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WASTE FROM THE WATER TREATMENT PLANT AT ALTON AND ITS IMPACT ON THE MISSISSIPPI RIVER

by

Ralph Evans, Thomas Hill,

Donald Schnepper, and David Hullinger

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INTRODUCTION

The treatment of water for public supplies in Illinois is accomplished by a variety of processes. The basic methods require facilities for clarification; softening by lime, soda ash, and ion exchange; iron and manganese removal; and solely chlorination. With the exception of chlorination, each treatment process produces a quantity of wastes. These wastes consist mainly of solids in the suspended and dissolved form at concentrations exceeding that of the raw water being treated. The solids are derived from suspended and dissolved forms in the source water, the chemical additions, and the resultant chemical reactions.

The two principal sources of waste from water treatment plants in Illinois are basin sludge and waste derived from backwash operations. The characteristics of the waste are a function of the treatment process. Basin sludge from lime softening plants consists principally of calcium carbonate, hydroxides of magnesium, aluminum, and other coagulants; inorganic debris; and organic matter. Sludges from clarification units are basically a mixture of aluminum hydroxide, polyelectrolytes or other coagulants, inorganic debris, and organic matter. The quantity and composition of the filter backwash water are functions of the process and the efficiency of the treatment units preceding the filter. Wastes from ion exchange units are derived from recharge operation and are exceedingly high in dissolved solids.

The State Water Survey initiated an examination of the production, composition, and disposal practices of wastes from water treatment plants in Illinois during 1968-1969. This work by Evans and Schnepper (1970) led to several findings. One was that "The variability of treatment plant processes, dictated by raw water quality and the habits of operating personnel, precluded any definitive conclusions applicable to *all* areas of the state." Nevertheless considerable experience was gained toward the development of sampling and analytical techniques designed to quantify and characterize the waste generated at water treatment plants. But a lesson had been learned — one cannot generalize about the production of wastes at water treatment facilities nor the impact of the wastes on the aquatic environment.

Several years later an opportunity developed leading to a site-specific study at water treatment facilities serving the city of Pontiac, Illinois. The study by Evans et al. (1979) was designed to assess the impact of wastes on a small stream as well as to test certain evaluative procedures. The experience gained during the course of the work confirmed the basic principle that waters of a stream possess the capability of assimilating waste without significant degradation in water quality for normal usage. This capability is a function of many variables. Because of this variability, an intelligent examination at each site is necessary to permit rational decisions.

The study at Pontiac involved a relatively small treatment facility of 1.8 million gallons per day (mgd) on a relatively small stream with an average flow of about 370 cubic feet per second (cfs). An opportunity to examine a large community on a large stream, as proposed by the American Water Works Service Company, was welcomed. This report deals with wastes produced at the water treatment facility at Alton, Illinois, using the Mississippi River as the raw water source. The procedures used and the results obtained for assessing the effects on the river of wastes from the water treatment facility are summarized.

Study Area

The water treatment plant in the city of Alton (pop. 40,000) in Madison County is operated by the Alton Water Company. In addition to the citv of Alton the plant services the communities of Godfrey (pop. 15,000) and Elsah (pop. 1,000) as well as several water districts and assorted industries. The plant is located along the Mississippi River in the vicinity of and upstream of Lock and Dam No. 26. Plant buildings and the water intake are shown in figure 1. Wastes from the plant are discharged into the Mississippi River below the water intake. Figure 2 shows the location of the water treatment plant and the configuration of the receiving stream.

The drainage area of the river above the plant is about 171,500 square miles. Average streamflow is about 99,675 cfs or 64,431 mgd. Streamflows

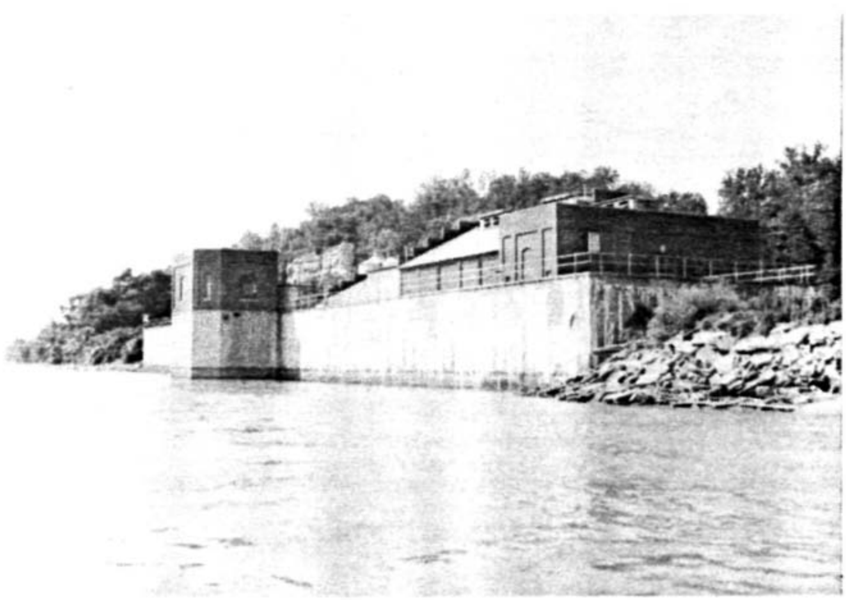


Figure 1. Water intake and plant buildings at Alton

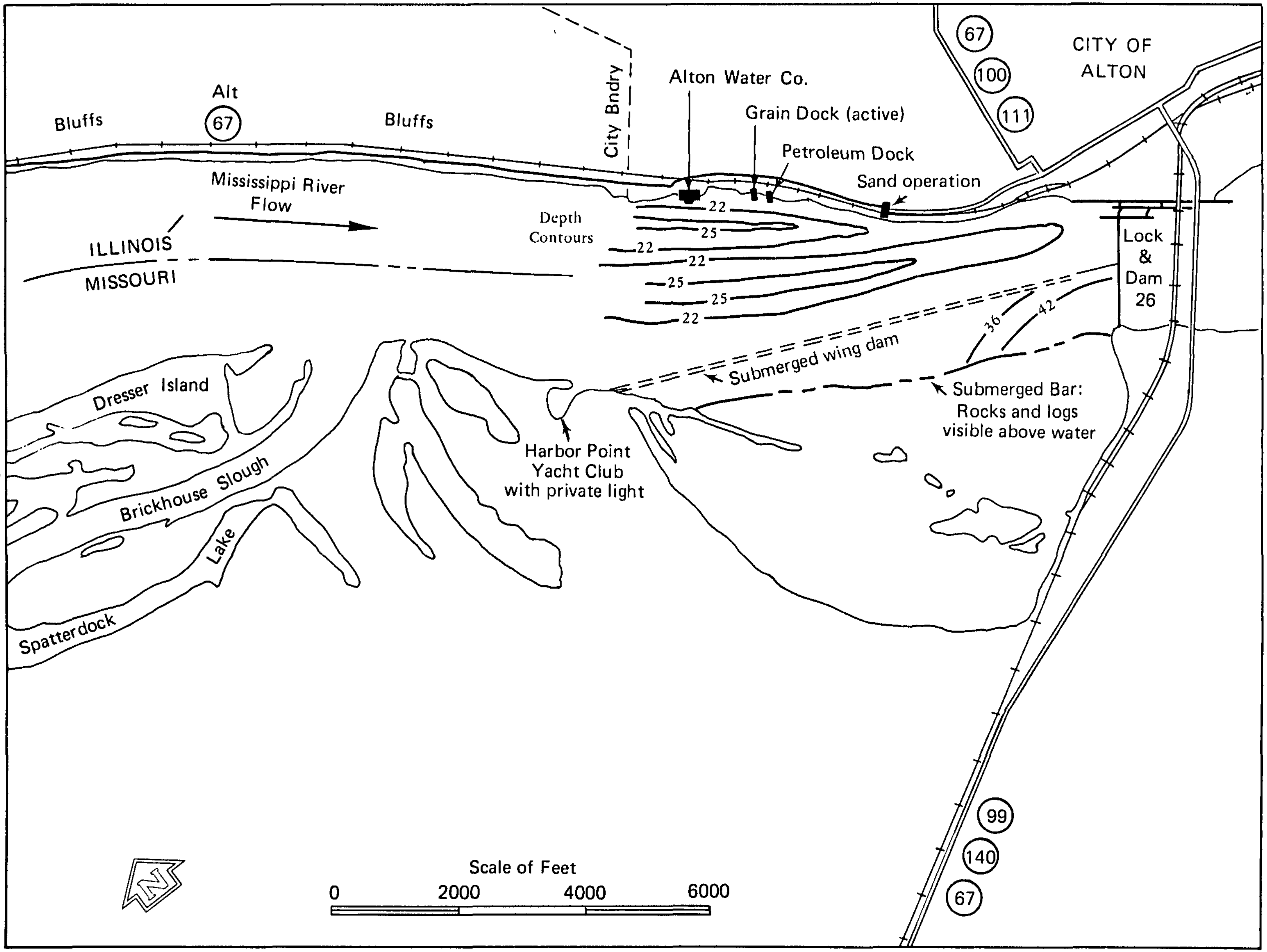


Figure 2. Site map: Alton Water Company

are variable. For example, during the 1980 water year (provisional data) the minimum flow was 28,500 cfs while the maximum flow was 223,000 cfs. As shown in figure 3, the highest normal monthly mean flows based on daily records occur during March through June. Like the flows, the turbidity of the river water is also variable. From data gained from operation reports maintained by plant personnel at Alton, table 1 was prepared. The mean daily turbidity

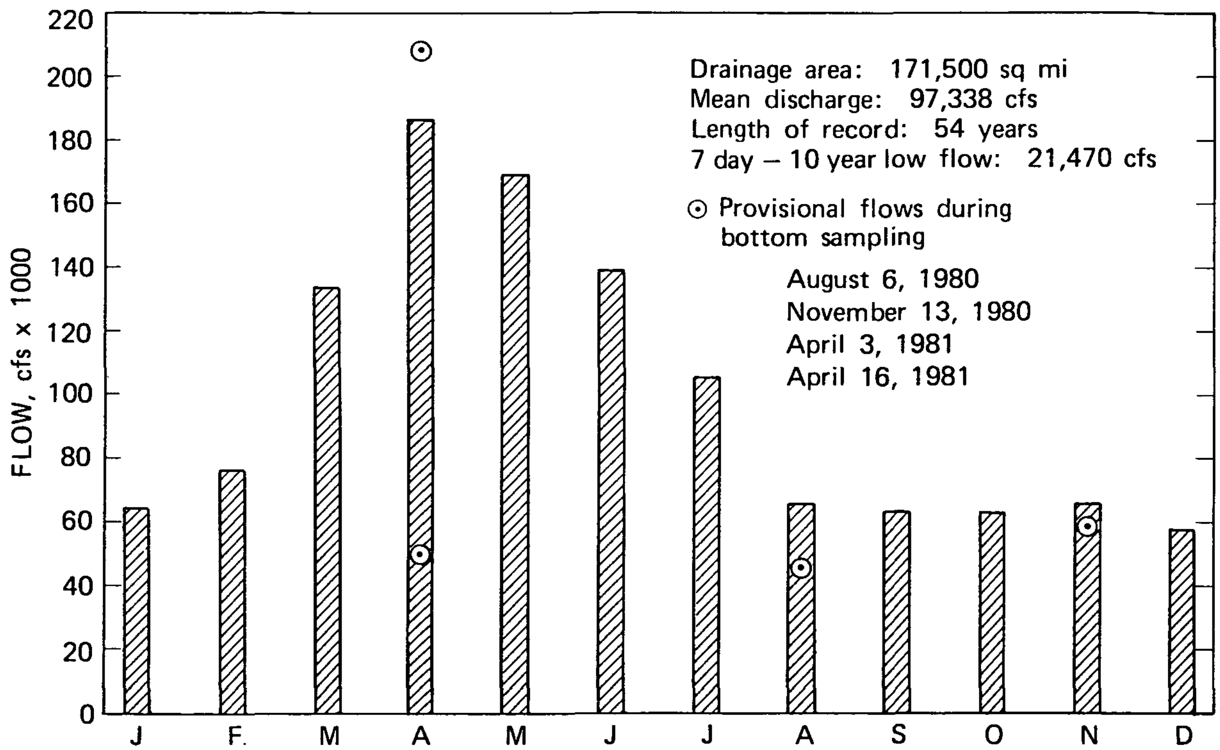


Figure 3. Normal monthly mean flow (all days), Mississippi River at Alton

Table 1. Mean Daily Turbidity for Succeeding Months

J	F	M	A	M	J	J	A	S	O	N	D
33	31	153	130	82	133	97	47	69	39	30	38

M, A, M, J, J, A, S, O **Avg: 94 JTU**

N, D, J, F **Avg: 33 JTU**

For period March 1978 to February 1981
Turbidity in Jackson Turbidity Units (JTU)

during November, December, January, and February averages 33 Jackson Turbidity Units (JTU). During other months the average is about 94 JTU. From computed relationships of turbidity to suspended solids, which will be discussed later, the average concentration of suspended solids in the river water is estimated to be 118 milligrams per liter (mg/l).

Within the vicinity of the plant's waste outfall are three commercial installations that may inadvertently contribute material to the river water. These include grain, petroleum, and sand transfer operations (see figure 2).

Objectives and Scope

A principal objective of the study was the refinement of procedures that others might find useful in similarly examining the effects, if any, of waste loads from water treatment plants on the water quality of receiving streams. The basic tasks performed to accomplish this objective were:

1) Determine quantities, characteristics, and release patterns of waste generated within the water plant

2) Compare the relative loads of wastes discharged to the loads conveyed by the stream waters

3) Document the physical and chemical characteristics of bottom sediments of the receiving stream within and without the area of waste discharge influence

4) Ascertain the type and abundance of benthic organisms in the stream bottom sediment

These findings are reported here in two sections, i.e., the water treatment plant study, and the benthic (physical, chemical, and biological) characteristics of the stream bottom. There is also a concluding section. All pertinent data developed during the course of the study (April 1980-June 1981) are included in the appendices.

Acknowledgments

This report was prepared under the general administrative direction of Stanley A. Changnon, Chief of the Illinois State Water Survey. Clarence Blanck, Director of Water Quality of the American Water Works Service Company, proposed the site for the study and provided cooperation and encouragement throughout. All operating personnel at the plant site capably assisted in sampling and measurements. James Carter, Water Quality Supervisor, and Harold Etzkorn, Production Superintendent of the water treatment plant were most helpful in arranging for sampling schedules, making available operational data, and offering guidance. The authors are grateful to other members of the Survey who participated in the work. Daniel Gallagher, Richard Twait, and Dave Cooksley assisted in benthic sampling; Dana Shackleford and Brent Gregory assisted in chemical analyses. Linda Johnson typed the original manuscript, and J. Loreena Ivens edited it. John W. Brother, Jr., and William Motherway, Jr., prepared the illustrations.

