WATER QUALITY DEMONSTRATION STUDY

WAXAHATCHEE CREEK
COLUMBIANA, ALABAMA
1987, 1988, 1989

SPECIAL SERVICES SECTION
FIELD OPERATIONS DIVISION
ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

WATER QUALITY DEMONSTRATION STUDY
WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
1987, 1988, 1989

INTRODUCTION

The City of Columbiana, Alabama utilizes a tributary to Waxahatchee Creek as a receiving stream for the treated effluent from its municipal wastewater treatment facility. Approximately 1 mile downstream, the tributary empties into Waxahatchee Creek. During the period from July 1987 to October 1989, the City of Columbiana underwent construction to upgrade the old disposal plant. Staff members of the Field Operations Division of the Alabama Department of Environmental Management (ADEM), at the request of the Municipal Branch of the Water Division of ADEM, conducted a water quality demonstration study to assess the effects of the new treatment facility on the tributary to- and Waxahatchee Creek.

EPA CONSTRUCTION GRANTS PROGRAM

Since 1972, approximately $534 million in EPA grant funds has been expended on construction of municipal wastewater treatment systems in Alabama. FY-90 marks the last year of the EPA Construction Grants Program. One recipient of EPA funding was the City of Columbiana, Alabama in Shelby County.

To encourage the advancement of wastewater technology, EPA designated some projects as innovative/alternative technology. This means that, while it is recognized that their might be some risk associated with using a new technology, it is worth the risk to give new technology a try in the interest of advancing knowledge in the field. To encourage municipalities participation in this program, EPA offered 75% grants for projects that involved innovative/alternative technology, instead of the usual 55% grants for projects that involve proven technology.

The Biolac system proposed for Columbiana was judged to be innovative technology and Columbiana recieved a 75% EPA Step 3 Construction Grant in September 1986 for construction of a 0.75 MGD Biolac treatment system. The total EPA eligible construction cost for the treatment facility was approximately $1,056,474.00. Of this total, the EPA grant was approximately $674,492.00.

The project engineer was Robinson and Layton of Birmingham, Alabama and the construction company was Lloyd Wood Construction of Tuscaloosa, Alabama. Construction of the new WWTP began in January 1988 and operation commenced in December 1988. The new construction included facilities for screening and grit removal, flow monitoring, aeration/clarification using the Biolac process, post aeration via a partial mix aeration pond, and cascade aeration.

The new Biolac system replaced a 6.6 acre single cell lagoon which was discharging secondary treated wastewater to an unnamed tributary of Waxahatchee Creek. The new Biolac system is an extended aeration system. The aeration cell is 12 to 14 feet deep and is aerated by a system of floating chains. The aerators are perforated tubes which are suspended below the floating chains. As the air is forced through the thousands of tiny openings along the length of these tubes, it aerates the water and moves the chains from side to side in a snake-like fashion. This action provides mixing of activated sludge and at the same time supplies oxygen to the bacteria that break down the waste. In extended aeration systems, more air is usually required to keep the solids in suspension than is required to aerate the wastewater; therefore, the mixing requirements control. In the Biolac system, this is reversed and the aeration requirements control. Thus, if a sufficient volume of air is supplied to aerate the water, the water will maintain a mixed state and the solids will stay in suspension. This reduces the demand for blower capacity which results in energy savings.

Monthly NPDES permit limits for the 0.75 MGD Biolac system are as follows:

BOD5	12 mg/L
NH3-N	3 mg/L
TSS	30 mg/L
D.O.	6 mg/L

Average monthly performance by the treatment facility for the twelve month period from July 1989 to June 1990 is as follws:

