage Treatment Plant	--	227.00	427.00	--	3.000	X	115.00	0.0360	0.0060
				paper products	Surface Water	125.0	3.50	16.50	0.31	1.690	X	3.10	0.0050	0.0005
	Milprint, Inc.	Milwaukee	Milwaukee	Miscellaneous converted	Milwaukee Sewage Treatment Plant	--	67.00	24.00	6.00	1.270	X	14.00	0.0030	0.0730
				paper products	Milwaukee River	--	--	--	--	--	--	--	0.3020	--
	Packaging Corporation of America, Burlington Continental	Burlington	Racine	Paperboard containers and boxes	Fox River	--	--	--	--	--	--	--	--	--
	St. Regis Paper Company	Milwaukee	Milwaukee	Paperboard mills	Milwaukee Sewage Treatment Plant	--	142.00	551.00	--	0.200	X	7.00	0.2610	4.8650
	Rexford Paper Company, Inc.	Milwaukee	Milwaukee	Paper coating and glazing	Milwaukee Sewage Treatment Plant	--	201.00	290.00	2.80	0.700	X	76.00	0.0110	0.0080
					Storm Sewer	70.0	--	--	--	--	--	--	0.0150	--
	W. H. Brady Company													
	Florist Avenue	Milwaukee	Milwaukee	Paper coating and glazing	Milwaukee River	--	--	--	--	--	--	--	--	--
	Glendale Avenue	Milwaukee	Milwaukee	Paper coating and glazing	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Keiding, Inc.	Milwaukee	Milwaukee	Dressed and molded pulp goods	Milwaukee Sewage Treatment Plant	--	85.00	380.00	--	0.000	X	--	0.0040	0.0360
	Alton Box Board Company	Milwaukee	Milwaukee	Corrigated and solid fiber boxes	Milwaukee Sewage Treatment PLant	--	58.00	70.00	--	4.250	X	33.00	--	0.0390
	Crown Zellerbach	Milwaukee	Milwaukee	Corrigated and solid fiber boxes	Milwaukee Sewage Treatment Plant	--	108.00	593.00	--	--	X	52.50	0.0150	0.0090
	Inland Container Corporation	Milwaukee	Milwaukee	Corrigated and solid fiber boxes	Milwaukee Sewage Treatment Plant	--	105.00	250.00	--	0.200	X	30.00	0.0260	0.0470
	Mead Corporation Milwaukee Container Division	Milwaukee	Milwaukee	Corrigated and solid fiber boxes	Milwaukee Sewage Treatment Plant	--	67.00	57.00	20.70	0.090	X	4.00	--	0.0240
	Packaging Corporation of America	Burlington	Racine	Corrigated and solid fiber boxes	Fox River	61.0	21.00	0.20	0.68	0.040	X	0.20	0.0060	0.0020
2700	PRINTING, PUBLISHING, AND ALLIED INDUSTRIES													
	Newspapers, Inc.	Milwaukee	Milwaukee	Newspapers	Milwaukee Sewage Treatment Plant	--	6.90	2.00	0.90	0.170	X	1.90	0.0230	0.0630
	W. A. Krueger Company	New Berlin	Waukesha	Book printing	New Berlin Sewer System	--	426.00	55.00	8.50	2.100	X	34.00	0.0190	0.0290
	Mandel Company	Milwaukee	Milwaukee	Lithographic platemaking services	Milwaukee Sewage Treatment Plant	--	49.00	18.00	--	1.200	X	19.00	--	0.0150
	Printing Developments, Inc.	Racine	Racine	Lithographic platemaking services	Racine Sewage Treatment Plant	--	--	150.00	--	--	X	--	0.0030	0.2600
	W. A. Krueger Company	Brookfield	Waukesha	Books	Underwood Creek	70.0	1.50	119.00	0.25	0.750	X	10.20	0.0260	--
					Milwaukee Sewage Treatment Plant	--	105.00	50.00	--	5.800	X	12.00	--	0.0490
	Western Publishing Company, Inc.	Racine	Racine	Books	Root River	--	12.90	6.00	0.19	0.410	X	0.84	0.1810	--
	Main Plant				Racine Sewage Treatment Plant	--	67.00	16.00	--	4.590	X	1.40	0.3550	0.2380
	Wisconsin Cuneo Press, Inc.	Milwaukee	Milwaukee	Books	Milwaukee Sewage Treatment Plant	--	1,400.00	177.00	5.80	6.250	X	66.00	0.0180	0.0420
					Lincoln Creek	64.0	220.00	15.00	1.20	--	--	--	0.0700	0.0100

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics							Flow, mgd	
						T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Cooling	Process
2800	CHEMICALS AND ALLIED PRODUCTS													
	Lakeside Laboratories	Milwaukee	Milwaukee	Pharmaceutical preparations	Milwaukee Sewage Treatment Plant	--	100.00	75.00	--	112.000	X	14.00	0.1210	0.1310
	PPG Industries	Milwaukee	Milwaukee	Paints and allied products	Milwaukee Sewage Treatment Plant	--	1,230.00	47.00	--	--	X	--	0.4260	0.2380
	Findley Adhesives, Inc.	Milwaukee	Milwaukee	Adhesives and sealants	Milwaukee Sewage Treatment Plant	--	3,900.00	1,342.00	--	3.600	--	431.00	0.0040	0.0180
	Findley Adhesives, Inc.	Milwaukee	Milwaukee	Adhesives and sealants	Milwaukee Sewage Treatment Plant	--	10.60	5.00	--	0.320	--	1.00	0.0070	0.0020
	Hercules, Inc.	Milwaukee	Milwaukee	Adhesives and sealants	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.1700
					Lincoln Creek	50.0	--	--	--	--	--	--	0.0250	--
	S. C. Johnson & Sons, Inc.	Racine	Racine	Soap, cleaners, and	Lake Michigan	--	--	--	--	--	--	--	0.5870	--
				toilet goods	Racine Sewage Treatment Plant	--	180.00	140.00	--	0.530	X	28.00	--	0.1500
	S. C. Johnson & Sons, Inc.	Sturtevant	Racine	Soap, cleaners, and	Pike River Tributary	--	--	--	--	--	--	--	1.7900	--
				toilet goods	Sturtevant Sewage Treatment Plant	--	513.00	220.00	--	5.620	X	56.00	--	0.4900
	Hentzen Chemical Coating, Inc.	Milwaukee	Milwaukee	Paints and allied products	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Noyes Creek	55.5	0.00	9.00	--	--	X	6.00	0.0510	--
	PPG Industries, Inc.	Oak Creek	Milwaukee	Paints and allied products	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	CHR Hansens Laboratory, Inc.	Milwaukee	Milwaukee	Industrial organic chemicals	Milwaukee Sewage Treatment Plant	--	6,720.00	9,518.00	--	6.400	X	3,102.00	--	0.0390
					Honey Creek	--	--	--	--	--	--	--	0.0300	--
	Essential Chemicals	Merton	Waukesha	Soap, cleaners, and	Bark Creek	--	--	--	--	--	--	--	--	--
				toilet goods										
	Freeman Chemical Corporation	Saukville	Ozaukee	Plastics, materials,	Saukville Sewage Treatment Plant	--	21.00	18.00	--	0.070	X	6.90	0.0030	0.0070
				no synthetics	Milwaukee River	56.0	7.00	16.00	0.66	0.210	X	7.70	0.2500	--
	Peter Cooper Corporation	Oak Creek	Milwaukee	Miscellaneous chemical	Lake Michigan	80.5	6.00	106.00	0.50	0.600	X	--	4.0590	0.0410
				products	Milwaukee Sewage Treatment Plant	--	1,670.00	1,704.00	25.00	6.600	X	776.00	--	3.5000
2900	PETROLEUM, REFINING, AND RELATED INDUSTRIES													
	Industrial Fuel, Inc.	Oak Creek	Milwaukee	Oil distribution	Oak Creek	--	--	--	--	--	--	--	--	--
	Mobil Oil Corporation–	Milwaukee	Milwaukee	Miscellaneous petroleum	Menomonee River	70.0	2.30	1.60	0.13	0.450	X	5.50	0.0040	--
	Milwaukee Lube Plant			and coal products										
	Payne and Dolan of Wisconsin, Inc.	Waukesha	Waukesha	Asphalt	Fox River	--	--	--	--	--	--	--	--	--
3000	RUBBER AND PLASTICS PRODUCTS													
	A. K. Rubber Products Company, Inc.	Elkhorn	Walworth	Fabricated rubber products	Jackson Creek	--	--	--	--	--	--	--	--	--
	Bardon Rubber Products Company	Union Grove	Racine	Fabricated rubber products	Storm Sewer	--	--	--	--	--	--	--	0.1210	--
	Lavelle Industries, Inc.	Burlington	Racine	Fabricated rubber products	Fox River	--	34.00	21.00	0.00	2.800	X	42.00	0.0500	0.0060
					Burlington Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0020
	Wisconsin Rubber Products Company	Union Grove	Racine	Fabricated rubber products	Des Plaines River	--	--	--	--	--	--	--	0.1300	--
	Continental Can Company	Burlington	Racine	Miscellaneous plastics products	Fox River	--	--	--	--	--	--	--	--	--
	Molded Rubber & Plastic Corporation	Butler	Waukesha	Fabricated rubber products	Menomonee River	--	--	--	--	--	--	--	--	--
	Globe-Union, Inc. HMP Plant	Menomonee Falls	Waukesha	Miscellaneous plastics products	Menomonee Falls Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0030
					Menomonee River	--	0.00	0.00	--	--	X	5.00	0.0230	--
	MSD Plastics, Inc.	Grafton	Ozaukee	Miscellaneous plastics products	Milwaukee River	--	7.00	4.00	--	--	X	8.00	0.0200	--
					Grafton Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0006
	Plastic Parts, Inc.	Union Grove	Racine	Miscellaneous plastics products	Des Plaines River	--	0.00	1.00	--	0.250	X	0.00	0.1410	0.0010
	Product Miniature Company, Inc.	Pewaukee	Waukesha	Miscellaneous plastics products	--	--	--	--	--	--	--	--	--	--
	U. S. Gypsum Company	Walworth	Walworth	Miscellaneous plastics products	Groundwater	--	--	--	--	--	--	--	--	--

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics							Flow, mgd	
						T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Cooling	Process
3100	LEATHER AND LEATHER PRODUCTS													
	A. F. Gallon and Sons Corporation	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	528.00	611.00	--	2.570	--	259.00	--	0.5000
					Milwaukee River	--	--	--	--	--	--	--	0.0050	--
	Amity Leather Products Company	West Bend	Washington	Personal leather goods	West Bend Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Milwaukee River	--	--	--	--	--	--	--	--	--
	Badger State Tanning Corporation	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	7,799.00	690.00	--	--	X	755.00	--	0.0340
	Blackhawk Tanning Corporation	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	2,080.00	1,320.00	--	3.800	X	166.00	--	0.1100
	Cudahy Tanning Company	Cudahy	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	3,200.00	5,260.00	--	19.000	X	352.00	--	0.3900
	Flagg Tanning Corporation	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	341.00	996.00	--	--	X	100.00	0.0120	0.5880
	Gebhardt-Vogel Tanning Company	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	2,964.00	3,440.00	--	1.000	X	590.00	--	0.1580
	Gebhardt-Vogel Tanning Company	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	1,370.00	870.00	--	0.100	X	99.00	--	0.1230
	General Split Corporation	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	93.00	978.00	--	--	X	83.00	--	0.7850
	Great Lakes Tanning Company	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	690.00	244.00	100.00	3.000	X	558.00	--	0.1200
	Law Tanning Company	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	572.00	1,182.00	--	2.300	X	283.00	0.0110	0.1220
	Midwest Tanning Company	South Milwaukee	Milwaukee	Leather tanning and finishing	South Milwaukee Sewage Treatment Plant	--	1,000.00	982.00	180.00	1.000	X	250.00	--	0.1420
	Pfister & Vogel Tanning Company	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	1,780.00	2,700.00	--	--	X	695.00	0.0240	1.4000
	Rapco Leather Company	South Milwaukee	Milwaukee	Leather tanning and finishing	South Milwaukee Sewage Treatment Plant	--	960.00	1,090.00	12.00	3.400	X	120.00	--	0.0700
	Seidel Tanning Corporation	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	679.00	680.00	--	500.000	X	89.00	--	0.0250
	Spencer Leathers	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	1,620.00	6,740.00	--	2.200	X	102.00	0.0030	0.3630
	Thiele Tanning Company	Milwaukee	Milwaukee	Leather tanning and finishing	Milwaukee Sewage Treatment Plant	--	376.00	577.00	--	--	X	291.00	--	0.0950
	W. B. Place and Company	Hartford	Washington	Leather tanning and finishing	Hartford Sewage Treatment Plant	--	2,975.00	2,400.00	44.80	4.600	X	168.00	--	0.1200
					Rubicon River	120.0	--	645.00	--	24.500	X	--	--	--
3200 and 1400	STONE, CLAY, GLASS, AND CONCRETE PRODUCTS: NONMETALLIC MINERALS													
	Wissota Sand and Gravel Company	Hubertus	Washington	Construction, sand, and gravel	Bark Creek	--	--	--	--	--	--	--	--	--
	State Sand and Gravel Company	North Lake	Waukesha	Sand and gravel	Unnamed Creek to North Lake	--	--	--	--	--	--	--	--	--
	State Sand and Gravel Company	Muskego	Waukesha	Sand and gravel	Muskego Lake	--	--	--	--	--	--	--	--	--
	White Construction Company	Salem	Kenosha	Sand and gravel	Fox River	--	--	--	--	--	--	--	--	--
	Best Block Company	Butler	Waukesha	Concrete block and brick	Menomonee river	--	--	--	--	--	--	--	--	--
	Best Block Company	Menomonee Falls	Waukesha	Concrete, gypsum, and plaster products	Land Disposal	--	--	--	--	--	--	--	--	--
	Best Block Racine, Inc.	Racine	Racine	Concrete, gypsum, and plaster products	--	--	--	--	--	--	--	--	--	--
	Butler Lime & Cement Company	Milwaukee	Milwaukee	Concrete, gypsum, and plaster products	Menomonee River	--	3.00	16.00	0.05	0.100	--	2.00	--	0.0020
	J. I. Case Company	Waterford	Racine	Concrete, gypsum, and plaster products	Fox River	--	12.30	8.00	0.00	4.400	X	2.70	--	--
	Marquette Cement Manufacturing Company	Milwaukee	Milwaukee	Cement, hydraulic	South Menomonee Canal	78.0	--	236.00	--	0.290	--	0.00	0.3690	3.7310
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.2200
	North Milwaukee Lime and Cement Company	Milwaukee	Milwaukee	Concrete, gypsum, and plaster products	Lincoln Creek	--	2.00	18.00	0.05	0.100	--	1.00	--	0.0020
	Foster-Forbes Glass Company	Burlington	Racine	Glass and glassware - pressed or blown	Fox River	54.0	3.00	3.00	0.00	0.000	X	4.80	0.5060	--
					Burlington Sewage Treatment Plant	--	200.00	--	--	--	--	--	--	0.0030
	Halquist Lannon Stone Company, Inc.	Sussex	Waukesha	Crushed and broken stone	Sussex Creek	--	--	--	--	--	--	--	--	--
	Milwaukee Marble Company	Milwaukee	Milwaukee	Cut stone and stone products	Menomonee River	--	48.00	422.00	7.75	0.110	--	10.32	--	0.0055
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0005
	Universal Atlas Cement Company	--	--	--	--	--	--	--	--	--	--	--	--	--
	Fredrick R. Redi-Mix Company	Waukesha	Waukesha	--	Marsh Tributary to Fox River	--	--	--	--	--	--	--	--	--
	Vulcan Materials Company	Franklin	Milwaukee	Crushed and broken limestone	Root River	--	3.00	7.00	0.25	0.260	--	1.10	--	0.0390
	Vulcan Materials Company	Racine	Racine	Crushed and broken limestone	Root River	--	1.20	18.00	0.13	0.018	--	13.00	--	0.0710
	Vulcan Materials Company	Sussex	Waukesha	Crushed and broken limestone	Fox River	--	2.00	24.00	0.33	0.180	--	1.50	--	0.0900

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics: T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd: Cooling	Process
3300	PRIMARY METALS INDUSTRY													
	Briggs & Stratton- Good Hope Road	Milwaukee	Milwaukee	Iron and steel foundries	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0080
	Advance Boiler and Tank Company	Milwaukee	Milwaukee	Iron and steel foundry	Lake Michigan	--	--	--	--	--	--	--	--	--
	Allied Smelting Corporation	Milwaukee	Milwaukee	Secondary nonferrous metals	Storm Sewer	--	--	--	--	--	--	--	1.380	--
	Dayton Malleable, Inc.— Meta-Mold Division	Cedarburg	Ozaukee	Nonferrous foundries	Cedar Creek	64.0	125.00	15.00	0.90	0.220	X	1.30	0.0220	0.0060
	EST Company, Inc.	Grafton	Ozaukee	Nonferrous foundries	Milwaukee River	--	--	--	--	--	--	--	0.0700	--
					Grafton Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0090
	Federal Malleable Company	West Allis	Milwaukee	Iron and steel foundries	Menomonee River	--	0.00	12.00	0.00	2.030	X	5.00	0.0360	0.0010
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0040
	Froemming Cast Products, Division Janes Manufacturing	Oak Creek	Milwaukee	Iron and steel foundries	--	--	--	--	--	--	--	--	--	--
	General Casting Corporation	Waukesha	Waukesha	Iron and steel foundries	Fox River	--	0.00	16.00	0.00	0.000	X	0.10	0.3440	--
					Waukesha Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Grede Foundries, Inc.	Waukesha	Waukesha	Iron and steel foundries	Fox River	--	--	--	--	--	--	--	0.2280	--
	Grede Foundries, Inc.	Wauwatosa	Milwaukee	Iron and steel foundries	Storm Sewer	--	--	--	--	--	--	--	0.0190	--
	Grey Iron Foundry, Inc.	West Allis	Milwaukee	Iron and steel foundries	Kinnickinnic River	--	10.00	30.00	0.05	0.000	X	1.70	0.3400	--
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0020
	Howmet Corporation	Milwaukee	Milwaukee	Iron and steel foundries	Kinnickinnic River	--	2.00	23.00	0.00	0.000	X	0.70	0.6780	0.1180
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0590
	International Harvester	Waukesha	Waukesha	Iron and steel foundries	Fox River	--	0.30	2.30	0.00	0.670	X	3.00	0.3980	0.0350
					Waukesha Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	J. M. Bruce Foundry, Inc.	Cedar Grove	Ozaukee	Iron and steel foundries	--	--	--	--	--	--	--	--	--	--
	Johnson Brass & Machine Foundry, Inc.	Saukville	Ozaukee	--	Milwaukee River	--	--	--	--	--	--	--	--	--
	Maynard Steel Casting Company	Milwaukee	Milwaukee	Iron and steel foundries	Kinnickinnic River	60.0	40.00	27.00	0.61	0.000	X	4.70	0.1910	0.0140
					Milwaukee Sewage Treatment Plant	--	0.00	0.00	0.06	--	X	--	0.0970	0.0360
	Milwaukee Die Casting Company	Milwaukee	Milwaukee	Nonferrous foundries	Milwaukee River	68.0	17.00	29.00	--	0.460	--	11.50	0.0120	--
					Milwaukee Sewage Treatment Plant	--	18.00	20.00	--	0.850	X	4.60	--	0.0250
	Motor Casting Company—Plant No. 1	West Allis	Milwaukee	Iron and steel foundries	Woods Creek	--	3.00	491.00	0.78	0.080	X	0.10	0.2200	--
					Milwaukee Sewage Treatment Plant	--	121.00	98.00	18.00	0.060	X	1.20	--	0.0030
	Motor Casting Company—Plant No. 2	Milwaukee	Milwaukee	Iron and steel foundries	Honey Creek	84.0	0.00	2.00	0.00	0.070	X	0.00	0.0180	--
					Milwaukee Sewage Treatment Plant	--	35.00	340.00	6.30	1.700	X	13.30	--	0.0250
	Pelton Casteel, Inc.	Milwaukee	Milwaukee	Iron and steel foundries	Kinnickinnic River	60.0	256.00	357.00	0.83	0.400	X	8.60	0.0950	0.0050
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Port Shell Molding, Inc.	Pewaukee	Waukesha	Nonferrous foundries	--	--	--	--	--	--	--	--	--	--
	Quality Aluminum Casting Company	Waukesha	Waukesha	Nonferrous foundries	Waukesha Sewage Treatment Plant	--	36.00	57.00	--	29.500	X	19.00	0.0700	0.0240
					Fox River	--	--	--	--	--	--	--	--	--
	Sharon Foundry, Inc.	Sharon	Walworth	Iron and steel foundries	--	--	--	--	--	--	--	--	--	--
	Waukesha Foundry Company, Inc.	Waukesha	Waukesha	Iron and steel foundries	Fox River	--	0.00	0.00	0.00	0.130	X	--	0.2850	--
					Waukesha Sewage Treatment Plant	--	--	--	--	--	--	--	0.0010	0.0730
	Wehr Steel Company	West Allis	Milwaukee	Iron and steel foundries	Milwaukee River	--	0.00	0.00	0.00	0.000	X	0.00	0.2280	0.0200

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SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd Cooling	Process
	PRIMARY METALS INDUSTRY (continued)													
	Acme Die Casting Corporation	Racine	Racine	Gray iron foundries	Racine Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Alpha Cast, Inc.	Whitewater	Walworth	Gray iron foundries	Whitewater Creek	--	38.00	0.80	--	--	--	5.00	0.0960	--
	Slinger Foundry	Slinger	Washington	Gray iron foundries	--	--	--	--	--	--	--	--	--	--
	Evans Products Company	Racine	Racine	Steel foundries	Racine Sewage Treatment Plant	--	0.00	717.00	--	0.000	X	0.00	0.1940	0.1940
	Stainless Foundry & Engineering, Inc.	Milwaukee	Milwaukee	Steel foundries	--	--	--	--	--	--	--	--	--	--
	Quality Aluminum Casting Company	Waukesha	Waukesha	Aluminum foundries	Waukesha Sewage Treatment Plant	--	43.00	34.00	--	1.820	X	10.00	0.0220	0.0080
					Fox River	64.0	1.00	5.00	--	0.220	X	0.00	0.0020	--
	Wisconsin Centrifugal, Inc.	Waukesha	Waukesha	Brass, bronze, and copper foundries	Fox River	--	5.50	15.00	--	--	X	134.00	0.4440	--
	Anaconda American Brass	Kenosha	Kenosha	Nonferrous rolling	Lake Michigan	50.0	4.00	4.00	0.20	0.100	X	6.00	2.2000	0.3000
					Kenosha Sewage Treatment Plant	--	6.00	10.00	--	0.240	X	19.80	1.9400	0.0600
	Ataco Steel Products Company	Grafton	Ozaukee	Blast furnace and basic steel products	Milwaukee River	62.6	1.80	10.40	--	0.230	X	2.00	0.0200	--
					Grafton Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0070
	Babcock & Wilcox Company	West Milwaukee	Milwaukee	Blast furnace and basic steel products	Menomonee River	--	16.00	--	0.00	0.000	X	17.00	0.6000	--
					Milwaukee Sewage Treatment Plant	--	129.00	44.00	0.20	4.900	X	35.00	--	0.5260
	Colt Industries, Trent Tube Division	East Troy	Walworth	Blast furnace and basic steel products	Honey Creek	--	0.00	18.00	0.33	0.023	X	26.00	0.1660	0.3120
					East Troy Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0060
	Huber Supreme Metal	New Berlin	Waukesha	Miscellaneous primary metal products	Kinnickinnic River									
					--	--	--	--	--	--	--	--	--	--
	Milwaukee Solvay Coke Company	Milwaukee	Milwaukee	Blast furnace and basic steel products	Kinnickinnic River	--	0.00	57.00	3.20	0.300	X	4.50	3.8700	0.4300
					Milwaukee Sewage Treatment Plant	--	1,128.00	32.00	220.00	1.100	X	32.00	--	0.3000
	Charter Wire—Division of Charter Manufacturing Company, Inc.	Milwaukee	Milwaukee	Steel wire and related products	Milwaukee Sewage Treatment Plant	--	37.00	75.00	--	0.050	--	7.00	0.0090	0.0780
	Mellowes Company—Division of Charter Manufacturing, Inc.	Milwaukee	Milwaukee	Steel wire and related products	Milwaukee Sewage Treatment Plant	--	118.00	34.00	--	29.000	X	16.00	0.0200	0.0780
	Colt Industries	East Troy	Walworth	Steel pipe and tubes	Land Disposal Pond	--	0.00	33,100.00	8.70	0.000	X	9.00	--	0.0770
					Surface Water Swamp	--	6.40	69.00	--	--	X	110.00	0.0850	--
					East Troy Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0020
	Utility Products Company	Milwaukee	Milwaukee	Steel pipe and tubes	Milwaukee Sewage Treatment Plant	--	845.00	10.50	--	2.810	X	22.60	--	0.0370
	Mirro Aluminum Company	Oconomowoc	Waukesha	Aluminum m sheet, plate, and foil	Oconomowoc Sewage Treatment Plant	--	13.00	0.00	--	1.400	X	0.00	0.0380	0.0090
					Land Disposal	--	--	--	--	--	--	--	--	--
	E. C. Styberg Engineering Company	Racine	Racine	Metal heat treating	--	--	--	--	--	--	--	--	--	--
	Treat All Metals, Inc.	Milwaukee	Milwaukee	Metal heat treating	Milwaukee River	53.0	4.00	3.00	0.11	0.130	X	4.00	0.2000	--
3400	FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND TRANSPORTATION EQUIPMENT													
	American Can Company	Milwaukee	Milwaukee	Metal cans and shipping containers	Surface water	48.0	86.00	39.00	35.00	X	2.56	14.20	0.0300	--
					Milwaukee Sewage Treatment Plant	--	59.00	50.00	3.90	X	1.30	34.00	0.0620	0.1380
	Burlington Brass Works	Burlington	Racine	Plumbing and heating, except electric	Fox River	63.0	3.00	5.00	--	0.150	X	0.00	--	0.0017
					Burlington Sewage Treatment Plant	--	3.00	162.00	--	9.700	X	14.00	0.0080	0.0330
	Carnation Company—Can Division	Menomonee Falls	Waukesha	Metal cans and shipping containers	Menomonee River	84.0	0.10	1.00	0.97	0.040	X	1.50	0.0200	--
	Eaton Corporation	Milwaukee	Milwaukee	Metal forgings and stampings	Kinnickinnic River	--	0.00	30.00	0.00	0.710	X	94.00	0.2050	0.1200
					Milwaukee Sewage Treatment Plant	--	5.00	34.00	--	0.320	X	554.00	0.0100	0.0150
	Harris Metals, Inc.	Racine	Racine	Miscellaneous metal products	--	--	--	--	--	--	--	--	--	--
	Inland-Ryerson Construction Products Company	Milwaukee	Milwaukee	Fabricated structural metal products	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Interstate Drop Forge Company	Milwaukee	Milwaukee	Metal forgings and stampings	--	--	--	--	--	--	--	--	--	--
	Kickhaefer Manufacturing Company—Stamping Division	Grafton	Ozaukee	Metal forgings and stampings	--	--	--	--	--	--	--	--	--	--
	Ladish Company	Cudahy	Milwaukee	Miscellaneous fabricated metal products	Oak Creek	--	--	--	--	--	--	--	0.5300	--
					Kinnickinnic River	--	--	--	--	--	--	--	0.0500	--
					Lake Michigan	--	--	--	--	--	--	--	0.6200	--
					Milwaukee Sewage Treatment Plant	--	49.00	294.00	--	1.200	X	84.00	--	2.8110

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd Cooling	Process
	FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND TRANSPORTATION EQUIPMENT (continued)													
	Perfex Division, McQuay-Perfex, Inc. (copper tubing)	Milwaukee	Milwaukee	Plumbing and heating—except electric	Kinnickinnic River	42.0	1.00	1.30	0.56	0.120	X	0.00	0.1300	--
					Milwaukee Sewage Treatment Plant	--	60.00	228.00	--	1.000	X	14.00	--	0.1950
	Treat All Metals, Inc.	Milwaukee	Milwaukee	Miscellaneous primary metal products	Milwaukee River	53.0	4.00	3.00	0.11	0.130	X	4.00	0.2000	--
	Western Metal Specialty Division	Wauwatosa	Milwaukee	Miscellaneous fabricated metal	--	--	--	--	--	--	--	--	--	--
	Wire and Metal Specialities Company	St. Francis	Milwaukee	--	--	--	--	--	--	--	--	--	--	--
	Wisconsin Bridge and Iron Company	Milwaukee	Milwaukee	Fabricated structural metal products	--	--	--	--	--	--	--	--	--	--
	Carnation Company	Oconomowoc	Waukesha	Metal cans	Oconomowoc River	77.0	0.90	4.00	0.00	0.300	X	11.50	0.0270	--
					Oconomowoc Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Jos. Schlitz Brewing Company	Oak Creek	Milwaukee	Metal cans	Oak Creek Sewage Treatment Plant	--	39.00	3.60	26.70	4.600	X	40.80	0.0060	0.1190
					Oak Creek	--	--	--	--	--	--	--	--	--
	Snap-On Tools Corporation	Kenosha	Kenosha	Hand and edge tools	Kenosha Sewage Treatment Plant	--	50.00	66.00	--	3.500	X	6.30	0.3300	0.1420
					Lake Michigan	--	--	--	--	--	--	--	--	--
	Master Lock Company	Milwaukee	Milwaukee	Hardware	Milwaukee Sewage Treatment Plant	--	6.00	82.00	--	12.500	X	29.00	0.2600	0.7810
	Frost Company	Kenosha	Kenosha	Plumbing and fittings and brass goods	Kenosha Sewage Treatment Plant	--	132.00	339.00	--	--	X	87.00	0.0100	0.1200
	Modine Manufacturing Company	Racine	Racine	Heating equipment, except electrical	Racine Sewage Treatment Plant	--	23.00	112.00	2.00	0.600	X	6.00	0.0600	0.0700
	Perfex Division, McQuay-Perfex, Inc.	Milwaukee	Milwaukee	Heating equipment, except electrical	Milwaukee Sewage Treatment Plant	--	16.00	125.00	--	2.200	X	1.00	--	0.2370
	Industrial Cylinders Company	West Milwaukee	Milwaukee	Fabricated plate work (boiler shops)	Milwaukee Sewage Treatment Plant	--	80.00	12,200.00	--	59.000	X	--	--	0.4260
	Pressed Steel Tank Company	West Allis	Milwaukee	Fabricated plate work (boiler shops)	Milwaukee Sewage Treatment Plant	--	22.00	347.00	--	1.400	X	862.00	--	0.1890
					Honey Creek	--	11.00	307.00	--	0.360	X	600.00	--	0.5440
	INRYCO, Inc.	West Milwaukee	Milwaukee	Sheet metal work	Milwaukee Sewage Treatment Plant	--	156.00	694.00	11.60	18.800	X	564.00	0.0160	0.2110
					Menomonee River	70.0	--	--	--	--	--	--	0.3270	--
	Milwaukee Forge	Milwaukee	Milwaukee	Iron and steel forgings	Milwaukee Sewage Treatment Plant	--	141.00	1,674.00	2.70	0.600	X	597.00	--	0.0740
	E. R. Wagner Manufacturing Company—Engineered Products Division	Milwaukee	Milwaukee	Metal stamping	Milwaukee Sewage Treatment Plant	--	64.00	88.00	--	1.200	X	137.00	--	0.1160
					Storm Sewer	--	--	--	--	--	--	--	--	--
	GPF	Milwaukee	Milwaukee	Metal stamping	Milwaukee Sewage Treatment Plant	--	--	41.00	--	--	X	--	--	0.2000
	E. F. Brewer Company	Menomonee Falls	Waukesha	Plating and polishing	Menomonee Falls Sewage Treatment Plant	--	84.00	8.20	--	0.600	X	14.10	--	0.0240
					Storm Sewer	--	--	--	--	--	--	--	--	--
	Electro-Coating, Inc.	Milwaukee	Milwaukee	Plating and polishing	Milwaukee Sewage Treatment Plant	--	11.30	13.00	--	--	X	0.00	0.0230	0.0030
	Finishing and Plating Service, Inc.	Kenosha	Kenosha	Plating and polishing	Kenosha Sewage Treatment Plant	--	12.00	178.00	0.70	4.400	X	40.00	--	0.1660
	Milwaukee Plating Company	Milwaukee	Milwaukee	Plating and polishing	Milwaukee Sewage Treatment Plant	--	8.30	245.00	1.48	1.860	X	10.40	--	0.1840
	Modern Plating Company	Milwaukee	Milwaukee	Plating and polishing	Milwaukee Sewage Treatment Plant	--	0.00	193.00	--	3.200	X	--	--	0.0070
	Murray Metal Plating Works, Inc.	Milwaukee	Milwaukee	Plating and polishing	Milwaukee Sewage Treatment Plant	--	44.00	83.00	2.00	1.400	X	12.00	--	0.1600
	National Plating Company, Inc.	Milwaukee	Milwaukee	Plating and polishing	Milwaukee Sewage Treatment Plant	--	10.20	103.00	2.10	1.100	X	8.00	--	0.0200
	Oconomowoc Electroplating, Inc.	Waukesha	Waukesha	Plating and polishing	Waukesha Sewage Treatment Plant	--	--	456.00	--	1.000	X	6.90	--	0.0170
	Plating Engineering Company	Milwaukee	Milwaukee	Plating and polishing	Milwaukee Sewage Treatment Plant	--	105.00	192.00	2.60	0.900	X	1.50	--	0.0700
	Racine Plating Company	Racine	Racine	Plating and polishing	Racine Sewage Treatment Plant	--	--	--	--	0.800	X	--	0.0020	0.2380
	Reliable Plating Works, Inc.	Milwaukee	Milwaukee	Plating and polishing	Milwaukee Sewage Treatment Plant	--	--	176.00	--	--	X	2.00	--	0.0430
	S. K. Williams Company	Wauwatosa	Milwaukee	Plating and polishing	Menomonee River	--	--	9.90	--	0.450	X	--	0.0300	0.2700
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0100
	Shephard Plating Company	Racine	Racine	Plating and polishing	Racine Sewage Treatment Plant	--	2.10	15.00	--	0.400	X	2.90	0.1620	0.1650
	Wisconsin Plating Works	Racine	Racine	Plating and polishing	Racine Sewage Treatment Plant	--	0.00	0.50	0.00	4.000	X	0.00	0.0010	0.0570
	Acme Galvanizing, Inc.	Milwaukee	Milwaukee	Metal coating and allied services	Milwaukee Sewage Treatment Plant	--	0.20	254.00	6.30	4.700	X	7.30	--	0.4140

