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Impact of Wastes from a Water Treatment Plant: Evaluative Procedures and Results

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IMPACT OF WASTES FROM A WATER TREATMENT PLANT: EVALUATIVE PROCEDURES AND RESULTS

by Ralph L. Evans, Donald H. Schnepper, and Thomas E. Hill

INTRODUCTION

Public water supplies in Illinois are treated by a variety of processes. The basic methods include facilities for iron and manganese removal; clarification; softening by lime, soda ash, and ion exchange; and solely chlorination. With the exception of chlorination, each treatment process produces a significant quantity of wastes. These wastes consist mainly of solids in the suspended and dissolved forms 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 direct discharge of the wastes to watercourses has been reported to cause floating scum, discoloration, increased turbidity, sludge deposits, and excessive dissolved solids in the receiving waters. The disturbance of aquatic biota is reported to be a consideration also in evaluating the effects of waste discharges to water bodies.

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, or 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 operations. Some particulate material may be contained in the waste but the principal constituents are in dissolved form.

The effects of waste discharges from water treatment plants on receiving streams have not been evaluated in Illinois. A basic requirement in this regard is the development of valid procedures for performing evaluations. This report summarizes the procedures used and the results obtained in assessing the effects on a stream in Illinois of waste discharges from a water plant that employs the clarification process.

Study Area

The water treatment plant serving the city of Pontiac (pop. 10,600) in Livingston County is owned and operated by the Northern Illinois Water Corporation. The plant, shown in figure 1, is located on a bank of the Vermilion River, the source of water for treatment. At a distance of about 1000 feet below the plant intake is a structure known locally as the Mill Street Dam. The dam, shown in figure 2, forms a pool with a maximum water depth of about 8 feet and width of 140 feet at normal pool stage. Wastes from the plant are discharged into the pool below the water intake.

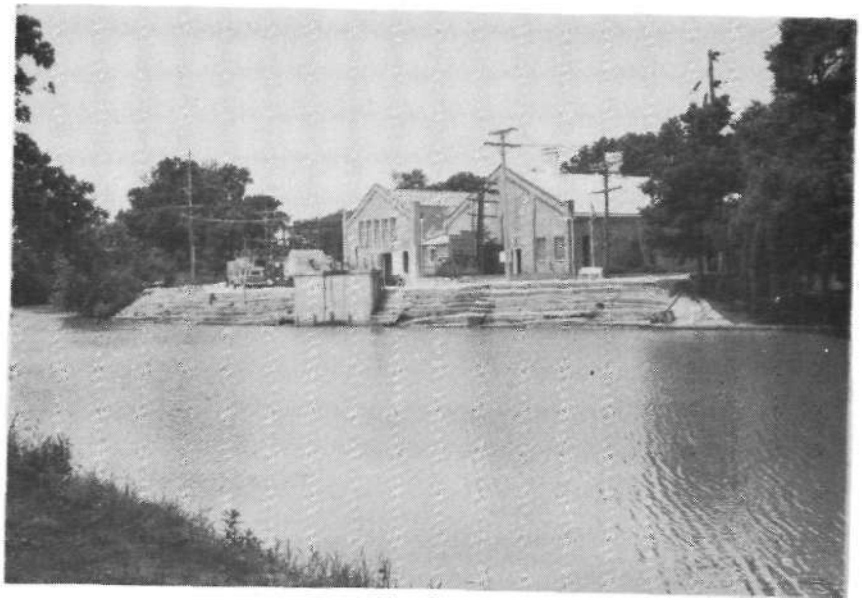

Figure 1. Water treatment plant at Pontiac

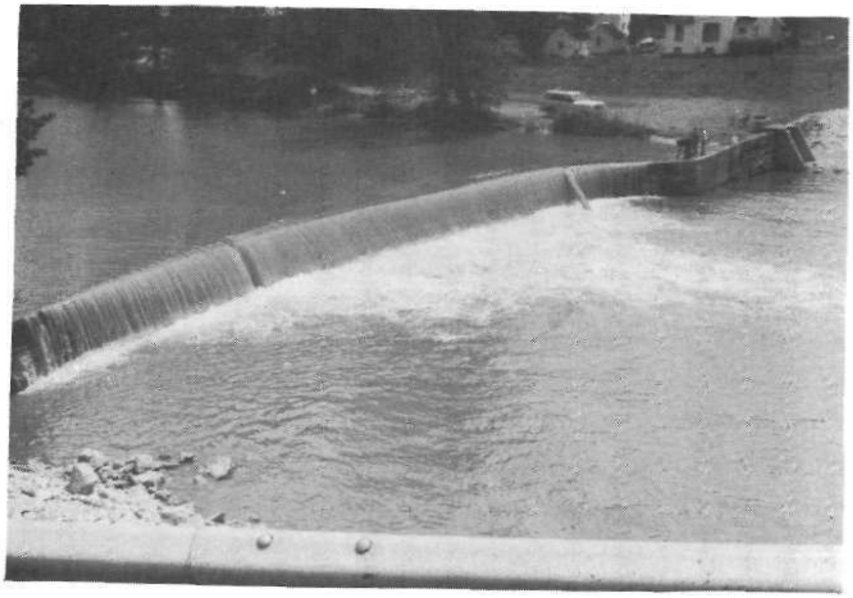

Figure 2. Mill Street dam on Vermilion River at Pontiac

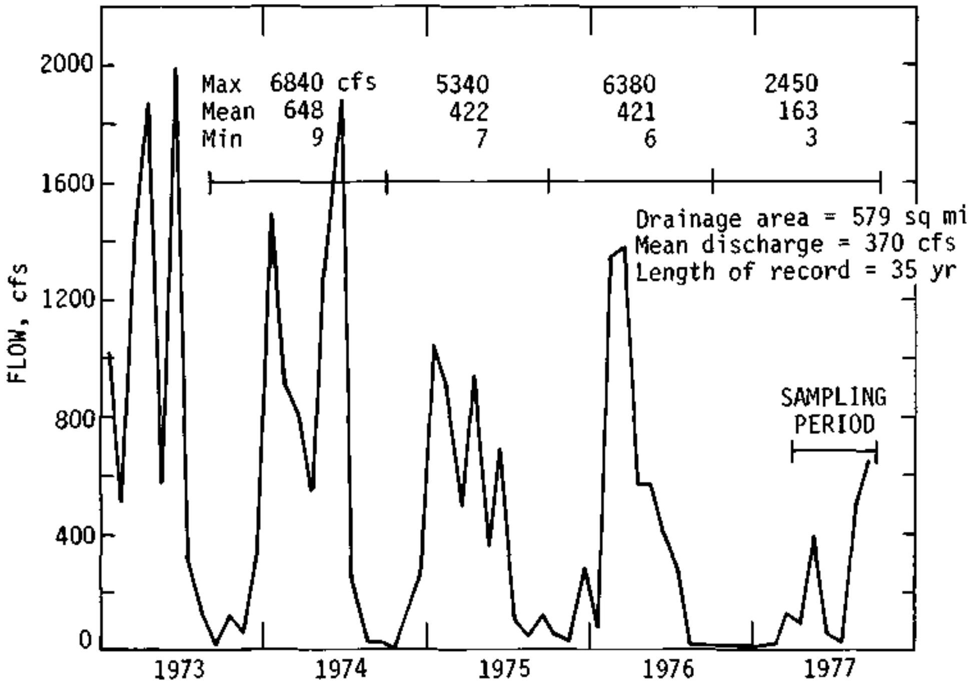

Figure 3. Five-year hydrograph of mean monthly flows of Vermilion River at Pontiac

The drainage area of the river above the plant is about 580 square miles. Average streamflow is about 370 cubic feet per second (cfs) or 239 million gallons per day (mgd). Streamflows are variable as depicted in figure 3. Maximum flows for the year often exceed 6000 cfs; minimum flows are generally less than 10 cfs. The temperature regime of the river waters is similar to that of other central Illinois streams. Mean monthly water temperatures and ranges are shown in figure 4.

The only significant point source of wastes upstream of Pontiac is the city of Fairbury (pop. 3360). It is located about 20 to 25 river miles upstream. Periodic occurrences of nitrate-nitrogen (NO_3 -N) concentrations in excess of 10 milligrams per liter (mg/1) in the stream waters is a source of concern to the owners of the water treatment plant. Figure 4 also shows the mean monthly concentrations of NCb -N that have been recorded during the 52-month period of June 1957 to September 1961 and the 57-month period extending from January 1972 to September 1976. Other than NCb -N the water quality of the river is amenable to satisfactory treatment by the facilities maintained at the plant.

Objectives and Scope

A principal objective of this study was the development 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 four basic tasks performed to accomplish this objective were:

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

2) Review the available historical record of water quality in the receiving stream waters and establish a water quality sampling program for assessing the detectability of waste in the stream

3) Ascertain the type and abundance of benthic organisms in the stream bottom muds and determine the location and extent, if any, of waste sludge deposits

4) Establish a biological monitoring system in the receiving stream for identifying the types and abundance of macroinvertebrates that will colonize artificial substrates located upstream of and within the influence of waste discharges

The findings are reported here in three sections, i.e., the water treatment plant study, chemical characteristics of the stream, and biological characteristics of the stream. There is also a concluding section. All pertinent data developed during the course of the study are included in the appendix.

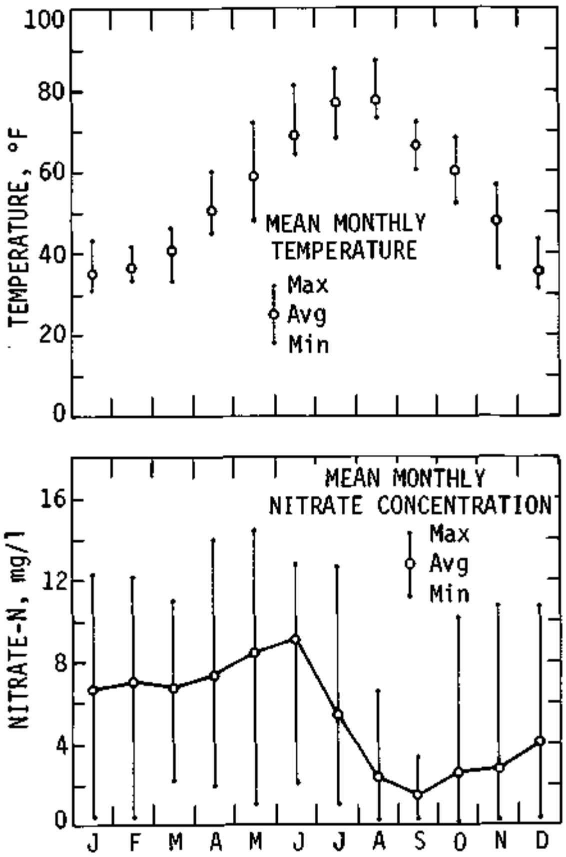

Figure 4. Mean monthly temperatures and nitrate concentrations for Vermilion River at Pontiac

Acknowledgments

This report was prepared under the general administrative direction of Dr. William C. Ackermann, Chief of the Illinois State Water Survey. George Russell of the Northern Illinois Water Corporation proposed the site for the study and provided cooperation and encouragement throughout. John Shirkey, Superintendent, and Norm Wilson, Chief Operator, of the water treatment plant were most helpful in arranging for sampling schedules and making available operation reports. The authors are grateful to other members of the Survey who participated in the work. Mel Jannett and Gary Benker collected waste samples and performed chemical analyses; Dave Hullinger performed heavy metal analyses; Patricia Schulz, Randy Rohman, and Scott Bell assisted in biological sampling and identification. Linda Johnson typed the original manuscript. John W. Brother, Jr., and William Motherway, Jr., prepared the illustrations and Mrs. J. Loreena Ivens edited the manuscript; Mrs. Marilyn Innes typed the camera copy.

WATER TREATMENT PLANT STUDY

The water treatment plant serving the city of Pontiac provides facilities for coagulation, flocculation, settling, and filtration. A flow diagram of the treatment units is shown in figure 5. The intake structure is located along a bank of the river, as shown in figure 6, and it houses four pumps. Two pumps have a rated capacity of 1.5 mgd, one is rated at 1.0 mgd, and the other is rated at 0.5 mgd. Pumpage of raw water during the period of study averaged about 1.83 mgd.

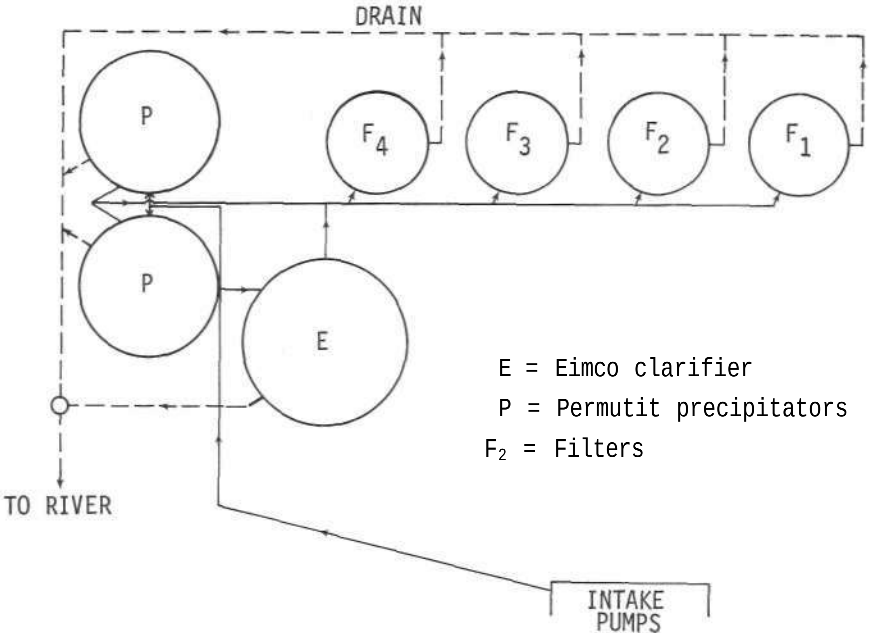

Figure 5. Water treatment units at Pontiac

Figure 6. Intake structure of water treatment plant

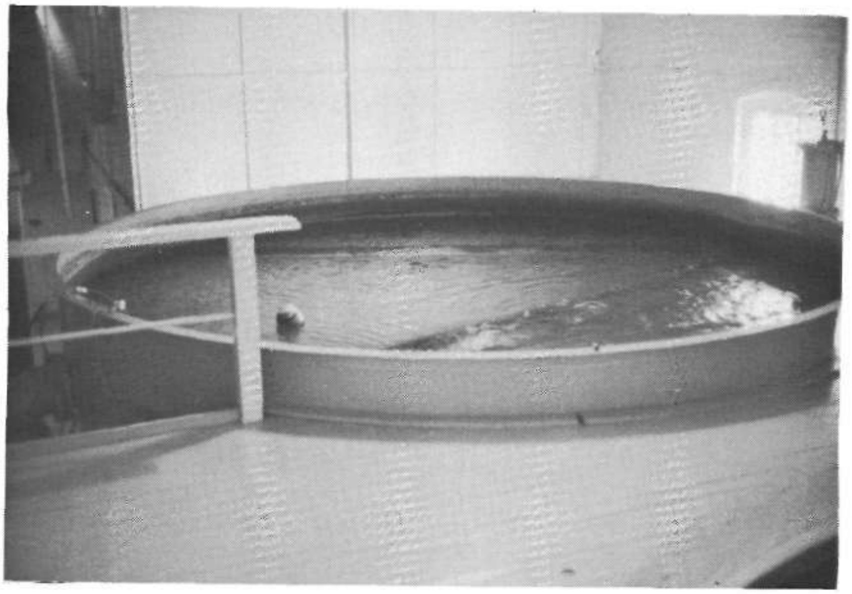

Figure 7. View of rapid sand filter

The raw water is dosed with alum at an average concentration in the water of 55 mg/1 before flow is divided between an Eimco clarifier and two Permutit precipitators. Flow from these basins proceeds to four rapid sand filters operating in parallel with anthrafilt atop them Each filter is 15 feet in diameter. A top view of filter No. 1 is shown in figure 7. If we assume that the average flow of water being treated is equally divided among the four filters, the filtration rate is about 1.7 gallons per minute per square foot (gpm/ft^2) of filter area.