WATER TREATMENT PLANT STUDY

The water treatment plant at Alton (see figure 4) provides facilities for coagulation, settling, and filtration. A flow diagram of the treatment units is shown in figure 5. Until August 1976 lime softening was practiced at the plant. Since then the plant has provided clarification treatment utilizing polymers supplemented by alum. Three pumps are available for pumping water from the intake structure to the two mixers. Two of the pumps have a rated capacity of 10 mgd at a total dynamic head (TDH) of 48 feet. The other pump has a capacity of 6 mgd at a TDH of 50 feet. Pumpage of raw river water during the period of study, and for the past three years, averages 12.546 mgd. During this three-year period the maximum daily pumpage (July 16, 1980) was 16.0 mgd. This provides a maximum to average pumpage ratio of 1.28.

The raw water is dosed with alum and polymer at the intake on the suction side of the raw water pumps. Dosages vary with river water quality but the average concentration of alum in the water is about 29 mg/l. Polymer (NALCO 8793) concentrations in the water are generally less than 1 mg/l. From the pumps the dosed flow is conveyed to two circular mixers operating in parallel. Each mixer is 40 feet in diameter with a side water depth (SWD) of 19.5 feet. For average flow conditions a detention time of about 42 minutes is provided.

Flow from the mixers proceeds to a clarifier (see figure 6) with a diameter of 75 feet and an SWD of 19 feet. A small quantity of lime, providing a concentration in the water of 3 to 10 mg/l, is added for pH adjustment at the influent of the clarifier. At average flow the detention time provided by the clarifier is about 75 minutes. Pre-chlorination and, at times, a coagulant aid is also provided at the clarifier influent.

Figure 4. Main building of water plant at Alton

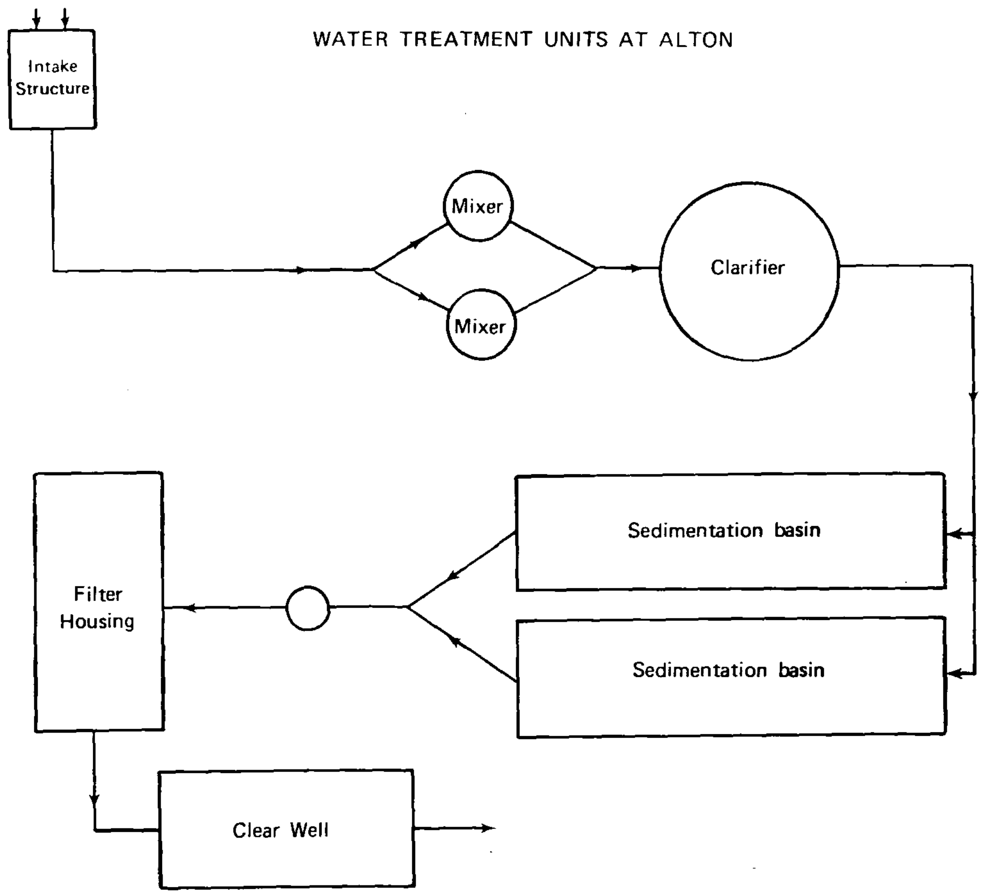


Figure 5. Water treatment units at Alton

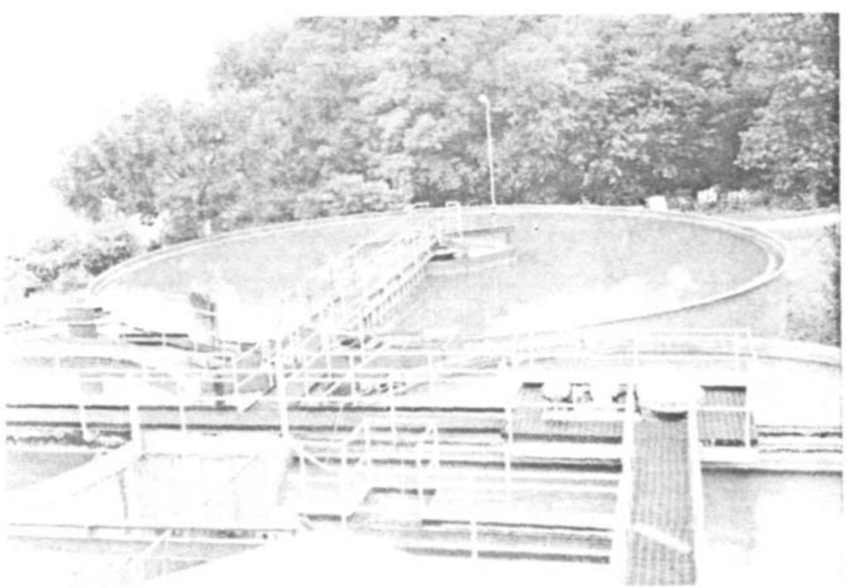


Figure 6. Two mixers in foreground with elarifier in background

Effluent from the clarifier is tributary to two sedimentation basins (see figure 7) operating in parallel. Each basin, rectangular in form, is about 160 feet long and 50 feet wide with an SWD of 21 feet. The basins are the two-cell type with a single tray providing for an under and over flow pattern. At average pumpage the total detention time provided by the basins is 4.8 hours. From the sedimentation basins flow is to 14 filters equipped with Leopold bottoms and a media of 30 inches of sand over gravel. The filters (see figure 8) vary in size because of periodic plant expansions. For purposes of sampling and discussion the filters are here grouped in five sets. The grouping, corresponding area per filter, and number of filters are as follows:

Group	A	B	C	D	E*
Area (sq ft)	201	236	231	217	243
Number	4	4	2	2	4
Total area (sq ft)	804	944	462	434	972

* Group E contains two double filters but each half is backwashed at a time. For the purpose of this report these two double filters are considered four filters. Thus the total number of filters considered here is 16.

The total area for filtration of the clarified water is about 3616 square feet. Although designed for a filtration rate of 2.0 gallons per minute per square foot (gpm/ft^2), at the average pumpage of 12.546 mgd, the filtration rate is about 2.4 gpm/ft^2. This is assuming that all flow is distributed equally among the filters. Post-chlorination and fluoride additions are made at the influent to the filters at a structure previously used for recarbonation. When required, a filter aid is also added.

Flow from the filters proceeds to a clear well with a total capacity of about 0.65 million gallons, from which it moves to service lines.

The units producing wastes include the mixers, clarifier, sedimentation basins, and filters. Wastes are discharged to the Mississippi River. At river stage of 414 feet above mean sea level (msl) or less, wastes can be discharged by gravity. Above this elevation pumping is required. The normal pool stage at Alton is about 419 msl.

Sampling Procedures

The mixers and sedimentation basins are decanted two times a year and the residual solids flushed by fire hose to the river. The operation is usually performed during the spring and fall. During the period of study these operations occurred during November 3-5, 1980, and March 30-April 1, 1981. A previous decanting and flushing operation had occurred on April 21-23, 1980. About 2 to 3 days are required for cleaning the mixers and sedimentation basins.

The clarifier is "blown-down" about once every three days at a rate of 58 gpm for a period of 60 minutes. The sand filters are backwashed at a rate of 4200 gpm on the average of once every 16 hours. The duration of backwash per filter averages about 5 to 7 minutes. Generally 24 filters are backwashed per day.

Figure 7. Sedimentation basin at Alton

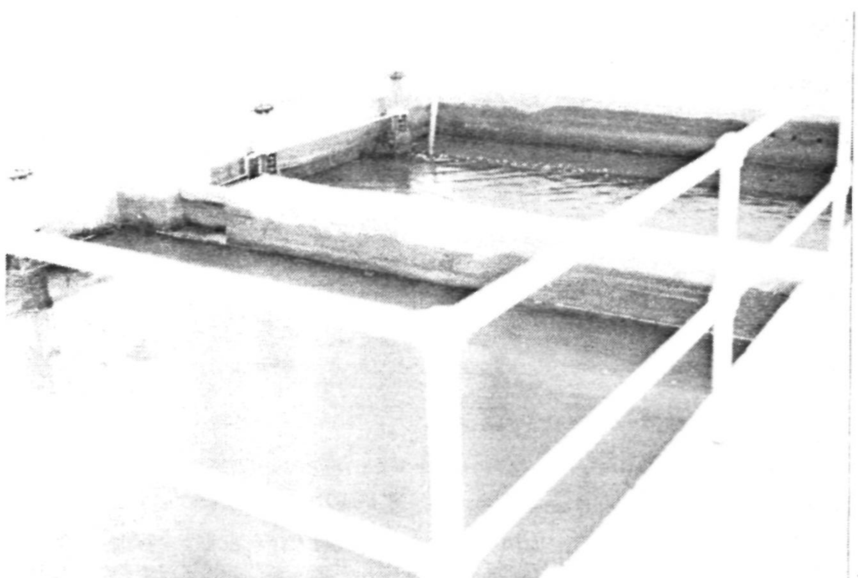


Figure 8. Top view of sand filter at Alton

Measurements for sludge residues in the mixers and basins after de-watering were accomplished in the following fashion. Depth measurements in the mixers were performed along two lines representing the diameter of the circular tanks at right angles to each other. About 5 measurements were made along each line, and sludge depths varied from 1 to 3 feet. During each depth measurement a sample was collected. All samples were combined to provide a composite sample. Analyses for iron and aluminum content were performed later. Analyses for moisture content and specific gravity were performed on one collection.

The clarifier blow-down was sampled at the same time that observations were made on the filter backwash operations. Samples were generally collected at 5-minute intervals during the 60-minute blow-down period. Analyses were performed on each sample for suspended solids (mg/l), volatile suspended solids (mg/l), and settleable solids (ml/l).

The depth of sludge residues in the de-watered basins was measured at 40-foot intervals along the 160-foot length of the basins and at 25-foot intervals along the 50-foot width of the basins. This procedure was carried out on both levels of the basins, requiring 60 measurements during each of the two periods of observations, i.e., November 1980 and March-April 1981. Sludge residue depths varied from 0.1 to 0.9 foot. As in the case of the mixers, sludge samples were collected during each measurement, composited, and analyzed for iron and aluminum content. Determination for moisture content and specific gravity was performed on one sample.

Sampling during filter backwash operations was undertaken at five filters. Each of the filters examined was considered representative of one of the five groups of filters. Samples were obtained sequentially near the wash trough with an extended aluminum rod to which was affixed a sample bottle carrier. Samples were generally collected at 20-second intervals during the first 3 minutes and at 30-second intervals thereafter. This time frame was selected, after an initial run, to provide about an equal percentage of the total load released in each sample collected. The procedure required 12 to 15 sample collections per filter backwash. Each selected filter was sampled during backwash periods on five occasions; and each sample collected was examined for pH, suspended solids (mg/l), volatile suspended solids (mg/l), and settleable solids (ml/l). Data for each period of sampling are included in the appendices.

Waste Production and Characteristics

An initial consideration for developing a waste production scheme for each treatment unit within a water treatment plant is the quantification of the waste load likely to be produced in the whole system.. As mentioned earlier, the solids within the system are derived from suspended and dissolved forms in the source water, chemical additions, and the resultant chemical reactions. Because the Alton plant is principally operated as a clarification process, with minimal chemical additions, the main source of waste produced is that removed from its raw water source, the Mississippi River. Therefore the estimated waste loads produced within the treatment plant are here considered those imposed by the suspended solids content of the Mississippi River combined with those generated by alum coagulation. In terms of wastes produced, the quantities of lime and polymer additions are not considered significant contributors.

Operating personnel at the plant do not routinely perform suspended solids analyses on the raw water. However turbidity measurements are made at least three times per day and the average is recorded. As part of this study, operating personnel did make suspended solids analyses on 33 raw water samples in conjunction with turbidity measurements. The results are given in table 2.

Table 2. Observed Suspended Solids Concentration and Average Turbidity in Raw Water

Date	Observed suspended solids (mg/l)	Observed average turbidity (JTU)
9/18/80	109	98
9/25/80	65	70
10/02/80	30	72
10/09/80	70	46
10/16/80	45	25
10/22/80	40	32
10/29/80	20	32
11/05/80	53	27
11/10/80	25	20
11/19/80	37	19
11/26/80	23	18
12/03/80	25	17
12/11/80	90	72
12/16/80	82	71
12/23/80	45	39
12/29/80	35	29
1/08/81	20	17
1/13/81	15	10
1/19/81	10	8
1/26/81	12	12
2/03/81	17	11
2/10/81	15	14
2/17/81	15	11
2/25/81	33	50
3/02/81	47	66
3/09/81	45	37
3/18/81	30	31
3/23/81	20	29
5/08/81	62	50
5/11/81	157	152
5/13/81	210	163
5/15/81	193	120
5/19/81	873	337

The data from the suspended solids analyses were used to estimate the suspended solids concentrations likely to occur in the Mississippi River during a period extending from January 1978 through May 1981. The data in table 2 were used for a regression analysis. The resultant linear expression is:

$$\text{Suspended solids (mg/l)} = 2.2 \text{ Turbidity (JTU)} - 42.6$$

$$r = 0.934$$
$$N = 33$$

From this expression, the recorded raw water pumpage, and the turbidity and chemical additions set forth in table 3, the daily average waste load produced within the plant was computed. It was assumed that the minimal suspended solids concentration in the raw water was 10 mg/1. The average suspended solids concentration in the raw water was determined to be 118 mg/1.