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics: T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd: Cooling	Process
	FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND TRANSPORTATION EQUIPMENT (continued)													
	Metal Coatings, Inc.	Milwaukee	Milwaukee	Metal coating and allied services	Milwaukee Sewage Treatment Plant	--	7.00	234.00	--	0.100	X	8.00	--	0.0180
	Alloy Products Corporation	Waukesha	Waukesha	Valves and pipe fittings	Land Disposal-Lagoon	--	0.00	51.00	--	0.400	X	0.00	0.0026	0.0780
					Waukesha Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0100
	Milwaukee Valve Company, Inc.	Milwaukee	Milwaukee	Valves and pipe fittings	Milwaukee Sewage Treatment Plant	--	8.60	20.00	4.10	0.900	X	45.00	0.0480	0.0080
	Mac Whyte Wire Rope Company	Kenosha	Kenosha	Miscellaneous fabricated wire products	Kenosha Sewage Treatment Plant	--	14.00	32.00	--	0.900	X	0.00	0.0190	0.2590
	Milwaukee Wire Products, Inc.	Milwaukee	Milwaukee	Miscellaneous fabricated wire products	Milwaukee Sewage Treatment Plant	--	237.00	236.00	--	12.500	X	230.00	0.0020	0.0140
	Amron Corporation	Waukesha	Waukesha	Ordnance and accessories	Fox River	--	1.10	0.60	0.16	0.630	X	0.00	0.0630	0.0004
					Waukesha Sewage Treatment Plant	--	8.90	13.70	19.30	3.800	X	67.00	0.2490	0.5590
					Storm Sewer	--	0.10	3.40	--	--	--	7.50	0.0020	--
	Wright Metal Processors, Inc.	Milwaukee	Milwaukee	Metal Services	Milwaukee Sewage Treatment Plant	--	109.00	73.00	34.60	2.100	X	120.00	--	0.0450
	Wriqht Metal Processors, Inc.	Milwaukee	Milwaukee	Metal Services	Milwaukee Sewage Treatment Plant	--	41.00	18.00	4.00	2.100	X	8.00	--	0.1100
	Butler Bin Company	Waukesha	Waukesha	--	Fox River	--	--	--	--	--	--	--	--	--
3500	MACHINERY, EXCEPT ELECTRICAL													
	Allis-Chalmers Corporation	Oak Creek	Milwaukee	Farm and garden machinery	Lake Michigan	--	--	--	--	--	--	--	0.0110	--
					Land Disposal-Septic System	--	--	--	--	--	--	--	--	--
	Allis-Chalmers Corporation	West Allis	Milwaukee	Farm and garden machinery	Milwaukee Sewage Treatment Plant	--	62.00	112.00	16.60	3.600	X	43.90	--	0.5700
					Honey Creek	60.0	3.00	58.00	0.30	0.300	X	6.00	--	0.0700
	Briggs & Stratton–Good Hope Road	Milwaukee	Milwaukee	Engines and turbines	Milwaukee Sewage Treatment Plant	--	125.00	43.00	0.40	0.700	X	50.00	0.3950	0.1180
					Surface Water	--	3.70	2.60	0.05	0.030	X	0.00	0.0036	--
	Briggs & Stratton–N. 32nd Street	Milwaukee	Milwaukee	Engines and turbines	Milwaukee Sewage Treatment Plant	--	90.75	17.52	0.81	1.500	X	11.21	0.0900	0.0300
	Briggs & Stratton–N. 124th Street	Wauwatosa	Milwaukee	Engines and turbines	Menomonee River	76.0	10.20	0.00	0.00	0.160	X	0.00	0.0250	--
					Milwaukee Sewage Treatment Plant	--	410.00	300.00	0.22	1.030	X	186.00	1.0800	0.4200
	Mercury Marine Division– Brunswick Corporation	Cedarburg	Ozaukee	Engines and turbines	Cedar Creek	--	--	--	--	--	--	--	--	--
					Cedarburg Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Bucyrus-Erie Company	South Milwaukee	Milwaukee	Construction and related machinery	Oak Creek	--	1.50	9.70	--	0.120	X	22.40	--	0.5340
					South Milwaukee River	--	26.30	9.40	--	0.800	X	31.10	0.0190	0.4460
	Caterpillar Tractor Company	Milwaukee	Milwaukee	Construction and related machinery	Milwaukee Sewage Treatment Plant	--	100.00	218.00	--	96.000	X	34.00	--	0.0170
					Kinnickinnic River	--	11.00	15.00	1.30	0.250	--	--	0.0340	0.0002
	Continental Can Company	Milwaukee	Milwaukee	Special industrial machinery	--	--	--	--	--	--	--	--	--	--
	Continental Equipment Corporation	Milwaukee	Milwaukee	Special industrial machinery	--	--	--	--	--	--	--	--	--	--
	Eaton Corporation–Industrial Drives Division	Kenosha	Kenosha	General industrial machinery	Lake Michigan	--	2.00	0.50	--	--	X	0.00	0.1150	--
					Kenosha Sewage Treatment Plant	--	1.50	32.90	1.20	2.260	X	2.00	0.0900	0.0900
	Falk Corporation	Milwaukee	Milwaukee	General industrial machinery	Milwaukee Sewage Treatment Plant	--	91.00	35.00	--	4.360	X	9.30	--	0.0120
					Menomonee River	--	8.00	176.00	1.01	0.330	X	0.00	0.1870	0.0990
	Falk Corporation	Milwaukee	Milwaukee	General industrial machinery	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Menomonee River	--	--	--	--	--	--	--	--	--
	Falk Corporation	Wauwatosa	Milwaukee	General industrial machinery	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Menomonee River	--	--	--	--	--	--	--	--	--
	Gehl Company	West Bend	Washington	Farm and garden machinery	Milwaukee River	--	--	--	--	--	--	--	0.1810	--
	Harnischfeger Corporation	Milwaukee	Milwaukee	Construction and related machinery	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Storm Sewer	--	--	--	--	--	--	--	--	--
	J. I. Case Company	Racine	Racine	Farm and garden machinery	Lake Michigan	--	12.10	264.00	0.82	0.290	X	7.90	0.6640	1.3270
					Racine Sewage Treatment Plant	--	5.40	0.00	0.00	0.310	X	1.30	0.0870	0.0190
	Murphy Diesel Company	Milwaukee	Milwaukee	Engines and turbines	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Kinnickinnic River	--	--	--	--	--	--	--	0.0290	--
	Oilgear Company	Milwaukee	Milwaukee	General industrial machinery	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	0.0070	0.0080
					Kinnickinnic Creek	57.0	--	--	--	--	X	4.00	0.0010	--

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics: T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd: Cooling	Process
	MACHINERY, EXCEPT													
	ELECTRICAL (continued)													
	Evinrude Motors—Division of	Milwaukee	Milwaukee	Engines and turbines	Lake Michigan	54.0	0.10	4.60	0.70	--	--	7.50	0.4200	--
	Outboard Marine Corporation				Milwaukee Sewage Treatment Plant	--	5.10	54.00	2.30	0.800	X	11.00	--	0.5800
	Plant No. 1				Lake Michigan	--	0.10	20.00	0.60	0.550	X	3.30	0.9600	--
					Milwaukee Sewage Treatment Plant	--	0.10	182.00	0.52	3.000	X	39.00	--	0.2000
	Evinrude Motors—Division of	Milwaukee	Milwaukee	Engines and turbines	Lake Michigan	--	3.40	25.50	0.40	0.480	X	3.00	0.0600	--
	Outboard Marine Corporation				Milwaukee Sewage Treatment Plant	--	51.00	214.00	25.60	2.070	X	17.50	--	0.1890
	Foundry and Machinery													
	Rexnord, Inc.	Milwaukee	Milwaukee	General industrial machinery	Menomonee River	--	3.90	7.00	0.48	0.200	X	4.00	0.2530	0.0440
					Milwaukee Sewage Treatment Plant	--	101.00	84.00	--	6.210	X	21.20	0.0150	0.0580
	Rexnord, Inc.	Milwaukee	Milwaukee	Construction and related	Kinnickinnic River	--	4.10	47.00	0.35	7.510	X	11.30	0.4460	0.1330
				machinery	Milwaukee Sewage Treatment Plant	--	23.60	135.00	--	1.200	X	21.70	0.1190	0.1210
	Rexnord, Inc.	Racine	Racine	Miscellaneous machinery,	Pike River	56.0	--	--	--	--	--	--	0.1460	--
				except electrical	Racine Sewage Treatment Plant	--	100.00	227.00	--	3.270	X	16.70	0.0030	0.0100
	Russell T. Gilman, Inc.	Grafton	Ozaukee	Metal-working machinery	--	--	--	--	--	--	--	--	--	--
	Teledyne Wisconsin Motor	West Allis	Milwaukee	Engines and turbines	Milwaukee Sewage Treatment Plant	--	68.00	28.00	--	0.810	X	23.90	0.0360	0.0570
					Kinnickinnic River	--	11.70	7.70	0.40	0.350	X	13.50	0.0630	0.0210
	Twin Disc., Inc.	Racine	Racine	General industrial machinery	Racine Sewage Treatment Plant	--	1,973.00	175.00	--	0.000	X	229.00	0.0450	0.0120
					Storm Sewer	--	0.00	2.30	0.21	0.000	X	12.00	0.0370	0.0080
	Twin Disc., Inc.	Racine	Racine	General industrial machinery	Racine Sewage Treatment Plant	--	142.00	77.00	--	11.300	X	444.00	--	0.0110
					Storm Sewer	--	0.00	0.00	0.40	0.000	X	560.00	0.1240	--
	Waukesha Engine Division,	Waukesha	Waukesha	Engines and turbines	Fox River	68.0	8.70	7.00	0.00	0.700	X	5.10	0.2800	0.3710
	Dresser Industries				Waukesha Sewage Treatment Plant	--	96.00	--	3.43	4.640	X	20.40	0.0570	0.3740
	Briggs & Stratton	Milwaukee	Milwaukee	Engines and turbines	Milwaukee Sewage Treatment Plant	--	91.00	17.50	11.20	1.500	X	11.20	0.0930	0.0330
	Chrysler Outboard Corporation	Hartford	Washington	Internal combustion engines	Hartford Sewage Treatment Plant	--	65.00	73.00	1.10	10.600	X	4.00	--	0.1510
					Muni Landfill	--	--	--	--	--	--	--	--	0.0010
					Rubicon River	--	--	--	--	--	--	--	--	--
	Tecumseh Products Company	Grafton	Ozaukee	Internal combustion engines	Grafton Sewage Treatment Plant	--	1,110.00	806.00	--	184.000	X	174.00	--	0.1020
					Milwaukee River	--	--	--	--	--	--	--	--	--
	Milsco Manufacturing Company	Brown Deer	Milwaukee	Farm machinery and	Municipal Sewage Treatment Plant	--	393.00	--	3.40	420.000	X	40.00	--	0.0280
				equipment										
	Jacobsen Manufacturing Company	Racine	Racine	Lawn and garden equipment	Racine Sewage Treatment Plant	--	33.00	208.00	10.70	35.700	X	18.00	0.0600	0.1100
	Outdoor Power Equipment	Port Washington	Ozaukee	Lawn and garden equipment	Port Washington	--	66.00	61.00	--	15.600	X	8.00	--	0.0400
					Sewage Treatment Plant									
	Simplicity Manufacturing Company	Port Washington	Ozaukee	Lawn and garden equipment	Port Washington	--	89.00	32.00	--	2.100	X	11.00	0.0340	0.0660
					Sewage Treatment Plant									
					Sauk Creek	56.0	8.80	7.30	0.40	0.160	X	0.00	0.0600	--
	Milwaukee Electric Tool Corporation	Brookfield	Waukesha	Power-driven hand tools	Milwaukee Sewage Treatment Plant	--	258.00	385.00	1.50	1.810	X	7.50	--	0.0090
					Unnamed Creek	--	2.30	3.60	0.45	0.160	X	--	--	0.1300
					Storm Sewer	--	--	--	--	--	--	--	--	--
	Ladish Company, Tri-Clover Division	Pleasant Prairie	Kenosha	Food products machinery	Des Plaines River	71.0	5.90	6.30	0.10	0.500	X	3.90	0.0790	0.0100
	Milwaukee Chaplet and	New Berlin	Waukesha	Special industrial machinery	New Berlin Sewer System	--	3.30	754.00	--	4.300	X	37.90	--	0.0100
	Manufacturing Company				Storm Drainage Ditch	--	--	--	--	--	--	--	--	--
					Land Disposal Irrigation	--	--	--	--	--	--	--	--	--
	Massey-Ferguson, Inc.	Racine	Racine	--	Lake Michigan	--	--	24.00	--	1.100	--	--	--	0.0080
	J. I. Case Company	Racine	Racine	Concrete Machinery	Racine Sewage Treatment Plant	--	6.40	32.00	0.00	0.170	X	2.10	--	0.0140
	Kearney and Trecker Company	West Allis	Milwaukee	Metal-working machinery	--	--	--	--	--	--	--	--	--	--
	Perlick Company, Inc.	Milwaukee	Milwaukee	Refrigeration and service	Milwaukee Sewage Treatment Plant	--	--	18.00	0.00	--	X	0.00	0.0060	0.0540
				machinery	Little Menomonee River	75.0	--	--	--	--	--	--	0.0010	--

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics: T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd: Cooling	Process
3600	ELECTRICAL AND ELECTRONIC MACHINERY													
	Appleton Electric Company	South Milwaukee	Milwaukee	Electronic components and accessories	South Milwaukee Sewage Treatment Plant	--	89.00	88.00	1.89	2.520	X	13.50	--	0.0170
					Oak Creek	--	14.00	4.40	2.70	1.350	X	29.00	0.0530	0.2070
	Appleton Electric Company	South Milwaukee	Milwaukee	Electric lighting and wiring equipment	Oak Creek	--	0.10	0.60	--	--	X	2.30	0.0450	--
					South Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0070
	Cutler-Hammer, Inc.	Milwaukee	Milwaukee	Miscellaneous electrical equipment and supplies	Lincoln Creek	48.0	--	--	--	--	--	--	0.1100	--
					Milwaukee Sewage Treatment Plant	--	18.60	45.00	--	1.900	X	11.30	--	0.0340
	Cutler-Hammer, Inc.	Milwaukee	Milwaukee	Miscellaneous electrical equipment and supplies	Milwaukee Sewage Treatment Plant	--	18.40	66.00	1.26	0.280	X	7.70	--	0.8400
	Doerr Electric Corporation	Cedarburg	Ozaukee	Electrical industrial apparatus	--	--	--	--	--	--	--	--	--	--
	Globe-Union, Inc.	Milwaukee	Milwaukee	Electronic components and accessories	Milwaukee Sewage Treatment Plant	--	4.00	20.00	--	0.500	X	2.00	0.0110	0.0980
					Lincoln Creek	--	2.50	11.50	--	--	X	4.00	0.0600	--
	Globe-Union, Inc.	Milwaukee	Milwaukee	Electronic components and accessories	Milwaukee Sewage Treatment Plant	--	11.00	44.00	--	8.600	X	6.00	0.0080	0.0720
	Leeson Electric Corporation	Grafton	Ozaukee	Electrical industrial apparatus	--	--	--	--	--	--	--	--	--	--
	Square D Company	Milwaukee	Milwaukee	Electrical industrial apparatus	Milwaukee River	--	5.10	6.00	0.60	0.250	X	8.10	0.1830	--
					Milwaukee Sewage Treatment Plant	--	68.00	95.00	--	7.600	X	21.00	0.0250	0.0350
	RTE Corporation	Waukesha	Waukesha	Electric distributing equipment	Fox River	--	--	--	--	--	--	--	--	--
	RTE Corporation	Waukesha	Waukesha	Transformers	Fox River	64.0	2.40	2.80	7.40	2.600	X	8.60	0.2400	--
					Waukesha Sewage Treatment Plant	--	21.00	10.80	11.30	8.500	X	2.30	0.0360	0.0440
					Waukesha Sewage Treatment Plant	--	6.10	100.00	4.20	11.500	X	3.00	0.0120	0.0120
					Storm Sewer	--	--	--	--	--	--	--	--	--
					Surface Water Ditch	--	--	--	--	--	--	--	--	--
	Allis-Chalmers Corporation	West Allis	Milwaukee	Switchgear and switchboard apparatus	Milwaukee Sewage Treatment Plant	--	18.60	21.80	4.70	4.100	X	4.70	--	0.0730
	Webster Electric Company	Racine	Racine	Motors and generators	--	--	--	--	--	--	--	--	--	--
	Allen-Bradley Company	Milwaukee	Milwaukee	Industrial controls	Milwaukee Sewage Treatment Plant	--	11.00	45.00	--	0.400	X	--	1.2480	2.5690
	Sprague Electric Company	Grafton	Ozaukee	Electrical industrial apparatus	--	--	--	--	--	--	--	--	--	--
	Broan Manufacturing Company	Hartford	Washington	Electric housewares and fans	--	--	--	--	--	--	--	--	--	--
	Delco Electronics— General Motors Corporation	Oak Creek	Milwaukee	Semiconductor and related devices	Milwaukee Sewage Treatment Plant	--	72.00	262.00	--	12.200	X	8.80	0.0060	0.0470
					Oak Creek	--	--	--	--	--	--	--	--	--
	Globe-Union—Teutonia Plant	Milwaukee	Milwaukee	Electronic components	Milwaukee Sewage Treatment Plant	--	2.00	2.00	--	0.200	X	2.00	0.0140	0.0370
	Pho-Tronics, Inc	Butler	Waukesha	Electronic components	Milwaukee Sewage Treatment Plant	--	26.00	16.00	--	3.600	X	1.20	--	--
	Globe-Union, Inc.	Milwaukee	Milwaukee	Electronic components	Milwaukee Sewage Treatment Plant	--	5.50	16.20	51.00	0.400	X	5.80	0.0320	0.3490
					Milwaukee Sewage Treatment Plant Combined Sewer	--	--	--	--	--	--	--	0.1340	--
	ESB, Inc.	Racine	Racine	Primary batteries, dry and wet	Racine Sewage Treatment Plant	--	12.00	35.00	0.00	0.600	X	0.00	0.0170	0.0370
					Surface Water	--	--	--	--	--	--	--	--	--
	Globe-Union, Inc.	Glendale	Milwaukee	Primary batteries, dry and wet	Milwaukee Sewage Treatment Plant	--	13.00	46.00	--	1.300	X	1.10	0.1550	0.0550
					Lincoln Creek	--	5.00	19.00	0.10	0.040	X	8.00	0.0030	--
	McGraw-Edison Company, Power Systems Division	South Milwaukee	Milwaukee	Electrical equipment and supplies	Milwaukee Sewage Treatment Plant	--	1.00	25.00	0.10	4.600	X	6.00	0.0080	0.1440
					Lake Michigan	--	--	--	--	--	--	--	--	--
	Insinkerator Division— Emerson Electric Company	Racine	Racine	Household appliances	Racine Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
					Lake Michigan	--	--	--	--	--	--	--	0.0020	0.0040
					Root River	68.5	--	--	--	--	--	--	0.0030	0.0060
	General Electric Company— Dishwasher and Disposal Products	Milwaukee	Milwaukee	Household appliances	Lincoln Creek	--	2.30	1.80	--	--	X	5.00	0.1970	--
					Milwaukee Sewage Treatment Plant	--	81.00	184.00	--	17.000	X	27.00	--	0.8920
	Oster Corporation	Milwaukee	Milwaukee	Household appliances	Milwaukee Sewage Treatment Plant	--	--	--	--	0.270	X	--	--	0.0490
					Milwaukee River	--	--	--	--	--	--	--	0.0410	--
	Regal Ware, Inc.	Kewaskum	Washington	Household applicances	Milwaukee River	--	1.00	5.00	0.04	0.330	--	0.90	0.1290	--
					Kewaskum Sewage Treatment Plant	--	84.60	146.00	--	25.000	X	18.40	--	0.0790

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd Cooling	Process
	ELECTRICAL AND ELECTRONIC MACHINERY (continued)													
	West Bend Company	West Bend	Washington	Household appliances	Milwaukee River	--	--	--	--	--	--	--	0.2200	0.0010
					West Bend Sewage Treatment Plant	--	32.00	138.00	0.00	3.740	X	7.60	--	1.1160
	Delco Electronics Division— General Motors Corporation	Oak Creek	Milwaukee	Engine electrical equipment	Milwaukee Sewage Treatment Plant	--	80.00	611.00	--	10.500	X	211.00	0.0230	0.6490
	AC Spark Plug Division				Oak Creek	--	--	--	--	--	--	--	--	--
	G.T.E. Automatic Electric, Inc.	Waukesha	Waukesha	--	Fox River	--	--	--	--	--	--	--	--	--
	Sealite Insulation Manufacturing Corporation	Merton	Waukesha	--	Bark River	--	--	--	--	--	--	--	--	--
3700	TRANSPORTATION EQUIPMENT													
	A. O. Smith Corporation	Milwaukee	Milwaukee	Motor vehicles and equipment	Milwaukee Sewage Treatment Plant	--	27.80	108.00	--	0.340	X	28.60	1.8720	1.6280
					Lincoln Creek	--	3.25	7.10	0.48	0.010	X	2.65	3.1900	--
	American Motors Corporation	Milwaukee	Milwaukee	Motor vehicles and	Milwaukee Sewage Treatment Plant	--	32.00	81.00	--	4.700	X	9.30	--	0.2720
				equipment—body plant	Milwaukee River	--	0.00	7.10	0.34	0.000	X	3.80	1.4780	--
	American Motors Corporation	Kenosha	Kenosha	Motor vehicles and	Kenosha Sewage Treatment Plant	--	341.00	237.00	--	4.000	X	758.00	0.4820	1.9360
				equipment—main plant	Pike Creek	63.0	3.00	0.00	0.00	0.100	X	4.00	1.7770	--
	American Motors Corporation	Kenosha	Kenosha	Motor vehicles and equipment	Kenosha Sewage Treatment Plant	--	168.00	2,839.00	--	33.000	X	2,362.00	0.4480	0.3520
	American Motors Corporation	Milwaukee	Milwaukee	Motor vehicles and equipment—parts and distribution	Milwaukee	--	--	--	--	--	--	--	--	--
	AMF, Inc.—Harley-Davidson	Wauwatosa	Milwaukee	Motorcycles, bicycles,	Milwaukee Sewage Treatment Plant	--	200.00	284.00	24.00	2.680	X	33.00	--	0.1000
	Motor Company			and parts	Menomonee River	56.0	4.30	6.70	0.68	0.270	X	11.50	0.0650	0.0130
	AMF, Inc.—Harley-Davidson Motor Company	Milwaukee	Milwaukee	Motorcycles, bicycles, and parts	Milwaukee Sewage Treatment Plant	--	12.50	35.00	15.50	2.000	X	1.80	0.0130	0.0970
	Harley-Davidson Motor Company, Inc.	Oak Creek	Milwaukee	Motorcycles, bicycles,	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
				and parts	Oak Creek	--	--	--	--	--	--	--	--	--
	Fruehauf Corporation	Milwaukee	Milwaukee	Motor vehicles and equipment	Underwood Creek	--	--	--	--	--	--	75.00	0.0010	0.0020
	Heil Company—Solid Waste Systems	Milwaukee	Milwaukee	Motor vehicles and equipmen	Milwaukee Sewage Treatment Plant	--	120.00	276.00	--	5.700	X	34.00	--	0.1010
	and Truck Equipment				Kinnickinnic River	--	0.00	3.00	0.00	0.000	X	0.00	0.1300	--
	Heil Company—	Milwaukee	Milwaukee	Motor vehicles and equipment	Milwaukee Sewage Treatment Plant	--	82.00	84.00	--	9.900	X	0.00	--	0.0210
	Bulk Trailer Division				Kinnickinnic River	--	163.00	167.00	0.00	27.200	X	0.00	0.0170	0.0380
	Peter Pirsch and Sons Company	Kenosha	Kenosha	Motor vehicles and equipment	--	--	--	--	--	--	--	--	--	--
	Pick Automotive Corporation	West Bend	Washington	Motor vehicles and equipment	--	--	--	--	--	--	--	--	--	--
	Dynex—Division of Applied Power, Inc.	Pewaukee	Waukesha	Motor vehicle parts and accessories	--	--	--	--	--	--	--	--	--	--
	International Stamping Company, Inc.	Hartford	Washington	Motor vehicle parts	Rubicon River	53.0	1.10	9.00	--	--	X	2.80	0.1670	--
				and accessories	Hartford Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0050
	J. I. Case Company	Racine	Racine	Motor vehicle parts and accessories	Pike River	--	4.30	--	0.03	0.070	X	--	0.0700	--
	Walker Manufacturing Company	Racine	Racine	Motor vehicle parts and accessories	Racine Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Young Radiator	Racine	Racine	Motor vehicle parts and accessories	Racine Sewage Treatment Plant	--	0.60	10.50	--	26.000	X	16.10	--	0.0200
	Young Radiator	Caledonia	Racine	Motor vehicle parts and accessories	North Park Sewage Treatment Plant	--	--	--	--	--	X	--	0.0020	0.0130

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd Cooling	Process
3800	MEASUREMENTS, ANALYTICAL, AND CONTROL INSTRUMENTS: PHOTO, MEDICAL, AND OPTICAL: WATCHES, ETC.													
	Aqua-Chem, Inc.,—Plant No. 1	Milwaukee	Milwaukee	Measuring and controlling	Lincoln Creek	77.0	--	9.00	1.30	0.740	X	3.00	0.0100	0.0020
				devices	Milwaukee Sewage Treatment Plant	--	600.00	100.00	--	--	X	--	0.0020	0.0070
	Aqua-Chem, Inc.,—Plant No. 2	Milwaukee	Milwaukee	Measuring and controlling	Lincoln Creek	80.0	0.00	99.00	2.10	0.300	X	10.00	0.0200	0.0080
				devices	Milwaukee Sewage Treatment Plant	--	--	405.00	--	31,613.000	X	--	0.0020	0.0070
	Badger Meter, Inc.	Milwaukee	Milwaukee	Measuring and controlling	Milwaukee River	--	--	--	--	--	X	--	0.0070	0.0070
				devices	Milwaukee Sewage Treatment Plant	--	3.90	50.00	--	1.390	X	5.00	--	0.2600
	General Electric Company—	Milwaukee	Milwaukee	Measuring and control	Milwaukee Sewage Treatment Plant	--	31.00	11.00	0.59	0.530	X	27.00	0.0890	0.5960
	Medical System Division			devices	Kinnickinnic River	56.0	2.00	0.00	0.02	0.040	X	2.00	0.5000	0.0440
	General Electric Company—													
	Medical Systems Business	Waukesha	Waukesha	Measuring and control devices	--	--	--	--	--	--	--	--	--	--
	Erie Manufacturing Company, Inc.	Milwaukee	Milwaukee	Environmental controls	Milwaukee Sewage Treatment Plant	--	0.50	4.40	--	--	X	8.00	0.0060	0.0090
	Johnson Controls, Inc.	Milwaukee	Milwaukee	Environmental controls	Milwaukee Sewage Treatment Plant	--	47.50	1.50	--	0.020	X	0.50	0.0010	0.2900
	The Singer Company	Milwaukee	Milwaukee	Environmental controls	Milwaukee Sewage Treatment Plant	--	5.00	13.00	6.10	0.600	X	4.00	0.0520	0.2530
	The Singer Company	Wauwatosa	Milwaukee	Environmental controls	Milwaukee Sewage Treatment Plant	--	0.00	90.00	0.10	0.500	X	5.00	0.1830	0.0570
					Fox River	--	--	--	--	--	--	--	--	--
	Bunker Ramo Corporation	Delavan	Walworth	Measuring and controlling	Delavan Sewage Treatment Plant	--	35.00	28.00	--	0.270	X	3.30	0.0200	0.0950
				devices	Swan Creek	--	1.00	2.00	--	--	X	0.70	0.0040	--
3900	MISCELLANEOUS MANUFACTURING INDUSTRIES													
	E-Z Paintr Corporation	Milwaukee	Milwaukee	Miscellaneous manufactures	Lake Michigan	--	--	--	--	--	--	--	0.0600	--
					Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	0.0010	0.0090
	Frank Holton and Company	Elkhorn	Walworth	Musical instruments	--	--	--	--	--	--	--	--	--	--
	Globe Skate Corporation	Menomonee Falls	Waukesha	Games, toys, and	Menomonee Falls	--	7.60	22.40	--	0.360	X	0.60	--	0.0500
				children's vehicles	Sewage Treatment Plant									
	Everbrite Electric Sign Company	South Milwaukee	Milwaukee	Signs and advertising displays	South Milwaukee	--	38.60	312.00	13.70	1,620.000	X	0.00	--	0.0340
					Sewage Treatment Plant									
					Lake Michigan	--	--	--	--	--	--	--	--	--
7200	LAUNDRIES													
	Adelman Laundry and Cleaners, Inc.	Milwaukee	Milwaukee	Power laundries, family	Milwaukee Sewage Treatment Plant	--	249.00	144.00	--	2.700	X	121.00	--	0.1370
				and commercial										
	Adelman Laundry and Cleaners, Inc.	Milwaukee	Milwaukee	Power laundries, family	Milwaukee Sewage Treatment Plant	--	74.00	55.00	--	27.800	X	46.00	0.0010	0.0950
				and commercial										
	Buckley Laundry Company	Milwaukee	Milwaukee	Power laundries, family	Milwaukee Sewage Treatment Plant	--	14.00	12.00	--	0.380	--	--	--	0.0260
				and commercial										
	Clothes Clinic	West Bend	Washington	Power laundries, family	--	--	--	--	--	--	--	--	--	--
				and commercial										
	Kenosha Laundry Company	Kenosha	Kenosha	Power laundries, family	Kenosha Sewage Treatment Plant	--	178.00	166.00	6.00	2.900	X	43.70	--	0.0280
				and commercial										
	Mickey's Linen and Towel Supply	Milwaukee	Milwaukee	Power laundries, family	Milwaukee Sewage Treatment Plant	--	350.00	157.00	--	1.200	--	174.00	--	0.0390
				and commercial										
	South Side Laundry and Cleaners	Milwaukee	Milwaukee	Power laundries, family	Milwaukee Sewage Treatment Plant	--	260.00	80.00	0.50	6.000	--	70.00	--	0.0400
				and commercial	Storm Sewer	--	--	--	--	--	--	--	--	--
	Spic and Span, Inc.	Milwaukee	Milwaukee	Dry cleaning plants, except rug	Milwaukee Sewage Treatment Plant	--	2,917.00	585.00	--	13.000	--	1,520.00	0.0030	0.1270
	American Industrial Service	West Allis	Milwaukee	Industrial launderers	Milwaukee Sewage Treatment Plant	--	354.00	382.00	18.50	120.000	--	11.00	--	0.0900
	Industrial Towel and Uniform	New Berlin	Waukesha	Industrial launderers	New Berlin Sewer System	--	213.00	2,950.00	--	48.000	--	4,320.00	0.0090	0.1470
					Surface Water	--	--	--	--	--	--	--	--	--
	Peerless Overall Cleaner, Inc.	Milwaukee	Milwaukee	Industrial launderers	Milwaukee Sewage Treatment Plant	--	2.00	1,660.00	1.80	2.700	X	204.00	--	0.0160
	American Linen Supply	Milwaukee	Milwaukee	Linen supply	Milwaukee Sewage Treatment Plant	--	455.00	510.00	23.50	53.600	--	14.00	--	0.1200
	Veterans Linen Supply	Milwaukee	Milwaukee	Linen supply	Milwaukee Sewage Treatment Plant	--	500.00	445.00	0.60	0.020	--	132.00	--	0.0400