All filters are backwashed daily during early morning hours. The water storage provided for backwash purposes is about 100,000 gallons. At times the storage is not sufficient for backwash, and on those occasions water is withdrawn from storage for the distribution system. Backwash flows are at a rate of 2500 gpm, thus providing a backwash rate of about 14 gpm/ft^2 of filter surface area.

During the period of sampling the filter backwash waters, the average waste volume was 102,600 gallons per day (gpd). The volume of wastes intermittently discharged from the basins (clarifier and precipitators) was reported to be about 700 to 1000 gpd. To estimate the daily waste volumes from the plant, reliance was placed on data recorded daily in operation reports in which pumpages for low service and high service are included.

Generally, the difference between the volume of raw water introduced to the plant and that volume pumped to the distribution system is a reasonable estimate of waste water volume A review was made of the daily records for the years 1975, 1976, and 1977 (January to October) Table 1 includes a tabulation of the mean monthly pumpage and estimated waste volumes Any estimated waste volumes substantially lower than 80,000 gpd or higher than 110,000 gpd are difficult to resolve in light of the waste volumes noted during filter backwash and the reported volumes (700 to 1000 gpd) of basin waste. To gain further insight into the volume of waste likely to be originating from the basins, a solids balance was evaluated in the following manner.

As part of a separate investigation, Harmeson (1977) collected 240 composited samples of the raw water from the Vermilion River between October 4, 1976, and June 2, 1977. Suspended

Table 1. Mean Monthly Water Pumpage and Estimated Waste Volumes

	Raw water pumpage			*Treated water pumpage*			*Estimated waste volume*		
	1975	*1976 (mgd)*	*1977*	*1975*	*1976 (mgd)*	*1977*	*1975*	*1976 (gpd)*	*1977*
J	1.66	1.45	1.73		1.40	1.68		50,000	50,000
F	1.64	1.60	1.93		1.48	1.85		120,000	80,000
M	1.62	1.66	1.80		1.56	1.69		100,000	110,000
A	1.68	1.67	1.89	1.36	1.57	1.78	320,000	100,000	110,000
M	1.79	1.70	1.94	1.64	1.62	1.83	150,000	80,000	110,000
J	1.72	1.86	2.15	1.74	1.81	2.03		70,000	120,000
J	1.99	1.84	2.09	1.86	1.76	2.03	130,000	80,000	60,000
A	1.89	1.92	1.88	1.79	1.83	1.85	100,000	90,000	30,000
S	1.75	1.77	1.84	1.57	1.73	1.78	180,000	40,000	60,000
O	1.68	1.54	1.63	1.48	1.52	1.62	200,000	20,000	10,000
N	1.57	1.49		1.39	1.45		180,000	40,000	
D	1.56	1.54		1.41	1.48		150,000	60,000	
Average	1.71	1.67	1.89	1.58	1.60	1.81	130,000	70,000	80,000

solids concentrations ranged from 3 to 169 mg/1 with an average of 28 mg/1. As shown in figure 3, the streamflows were quite low during the first six months of Harmeson's work. During our study reported here, 20 grab samples were obtained from the river between April and October 1977 upstream of the intake. Suspended solids ranged from 7 to 162 mg/1 with an average of 56 mg/1. The samples were representative of variable streamflows. Based on these two sampling periods, the solids loadings to the plant ranged, on the average, from 427 to 854 pounds per day. The suspended solids loadings released during filter backwash averaged 125 pounds per day. This suggests that the basins contribute waste loadings ranging from 300 to 730 pounds of solids per day. From the limited analyses of waste flows from the basins, an average concentration of 3000 mg/1 suspended solids is not unreasonable. The volumes of waste containing 3000 mg/1 suspended solids and producing 300 and 730 pounds per day of solids are computed to be 11,990 gallons and 29,140 gallons, respectively.

On the basis of the solids balance concept, the waste volume produced by the plant is estimated to vary, on the average, from 115,000 to 132,000 gpd. About 103,000 gpd originates from the filter backwash operations and the remainder from the basins. It is concluded that the volume of waste produced daily by the water treatment plant varies from 6.3 to 7.2 percent of the volume of water treated.

Sampling Procedures

Waste discharges from the basins and the rapid sand filters were sampled and analyzed. The unscheduled intermittent discharge from the basins made representative sampling of them most difficult. Six grab samples from each type of basin were obtained and analyses were performed for suspended solids, (SS) volatile suspended solids (VSS), settleable solids (Set. S), chemical oxygen demand (COD), aluminum (Al), magnesium (Mg), calcium (Ca), iron (Fe), silica (SiO_2), and total phosphorus (T.P). In retrospect the procedure used for sampling waste from the basins was poor.

The current design of sludge inlet appurtenances within most clarifiers and of their outlet piping arrangement precludes the release of waste with predictable quality characteristics. The waste flow in terms of suspended solids usually commences 'thin' followed by alternate occurrences of 'thick' to 'thin' surges as the sludge moves in an uncontrolled pattern within the tanks to within the influence of the tank outlet. Normal operation, independent of sampling, involves slowly opening the valve on the waste discharge line and allowing drainage until the waste stream is clear for a period of time. Presumably, waste releases are governed by the elevation of the sludge blanket within the treatment units.

The sampling of backwash waters from the four filters was performed sequentially at arbitrary time intervals during the first several sampling periods. Samples were collected at 15-second intervals for the first 2 minutes. For the next 2 minutes, collections were made at 30-second intervals. Thereafter samples were obtained at 2-minute intervals until the backwash cycle terminated. From the analyses for suspended solids, it became apparent that the peak concentrations were occurring from 2 to 3 minutes after the start of backwash. Computations were made to determine the loads (pounds) being released for those time intervals in which loads would be equal from the filters. From this information new time of collection intervals were selected that provided about an equal percentage of the total load in each sample collected.

Filter backwash cycles were generally 10 to 12 minutes in length and about 15 samples were collected per filter. Sampling was performed on six different dates. Analyses of the samples included pH, suspended solids, volatile suspended solids, settleable solids, and chemical oxygen demand after settling.

The samples were obtained from the wash trough with an extended aluminum rod to which was affixed a sample bottle carrier. Two persons were generally required to collect samples, keep time, and handle the sampling containers.

Results and Discussion

Wastes from the plant discharge into the river about 120 feet downstream of the plant intake. The discharge point is located near the right edge of the tree line shown in figure 8. As previously discussed the estimated daily volume of wastes varies from 115,000 to 132,000 gpd. The volume of waste from the basins is about 10 to 22 percent of the total volume. Of the total suspended solids being discharged in the river daily, the basins' contribution is about 65 to 70 percent. Basin solid loads vary from about 165 to 390 pounds per million gallons of water treated.

The chemical characteristics of the basin sludges were not well defined in this study. A summation of the results obtained from analyses are included in appendix table A. The constituents in the wastes considered most pertinent to detectability in the receiving stream are aluminum and iron, and it is likely that these elements are mainly in particulate form. On that assumption, computations were made for assessing their concentration, on a dry basis, in the basin sludge. The results for sample collections on three dates are shown in table 2.

Although the concentrations of aluminum seem high, ranging from 1000 to 134,000 parts per million (ppm), they are not high in comparison with those in soils and sediments. Bowen (1966) reports that the mean concentration of aluminum in dry soil is 71,000 ppm with a range of 10,000 to 300,000 ppm. Kemp and Thomas (1976) report that aluminum concentrations in the sediments of Lake Huron, Lake Erie, and Lake Ontario range from 50,500 to 81,000 ppm. Gross (1978) found aluminum concentrations in the sediments of Horseshoe Lake near Collinsville, Illinois, ranging from 48,900 to 52,100 ppm.

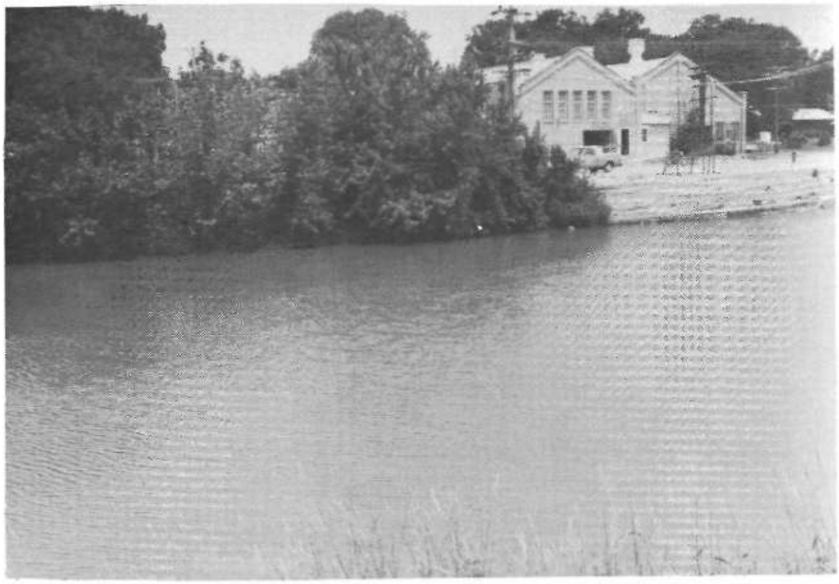

Figure 8. Vermilion River in vicinity of waste outfall

Iron concentrations in the sludges were variable, ranging from 13,000 to 114,000 ppm. The concentrations, however, were not as irregular as those for aluminum. Roseboom et al. (1978) observed iron concentrations in southern Illinois ranging from 9000 to 20,000 ppm in soils, 10,500 to 15,000 ppm in stream sediments, and 9300 to 36,000 ppm in lake sediments. On the basis of Roseboom's observations, concentrations exceeding 20,000 to 25,000 ppm appear excessive for introduction into the environment without a mechanism for dispersal.

Evans and Schnepper (1970) observed that basin sludges from two other municipal clarification water plants contained average concentrations of 15,400 and 30,480 ppm of aluminum. The same plants showed an average iron content of 16,100 to 22,400 ppm. Relatively high concentrations of aluminum and iron in basin sludges of water treatment plants employing the clarification process is a singular characteristic. An evaluation of their distribution in an aquatic system is pertinent to determining the influence of these water plant wastes on the water quality of a receiving stream.

The average volume of waste and duration of backwash for each filter at the Pontiac plant are shown in table 3. A summation of all analytical results for the six dates of backwash sampling for each filter is given in appendix table B.

On several occasions, especially during the colder months, the filters foamed considerably during backwash operations. The operator used a broom to sweep the foam into the wastewater wash troughs in these cases. During the sampling in August, a pronounced 'earthy' odor

Table 2. Aluminum and Iron Concentrations in Basin Sludge (Dry Weight)

(In parts per million)

	Al	Fe
12/16/76		
E	81,000	75,000
P	134,000	114,000
5/6/77		
E	3,000	13,000
P	1,000	33,000
8/9/77		
E	2,000	17,000
P	16,000	19,000

E = Eimco clarifier
P = Permutit precipitators

Table 3. Average Volume of Waste and Duration of Backwash

	Filter number				
	1	*2*	*3*	*4*	*Total*
Volume, *gallons*	30,500	24,800	24,000	23,300	102,600
Duration, *minutes*	12	10	10	9	41

Average rate of backwash: 2500 gpm

Table 4. Pounds of Suspended Solids Released during Backwash of Filters

Filter number	*12/16/76*	*1/11/77*	*2/15/77*	*4/8/77*	*5/6/77*	*8/9/77*	*Avg*
1	39	41	17	52	41	36	38
2	32	45	14	42	37	25	32
3	25	35	8	25	26	17	23
4	24	60	12	31	46	21	32
Total	120	180	51	150	150	99	125

Average pounds per filter: 31

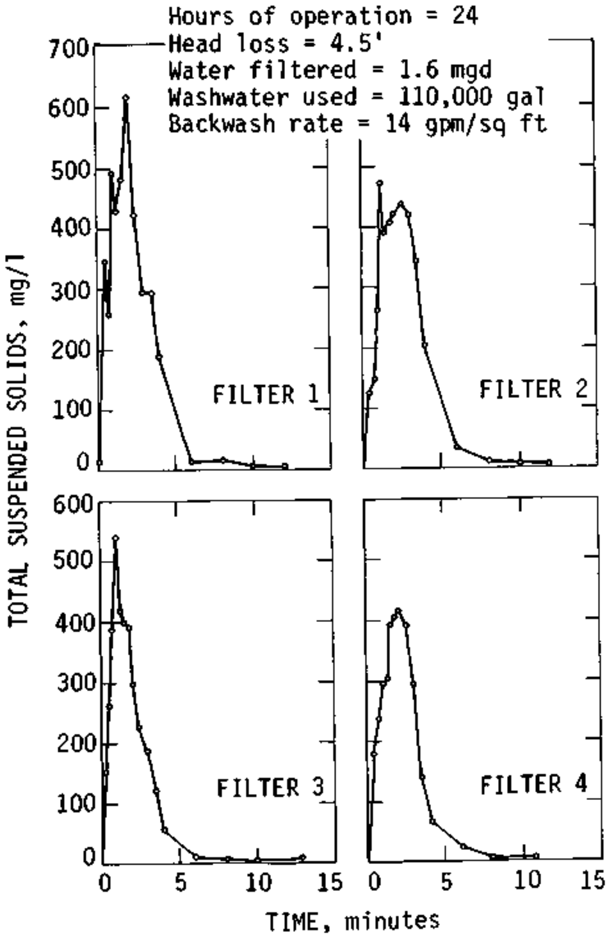

Figure 9. Suspended solids released during backwash, December 16, 1976

was noted during backwash for each filter. Generally however, filter backwash was normal and the operation performed well. An atypical performance was observed on February 15 when only 51 pounds of solids was removed from the filters. This is shown in table 4 where the pounds of solids released for each filter are summarized. As mentioned previously, the average load released from all filters was 125 pounds per backwash. For some reason, filter 3, as shown in table 4, consistently released less solids than the other three units.