A reasonable basis for estimating the production of solids by alum is based on the following reactions:

$$Al_2(SO_4)_2 \cdot 14\ H_2O \longrightarrow 2\ Al^{+++} + 3\ SO_4^{=} + 14\ H_2O$$

$$2\ Al^{+++} + 6\ OH^{-} \longrightarrow 2\ Al(OH)_3 \downarrow$$

Commercial alum contains about 17 percent Al_2O_3. On the basis of the chemical reaction about 0.26 pounds of precipitate $Al(OH)_3$ will be produced per pound of dry alum used. The following expression was used to estimate the pounds of solids produced per day:

$$\text{lbs of alum used} \times 0.17 \times 0.26 = \text{lbs of precipitate}$$

Commercial alum use at the plant averages about 264 pounds per day per million gallons of water treated.

Based upon raw water pumpage, suspended solids concentrations in the raw water, and alum usage, the average daily production of dry solids in the treatment system is about 12,500 pounds. Alum usage contributes about 150 pounds of dry solids per day with the remainder derived from suspended solids in the raw water.

The sludge residue volume in the mixers as measured during November 1980 represented accumulations that occurred during 192 days of operation. That volume measured in March-April 1981 represented accumulations over a period of 148 days. The estimated volume of sludge residue in the mixers together with pertinent characteristics is summarized as follows:

Period (days)	Volume (cu ft)	Avg iron content (ppm)	Avg aluminum content (ppm)
192	6378	32,300	26,300
148	4777	44,000	20,000

Table 3. Mean Daily Pumpage, Turbidity, Backwash Volume, and Quantity of Chemicals

	Raw water pumpage (mgd)	Turbidity (JTU)	Estimated filter backwash (MG)	Lime (lbs/MG)	Alum (lbs/MG)	Polymer (lbs/MG)
1978						
J	12.67	27	0.95	65	165	7.5
F	12.52	16	0.95	61	155	6.8
M	12.34	155	0.78	97	387	12.6
A	11.50	138	0.36	34	179	10.4
M	11.66	142	0.42	45	201	9.0
J	12.76	89	0.47	33	165	7.4
J	12.71	212	0.47	68	218	9.2
A	13.03	35	0.48	35	134	8.8
S	12.45	70	0.48	48	193	9.9
0	11.78	49	0.48	47	228	10.3
N	11.76	32	0.48	40	234	10.0
D	11.93	25	0.54	44	249	9.3
Average	12.26	83	0.57	--	209	---
1979						
J	12.33	15	0.62	17	146	10.6
F	12.48	41	0.55	48	206	7.3
M	11.96	224	0.56	96	597	9.3
A	11.64	139	0.61	47	277	8.0
M	12.46	72	0.54	31	97	4.5
J	13.83	74	0.54	24	152	4.4
J	14.40	47	0.62	23	115	3.4
A	13.93	60	0.70	27	70	4.6
S	13.26	45	0.65	14	43	4.1
0	12.56	28	0.68	--	112	3.9
N	11.77	38	0.66	0	223	5.3
D	12.11	48	0.75	0	271	6.6
Average	12.73	69	0.62	--	192	---
1980						
J	12.17	70	0.74	17	242	7.7
F	12.50	26	0.82	76	490	8.0
M	11.80	70	0.73	76	449	7.0
A	12.08	113	0.69	47	241	6.8
M	12.18	31	0.75	21	146	6.2
J	12.99	234	0.70	114	372	7.2
J	14.52	33	0.81	40	136	6.2
A	14.02	44	0.83	49	208	5.1
S	12.79	83	0.75	47	140	6.3
0	12.25	41	0.71	39	263	4.3
N	12.22	21	0.70	32	331	5.2
D	12.29	42	0.81	63	552	8.8
Average	12.65	67	0.75	--	324	---
1981						
J	12.42	14	0.93	54	355	10.1
F	12.50	25	0.87	52	454	8.7
M	12.00	37	0.60	55	335	8.0
A	11.82	152	0.65	45	322	10.2
M	11.53	110	0.43	60	179	12.3
Average	12.05	68	0.69	--	329	---

Note: MG = million gallons

The percent solids and specific gravity of the sludge are estimated to be 32.6 and 1.28, respectively. On a dry weight basis the estimated weight of the sludge is about 26.0 pounds per cubic foot. The average daily accumulation varied from 840 to 865 pounds during periods of measurement.

Similar measurements for like periods of the sludge residue in the sedimentation basins are summarized in table 4. The west basin accumulates more sludge than the east basin and the lower levels accumulate about 55 to 65 percent of the total sludge volume. The percent solids and specific gravity are estimated to be 15.3 and 1.0, respectively. On a dry weight basis the estimated weight of the sludge is about 9.54 pounds per cubic foot. The average daily accumulation varied from 560 to 707 pounds during the periods of measurement.

Table 4. Sludge Volume and Characteristics

	Volume (eu ft)	Average iron (ppm)	Range of iron (ppm)	Average aluminum (ppm)	Range of aluminum (ppm)
***11/3-5/80**					
West Basin		**32,950**		**39,250**	
Upper Level	**3333**		**30,700**		**32,000**
Lower Level	**5605**		**35,700**		**46,500**
Total	**8938**				
East Basin		**33,550**		**46,500**	
Upper Level	**1775**		**33,200**		**54,000**
Lower Level	**3533**		**33,900**		**39,000**
Total	**5308**				
Mixers	**6378**	**32,300**		**26,300**	
****3/30/81-4/01/81**					
West Basin		**41,800**		**55,000**	
Upper Level	**2325**		**38,000**		**51,000**
Lower Level	**2825**		**45,600**		**59,000**
Total	**5150**				
East Basin		**41,800**		**55,000**	
Upper Level	**1575**		**44,000**		**59,000**
Lower Level	**1950**		**39,600**		**51,000**
Total	**3525**				
Mixers	**4777**	**44,000**		**20,000**	

***192 days accumulation**
****148 days accumulation**

In earlier efforts by the Water Survey to quantify wastes from water treatment plants, a basic weakness lay in determining the quantity and representative characteristics of sludge released from clarifiers. The effort at Alton was not an exception. Although the clarifier was sampled during five blow-down periods and 45 samples were analyzed, the results are not useful. The design of sludge inlet appurtenances within most clarifiers, the tendency of the wastes to surge alternately from "thick" to "thin," and the uncontrolled pattern of sludge movement within the tank simply preclude meaningful sampling. The method of estimating sludge loads from the clarifier at Alton will be discussed later.

The observed average volume of waste from each group of filters during backwash and the average duration of backwash for each filter in the groups are shown in table 5. Backwash rates vary from 17.3 to 20.9 gpm/ft^2. The total volume of backwash from the 16 filters is 389,592 gallons. However, an average of 24 filters are backwashed daily. During the days of sampling the average daily backwash volume was 584,640 gallons. This compares reasonably well with the estimated average of 650,000 gpd recorded on operation reports for over a 3-year period.

Typical suspended solids release patterns for the five groups of filters during backwash operations are shown in figure 9. Maximum suspended solids concentrations vary from 500 to 1500 mg/l with maximum values generally occurring within 1 minute of backwash commencement.

The estimated pounds of suspended solids released from the filter group during backwash are summarized in table 6. The average of 864 pounds is for 16 filters. Since the average number of filters backwashed daily is 24, the estimated quantity of waste solids produced by the filters is 1296 pounds per day. The volatile content of the solids is about 23 percent on the average.

The quantity of solids released from the filters that are likely to settle in a quiescent body of water is defined by the volume of settleable solids. These are summarized in table 7. For the 24 filter backwashes daily the estimated average gallons of settleable solids is about 6327. The volume of settleable solids represents about 1.1 percent of the total daily volume of backwash.

Table 5. Average Volume of Waste and Duration of Backwash

Group	A	B	C	D	E
*Volume, gallons	81,144	105,672	59,640	59,640	83,496
**Duration, minutes	4.8	6.3	7.1	7.1	5.0

*Total volume for group
**Per filter in group

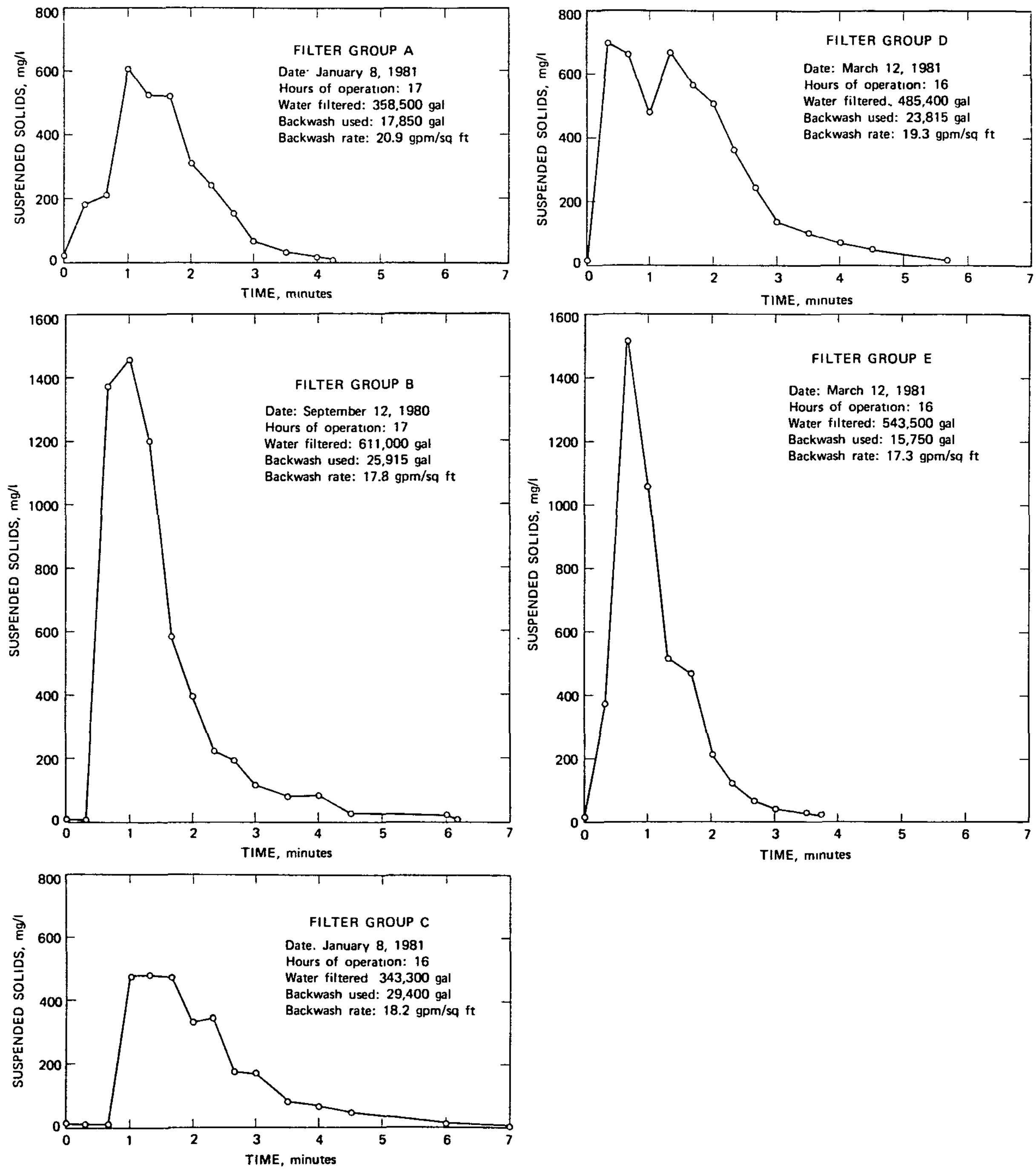


Figure 9. Suspended solids release during backwash

Table 6. Pounds of Suspended Solids Released during Filter Backwash

Filter group	7/17/80	9/12/80	10/24/80	1/08/81	3/12/81	Avg
A	296	56	96	110	232	164
B	212	280	240	252	480	293
C	102	68	70	100	114	91
D	98	82	114	126	112	106
E	188	228	268	156	208	210
Total	396	714	788	774	1146	864

Average pounds per filter: 54

Table 7. Gallons of Settleable Solids Released during Filter Backwash

Filter group	7/17/80	9/12/80	10/24/30	1/08/81	3/12/81	Avg
A	508	180	544	1268	1240	748
B	232	756	1252	2260	2724	1445
C	134	166	418	884	934	517
D	130	214	584	1128	474	506
E	388	548	1548	1464	1064	1002
Total	1442	1364	4346	7004	6436	4218

Average gallons per filter: 264

To determine the total daily volume of waste likely to be produced at the Alton plant the following were considered:

1) Completely dewatering the mixers and sedimentation basins twice a year

2) Discharging blow-down from the clarifier at a rate of 58 gpm for a period of 60 minutes once every three days

3) Flushing the mixers and sedimentation basins with a fire hose at a rate of 200 gpm for 4 hours

4) Assuming filter backwash for 24 filters per day at observed daily volumes

On the basis of these considerations an average of about 602,000 gpd of waste is generated at the plant. This represents about 4.8 percent of the volume of raw water pumped or 48,000 gallons per million gallons of water treated.

Results and Discussion

Although considerable reliance has been placed on *avevage* values in the development of this report, there is a need to take into consideration the variability of average values in estimating a mass solids balance for the water treatment system. Two periods of time were evaluated. That period of 192 days extending from April 1980 to November 1980 is called period 1; that period of 148 days extending from November 1980 to March 1981 is period 2.

During period 1 the average suspended solids concentration in the raw water was estimated, from turbidity measurements, to be 128 mg/l. At an average pumpage rate of 12.5 mgd the average daily solids load to the plant was 13,214 pounds. From the alum use recorded, the estimated solids produced by chemical precipitation was 126 pounds per day. Thus the total solids required to be removed by the plant for period 1 averaged 13,340 pounds per day.

During period 2 the average suspended solids concentration in the raw water was similarly estimated to be 23 mg/l. At an average pumpage rate of 12.5 mgd the average daily solids load to the plant was 2458 pounds. Another 221 pounds per day was contributed by alum precipitation, resulting in an average daily solids load of 2679 pounds to be removed for period 2.

As shown in table 1, during the winter months representative of period 2, the average turbidity of the river water is considerably less than during the rest of the year. Consequently solids loads to the plant are considerably lessened. This situation imposes some changes in operation methods, particularly with regard to sedimentation efficiencies and filter backwash intervals, which will be discussed later.

During period 1 about 24 filters were backwashed daily and for purposes here it is assumed that an average release load of 1296 pounds per day occurred.

For period 2 the number of filters backwashed per day was quite variable, ranging as high as 40. For estimating the load released from the filters the data developed from monitoring the filters on January 8, 1981, were used along with the number of filters backwashed as recorded on monthly operation reports. The estimated daily load released from the filters during period 2 is 1364 pounds per day.