SIC Series	Industry	Civil Division	County	Product Information	Discharge To:	Discharge Characteristics: T, F	BOD, mg/l	TSS, mg/l	NH_4, mg/l	P, mg/l	Metals	O & G, mg/l	Flow, mgd: Cooling	Process
7542	CAR WASHES													
	Safe Way Wash-A-Car	West Allis	Milwaukee	Automotive services, except repair	--	--	--	--	--	--	--	--	--	--
	Pure Oil Company— Oklahoma Avenue Car Wash	Milwaukee	Milwaukee	Car washes	--	--	--	--	--	--	--	--	--	--
	Capitol Court Car Wash	Milwaukee	Milwaukee	Car washes	Milwaukee Sewage Treatment Plant	--	100.00	140.00	--	1.100	--	49.00	--	0.0120
	DJ & K Enterprises, Inc.—	Milwaukee	Milwaukee	Car washes	Milwaukee Sewage Treatment Plant	--	12.00	184.00	--	1.100	X	21.00	--	0.0100
	Penny-Wise Car Wash				Storm Sewer	--	--	--	--	--	--	--	--	--
	Imperial Car Wash, Inc.	Milwaukee	Milwaukee	Car washes	Milwaukee Sewage Treatment Plant	--	63.00	386.00	0.08	37.000	--	24.00	--	0.0115
	Jerry's Forrest Park Car Wash	Kenosha	Kenosha	Car washes	Kenosha Sewage Treatment Plant	--	35.00	271.00	--	8.900	--	110.00	--	0.0080
	Magic Car Wash, Inc.	Milwaukee	Milwaukee	Car washes	Milwaukee Sewage Treatment Plant	--	161.00	800.00	0.10	25.000	--	47.00	--	0.0090
	Modern Car Wash, Inc.	Milwaukee	Milwaukee	Car washes	Milwaukee Sewage Treatment Plant	--	53.00	394.00	--	115.000	--	10.00	--	0.0060
	Suburban Car Wash, Inc.	Milwaukee	Milwaukee	Car washes	Milwaukee Sewage Treatment Plant	--	8.00	114.00	0.02	0.800	--	16.00	--	0.0150
	Willows Car Wash, Inc.	Milwaukee	Milwaukee	Car washes	Milwaukee Sewage Treatment Plant	--	110.00	197.00	--	0.400	--	47.00	--	0.0110
	Your Car Wash, Inc.	Kenosha	Kenosha	Car washes	Kenosha Sewage Treatment Plant	--	--	--	--	23.300	X	37.00	--	0.0120
4940	WATER TREATMENT PLANTS													
	South Milwaukee Water Utility	South Milwaukee	Milwaukee		--	--	--	--	--	--	--	--	--	--
	Kenosha Water Facility	Kenosha	Kenosha		--	--	--	--	--	--	--	--	--	--
	Bristol Water Utility	Bristol	Kenosha		--	--	--	--	--	--	--	--	--	--
	Cudahy Water Treatment Plant	Cudahy	Milwaukee		--	--	--	--	--	--	--	--	--	--
	Genoa City Water Treatment Plant	Genoa City	Walworth		--	--	--	--	--	--	--	--	--	--
	Menomonee Falls Water Utility	Menomonee Falls	Waukesha		--	--	--	--	--	--	--	--	--	--
	Milwaukee Waterworks— Howard Avenue	Milwaukee	Milwaukee		Lake Michigan	--	--	--	--	--	--	--	--	--
	Milwaukee Waterworks— Linwood Avenue	Milwaukee	Milwaukee		Lake Michigan	--	--	--	--	--	--	--	--	--
	North Shore Water Commission	Glendale	Milwaukee		--	--	--	--	--	--	--	--	--	--
	Oak Creek Water Treatment Plant	Oak Creek	Milwaukee		--	--	--	--	--	--	--	--	--	--
	Racine Water Department	Racine	Racine		--	--	--	--	--	--	--	--	--	--
	Williams Bay Water Utility	Williams Bay	Walworth		--	--	--	--	--	--	--	--	--	--
	MISCELLANEOUS													
	Chicago and North Western	Butler	Milwaukee	Railroads	Menomonee River	--	1.40	3.60	0.00	0.010	--	7.00	--	0.0030
	Transportation Company				Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Chicago, Milwaukee, St. Paul, and	Milwaukee	Milwaukee	Railroads	Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	--
	Pacific Railroad				Menomonee River	--	16.30	21.00	0.40	1.630	--	40.00	--	0.4300
	Getzen Company, Inc.	Elkhorn	Walworth	--	--	--	--	--	--	--	--	--	--	--
	Western Electric Company—	Milwaukee	Milwaukee	Miscellaneous business services	Milwaukee River	65.00	4.00	2.80	--	--	X	--	0.0010	--
	SVC Center				Milwaukee Sewage Treatment Plant	--	--	--	--	--	--	--	--	0.0140
	Wisconsin Electric Power Company	Milwaukee	Milwaukee	Electric services	Milwaukee River	--	--	--	--	--	--	--	--	--
	Wisconsin Electric Power Company	Oak Creek	Milwaukee	Electric services	Lake Michigan	--	--	--	--	--	--	--	--	--
	Wisconsin Electric Power Company	Milwaukee	Milwaukee	Electric services	Menomonee River Canal	--	--	--	--	--	--	--	--	--
					Menomonee River	--	--	--	--	--	--	--	--	--
	Wisconsin Electric Power Company	Milwaukee	Milwaukee	Electric services	Lake Michigan	--	--	--	--	--	--	--	--	--
	Wisconsin Electric Power Company— Heating Plant	Milwaukee	Milwaukee	Steam supply	Milwaukee and Menomonee Rivers	--	--	--	--	--	--	--	--	--
	Wisconsin Electric Power Company— Lakeside, Port Washington	Port Washington	Ozaukee	Electric services	Lake Michigan	--	--	--	--	--	--	--	--	--
	West Shore Pipe Line Company	Milwaukee	Milwaukee	–	--	--	--	--	--	--	--	--	--	--
	West Shore Pipe Line Company	Milwaukee (Jones Island)	Milwaukee	–	--	--	--	--	--	--	--	--	--	--
	American Telephone and Telegraph Company	Waukesha	Waukesha	Telephone communications	--	--	--	--	--	--	--	--	--	--
	Waukesha Telephone Office	Waukesha	Waukesha	Communication services	Fox River	59.0	0.60	4.00	0.00	0.200	X	8.40	0.0080	--
	Wiscold, Inc.—Mohawk Division	Milwaukee	Milwaukee	--	--	--	--	--	--	--	--	--	--	--
	Wiscold, Inc.—Mohawk Division	Milwaukee	Milwaukee	--	--	--	--	--	--	--	--	--	--	--
	Gimbels Midwest, Inc.	Milwaukee	Milwaukee	--	Milwaukee River	78.0	--	--	--	--	--	--	1.8700	0.0020
	First Wisconsin National Bank	Milwaukee	Milwaukee	--	Milwaukee River	87.0	0.00	5.00	--	0.000	X	0.00	0.6600	--
	Wesbar Corporation	West Bend	Washington	--	--	--	--	--	--	--	--	--	--	--
	Vitamin Products Company	Brookfield	Waukesha	--	Soil Absorption	--	--	--	--	--	--	--	--	--
	Boldt Incorporated	Muskego	Waukesha	–	Tess Corners Creek	--	--	--	--	--	--	--	--	--

Source: Compiled from 1974 industrial discharge reports filed under Section 101 of the Wisconsin Administrative Code, Rules of the Department of Natural Resources Environmental Protection, and the first reference in reference list.

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Appendix C

PROCESSES FOR BPCTA AND BATEA

Industry	BPCTCA	BATEA
Asbestos (39 FR 31592, August 29, 1974)	Sedimentation and pH control—coagulation may be necessary before sedimentation	No discharge of wastewater pollutants by expanding capacity of water recycle systems to accommodate upsets and surges
Builders Paper and Board (39 FR 1818, January 14, 1974)	Two-stage biological treatment—most common activated sludge followed by aerated stabilization basin	Two-stage biological treatment and mixed media filtration with, if necessary, chemical addition and coagulation
Builders Paper and Roofing Felt (39 FR 16578, May 9, 1974)	Two-stage biological treatment—most common activated sludge followed by aerated stabilization basin	Two-stage biological treatment and mixed media filtration with, if necessary, chemical addition and coagulation
Canned and Preserved Fruits and Vegetables (39 FR 10862, March 21, 1974)	Preliminary screening and biological treatment using multiple aerated lagoons, activated sludge, anaerobic plus aerobic lagoons, trickling filters plus aerated lagoons or activated sludge plus aerated lagoons and disinfection	Same as BPT with additional biological treatment components and in a few cases advanced treatment such as multimedia or sand filtration
Canned and Preserved Seafood (39 FR 23134, June 26, 1974)	BPT and BAT broken into 15 separate categories employing biological treatment, including activated sludge, extended aeration, rotating biological contactors, high rate trickling filters, stabilization ponds and aerated lagoons. Alternatives include screening, sedimentation, air flotation, and concentration.	BPT and BAT broken into 15 separate categories employing biological treatment, including activated sludge, extended aeration, rotating biological contactors, high rate trickling filters, stabilization ponds and aerated lagoons. Alternatives include screening, sedimentation, air flotation, and concentration.
Cement (39 FR 6590, February 20, 1974)	Nonleaching—No discharge of wastes into navigable water Leaching—Neutralization to reduce alkalinity and chemical treatment and sedimentation to reduce suspended solids.	
Inorganic Chemicals (39 FR 9612, March 12, 1974)	BPT and BAT are specific for each of 22 chemical manufacturing processes	BPT and BAT are specific for each of 22 chemical manufacturing processes
Organic Chemicals (39 FR 14676, April 25, 1974)	Activated sludge, activated sludge preceded by trickling filters, aerated lagoons, anaerobic and aerobic lagoons, and activated sludge followed by aerated lagoons	Addition of activated carbon to the biological waste treatment model
Dairy Products (39 FR 18594, May 28, 1974)	Represented by but not limited to: activated sludge, activated sludge plus sand filtration, other biological treatment plus sand filtration, and various irrigational systems	
Electroplating (40 FR 10130, April 24, 1975)	Chemical precipitation	No discharge
Feedlots (39 FR 5704, (February 14, 1974)	No discharge of wastewater pollutants to navigable waters	Refinement of control systems to contain the runoff from the 25-year, 24-hour storm or equivalent

Industry	BPCTCA	BATEA
Ferroalloy (40 FR 8030, February 24, 1975)		
Open Electric Furnaces	Clarifier flocculator, with chemical treatment where needed, sludge dewatering and water recirculation where needed	BPT technology plus sand or multimedia filters and optimum process water circulation
Covered Electric Furnaces	Clarifier flocculator, sludge dewatering, and biological or chemical treatment. The latter by alkaline (breakpoint) chlorination and other chemical treatment as needed	BPT technology plus sand or multimedia filters and optimum process water recirculation
Slag Processing	Sedimentation in clarified flocculators	Total recirculation of process wastewater after sedimentation in clarifier flocculators
Noncontact Cooling Water	Cooling towers, spray ponds, or cooling ponds. Currently used recirculation may require chemical treatment to reach specified levels for chromium and phosphate	Partial recirculation through cooling towers and chemical treatment of blowdown
Fertilizer (39 FR 36094, October 7, 1974)		
Phosphate	No discharge and pond water discharge. Gypsum contaminated water treated by double-liming or two-stage lime neutralization	No listing
Ammonia	Ammonia stripping by air and/or steam. Alternate treatments include biological nitrification and denitrification or selective ion exchange for ammonia subsequent to ammonia stripping	Advanced ammonia stripping units
Urea	Hydrolysis of urea to NH_3 and CO_2	Urea hydrolysis units
Ammonium Nitrate	Ion exchange removal of ammonium and nitrate ions	
Nitric Acid	Containment and detection of leaks and prevention of spills	No listing
Ammonium Sulfate	Contaminated water recirculation system resulting in no discharge	Contaminated water recirculation system resulting in no discharge
Glass (39 FR 5112, February 14, 1974)		
Sheet and Rolled	No treatment	No treatment
Plate	Partitioning existing one-celled lagoons into two cells with polyelectrolyte addition at the entrance of each cell	Recycling 80 percent of lagoon effluent to grinding operation, sand filtration of remaining 20 percent, and return of the filter backwash to the head of the lagoon system
Float	Elimination of detergents in the float washer	No discharge of process wastewaters or use of diatomaceous earth filter
Automotive Tempering	Coagulation and sedimentation	Diatomaceous earth filtration
Automotive Lamination	Modification of the post lamination washer sequence to provide a continuously recycling initial hot water rinse, oil removal by centrifugation of the hot rinse water, recycle of oil back to the process, and treatment of the post lamination rinse waters by gravity oil separation	BPT plus diatomaceous earth filtration

Industry	BPCTCA	BATEA
Pressed and Blown Glass Container	Normal maintenance and cleanup operations	The cullet quench stream be segregated from the noncontact cooling water stream, that the cullet quench stream be recirculated through a gravity separator with treatment of the blowdown by dissolved air flotation, and effluent from the dissolved air flotation system be filtered through diatomaceous earth
Machine Pressed and Blown	Segregation of process	The cullet quench stream be segregated from the noncontact cooling water stream, that the cullet quench stream be recirculated through a gravity separator with treatment of the blowdown by dissolved air flotation, and effluent from the dissolved air flotation system be filtered through diatomaceous earth
Tubing	Housekeeping techniques	The cullet quench stream be segregated from the noncontact cooling water stream, that the cullet quench stream be recirculated through a gravity separator with treatment of the blowdown by dissolved air flotation, and effluent from the dissolved air flotation system be filtered through diatomaceous earth
Television Picture Tube	Lime precipitation with pH adjustment upgrading and improved housekeeping	Sand filtration of treated lime and passage through a bed of activated alumina
Incandescent Lamp Envelope	Oil separation and sedimentation applied to cullet quench water stream, lime treatment, suspended solid removal from frosting wastewater. Steam stripping and a recarbonation system for pH adjustment	Sand filtration of treated lime and passage through a bed of activated alumina. Diatomaceous earth filtration of the cullet quench stream
Hand Pressed and Blown	Sedimentation, clarification, land disposal, improved housekeeping, and batch lime	Sand filtration and activated alumina
Insulation Fiberglass	No discharge of process wastewater by total recirculation	No discharge of process wastewater by total recirculation
Grain (39 FR 10512, March 20, 1974)		
Corn Wet Milling	Recirculation over cooling towers and blowdown sent to treatment system, or surface condensors with condensate treated. Process wastewater treatment; equalization, neutralization, biological treatment, and solids separation	Increased water reuse, improved solids recovery, deep bed filtration of treated wastewater
Corn Dry Milling	Biological treatment followed by solids separation	BAT includes solids separation
Normal Wheat Flour	No discharge of wastewater	No discharge of wastewater
Bulgur Wheat	Biological treatment comparable to activated sludge followed by solids separation	Biological treatment comparable to activated sludge followed by solids separation. Solids filtration
Normal Rice	No discharge	No discharge
Parboiled Rice	Biological treatment comparable to activated sludge followed by solids separation	Biological treatment comparable to activated sludge followed by solids separation. Solids filtration

Industry	BPCTCA	BATEA
Animal Feed	No discharge	No discharge
Hot Cereal	No discharge	No discharge
Ready-to-Eat Cereal	Equalization and activated sludge Sedimentation and sludge handling facilities included	Equalization and activated sludge Sedimentation and sludge handling facilities included. Deep bed filtration
Wheat Starch and Gluten	Minimization of inplant water use, treatment including pH, neutralization, equalization and activated sludge Sedimentation, sludge handling, and effluent chlorination	Equalization and activated sludge Sedimentation and sludge handling facilities included. Deep bed filtration
Iron and Steel (39 FR 24114, June 28, 1974)	BPT and BAT are specific for each of 26 iron and steel manufacturing processes	BPT and BAT are specific for each of 26 iron and steel manufacturing processes
Leather Tanning and Finishing (39 FR 12958, April 9, 1974)	Current use is lagoons with biological systems employing various combinations of anaerobic lagoons, aerobic lagoons, aerated lagoons, anaerobic-aerobic lagoons, and polishing lagoons	Current use is lagoons with biological systems employing various combinations of anaerobic lagoons, aerobic lagoons, aerated lagoons, anaerobic-aerobic lagoons, and polishing lagoons. Biological systems adaptable to the treatment model.
Meat Products (39 FR 7894, February 28, 1974)	Product recovery systems such as blood and grease recovery. Treatments range from simple anaerobic-aerobic lagoons to refined activated sludge systems followed by clarification and chlorination	Product recovery systems such as blood and grease recovery. Treatments range from simple anaerobic-aerobic lagoons to refined activated sludge systems followed by clarification and chlorination. Limiting nutrients including ammonia, nitrates, and phosphorus
Nonferrous Metals (39 FR 12822, April 8, 1974)		
Bauxite Refining	Total impoundment of wastewater	Total impoundment
Primary Aluminum Smelting	Cryolite precipitation or precipitation with lime or dry fume scrubbing or total impoundment	Dry fume scrubbing and total impoundment. Dry fume scrubbing techniques on the pot room air and the treatment of wastewater from anode plant wet scrubbers and the cast house
Secondary Aluminum Smelting		
Metal Cooling	Air cooling, or total consumption of cooling water, or recycle of cooling water for deoxidizer—shot cooling or ingot cooling	Air cooling, or total consumption of cooling water, or recycle of cooling water for deoxidizer—shot cooling or ingot cooling
Fume Scrubbing	When chlorination is used for magnesium removal, adjustment of the scrubber effluent pH to 6.5-8.5 followed by settling for solids removal, or prior adjustment of pH of the scrubber liquor to 6.5-8.5 followed by settling for solids removal. When aluminum fluoride is used for magnesium removal, scrubber effluent pH to 6.5-8.5 followed by settling for solids removal. After neutralization and settling, supernatant is recycled continuously and solid fluorides are removed continuously	No discharge by fumeless chlorine magnesium removal. Aluminum fluoride for magnesium removal and continuous recycling of scrubber water. Aluminum fluoride for magnesium removal and a coated baghouse for air pollution control

Industry	BPCTCA	BATEA
Wet Residue Processing	Settling treatment of 3-4 stages with partial recycle of sludge and clear supernatant. Polyelectrolyte may be required to reduce suspended solids	Countercurrent wet milling techniques with evaporation to reclaim salts from the process and eliminate discharge of process wastewater pollutants
Offshore Oil and Gas Extraction (40 FR 42572, September 15, 1975)	Not applicable	Not applicable
Ore Mining and Dressing (40 FR 51722, November 6, 1975)	BPT and BAT are special for each of seven categories divided into 22 subdivisions	BPT and BAP are special for each of seven categories divided into 22 subdivisions
Petroleum (40 FR 21939, May 20, 1975)	Equalization and storm diversion: initial oil and solids removal using API separators or baffle plate separators; further oil and solids removal using clarifiers, dissolved air flotation, or filters; carbonaceous waste removal using activated sludge, aerated lagoons, oxidation ponds, trickling filter, activated carbon, or combinations of these; and filters (sand, dual media; or multimedia) following biological treatment	BPT effluent is fed to an activated carbon unit
Phosphate (39 FR 6580, February 22, 1974)		
Phosphorus Production	Process wastewater can be completely recycled and reused by lime neutralization and sedimentation	Process wastewater can be completely recycled and reused by lime neutralization and sedimentation
Phosphorus Consuming	Segregation of cooling water from process water and treatment and recycle, and reuse of process wastewater	Segregation of cooling water from process water and treatment and recycle, and reuse of process wastewater with evaporation of blowdown for the chlorinated products
Phosphate	Total recycle, with lime precipitate and dry dust collection	Total recycle, with lime precipitate and dry dust collection
Plastics and Synthetics (39 FR 12502, April 5, 1974)	Biological treatment for BOD reduction as typified by activated sludge, aerated lagoons, trickling filters, and aerobic-anaerobic lagoons with appropriate preliminary treatment typified by equalization to dampen shock loadings, settling, clarification, and chemical treatment for removal of suspended solids, oils, other elements, and pH control	Minimization of the volume of waste generating water as typified by segregation of contact process waters from noncontact wastewater, maximum wastewater recycle and reuse, elimination of once through barometric condensers, and control of leaks
Pulp, Paper and Board (39 FR 18744, May 29, 1974)	Two-stage biological treatment including aerated stabilization basins and storage oxidation lagoons; or two biological treatment units operated in series such as an activated sludge plant followed by an aerated stabilization basin	Two-stage biological treatment and mixed media filtration with, if necessary, chemical addition and coagulation
Rubber (39 FR 6660, February 21, 1974)		
Older Tire and Inner Tube, Newer Tire and Inner Tube	Isolate soapstone and latex dip solution drippings, machinery oil drippings, and oil contaminated water from molding and curing areas, isolation of process wastewater from nonprocesss wastewater	Isolate soapstone and latex dip solution drippings, machinery oil drippings, and oil contaminated water from molding and curing areas, isolation of process wastewater from nonprocess wastewater

Industry	BPCTCA	BATEA
Emulsion Crumb Rubber	Coagulation liquor and crumb rinse overflow stream passed through crumb pits. Pits should be dual units. Stream then sent back to treatment system including chemical coagulation and clarification, and biological treatment. Total plant effluent passed through an equalization basin providing approximately 24-hour detention. Equalization basin should be aerated	Activated carbon treatment of secondary treatment effluent. Dual media filter should precede activated carbon system
Solution Crumb	Coagulation liquor and crumb rinse overflow stream passed through crumb pits. Pits should be dual units. Stream then sent back to treatment system including chemical coagulation and clarification, and biological treatment. Total plant effluent passed through an equalization basin providing approximately 24-hour detention. Equalization basin should be aerated.	Activated carbon treatment of secondary treatment effluent. Dual media filter should precede activated carbon system
Latex Rubber	Coagulation liquor and crumb rinse overflow stream passed through crumb pits. Pits should be dual units. Stream then sent back to treatment system including chemical coagulation and clarification, and biological treatment. Total plant effluent passed through an equalization basin providing approximately 24-hour detention. Equalization basin should be aerated	Activated carbon treament of secondary treatment effluent. Dual media filter should precede activated carbon system
Molded, Small Size, Extruded, and Fabricated	Inplant controls to eliminate anti-tack or latex solution discharge. Treatment to remove oil and grease, suspended solids and lead, by isolation of process wastewaters	Inplant controls to eliminate anti-tack or latex solution discharge. Treatment to remove oil and grease, suspended solids and lead, by isolation of process wastewaters. Plus sand filtration
Medium Size Molded, Extruded, and Fabricated	Inplant controls to eliminate anti-tack or latex solution discharge. Treatment to remove oil and grease, suspended solids and lead, by isolation of process wastewaters	Inplant controls to eliminate anti-tack or latex solution discharge. Treatment to remove oil and grease, suspended solids and lead, by isolation of process wastewaters. Plus sand filtration
Large Size Molded, Extruded, and Fabricated	Inplant controls to eliminate anti-tack or latex solution discharge. Treatment to remove oil and grease, suspended solids and lead, by isolation of process wastewaters	Inplant controls to eliminate anti-tack or latex solution discharge. Treatment to remove oil and grease, suspended solids and lead, by isolation of process wastewaters. Plus sand filtration
Wet Digestion Reclaimed Rubber	Inplant controls to isolate and contain processing solutions and recycle and reuse of oil contaminated dewatering liquors and discharges from wet-air pollution equipment	Inplant controls to isolate and contain processing solutions and recycle and reuse of oil contaminated dewatering liquors and discharges from wet-air pollution equipment
Pan Dry Digestion and Mechanical Reclaimed	Inplant controls to isolate process waste streams, contain processing solution wastes, and treatment for suspended solids	Inplant controls to isolate process waste streams, contain processing solution wastes, and treatment for suspended solids
Latex-dipped, Thread, and Molded	Coagulation and clarification of latex laden wastes, and biological treatment. Segregate process wastewater streams	Coagulation and clarification of latex laden wastes, and biological treatment. Segregate process wastewater streams

Industry	BPCTCA	BATEA
Latex Foam	Coagulation and clarification of latex laden wastes, and biological treatment. Segregate process wastewater streams. Plus chemical addition to precipitate zinc	Coagulation and clarification of latex laden wastes, and biological treatment. Segregate process wastewater streams. Plus chemical addition to precipitate zinc
Soap and Detergent (39 FR 13370, April 12, 1974)	Any treatment available, the equivalent of a biological treatment attaining reductions of 90 percent for BOD_5, total suspended solids, oil and grease, and surfactants and a reduction of 85 percent for COD	Various lagoons and sand, mixed media or carbon filters, two-stage activated sludge, and chemical-physical techniques
Steam Electric Power Generating (39 FR 36186, October 8, 1974)	Evaporative external cooling to achieve essentially no discharge of heat, except for cold-side blowdown, in a closed recirculating cooling system Other Pollutants Cooling systems: chlorination for biological control. Oil and grease removal by chemical addition and sedimentation Low volume wastes: segregation from high volume wastes, equalization, oil separation, chemical addition, solids separation, and pH adjustment. Rainfall runoff; diking, oil water separation, solids separation, and neutralization	Reuse and recycle of all wastewater to maximum practical extent, with distillation to concentrate all low volume water wastes and to recycle water to the process, and with evaporation to dryness of the concentrated waste followed by suitable land disposal
Sugar (39 FR 10522, March 20, 1974)		
Liquid and Crystalline Cane	Containment of filter mud slurry or dry handling of filter cake with land disposal. Prevention of raw sugar spillage. Entrainment prevention in evaporators and pans through baffling, centrifugal separators, demisters, and utilization of the proper height of the vapor belt. Maximum reuse of all waste streams. Biological treatment of process waters by activated sludge or equivalent	Containment of filter mud slurry or dry handling of filter cake with land disposal. Prevention of raw sugar spillage. Entrainment prevention in evaporators and pans through baffling, centrifugal separators, demisters, and utilization of the proper height of the vapor belt. Maximum reuse of all waste streams. Biological treatment of process waters by activated sludge or equivalent. Plus recycle of barametric condenser cooling water, recycle of blowdown stream to biological treatment, addition of sand filtration of the effluent from the activated sludge or equivalent biological system
Beet Sugar (39 FR 4035, January 31, 1974)	No discharge by: recycle of flume waters with land retention of excess wastewaters including screening, suspended solids removal and pH control; recycling of condensor water; containment of lime mud slurry or reuse; reduction of moisture in lime cake conveyance or transport; return of pulp press water to the diffuser; use of continuous diffusers; use of pulp dryers; concentration of Steffen waste for disposal on beet pulp; dry conveyance of beet pulp from diffusers to pulp dryers	No discharge

Industry	BPCTCA	BATEA
Textiles (39 FR 24736, July 5, 1974)	Preliminary screening, biological treatment, and chlorination, also primary sedimentation of process wastewater for grease removal at wool scouring plants and acid coagulation for latex removal at carpet mills	Preliminary screening, biological treatment, and chlorination, also primary sedimentation of process wastewater for grease removal at wool scouring plants and acid coagulation for latex removal at carpet mills. Plus multimedia filtration or activated carbon absorption. Some plants will require activated carbon absorption and multimedia filtration
Timber Products (40 FR 23825, June 2, 1975)		
Barking	No discharge—use of primary screening and settling followed by biological treatment	No discharge—use of primary screening and settling followed by biological treatment. More stringent
Veneer	No discharge—hot water spray tunnels, indirect or modified steaming with water collected and reused after settling and screening	No discharge—hot water spray tunnels, indirect or modified steaming with water collected and reused after settling and screening
Plywood	Complete retention of glue wastes through recycle and reuse in glue preparation	Complete retention of glue wastes through recycle and reuse in glue preparation
Hardboard—Dry	Recycle of log wash and chip wash water and disposal of solids by landfill. Closed resin system, neutralization of caul water. Elimination of discharge from humidification	Recycle of log wash and chip wash water and disposal of solids by landfill. Closed resin system, neutralization of caul water. Elimination of discharge from humidification
Hardboard—Wet	Recycle of process water and heat exchangers, gravity settling, screening, filtration, or flotation. Primary settling combined with screening followed by aerated lagoons, and/or activated sludge, with pH adjustment and biological treatment	No discharge—use of primary screening and settling followed by biological treatment. More stringent
Wood Preserving	Recovery and reuse of contaminated water and good housekeeping techniques to reduce spills resulting in no discharge	Recovery and reuse of contaminated water and good housekeeping techniques to reduce spills resulting in no discharge
Wood Preserving, Steam	Recycle of all contact cooling water and reuse of a portion of process water for cooling, insulation of retorts and steam pipes; closed steaming or modified closed steaming; modification of oil-recovery systems or replacement	Recycle of all contact cooling water and reuse of a portion of process water for cooling, insulation of retorts and stream pipes; closed steaming or modified closed steaming; modification of oil-recovery systems or replacement. Biological treatment (trickling filter, activated sludge), soil irrigation, oxidation ponds, chemical oxidation, containment and spray evaporation, pan evaporation, evaporation in cooling towers, or incineration of oily wastes
Wood Preserving, Boultonizing	Implant water conservation, segregation of contaminated water streams, oil recovery equipment, containment and spray evaporation, pan evaporation, or cooling tower evaporation	Implant water conservation, segregation of contaminated water streams, oil recovery equipment, containment and spray evaporation, pan evaporation, or cooling tower evaporation
Other Timber	Eight categories—control as above	

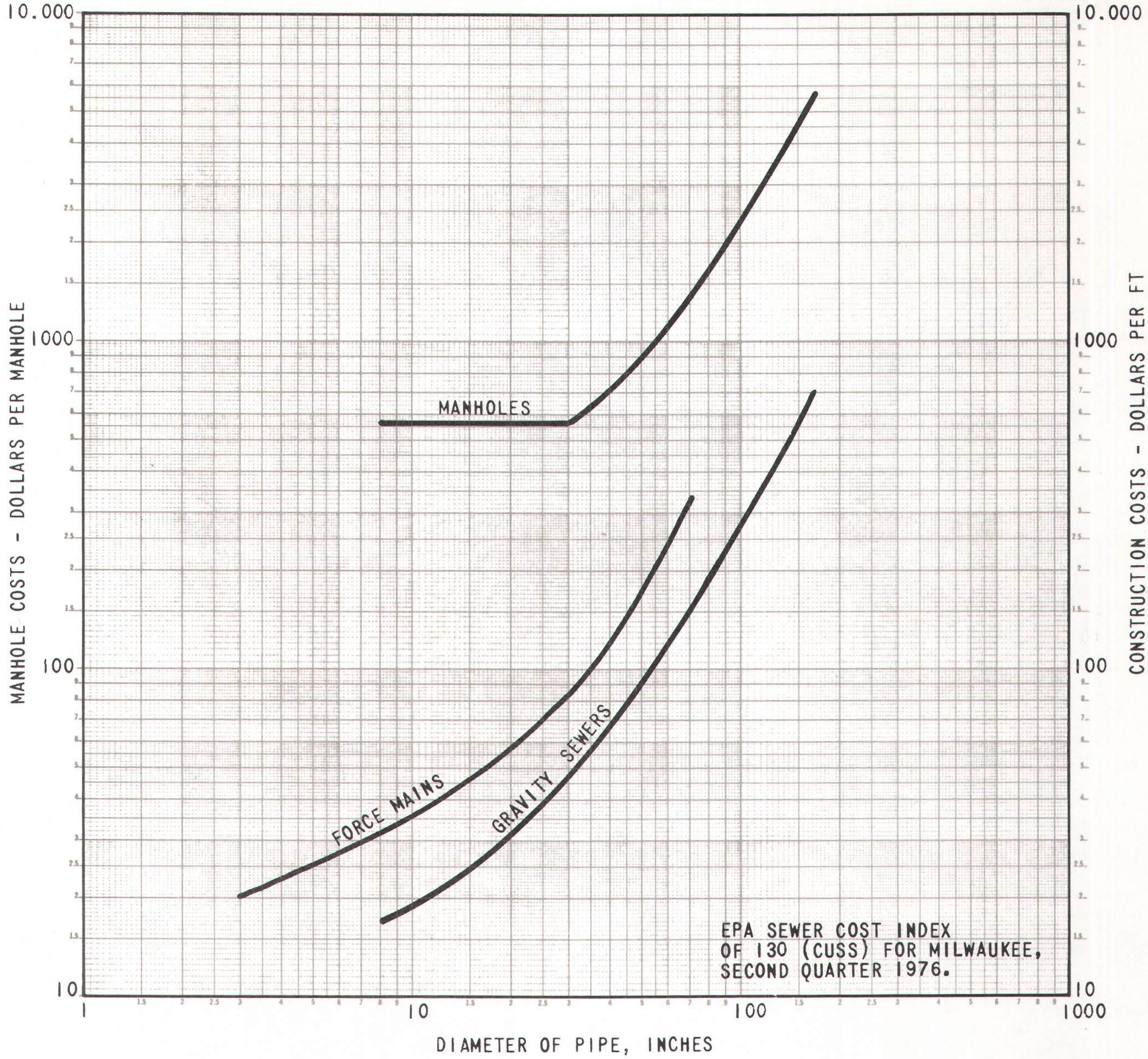
Source: U. S. Environmental Protection Agency.