A typical suspended solids release pattern for the four filters is depicted in figure 9 as taken for the December 16, 1976, sampling date. The maximum concentration of suspended solids released occurred within 2 to 3 minutes from the start of backwash, and generally there was no significant change in suspended solids concentrations in the wastewater after 6 to 8 minutes of backwash. Maximum concentrations varied from 400 to 1000 mg/1 on filters 1, 2, and 4. The maximum concentration of suspended solids released from filter 3 was 580 mg/1. On the average, the volatile content of the solids was 25 percent. This is consistent with the earlier findings of Evans and Schnepper (1970). The volume of settleable solids averaged about 0.4 percent of the total volume of the backwash wastewater. In terms of the quantity of water treated, the volume of filter backwash wastes was 56,000 gallons per million gallons; suspended solids were 68 pounds per million gallons; and settleable solids were 218 gallons per million gallons.

Summary of Water Treatment Plant Study

1) The sources of waste in the water treatment plant at Pontiac are the clarifiers and rapid sand filters.
2) The estimated waste volume from the water treatment plant varies from 115,000 to 132,000 gpd.
3) The waste volume produced daily ranges from 6.3 to 7.2 percent of the average volume of water treated, i.e., 1.83 mgd.
4) The sampling of basin sludge for defining its chemical and physical characteristics is difficult and a worthwhile procedure for sampling was not developed during this study.
5) The *volume* of waste from the basins makes up between 10 to 22 percent of the total volume of waste. However, the solids originating from the basins contribute about 65 to 70 percent of the total waste load.
6) Solids produced by basin sludges vary from about 165 to 390 pounds per million gallons of water treated.
7) The major chemical constituents in the basin sludge are aluminum and iron.
8) A sequential sampling procedure for filter backwash samples was successfully used.
9) The average load released in the filter backwash is 125 pounds per day in a volume of about 103,000 gpd. The production of solids per million gallons of water treated is about 68 pounds.
10) Maximum concentrations of suspended solids occur 2 to 3 minutes after backwashing commences and range from 400 to 1000 mg/1.
11) Settleable solids volume averages about 0.4 percent of the total filter backwash volume.

CHEMICAL CHARACTERISTICS OF THE STREAM

The Vermilion River in the vicinity of Pontiac is normally a sluggish moving stream with a maximum depth of about 8 feet at dam crest elevation. Its bottom in the pool consists principally of silt with some clay intermixed. About 2000 feet downstream of the dam the U.S. Geological Survey (USGS) maintains a stream gaging station which has provided a continuous record of streamflow since 1942. In a cooperative agreement with the USGS the State Water Survey has examined the mineral quality of the river at the gaging station site at monthly intervals during the periods June 1957 to September 1961 and January 1972 to September 1976. Harmeson and Larson (1969) have published the results for the earlier period. Harmeson and Sinclair (1978) are preparing a report which will include the analytical results during the second period.

Table 5. Mean Monthly Water Quality Measurements
for Vermilion River at Pontiac

(Chemical constituents in milligrams per liter)

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Temperature	35.7	36.6	40.9	50.9	59.3	69.2	77.8	77.7	66.5	60.2	48.6	36.1
Turbidity	16	61	42	59	38	82	46	29	36	33	15	18
Total iron	0.7	2.0	1.8	2.1	1.9	4.2	1.7	1.1	1.6	1.3	0.80	0.90
Manganese	0.06	0.09	0.09	0.10	0.08	0.20	0.05	0.09	0.10	0.08	0.08	0.10
Fluoride	0.20	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20
Boron	0.10	0.09	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.20
Silica	6.2	5.5	6.0	5.9	6.1	9.2	6.2	6.3	6.7	6.7	6.1	5.7
Chloride	15	14	13	14	13	11	10	13	17	16	17	15
Sulfate	102	84	96	90	99	81	88	109	125	124	130	114
Nitrate-N	6.7	7.0	6.7	7.3	8.5	9.1	5.5	2.3	1.5	2.6	2.8	4.1
Ammonia	0.10	0.13	0.12	0.10	0.12	0.13	0.14	0.18	0.13	0.13	0.14	0.17
Calcium	81	81	77	74	82	75	70	71	71	79	87	83
Magnesium	42	31	35	34	38	33	35	37	40	42	41	40
Alkalinity	240	200	211	203	225	206	207	221	217	238	246	243
Hardness	373	317	337	324	353	324	317	332	342	368	384	371
T. diss. solids	463	400	412	398	433	406	396	413	454	463	478	458
Diss. phosphorus	0.05	0.06	0.05	0.03	0.04	0.04	0.03	0.03	0.03	0.05	0.04	0.06
T. phosphorus	0.06	0.06	0.06	0.06	0.07	0.10	0.04	0.06	0.06	0.08	0.06	0.11

On the basis of an evaluation of the data for the two periods of sampling, table 5 has been prepared. As shown, the stream waters are high in the salts of calcium and magnesium and well buffered as evidenced by the alkalinity. These qualities are typical of streams in central Illinois.

Total iron is usually greater than 1.0 mg/1 and contributes significantly to the turbidity — frequently in excess of 30 Formazin turbidity units (Ftu). As mentioned earlier, the only water quality constituent in the waters of the river that creates concern is NO_3 -N. With the exception of periodic algal blooms in the pool, no complaints or observed nuisance conditions associated with water quality have been reported by users of the stream at Pontiac.

Sampling Procedures

Four stream stations, identified in this report as 1, 2, 3, and 4, were selected for routinely obtaining stream water and bottom sediment samples. In addition two other stations, D and F, were established for the collection of bottom sediment. At five other locations within the pool, measurements for cross sections were performed. They are noted here as A, B, C, E, and F. The relative locations of the stations where samples were obtained and cross sections determined are depicted in figure 10.

The locations of the sampling stations were chosen to demonstrate the effects, if any, of waste discharges from the water treatment plant on the stream water quality and its macroinvertebrate inhabitants.

Station 1 is located upstream of the waste discharge. Station 2 is located in the vicinity of the point of waste discharge and stations 3 and 4, as well as D and F, are located at varying distances downstream of waste discharge. All stations are located within the influence of the pool except station 4. The approximate distances of all stations with respect to the waste outfall are shown in figure 11.

Water samples at the four stations were collected near the water surface at weekly intervals for a period of 20 weeks. Water temperature and dissolved oxygen measurements.were performed

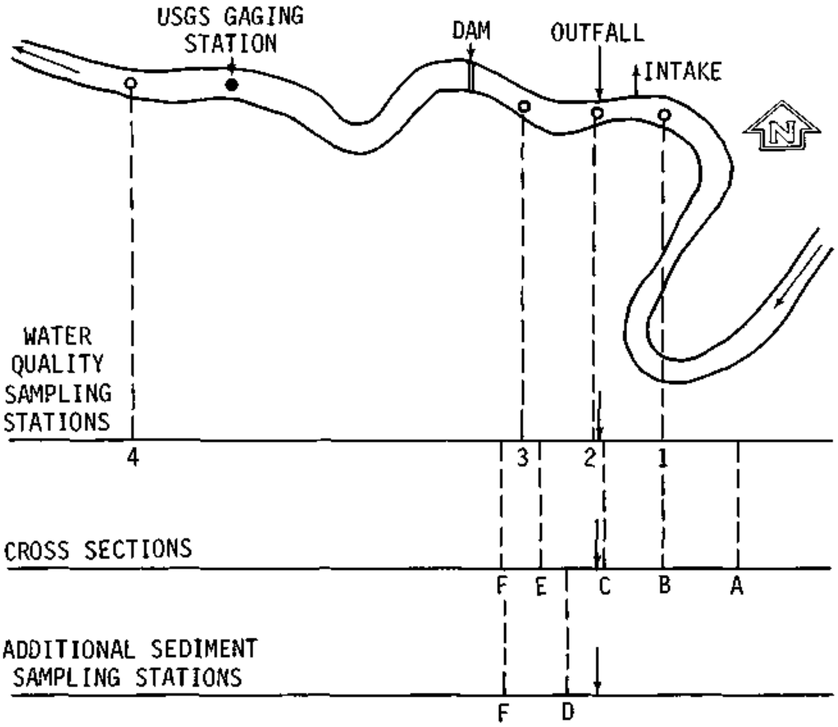

Figure 10. Relative locations of stations sampled and cross sections obtained on Vermilion River at Pontiac

in the field. Water samples were kept cool enroute to the laboratory where analyses were performed for pH, alkalinity, hardness, nitrate-nitrogen (NO_3 -N), ammonia-nitrogen (NH3 -N), silica, total iron (T. Fe), sulfate (SO_4), total solids (TS), suspended solids (SS), turbidity (Ftu), total phosphorus (T. P) and total aluminum (T. Al). Streamflows ranged from 13 to 2320 cfs during the period of sampling. The results of water analyses for each station are included in appendix table C.

Sediment samples were collected with an Eckman dredge having a 6-by 6-inch opening. The samples were composited, as described in the following section of this report. Analyses were performed for total phosphorus, total silica, total aluminum, and total iron. The results are summarized in appendix table D for each station and date of collection.

Results and Discussion

The principal methods used to determine the effects of waste discharges from the water treatment plant on the chemical quality of the stream's waters and sediments were as follows:

1) Ascertain, first, if the 20 weeks of sampling provided a representative water quality, as compared with the long-term sampling reported by others.

2) Compare the mean values for those chemical and physical constituents of the stream water at each station likely to be affected by waste discharges.

3) Perform a statistical evaluation to define significant differences, if any, between those observations made at station 1 compared with those made at the downstream stations 2 and 4.

4) Examine the differences, should they occur, of aluminum, iron, and phosphorus concentrations in the stream bottom sediments at each sampling station.

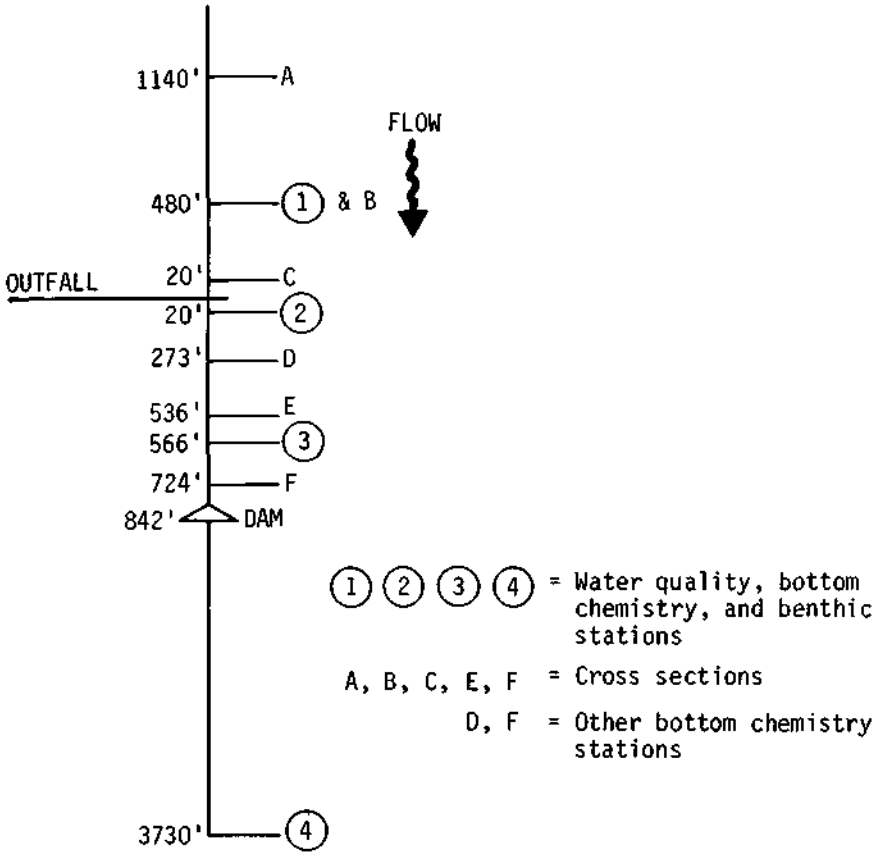

Figure 11. Approximate distances of sampling stations and cross sections from water treatment plant waste outfall

Those constituents chosen for comparison with the long-term record include alkalinity, hardness, and total dissolved solids. They were selected because it is unlikely that waste discharges will significantly affect their concentrations in the stream. The mean concentrations of these constituents at station 1 were compared with mean concentrations observed by Harmeson (1969, 1978) and others at a station farther downstream. The results are summarized in table 6. Generally, there is little difference in the concentrations observed during the study compared with the long-term observations. It is concluded that during the period of sampling in this investigation the water quality upstream of the water plant did not differ significantly from that during prior years of record.

Those water quality characteristics of the stream likely to be affected by waste discharges are dissolved oxygen, total solids, suspended solids, turbidity, and total aluminum. Significant differences between station 1 and downstream stations in concentrations of these parameters will indicate the influence of the waste discharges.