As mentioned earlier, the data obtained from monitoring the clarifier blow-down were not considered reliable. The daily sludge production for that unit was estimated from the differences between the daily load applied to the plant and that estimated by measurement in the mixers, basins, and that released by the filters. A summation of the solids applied to the water treatment plant and the probable distribution of sludge production for the treatment units are set forth in table 8 for the two periods.

The implication of the results shown in table 8 is that during most of the year the clarifier is an effective remover of solids, but during the winter months most of the load is imposed on the filters. In terms of percent removal, based upon the data in table 8, the following removal efficiencies have been computed:

	Period 1	Period 2
Mixer	6.5%	30.3%
Basins	5.3%	20.3%
Filters	9.7%	49.4%
Clarifier	78.5%	--
	100.0%	100.0%

Table 8. Estimated Mass Balance of Solids for Treatment Units

	Period 1 Lbs of solids/day	Period 2 Lbs of solids/day
Input	13,340	2,679
In mixers	865	840
In basins	707	560
Off filters	1,296	1,364
*From clarifier	10,472	-----
Total	13,340	2,764

*By difference

Although the load per day released by the filters does not vary much for the two periods, i.e., 1296 vs 1364 pounds, the nature of material captured is probably very different. Other than during the winter months a filter aid is not used; that is, during November, December, January, February, and often in March, a filter aid is used. This may be the primary reason for more frequent backwashing during cold weather. It is conceivable also that some sludge residue is transported from the mixers and basins during decanting and prior to sludge depth measurements. It is unlikely that the overall concentration of 200 mg/l suspended solids is exceeded in the discharge. This would be equivalent to a sludge accumulation over a 10-day period.

It is not unreasonable to expect a solids removal efficiency of 70 to 80 percent in the clarifier. In fact most water treatment plants do not have sedimentation basins following clarifiers where clarification is the principal process. And it is not unreasonable to expect minimum sedimentation rates during cold weather. With these thoughts in mind it is quite likely that the estimated mass balance set forth in table 8 reflects the unit production of solids on a seasonal basis.

Evans and Schnepper (1970) observed that sludges from clarifiers at municipal water treatment plants contained considerable quantities of iron and aluminum. These are the constituents in the wastes from a clarification process that are likely to be the most detectable in the receiving stream. As shown in table 9 the average iron (Fe) and aluminum (Al) concentration in the mixer sludge ranged from 32,300 to 44,000 parts per million (ppm) and 20,000 to 26,300 ppm, respectively. In the basin sludges the average Fe and Al concentrations ranged from 32,950 to 41,000 ppm and 39,250 to 55,000 ppm. A comparison of iron and aluminum content of sludge, soil, and sediments is included

Table 9. Comparison of Iron and Aluminum Concentrations in Sludge, Soil, and Sediments

		Fe (ppm)	Al (ppm)
	Alton mixers	32,300 - 44,000	20,000 - 26,300
	Alton basins	32,950 - 41,000	39,250 - 55,000
(1)	Soils in So. Illinois	9,000 - 20,000	
(1)	Stream sediments	10,500 - 15,000	
(1)	Lake sediments	9,300 - 36,000	
(2)	L. Mich, sediments		4,200 - 40,000
(3)	Dry soil		10,000 -300,000
(4)	Great Lakes sediments		50,000 - 81,000
(5)	Horseshoe Lake sediments		48,900 - 52,100
(6)	Miss. R. sediments		27,400

(1) Roseboom et al. (1978)
(2) Cahill (1981)
(3) Bowen (1966)
(4) Kemp and Thomas (1976)
(5) Gross (1978)
(6) MRPWSA(1972)

in table 9. On the basis of these comparisons it is probable that the iron content of the sludge is higher than normally found in the sediments of the aquatic environment. On the other hand, aluminum concentrations in the sludge are not unlike those concentrations occurring naturally in aquatic sediments. The content of iron and aluminum in the sediments of the Mississippi River will be discussed later.

Earlier work at the water treatment plant at Pontiac, Illinois (Evans et al., 1979) showed a perceptible increase in sulfate, turbidity, and aluminum concentration within the receiving stream waters immediately downstream of the point of waste discharge compared to upstream water quality. Nevertheless, the elevations in concentrations were transitory. There were not any differences detected for suspended solids, dissolved oxygen, silica, and other chemical characteristics. For this reason there was no attempt made during this study to monitor in-stream water quality. To determine the prudence of omitting such measurements, computations were performed to assess the impact of wastes discharge on the suspended solids concentrations of the Mississippi River under worse case conditions.

For this purpose the waste load applied to the river was that released by 1) decanting the mixers and basins and flushing out the sludge residue representative of 6 months accumulation, 2) the daily discharge of the clarifier at a solids capture rate of 78 percent of the solids applied, and 3) the backwashing of 24 filters — all to occur within 24 hours. The daily load of suspended solids was assumed to be 12,500 pounds. The 7-day 10-year low flow of the Mississippi River at Alton is 21,740 cfs (Singh and Stall, 1973). This is the assumed flow of the stream during the period of the computed maximum wastes load discharge. At this low flow a 10 percent mixing, as suggested by MRPWSA (1972), is realistic. That is, the calculated suspended solids in the stream is based upon the dispersion of the waste load through only 10 percent of the streamflow. During this period of flow it is probable that the in-stream suspended solids are minimal. A concentration of 10 mg/l was used for comparative purposes.

With the use of these conditions for waste discharge and streamflow, in which about 278,200 pounds of solids will be applied in a volume of about 5.4 cfs to a streamflow of 2174 cfs at a background suspended solids concentration of 10 mg/l, the resultant suspended solids in the river is estimated to be 34 mg/l. An increase of 24 mg/l above background will occur. Table 10 shows anticipated increases in suspended solids concentration in the receiving stream at maximum waste loads for other streamflow conditions but including the 7-day 10-year low flow. The flows during November and April were selected because they are the months when the maximum loads are released from the water treatment plant.

Another aspect worth pondering is the relationship between the river load and the waste load. The average daily waste production of 12,500 pounds at the plant represents about 0.018 percent of the average daily load conveyed by the river at Alton.

On the basis of the anticipated increases in suspended solids, as determined here, when maximum waste loads are applied at varying streamflows, the

Table 10. Anticipated Increase above Ambient in Mississippi River during Maximum Waste Loads

	10% mixing suspended solids	100% mixing suspended solids
Average annual flow (97,338 cfs)	+ 5 mg/l	+ 0.5 mg/l
Average November flow (66,810 cfs)	+ 7 mg/l	+ 0.7 mg/l
Average April flow (185,700 cfs)	+ 3 mg/l	+0.3 mg/l
7 day-10 yr low flow (21,740 cfs)	+ 24 mg/l	+2.4 mg/l

decision not to monitor instream water quality during the course of this study is well justified.

Summary of Water Treatment Plant Study

- The sources of waste in the water treatment plant at Alton are the mixers, clarifier, sedimentation basins, and rapid sand filters.
- The solids generated in the plant average about 12,500 pounds per day. About 1.5 percent of the load is derived from alum precipitation; the remainder originates from the suspended solids in the raw water.
- The solids produced in the plant are equivalent, on the average, to 1000 pounds of solids per million gallons of water treated.
- On the average, the sand filters release about 1296 pounds of solids per day or about 10 percent of the total solids produced.
- Although differences occur during winter months, the clarifier captures about 78 percent of the solids produced.
- The volume of waste produced varies on the average from 602,000 to 670,000 gallons per day.
- About 97 percent of the waste volume originates from the sand filters with the remainder from the clarifier, mixers, and sedimentation basins.
- The volume of waste produced daily ranges from 4.8 to 5.3 percent of the average daily volume of water treated.

- The settleable solids produced during filter backwash represent about 1.1 percent of the volume of backwash.
- The major chemical constituents of the settled sludges within the plant are iron and aluminum.
- The concentration of iron in the sludges is higher than normally observed in the aquatic environment; concentrations of aluminum in the sludges are not.
- Except during 7-day 10-year low flows at 10 percent mixing, increases in suspended solids in the receiving stream during maximum waste discharges will not be perceptible.
- On the average, the quantity of solids produced in the plant daily represent about 0.018 percent of the solids conveyed by the receiving stream daily.

CHARACTERISTICS OF BOTTOM SEDIMENTS

The ratio of streamflow to waste flow at Alton, assuming 10 percent mixing, averages about 10,000:1. For a high dilution ratio of this nature there is a need to seek traces or impacts of the waste flows on the receiving stream by means other than examining the flowing waters of the Mississippi River. As described earlier, sludge and to a lesser extent settleable solids are major components of the waste. A significant characteristic of the waste is its concentration of Fe and Al. It makes sense therefore to examine the bottom sediments of the receiving stream for concentrations of these elements, as well as any other characteristic that will define the extent of the influence of the wastes on the bottom sediments.

Just as important is the need to assess the sediments in terms of their capability to provide suitable habitat for benthic organisms. One aspect of suitable macroinvertebrate habitat is particle size distribution of the sediments, i.e., percent sand, silt, and clay. A predominantly sandy bottom with its inherent instability is not a productive benthic habitat, whereas silt and clay in combination with organic (volatile) matter can be very productive. Finally, it is desirable to identify the types and number of macroinvertebrates existing in the bottom sediments for comparative purposes.

With these objectives in mind a sampling program was implemented to determine:

1) The extent and concentrations of Fe, Al, and the volatile and moisture content of the bottom sediments

2) The particle size distribution of the bottom sediments

3) The types and densities of macroinvertebrates in the bottom sediments

The relative locations of the sampling stations to the water company are shown in figure 10. The sampling schedule and types of analyses are included in table 11. Thirty-nine samples were obtained for physical and chemical examinations requiring 195 analyses; 23 samples were examined for macroinvertebrate density and types of organisms. The provisional streamflows occurring during the period of bottom sediment sampling are noted in figure 3.

Sampling Procedures

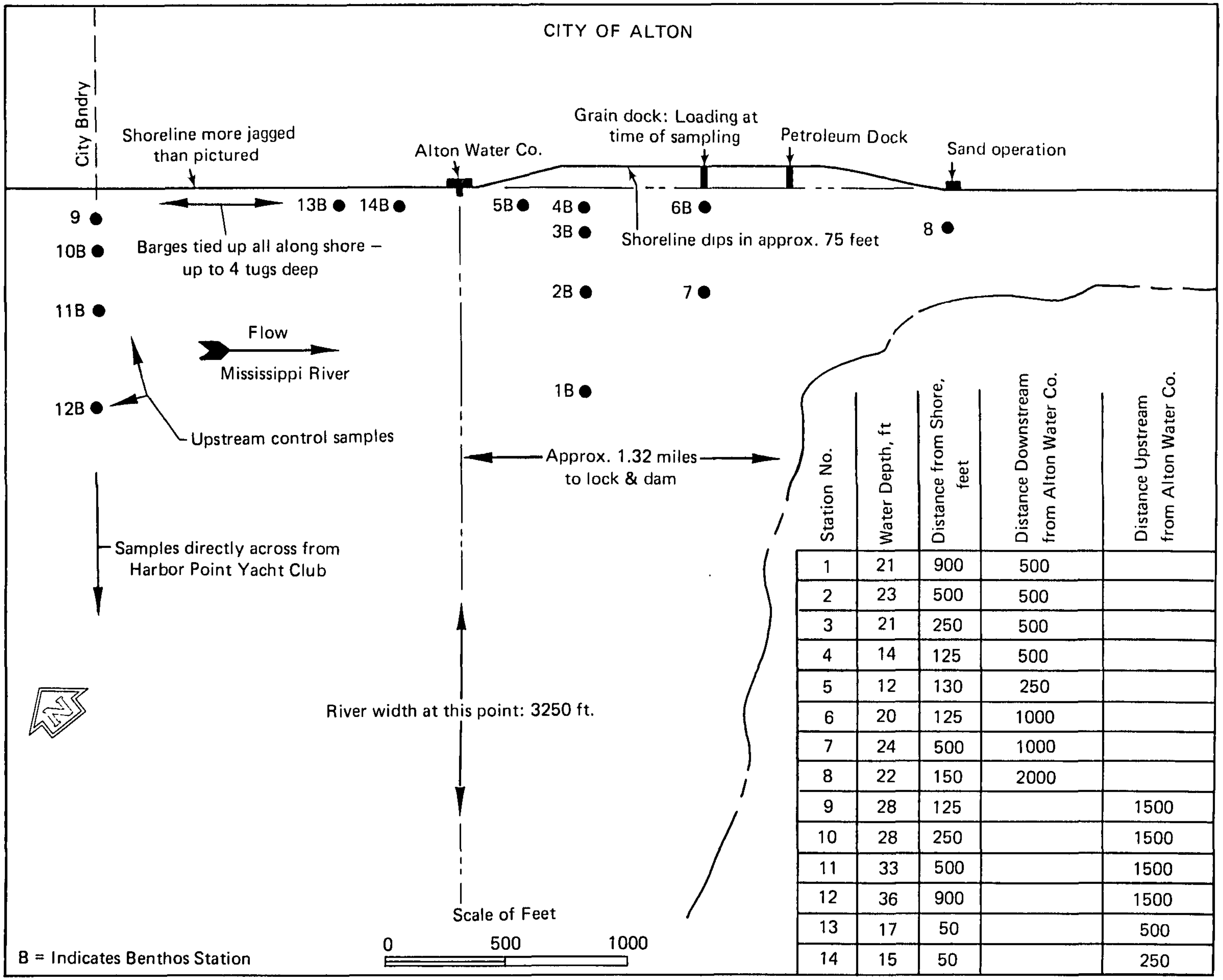
Twelve stations were originally selected for sampling. Four of them were located above the water plant outfall and the remaining eight below the outfall. Subsequent analyses indicated that stations 1, 2, and 3, though below the outfall, were not being impacted by the waste flow. Their value as originally conceived for benthic monitoring subsequently diminished. To overcome this difficulty in assessing benthic organism populations, three other stations -- 4, 5, and 6 -- were selected for benthic sampling, and two additional stations upstream of the outfall were established (13 and 14) for similar monitoring.

In all cases an effort was made to locate stations in a manner that would provide a comparison between locations upstream of the plant outfall and those located downstream. Site selection was compounded by the existence of grain and sand transfer operations, as shown in figures 11 and 12, in the vicinity of the water plant. Sampling was also made difficult at times because of the expanse of the water area coupled with navigation traffic. Problems that had to be overcome included varying stream discharge rates, high wind and waves, heavy navigation traffic, and the nature of bottom materials. These posed problems for "staying on a station," overcoming excessive angles of descent for the dredge used, and encountering rocky substrates. Nevertheless the samples collected are confidently considered representative of the bottom material in the locale investigated.

All samples were collected with a ponar dredge operating from a 21-foot boat equipped with a 70 horsepower motor. Site selection was established by landmarks and an optical rangefinder. After anchoring, the ponar dredge was allowed to free fall to the bottom. It was retrieved by a motorized winch. Upon retrieval the contents of the ponar dredge were emptied on a tiltable washtable and observations noted of its physical characteristics.