Flow	0.451 MGD
BOD	7.4 mg/L
NH3-N	0.6 mg/L
TSS	8.1 mg/L
D.O.	8.6 mg/L

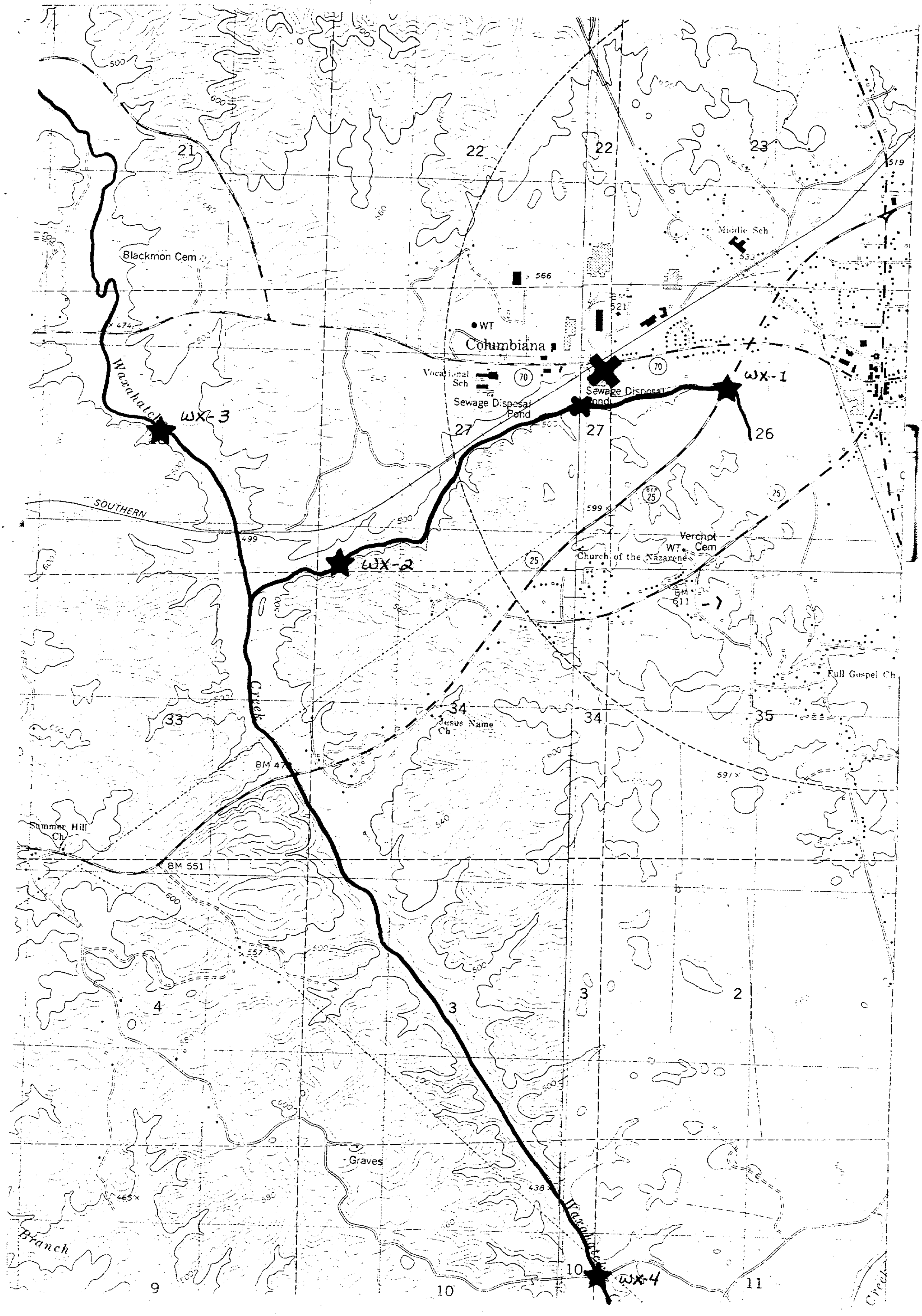
FIELD OPERATIONS

During the periods of July 1987 to September 1987 and May 1988 to October 1988, staff members of the Field Operations Division collected data to establish conditions and provide a comparative base of information on Waxahatchee Creek and its' tributary prior to construction and implementation of the new treatment plant. During May to October 1989, data were collected to demonstrate the improvement, if any, of water quality in the receiving stream attributable to the new plant.