Table 7 shows the comparison in terms of mean values and range. With the exception of the increase of total aluminum concentrations at station 2, the mean concentrations of other constituents during passage downstream of station 1 do not materially change. Although it may be suggested that the lower dissolved oxygen concentrations at station 4 are a function of waste loads, it is more likely that the reduction is caused by the deoxygenation of supersaturated dis-

Table 6. Comparison of Certain Constituent Concentrations with Long-Term Values

(In milligrams per liter)

	Alkalinity		*Hardness*		*Total dissolved solids*	
	Station 1	*Long-term*	*Station 1*	*Long-term*	*Station 1*	*Long-term*
April	202	203	348	324	411	398
May	195	225	303	353	438	433
June	222	206	334	324	454	406
July	176	207	300	317	395	396
August	182	221	338	332	375	413

Table 7. Means and Ranges of Values During Sampling Period

	Station 1	*Station 2*	*Station 3*	*Station 4*
DO, *mg/l*	9.2	9.1	9.1	8.5
	5.6-18.0	5.2-16.6	5.1-19.2	5.6-17.2
TS, *mg/l*	469	460	461	464
	346-582	304-568	326-561	330-640
SS, *mg/l*	56	49	61	52
	7-162	8-134	8-130	7-152
Turb,*Ftu*	18	20	19	19
	5-49	11-45	6-52	7-49
T.Al, *mg/l*	0.07	0.13	0.08	0.09
	0.04-0.28	0.00-0.43	0.00-0.18	0.03-0.24

solved oxygen water during turbulence at the foot of the dam (see figure 2). From these comparisons it is concluded that the waste discharges do elevate aluminum concentrations in the stream in the vicinity of the outfall. However, the increase is temporary in terms of spatial distribution and is not detectable in the water 600 feet or more below the outfall.

To define significant differences, if any, between observations made at station 1 and those made at stations 2 and 4, reliance was placed on the student's *'t'* test. The procedure used not only permits a determination for differences that may exist between stations but also indicates whether or not the differences are indeed increases in concentration at stations 2 and 4 versus station 1. Paired observations for 15 parameters were examined. The results are shown in table 8.

At a confidence level of 95 percent the concentrations of sulfate, aluminum, and ammonia-N were higher at station 2 than at station 1. Turbidity was also higher at station 2 compared with station 1. The increase in sulfate, aluminum, and turbidity at station 2 is not totally unexpected even though mean values for turbidity (see table 7) did not suggest an overall change in that parameter. The increase in sulfate and aluminum at station 2 is derived from the same source, i.e., alum. The following reaction is typical of alum dissolution in water:

$$Al_2(SO_4)_3 \cdot 14H_2O \rightarrow 2Al^{+++} + 3SO_4^{=} + 14H_2O$$

The sulfate component is generally considered to remain in the treated water and the alum precipitates, in the presence of adequate alkalinity, thusly:

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

The fact that detectable increases in sulfate occur at station 2 indicates that the dissolution of alum is not complete in every case and/or a buildup of sulfate concentrations occurs within the alum sludge blanket. This is a matter of conjecture that could be verified or disproven in the analyses of the basin sludges. In any case, the increase in sulfates in the stream does not pose a significant water quality consideration.

Table 8. Calculated 't' Values for Paired Samples

(t at 95% level = 1.73)

	Sta 1 vs Sta 2	*Sta 1 vs Sta 4*	*Sta 1 vs Sta 2 Significant diff 95%*	Sta *1 vs Sta 4 Significant diff 95%*
pH	0.68	1.45	No	No
Alkalinity	0.13	0.20	No	No
Hardness	0.25	0.17	No	No
Nitrate-N	1.23	0.94	No	No
Total iron	0.96	2.00	No	Yes
Sulfate	2.14	0.04	Yes	No
Chloride	0.76	3.07	No	Yes
Total solids	0.62	0.37	No	No
Suspended solids	0.50	0.51	No	No
Turbidity	2.99	1.17	Yes	No
Total phosphorus	0.33	1.11	No	No
Total aluminum	1.77	0.41	Yes	No
Dissolved oxygen	0.62	1.67	No	No
Ammonia-N	2.46	1.09	Yes	No
Silica	1.02	1.23	No	No

The increase in ammonia-nitrogen at station 2 is more speculative in terms of origin. From the data shown in appendix table C, it is not a major increase. The procedures used for assessing the dissolved oxygen concentrations of the water within the pool were not designed to determine the occurrence of temperature or dissolved oxygen stratification. There may be relatively long periods of low streamflow and high water temperatures during which dissolved oxygen within the pool becomes depleted at the water-mud interface. Under these conditions, ammonia-N will be generated. Whether or not this is the source of the ammonia increases at station 2 is not known.

At a confidence level of 95 percent there are no significant increases in sulfate, turbidity, aluminum, or ammonia-N at station 4 compared with station 1. It is clear that the changes in these constituents are only occurring upstream of the dam. However, significant differences do occur between station 4 and station 1 for total iron and chlorides. Increases in chloride, though minor as shown in appendix table C, are not a function of the waste originating from the water treatment plant. If so, the increases would be detected in the pool. The source is unknown. If there had been an increase in suspended solids or turbidity at station 4 compared with station 1, the detected increase in total iron at station 4 would be explainable by the fact that most of the iron in the stream is in particulate form. Since this is not the case, it is difficult to assume that the increase in iron at station 4 is related to waste discharges.

Cross sections for the pool were made when pool elevations were about 1.5 feet above the crest of the dam (see figure 12). Streamflow at the time (May 12, 1977) averaged about 489 cfs and the stream velocities within the pool ranged from 0.48 to 0.63 feet per second (fps). On the basis of about 18 observations of depth of flow over the dam crest versus flows ranging from 100 to 2000 cfs, it appears that flows equal to or less than 500 cfs will produce velocities within sectors of the pool of 0.6 fps or less. At velocities not exceeding 0.6 fps it is probable that settleable solids within the waste discharge will deposit on the stream bottom. These deposits will be scoured at velocities in excess of 0.6 fps. A flow duration curve for the Vermilion River at Pontiac in figure 13 shows that flows equal to or less than 500 cfs will probably occur 80 percent of the time.

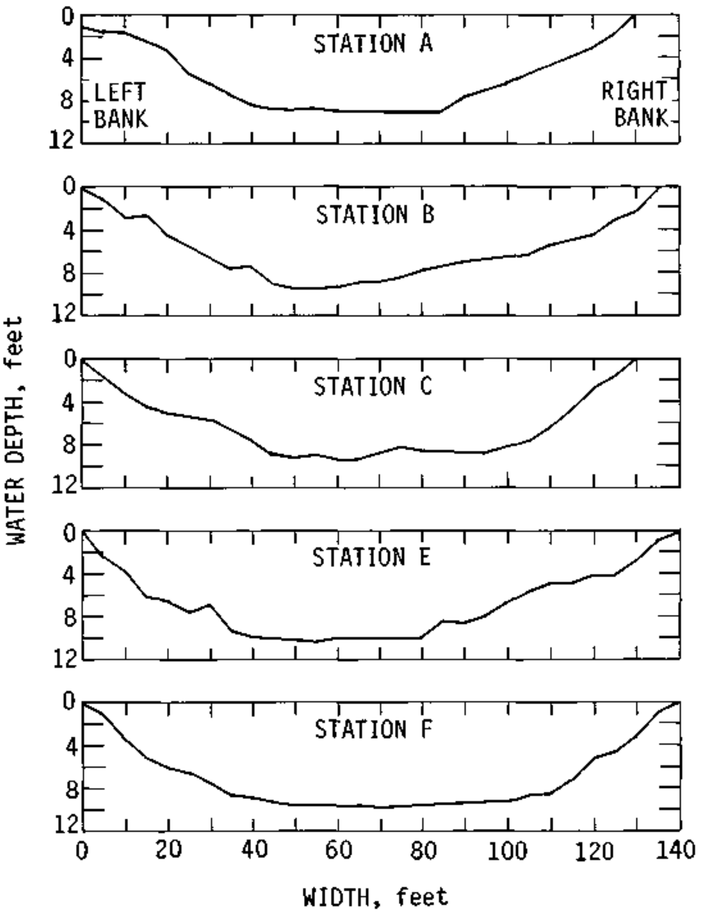

Figure 12. Cross sections of Vermilion River above dam at Pontiac

Despite the fact that streamflow conditions are such that settleable solids are likely to deposit on the stream bottoms 80 percent of the time, excessive quantities of sludge on the river bottom were not detected. This suggests that the flocculent nature of solids in the waste are such that they are easily scoured and dispersed within the water column.

An examination of the stream bottoms, however, did indicate the influence of waste discharge. Mean values for aluminum, phosphorus, and iron in the bottom sediments at 6 stations are shown in table 9. Although the concentrations of aluminum and iron may not appear high considering the findings of other workers previously mentioned, the relative magnitude of aluminum concentrations in most of the downstream stations in the pooled segment compared with station 1 is quite apparent. This is even more obvious in the graphic depiction of the relative magnitude of aluminum concentrations in the bottom sediments with downstream movement shown in figure 14. Aluminum concentrations in the sediments at station 2 are about 7 times the concentrations in sediments at station 1. The other constituents, phosphorus and iron, do not show a similar increase.

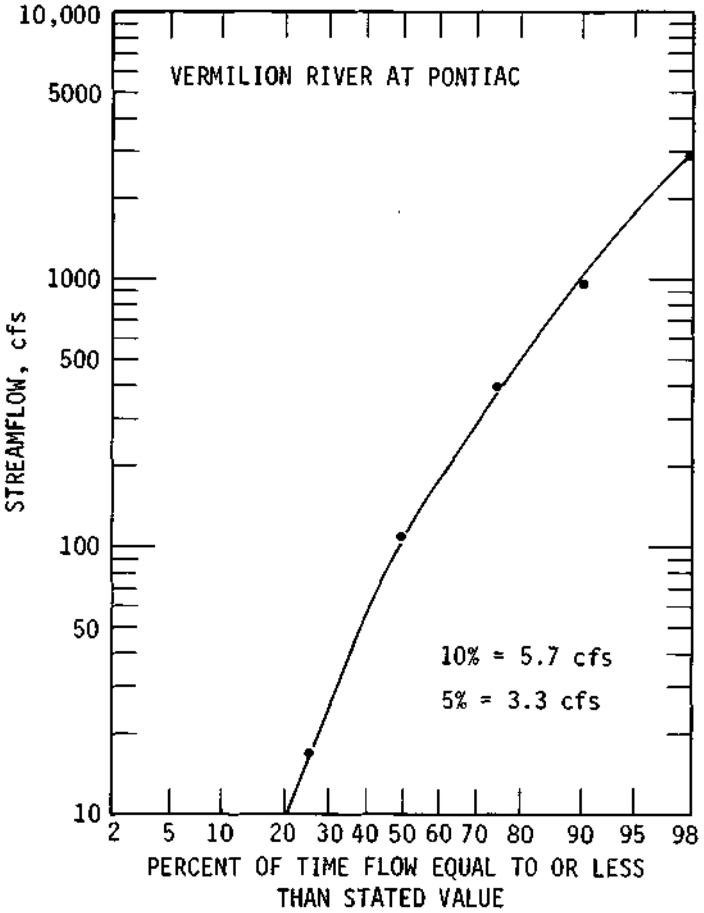

Figure 13. Flow duration curve for Vermilion River at Pontiac

Table 9. Mean Values of Aluminum, Phosphorus, and Total Iron in Sediments

(Concentrations in parts per million)

Station	Al	*RM**	P	*RM**	Fe	*RM**
1	198	1.0	727	1.0	24,723	1.0
2	1465	7.4	867	1.2	28,663	1.2
D	647	3.3	790	1.1	28,310	1.1
3	348	1.7	810	1.1	22,723	0.9
F	231	1.2	720	0.97	23,670	0.9
4	192	1.0	603	0.83	20,970	0.8

**RM = relative magnitude, i.e., all values divided by value for station 1*

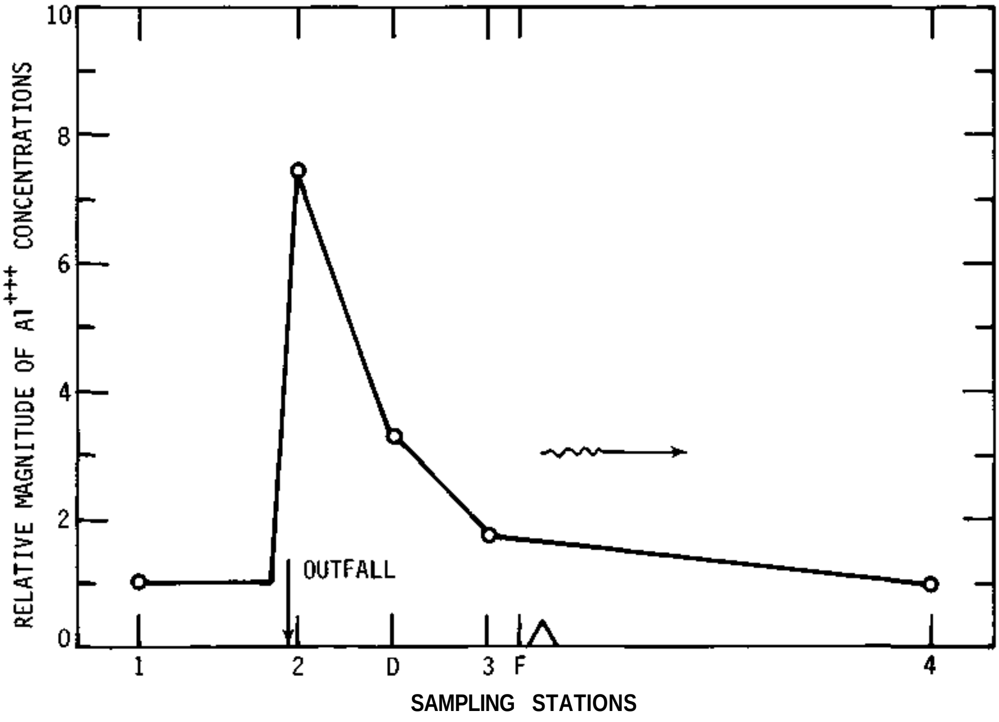

Figure 14. Relative magnitude of aluminum concentrations in bottom muds of Vermilion River at Pontiac

Summary of Stream Chemical Characteristics

1) Four stations were established for routinely sampling water and bottom sediments for the purpose of detecting the influence of waste discharges.
2) The comparison of upstream water quality data obtained during the study with long-term data of previous years suggests that the water quality of the river during the study was not atypical.
3) From comparison of the mean concentrations of dissolved oxygen, total solids, suspended solids, turbidity, and total aluminum at each station it was concluded that the aluminum concentration in the *stream waters* is elevated in the vicinity of the waste outfall.
4) At the 95 percent confidence level there is a significant increase of sulfate, turbidity, total aluminum, and ammonia-N in the stream water at station 2 compared with station 1.
5) Increases at station 2 of sulfate, turbidity, and total aluminum are a function of waste discharges. The source of ammonia-N is unknown.
6) Increases in sulfate, turbidity, and total aluminum at station 2 are limited to the pooled water and do not occur at station 4.
7) The increases in concentrations of chloride and iron at station 4 compared with station 1, at a confidence level of 95 percent, are not due to waste discharges.