For physical and chemical examination the dredged material was then thoroughly mixed and placed in a plastic quart bottle, with a plastic bag liner, until full. All samples were labeled and placed in an ice chest. Upon delivery to the laboratory the samples were refrigerated until analyses were performed.

Each sample obtained for macroinvertebrate examination consisted of three ponar collections. The collections were composited, salt floated, sieved, and preserved. The salt flotation technique consists of adding a saturated salt solution to a bucket containing the sediment sample, stirring vigorously and decanting immediately through a U.S. Standard 30 mesh sieve bucket. The pro-



Station No.	Water Depth, ft	Distance from Shore, feet	Distance Downstream from Alton Water Co.	Distance Upstream from Alton Water Co.
1	21	900	500	
2	23	500	500	
3	21	250	500	
4	14	125	500	
5	12	130	250	
6	20	125	1000	
7	24	500	1000	
8	22	150	2000	
9	28	125		1500
10	28	250		1500
11	33	500		1500
12	36	900		1500
13	17	50		500
14	15	50		250

Figure 10. Station location map

Table 11. Sampling Schedule for Bottom Sediments

Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14
August 6, 1980														
Fe & Al	X	X	X	X	X	X	X	X	X	X	X	X	-	-
% Volatile	X	X	X	X	X	X	X	X	X	X	X	X	-	-
% Moisture	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Particle size	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Benthie	X	X	X	-	-	-	-	-	-	X	X	X	-	-
November 13, 1980														
Fe & Al	X	X	X	X	X	X	X	X	X	X	X	X	-	-
% Volatile	X	X	X	X	X	X	X	X	X	X	X	X	-	-
% Moisture	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Particle size	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Benthic	X	X	X	-	-	-	-	-	-	X	X	X	-	-
April 3, 1981														
Fe & Al	X	X	-	X	X	X	X	X	X	X	X	X	-	-
% Volatile	X	X	-	X	X	X	X	X	X	X	X	X	-	-
% Moisture	X	X	-	X	X	X	X	X	X	X	X	X	-	-
Particle size	X	X	-	X	X	X	X	X	X	X	X	X	-	-
Benthic	-	-	-	-	-	-	-	-	-	X	X	X	-	-
April 16, 1981														
Fe & Al	-	-	-	X	X	X	-	X	-	-	-	-	-	-
% Volatile	-	-	-	X	X	X	-	X	-	-	-	-	-	-
% Moisture	-	-	-	X	X	X	-	X	-	-	-	-	-	-
Particle size	-	-	-	X	X	X	-	X	-	-	-	-	-	-
Benthic	X	X	X	-	-	-	-	-	-	-	-	-	-	-
June 29, 1981														
Benthic only	-	-	-	X	X	X	-	-	-	-	-	-	X	X

cedure was repeated at least three times for each sample. The material retained on the sieve was then rinsed with river water and placed in a plastic bottle. All sieved samples were preserved in 95 percent ethanol and labeled. At the laboratory each sample was washed again through a 30 mesh sieve and the residue picked for organisms. The organisms were identified, enumerated, and preserved in 70 percent ethanol..

Chemical and Physical Measurements

The samples collected for chemical and physical measurements were examined for concentrations of Fe, Al, percent volatile, and percent moisture; they were also examined for percent, by weight, of sand, silt, and clay.

Iron and aluminum analyses were accomplished by digestion with nitric acid and subsequent atomic absorption spectrophotometry. Volatile solids analyses

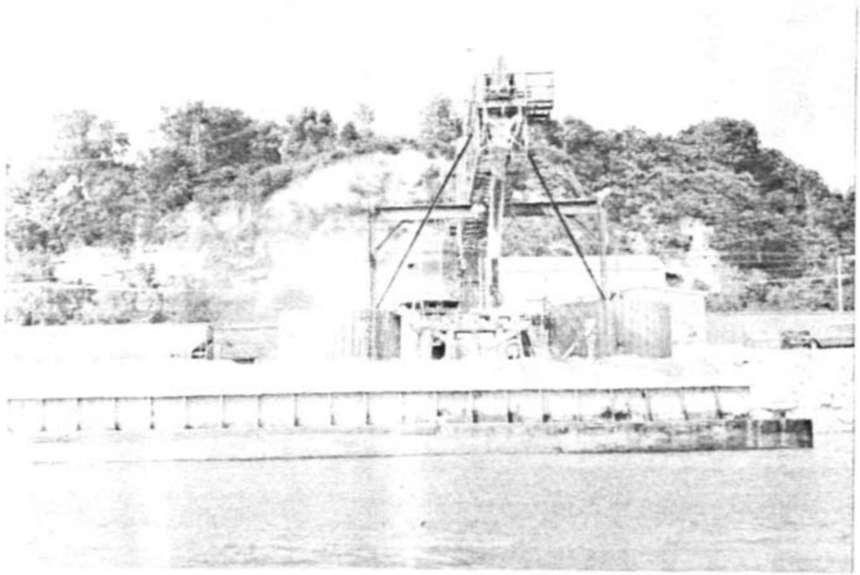


Figure 11. Grain transfer operation downstream of Alton plant

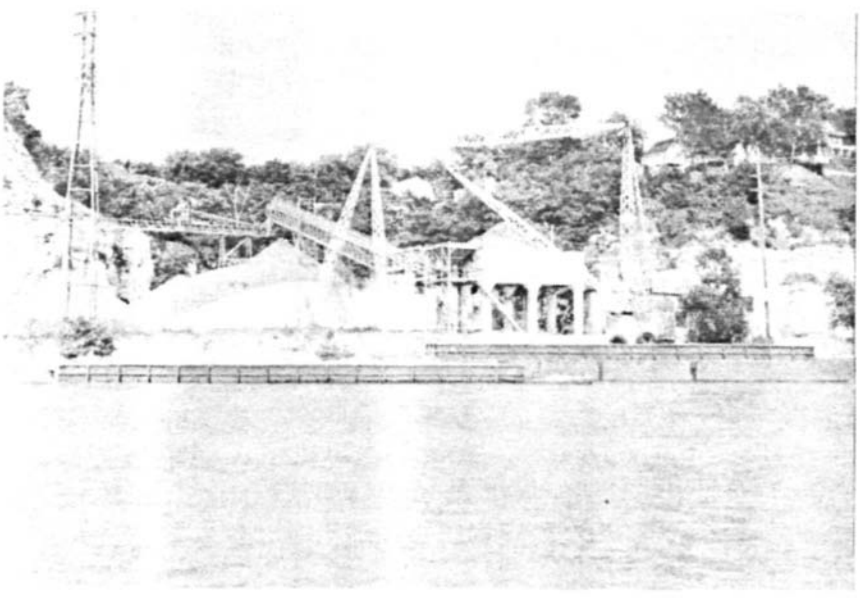


Figure 12. Sand transfer operation downstream of Alton plant

were performed according to procedures set forth by the American Public Health Association (1975). The percent moisture was determined by decanting the supernatant from the sediment samples after the samples were left undisturbed for at least 24 hours, and then oven-drying the remaining material at 103 Celsius.

Analyses for particle size distribution were performed in accordance with procedures reported by Guy (1969). Sand was separated from the bottom sediments by mechanical analysis using a wet sieving process. Silt and clay partitioning was accomplished by the pipet method. For the purposes of this report the ranges of grain size, in millimeters, for each of the three fractions are as follows:

Sand	0.062 - 2.0
Silt	0.004 - 0.062
Clay	Less than 0.004

All data derived from the analyses for chemical and physical measurements, including observations noted during sampling, are given in the appendices.

Biological Measurements

For this study the aquatic fauna relied upon as indicators of water quality were aquatic macroinvertebrates. Their sensitivity and limited mobility provide a means of assessing the summation of the physical and chemical attributes of the aquatic environment. Aquatic macroinvertebrates as here considered are animals within the aquatic system visible to the unaided eye and capable of being retained by a U.S. Standard 30 mesh sieve.

The tolerance of these organisms to contaminants varies, and this fact has provided the means for developing a classification system (Tucker and Ettinger, 1975) which has been used by the Illinois Environmental Protection Agency to classify streams on the basis of the abundance of organisms intolerant to pollution found in streams. The four tolerance status categories for aquatic macroinvertebrates found in Illinois waters are defined as:

Intolerant: Organisms whose life cycle is dependent upon a narrow range of environmental conditions. They are rarely found in areas of organic enrichment and are replaced by more tolerant species upon degradation of their environment.

Moderate: Organisms which lack the extreme sensitivity to environmental stress displayed by intolerant species but which cannot adapt to severe environmental degradation. Such organisms normally increase in abundance with slight to moderate levels of organic enrichment.

Facultative: Organisms which display the ability to survive over a wide range of environmental conditions and which possess a greater degree of tolerance to adverse conditions than either intolerant or moderate species. The facultative tolerance status also includes all organisms which depend upon surface air for respiration.

Tolerant; Organisms which not only have the ability to survive over a wide range of environmental extremes but which are generally capable of thriving in water of extremely poor quality and even anaerobic conditions. Such organisms are often found in great abundance in areas of organic pollution.

The classification of stream environments assigned to each sampling station on the Mississippi River are:

1) *Balanced (B):* Intolerant organisms are many in number and species, or more in number than other forms present.

   Intolerant present ≥ 50% Moderate, facultative, and tolerant usually present ≤ 50%

2) *Unbalanced (UB):* Intolerant organisms are fewer in number than other forms combined, but combined with moderate forms, they usually outnumber tolerant forms.

   Intolerant present < 50% but ≥ 10% Moderate, facultative, and tolerant usually present < 50%

3) *Semi-polluted (SP):* Intolerant organisms are few or may not be present. Moderate and/or facultative organisms present.

   Intolerant present < 10% Moderate, facultative, and tolerant usually present > 90%

4) *Polluted (P):* Intolerant organisms absent; only tolerant organisms present or no organisms present.

   Tolerant present 100%*

   * Organisms which are not adapted to inhabit a polluted environment are occasionally collected as a result of factors produced by the drift and are not representative.

5) *Natural or artificial bare area (BA):* No organisms present.

As mentioned earlier stations 1, 2, 3, 10, 11, and 12 were selected for benthic organism monitoring. Samples were collected on three different occasions at these stations before it became apparent that stations 1, 2, and 3 were not within the area of waste water influence. Consequently stations 4, 5, and 6 were examined for macroinvertebrate populations on June 29, 1981. At that time two other stations (13 and 14) were examined as representative of upstream near-shore conditions. All data pertaining to the benthic organisms collected are included in the appendices.

Results and Discussion

The relative distances of the sampling stations to the waste outfall and shoreline are shown in figure 10. As depicted, stations 4, 5, 6, and 8 are downstream of the outfall and closest to the shoreline. Their distances from shoreline vary from 125 to 150 feet. Other stations downstream from the outfall include stations 1, 2, 3, and 7, with distances from the shoreline varying from 250 to 900 feet. The principal upstream stations for which the sediments were characterized include 9, 10, 11, and 12. These are located about 1500 feet upstream of the outfall and vary in distances from the shoreline by 125 to 900 feet.

The mean concentrations of Fe, Al, percent moisture, and percent volatile (organic) material observed in the bottom sediments are given in table 12. Mean Fe concentrations vary from 7073 ppm at station 3 to 33,375 ppm at station 6. The concentrations of Fe at stations 4, 5, and 6 are not unlike those observed in the plant sludges (see table 4). It is probable that the elevated concentrations of Fe in the sediments are due to the silt and clay removed from the raw water during treatment and reintroduced to the river in waste flows. Nevertheless it is clear that the impact of waste loads is detectable at stations 4, 5, and 6.

This is also the case for Al. As shown in table 12, the mean concentrations of Al vary from 1965 ppm at station 12 to 17,750 ppm at station 5. However the maximum mean values occurring at stations 4, 5, and 6 are considerably less than the concentrations of Al in the plant sludges (see table 4). It is likely that the flocculent nature of alum sludge permits it to be easily scoured or partially dispersed by streamflow, thus lessening the accumulation of the alum sludge in the bottom sediments.

As with Fe and Al, the percent moisture and volatile content of the bottom sediments follows a similar distribution pattern. Moisture content average maximum was 42 percent at station 5 with an average minimum of 13.2 percent at station 1; the percent volatile was highest at station 6 with a value of 6.3 compared to a low average of 0.5 percent at station 12.

Table 12. Mean Values of Some Chemical and Physical Characteristics of Bottom Sediments

Stations	Fe (ppm)	Al (ppm)	Moisture (%)	Volatile (%)
1	8,900	2,170	13.2	0.8
2	11,050	3,585	21.5	1.8
3	7,073	4,270	15.0	1.6
4	30,025	16,870	40.0	5.8
5	30,675	17,750	42.0	5.4
6	33,375	14,560	41.3	6.3
7	7,840	2,248	16.0	0.6
8*	9,125	3,170	19.2	1.1
9	9,070	3,367	16.4	1.5
10	7,825	2,900	13.3	0.8
11	8,900	2,455	16.2	0.8
12	7,100	1,965	16.4	0.5

*** Excludes an aberrant value obtained 8/06/80**

The distribution pattern of these chemical and physical characteristics of the bottom sediments are graphically depicted in figures 13 and 14. For further comparison between stations, the average values for all constituents were determined for stations 4, 5, and 6. This was similarly done for all other stations and the results obtained from those stations are considered an estimate of *background* conditions. The results are as follows:

	Fe(ppm)	Al(ppm)	Moisture(%)	Volatile(%)
(1) Stations 4, 5, 6	31,358	16,393	43.1	5.8
(2) Background	8,542	2,903	16.3	1.0
(3) Ratio (1):(2)	3.7:1	5.6:1	2.5:1	5.8:1

From the work related to aquatic sediments by other investigations (see table 9) the Fe concentrations in the sediments at stations 4, 5, and 6 are elevated. Al values, though considerably elevated (5.6:1) at the Alton locale, are not unlike those found in other aquatic sediments. In addition to significant increases in Fe and Al, there is a substantial increase in organic enrichment as reflected by volatile content. And the increase in liquidity of the sediments at stations 4, 5, and 6, caused by increasing silt and clay content versus sand, is obvious.

The composition of the bottom sediments in terms of sand, silt, and clay content is depicted in figure 15 for 12 sampling stations. On the average the composition of the sediment at stations 4, 5, and 6 compared to all other stations is as follows:

	Stations 4, 5, 6	All other stations
Sand	33%	94%
Silt	49%	4%
Clay	18%	2%

The examination of the sediments did not reveal a measurable blanket of sludge deposits foreign to the sediments of the river. On the other hand the change in grain size composition at stations 4, 5, and 6 compared to other upstream and downstream stations is substantial evidence that the suspended sediment removed by treatment from the raw water is impacting stations 4, 5, and 6 upon its reintroduction to the river in waste flows.