SAMPLING LOCATIONS AND METHODOLOGY

Four sampling locations were selected and utilized for data collection during the water quality demonstration study. The station names and locations were as follows:

STATION	LOCATION:
WX-1 (control)	Tributary to Waxahatchee Creek approximately 1/2 mile upstream of treatment plant at State Highway 25 crossing. T21S,R1W,S26,NW1/4,SE1/4,SE1/4
WX-2	Tributary to Waxahatchee Creek approximately 3/4 mile downstream of treatment plant at trail crossing. T21S,R1W,S27, SW1/4,SW1/4,SW1/4
WX-3 (control)	Waxahatchee Creek approximately 1/2 mile upstream of confluence of tributary. T21S,R1W,S28,SW1/4,NE1/4,NE1/4
WX-4	Waxahatchee Creek approximately 3&1/4 miles downstream of treatment plant at County Road 315 crossing. T22S,R1W,S11, NW1/4,SW1/4,SW1/4



21
22
22
23
Blackmon Cem
Middle Sch
566
521
533
519
WT
Columbiana
Vocational Sch
70
70
Sewage Disposal Pond
Sewage Disposal Pond
WX-1
26
WX-3
27
27
Waxahatchee
SOUTHERN
499
500
WX-2
599
25
25
25
Verchot Cem
WT
Church of the Nazarene
BM 611
Full Gospel Ch
Creek
33
34
34
35
Jesus Name Ch
591
Summer Hill Ch
BM 551
600
557
500
540
4
3
3
2
Graves
438
465
Branch
Waxahatchee
9
10
10
WX-4
11
Creek

The following parameters were collected at each sampling location:

1). Date
2). Time
3). Air Temperature
4). Water Temperature
5). Conductivity
6). pH
7). Dissolved Oxygen (D.O.)
8). Biochemical Oxygen Demand (BOD_5)
9). Total Suspended Solids (TSS)
10). Nitrate (NO_3-N)
11). Ammonia (NH_3-N)
12). Total Kjeldahl Nitrogen (TKN)
13). Total Organic Nitrogen (TON)
14). Phosphate (PO_4-P)
15). Stream Flow
16). Fecal Coliform
17). Aquatic Macroinvertebrates

All sampling, sample handling techniques, and field parameter analyses utilized in the acquisition of data for this water quality demonstration study were as described in the Field Operations Standard Operating Procedures and Quality Control Assurance Manual (Field Operations Division, ADEM, December 1986), as amended. Chain- of-custody was maintained by locking the samples in a Departmental vehicle when not in sight of a Field Operations employee. The samples requiring laboratory analysis were transported to the ADEM Environmental Laboratory in Montgomery, Alabama. Analysis methodology were as specified in the Federal Register, 40 CFR Part 136, October 1984, as amended. Analysis of the samples yielded the data which are reported in Tables 1 and 2.

BIOLOGICAL METHODOLOGY

Aquatic macroinvertebrates, defined as organisms which are retained on a U.S. Standard No. 30 sieve (0.595 mm openings) (Weber, 1973), were collected by two staff biologists utilizing Hester-Dendy multiple plate artificial substrate samplers. A total of three samplers were deployed at each sampling location. Each sampler was placed in such a manner as to be suspended at a depth of 12 to 18 inches in the water column. The samplers were deployed for a period of approximately six weeks. At the end of the sampling period, the samplers were collected in wide-mouth jars, returned to the laboratory, cleaned over a No. 30 sieve, and the materials retained on the sieve preserved in 90% ethanol. The macroinverte-brate organisms were then sorted and identified to the lowest possible taxonomic level. The purpose of this sampling method is to provide a quanitative representation of the aquatic macroinvertebrate community at each station.

The macroinvertebrate data were analyzed using the following methods:

1). Relative Abundance- total number of organisms and total number of taxa were enumerated and compared station to station.