8) Sludge deposits attributable to waste discharges were not detectable by soundings. Observations of the river bottom in the immediate vicinity of the outfall showed discoloration suggesting slight accumulations of sludge.

9) An examination of bottom sediments revealed that aluminum concentrations are increased about 7-fold in the vicinity of the outfall compared with sediments upstream. The effects of aluminum in waste discharges are detectable within the pool's bottom downstream of the outfall but not in the stream bottom below the dam.

BIOLOGICAL CHARACTERISTICS OF THE STREAM

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 No. 30 mesh seive. Those frequently found in the streams and lakes of Illinois include adult snails, aquatic worms, beetles, sowbugs, crayfish, and scuds. Those often found in the immature stages include damselflies, caddisflies, alderflies, midges and phantom midges, and mayflies.

Classification

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 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 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 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 classifications of stream environments assigned to each sampling station on the Vermilion 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 less in number than other forms combined, but combined with moderate forms, they usually outnumber tolerant forms.

Intolerant present $< 50\%$ but $\geq 10\%$	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.

Sampling Procedures

Macroinvertebrate sampling at each of the four stream stations was performed by two techniques. One procedure involved placing the artificial substrate, in triplicate, at each station and collecting them at about 30-day intervals. The other procedure required the use of an Ekman dredge with which samples were collected from the bottom muds at intervals of once every two months.

The artificial substrates used are modified Hester-Dendy multiple plates described by Fullner (1971). Figure 15 shows the plates and the arrangement for attachment to a rod. The substrates were suspended in 2 to 3 feet of water. Figure 16 shows how the samplers are suspended from the rod just before being placed at a sampling station. Six collections were made. Recovery at stations 1 and 2 was 100 percent. Sets of samplers were lost on one occasion at stations 3 and 4. Overall, 72 multiple plates were placed and 66 were recovered. Upon recovery the samplers were placed in ziplock bags. At the laboratory they were disassembled and washed in a U.S. Standard No. 30 mesh seive. Organisms were picked from the detritus, identified, counted, and preserved in 70 percent ethyl alcohol.

The Ekman dredge used has a 6- by 6-inch opening. Three grab samples were obtained along the cross section of each of the four stations on three occasions. The samples, in triplicate, were combined for each of the stations during each time of collection. They were washed in the field through a No. 30 mesh seive bucket and preserved in 95 percent ethyl alcohol. In the laboratory the organisms were separated from detritus and handled by a procedure similar to that previously described for the artificial substrates.

A summary of the data for the 78 biological samples analyzed is included in appendix tables E and F.

The use of artificial substrates permits an assessment of the abundance and the pollutional intolerance of the macroinvertebrate population that the pooled stream waters can sustain somewhat independent of their *natural habitat,* the stream bottom muds. The biological analyses of mud samples allows an assessment, principally, of the suitability of the in-place habitat for the maintenance of benthic populations. Other conditions such as predation, limitations in available food, and competition will influence the make-up and abundance of the organisms. But in the main the techniques employed in this study will produce information so that differences between stream stations in terms of abundance and composition of organisms can be attributed to water quality changes and/or the suitability of the bottom muds to support intolerant organisms.

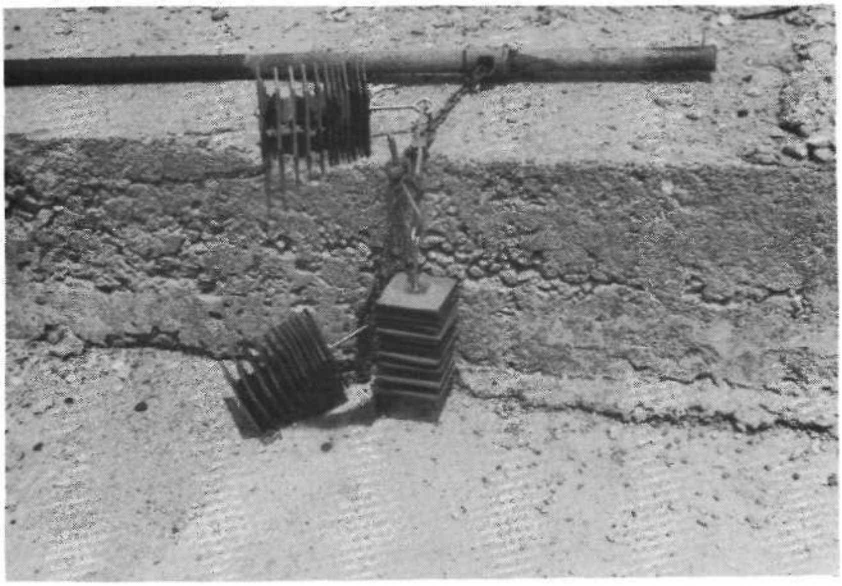

Figure 15. Modified Hester-Dendy multiple plate samplers

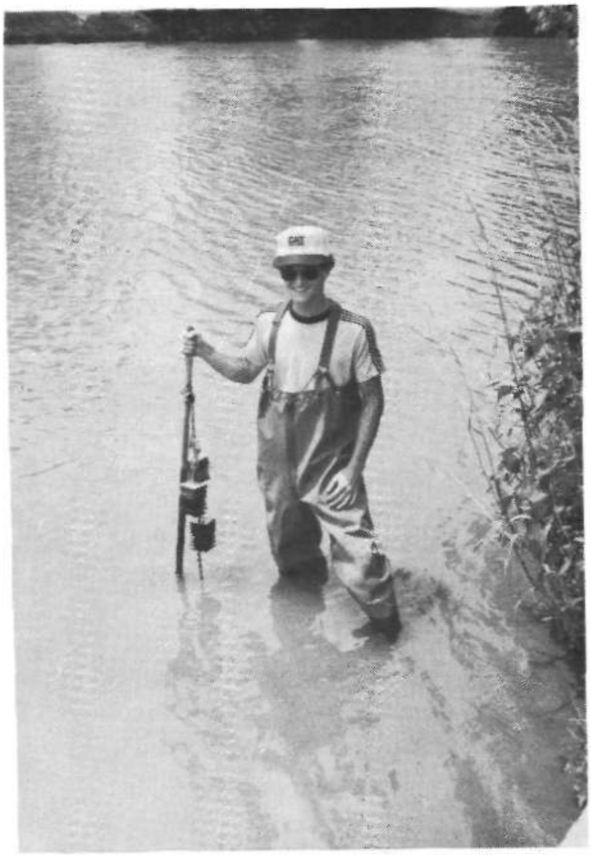

Figure 16. Arrangement of artificial substrates at sampling stations

Results and Discussion

Twenty-three taxa were recovered from the sampling for aquatic macroinvertebrates. The communities colonizing the artificial substrates were dominated by midge fly larvae (Chironomidae) which accounted for 84 percent of the total population. Mayfly nymphs, *Stenonema* sp. and *Caenis* sp., accounted for 6 and 4 percent of the population, respectively.

The average number of individuals recovered per collection of artificial substrate was 424 at station 1; 217 at station 2; 366 at station 3, and 292 at station 4. The number of taxa obtained per station varied from 17 to 18.

The communities recovered from bottom muds were dominated by aquatic worms (Tubificidae), phantom midge fly larvae *(Cbaoborus* sp.), and midge fly larvae *(Chironomidae).* They, respectively, accounted for 50, 28, and 19 percent of the population. Generally the greater number of organisms was recovered at station 3; the least number was most often collected at station 2. The average number of individuals per square meter obtained per collection was 770 at station 1; 240 at station 2; 1138 at station 3, and 330 at station 4. Only six taxa were recovered from the muds and only on one occasion, at station 4, were organisms recovered representative of the pollution intolerant type. They were *Stenonema* sp.

The most numerous intolerant organisms obtained during sampling were *Stenonema* sp. and caddisfly larvae (Psychomyiid Genus A). Damselfly naiads *(Argia* sp.) were the most prevalent in the moderate tolerance category, and snails *(Ferrissia* sp.) and mayfly nymphs *(Caenis* sp.) dominated the facultative category. Worms (Tubificidae) and midge fly larvae (Chironomidae and *Chaoborus* sp.) made up the pollution tolerant types. The Chironomidae, in accordance with Illinois Environmental Protection Agency procedures, were all classified as pollution tolerant. There are genera and species in this family that are less tolerant to pollution than indicated; therefore, the classification system as applied to Chironomidae has the tendency to depict a less favorable environment than may actually exist. The development of less costly and time consuming techniques for better identification of Chironomidae would rectify this tendency.

Figure 17 shows a comparison of the pollution tolerant status of the four stream stations. Pollution tolerant organisms account for over 80 percent of the total macroinvertebrate population

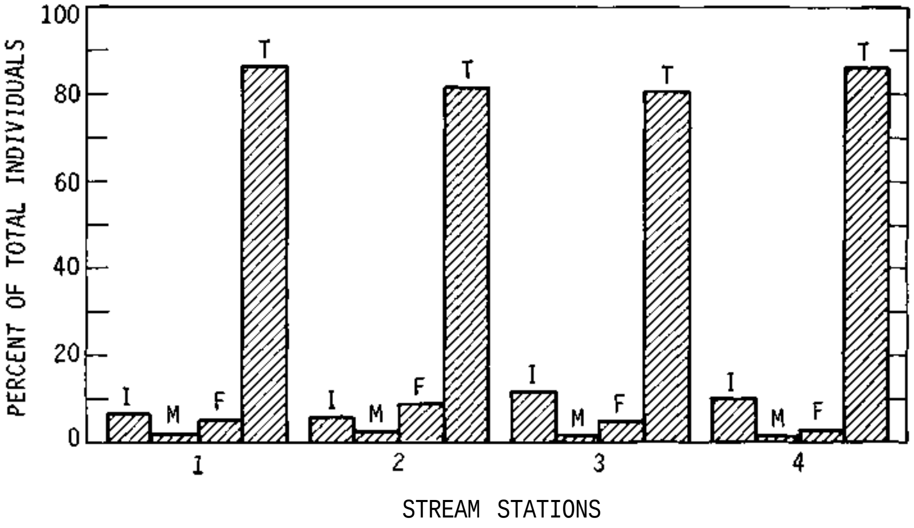

Figure 17. Tolerance status of total individuals on percentage basis (I = intolerant; M = moderate; F = facultative; T = tolerant)

at *all* stations using artificial substrates. From 6 to 7 percent of the populations at stations 1 and 2 were made up of the pollution intolerant types. The portion of pollution intolerant organisms for stations 3 and 4 was about 12 and 10 percent, respectively. On the basis of bottom mud collections, practically all organisms collected at those stations were the pollution tolerant type.

Table 10. Biological Classification of Stations in Vermilion River at Pontiac

	Stations			
	1	*2*	*3*	*4*
Artificial substrate	SP	SP	UB	SP
Bottom mud samples	P	p	P	P
Average	SP	SP	SP	SP

To classify the four stream stations, numerical values were assigned to the Illinois Environmental Protection Agency's scheme whereby B = 1; UB = 2, SP = 3: P = 4; and BA = 5 for each date of collection. The values were summarized and a numerical tabulation prepared. Classifications for each collection are included in appendix table G. The results are summarized in table 10. All stations except station 3 are classified as semi-polluted on the basis of the results from artificial substrate collections. The bottom mud samples reflected a habitat at all stations, upstream and downstream of waste discharges, principally suited for organisms tolerant of pollution. On the average the stream waters are classified semi-polluted when based solely on macroinvertebrate composition and abundance. Although stream station 2 is the least productive in terms of abundance, an assessment on the basis of tolerance status suggests that the influence of waste discharges into the Vermilion River from the water treatment plant are imperceptible.

Summary of Stream Biological Characteristics

1) Collections of aquatic macroinvertebrates on 66 artificial substrates and 12 composited mud samples were made at four stream stations.
2) On the basis of the tolerance of the organisms to pollution, each stream station was classified according to a procedure used by the Illinois Environmental Protection Agency.
3) In terms of abundance, station 1 was the most productive on artificial substrates; station 3 was the most productive based on mud samples. Station 2 was the least productive by both means of sampling.
4) The communities colonizing the artificial substrates were dominated by midge fly larvae (Chironomidae). Those organisms recovered from bottom muds consisted principally of aquatic worms (Tubificidae) and midge fly larvae *(Chaoborus* sp. and Chironomidae).
5) The clean water organisms, observed mostly on artificial substrate, were mainly mayfly nymphs *{Stenonema* sp.) and caddisfly larvae (Psychomyiid Genus A).
6) The classified tolerance status of all stations is semi-polluted.
7) In terms of the tolerance status of macroinvertebrates, the influence of waste discharges on the Vermilion River at Pontiac is imperceptible.
8) The abundance and composition of macroinvertebrates on artificial substrates versus those in bottom muds suggest that the character of the bottom muds is more of a limiting factor than the overlying water quality.

CONCLUSIONS

This study deals with an assessment of the impact on the water quality of a receiving stream of waste from a water treatment plant that employs the clarification process. The methods used are applicable to other types of water treatment facilities, though the kind of chemical analyses will differ. In the evaluation process the basic weakness involves determining the quantity and representative characteristics of the basin sludge. Because of the lack of adequate sampling ports and flow measuring devices on waste lines from basins at most water treatment plants, the only alternative is to develop a solids balance procedure based upon operation reports. This is most difficult to do unless data are available on the suspended solids concentrations of the intake water. In Illinois, suspended solids determinations are not routinely performed at water treatment plants; sufficient process control is obtained by reliance on turbidity measurements. Nevertheless, as more concern develops regarding the environmental impact of wastes from water treatment plants, suspended solids analyses on the intake water will become a necessity.

The major portion of the solids occurring in the waste from water treatment plants originates from the basin sludge. It is estimated that 65 to 70 percent of the total solids production at the Pontiac site comes from the basins — about 165 to 390 pounds per million gallons of water treated. Solids from the filters averaged 68 pounds per million gallons of water treated. On the other hand, most of the waste volume comes from the filter backwash operation. At Pontiac the filter waste averaged about 103,000 gpd compared with a total estimated waste volume of 115,000 to 132,000 gPd.