All of the chemical and physical examinations performed on the bottom sediments at Alton clearly show that waste flows are detectable. But regardless of the detectability of the wastes in the sediments, it is also clear that the areal extent of their influence is limited. Based upon the locations of the stations and the analysis of the characteristics of the sediments, the areal influence is confined to about 200 feet offshore and within 2000 feet downstream of the waste outfall. In the absence of unnatural sludge deposits and without evidence that the iron and aluminum concentrations observed are toxic to aquatic organisms, it is difficult to consider that mere changes in the chemical and physical composition of the sediments in the limited area are a mark of environmental degradation.

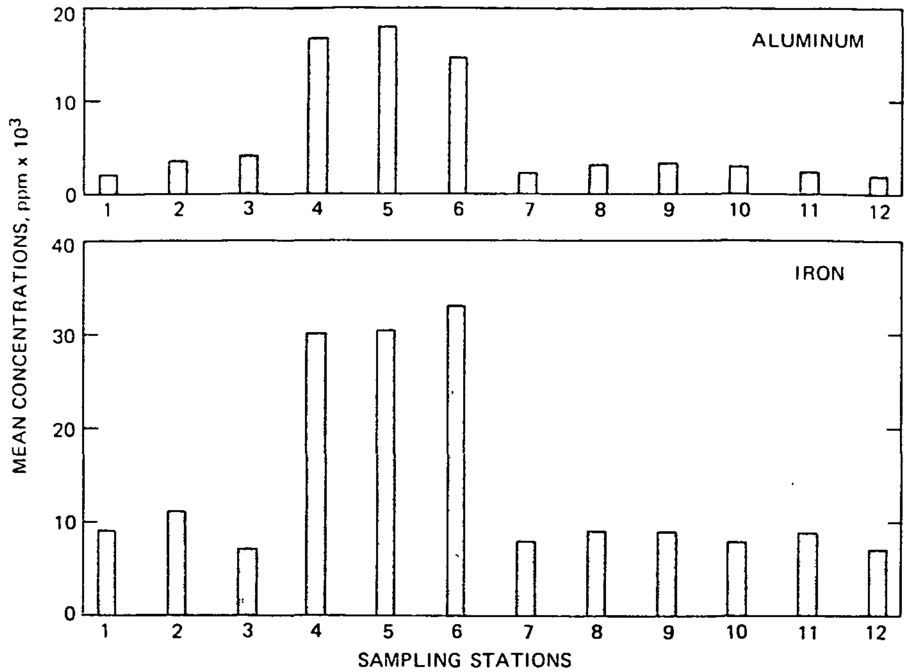


Figure 13. Concentrations of Fe and At in Mississippi River sediments at Alton

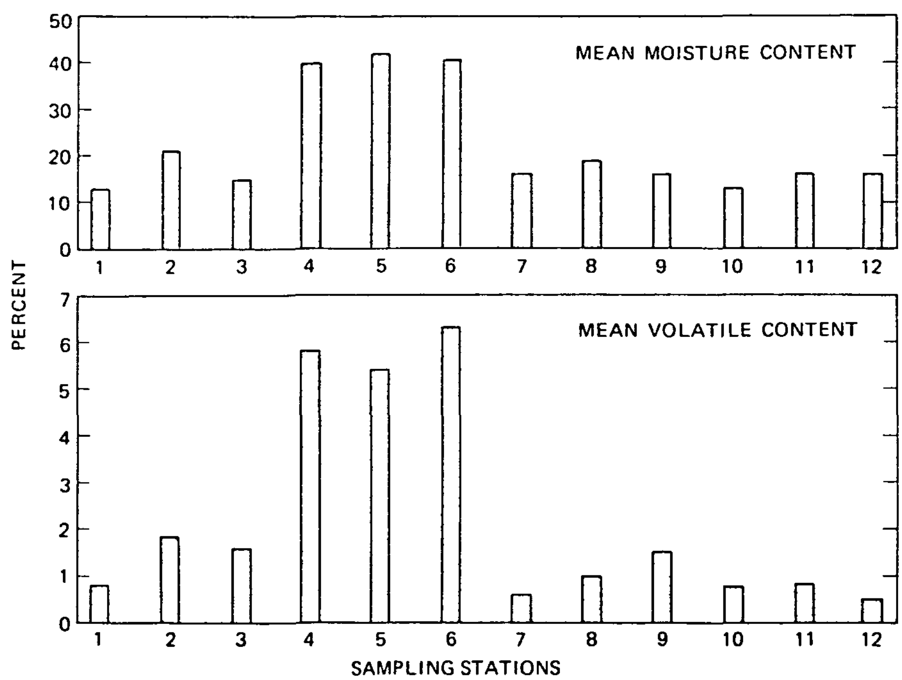


Figure 14. Volatile and moisture content of Mississippi River sediments at Alton

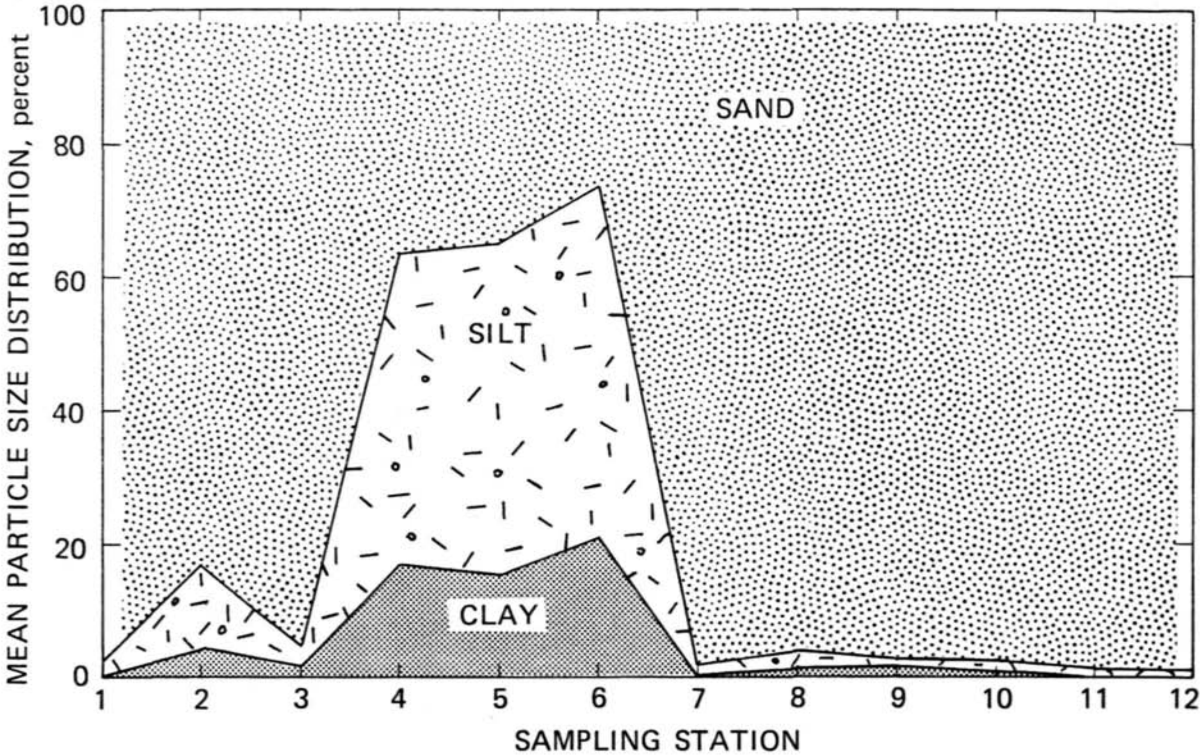


Figure 15. Grain size distribution of sediments in Mississippi River at Alton

The sampling stations selected for the examination of the bottom sediments for benthic macroinvertebrates are also designated in figure 10. Eleven stations were examined and 17 taxa were identified from 23 samples. The predominant organisms recovered were aquatic worms (Tubificidae), midge fly larvae (Chironomidae), burrowing mayflies *(Hexagenia)*, caddisflies *(Cheumatopsyohe),* and fingernail clams *(Sphaerium)*. They accounted, respectively, for 69, 14, 5, 4, and 4 percent of the total population.

Population densities were significantly different between stations 1, 2, 3, 10, 11, and 12 compared to stations 4, 5, 6, 13, and 14. As a group the densities of macroinvertebrates for stations 1, 2, 3, 10, 11, and 12 ranged from 25 to 880 individuals per square meter, with an average of 194. The group of stations consisting of 4, 5, 6, 13, and 14 contained densities ranging from 378 to 3036 individuals per square meter with an average of 1792.

The IEPA aquatic classification system was outlined earlier. A summary of the application of that system to the macroinvertebrate populations observed at Alton is included in table 13. Numerical values were assigned to each aquatic class to facilitate comparison. As shown in the table all stations are classified as semi-polluted except stations 2 and 10. These are classified as polluted.

In accordance with IEPA procedures all the Chironomidae are considered pollution tolerant. There are genera and species of this family that are

Table 13. IEPA Aquatic Classification of Stations

Date	Station	1	2	3	4	5	6	10	11	12	13	14
8/06/80		3	3	3				3	3	3		
11/13/80		3	4	3				4	3	3		
4/03/81								3	3	3		
4/16/81		3	3	3								
6/29/81					3	3	3				3	3
Average		3.0	3.3	3.0	3.0	3.0	3.0	3.3	3.0	3.0	3.0	3.0

Aquatic class	Abbreviation	Assigned point value
Balanced	B	1
Unbalanced	UB	2
Semi-polluted	SP	3
Polluted	P	4
Barren Areas	BA	5

less tolerant of pollution than indicated. Thus the system as applied to Chironomidae tends to depict a less favorable environmental condition than may actually exist. The development of less costly and time consuming techniques for better identification of Chironomidae would modify this tendency.

Among the 11 stations examined the only station from which pollution intolerant organisms were retrieved was station 4. Those organisms were mayflies (*Isonychia* and Stenonema). This condition at station 4 is probably due more to the characteristics of the bottom sediments than to the overlying water quality. The bottom sediments at station 4 consisted mainly of silt with exposed rock and gravel.

An important factor to the production and diversity of benthic invertebrate macrofauna is the type and stability of the bottom sediments. Abundance is related to the stability of the sediments and access to organic detritus. Sand is a relatively poor habitat for macroinvertebrates because of its instability, especially when its inherent instability is influenced by navigation traffic. On the other hand, the samples collected near the river bank, consisting of a mixture of sand, silt, and clay, provide a stable habitat which permits "burrowing" and "clinging" organisms to colonize.

Stations 13 and 14 are close to the shoreline but *upstream* of the waste outfall. Stations 4, 5, and 6 are close to the shoreline but *downstream* of the outfall. Stations 4, 5, and 6, as described earlier, are impacted by waste flows. Figure 16 shows a comparison of the pollution tolerance status between the upstream and downstream stations. Station 4, a downstream station, was the only station not dominated by pollution tolerant organisms. All stations are classified as semi-polluted.

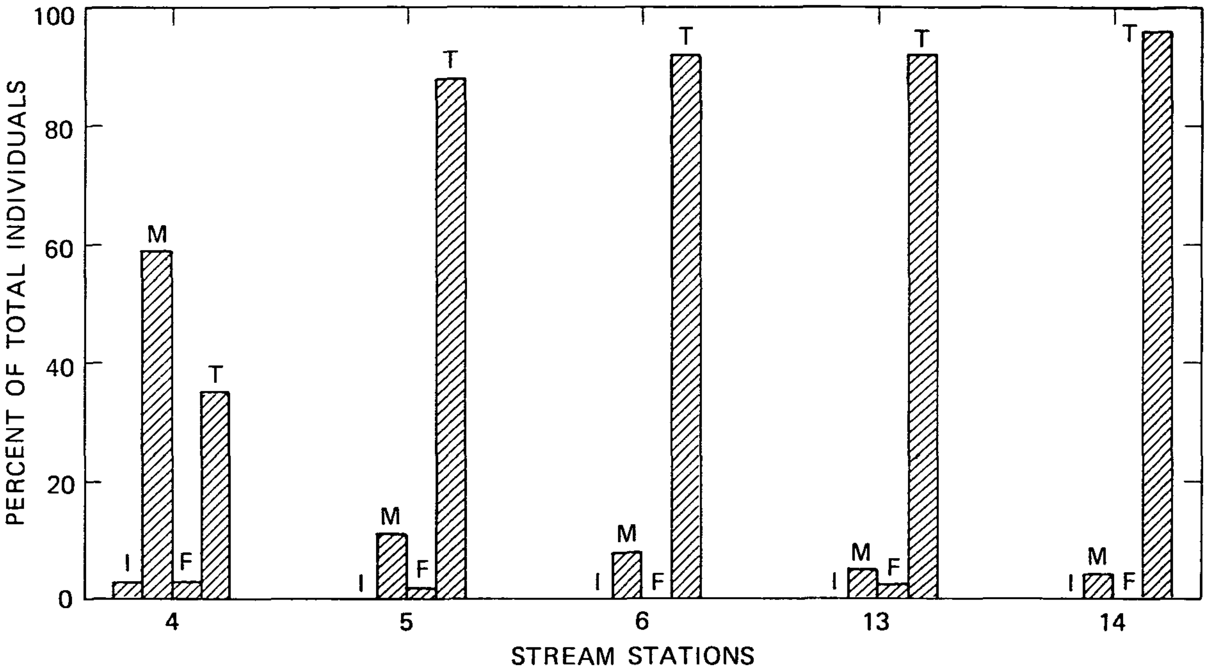


Figure 16. Tolerance status of total individuals on percentage basis

The main point is that the impact of waste flows on the benthic macroinvertebrates of the river at Alton is not an adverse one. Nor can it be considered solely beneficial. The waste flow contribution appears to maintain an aquatic habitat more desirable from the standpoint of macroinvertebrate abundance and diversity than found in those stations more offshore. And there is some evidence (see the appendices) that this influence may be extending to station 3 in terms of abundance of organisms.

Summary of Characteristics of Bottom Sediments

- The bottom sediments at twelve stations located upstream and downstream of the waste outfall, at varying distances from the shoreline, were examined for their chemical, physical, and biological characteristics.

- The impact of the wastes on bottom sediments, as measured by their physical and chemical characteristics, was limited to three stations.

- The impacted area, based upon the location of the three stations, is confined to about 200 feet offshore and 2000 feet downstream of the waste outfall.

- Within the zone of influence Fe and Al concentrations increased about 3.7-fold and 5.6-fold above estimated background concentrations of 8542 and 2903 ppm, respectively.

- Within the zone of influence the liquidity (moisture content) and volatile content of the sediments increased also.

- The natural bottom in the Mississippi River consists mostly of *sand*. The nine stations sampled outside the zone of influence had an average composition of 94 percent sand, 4 percent silt, and 2 percent clay.