Appendix D

COST CURVES

Figure D-1

COLLECTOR AND INTERCEPTOR SEWERS



COSTS BASED ON: INVERT DEPTH 10' IF DIAM. < 60" FOR GRAVITY SEWERS
INVERT DEPTH INCREASED TO 20' AT DIAM. =168"
FORCE MAINS HAVE INVERT DEPTH OF 6' IF DIAM. < 36".

COSTS INCLUDE: MATERIAL, LAYBACK TRENCHING, LABOR

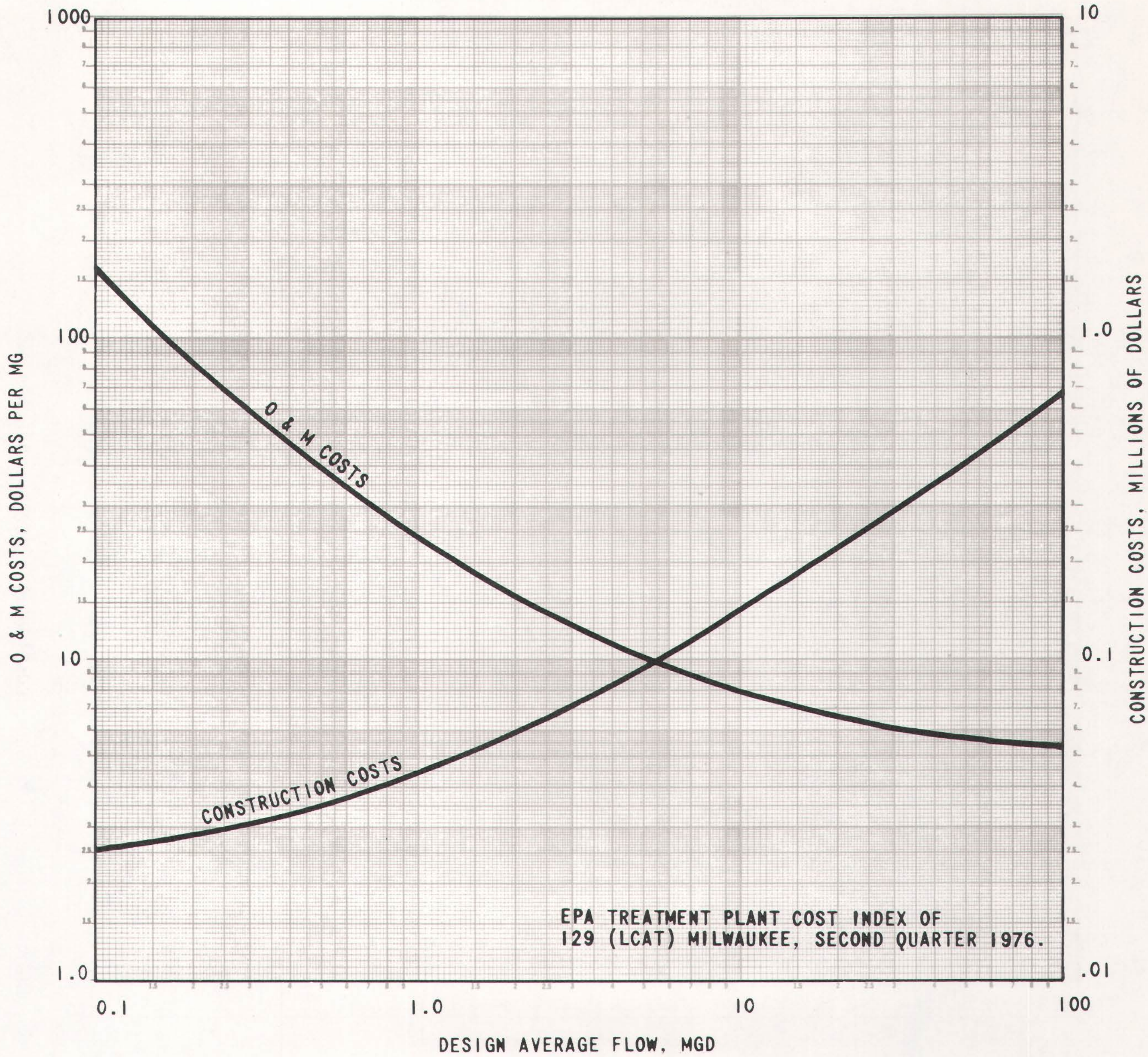
NOTE: SEWER CONSTRUCTION COST DEPENDENT ON LOCAL CONDITIONS
LOCAL ADJUSTMENTS ARE SUGGESTED AS:

CONSTRUCTION IN 100% RESIDENTIAL AREA	6% INCREASE
WELL POINTING ALONG ROUTE	7% INCREASE
SLIP FORMING	25% INCREASE
ROCK EXCAVATION	100%-200% INCREASE
ADDITIONAL FOOT OF DEPTH	3% INCREASE
SHEETING	60% INCREASE

Source: Stanley Consultants.

Figure D-2

PRELIMINARY TREATMENT



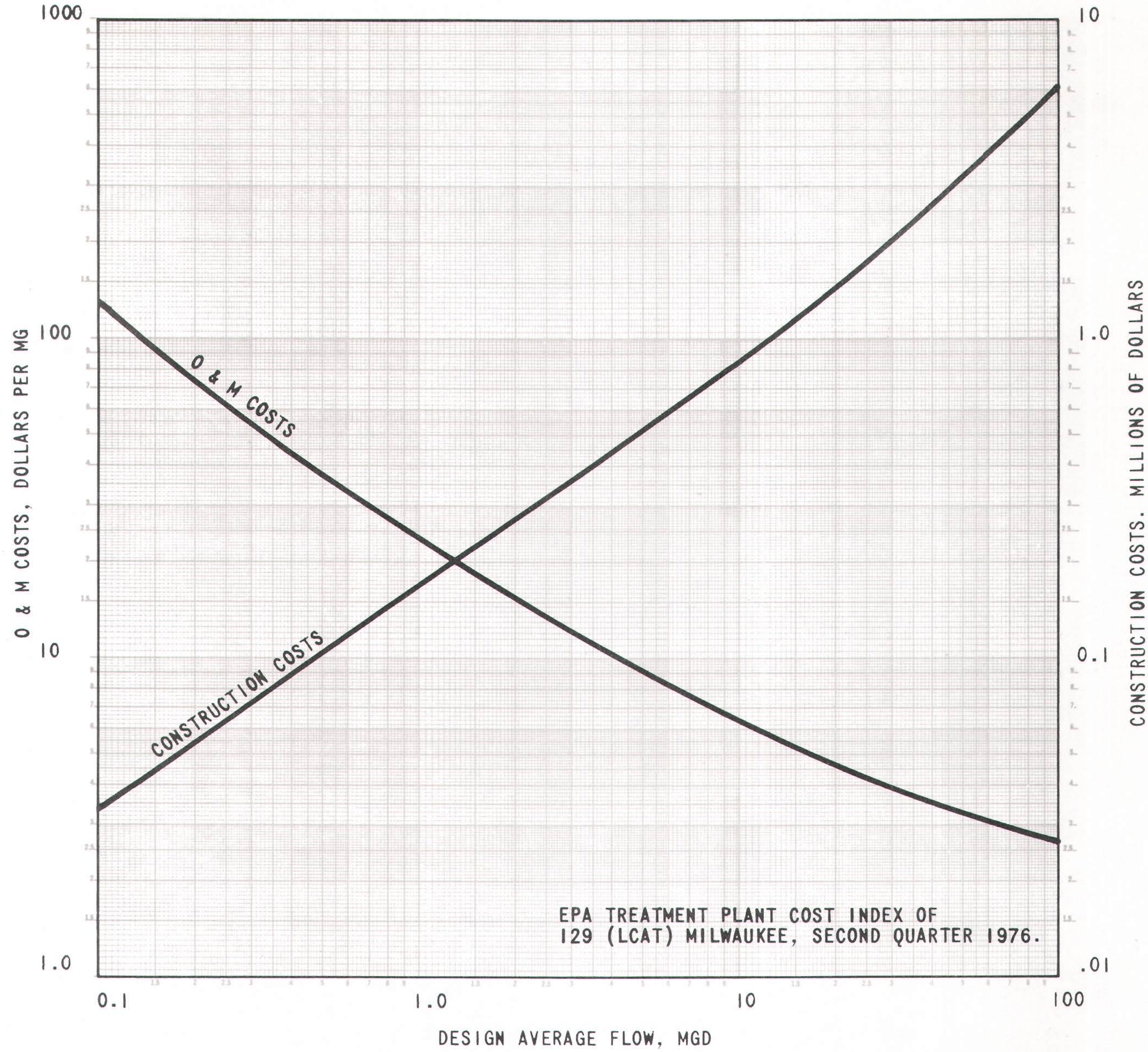
COST BASED ON: DESIGN CAPACITY EQUAL TO MAXIMUM FLOW RATE

COSTS INCLUDE: SCREENING, GRIT REMOVAL AND METERING

Source: Stanley Consultants.

Figure D-3

RAW WASTE PUMPING



COSTS INCLUDE: VALVES, CONTROLS, WET WELL, DRY WELL AND ENCLOSING STRUCTURE

COSTS BASED ON TOTAL PUMPING CAPACITY GREATER THAN DESIGN AVERAGE FLOW AS FOLLOWS: FOR AVERAGE FLOW (Q_A) LESS THAN MGD, TOTAL CAPACITY = 3.33 X Q_A;

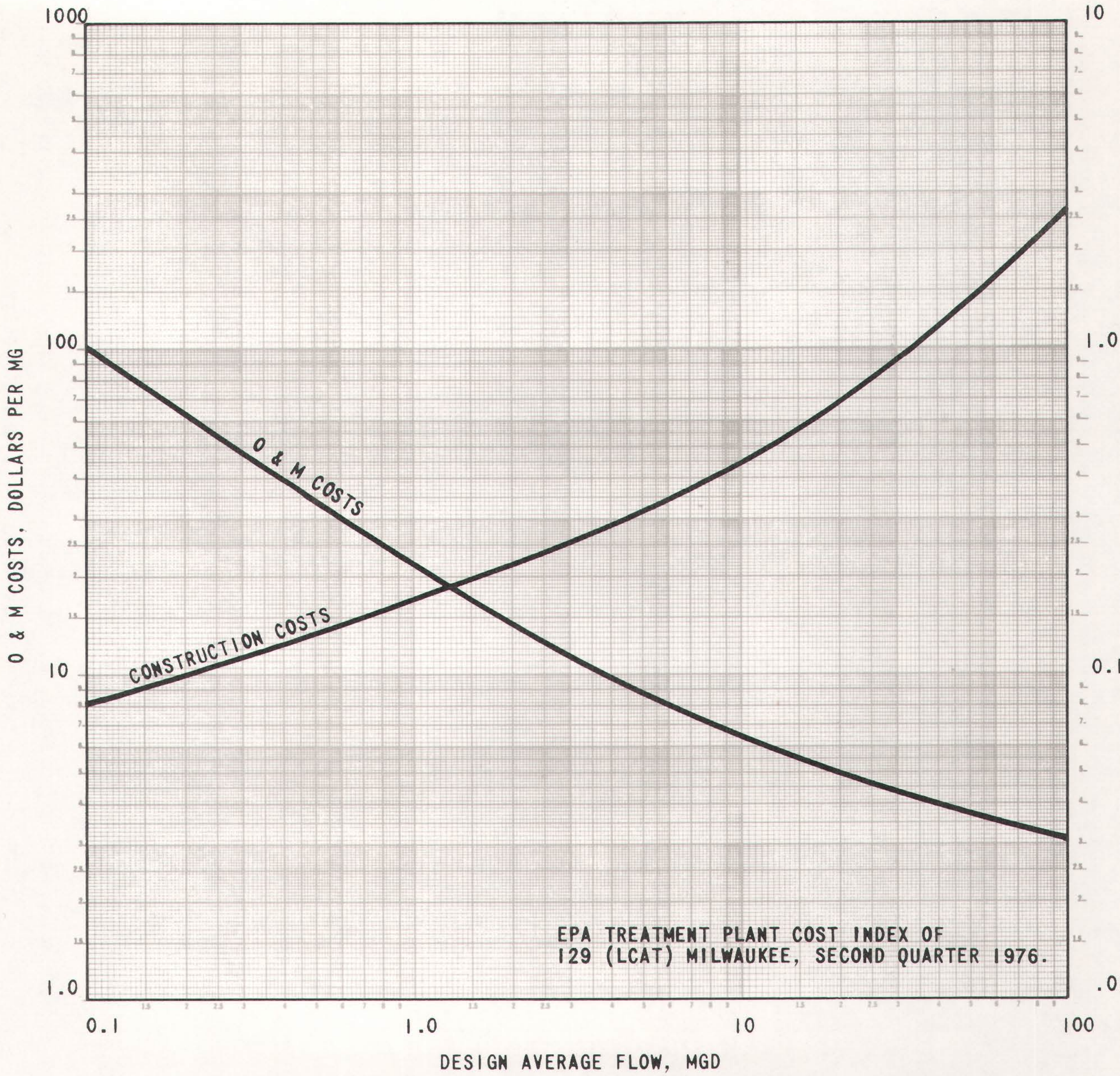
FOR AVERAGE FLOW (Q_A) BETWEEN 1 AND 10 MGD, TOTAL CAPACITY = 3.00 X Q_A;

AND FOR AVERAGE FLOW (Q_A) GREATER THAN 10 MGD, TOTAL CAPACITY = 2.25 X Q_A.

Source: Stanley Consultants.

Figure D-4

PRIMARY CLARIFIERS



COSTS BASED ON: $Q_A < 1$ SURFACE OVERFLOW RATE 500 GPD/FT^2

$1 < Q_A < 10$ SURFACE OVERFLOW RATE 800 GPD/FT^2

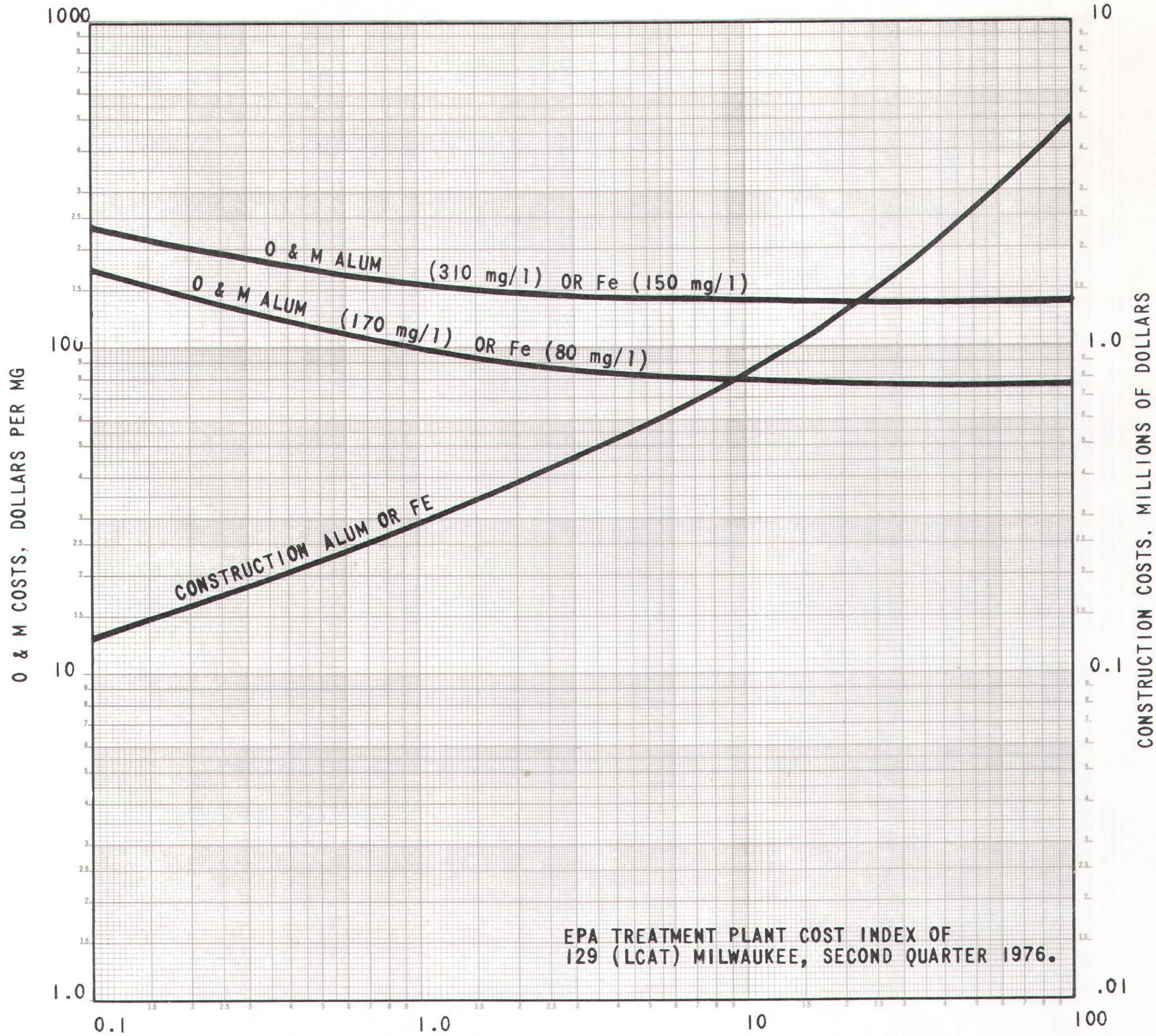
$Q_A > 10$ SURFACE OVERFLOW RATE 1000 GPD/FT^2

COSTS INCLUDE: CLARIFIER, SLUDGE PUMPS

Source: Stanley Consultants.

Figure D-5

PRIMARY CLARIFIERS WITH CHEMICAL ADDITION



COSTS BASED ON: SURFACE OVERFLOW RATE OF 600 GPD/FT^2 FOR ALUM OR FE SALTS

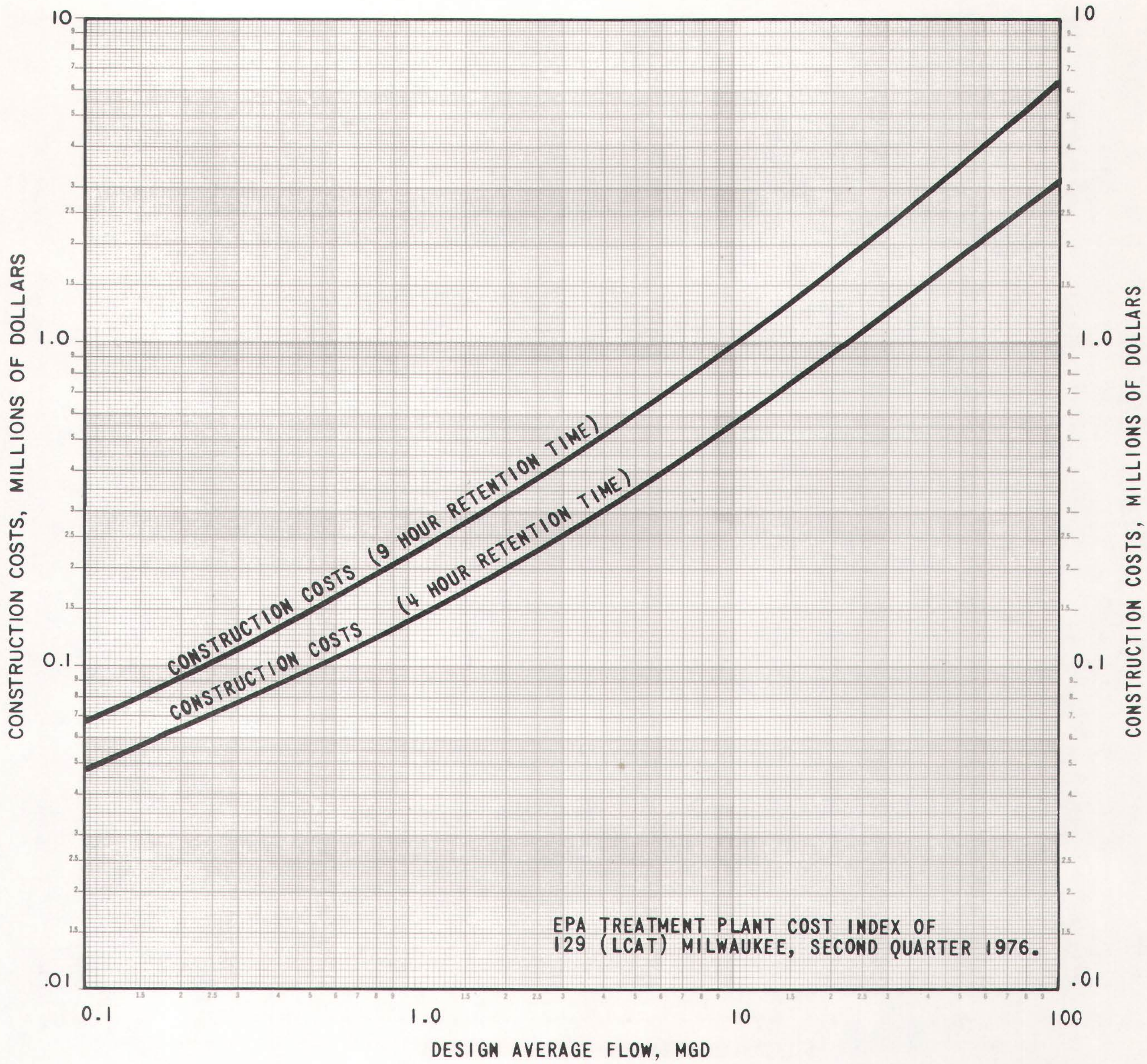
COSTS INCLUDE: FLOCCULATOR-CLARIFIER, CHEMICAL FEED, SLUDGE PUMPS, & THICKENER
FERRIC CHLORIDE: 80 mg/l & 1 mg/l POLYMER, 150 mg/l & 1 mg/l POLYMER
ALUM.: 170 mg/l & 0.5 mg/l POLYMER, 310 mg/l & 0.5 mg/l POLYMER

Fe CL_3 = $115/TON; ALUM. = $90/TON; POLYMER = $1.80/LB.

Source: Stanley Consultants.

Figure D-6

AERATION TANKS

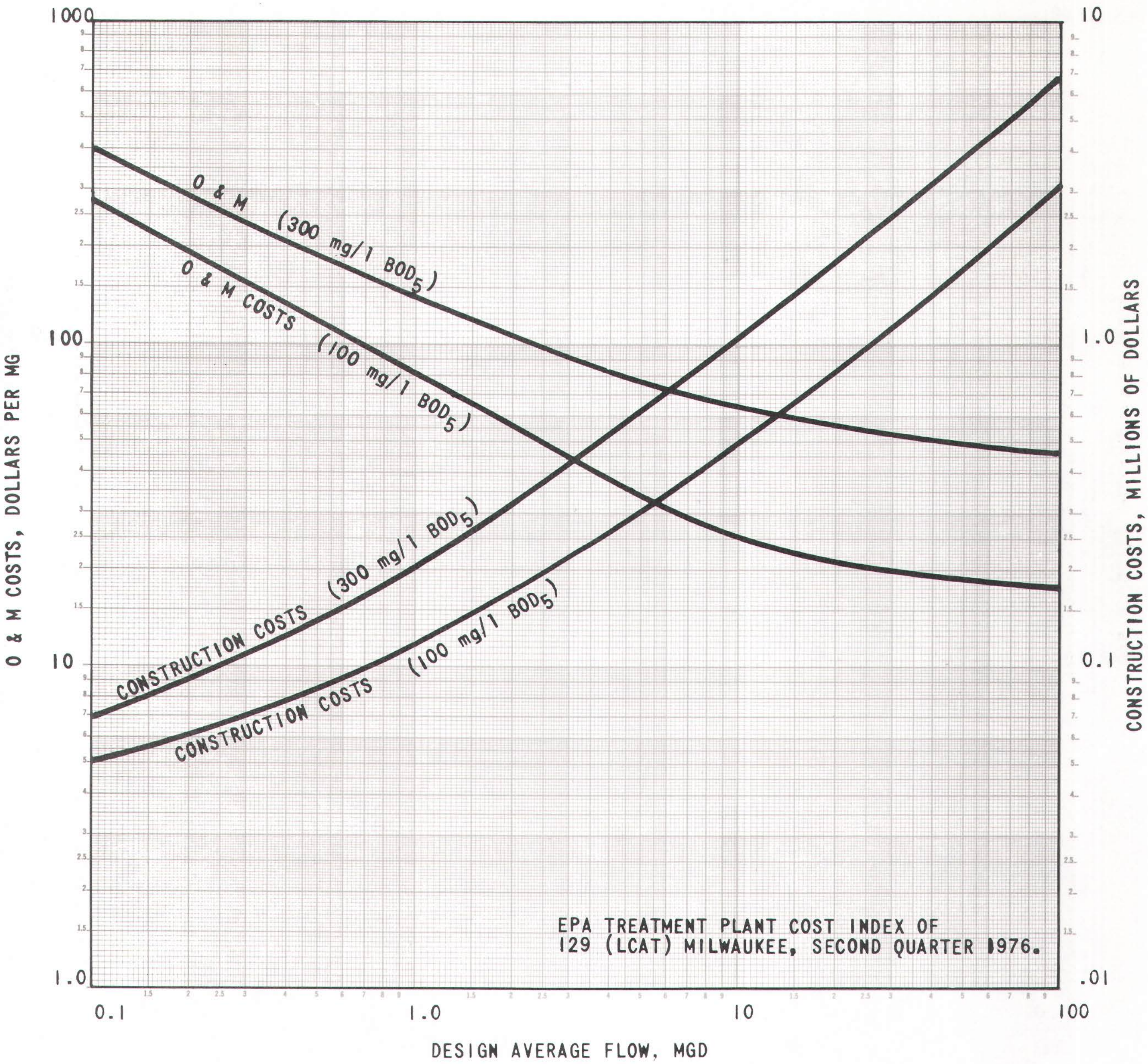


COSTS BASED ON: AVERAGE DETENTION TIME OF 4 HOURS (CONVENTIONAL ACTIVATED SLUDGE)
AVERAGE DETENTION TIME OF 9 HOURS (FOR SINGLE-STAGED NITRIFICATION SYSTEMS)

Source: Stanley Consultants.

Figure D-7

DIFFUSED AIR SYSTEM, CONVENTIONAL ACTIVATED SLUDGE



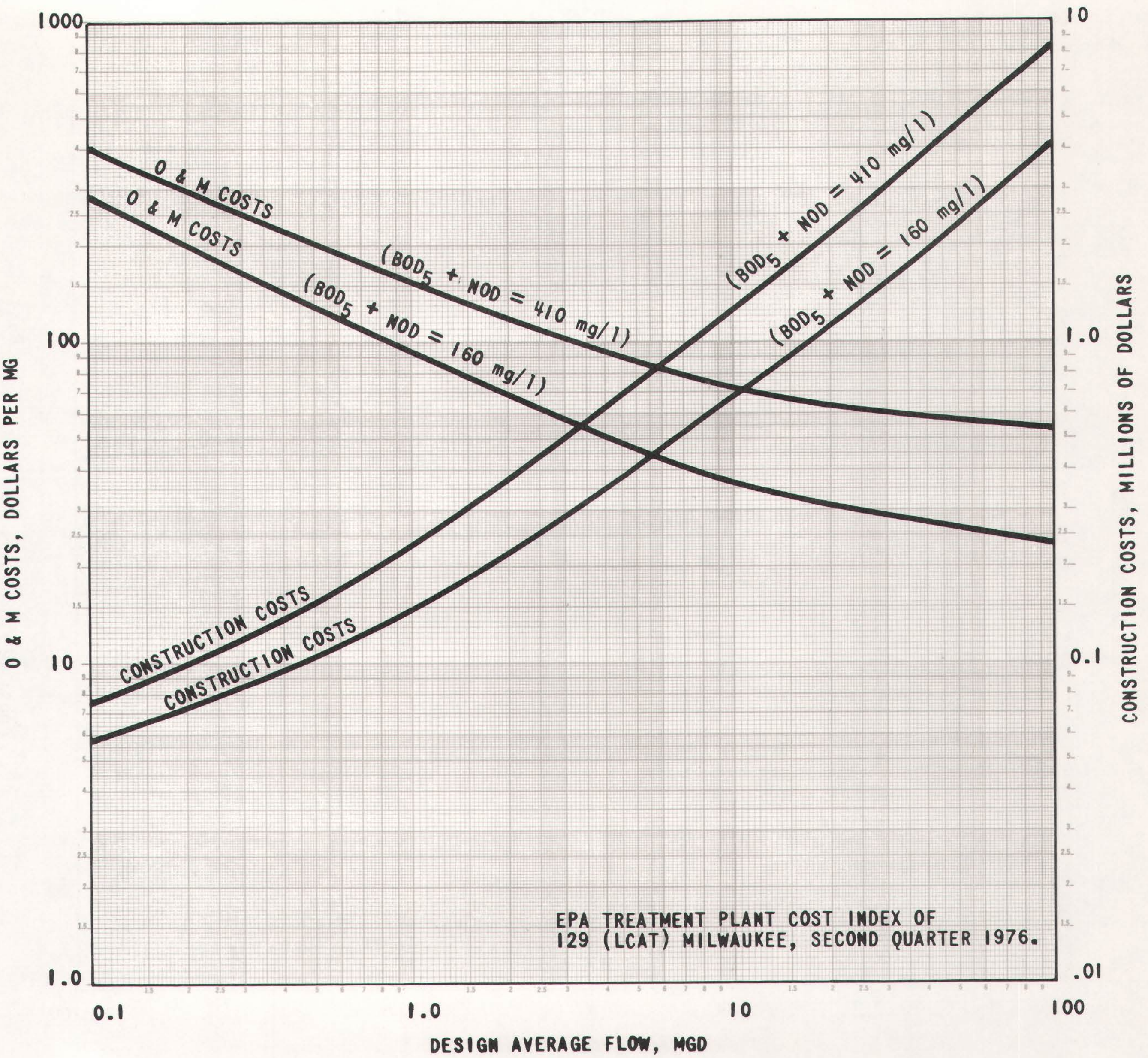
COSTS BASED ON: 1500 CF AIR/LB BOD_5; BOD_5 = 300 mg/l AFTER PRIMARY
BOD_5 = 100 mg/l AFTER PRIMARY

COSTS INCLUDE: BLOWERS, DIFFUSERS, AIR PIPING & ACCESSORIES, BLOWER BUILDING AND FOUNDATIONS

Source: Stanley Consultants.