When developing a schedule for chemical analyses of wastes, the tendency is to be more encompassing than necessary in order that nothing is missed. In retrospect, the performance of analyses for COD, magnesium, calcium, silica, and phosphorus on the basin sludges and for COD on the filter backwash is not necessary. For a clarification plant, analyses for pH, suspended solids, settleable solids, aluminum, and iron will suffice for the basin sludge. Analyses on the filter backwash can be limited to pH, suspended solids, and settleable solids.

The sequential sampling of the filter backwash at adequate time intervals is essential for estimating the quantity and quality of waste. Average values based upon indiscriminate sampling are worthless.

Water quality data are available for all but a few streams in Illinois. Most streams have either been gaged for flow or sufficient information is available regarding other streams in a basin to permit reasonable extrapolation of flow data from one stream to another. The incorporation of historical water quality and streamflow data is necessary to assess the severity and duration of the impact of waste discharges on stream waters. In this study reliance was placed on data previously developed by the Survey and the U.S. Geological Survey. Where channel dams are involved, cross sections as outlined in this report are useful.

The selection of sampling stations is dependent upon accessibility and the extent of study. Some judgment obviously is required in ascertaining how far downstream the water quality of a stream may be influenced by a waste discharge. The nature of wastes from most water treatment plants suggest that their measurable influence will be local. The analyses to be performed on water collected should include all the basic elements necessary to characterize the background water quality along with those constituents anticipated in the waste. The latter are those associated with the chemicals used in the treatment process. To have done otherwise in this study would have made remote the probability of detecting increases in sulfate, ammonia-N, and chlorides at downstream stations.

Increases in aluminum and turbidity in stream waters near the waste outfall were not unexpected. The fact that the increases were limited to a relatively short sector of the stream was surprising. The absence of a sludge buildup in the pooled waters was also surprising suggesting, as mentioned earlier, that alum sludge must be easily dispersed in the water column.

The evaluation of waste discharge impacts on a stream cannot be limited to its waters alone. Its bottom must also be explored. As shown in this study the concentration of aluminum in the bottom sediments is greater and more expansive than observed in the overlying water. The relative magnitude of aluminum in sediments near the outfall is about 7 times that observed upstream. It diminishes with downstream movement and concentrations above background levels appear limited to the pooled area. Iron and phosphorus are not found in higher concentrations in the sediments. The effects of the elevated aluminum, though localized, are not known. However, the use of macroinvertebrates as monitoring indicators suggests that they may be intolerant to elevated aluminum concentrations.

The artificial substrates in combination with benthic sampling permitted the conclusion that the bottom muds are more hostile to the environmental necessities of macroinvertebrates than the overlying water. This conclusion is based principally on the lack of abundance of the organisms retrieved from bottom muds compared with those collected on artificial substrates. However, the Illinois Environmental Protection Agency classification system indicates that all stations are semi-polluted suggesting, from a tolerance status standpoint, that the influence of waste discharges at Pontiac is imperceptible. There is some indication, however, that the abundance of organisms may be influenced by aluminum. The average number of organisms collected on the artificial substrates as well as from the bottom muds is less in the area of elevated aluminum than at other stations. There is evidence reported by the Committee on Water Quality Criteria (1972) that aluminum can have an adverse effect on bottom communities. Currently there are not any water quality regulations governing the concentrations of aluminum in surface waters in Illinois.

The experience gained during the course of this work confirms the basic principle that the 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 stream geometry, flow, upstream water quality, and the characteristics and magnitude of the waste load. At the sites of water plants treating surface waters in Illinois these relationships are variable. Because of this variability an intelligent examination at each site is necessary to permit rational decisions governing the impact of waste on water quality. This study may be useful for such examinations.

REFERENCES

Bowen, H. J. M. 1966. *Trace elements in biochemistry.* Academic Press, Inc., London, p. 40.

Evans, Ralph L., and Donald H. Schnepper. 1970. *Wastes from water treatment plants.* Unpublished data. Illinois State Water Survey.

Fullner, R. W. 1971. *A comparison of macroinvertebrates collected by basket and modified multiple-plate samplers.* Journal Water Pollution Control Federation 43(3):494-499.

Gross, Dave. 1978. Personal communication. Illinois State Geological Survey.

Harmeson, Robert H. 1977. Personal communication. Illinois State Water Survey.

Harmeson, Robert H., and Robert Sinclair. 1978. *Quality of surface water in Illinois, 1971-1976.* Illinois State Water Survey Bulletin, in preparation.

Harmeson, Robert H., and T. E. Larson. 1969. *Quality of surface water in Illinois, 1956-1966.* Illinois State Water Survey Bulletin 54, p. 172.

Kemp, A. L. W., and R. L. Thomas. 1976. *Impact of man's activities on the chemical composition in the sediments of Lake Ontario, Erie and Huron.* Water Air and Soil Pollution 5:469-490.

National Academy of Sciences and National Academy of Engineering. 1972. *Water quality criteria 1972.* Report of the Committee on Water Quality Criteria. p. 179 and 242.

Roseboom, Donald P., Ralph L. Evans, and Thomas E. Hill. 1978. *Water quality in Cedar Lake and the relevance of its watershed.* Illinois State Water Survey contract report 192. 93 p.

Tucker, William J., and William H. Ettinger. 1975. *A biological investigation of the South Fork, Sangamon River and Tributaries.* Illinois Environmental Protection Agency, Springfield. 56 p.

APPENDIX

Table A. Chemical Characteristics of Basin Sludge

(Chemical concentrations in milligrams per liter)

	pH	SS	VSS	Set.S	COD	Al	Mg	Ca	Fe	Sio_2	P
12/16/76											
E	8.6	58	28	0.05	16	4.68	0.14	0.80	4.36	2.96	0.19
P	8.4	34	15	1.20	10	4.57	0.14	0.60	3.88	2.74	0.12
1/11/77											
E	7.7			0	14.3	1.12	14.8	5.20	1.37	4.60	1.16
P	7.7			0	16.2	0.38	9.1	0.80	0.61	3.90	0.39
2/15/77											
E	7.5	7	3		1.3	0.07	0.33	1.30	4.56	0.17	0.01
P	7.6	5	1		1.3	0.67	0.70	2.60	1.60	0.69	0.99
4/8/77											
E	7.6	45	27	0	0.8						
P	7.6	3720	550	74	34.2						
5/6/77											
E	7.3	310	220	2	10	1.08	2.3	37.0	3.93	2.10	0.13
P	7.5	3772	382	73	46	4.3	2.4	9.8	122.8		0.02
8/9/77											
E	7.0	10240	900	216	*96*	18.8	3.2	6.5	172		12.75
P	7.0	4866	380	50	48	77.3	3.2	4.5	92		10.60

E = Eimco clarifier
P = Permutit precipitators

Table B. Water Quality of Filter Backwash

December 16,1976

(Concentrations in milligrams per liter)

Time *(min)*	pH	SS	VSS	Set.S	Set. COD	Time *(min)*	PH	SS	VSS	Set.S	Set. COD
Filter 1						*Filter 2*					
0.0	7.85	17	17	0	10.5	0.0	8.30	9.5	9.5	0	22.4
0.25	7.70	19	19	Tr	18.1	0.25	8.55	14	13	Tr	12.6
0.5	8.10	348	196	2.4	59.9	0.5	8.35	125	74	0.2	21.8
0.75	7.75	268	180	14	28.7	0.75	8.20	148	80	4	20.2
1.0	8.00	496	316	34.5	72.4	1.0	7.95	264	156	15.5	34.9
1.25	8.05	432	276	32	33.5	1.25	7.85	472	296	21	31.4
1.5	7.80	488	308	37	72.7	1.5	7.95	388	248	25	41.3
1.75	8.40	480	312	40	38.3	1.75	7.85	408	256	29	32.8
2.0	8.22	622	372	51	54.4	2.0	8.00	420	272	32	34.8
2.5	8.09	424	292	37	35.9	2.5	8.10	432	284	33	36.2
3.0	8.10	296	180	23	49.1	3.0	8.20	420	280	34	34.8
3.5	8.10	296	196	24	31.1	3.5	8.25	340	240	27	37.3
4.0	8.50	188	132	11.5	52.9	4.0	8.30	200	152	15	24.5
6.0	8.55	12	72	3.4	21.2	6.0	8.40	28	21	Tr	15.7
8.0	8.10	23	23	Tr	34.6	8.0	8.60	10	10	0	10.3
10.0	8.50	6.0	6.0	0	14.0	10.0	8.60	2.0	2.0	0	16.1
12 + 33 sec	8.25	7.6	7.2	0	14.7	11 + 42 sec	8.40	2.2	1.0	0	12.7
Filter 3						*Filter 4*					
0.0	8.50	309	105	0.3	11.8	0.0	8.27	16	12	Tr	20.2
0.25	8.10	156	96	3	18.8	0.25	8.37	17	7.5	Tr	12.0
0.5	8.10	266	130	10	20.7	0.5	7.95	182	96	8.5	32.5
0.75	7.90	388	272	24	30.4	0.75	7.85	232	126	13	26.4
1.0	8.15	540	340	27	28.0	1.0	7.90	296	156	19	66.3
1.25	8.05	424	300	30	32.8	1.25	7.85	304	162	29	32.2
1.5	8.00	400	212	25	25.4	1.5	8.05	398	216	34	78.1
1.75	8.20	396	240	28	35.9	1.75	7.70	404	228	35	38.0
2.0	8.30	298	156	21	27.8	2.0	7.80	416	244	34	73.8
2.5	8.20	226	126	15	25.6	2.5	7.85	388	220	31	35.3
3.0	8.00	186	112	8	35.7	3.0	8.10	292	168	22	64.3
3.5	8.10	124	70	4.5	21.9	3.5	8.15	134	74	6.5	21.9
4.0	7.95	67	37	1.5	18.3	4.0	8.20	69	39	1,5	23.9
6.0	8.55	5.6	3.6	0	17.8	6.0	8.4	24	16	0.1	13.0
8.0	8.45	4.9	3.3	0	10.3	8.0	8.45	2.4	1.6	0	14.0
10.0	8.50	1.8	1.8	0	15.7	10 + 53 sec	8.50	2.4	2.2	0	10.3
12 + 42 sec	8.20	9.0	8.0	0	12.6						

(Continued on next page)

Table B. Continued

January 11,1977

(Concentrations in milligrams per liter)

Time (min)	pH	SS	VSS	Set.S	Set. COD
Filter 1					
0.0	7.62	175	158	0	15.9
0.25	7.70	64	52	0	14.3
0.5	7.58	92	72	Tr	14.9
0.75	7.62	80	52	Tr	15.9
1.0	7.60	164	104	Tr	16.8
2.0	7.70	440	270	0.5	19.1
3.0	7.62	430	280	1.0	17.8
4.0	7.73	270	220	Tr	16.5
4.5	7.68	252	140	Tr	16.2
5.0	7.70	165	105	Tr	15.0
5.5	7.40	128	80	Tr	14.3
6.0	7.60	96	80	Tr	14.9
8.0	7.63	76	60	0	13.9
10.0	7.62	53	40	0	14.3
12 + 5 sec	7.73	34	34	0	14.6

Time (min)	pH	SS	VSS	Set.S	Set. COD
Filter 2					
0.0	7.70	70	58	0	14.6
0.25	7.57	77	69	0	17.5
0.5	7.71	88	80	Tr	15.5
0.75	7.67	132	96	0	13.6
1.0	7.71	152	116	Tr	14.3
2.0	7.70	640	380	Tr	20.1
3.0	7.70	580	400	Tr	20.1
4.0	7.70	370	280	0	17.8
4.5	7.72	220	220	0	19.4
5.0	7.70	170	150	0	18.1
5.5	7.70	128	80	Tr	15.5
6.0	7.69	70	50	0	14.9
8.0	7.69	78	55	0	15.5
9 + 4 sec	7.71	92	64	0	16.2

Time (min)	pH	SS	VSS	Set.S	Set. COD
Filter 3					
0.0	7.69	37	37	0	14.3
0.25	7.67	47	40	0	13.3
0.5	7.64	132	92	0	13.9
0.75	7.62	120	75	0	12.6
1.0	7.62	127	113	3.5	11.0
2.0	7.65	580	300	1	15.5
3.0	7.63	390	210	0	13.9
4.0	7.65	340	150	0	10.7
4.5	7.61	120	95	0	13.0
5.0	7.64	130	100	0	13.9
5.5	7.62	50	45	0	14.3
6.0	7.62	39	39	0	11.3
8.0	7.61	23	23	0	10.4
9 + 28 sec	7.62	24	24	0	11.0

Time (min)	pH	SS	VSS	Set.S	Set. COD
Filter 4					
0.0	7.61	50	50	0	14.3
0.25	7.68	27	27	0	17.8
0.5	7.61	76	72	0	15.9
0.75	7.64	280	200	0.3	16.5
1.0	7.63	140	107	Tr	15.9
2.0	7.65	880	600	7	19.1
3.0	7.63	1020	660	8	18.8
4.0	7.60	520	440	2.5	16.2
4.5	7.68	350	190	0.6	16.2
5.0	7.71	200	170	Tr	15.5
5.5	7.68	90	80	Tr	14.3
6.0	7.63	40	40	0	13.3
8.0	7.77	18	18	0	13.3
8 + 43 sec	7.65	32	32	0	11.0

(Continued on next page)

Table B. Continued

February 15,1977

(Concentrations in milligrams per liter)

Filter 1

Time (min)	pH	SS	VSS	Set.S	Set. COD
0.0	7.63	5.8	3.4	0	3.5
0.25	7.62	6.6	3.6	0	5.5
0.5	7.60	6.2	3.8	0	5.2
0.75	7.60	7.4	3.4	0	8.3
1.0	7.59	33	14	0	5.2
2.0	7.85	220	84	2	14.8
3.0	7.60	176	58	1.4	10.0
4.0	7.50	240	84	0.75	8.6
4.5	7.60	48	23	0.15	8.6
5.0	7.61	73	30	0.20	4.5
5.5	7.59	54	18	0	8.6
6.0	7.60	38	19	0	2.1
8.0	7.60	20	9.6	0	6.2
10.0	7.59	9.5	4.5	0	1.0
12.0	7.59	8.0	4.0	0	1.7
12.78	7.63	8.0	4.6	0	1.0