- Within the zone of influence the bottom sediments consisted of *sandy silt* with an average composition of 33 percent sand, 49 percent silt, and 18 percent clay.

- The change in composition of the bottom sediments from sand to sandy silt is the result of the reintroduction of river silt to the river by waste flows containing material captured during the treatment process.

- There was not a measurable blanket of unnatural sludge deposits within the area of waste flow influence.

- The abundance of benthic macroinvertebrates is a function of the composition of the bottom sediments.

- Near-shore bottom sediments, including those stations within the influence of waste flows, support a higher density and diversity of macroinvertebrates than other locations.

- All stations examined except stations 2 and 10 are classified as semi-polluted. Stations 2 and 10 are classified as polluted.

- There is no significant difference in the near-shore stations upstream or downstream of the waste outfall in terms of types and density of macroinvertebrates.

- The impact of waste flows does not adversely affect the benthic macroinvertebrate population.

- The maintenance of silty-sand bottom sediments in the Mississippi River, in contrast to a natural sandy bottom, is conducive to increasing the macroinvertebrate population.

CONCLUSIONS

This study has been an effort to determine the quantity and characteristics of wastes produced in a moderately sized water treatment plant employing the clarification process, and to assess the effects, if any, of the discharge of the waste on a large river. The methods used are applicable to other types of water treatment plants and, with some modification, to other flowing streams. In developing a solids balance for the water treatment plant a basic weakness lies in evaluating the quantity of waste from clarifiers that operate on an intermittent "blow-down" cycle. Another weakness lies in the absence of available data for characterizing the suspended solids content of the source water. In Illinois, suspended solids determinations are not routinely performed at water treatment plants; sufficient process control is obtained by reliance on turbidity measurements. These two weaknesses had to be compensated during this study.

The major sources of waste in the water treatment plant at Alton are the mixers, clarifier, sedimentation basins, and rapid sand filters. For the plant, which processes an average of 12.5 mgd, the waste solids generated is about 12,500 pounds per day. About 1.5 percent of the solids load is derived from alum precipitation, with the remainder originating from the suspended solids in the raw water. The sand filters, during backwash, release about 10 percent of the total solids generated.

The volume of waste produced varies from 602,000 to 670,000 gallons per day, with about 97 percent of the waste volume originating from the rapid sand filters. The volume of waste represents about 4.8 to 5.3 percent of the average daily volume of water treated.

The major chemical constituents of the solids wastes are iron and aluminum. The concentrations of iron are probably inherent in the suspended sediments in-transport in the river. Aluminum concentrations are derived from the use of alum as a supplemental coagulant.

Except during 7-day 10-year low flow conditions, increases in suspended solids in the Mississippi River during occurrences of maximum waste discharges will not be perceptible.

The influence of the waste is readily detectable in the bottom sediments of the river by increases in iron, aluminum, moisture, and volatile (organic) content. However, that influence is limited to an impacted area about 200 feet offshore and within 2000 feet downstream of the waste outfall. Within the impacted area iron and aluminum increased about 3.7-fold and 5.6-fold above estimated background concentrations of 8542 and 2903 ppm, respectively. There was also a detectable modification of the composition of sand-silt-clay relationships within the impacted area. Whereas the natural bottom sediments of the Mississippi River are composed, on the average, of 94 percent sand, 4 percent silt, and 2 percent clay, the bottom sediments of the impacted sediments are composed, on the average, of 33 percent sand, 49 percent silt, and 18 percent clay. The change in grain size distribution is brought about by the reintroduction of river "silt" to the river by waste flows containing material captured by the treatment process. Despite the change in bottom sediment composition there is no measurable blanket of sludge deposits.

In the absence of unnatural sludge deposits and without evidence that the iron and aluminum concentrations observed in the bottom sediments are toxic to aquatic organisms, it would not appear that the types of changes in the chemical and physical composition of the sediments in the limited impacted area are a mark of environmental degradation. This conclusion is strengthened by observations of benthic macroinvertebrates in the Alton locale.

An examination of bottom sediments for the abundance and diversity of benthic macroinvertebrates revealed that populations in sandy sediments were sparse while those in silty-sand sediments were more abundant and diverse. This is consistent with the consensus that benthic macroinvertebrate abundance is related to the stability of the habitat. Sand is not a stable habitat, especially when influenced by navigation traffic. On the other hand, a mixture of sand, silt, and clay, with some organic enrichment, provides an aquatic substrate which permits "burrowing" and "clinging" organisms to colonize.

All stations sampled at the Alton locale were classified as either polluted or semi-polluted. There was no significant difference in the near-shore stations upstream or downstream of the waste outfall in terms of types and densities of macroinvertebrates. However, near-shore sediments, including those within the impacted area, supported a higher density and diversity of macroinvertebrates than any of the other locations.

The maintenance of silty-sand bottom sediments in the Mississippi River, in contrast to a natural sandy bottom, is conducive to increasing the benthic population. The waste flows from the water treatment plant at Alton contribute to that maintenance scheme.

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Appendix A. Water Quality of Filter Backwash
(July 17, 1980)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter A				
0	7.37	54	12	0.05
1	7.29	556	58	10.5
1.25	7.32	760	106	12.0
1.5	7.33	726	92	11.3
1.75	7.38	730	102	11.5
2	7.39	750	104	9.5
2.25	7.69	576	78	8.0
2.5	7.52	520	70	7.0
2.75	7.67	373	42	4.6
3	7.81	356	42	4.5
3.5	7.63	284	34	3.5
4	7.70	206	32	2.6
4.5	7.79	143	19	1.6
6	7.62	55	6	0.7
8	7.82	10	0.5	0.08

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter B				
0	7.28	12	2	0.05
1	7.38	582	88	5.3
1.25	7.30	574	82	5.4
1.5	7.49	548	80	5.2
1.75	7.32	358	60	5.1
2	7.48	484	74	4.5
2.25	7.49	436	60	3.8
2.5	7.68	366	56	3.0
2.75	7.38	246	38	2.8
3	7.38	230	34	2.3
3.5	7.71	166	28	1.5
4	7.52	105	16	1.0
4.5	7.6C	48	12	0.6
6	7.68	42	6	0.1
8	7.50	24	4	0.07

Appendix A. Continued

(July 17, 1980)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter C				
0	7.37	6	1	0
1	7.37	266	43	2.5
1.25	7.38	454	72	8
1.5	7.39	434	70	7.4
1.75	7.39	590	90	8
2	7.39	460	84	7.5
2.25	7.38	292	46	5
2.5	7.37	464	76	7.5
2.75	7.38	364	66	4.6
3	7.38	292	56	4.7
3.5	7.37	208	35	3.3
4	7.42	164	28	2.8
4.5	7.51	122	23	1.9
6	7.53	36	5	0.7
9	7.57	16	2	0.1

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter D				
0	7.78	6	0	0.01
1	7.78	576	70	7.5
1.25	7.54	334	46	4.7
1.5	7.72	290	52	4.5
1.75	7.77	117	28	1.5
2	7.79	138	29	1.6
2.25	7.51	217	42	2.4
2.5	7.69	300	58	3.5
2.75	7.68	180	34	1.9
3	7.88	276	50	3.0
3.5	7.72	342	57	3.0
4	7.56	191	32	1.7
4.5	7.92	163	29	1.8
6	7.86	38	10	0.2
8	7.64	33	10	0.1

Appendix A. Continued

(July 17, 1980)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter E				
0	7.55	7	1	0.01
1	7.67	825	135	15.7
1.25	7.42	792	126	12.2
1.5	7.41	608	112	10.6
1.75	7.52	344	62	7.5
2.25	7.69	254	56	3.8
2.75	7.65	146	30	2.1
3	7.83	174	32	2.3
3.5	7.73	73	17	0.9
4	7.65	49	11	0.5
4.5	7.72	30	8	0.3
6	7.66	22	8	0.2

Appendix A. Continued

(September 12, 1980)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter A				
0	8.52	5	5	0.0
0.33	8.43	7	5	0.0
0.67	7.79	174	56	11.0
1	8.08	354	64	10.0
1.33	8.19	206	68	5.0
1.67	7.99	166	84	2.3
2	8.53	92	26	1.8
2.33	7.99	92	27	1.0
2.67	8.41	53	19	0.5
3	8.50	34	22	0.4
3.5	7.92	17	8	0.1
4	8.44	9	3	0.05
4.40	7.98	12	3	0.02

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter B				
0	7.59	7	3	Tr
0.33	8.01	4	2	0.0
0.67	7.22	1376	192	41.0
1	7.22	1460	200	35.0
1.33	7.31	1200	172	27.0
1.67	7.48	584	88	13.0
2	7.48	394	56	5.7
2.33	7.61	224	34	4.2
2.67	7.98	194	28	3.0
3	7.59	116	16	1.7
3.5	7.61	82	21	1.1
4	8.19	86	21	0.6
4.5	8.30	29	13	0.4
6	8.12	21	7	0.1
6.17	7.66	6	5	0.03

Appendix A. Continued

(September 12, 1980)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter C				
0	7.51	640	108	11.0
0.33	7.40	560	100	10.9
0.67	7.53	230	58	7.5
1	7.40	324	70	6.5
1.33	7.88	252	58	6.5
1.67	7.73	200	50	4.6
2	7.75	130	36	3.2
2.33	7.53	158	34	3.1
2.67	8.00	130	24	2.5
3	7.63	98	21	1.8
3.5	7.97	75	18	1.4
4	8.12	76	17	1.2
4.5	7.68	48	12	0.6
6	8.02	23	9	0.2
6.90	7.70	22	8	0.1

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter D				
0	7.12	11	9	Tr
0.33	7.50	504	90	11.0
0.67	7.30	640	120	15.0
1	7.42	432	88	10.0
1.33	7.69	374	58	9.5
1.67	7.81	374	58	8.5
2	7.73	302	44	7.5
2.33	7.53	134	20	4.2
2.67	7.89	174	24	3.1
3	7.92	114	20	2.3
3.5	8.03	76	18	1.2
4	7.98	80	15	0.9
4.5	7.77	43	9	0.5
6	8.33	12	3	0.1
6.92	8.13	6	2	0.05

Appendix A. Continued

(September 12, 1980)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter E				
0	7.68	6	1	0.02
0.33	7.62	9	7	Tr
0.67	7.30	1208	192	30.9
1	7.30	1116	188	21.5
1.33	7.48	836	152	17.5
1.67	7.38	676	116	13.0
2	7.42	412	80	7.0
2.33	7.57	152	38	2.6
2.67	7.52	146	34	2.3
3	7.88	92	30	1.3
3.5	7.73	35	8	0.4
4	7.64	45	5	0.2
4.5	7.68	12	4	0.1
6	7.60	4	2	0.05
7.13	8.42	4	1	0.01

Appendix A. Continued

(October 24, 1980)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter A				
0	8.09	10	8	Tr
0.33	7.68	618	152	38
0.67	7.80	520	148	28
1	7.73	360	112	17.5
1.33	7.69	192	80	6.8
1.67	7.78	130	46	3.5
2	7.97	100	40	2
2.33	7.97	63	24	0.9
2.67	7.81	29	17	0.1
3	8.00	17	8	0.03
3.5	7.76	20	7	0.01

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter B				
0	7.86	14	9	Tr
0.33	7.83	12	3	Tr
0.67	7.40	1136	236	50
1	7.40	1244	264	55
1.33	7.68	1056	220	48
1.67	7.50	692	144	32
2	7.52	500	100	21
2.33	7.56	272	44	10
2.67	7.71	148	40	4
3	7.62	92	16	1.7
3.5	7.67	56	10	1.0
4	7.76	13	2	0.05
4.5	7.88	11	1	0.02
5.5	7.82	3	2	Tr

Appendix A. Continued

(October 24, 1980)

Time (min)	pH	SS rag/l	VSS mg/l	Set.S ml/l
Filter C				
0	7.92	13	4	0.0
0.33	8.02	11	3	0.0
0.67	7.85	12	3	Tr
1	7.65	480	96	26
1.33	7.68	480	104	27
1.67	7.50	473	96	26
2	7.54	332	84	16
2.33	7.48	344	92	16
2.67	7.71	176	48	13
3	7.62	172	40	8.5
3.5	7.68	83	18	2.5
4	7.98	70	18	2
4.5	7.78	48	14	1.4
6	7.89	13	2	0.8
7.10	7.67	5	0	0.2

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter D				
0	7.59	13	2	Tr
0.33	7.88	13	2	Tr
0.67	7.67	15	2	0.01
1	7.39	816	168	43
1.33	7.30	1060	212	48
1.67	7.48	852	168	42
2	7.36	688	124	33
2.33	7.51	372	72	15
2.67	7.52	236	40	8
3	7.71	156	28	4.3
3.5	7.82.	148	30	4.5
4	7.80	116	24	2.9
4.5	7.68	58	10	1.0
6	7.78	14	3	0.05
6.65	7.70	10	2	0.03

Appendix A. Continued

(October 24, 1980)

Time (min)	pH	S3 rag/l	VSS mg/l	Set.S ml/l
Filter E				
0	7.60	16	3	0.01
0.33	7.68	812	160	43
0.67	7.42	1508	308	95
1	7.40	1412	256	65
1.33	7.39	628	124	27
1.67	7.57	496	100	20
2	7.52	356	72	13
2.33	7.61	224	40	8
2.67	7.62	150	30	3.5
3	7.96	80	14	1.3
3.5	7.71	33	6	0.1
4	7.72	16	3	0.02
4.5	8.10	12	2	0.01

Appendix A. Continued

(January 8, 1981)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter A				
0	7.94	22	13	Tr
0.33	7.96	182	68	13
0.67	7.90	216	144	40
1	7.90	612	212	52
1.33	7.90	528	168	44
1.67	7.91	524	212	37
2	7.98	316	116	19
2.33	8.00	244	96	13
2.67	8.01	158	60	7.1
3	8.00	70	32	0.55
3.5	8.00	36	19	0.20
4	8.04	18	6	0.02
4.25	8.05	9	8	0.01

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter B				
0	8.04	23	11	0.02
0.33	8.03	404	120	38
0.67	7.95	524	144	44
1	7.96	768	212	80
1.33	8.00	900	244	80
1.67	8.00	644	180	45
2	8.03	560	172	40
2.33	8.00	436	140	28
2.67	8.00	256	96	13.5
3	8.06	228	84	12
3.5	8.06	190	54	6
4	8.00	146	42	6.4
4.5	8.06	38	11	0.51
5.75	8.02	12	5	0.04

Appendix A. Continued

(January 8, 1981)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter C				
0	8.02	21	10	0.03
0.33	8.00	58	20	1.48
0.67	7.94	792	224	84
1	7.87	840	244	86
1.33	7.88	664	184	52
1.67	8.00	420	120	28.5
2	8.00	400	116	26.5
2.33	7.97	312	92	20
2.67	8.05	232	44	3.95
3	8.01	152	50	6
3.5	8.11	83	26	2.9
4	8.11	49	17	1.4
4.5	8.11	36	13	0.6
6	8.09	6	8	0.15
7	8.04	10	5	0.06