2). EPT Index- total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera. This number, generally, increases with increasing water quality and summarizes taxa richness within the insect orders which are considered to be pollution sensitive (Plafkin, 1989).

3). Percent Contribution of Dominant Taxa- an indication of community balance at the lowest positive taxonomic level. A community dominated by relatively few taxa would indicate environmental stress (Plafkin, 1989).

Percent= # of Most Abundant Taxa/ Total # of Organisms

As environmental stress increases, percentage increases. 4). Sorenson's Community Similarity as modified by Mathews (1978)- measures the degree of similarity in taxonomic composition between two stations in terms of presence or absence. Station of interest is compared to a reference station.

SCS= 2c/a+b

c= # of taxa common to both samples
a= total # of taxa at station 1.
b= total # of taxa at station 2.

Values range between 0 and 1. As value approaches 1.0, samples are considered more similar.

5). Dominants in Common- provides a measure of replacement or substitution, between the reference community and the downstream station, utilizing the dominant five taxa. Four or more dominant taxa in common indicates no impairment (Plafkin, 1989).

6). Indicator Assemblage Index- integrates the relative abundances of the EPT taxonomic groups and the relative abundances of chironomids and annelids (CA) upstream and downstream to evaluate impairment (Plafkin, 1989).

IAI=0.5* [(%EPT @ test station / %EPT @ control station) +(%CA @ control station / %CA @ test station)]

As IAI approaches 1.0, value indicates good community balance.

7). Shannon-Weaver Species Diversity Index ($\bar{d}$)- a general representation of taxa richness and water quality. Values between 3 and 4 generally indicate unimpaired waters, whereas, in impacted waters, values are less than 1 (Weber, 1973).

$$\bar{d} = [\ (C/N)*\ ((N \log_{10} N)-(n_i \log_{10} n_i))]$$

C= 3.32928 (a constant)
N= total # of individuals
n_i= total # of individuals in the i^{th} species

8). Equitability (e)= s'/s -compares the number of taxa in a sample (s) with the number of taxa expected (s') from a community that conforms to the MacArthur's Broken Stick Model. Equitability has been found to be very sensitive to even slight levels of degradation due to oxygen demanding wastes. Generally, values greater than 0.5 indicate little stress, whereas, values less than 0.5 indicate that the communities are impacted (Weber, 1973).

9). Indicator organism analysis, using the Hilsenhoff Biotic Index (Plafkin, 1989), and Weber's Tolerance Classification system (Weber,1973) was used to evaluate the composition and environmental requirements of the taxa. The Hilsenhoff Biotic Index is a whole number tolerance value ranging from 0 (least tolerant) to 10 (most tolerant). Weber's Tolerance Classification system rates an organism as T (tolerant), F (facultative), I (intolerant) or combinations of these based on the number of literary descriptions of the referenced organism.

DISCUSSION AND RESULTS

A. PHYSICAL

The tributary to- and Waxahatchee Creek are first and third order streams, respectively. Both streams are typical pool-riffle streams with varying bottom structure. The bottom primarily consists of differing size rocks, gravel, and exposed bedrock. During low flow conditons, flows on the tributary to- and Waxahatchee Creek average less than two cubic feet per second (Table 1, Figure 1). At all locations, there is riparian vegetation and available habitat for macroinvertebrate colonization. Beaver activity has not been noted on Waxahatchee Creek, however, there is a dam upstream of the WX-1 location. Though there is some accumulation of organic silt, stream velocity and bottom structure precludes major deposition and retention. During both periods of sampling, filamentous algae was noted as growing at sampling locations downstream of the confluence of the tributary and Waxahatchee Creek. Lay Lake, on the Coosa River, receives the flow from Waxahatchee Creek.