Filter 2

Time (min)	pH	SS	VSS	Set.S	Set. COD
0.0	7.65	6.8	3.6	0	2.5
0.25	7.65	6.4	3.6	0	2.2
0.5	7.70	4.8	3.0	0	2.2
0.75	7.70	6.4	2.8	0	1.5
1.0	7.71	6.4	2.8	0	3.4
2.0	7.69	84	33	0.4	7.1
3.0	7.69	272	92	5.0	14.2
4.0	7.65	154	54	2.0	11.1
4.5	7.60	108	28	1.2	8.7
5.0	7.60	82	26	0.5	7.7
5.5	7.61	43	21	0	5.3
6.0	7.60	37	13	0	3.7
8.0	7.60	8.2	4	0	1.5
10.0	7.61	5.0	2	0	1.9
12.22					2.2

Filter 3

Time (min)	pH	SS	VSS	Set.S	Set. COD
0.0	7.60	9.6	3.6	0	2.6
0.25	7.60	5.4	3.8	0	1.9
0.5	7.61	5.6	3.2	0	3.2
0.75	7.61	6.4	3.2	0	1.6
1.0	7.59	6.0	2.8	0	2.6
2.0	7.59	6.6	2.4	0	3.2
3.0	7.58	134	42	1.4	8.4
4.0	7.60	124	38	0.9	10.3
4.5	7.58	80	36	0.6	5.8
5.0	7.57	69	24	0.3	5.8
5.5	7.57	32	11	0	3.5
6.0	7.55	21	10	0	2.3
8.0	7.55	6	3	0	6.1
10.0	7.55	3.4	2.4	0	13.9
12.25	7.56	2.8	2.4	0	1.6

Filter 4

Time (min)	pH	SS	VSS	Set.S	Set. COD
0.0	7.58	6.0	1.0	0	4.2
0.25	7.58	6.0	3.0	0	9.7
0.5	7.60	5.0	2.8	0	2.3
0.75	7.60	5.4	2.4	0	1.9
1.0	7.60	15	6.0	0	8.4
2.0	7.62	50	8.4	0.6	0.3
3.0	7.62	260	112	6.5	15.8
4.0	7.60	122	38	0.8	8.4
4.5	7.60	94	30	0.55	8.7
5.0	7.60	54	20	0.1	6.8
5.5	7.59	47	14	0	4.8
6.0	7.58	37	12	0	2.9
8.0	7.59	6.4	3.6	0	1.6
10.0	7.60	2.7	1.5	0	3.2
12.1	7.57	2.3	1.0	0	4.8

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Table B. Continued

April 8, 1977

(Concentrations in milligrams per liter)

Time *(min)*	pH	SS	VSS	Set.S	Set. COD	Time *(min)*	pH	SS	VSS	Set.S	Set. COD
Filter 1						*Filter 2*					
0.0	7.72	11	3.6	0	6.9	0.0	7.73	11	2.9	0	2.0
0.25	7.67	11.6	8.4	0	4.9	0.25	7.73	12	5.6	0	0.4
0.5	7.63	24.4	6.4	0.15	4.5	0.5	7.73	12	5.2	0	1.6
0.75	7.64	320	68	11	15.9	0.75	7.74	12	6.8	0	1.6
1.0	7.67	198	52	6	18.4	1.0	7.74	35	9.0	0.1	2.4
2.0	7.65	820	104	20.8	24.5	2.0	7.60	1004	176	40	32.0
3.0	7.64	416	88	14.5	33.9	3.0	7.61	672	120	24.5	20.4
4.0	7.65	580	108	16.5	19.6	4.0	7.65	282	74	11.4	9.8
4.5	7.71	308	128	8.3	15.5	4.5	7.69	202	48	6.5	7.3
5.0	7.74	234	58	6	10.6	5.0	7.65	176	42	4.8	6.5
5.5	7.73	178	54	4.3	6.5	5.5	7.67	88	30	2.2	3.3
6.0	7.74	129	33	2.6	7.3	6.0	7.70	46	16	0.85	2.0
8.0	7.76	20	6.4	2.1	2.9	8.0	7.71	11	3.6	0.05	0.8
10.0	7.75	15	7.6	0.05	2.0	8.60	7.70	9.2	3.2	0.03	0
11.42	7.80	9.6	4.0	0.03	6.5						
Filter 3						*Filter 4*					
0.0	7.63	12	4.8	0	0.8	0.0	7.66	11	10	0	8.0
0.25	7.65	16	6.4	0	1.2	0.25	7.70	8.2	2.7	0	0
0.5	7.63	49	12	1.4	2.8	0.5	7.71	12	4.2	0	2.8
0.75	7.65	148	36	5.0	6.8	0.75	7.69	12	4.9	0	3.2
1.0	7.64	192	84	6.5	7.2	1.0	7.69	28	23	0	2.4
2.0	7.63	132	56	4.5	5.2	2.0	7.64	488	152	18	6.0
3.0	7.64	332	108	9.0	11.3	3.0	7.64	364	104	11	13.3
4.0	7.66	164	84	4.2	6.8	4.0	7.65	292	108	7	10.5
4.5	7.65	194	66	4.5	7.6	4.5	7.63	224	144	6.5	8.0
5.0	7.63	170	50	3.6	6.8	5.0	7.64	176	52	5.5	7.6
5.5	7.65	138	54	3.3	6.0	5.5	7.64	138	52	3.5	5.2
6.0	7.65	115	29	2.8	5.6	6.0	7.64	74	41	1.5	3.6
8.0	7.62	16	5.9	0	1.2	8.0	7.69	12	6.0	0.1	0
9.37	7.65	6.8	4.2	0	4.0	9.32	7.65	6.2	5.7	0	0.4

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Table B. Continued

May 6,1977

(Concentrations in milligrams per liter)

Time (min)	pH	SS	VSS	Set.S	Set. COD	Time (min)	PH	SS	VSS	Set.S	Set. COD
Filter 1						*Filter 2*					
0.0	7.56	8	2	0	5.5	0.0	7.66	0	6	0	4.2
1.0	7.39	10	4	0	3.2	1.0	7.62	0	4	Tr	4.8
1.25	7.74	8	0	Tr	4.9	1.25	7.72	64	8	2.5	9.0
1.50	7.52	16	10	0.05	4.5	1.50	7.65	276	38	12.5	18
1.75	7.46	246	16	9.5	12.0	1.75	7.54	340	50	15	23
2.00	7.52	568	84	20	24	2.00	7.48	636	110	24	32
2.25	7.52	522	52	21	28	2.25	7.38	790	118	30	18
2.50	7.43	778	62	33	39	2.50	7.54	822	124	30	19
2.75	7.53	676	64	26	36	2.75	7.64	752	114	28	39
3.00	7.65	658	100	24	29	3.00	7.61	642	98	23	29
3.50	7.49	528	30	19	23	3.50	7.82	390	52	14	17
4.00	7.69	402	36	14	20	4.00	7.62	274	36	5.55	12
4.50	7.64	288	16	10	13	4.50	7.78	196	26	5.25	8.5
6.00	7.73	84	0	3.5	12	6.00	7.74	36	2	0.9	11
10 + 4 sec	7.45	6	0	0.1	4.3	8 + 85 sec	7.88	6	0	0.3	4.5
Filter 3						*Filter 4*					
0.0	7.36	8	6	0	3.6	0.0	7.84	4	2	0	5.3
1.0	7.36	0	0	0	4.9	1.0	7.45	8	2	0.1	3.3
1.25	7.68	0	0	0.4	3.6	1.25	7.50	82	28	3.0	8.0
1.50	7.60	36	4	2.0	9.1	1.50	7.60	60	24	2.3	6.7
1.75	7.48	168	12	5.1	8.7	1.75	7.41	490	98	16	22
2.00	7.42	392	54	14	19	2.00	7.33	1004	184	33	43
2.25	7.27	310	38	10	20	2.25	7.50	954	178	31	39
2.50	7.61	358	48	12	19	2.50	7.43	844	158	26	35
2.75	7.57	448	66	15	23	2.75	7.48	814	144	22	32
3.00	7.42	576	90	21	29	3.00	7.56	680	120	21	32
3.50	7.35	286	40	10	17	3.50	7.55	504	100	15.5	23
4.00	7.55	216	32	7	14	4.00	7.69	366	80	12	19
4.50	7.65	172	24	6	10	4.50	7.74	270	56	7	19
6.00	7.64	98	22	3	5.8	6.00	7.76	92	18	1.5	9.1
8 + 30 sec	7.62	0	0	0.1	2.9	7 + 94 sec	7.73	10	8	0.3	3.6

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Table B. Concluded

August 9, 1977

(Concentrations in milligrams per liter)

Time *(min)*	PH	SS	VSS	Set.S	Set. COD	Time *(min)*	pH	SS	VSS	Set.S	Set. COD
Filter 1						*Filter 2*					
0.0	7.10	8	2	0	1.7	0.0	7.00	78	4	0.6	12
1.0	7.20	4	4	0	1.2	1.0	6.95	130	12	1.5	11
1.42	7.20	0	0	0	2.9	1.25	6.95	102	14	1.3	28
1.50	7.20	186	22	2.8	13	1.50	6.95	116	16	1.5	8.9
1.75	7.15	234	26	4.3	6.4	1.75	6.95	118	8	1.5	25
2.00	7.15	276	36	4.6	8.1	2.00	6.95	176	20	2.5	43
2.25	7.10	276	28	4.9	10	2.25	6.90	466	34	8.00	18
2.50	7.05	422	150	7.5	22	2.50	6.90	422	56	7.0	31
2.75	7.00	454	54	9.9	20	2.75	6.90	360	52	5.7	30
3.00	7.00	406	52	8.0	11	3.00	6.85	296	40	6.0	21
3.50	6.95	310	34	6.0	11	3.50	6.85	248	36	3.3	25
4.00	6.95	224	28	4.0	46	4.00	6.85	164	26	1.7	23
4.50	6.95	166	20	2.3	25	4.50	6.85	122	22	1.2	20
6.00	6.90	122	20	1.8	17	6.00	6.85	74	16	0.45	21
15.00	6.95	6	0	0.1	17	8.00 + 77 sec	6.75	24	8	0.10	27
Filter 3						*Filter 4*					
0.0	6.85	0	0	0	21	0.0	6.75	4	0	0	22
1.00	6.80	0	0	0	22	1.00	6.75	0	0	0	29
1.25	6.80	4	0	0	13	1.25	6.75	4	20	Tr(0)	20
1.50	6.85	70	8	0.3	22	1.50	6.75	88	8	0.7	23
1.75	6.80	204	18	3.0	26	1.75	6.70	426	54	9.0	30
2.00	6.80	424	30	10.0	23	2.00	6.70	468	54	10.0	26
2.25	6.70	358	34	7.0	27	2.25	6.70	352	40	6.0	32
2.50	6.70	382	40	8.0	21	2.50	6.70	332	46	6.0	27
2.75	6.75	286	28	4.5	24	2.75	6.70	168	18	3.2	23
3.00	6.75	168	28	4.0	27	3.00	6.70	250	34	3.3	14
3.50	6.75	236	26	3.8	30	3.50	6.70	198	38	2.7	5.1
4.00	6.75	170	8	2.1	28	4.00	6.70	188	38	2.6	11
4.50	6.70	106	16	0.8	18	4.50	6.70	164	24	1.8	19
6.00	6.75	18	0	0.1	24	6.00	6.70	58	28	0.4	17
7.00 + 89 sec	6.75	0	0	Tr(0)	24	7.00 + 40 sec	6.70	20	16	Tr(0)	21

Table C. Water Quality of Vermilion River at Pontiac

(Chemical constituents in milligrams per liter)