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter D				
0	7.98	22	8	0.04
0.33	7.91	220	76	19
0.67	7.95	456	144	45
1	7.90	576	172	58
1.33	7.90	828	236	75
1.67	7.96	816	244	63
2	7.97	672	196	46
2.33	7.94	576	176	42
2.67	7.98	320	116	21.5
3	8.02	240	84	12.5
3.5	8.11	142	50	4.8
4	8.05	92	34	2.9
4.5	8.10	54	26	1.4
6	8.06	24	11	0.35
8.17	8.07	4	4	0.03

Appendix A. Continued

(January 8, 1981)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter E				
0	8.08	14	7	Tr
0.33	7.91	1208	328	140
0.67	8.00	716	200	46
m120	8.00	684	172	43,
1.33	8.03	308	92	19.5
1.67	8.06	172	108	8.0
2	8.07	72	24	2.5
2.33	8.06	50	20	1.1
2.67	8.06	43	18	0.50
3	8.06	21	7	0.0
3.5	80.6	15	7	0.2

Appendix A. Continued

(March 12, 1981)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter A				
0	8.26	12	4	Tr
0.33	8.05	12	4	Tr
0.67	7.66	1642	332	88
1	7.65	1350	300	62
1.33	7.63	1020	220	43
1.67	7.89	400	95	15
2	7.94	276	64	8
2.33	8.06	92	16	2.4
2.67	8.05	82	16	2
3	8.03	32	9	0.5
3.5	7.96	14	5	0.05
4	8.32	6	2	0.01

Time (min)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter B				
0	8.23	18	8	Tr
0.33	8.04	108	80	8.5
0.67	7.71	1820	470	108
1	7.63	2150	550	120
1.33	7.81	1450	380	75
1.67	7.72	1300	340	60
2	7.71	990	250	38
2.33	7.83	690	200	25
2.67	7.92	630	180	21
3	7.80	532	136	19
3.5	7.99	156	44	3.8
4	8.13	65	19	0.6
4.5	8.24	31	12	0.1
6	8.17	9	4	Tr

Appendix A. Continued

(March 12, 1981)

Time (tain)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter C				
0	8.15	18	7	0.01
0.33	7.76	760	180	30
0.67	7.71	840	210	34
1	7.92	530	150	18.5
1.33	7.99	570	160	21
1.67	7.86	520	160	18
2	7.90	372	92	13
2.33	7.97	288	76	9
2.67	8.08	240	60	7
3	7.99	192	52	5
3.5	8.11	140	44	3.2
4	8.16	76	20	1.4
4.5	8.23	64	20	1.3
5.5	8.05	21	7	0.3

Time (rain)	pH	SS mg/l	VSS mg/l	Set.S ml/l
Filter D				
0	7.88	19	10	Tr
0.33	7.80	700	220	31
0.67	7.68	660	200	26.5
1	7.76	480	170	18
1.33	7.75	670	220	25.5
1.67	7.78	570	200	21
2	7.81	510	170	16
2.33	7.83	364	112	10.5
2.67	8.01	244	52	7.5
3	7.99	140	60	4
3.5	8.06	104	44	2.3
4	8.13	72	32	1.7
4.5	8.02	52	28	0.8
5.67	8.22	15	6	0.25

Appendix A. Concluded

(March 12, 1981)

Time (min)	pH	SS mg/l	VSS mg/l	Set.S mg/l
Filter E				
0	8.06	18	5	Tr
0.33	7.89	372	84	16.5
0.67	7.68	1520	350	76
1	7.72	1060	230	42
1.33	7.84	520	120	17.5
1.67	7.86	470	110	18
2	7.99	216	52	16
2.33	8.04	124	28	2.1
2.67	7.97	70	16	1.3
3	8.12	44	12	0.5
3.5	8.11	31	8	0.25
3.75	8.07	27	8	0.1

Appendix B. Chemical Characteristics of Bottom Sediments

Station	% Moisture	% Volatile	Fe—ppm	Al—ppm
8/06/80				
1	15.5	0.4	10,700	2,860
2	15.5	0.7	6,550	2,550
3	17.7	2.5	13,000	6,230
4	20.3	5.0	39,300	20,800
5	27.2	2.5	28,000	13,200
6	27.6	4.5	30,300	14,650
7	16.5	0.5	8,380	2,540
8	31.0	3.4	40,500	20,100
9	16.0	1.7	7,900	2,300
10	18.0	1.1	9,600	5,200
11	16.3	1.4	10,800	3,380
12	14.5	0.3	6,600	1,580
11/13/80				
1	10.2	0.3	6,600	1,800
2	17.4	0.4	7,200	1,600
3	11.9	0.7	8,220	2,310
4	38.3	4.4	23,400	12,880
5	39.7	5.1	37,700	21,700
6	44.7	6.3	52,000	32,200
7	14.8	0.4	9,150	2,700
8	17.1	0.4.	7,770	1,580
9	19.0	1.3	14,000	6,000
10	6.9	0.6	8,850	2,320
11	16.6	0.5	9,100	2,600
12	16.2	0.8	9,300	3,120
4/03/81				
1	13.9	1.62	9,440	1,840
2	31.5	3.64	19,400	6,600
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4	53.7	7.57	33,000	13,400
5	50.4	7.94	36,300	15,400
6	41.0	6.47	24,200	8,700
7	16.1	0.93	6,000	1,500
8	23.0	2.28	14,400	5,900
9	14.3	1.56	5,360	1,800
10	14.9	0.68	5,030	1,180
11	15.6	0.58	6,840	1,380
12	18.6	0.41	5,400	1,190
4/16/81				
4	47.6	6.4	24,400	11,000
5	50.3	6.2	20,700	11,100
6	51.7	8.0	27,000	13,700
8	17.7	0.6	5,200	1,300

Appendix C. Particle Size Distribution of Bottom Sediments (%)

Station	1	2	3	4	5	6	7	8	9	10	11	12
8/06/80												
Sand and larger	98.4	94.9	92.3	56.0	73.6	53.0	97.7	57.5	96.8	85.3	93.9	99.4
Silt	1.1	3.9	4.9	29.5	20.4	27.0	1.7	23.9	2.1	10.1	3.3	0.4
Clay	0.5	1.2	2.8	14.5	6.0	20.0	0.6	18.6	1.1	4.6	2.8	0.2
11/13/80												
Sand and larger	99.7	99.6	97.9	47.8	29.6	12.2	99.3	99.7	93.5	99.8	98.1	95.9
Silt	0.2	0.3	1.6	39.0	49.6	62.6	0.4	0.2	4.0	0.2	1.3	3.0
Clay	0.1	0.1	0.5	13.2	20.8	25.2	0.3	0.1	2.5	0.0	0.6	1.1
4/03/81												
Sand and larger	96.1	55.9		13.5	11.2	23.8	98.4	80.3	97.1	99.7	99.8	99.7
Silt	3.8	31.8		65.7	73.8	60.6	1.0	13.4	1.8	0.2	0.2	0.2
Clay	0.1	12.3		20.8	15.0	15.6	0.6	6.3	1.1	0.1	0.0	0.1
4/16/81												
Sand and larger				28.3	27.7	17.4		100.0				
Silt				51.7	53.1	59.6		0.0				
Clay				20.0	19.2	23.0		0.0				

Appendix D. Physical Characteristics of Bottom Sediments in the Mississippi River near the Alton Water Treatment Plant

Station	
	August 6, 1980 Collection
1	Thin watery tan-gray silt layer over clean coarse sand
2	Thin soft silt layer over clean sand with some pea gravel
3	Thin silt layer over clean sand with some gravel
4	Watery tan-gray layer over cinders embedded gray silt
5	Watery tan-gray layer over rocks and cinders in qray silt
6	Watery tan-gray layer on top of compact gray silt
7	Thin layer of watery tan-gray silt on top of clean medium sand
8	Tan-qray layer over sand over compact qray layer
9	Thin tan-gray layer over clean sand with some detritus
10	Tan-gray clayey silt over medium to coarse sand
11	Watery thin tan-gray layer over clean medium sand
12	Dirty sand layer over clean medium sand
	November 13, 1980 Collection
1	Clean medium to coarse sand
2	Clean medium sand
3	Some tan-gray clayey silt over medium sand
4	Watery tan-gray layer over gray layer with rocks
5	Thick layer of tan-gray over pasty gray layer with rocks
6	Thin layer of tan-gray over pasty gray layer
7	Very thin layer of tan-gray on medium clean sand
8	Clean medium sand
9	Thin layer tan-gray clayey silt over clean medium sand
10	Clean medium sand
11	Clean medium to coarse sand
12	Thin layer of tan-gray silt over clean sand
	April 3, 1981 Collection
1	Thin watery tan-gray layer over clean medium sand
2	Tan-gray gelatinous clayey silty sand
4	Tan-gray gelatinous clayey silt embedded with large cinders
5	Gelatinous clayey silt
6	Gelatinous clayey silt embedded with rocks and fiberous detritus
7	Thin watery tan-gray layer over clean medium sand
8	Watery clayey silty sand
9	Medium sand with some shells and clayey silt
10	Clean medium sand with some pea gravel and shells
11	Clean medium to coarse sand
12	Clean medium sand
	April 16, 1981 Collection
1	Clean medium to coarse sand
2	Clean medium sand
3	Pasty tan-gray layer over clean medium sand
4	Watery tan-gray clayey silt over gray silt
5	Gelatinous tan-gray clayey, sandy, silt embedded with rocks
6	Pasty tan-gray clayey silt
8	Clean coarse to medium sand
	June 29, 1981 Collection
4	Rocks and gravel with some silt
5	Tan-gray sandy, clayey silt with some gravel and cinders
6	Pasty gray silt with gravel and rock
13	Pasty gray silt with gravel and rock
14	Gelatinous tan-gray sandy, clayey silt

Appendix E. Benthic Macroinvertebrate Organisms (Individuals per Square Meter) Collected from Alton Water Treatment Plant

(August 6, 1980)

Tolerance category and organism	Station 1	2	3	10	11	12
Intolerant						
Isonychia (mayfly)						
Stenonema (mayfly)						
Moderate						
Cheumatopsyche (caddisfly)						
Hydropsyche orris (caddisfly)						
Sphaerium (fingernail clam)			13	6		
Faculative						
Caenis (mayfly)						
Ceratopogonidae (biting midge)						
Dubiraphia (riffle beetle)						
Hexagenia limbata (burrowing mayfly)	19	172	223	19	45	6
Pentagenia vittigera (burrowing mayfly)	6	6				
Stenelrais (riffle beetle)						
Tolerant						
Branchiura sowerbii (aquatic worms)						
Chaoborus (phantom midge)		13	45	6		
Chironomidae (midges)	57	217	344	102	96	13
Corbicula manillensis (asiatic clam)						
Hirudinca (leech)						
Tubificidae (sludge worms)	6	83	255	89		
Total number of individuals	88	491	880.	222	141	19
Total number of taxa	4	5	5	5	2	2
Aquatic classification	sp	sp	sp	sp	sp	sp
Assigned point value	3	3	3	3	3	3

Appendix E. Continued

(November 13, 1980)

Tolerance category and organism	Station					
	1	2	3	10	11	12
Intolerant						
Isonychia (mayfly)						
Stenonema (mayfly)						
Moderate						
Cheumatopsyche (caddisfly)			13		6	13
Hydropsyche orris (caddisfly)						
Sphaerium (fingernail clam)						
Faculative						
Caenis (mayfly)						
Ceratopogonidae (biting midge)	19		13		26	19
Dubiraphia (riffle beetle)						
Hexagenia limbata (burrowing mayfly)			38			
Pentagenia vittigera (burrowing mayfly)			6		6	
Stenelmis (riffle beetle)						6
Tolerant						
Branchiura sowerbii (aquatic worms)					26	19
Chaoborus (phantom midge)						
Chironomidae (midges)	6	26	172	38	83	51
Corbicula manillensis (asiatic clam)						6
Hirudinca (leech)						
Tubificidae (sludge worms)		26	115	6	57	26
Total number of individuals	25	52	357	44	204	140
Total number of taxa	2	2	6	2	6	7
Aquatic classification	sp	p	sp	p	sp	sp
Assigned point value	3	4	3	4	3	3

Appendix E. Continued

(April 3. 1981)

Tolerance category and organism	Station 1*	2*	3*	10	11	12
Intolerant						
Isonychia (mayfly)						
Stenonema (mayfly)						
Moderate						
Cheumatopsyche (caddisfly)	6	6		19		13
Hydropsyche orris (caddisfly)						
Sphaerium (fingernail clam)		6	19	6	6	6
Faculative						
Caenis (mayfly)						
Ceratopogonidae (biting midge)	13	6	6		6	32
Dubiraphia (riffle beetle)						
Hexagenia limbata (burrowing mayfly)						
Pentagenia vittigera (burrowing mayfly)				13		
Stenelmis (riffle beetle)						
Tolerant						
Branchiura sowerbii (aquatic worms)			6			
Chaoborus (phantom midge)						
Chironomidae (midges)	13	19	13		19	64
Corbicula manillensis (asiatic clam)						
Hirudinca (leech)						
Tubificidae (sludge worms)		19	35	102	26	26
Total number of individuals	32	56	401	140	57	141
Total number of taxa	3	5	5	4	4	5
Aquatic classification	sp	sp	sp	sp	sp	sp
Assigned point value	3	3	3	3	3	3

*Collected April 16,1981

Appendix E. Concluded

(June 29, 1981)

Tolerance category and organism	Station				
	4	5	6	13	14
Intolerant					
Isonychia (mayfly)	13				
Stenonema (mayfly)	13				
Moderate					
Cheumatopsyche (caddisfly)	332	6	89		70
Hydropsyche orris (caddisfly)	83		6		6
Sphaerium (fingernail clam)	45	140	51	153	38
Faculative					
Caenis (mayfly)	6		6		
Ceratopogonidae (biting midge)					
Dubiraphia (riffle beetle)	6				
Hexagenia limbata (burrowing mayfly)	6	26		83	
Pentagenia vittigera (burrowing mayfly)					
Stenelmis (riffle beetle)	6			19	6
Tolerant					
Branchiura sowerbii (aquatic worms)	6	26	26		45
Chaoborus (phantom midge)					
Chironomidae (midges)	51	70	185	96	96
Corbicula manillensis (asiatic clam)					
Hirudinca (leech)	13		13		26
Tubificidae (sludge worms)	204	1110	1480	2685	2622
Total number of individuals	784	1378	1856	3036	2909
Total number of taxa	13	6	8	5	8
Aquatic classification	sp	sp	sp	sp	sp
Assigned point value	3	3	3	3	3