Figure D-8

DIFFUSED AIR SYSTEM, SINGLE-STAGE NITRIFICATION SYSTEMS



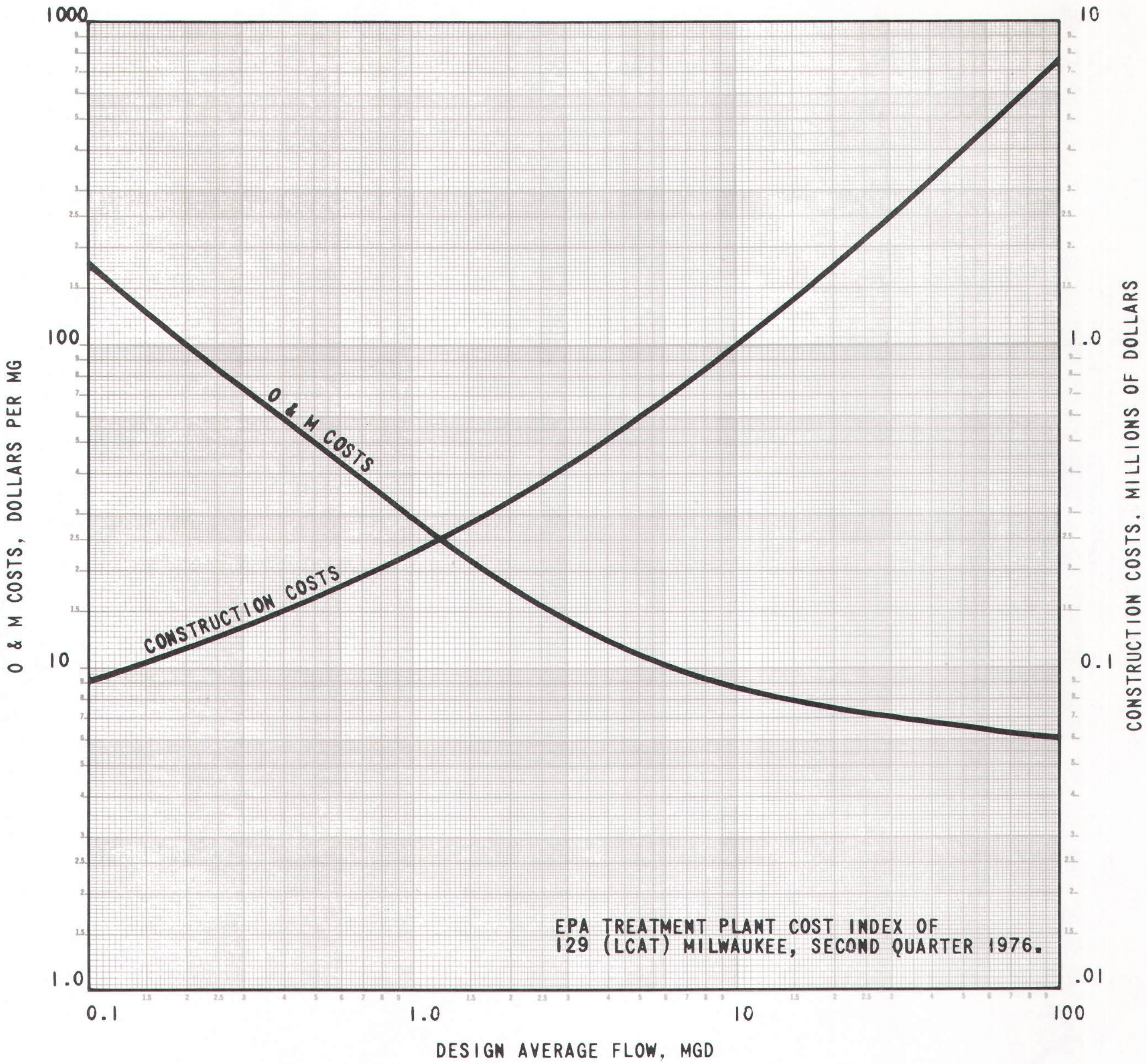
COSTS BASED ON: 1300 CF AIR/LB (BOD_5 + NOD): BOD_5 + NOD = 160 mg/1 AFTER PRIMARY
BOD_5 + NOD = 410 mg/1 AFTER PRIMARY

COSTS INCLUDE: BLOWERS, DIFFUSERS, AIR PIPING & ACCESSORIES, BLOWER BUILDING AND FOUNDATIONS

Source: Stanley Consultants.

Figure D-9

TRICKLING FILTERS



COSTS BASED ON: 1. ORGANIC LOADING OF 35 LB/DAY OF BOD_5 PER 1000 CUBIC FEET OF FILTER MEDIA AND INFLUENT BOD_5 OF 135-145 mg/l

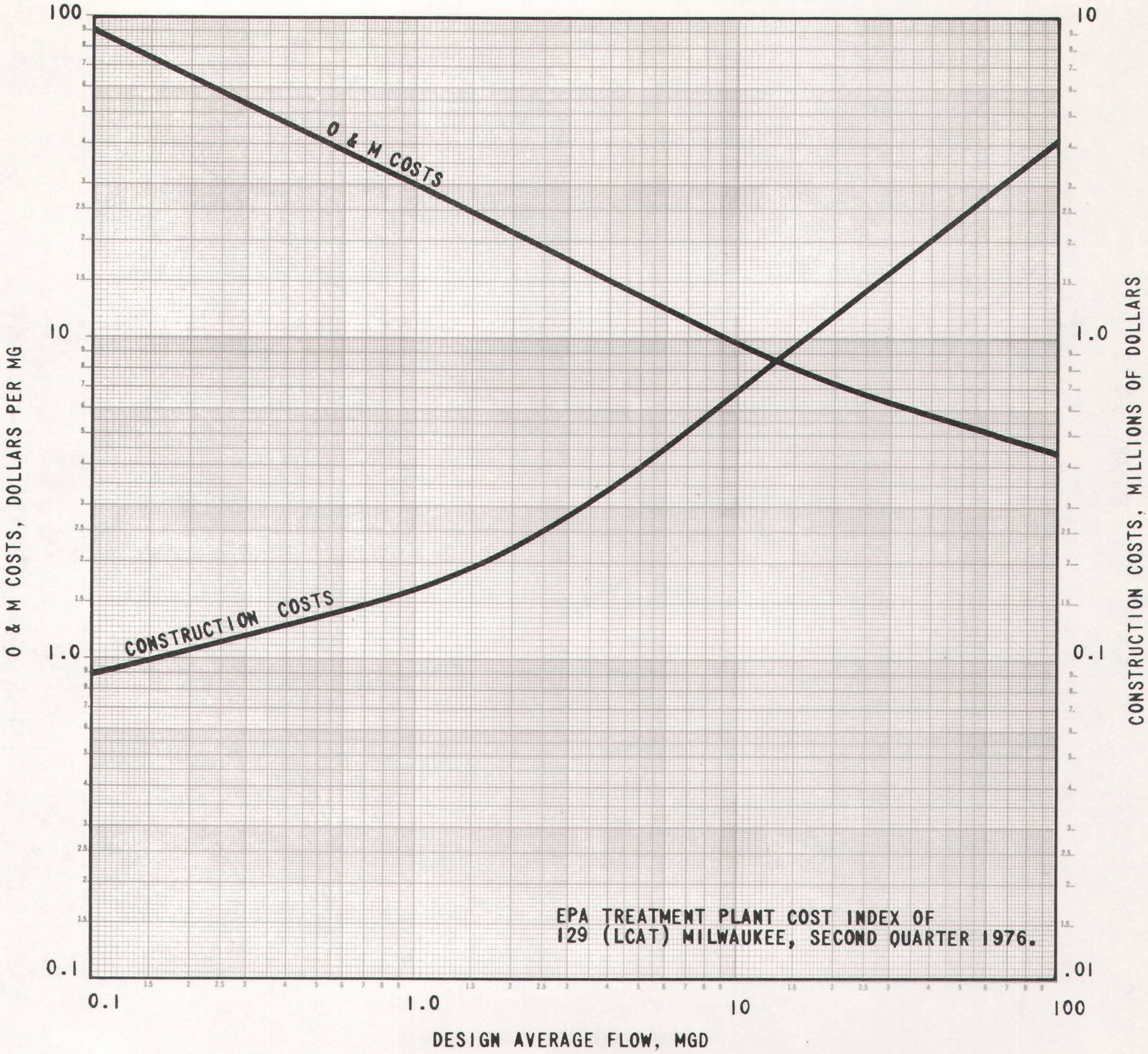
2. RECYCLE CAPACITY OF 2:1

COSTS INCLUDE: UNDERDRAINS, MEDIA, ROTARY DISTRIBUTOR, CONCRETE TANK, & RECYCLE PUMPING

Source: Stanley Consultants.

Figure D-10

FINAL CLARIFIERS



COSTS BASED ON: SURFACE OVERFLOW RATE = 500 GPD/FT^2 IF $Q_A < 2.0$

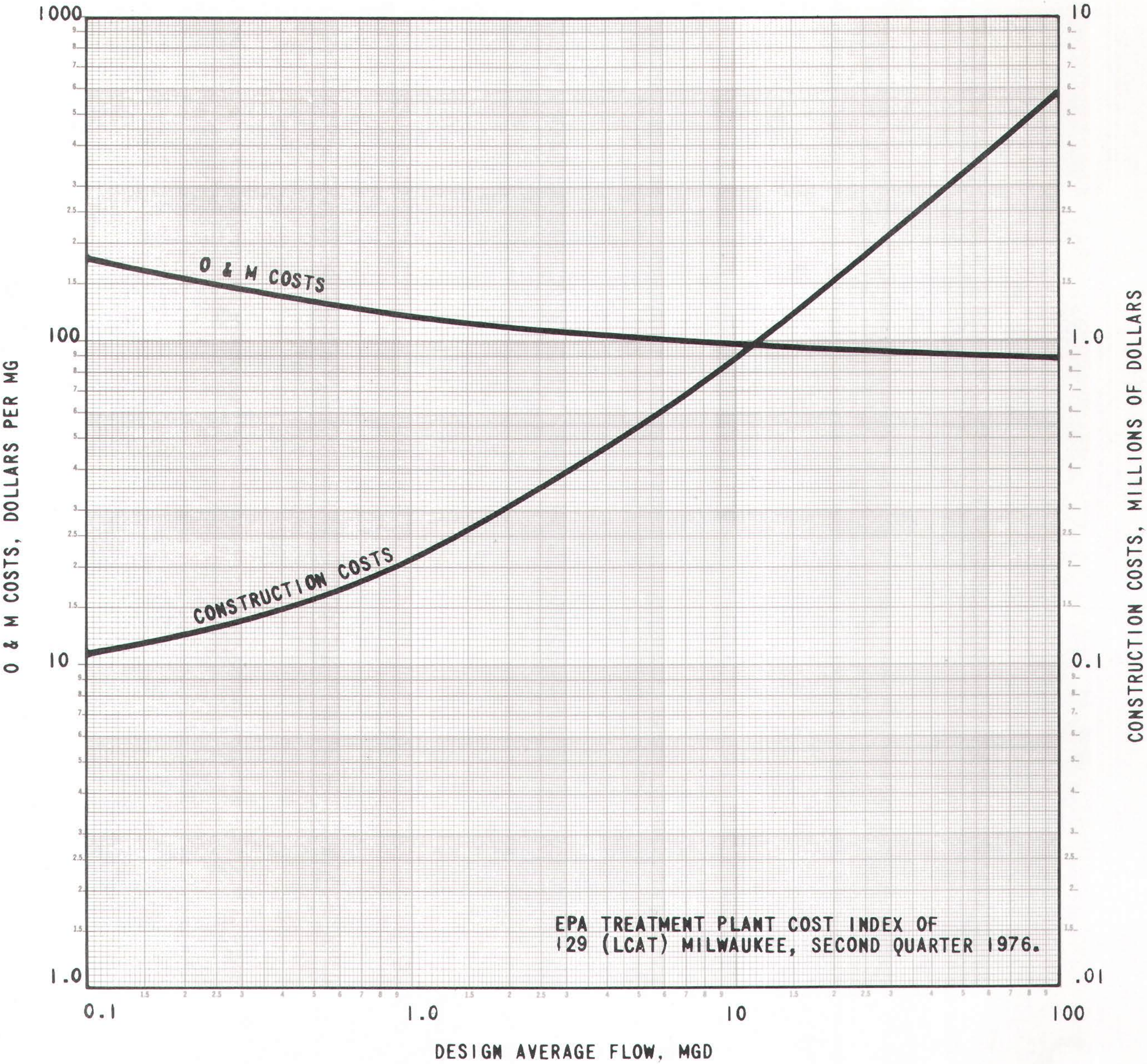
SURFACE OVERFLOW RATE = 800 GPD/FT^2 IF $Q_A > 2.0$

COSTS INCLUDE: RETURN SLUDGE PUMPING

Source: Stanley Consultants.

Figure D-11

FINAL CLARIFIER WITH ALUM OR FE SALT ADDITION



COST BASED ON: SURFACE OVERFLOW RATE OF 700 GPD/FT^2

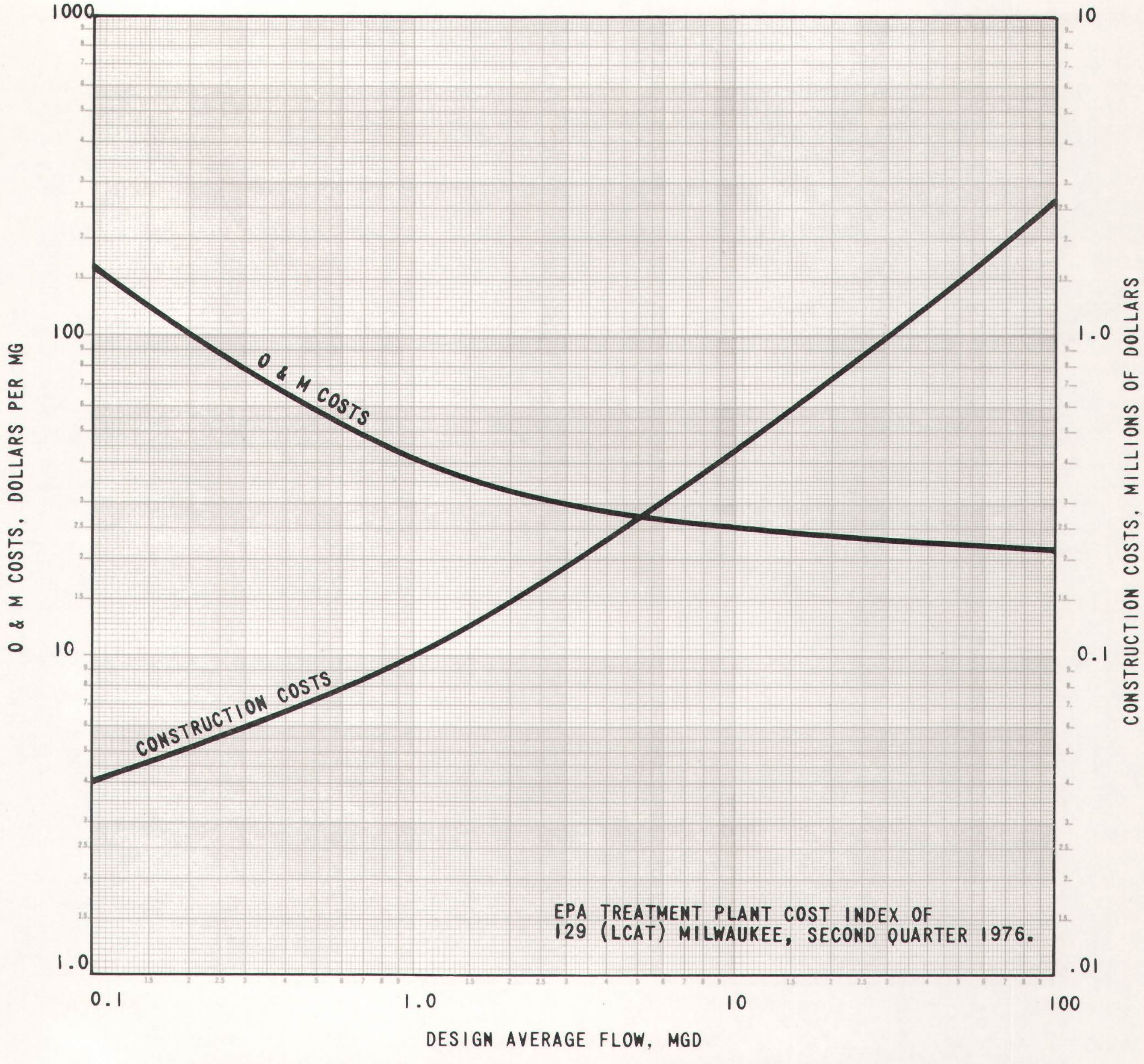
COST INCLUDE: RETURN SLUDGE PUMPING
FERRIC CHLORIDE: 70 mg/l + 1 mg/l POLYMER
ALUM: 155 mg/l + 0.5 mg/l POLYMER

$FeCL_3$ = $115/TON; ALUM = $90/TON; POLYMER = $1.80/LB.

Source: Stanley Consultants.

Figure D-12

AERATED LAGOONS



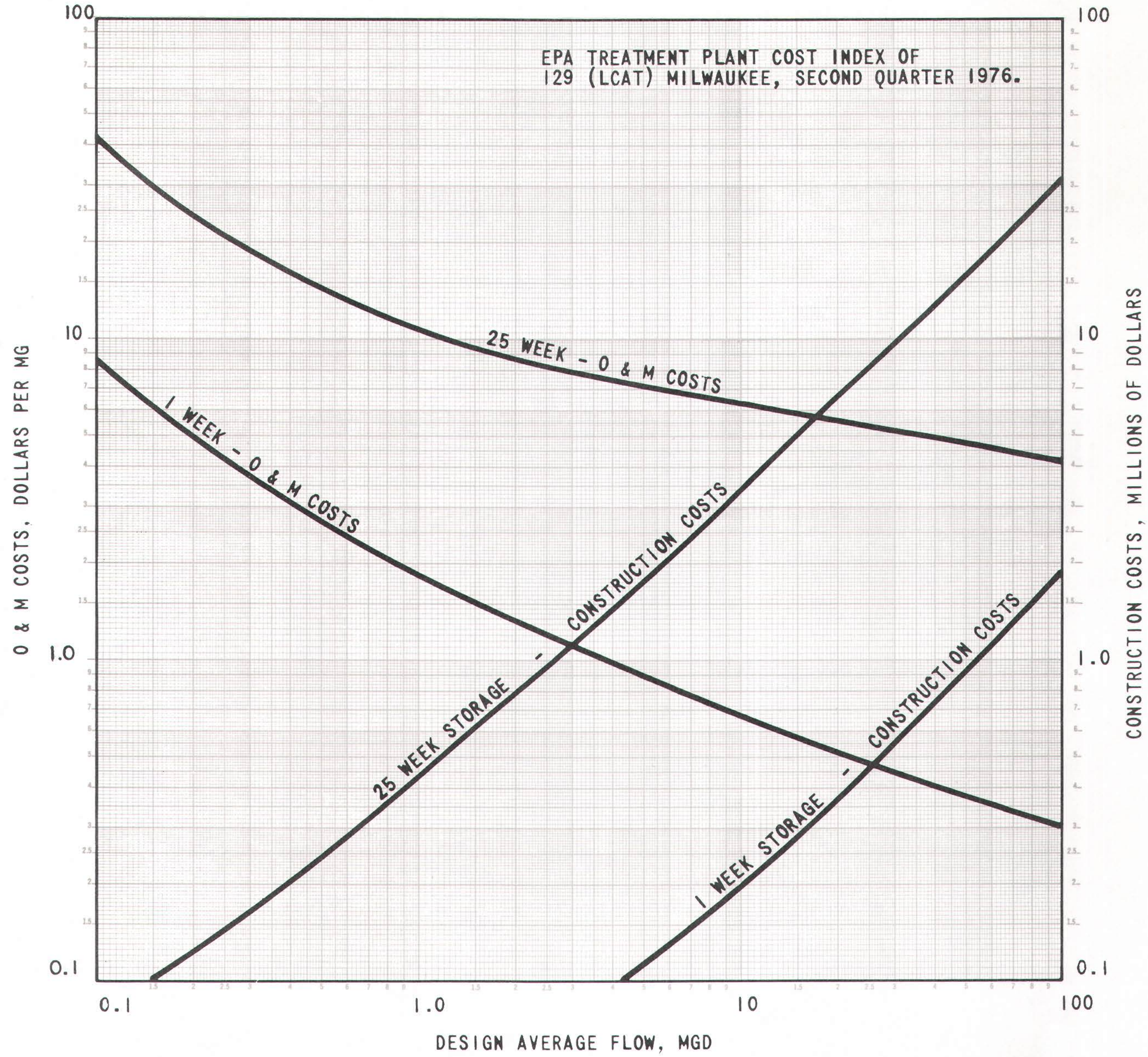
COSTS BASED ON: DETENTION TIME 7 DAYS, 15 FOOT DEPTH

COSTS INCLUDE: BASIN, EMBANKMENTS, AERATION EQUIPMENT (FLOATING OR BOTTOM TUBE AERATION) AND ARE BASED UPON EARTHEN BASINS WITH FAVORABLE CONSTRUCTION CONDITIONS

Source: Stanley Consultants.

Figure D-13

POLISHING LAGOONS



COST BASED ON: BASIN DEPTH 15' DETENTION AS SHOWN.

CURVES INCLUDE: BASINS AND HYDRAULIC WORKS

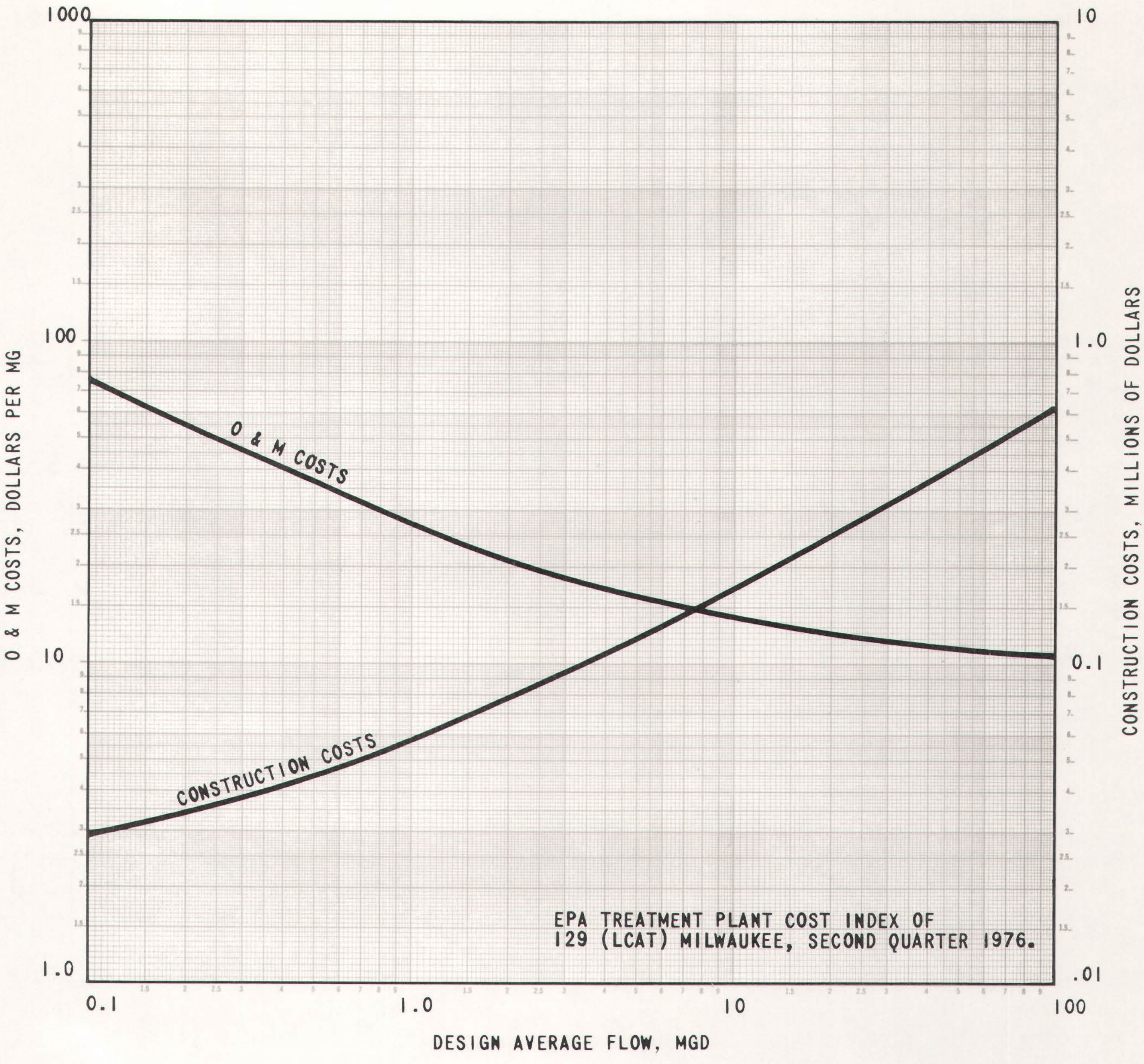
NOTES: 1. ONE WEEK FOR EQUALIZATION OR TERTIARY POLISHING

2. TWENTY-FIVE WEEK USED AS STORAGE FOR LAND APPLICATION SYSTEM

Source: Stanley Consultants.

Figure D-14

CHLORINATION



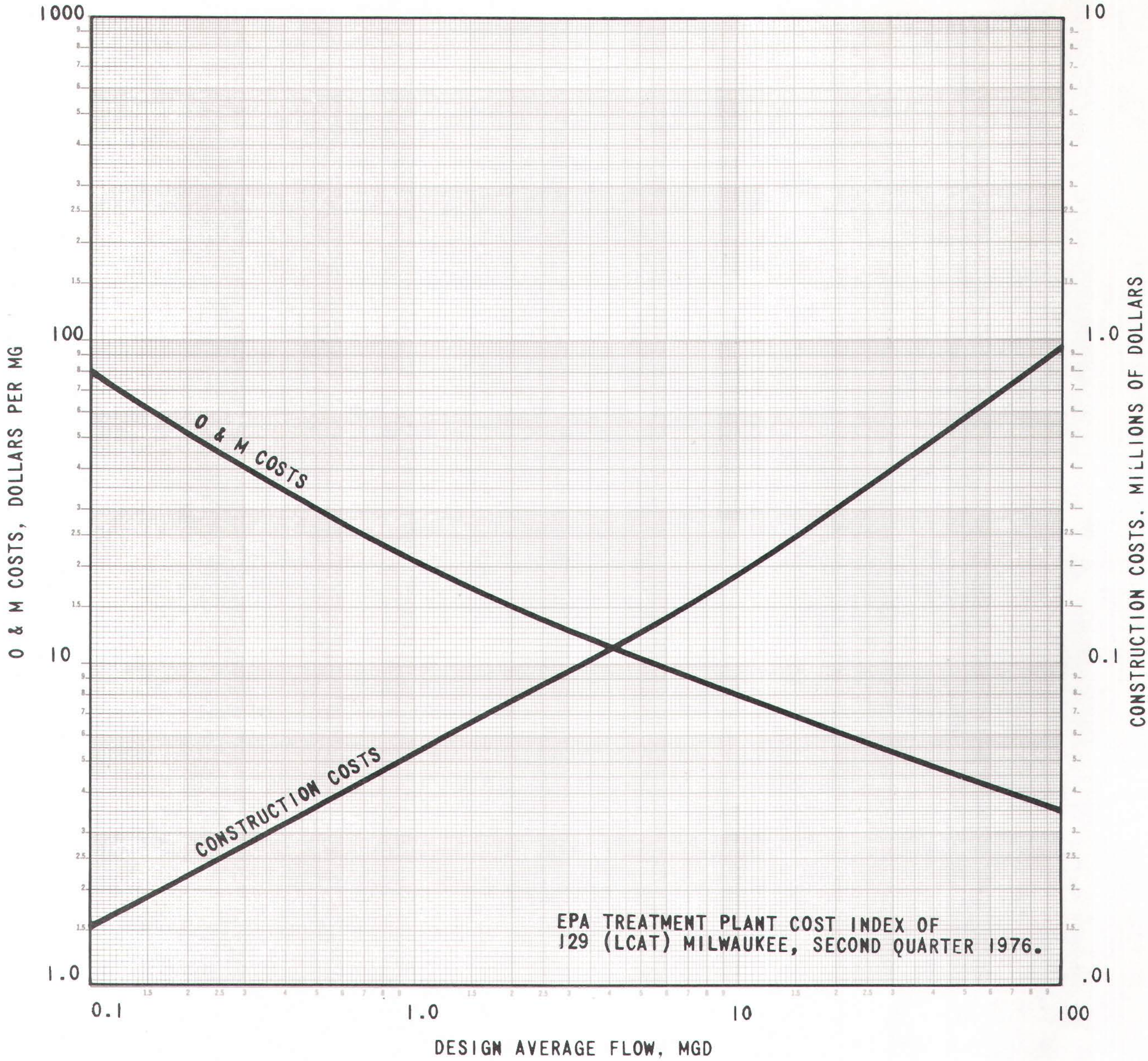
COSTS INCLUDE: CHLORINE CONTACT TANK & CHLORINE FEED SYSTEM

COSTS BASED ON: DETENTION TIME OF 15 MINUTES AT 4-HOUR PEAK FLOW
CHLORINE DOSAGE OF 12 mg/l OF CL_2 AT AVERAGE FLOW

Source: Stanley Consultants.

Figure D-15

POST-AERATION

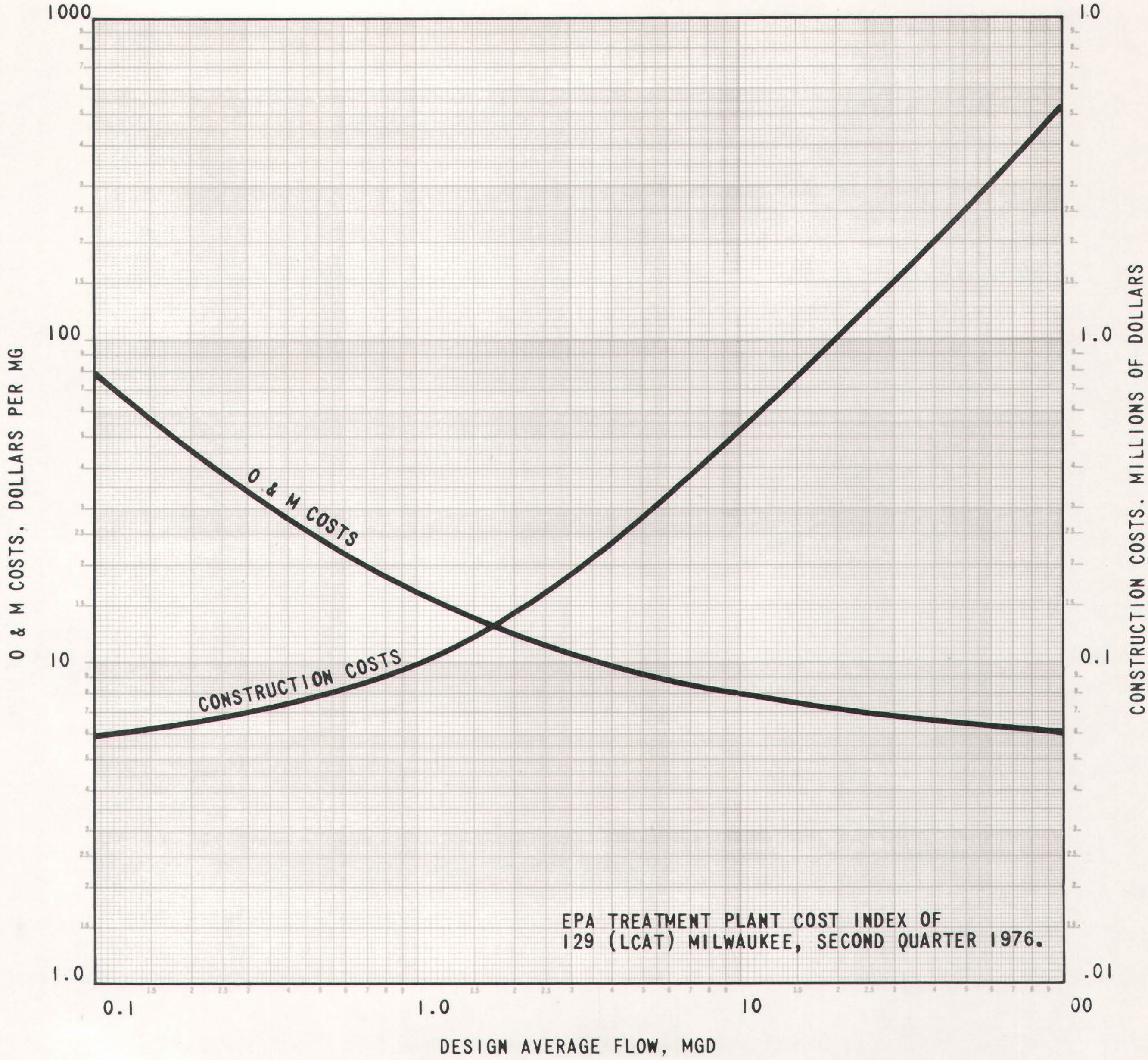


COSTS BASED ON: 1. DETENTION TIME OF 30 MINUTES AT AVERAGE FLOW.
2. AIR SUPPLY OF 100 CFM/MGD FLOW.