Date	Temp (F°)	DO	pH	Alk	Hard	NO_3-N	NH_3-N	SiO_2	Fe	SO_4	Cl	TS	SS	Turb (Ftu)	T.P	T.Al	Flow (cfs)
Station 1																	
4/11/77		9.1	8.2	197	344	7.3	0.08	2.8	2.4	97		496	51	21	0.12	0.05	113
4/18/77	72.5	9.2	8.2	197	344	5.3	0.03	0.8	1.4	107	28	479	162	15	0.15	0.04	61
4/25/77	60.4	10.7	8.4	212	358	3.7	0.06	3.2	1.0	113	26	511	28	11	0.07	0.04	43
5/2/77	62.0	11.8	8.5	215	311	2.8	0.01	1.1	0.8	117	26	422	20	10	0.11		25
5/9/77	57.4	8.2	7.9	172	311	13.8	0.00	6.5	5.6	64	25	582	162	49	0.17	0.18	1100
5/18/77	77.0	6.6	8.1	202	353	13.5	0.03	7.9	2.6	88	23	512	44	21	0.09	0.18	238
5/25/77	79.1	7.0	8.2	215	238	10.1	0.02	8.4	1.9	91	23	504	42	17	0.10	0.13	181
6/2/77	69.8	7.0	8.2	215	344	11.0	0.03	10.3	4.1	87	20	534	73	30	0.13	0.16	93
6/8/77	71.2	11.4	8.5	207	318		0.05	2.8	1.8		29		73	17	0.04	0.10	64
6/15/77	71.8	18.0	8.5	217	411	6.2	0.00	2.7	1.0	95	25	502	42	9	0.12	0.04	49
6/24/77	78.8	6.3	8.1	205	265	2.5	0.20	3.7	1.2	115	25	460	18	5	0.11	0.10	27
7/1/77	72.5	6.1	7.9	189	258	1.1	0.31	3.9	1.9	113	25	450	34	15	0.11	0.03	25
7/8/77	85.5	11.6	8.4	184	252	0.4	0.05	5.6	0.4	126	28	458	7	5	0.12	0.01	17
7/14/77	87.4	14.0	8.4		320	0.0	0.11	6.3	0.4	151	27	384	8	7	0.04	0.03	16
7/22/77	79.7	6.1	8.2	179	367	0.1	0.07	3.3	1.7	144	24	460	34	15	0.12	0.06	26
7/29/77	77.2	7.1	7.9	152		4.0	0.12	7.6	1.9	75	18	346	40	23	0.17	0.06	30
8/5/77	75.2	8.2	8.1	169	280	2.3	0.04	6.1	0.9	93	20	394	50	8	0.23	0.07	13
8/12/77	71.1	5.6	7.7	167	300	6.6	0.09	11.7	1.1	41	11	438	144	44	0.28	0.07	2320
8/19/77	71.2	12.1	8.0	210	433	7.6	0.03	10.4	9.7	78	20	530	42	18	0.12	0.08	242
10/6/77	58.1	8.6	8.0	268	453	7.7	0.07	7.5	2.3	65	18	444	36		0.11	0.03	
Station 2																	
4/11/77	64.6	6.7	8.1	177	341	7.3	0.26	2.5	2.4	93		512	67	23	0.13	0.02	113
4/18/77	73.4	8.6	8.2	194	344	4.9	0.01	0.2	1.2	108	28	469	40	15	0.08	0.06	61
4/25/77	60.4	10.7	8.5	222	351	3.7	0.02	2.2	1.5	112	26	518	94	17	0.10	0.00	43
5/2/77	61.8	12.7	8.6	215	344	2.9	0.01	0.7	0.8	119	27	410	22	13	0.08		25
5/9/77	57.4	8.2	8.0	164	318	14.6	0.31	8.6	5.6	65	23	568	134	45	0.17	0.08	1100
5/18/77	77.5	6.9	8.1	197	348	13.9	0.00	8.1	2.2	85	21	500	42	21	0.09	0.19	238
5/25/77	79.7	7.3	8.1	212	233	9.9	0.00	7.6	2.6	90	34	532	69	22	0.14	0.12	181
6/2/77	69.8	7.1	8.2	212	344	10.9	0.07	10.4	4.1	87	20	533	80	30	0.14	0.07	93
6/8/77	70.7	11.3	8.4	212	318		0.03	3.0	1.9		28		45	18	0.03	0.12	64
6/15/77	75.2	16.6	8.6	207	344	6.3	0.09	1.6	1.3	94	24	496	56	14	0.10	0.05	49
6/24/77	77.4	5.2	8.1	210	252	2.5	0.36	3.5	2.0	117	25	458	24	13	0.14	0.41	27
7/1/77	72.5	6.1	7.9	189	285	1.1	0.33	5.1	2.1	110	25	448	52	21	0.16	0.09	25
7/8/77	89.2	10.8	8.3	189	238	0.76	0.08	5.6	1.1	122	27	464	15	11	0.10	0.26	17
7/14/77	86.9	16.0	8.4		453	0.05	0.11	5.8	0.6	149	28	464	8	11	0.05	0.06	16
7/22/77	80.6	6.6	8.1	174	320	0.11	0.14	1.8	1.4	138	24	450	34	12	0.11	0.09	26
7/29/77	78.2	7.5	7.9	144		4.1	0.16	8.1	2.5	73	19	338	28	25	0.15	0.12	30
8/5/77	74.7	8.3	8.1	172	233	2.3	0.07	6.5	1.3	97	21	456	52	14	0.28	0.43	13
8/12/77	71.8	5.6	7.7	172	247	6.5	0.12	12.8	1.1	40	12	400	88	42	0.20	0.10	2320
8/19/77	71.4	12.2	8.3	260	460	7.7	0.06	8.7	8.6	75	20	304	68	18	0.11	0.09	242
10/6/77	60.8	7.8	8.1	258	440	7.7	0.10	8.4	1.8	63	18	430	8		0.10	0.05	
Station 3																	
4/11/77	63.1	5.9	8.2	197	331	7.6	0.15	3.02	2.3	91		485	48	23	0.18	0.03	
4/18/77	74.5	9.4	8.3	199	344	5.0	0.23	0.30	1.2	105	28	473	121	13	0.10	0.00	
4/25/77	58.4	10.2	8.6	215	351	3.6	0.02	2.9	1.6	115	26	522	42	14	0.09	0.05	
5/2/77	61.8	13.1	8.6	215	344	2.6	0.00	0.6	0.8	117	26	412	20	12	0.10		
5/9/77	57.4	8.2	8.2	167	311	14.6	0.00	8.8	4.8	63	27	548	130	44	0.20	0.02	
5/18/77	77.0	6.3	7.9	197	353	14.1	0.00	6.5	1.2	87	31	561	68	29	0.13	0.18	
5/25/77	79.1	7.0	8.2	217	258	10.1	0.05	6.4	2.2	88	24	517	58	18	0.09	0.14	
6/2/77	69.4	7.0	8.2	212	351	11.0	0.00	10.8	3.9	86	20	532	81	31	0.15	0.16	
6/8/77	70.0	10.4	8.4	210	298		0.04	2.8	2.3		29		24	15	0.03	0.10	
6/15/77	74.5	18.5	8.6	222	397	6.3	0.03	2.0	1.3	95	24	494	44	14	0.20	0.03	
6/24/77	76.8	5.1	8.1	210	278	2.5	0.36	3.5	1.0	115	25	438	14	8	0.11	0.18	
7/1/77	70.2	5.1	7.7	192	238	1.3	0.39	5.7	1.7	111	25	410	130	15	0.10	0.05	
7/8/77	89.1	10.4	8.3	192	232	0.5	0.02	3.9	0.5	123	26	450	8	6	0.08	0.03	
7/14/77	87.9	19.2	8.5		453	0.04	0.30	5.5	0.3	153	25	354	8	7	0.03	0.06	
7/22/77	80.6	5.0	8.0	182	287	0.17	0.14	0.5	1.4	138	25	444	30	12	0.12	0.08	

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Table C. (Concluded)

Date	*Temp (°F)*	*DO*	pH	*Alk*	*Hard*	*NO_3-N*	*NH_3-N*	*SiO_2*	*Fe*	SO_4	*Cl*	*TS*	*SS*	*Turb (Ftu)*	*T.P*	*T.Al*	*Flow (Cfs)*
Station 3 (Continued)																	
7/29/77	77.9	8.2	7.9	144		4.2	0.12	8.0	2.3	69	18	326	32	25	0.14	0.07	
8/5/77	74.8	7.6	8.0	172	253	2.4	0.04	5.8	0.8	95	19	478	48	8	0.58	0.16	
8/12/77	71.6	5.6	7.7	159	333	6.7	0.16	11.7	1.1	35	13	402	230	52	0.39	0.12	
8/19/77	71.2	11.8	8.0	263	407	7.6	0.05	9.2	7.4	75	20		44	16	0.11	0.05	
10/6/77	59.0	7.5	8.0	258	427	7.8	0.11	9.6	2.2	60	18	446	32		0.10	0.04	
Station 4																	
4/11/77	63.7	6.2	8.3	162	331	7.2	0.14	2.4	1.8	93		479	47	20	0.10	0.07	
4/18/77	70.7	10.3	8.2	197	344	4.8	0.02	0.2	1.7	108	29	513	52	15	0.13	0.09	
4/25/77	59.2	10.8	8.1	212	378	3.3	0.13	4.0	0.9	108	30	500	36	11	0.08	0.02	
5/2/77	61.8	10.8	8.5	215	344	2.9	0.01	0.4	0.9	116	28	396	24	12	0.11		
5/9/77	57.2	8.7	8.0	164	318	15.3	0.06	8.9	6.9	61	23	640	152	49	0.18	0.06	
5/18/77	76.1	7.2	8.2	197	353	14.1	0.04	9.1	3.4	87	24	534	87	33	0.12	0.17	
5/25/77	79.0	7.2	8.2	212	268	*9.9*	0.07	7.7	2.9	88	23	509	69	22	0.09	0.04	
6/2/77	69.6	7.3	8.2	217	371	10.9	0.21	11.0	5.1	85	22	523	65	29	0.13	0.08	
6/8/77	69.8	8.3	8.2	210	358		0.07	3.3	1.9		29		17	17	0.03	0.07	
6/15/77	73.4	17.2	8.6	215	391	6.4	0.00	1.1	1.3	98	24	528	50	7	0.37	0.04	
6/24/77	78.4	5.8	7.9	207	298	2.6	0.16	3.5	0.9	115	30	442	14	7	0.09	0.18	
7/1/77	71.8	8.1	8.1	197	245	1.1	0.07	3.8	0.8	118	27	430	20	7	0.09	0.03	
7/8/77	88.3	6.5	8.1	199	245	0.6	0.03	4.8	1.2	126	31	484	7	10	0.09	0.08	
7/14/77	88.7	9.4	8.3		333	0.1	0.10	3.0	1.4	147	28	402	32	14	0.03	0.04	
7/22/77	80.2	5.6	8.0	169	300	0.2	0.97	2.7	1.0	144	25	444	28	8	0.10	0.06	
7/29/77	77.5	7.6	7.3	119		3.9	0.10	7.4	2.2	94	20	330	36	25	0.12	0.10	
8/5/77	74.7	7.9	8.1	174	253	2.3	0.03	5.5	0.9	94	19	474	48	11	0.53	0.24	
8/12/77	74.3	6.0	7.9	164	280	6.7	0.12	11.6	1.3	35	13	444	132	47	0.23	0.13	
8/19/77	71.6	12.0	8.0	268	440	7.6	0.05	1.4	11.3	78	20	334	86	19	0.28	0.04	
10/6/77	57.4	8.0	7.9	258	287	7.8	0.06	8.3	2.5	64	19	410	32		0.09	0.04	

Table D. Analyses of River Bottom Muds

(In parts per million)

	Total P	*Total* SiO_2	*Total* Al	*Total* Fe
Station 1				
5/12/77	850	1220	215	26,360
7/14/77	670	3950	218	24,960
10/6/77	660	880	161	22,860
Station 2				
5/12/77	830	1150	572	27,240
7/14/77	930	1440	2482	29,000
10/6/77	840	1040	1342	25,750
Station 3				
5/12/77	710	660	261	21,270
7/14/77	890	1180	417	30,250
10/6/77	830	520	365	16,500
Station 4				
5/12/77	550	960	139	22,470
7/14/77	670	700	288	19,500
10/6/77	590	400	150	21,000
Others				
(5/12/77)				
Site D	790	1440	647	28,310
Site F	720	970	231	23,670

Table E. Macroinvertebrate Organisms Collected on Artificial Substrates in the Vermilion River at Pontiac

Tolerance category and organism	5/2/77*				6/2/77*				7/1/77*			
	1	2	3	4	1	2	3	4	1	2	3	4
Intolerant												
Cambarus (crayfish)					1	1	2					
Centroptilum (mayfly nymph)												
Hyalella (scud)		8	1	16						3		
Ischnura (damselfly nymphs)				3						1	2	
Psychomyiid Genus A (caddisfly larvae)											2	1
Stenonema (mayfly nymphs)			9		35	8	34	24	18	8	33	47
Moderate												
Argia (damselfly nymph)			1		1		5	9				1
Asellus (sawbug)					1							
Cheumatopsyche (caddisfly larvae)												
Potamanthus (mayfly nymph)						1						
Sialis (alderfly larvae)			1									1
Facultative												
Caenis (mayfly nymph)	9	6	2	8	4	9	10	2	41	16	29	14
Dineutus (beetle larvae)							1			1		
Dubirapbia (beetle)	4					3	7				2	
Elmidae (beetle)												
Ferrissia (snail)	34	3	8	1	1	1		6	7	3		
Oecetis (caddisfly larvae)	1		1									
Stenelmis (beetle)					2	3	6	1			1	2
Tricorythod.es (mayfly nymph)									6	1		
Tolerant												
Chironomidae (midge fly larvae)	138	201	79	208	43	39	76	29	485	194	829	318
Hirudinea *(leech)*							1	1	1	2	1	
Physa (snail)	2		1	3	1				1			
Tubificidae (aquatic worms)		1			1	3	1	3				
Total number of individuals	188	219	103	239	90	68	143	75	559	229	899	384
Total number of taxa	6	5	9	6	10	9	10	8	7	9	8	7
Aquatic classification	SP	SP	UB	SP	UB	UB	UB	UB	SP	SP	SP	UB
Assigned point value	3	3	2	3	2	2	2	2	3	3	3	2

	8/5/77*				9/1/77*				10/6/77*			
Intolerant												
Cambarus			X									X
Centropilum												1
Hyalella							1					
Ischnura					1							
Psychomyiid Genus A	3			16	5		12	29	19	3	23	
Stenonema	1	18		3	8	4	20	5	65	33	81	
Moderate												
Argia	12	9		1	6	10	3	2	13	26	2	
Asellus							1	1				
Cheumatopsyche								3		1	21	
Potamanthus								1				
Sialis												

(Concluded on next page)

Table E. Concluded

Tolerance category and organism	*8/5/77*				*9/1/77*				*10/6/77*			
	1	*2*	*3*	*4*	*l*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Facultative												
Caenis	4	*2*			*2*	18	5	1	17	28	13	
Dineutus	2	5										
Dubirapbia		1				1		*4*	1	1	1	
Elmidae					1							
Ferrissia		1				1						
Oecetis												
Stenelmis												
Tricorythodes												
Tolerant												
Chironomidae	1224	469		310	233	107	264	385	86	45	238	
Hirudinea						2				1		
Physa												
Tubificidae												
Total number of individuals	1246	505		330	256	143	306	431	201	138	380	
Total number of taxa	6	7		4	7	7	7	9	6	8	7	
Aquatic classification	SP	SP		SP	SP	SP	UB	SP	UB	UB	UB	
Assigned point value	3	3		3	3	3	2	3	2	2	2	2

* Date *substrates collected represents about 30 day colonization period*

X Substrates not recovered

Table F. Benthic Macroinvertebrate Organisms Collected by Dredge in the Vermilion River at Pontiac

Tolerance category and organism	*5/13/77*				*7/14/77*				*10/6/77*			
	1	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*/*	*2*	*3*	*4*
Intolerant												
Stenonema (mayfly nymphs)				43								
Facultative												
Caenis (mayfly nymphs)	*29*			43								
Dubiraphia (beetle)								86				
Tolerant												
Chaoborus (phantom midge fly larvae)			14		574	72	1378	43		14		
Chironomidae (midge fly larvae)	345	57	386	517		43	14		29	14		
Tubificidae (aquatic worms)	1119	474	1335	86	215	29	258	172		14	29	
Total number of individuals*	1493	531	1735	689	789	144	1650	301	29	42	29	0
Total number of taxa	3	2	3	4	2	3	3	3	1	3	1	0
Aquatic classification	SP	P	P	SP	P	P	P	SP	P	P	P	BA
Assigned point value	3	4	4	3	4	4	4	3	4	4	4	5

** Individuals per square meter*

Table G. IEPA Aquatic Classification of Stations Sampled on the Vermilion River at Pontiac

Date	*Station 1*	*Station 2*	*Station 3*	*Station 4*	*Average*
		Artificial Substrates			
5/2/77	3	3	2	3	2.8
6/2/77	2	2	2	2	2.0
7/1/77	3	3	3	2	2.8
8/5/77	3	3	X	3	3.0
9/1/77	3	3	2	3	2.8
10/6/77	2	2	2	X	2.0
Average	2.7	2.7	*2.2*	2.6	2.6

X = Substrates not recovered

		Benthic Samples			
5/13/77	3	4	4	3	3.5
7/17/77	4	4	4	3	3.8
10/6/77	4	4	4	5	4.3
Average	3.7	4	4	3.7	3.9
	Average of Substrate and Benthic Samples				
	3.0	3.1	2.9	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