Source: Stanley Consultants.

Figure D-16

MICROSTRAINERS

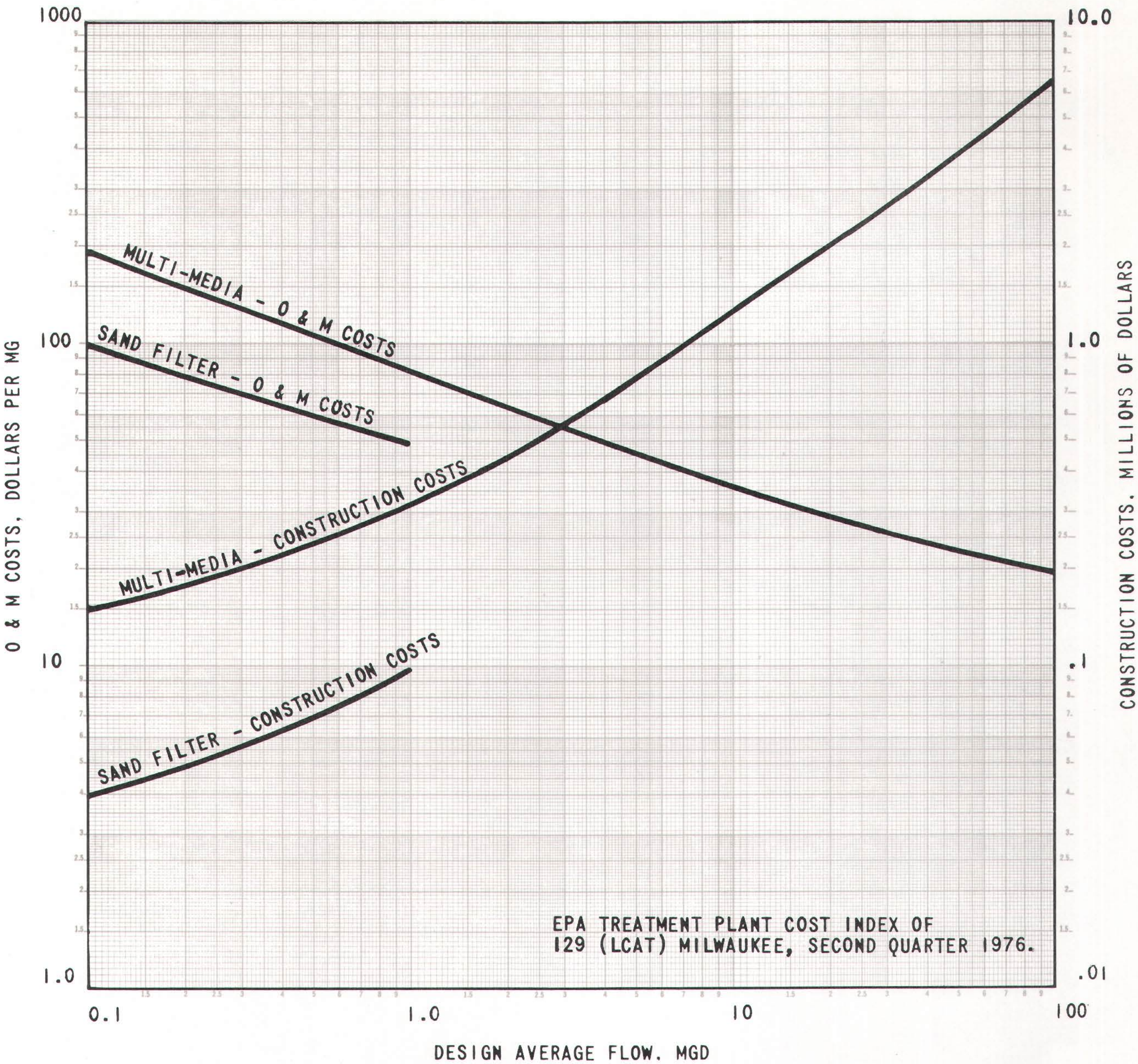


COST BASED ON: FLOW OF 5 GPM/FT^2 SUBMERGED SURFACE AT 66% SUBMERGENCE

Source: Stanley Consultants.

Figure D-17

MULTIMEDIA FILTRATION

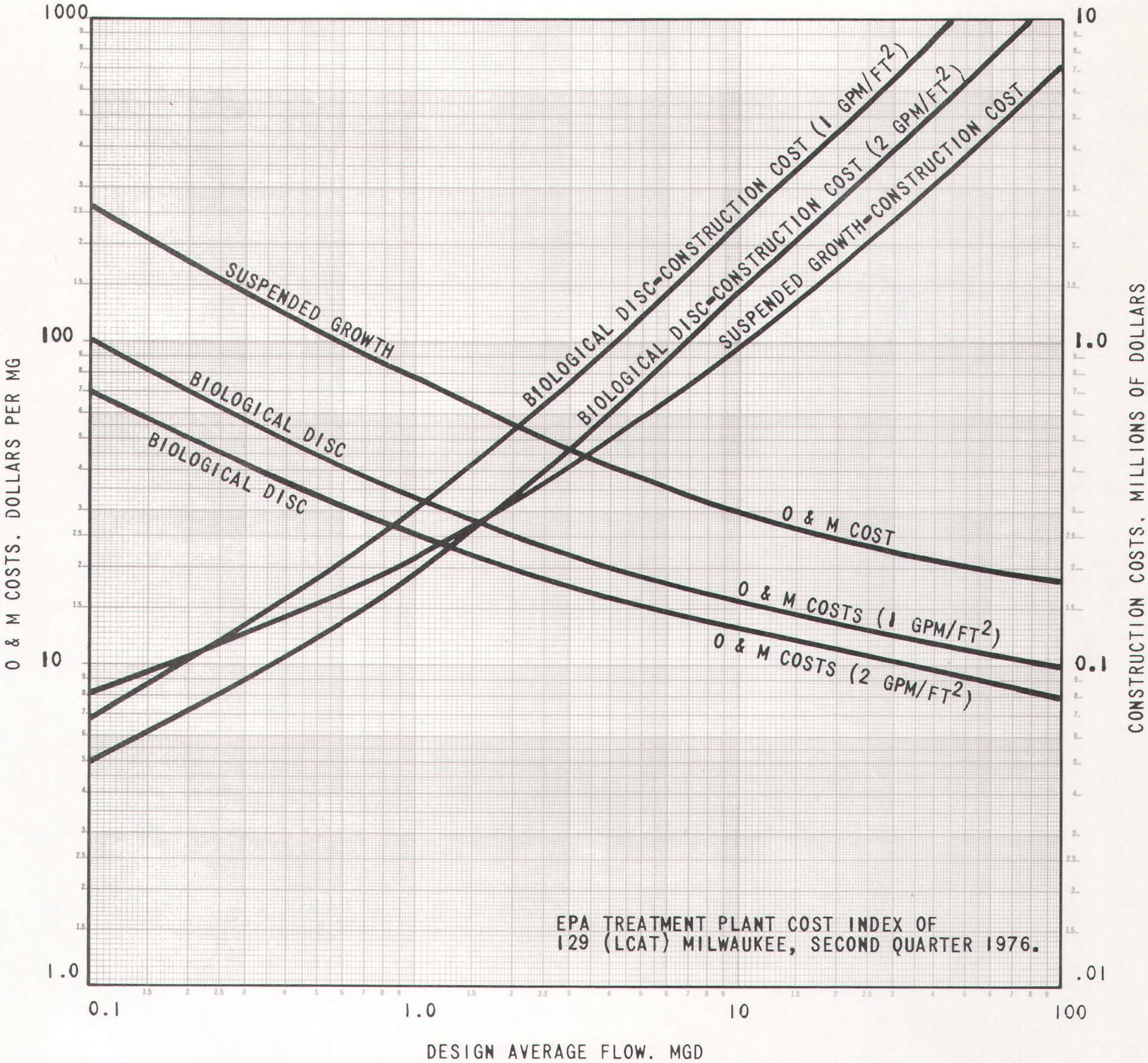


COSTS BASED ON: FILTRATION RATE OF 4 GPM PER SQ. FT.
(SAND FILTER 1 GPM PER SQ. FT.)

Source: Stanley Consultants.

Figure D-18

BIOLOGICAL NITRIFICATION



COSTS BASED ON: 1. SUSPENDED GROWTH - DETENTION TIME 4 HOURS AIR SUPPLY OF 1 CFM/GALLON.

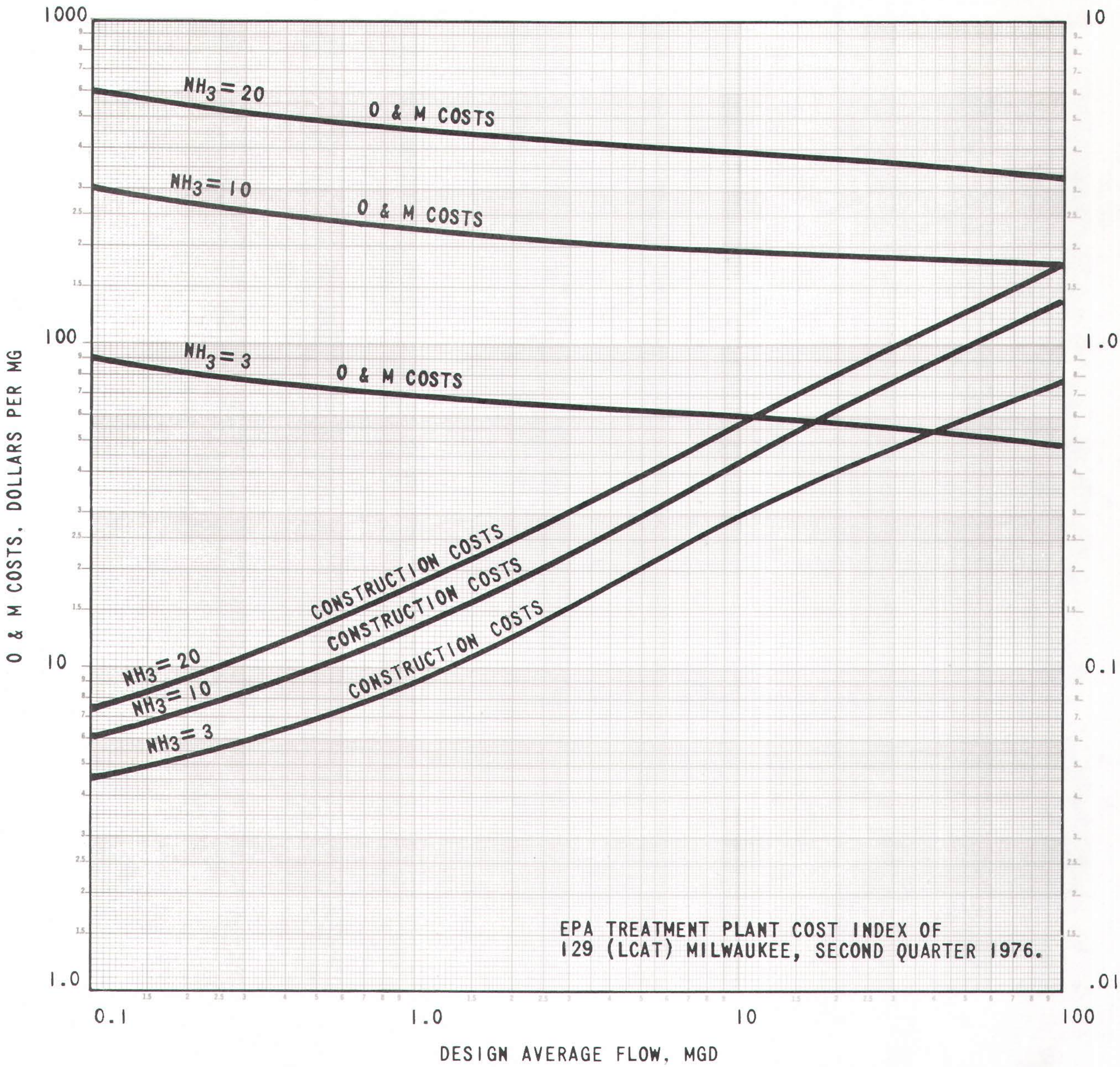
2. BIOLOGICAL DISCS: LOADING AS SHOWN.

NOTE: BIOLOGICAL DISK LOADING RATE OF 2 GPM/FT^2 APPLICABLE FOR NITRIFICATION IN SEPARATE STAGE. LOADING RATE OF 1 GPM/FT^2 APPLICABLE FOR SECONDARY TREATMENT IN LIEU OF ACTIVATED SLUDGE.

Source: Stanley Consultants.

Figure D-19

BREAKPOINT CHLORINATION

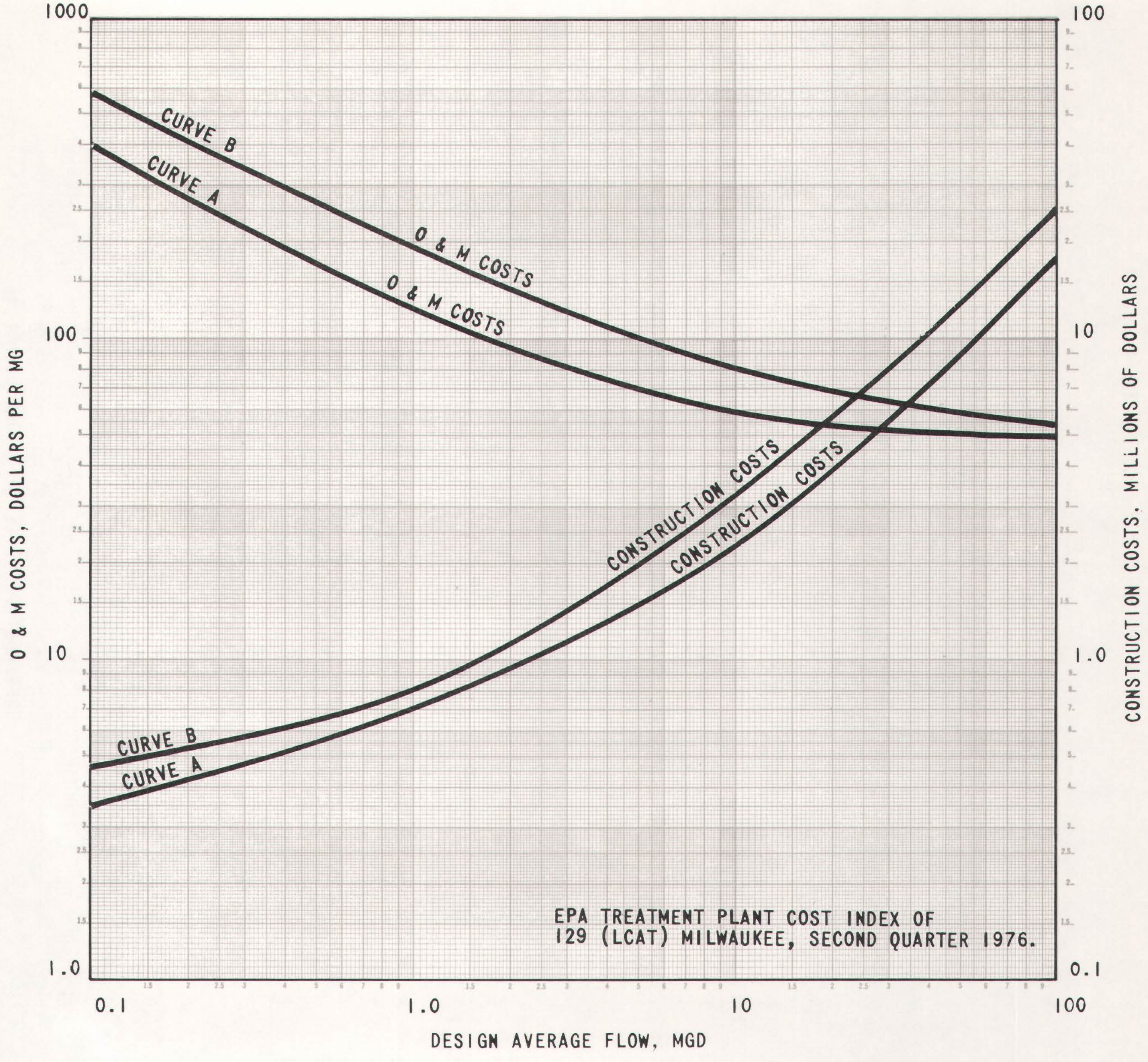


COSTS BASED ON: CHLORINE CONTACT TANK DETENTION TIME = 30 MINUTES
10 mg/l CL_2 PER mg/l AMMONIA
CHLORINE COSTS 10¢-22¢/LB VARYING WITH USE

Source: Stanley Consultants.

Figure D-20

GRANULAR CARBON ADSORPTION



COSTS BASED ON: A. CARBON CONTACT 20 MIN., DOSAGE = 300 LBS/MG

B. CARBON CONTACT 40 MIN., DOSAGE = 1200 LBS/MG

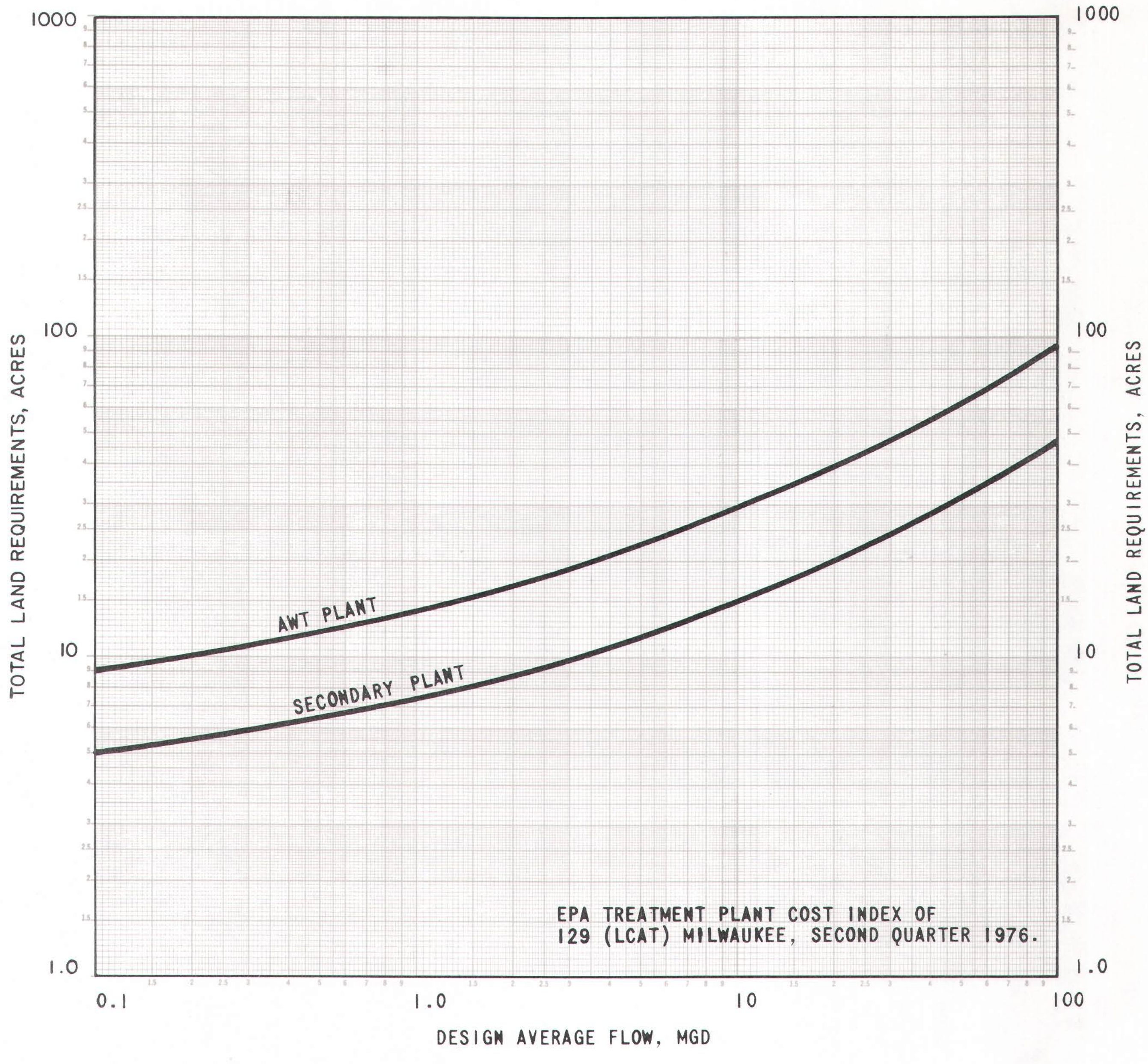
COSTS INCLUDE: CARBON REGENERATION

NOTE: CURVE "A" COST CAN BE USED FOR DECHLORINATION

Source: Stanley Consultants.

Figure D-21

MECHANICAL TREATMENT—LAND REQUIREMENTS

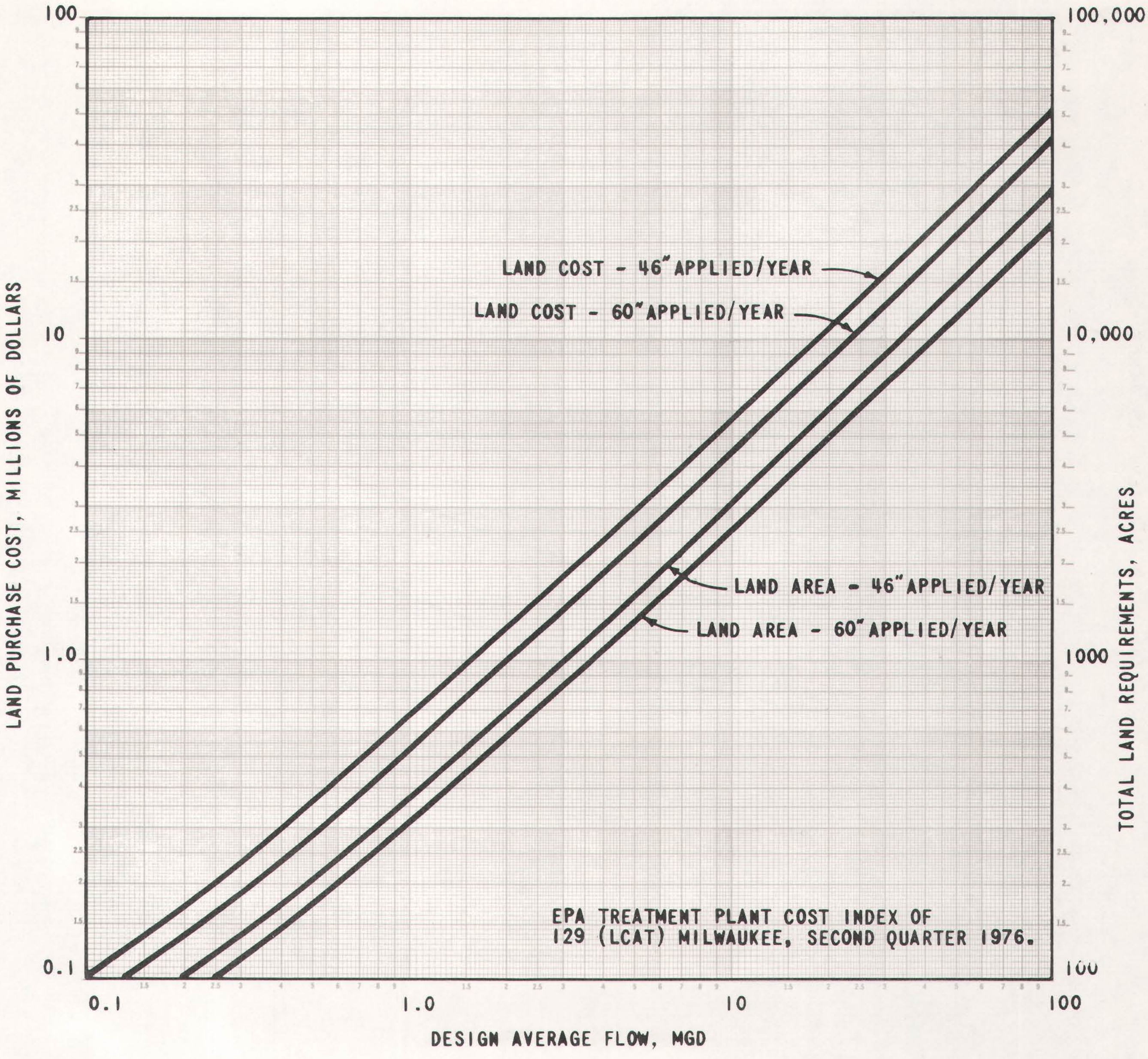


NOTES: 1. LAND AREAS ARE AVERAGE REQUIREMENTS.
2. AWT PLANT BASED ON MECHANICAL PLANT.

Source: Stanley Consultants.

Figure D-22

LAND APPLICATION—LAND REQUIREMENTS



CURVES BASED ON 23 WEEKS OF APPLICATION

CURVES INCLUDE: STORAGE, APPLICATION AREA, BUFFER AREA

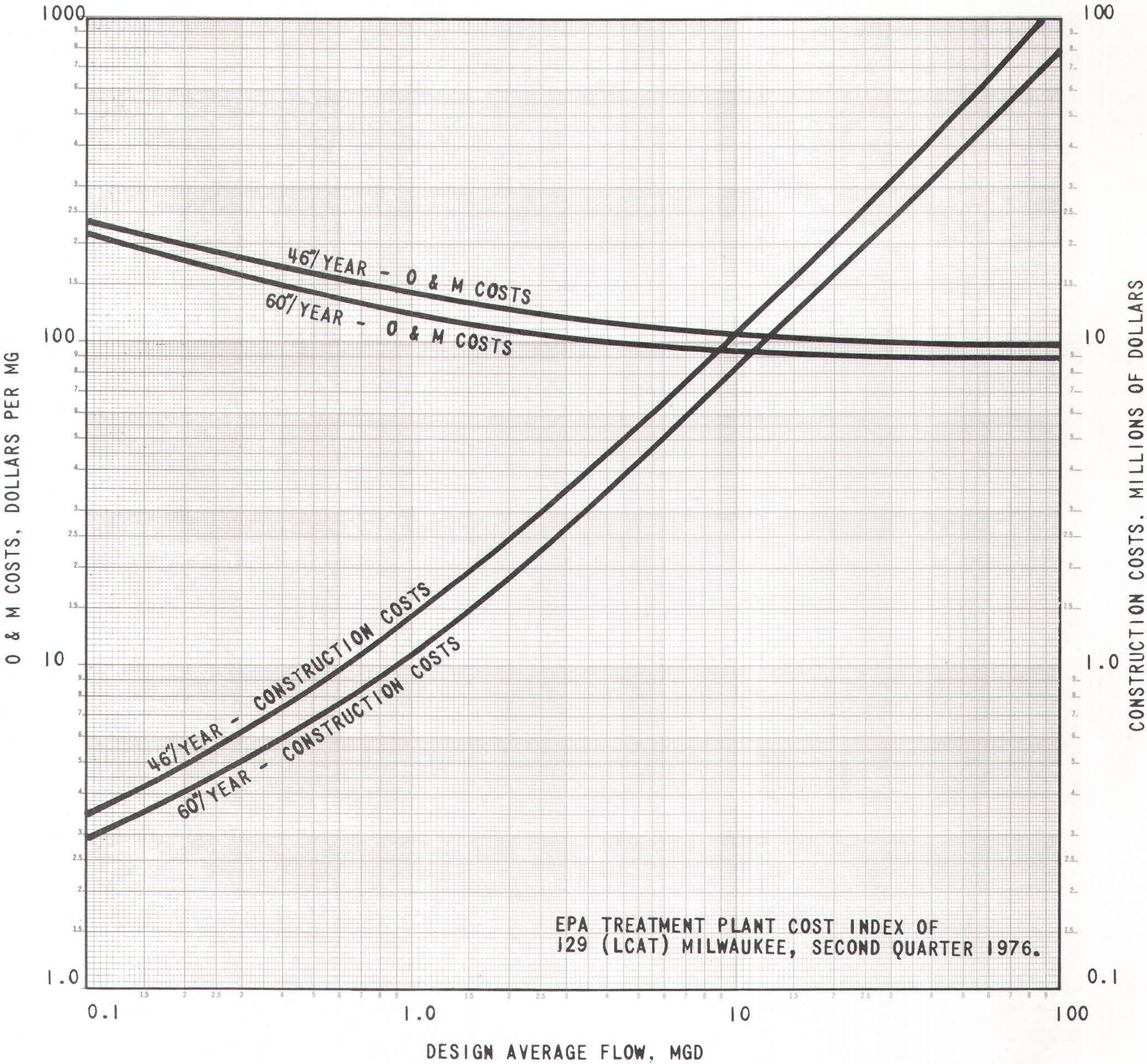
NOTES: LAND COST OF $1800/ACRE USED FOR COST.

FOR A SPECIFIC SITE, ACTUAL LAND COSTS SHOULD BE DEVELOPED.

Source: Stanley Consultants.

Figure D-23

LAND APPLICATION, SPRAY IRRIGATION—BURIED SOLID SET

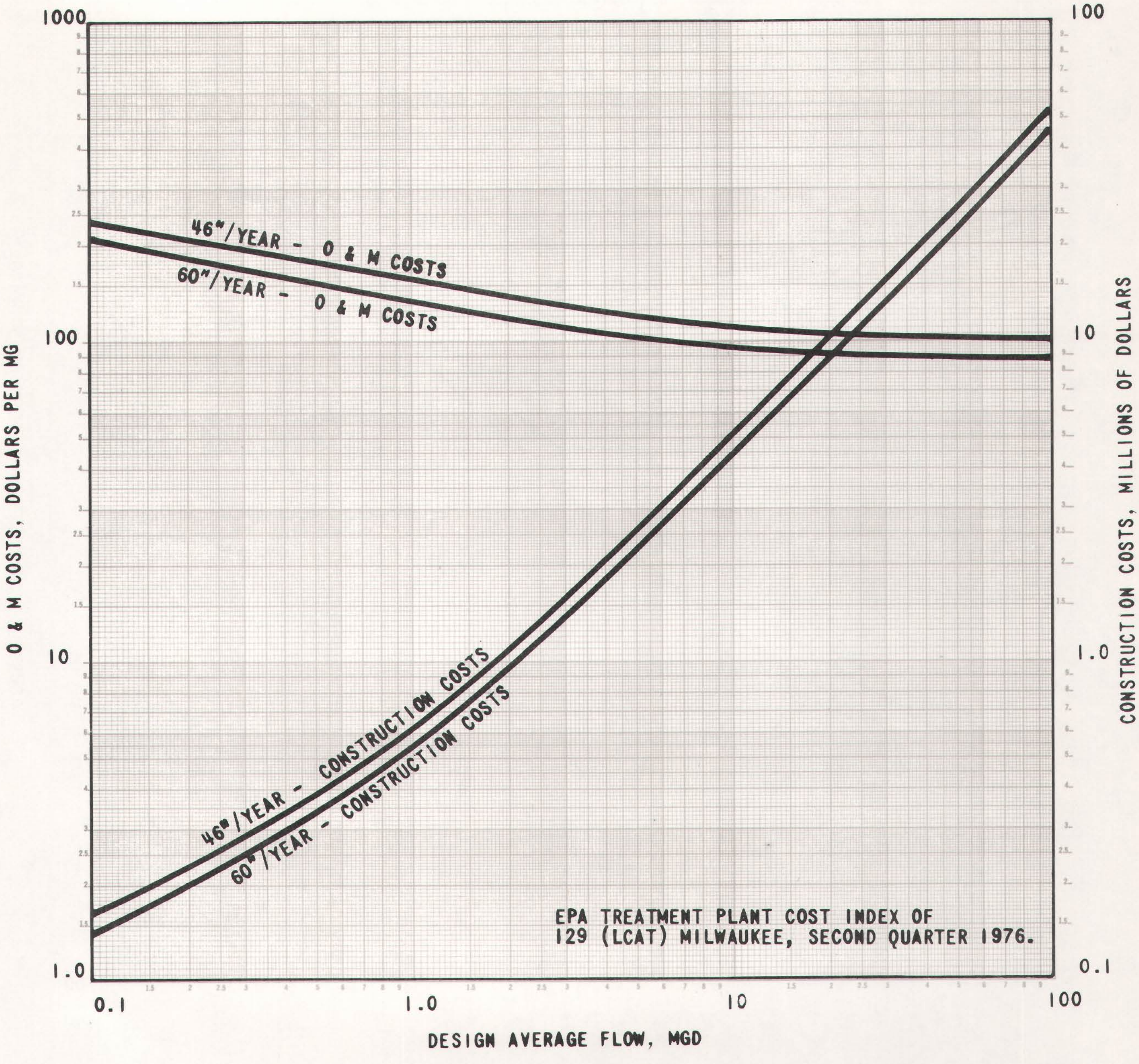


BASED ON: APPLICATION 23 WEEKS PER YEAR

Source: Stanley Consultants.

Figure D-24

LAND APPLICATION, SPRAY IRRIGATION—ABOVE GROUND SOLID SET

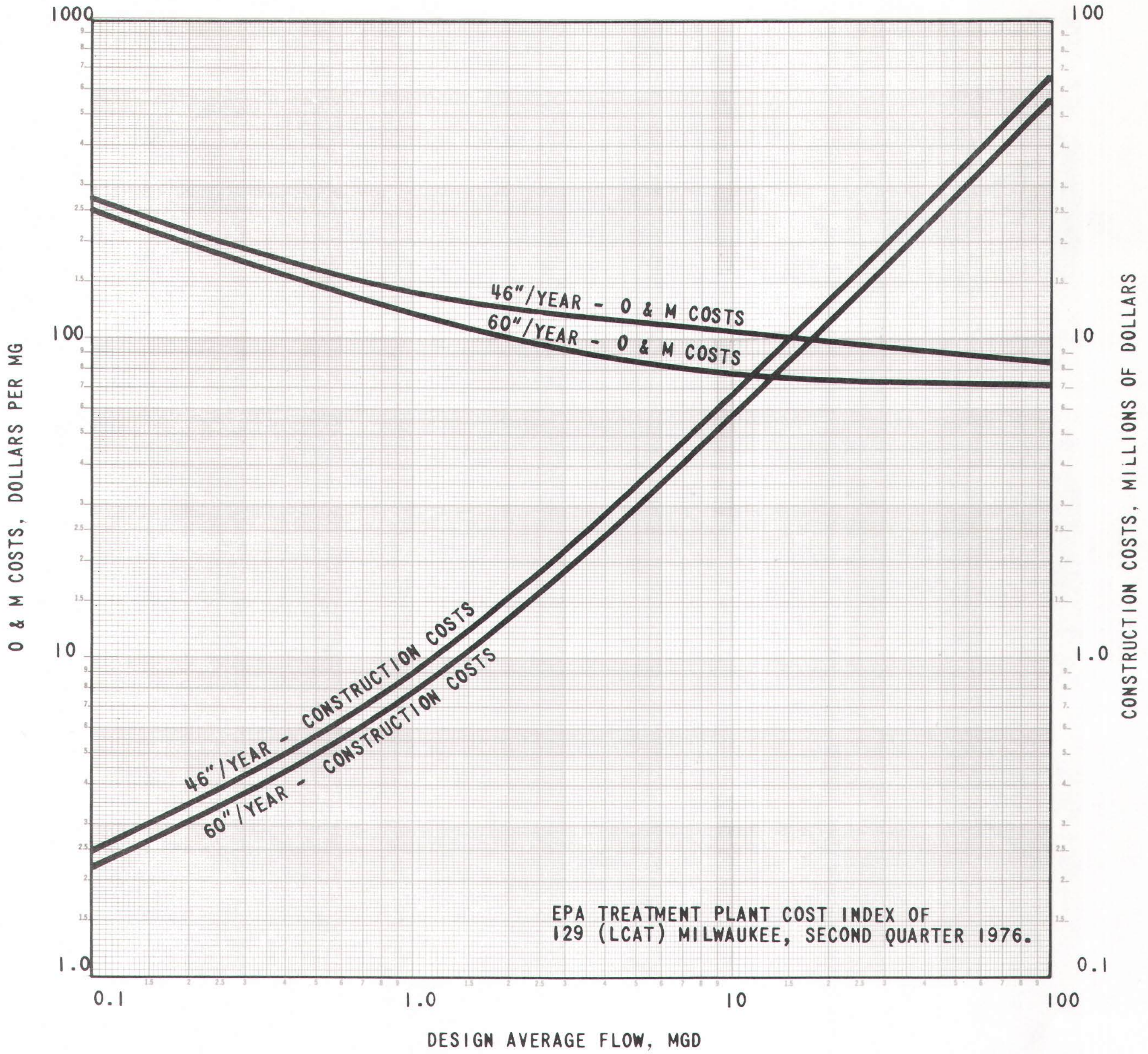


BASED ON: APPLICATION 23 WEEKS PER YEAR

Source: Stanley Consultants.

Figure D-25

LAND APPLICATION, SPRAY IRRIGATION—CENTER PIVOT

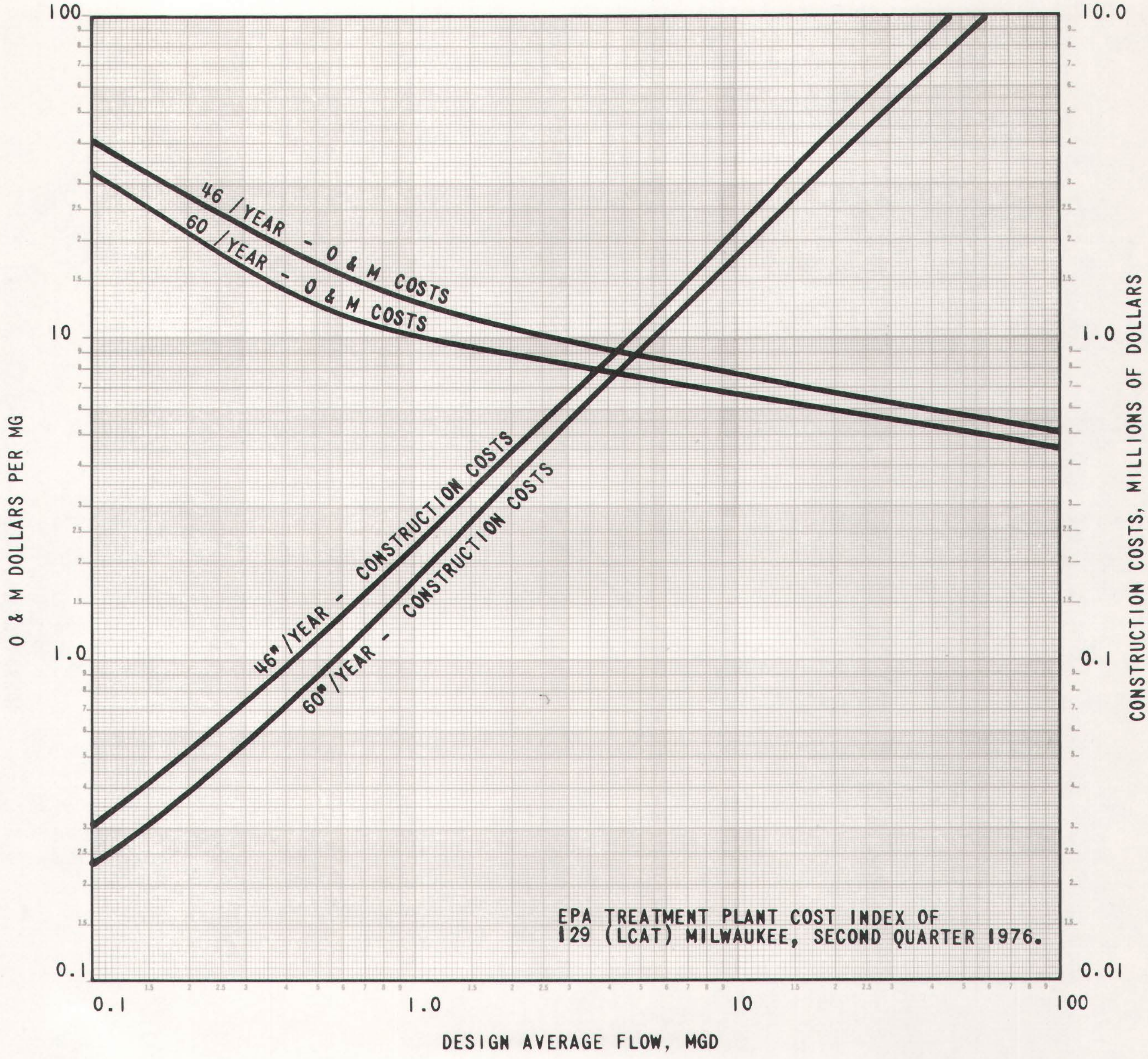


BASED ON APPLICATION 23 WEEKS PER YEAR

Source: Stanley Consultants.

Figure D-26

LAND APPLICATION, UNDERDRAINS

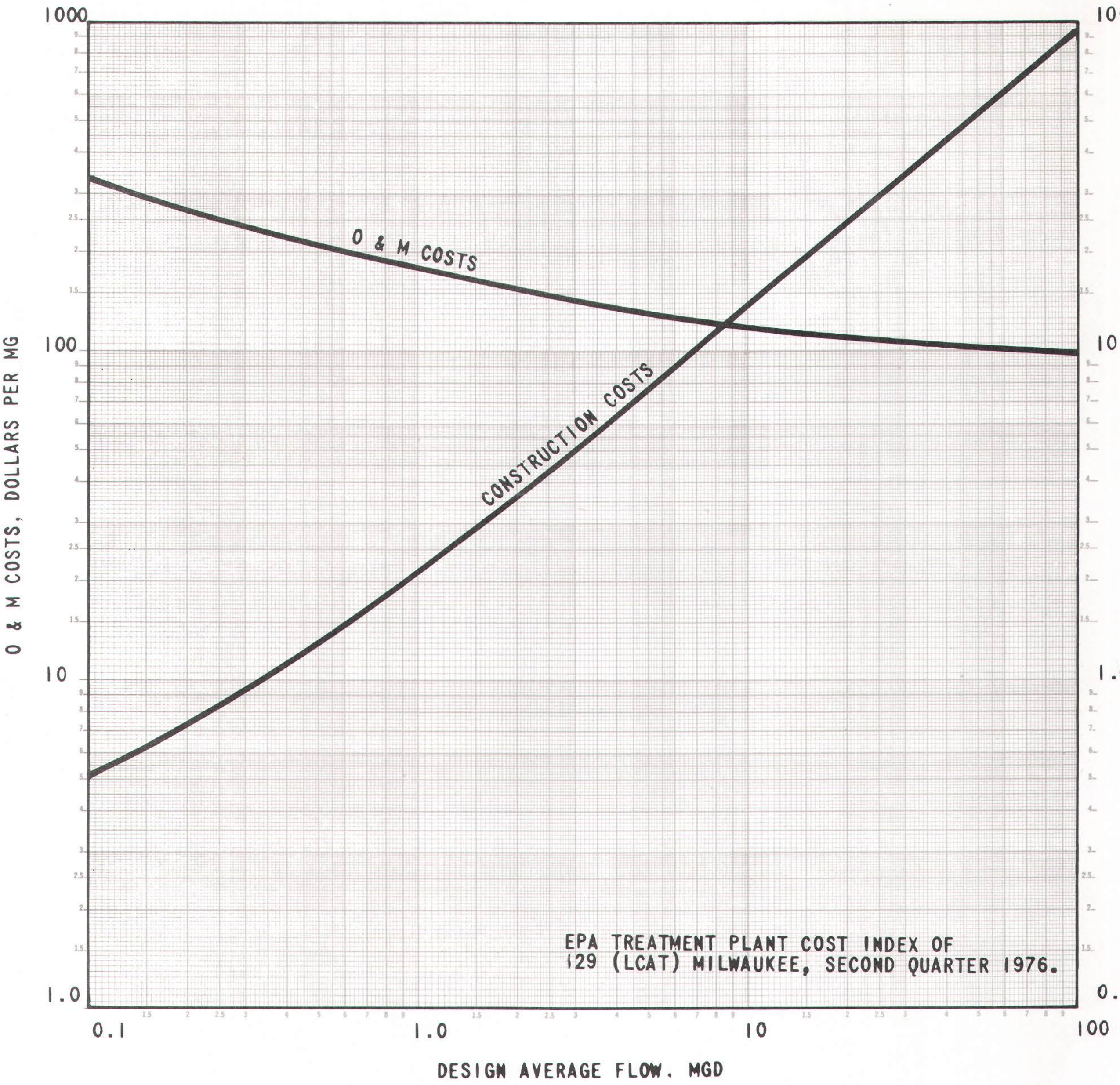


BASED ON COLLECTING TOTAL FLOW FROM APPLICATION 23 WEEKS PER YEAR.

Source: Stanley Consultants.

Figure D-27

LAND APPLICATION, TYPICAL SITE

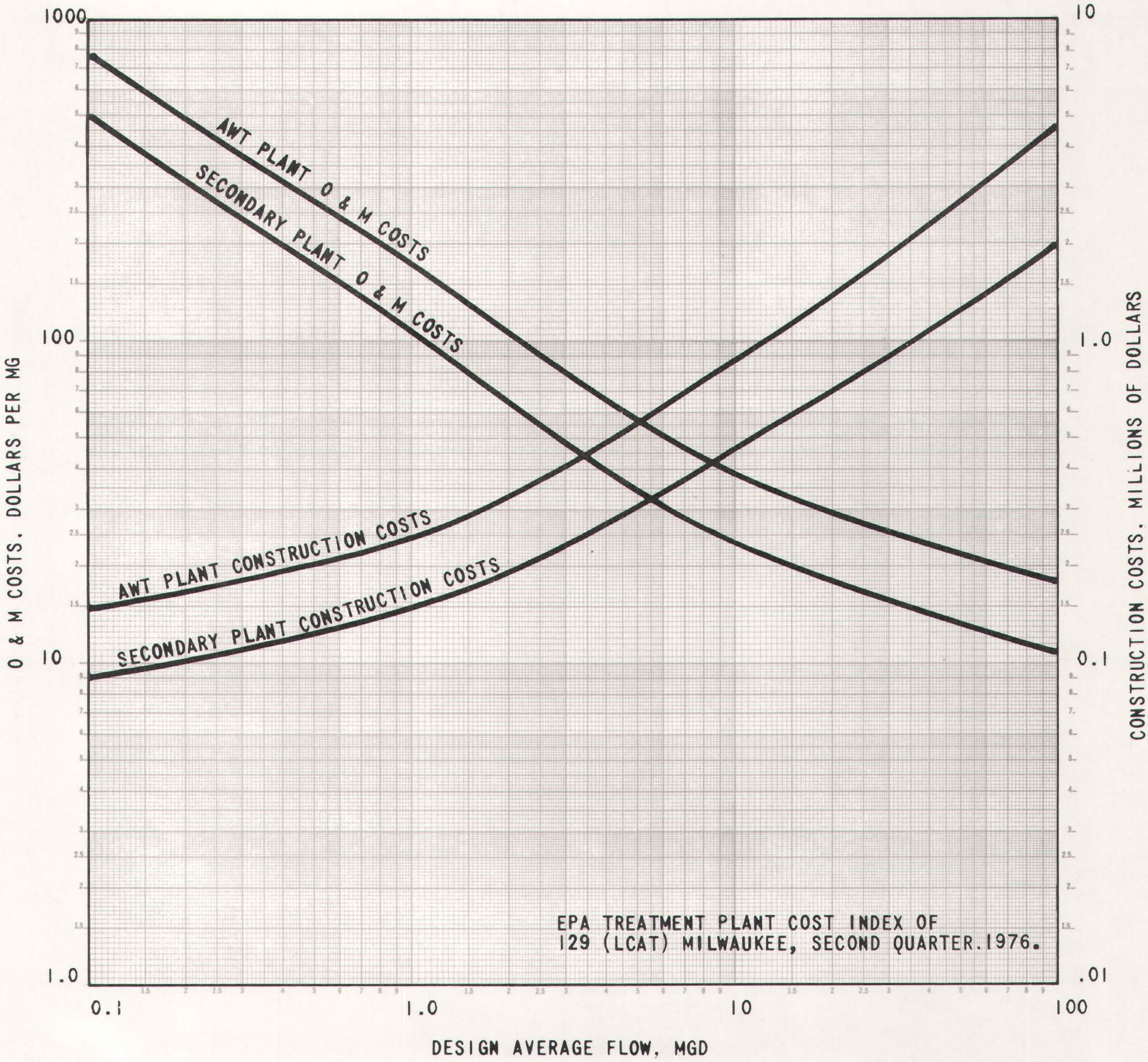


NOTES:
1. BASED ON PRIOR CURVES WITH:
   50% OF FLOW TO HAY AT 60"/YR, NO UNDERDRAINS, CENTER PIVOT
   25% OF FLOW TO CROP AT 46"/YR, UNDERDRAINS, SOLID SET (BURIED)
   25% OF FLOW TO CROP AT 46"/YR, UNDERDRAINS, SOLID SET (ABOVE GROUND)
2. COSTS INCLUDE LAND COST AT $1800/ACRE.
3. COSTS DO NOT INCLUDE PRETREATMENT OR STORAGE, TRANSMISSION, OR PUMPING TO APPLICATION SITE.

Source: Stanley Consultants.

Figure D-28

ADMINISTRATION AND LABORATORY FACILITIES, ETC.

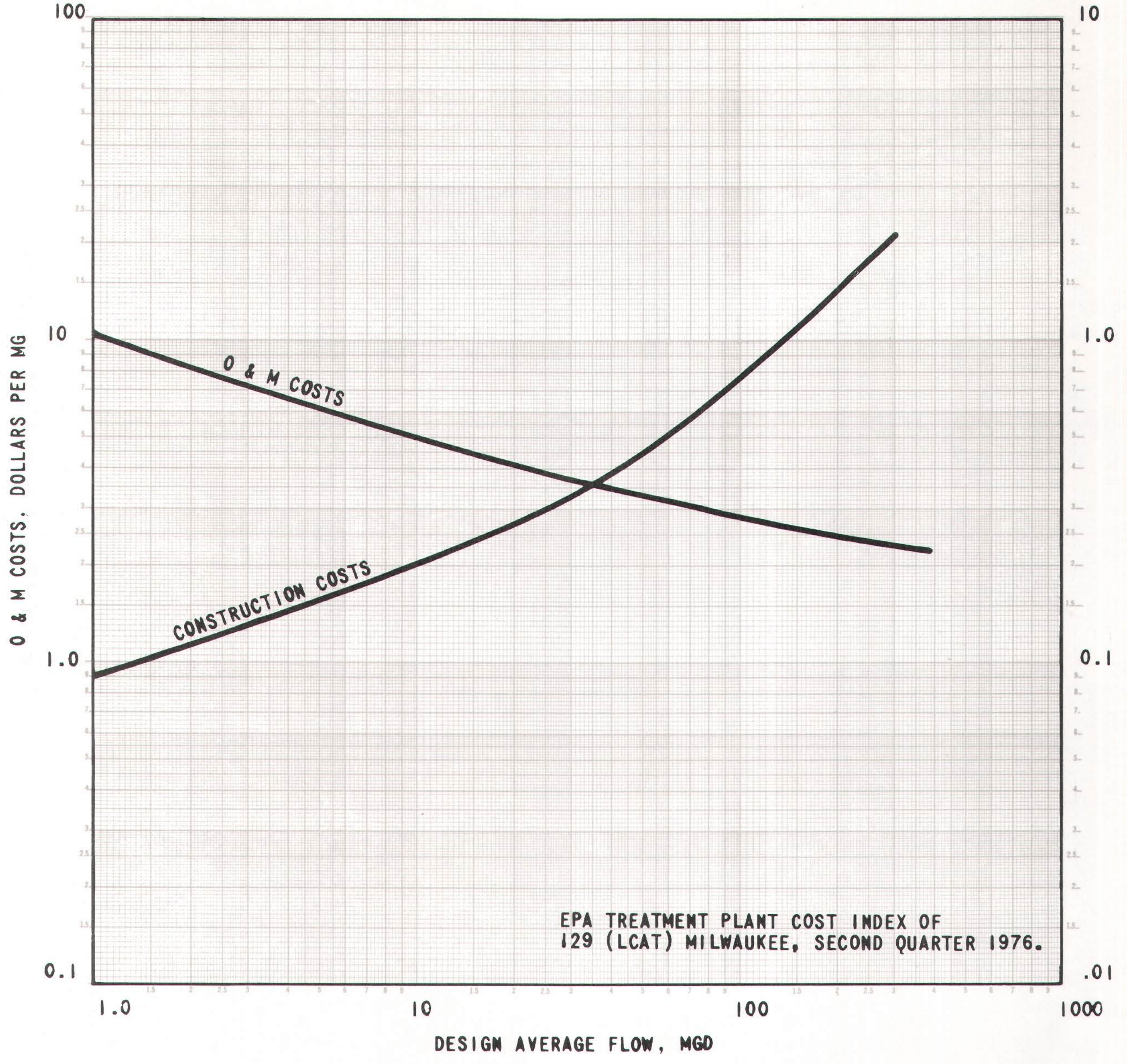


NOTE: COST INCLUDE PROVISIONS FOR CENTRALIZED PLANT INSTRUMENTATION AND MONITORING SYSTEM. ADDITIONAL COST CONSIDERATION MUST BE GIVEN FOR COMPUTER MONITORING AND CONTROL SYSTEMS

Source: Stanley Consultants.

Figure D-29

COOLING TOWERS



COSTS BASED ON: COOLING 20°F WITH 10° APPROACH

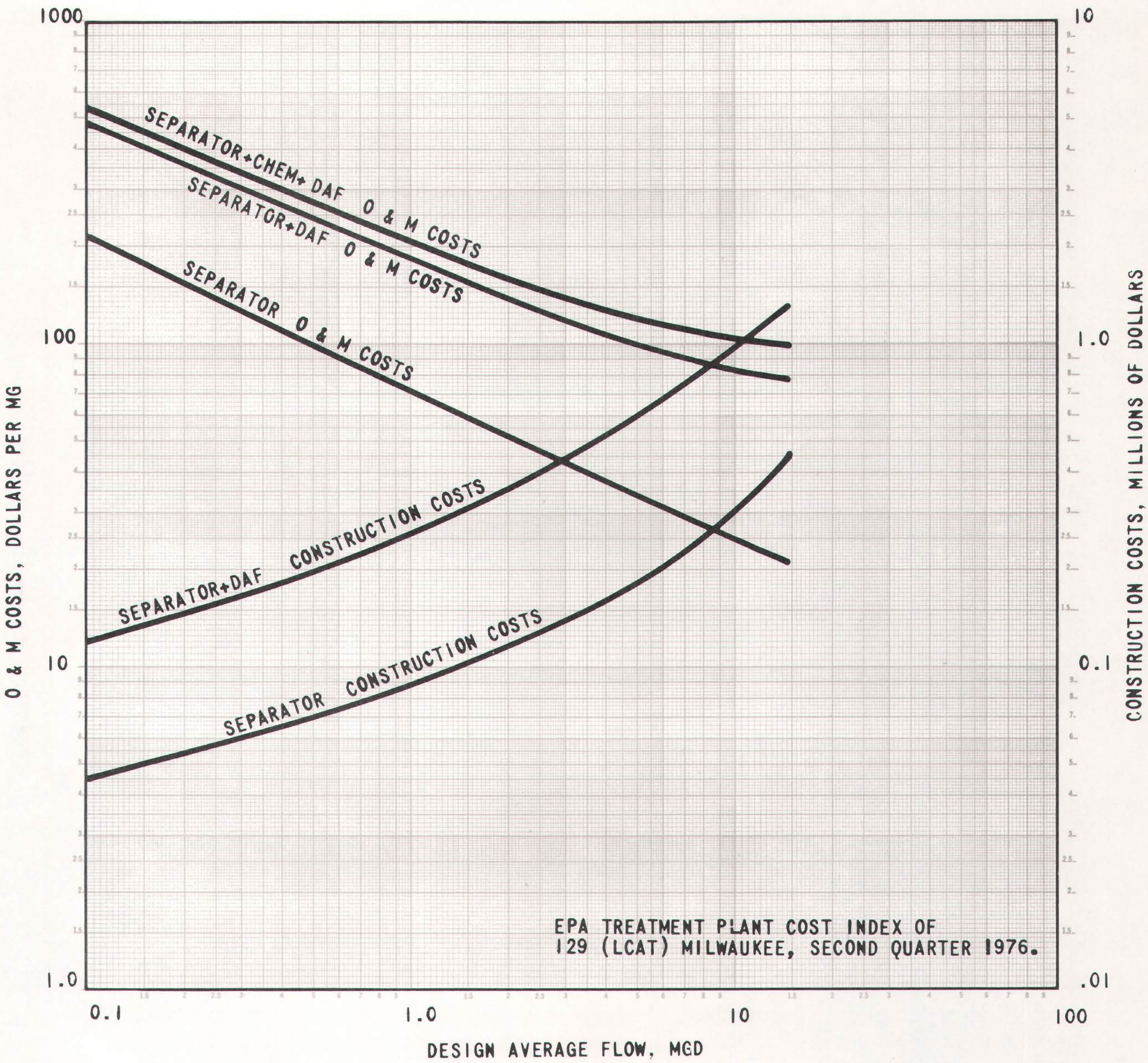
COSTS INCLUDE: COOLING TOWER & BASIN
SCALE CONTROL FEED & CHEMICALS

Source: Stanley Consultants.

RETURN TO
SOUTHEASTERN WISCONSIN
REGIONAL PLANNING COMMISSION
PLANNING LIBRARY

Figure D-30

OIL AND GREASE REMOVAL



NOTES: 1. PROCESS TREATS ONLY WATER. REMOVALS EXPECTED ARE:

	% REMOVAL	
	FREE OIL	EMULSIFIED OIL
SEPARATOR	75%	0%
SEPARATOR + DAF	85%	25%
SEPARATOR + CHEM + DAF	90%	75%

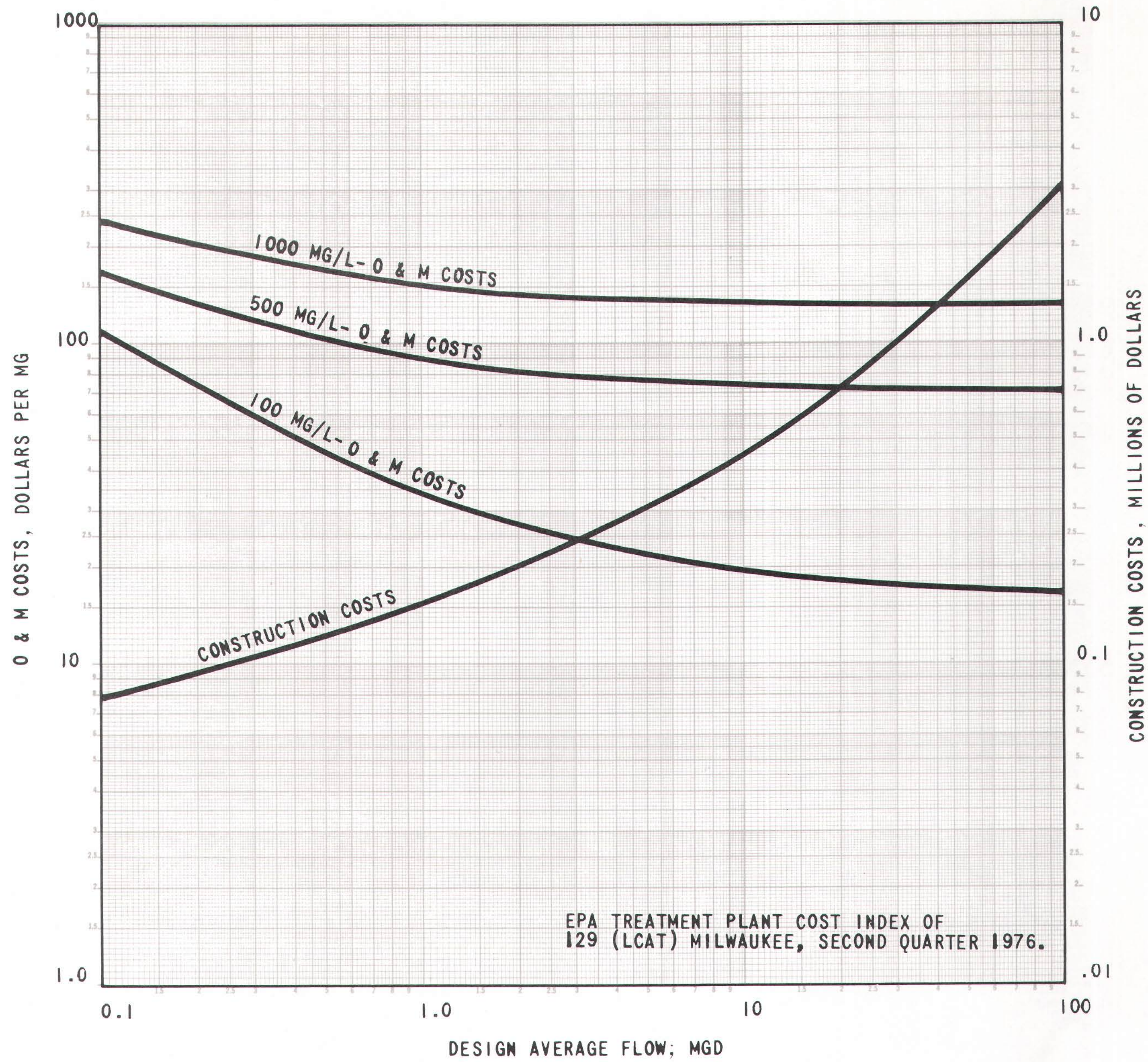
2. CHEMICAL ADDED TO DISSOLVED AIR FLOTATION (DAF) UNIT IS ALUM AT 60 mg/1.

3. PROCESS CAN BE FOLLOWED BY FILTRATION TO YIELD 95% TOTAL OIL REMOVAL.

Source: Stanley Consultants.

Figure D-31

HEAVY METAL PRECIPITATION

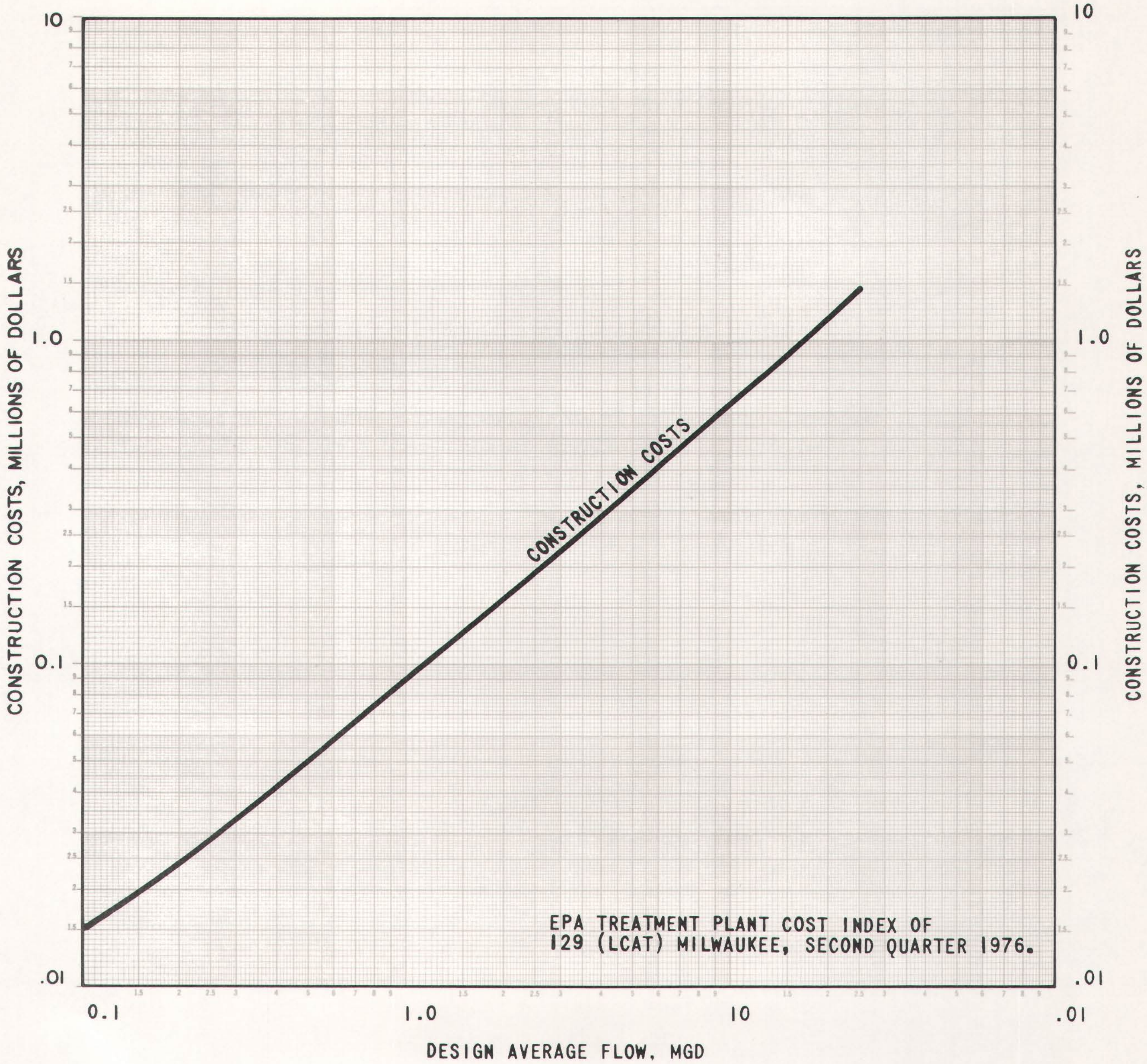


NOTES: 1. UNIT PROCESS IS LIME CLARIFICATION WITH DOSAGES AS SHOWN.
2. COSTS INCLUDE CLARIFIER AND CHEMICAL FEED.
3. SLUDGE DISPOSAL COSTS NOT INCLUDED.

Source: Stanley Consultants.

Figure D-32

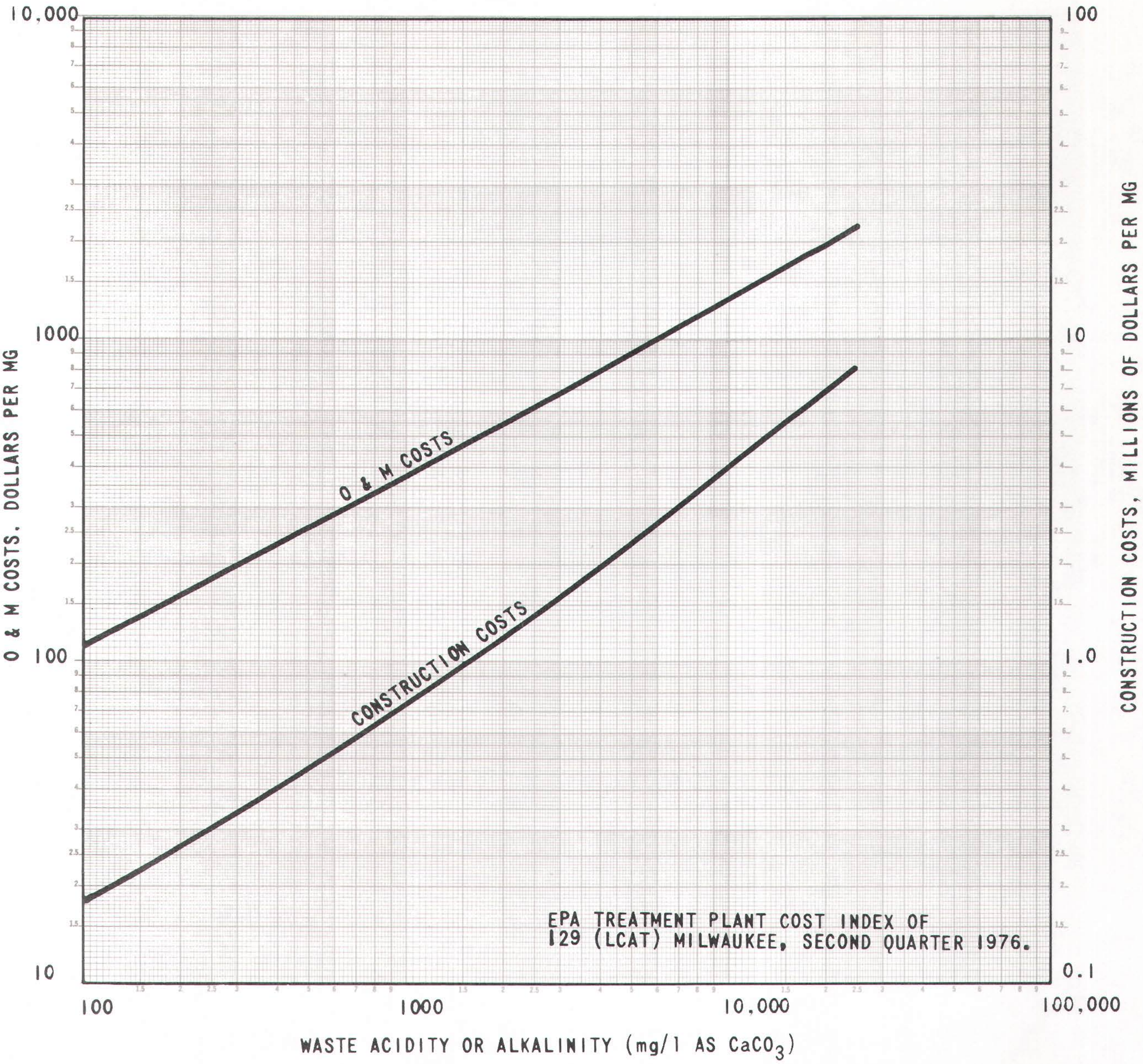
NEUTRALIZATION BASINS



Source: Stanley Consultants.

Figure D-33

NEUTRALIZATION, CHEMICAL, AND SLUDGE COSTS

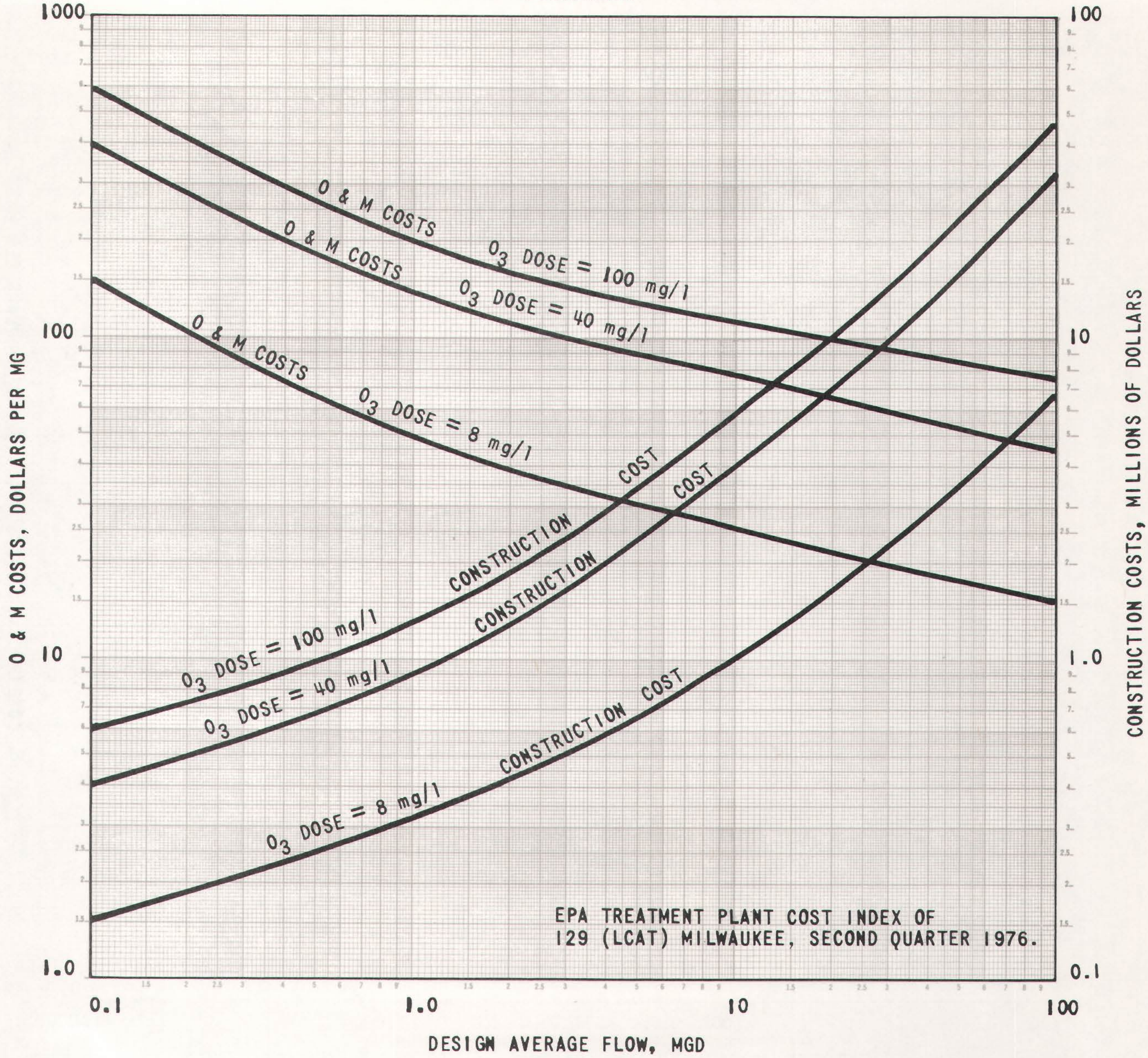


NOTES: 1. LIME OR SULFURIC ACID USED TO NEUTRALIZE.
2. COSTS INCLUDE SLUDGE DEWATERING BY VACUUM FILTRATION.

Source: Stanley Consultants.

Figure D-34

OZONATION



COST BASED ON: OZONE DOSE AS SHOWN.

COST INCLUDE: OZONE GENERATOR, AIR DRYER, CONTACTOR, CONTROL BUILDING AND CONTROLS.

NOTE

1. DOSE OF 8 mg/l WILL DISINFECT TO LESS THAN 200 FECAL COLIFORMS/100 ml AND PROVIDE EFFLUENT AERATION.
2. DOSE OF 40 mg/l AND 100 mg/l WILL REDUCE COD BY 10 AND 25 mg/l RESPECTIVELY, PROVIDE EFFLUENT AERATION, AND DISINFECTION.
3. COSTS BASED ON AIR FEED, USING OXYGEN FEED CAPITAL AND OPERATING COSTS WOULD BE ABOUT 40% OF CURVE VALUES, BUT OXYGEN (50 LB REQUIRED TO PRODUCE 1 LB OF 2% O_3) OF ABOUT \$60 TO \$75/TON WOULD NEED TO BE ADDED.

Source: Stanley Consultants.

Appendix E

CONSIDERATIONS FOR ZERO DISCHARGE

GENERAL

The Federal Water Pollution Control Act Amendments of 1972 introduced the concept of zero discharge of pollutants to be achieved as a goal by 1985. The level of treatment required to obtain zero discharge of pollutants has not been defined by regulatory agencies. Possible effluent criteria to be used for zero discharge were discussed in Chapter VIII. None of the schematics was developed for this high quality of effluent, and no facilities in the Region currently have discharge permits requiring this degree of treatment. Two additional schematics, and costs involved in the unit processes involved (that are not presented in Appendix D) are presented in this Appendix.

SCHEMATICS

Two schematics generally applicable to the Region for zero discharge are:

1. Land application for small facilities as discussed in Chapter IV.

2. A treatment and discharge system involving secondary biological treatment followed in sequence by biological nitrification-denitrification, two-stage lime clarification, multimedia filtration carbon adsorption, breakpoint chlorination, dechlorination, and post-aeration.

Both will achieve effluent requirements of 5 mg/l BOD_5, 5 mg/l TSS, 0.5 mg/l NH_3-N, 0.1 mg/l Total Phosphorus, 8 mg/l Total Nitrogen, while producing an effluent with dissolved oxygen greater than 6 mg/l and fecal coliform levels less than 200/100 ml for all influent levels discussed in Chapter II.[1] An alternative to breakpoint chlorination, dechlorination, and postaeration would be clinoptilolite ion exchange followed by postaeration. Ozonation is not expected to significantly alter ammonia or total nitrogen levels in the effluent and thus is not a viable alternative.

<u>Costs</u>

Additional unit processes involved in the above schematics include denitrification, two-stage lime clarification, lime sludge recalcination, and potentially clinoptilolite ion exchange. Costs for these unit processes are presented below. Costs for other unit processes involved in the schematics can be obtained using the cost curves in Appendix D.

Unit Process	Design Average Flow, mgd							
	Construction Cost[a] (Millions of Dollars)				O&M Cost[a] (Dollars per mg)			
	0.1	1	10	100	0.1	1	10	100
Two-stage lime clarification[b]	0.09	0.30	1.3	7.8	220	102	60	50
Lime recalcination[c]	0.20	0.50	1.5	4.9	430	80	35	20
Clinoptilolite ion-exchange[d]	0.10	0.22	1.7	13.0	300	160	95	60
Biological denitrification[e]	0.21	0.28	0.75	5.2	720	220	165	150

[a] *All costs August 1976, dollars.*

[b] *Costs include two flocculation/clarifier units, chemical storage and feed equipment, and recarbonation facilities, Clarifiers based on overflow rate of 1,000 gpm/ft^2 and lime dose is 300 mg/l.*

[c] *Costs include thickening and dewatering to 35 percent lime sludge which is fed to a furnace at 1,000 lbs/hour. Assumes lime sludge produced in 2,800 lb/mg treated.*

[d] *Costs include clinoptilolite regeneration with enclosed air stripping. Clinoptilolite regeneration rate of 450 lb/mg treated and exchange column loading of 1.5 gpm/ft^2 is assumed.*

[e] *Costs include denitrification tanks and clarifiers and methanol feed equipment. The tanks are sized for a detention time of two hours, clarifiers for an overflow rate of 1,000 gpm/ft^2, and methanol feed of 4.5 lbs methanol/lb nitrate nitrogen.*

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[1] *Effluent Limitations specified are based on a U. S. Army Corps of Engineers Analysis prepared as part of the Atlanta Urban Studies Program, under which Stanley Consultants, Inc., served as a primary contractor.*

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APPENDIX F

DEFINITION OF TERMS

The following list of definitions of terms related to sanitary sewerage systems includes and expands upon the definitions developed by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning and published in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974. The original list of definitions of terms set forth in Planning Report No. 16 was expanded to include terms utilized in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control for Southeastern Wisconsin, Volumes 1 and 2; and SEWRPC Planning Report No. 29, A Regional Sludge Management Plan for Southeastern Wisconsin. The additional definitions were derived from the following sources: Preliminary Draft of SEWRPC Planning Report No. 29—Chapter IV, Areawide Wastewater Sludge Management Planning Program, Camp Dresser and McKee, 1977; Glossary Water and Wastewater Control Engineering, APHA, ASCE, AWWA, NPCF, 1969; Process Design Manual for Carbon Adsorption, USEPA, 1973; Environmental Engineers Handbook—Volume 1—Water Pollution, 1974; Wastewater Engineering, Collection, Treatment, Disposal, 1972.

Activated Carbon Adsorption—The process which involves the accumulation or concentration of substances on an activated carbon surface. Adsorption of substances in wastewater onto activated carbon can occur as a result of two separate properties of the wastewater-activated carbon system: (1) the low solubility of a particular solute in the wastewater; and (2) a high affinity of a particular solute in the wastewater for the activated carbon.

Activated Sludge Process—A biological waste treatment process in which a mixture of sewage and activated sludge is agitated and aerated in a tank to oxidize the organic matter in the sewage. The activated sludge, which consists of a growth of zoogleal organisms, is subsequently separated from the treated sewage by sedimentation and wasted or returned to the process as needed.

Aeration, Extended—A modification of the activated sludge process which provides for aerobic sludge digestion within the aeration system.

Aeration, Step—A procedure for adding increments of settled sewage along the line of flow in the aeration tanks of an activated sludge sewage treatment plant.

Appurtenances—Appliances or auxiliary structures comprising an integral part of a sewerage system, such as manholes, manhole covers, ladders, frames, and screens to provide for ventilation, inspection, and maintenance of the sewerage system, as well as specialized structures for conveying sewage, such as depressed siphons and junctions.

Bypass—A flow relief device by which sanitary sewers entering a lift station, pumping station, or sewage treatment plant can discharge a portion or all of their flow, by gravity, directly into a receiving body of surface water to alleviate sewer surcharge; also a flow relief device by which intercepting or main sewers can discharge a portion or all of their flow, by gravity, into a receiving body of surface water to alleviate surcharging of intercepting or main sewers.

Centrate—The liquid extracted from a sludge in a centrifuge used either for thickening or dewatering. Its composition depends on the physical and/or chemical treatment of the sludge, the centrifugal force used in the unit, and the design of the centrifuge.

Centrifuge—A mechanical unit in which centrifugal force is used to separate solids from water.

Chlorination—The application of chlorine to sewage effluent generally for disinfection.

Clarifier—A unit of which the primary purpose is to secure clarification of waste water such as sedimentation tanks or basins.

Clarification—Any process or combination of processes the primary purpose of which is to reduce the concentration of suspended matter in a liquid.

Composting—A process using aerobic thermophilic organisms to stabilize dewatered sludge; usually placed in piles and mixed with material such as wood chips, leaves, and other organic matter to keep the pile aerobic. The piles can be artificially aerated.

Conditioning of Sludges—A process used to aid in releasing liquid from sludges. It consists of treating the sludges with various chemicals or subjecting them to physical conditioning such as heating or cooling, or processing them biologically.

Contact Stabilization Process—A modification of the activated sludge process in which raw sewage is aerated with a high concentration of activated sludge for a relatively short period of time to obtain CBOD removal by absorption, the solids being subsequently removed by sedimentation, and transferred to a stabilization tank where aeration is continued to further oxidize and condition the sludge before reintroduction to the raw sewage flow.

Crossover—A flow relief device by which sanitary sewers discharge a portion of their flow, by gravity, into storm sewers during periods of sanitary sewer surcharge or by which combined sewers discharge a portion of their flow, by gravity, into storm sewers to alleviate sanitary or combined sewer surcharge.

Design Capacity, Average Hydraulic—The average influent sewage flow at which a sewage treatment plant will operate at design pollutant removal efficiencies.

Design Capacity, Organic—The average biochemical oxygen demand of the influent sewage, expressed as pounds of $CBOD_5$ per day, which the sewage treatment plant is designed to treat.

Design Capacity, Peak Hydraulic—The maximum influent sewage flow for which the plant is designed to operate without flooding; pollutant removal is still performed under this flow condition but at a much lower efficiency than the design efficiency.

Dewatering—The removal of additional liquid so that thickened sludge attains properties of a solid—that is, it can be shoveled, conveyed on a sloping belt, and handled by typical solids handling methods. Such dewatered sludge is usually in the form of a "cake" such as that produced by a centrifuge, vacuum filter, or filter press.

Digestion, Aerobic—The decomposition of organic matter in the presence of elemental oxygen.

Digestion, Anaerobic—The decomposition of organic matter resulting in gasification, liquification, and mineralization through the action of microorganisms in the absence of elemental oxygen.

Fertilizer—A material of known nitrogen, phosphorus, and potash content which is applied to land for the purpose of increasing plant growth by increased availability of known chemicals. The chemical content is commonly expressed as a three-number sequence (such as 20-10-5) denoting relative weights of N, P_2O_5, and K_2O.

Filter Backwash Waters—The water resulting from backwashing for removal of solids retained by granular media filters which are used to physically remove suspended solids from wastewater treatment plant effluents.

Filter Press—A mechanical press for separation of water from sludge solids.

Filtrates—The liquid extracted from a sludge in vacuum filters, filter presses, belt filters, and other devices in which liquid is separated from solids by applying a differential force across a porous fabric, screen, or other medium.

Filtration—The process of passing a liquid through a filtering medium consisting of granular material, such as sand, magnetite, anthracite, garnet, activated carbon or diatomaceous earth, finely woven cloth, unglazed porcelain, or specially prepared paper, to remove suspended or colloidal matter.

Fixed-Growth Media Biological Treatment Processes—A general categorization of processes such as trickling filters and rotating biological contactors.

Flash Mixer—A device for quickly dispersing chemicals uniformly throughout a liquid.

Force Main—A pipeline joining the discharge of a pumping station with a point of gravity flow designed to transmit sewage under pressure flow throughout its length.

Grit Chamber—A detention chamber designed to reduce the velocity of the influent sewage to permit the removal of coarse minerals from organic solids by differential sedimentation.

Heat Treatment or Conditioning—The application of heat and pressure to sludge to make the sludge more amenable to dewatering.

Holding Tank—An onsite storage tank for short-term storage of sewage as part of a sewage disposal process whereby the wastes are periodically removed from the tank and transported by tank truck to a suitable treatment and discharge facility. The systems are generally only utilized where centralized sanitary sewerage service is unavailable and soils are not suitable for septic systems installation and use.

Incinerator—A mechanical device for controlled combustion. Special designs may be used to incinerate or to maximize energy recovery or volume reduction, or destruction of toxic or hazardous materials.

Infiltration—The water entering a sanitary sewerage system from the ground, through such means as, but not limited to, defective pipes, pipe joints, connections, or manhole walls. Infiltration does not include, and is distinguished from, inflow.

Inflow—The water discharged into a sanitary sewerage system from such sources as, but not limited to, roof leaders, cellar, yard, and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross-connections from storm sewers and combined sewers, catch basins. Inflow consists of storm water runoff, street wash waters, and other forms of surface drainage and does not include, and is distinguished from, infiltration.

Intercepting Structure—A structure designed to intercept all dry-weather sanitary sewage flow in a combined sewer and a proportionate amount of the mixed storm water and sanitary sewage flow during periods of rainfall or snowmelt and discharge such flows to an intercepting sewer.

Sludge Lagoon—A bermed or ponded area for the storage and partial dewatering of wastewater sludge.

Leachate—The liquid that is produced from landfills due to organic decomposition, dewatering of sludge, and rain water.

Loading, Average Hydraulic—The arithmetic average of the total metered daily flow at a sewage treatment plant for any selected year.

Loading, Peak Hydraulic—The greatest total daily sewage flow received by a treatment plant in any selected year.

Microstrainer—An extremely fine rotating screen for the removal of very small suspended solids in sewage.

Multimedia Filter—A treatment unit utilized to process wastewater by passing the liquid through a multiple of three media—usually combinations of sand, anthracite, activated carbon, weighted sperical resin beds, and garnet—for the removal of suspended or colloidal matter.

Neutralization—The reaction of acid or alkali with an opposite reagent until the concentrations of hydrogen and hydroxyl ions in the solution are approximately equal.

Nitrification—The conversion of nitrogenous matter—primarily ammonia—into nitrates by bacteria.

Package Plant—A relatively small, usually prefabricated, sewage treatment plant.

Polishing Lagoon—An unaerated lagoon designed and intended to upgrade or stabilize secondary, tertiary, or advanced wastewater treatment process effluent by natural oxidation of organic matter and settling.

Population Equivalent—The existing or design organic loading to a sewage treatment plant expressed in population and based on an average normal domestic sewage strength and flow.[1]

Precipitation—The phenomenon that occurs when a substance held in solution in a liquid passes out of solution into solid form.

Pretreatment—The conditioning of a waste at its source before discharge to remove or to neutralize substances injurious to sewers and treatment processes or to effect a partial reduction in load on the treatment process. The term generally applies to the conditioning of industrial wastes before discharge to municipal sewerage systems.

Private Sanitary Sewerage System—A waste water disposal system providing conveyance, treatment, and final disposal for wastes from users who have agreed-upon rights to the benefits of the facility which is owned and operated by an individual owner, either a private business or a public institution.

Public Sanitary Sewerage System—A wastewater disposal system providing conveyance, treatment, and final disposal for wastes from users who all have equal rights to the benefits of the utility which is owned and operated by a legally established governmental body.

Pyrolysis—A process for heating sludge so that the organic matter present decomposes into burnable gases, liquids similar to petroleum, and char. The process is carried on in the absence of air or with an air supply which is for combustion.

Reverse Osmosis—The process in which a solution is pressurized to a degree greater than the osmotic pressure of the solvent, causing it to pass through a membrane, carrying only reduced levels of the chemical constituents of the solution.

Sand Drying Beds—A layer of sand contained between low level concrete or wooden walls, underlaid by a system of drains. Sludge is placed or poured on the bed and partially dewatered by air drying and filtration of the liquid through the sand into the underdrains for return to the treatment plant.

Screening—The removal of floating and suspended solids in sewage by straining through racks or screens.

Sedimentation—The process of subsidence and deposition of the suspended matter in sewage by gravity, usually accomplished by reducing the velocity of the sewage below the point at which it can carry suspended matter. Primary sedimentation occurs in a complete sewage treatment process before biological or chemical treatment; secondary sedimentation occurs after such treatment.

Septic System (Mound Type)—A septic system which incorporates as a drain field, granular material placed on a mound above the existing grade and receiving pumped septic tank effluent for discharge to the inside of the mounded bed through tile levees. The granular material allows the liquid to be lifted to the surface by capillary action to evaporate or be used by vegetation atop the mound, or allows the liquid to infiltrate the underlying soil after undergoing some filtration within the mound.

Septic Tank—A settling tank in which organic solids are settled and decomposed by anaerobic bacterial action, with the settled sludge being an immediate contact with sewage flowing through the tank. The treated sewage is then discharged to the groundwater reservoir by underground tile lines.

Sewage—The spent water of a community consisting of a combination of liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, or storm water which may be unintentionally present.

Sewage Lagoon—A shallow body of water containing partially treated sewage in which aerobic stabilization occurs.

Sewage Treatment Plant—An arrangement of devices and structures for treating sewage in order to remove or alter its objectionable constituents and thus render it less offensive or dangerous.

Sewage Treatment Plant Efficiency—The ratio of the amount of pollutant removed by the sewage treatment plant to the amount of pollutant in the influent sewage expressed in percent.

Sewer—A pipe or conduit, generally closed but not normally flowing under pressure, for carrying sewage.

Sewer, Branch—A common sewer receiving sewage from two or more lateral sewers serving relatively small tributary drainage areas.

Sewer, Building—A private sewer conveying sewage from a single building to a common sewer; also called house connection.

Sewer, Combined—A common sewer intended to carry sanitary sewage, with component domestic, commercial, and industrial wastes, at all times, and which, during periods of rainfall or snowmelt, is intended to also carry storm water runoff from streets and other sources.

Sewer, Common—A sewer in which all abutters have equal rights; also called public sewer.

Sewer, Intercepting—A common sewer that receives dry-weather sanitary sewage flows from a combined sewer system and predetermined proportionate amounts of the mixed storm water and sanitary sewage flows during periods of rainfall or snowmelt and conducts these flows to a point of treatment or disposal.

Sewer, Lateral—A common sewer discharging into a branch or other common sewer and having no other common sewer tributary to it.

Sewer, Main—A common sewer which receives flows from many lateral and branch sewers serving relatively large tributary drainage areas for conveyance to a treatment plant; also called trunk sewer.

Sewer, Outfall—A sewer that receives flows from a collection system or from a treatment plant and conveys the untreated or treated waste flows to a point of discharge into a receiving body of surface water.

Sewer, Relief—A common sewer built to carry the flows in excess of the capacity of an existing sewer, thus relieving surcharging of the latter.

Sewer, Sanitary—A common sewer which carries sewage flows from residences, commercial buildings and institutions, certain types of liquid wastes from industrial plants, together with minor amounts of storm, surface, and ground waters that are not intentionally admitted.

Sewer, Storm—A common sewer which carries surface water and storm water runoff from open areas, rooftops, streets, and other sources, including street wash and other wash waters, but from which sanitary sewage or industrial wastes are specifically excluded.

Sewerage System—A system of piping, treatment facilities, and appurtenances, for collecting, conveying and treating wastewater.

Skimmings—The material that is skimmed from the surface of clarifier basins including liquid, such as oil, floating grease and other debris.

Sludge—An aqueous suspension of residual solids generated through the treatment of a municipal or industrial wastewater, and of such a nature and concentration as to require special consideration for disposal. Industrial residuals having economic value without significant processing are not included under this definition.

Soil Conditioner—A material which, when applied to land, increases the ability of the soil to absorb water and hold nutrients as well as improving soil tilth.

Stabilization Lagoon—A shallow pond for storage of wastewater before discharge. Such lagoons may serve only to detain and equalize wastewater composition before regulated discharge to a stream, but often they are used for biological oxidation.

Stabilization Pond—A type of oxidation pond in which biological oxidation of organic matter is affected by natural or artificially accelerated transfer of oxygen to the water from air.

Station, Lift—A relatively small sewage pumping installation designed to lift sewage from a gravity flow sewer to a higher elevation when the continuance of the gravity flow sewer would involve excessive depths of trench, or designed to lift sewage from areas too low to drain into available sewers. Lift stations normally discharge through relatively short force mains to gravity flow points located at or very near the lift station.

Station, Portable Pumping—A point of flow relief at which flows from surcharged sanitary sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of portable pumping units.

Station, Pumping—A relative large sewage pumping installation designed not only to lift sewage to a higher elevation but also to convey it through force mains to gravity flow points located relatively long distances from the pumping station.

Station, Relief Pumping—A flow relief device by which flows from surcharged main sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of permanent lift or pumping stations.

Supernatant—The liquid that is decanted from an anaerobic or aerobic digester and which generally contains a high concentration of suspended and dissolved organic matter plus inorganics such as ammonium compounds, phosphates, heavy metals, bicarbonates of calcium, and magnesium, as well as various types of pathogens.

Thickening—Processes for concentrating sludges up to a maximum of about 10 percent solids content.

Treatment, Advanced—This may be defined as additional physical and chemical treatment to provide removal of additional constituents, particularly phosphorus and nitrogen compounds, by such means as chemical coagulation, sedimentation, charcoal filtration, and aeration. Although advanced treatment is traditionally conceived of as following secondary treatment or as combined with tertiary treatment, it can be performed following primary treatment or as an integral part of secondary treatment. Advanced treatment may remove 90 percent or more of the raw influent phosphorus and may remove up to 90 percent of the raw influent nitrogen, or effect up to 95 percent reduction in the oxygen demand of ammonia in the sewage treatment plant influent by coverting the ammonia compounds to nitrate.

Treatment, Auxiliary—This may be defined as a treatment measure used in combination with all other treatment methods, and includes, for example, effluent aeration and disinfection by chlorination.

Treatment, Primary—This may be defined as physical treatment of raw sewage in which the coarser floating and settleable solids are removed by screening and sedimentation. Primary treatment normally provides 50 to 60 percent reduction of the influent suspended matter and 25 to 35 percent reduction of the influent carbonaceous biochemical oxygen-demanding organic matter ($CBOD_{ult}$). It removes little or no colloidal and dissolved matter.

Treatment, Secondary—This may be defined as biological treatment of the effluent from primary treatment, in which additional oxygen-demanding organic matter is removed by trickling filters or activated sludge tanks and additional sedimentation. Secondary treatment normally provides up to 90 percent removal of the raw influent suspended matter and 75 to 95 percent removal of the raw influent $CBOD_{ult}$. Secondary treatment facilities can be designed and operated to also remove 30 to 50 percent of the raw influent nitrogenous biochemical oxygen demand ($NBOD_{ult}$) and 30 to 40 percent of the raw influent phosphorus content of the influent sewage.

Treatment, Tertiary—This may be defined as physical and biological treatment of the effluent from secondary treatment, in which additional oxygen-demanding matter is removed by use of shallow detention ponds to provide additional biochemical treatment and settling of solids of filtration using sand or mechanical filters. Tertiary treatment normally provides up to 99 percent removal of the raw influent suspended matter and 95 to 97 percent of the raw influent $CBOD_{ult}$.

Trickling Filter Process—A biological waste treatment process in which sewage is applied in spray form from nozzles or other distribution devices over a filter consisting of an artificial bed of coarse material, such as broken stone, through which the sewage trickles to underdrains, giving opportunity for the formation of zoogleal slimes which clarify and oxidize the sewage.

Vacuum Filter—A filter consisting of a cylindrical metal drum covered with cloth or other media revolving on a horizontal axis with partial submergence in liquid sludge. A vacuum is maintained under the media to extract moisture from the sludge which adheres to the cloth or media and is scraped off continuously for disposal.

Wet Air Oxidation—A method of sludge disposal that involves oxidation under pressure, at high temperatures.

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[1] *In the regional sanitary sewerage system planning program the average sewage strength was assumed to be 200 mg/l of $CBOD_5$ and the average domestic sewage flow was assumed to be 125 gallons per capita per day. This concentration and daily per capita flow are equivalent to 0.21 pound of $CBOD_5$/capita/day. The population equivalent was computed for either the existing or design loading by dividing the daily $CBOD_5$ loading in pounds by 0.21 pound of $CBOD_5$/capita/day. The computation of equivalent population can also be based on suspended solids by dividing the daily suspended solids loading in pounds by 0.21 pound suspended solids/capita/day.*