B. CHEMICAL

The Water Use Classification for the tributary to Waxahatchee Creek (WX-1, WX-2) and Waxahatchee Creek from Camp Branch to the Southern Railroad Crossing (WX-4) is classified as Agricultural and Industrial Water Supply (A&I). Waxahatchee Creek from the Southern Railroad Crossing to its source (WX-3) is classified as Fish and Wildlife (F&W) . A&I designates the waters to be suitable for agricultural irrigation, livestock watering, industrial cooling and process water supplies, and any other usage except fishing, bathing, recreational activities, including water contact sports, or as a source of water supply for drinking of food processing purposes. F&W designates the waters to be suitable for fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water contact sports or as a source of water supply for drinking or food processing purposes.

As seen in Table 1 and Figure 2, data collected prior to the upgrade of the treatment plant indicated that the waters below the discharge point were consistently meeting the dissolved oxygen standard for the A&I classification (3.0 mg/L) The dissolved oxygen values at station WX-2 ranged, during the summer of 1987 and 1988, from a low of 3.4 mg/L to a high of 6.8 mg/L with an average 4.7 mg/L. At station WX-4, the dissolved oxygen values ranged from a low of 4.3 mg/L to a high of 7.5 mg/L with an average of 5.9 mg/L. The dissolved oxygen values at reference station WX-1 were consistently above their Water Use Classification of 3.0 mg/L. The dissolved oxygen values at reference station WX-3 were consistently below their Classification of 5.0 mg/L.

As seen in Table 2 and Figure 1, data collected after the upgrade of the treatment plant show a definite improvement. The dissolved oxygen values were frequently maintained above the 5.0 mg/L F&W standard for all stations, during the summer of 1989.

Station WX-2 had D.O. values averaging 9.4 mg/L. D.O. values at WX-4 had values averaging 8.3 mg/L. Reference stations WX-1 and WX-3 had D.O. values averaging 8.5 mg/L and 7.8 mg/L, respectively.

In addition to improved dissolved oxygen content, other improvements were evident. At all downstream stations, biochemical oxygen demand was significantly reduced, as was the amount of suspended solids below the discharge point. The pH values , generally, remained in the 7.0 standard unit to 8.0 standard unit range. Conductance, however, showed a marked improvement. It should be noted, as seen in Figure 1, that, due to high precipitation events, stream flows during the 'after' portion of this study were increased. This makes a determination of improved stream conditions difficult due to the potential for greater dilution than what would normally be expected during low flow conditions.

Phosphates also experienced a noticeable decrease. Before the upgrade of the plant, ammonia, nitrates, and phosphates were present in varying quantities, when downstream locations were compared to reference stations (Table 1). It should be noted that at WX-1 the presence of nitrates were greater than at WX-2. After the upgrade, ammonia and phosphate were significantly reduced. Nitrates continue to be present in quantity.

C. BIOLOGICAL

Stations WX-1, and WX-3, upstream of the WWTP effluent, were sampled for aquatic macroinvertebrates before and after upgrade to use as a reference database (Table 3, Figures 3 & 5).

The macroinvertebrate sampling at the tributary to Waxahatchee Creek in 1987, 1988, and 1989 revealed an aquatic community that was not balanced and showed some indication of severe stress from pollution. Species diversity values at WX-1 in 1987, 1988, and 1989 indicated a stressed aquatic community, however, equitability values at WX-1 indicated no impairment to the aquatic community until the 1989 sampling period. The equitability values, however, do not reflect the true condition of the stream, as the sample contained less than 100 organisms. This value becomes erratic with small collections.

In 1987, the number of organisms per meter squared was calculated as 310. A total of 62 organisms were collected representing 10 taxa. Of the ten taxa present, seven were classified as tolerant organisms, two were moderately tolerant, and one was intolerant. The EPT Index value was 0, indicating the absence of pollution sensitive organisms. A member of the Odonate order, <u>Chromagrion</u>, was the dominant taxa comprising 58% of the sampled population.

In 1988, a total of 187 organisms representing 14 taxa were collected at WX-1. Of the taxa present, ten were classified as tolerant organisms, three were moderately tolerant, one was intolerant, and one was undetermined. The EPT Index value was one, representing a pollution tolerant taxa, <u>Caenis</u>. The most dominant taxa was Oligochaeta which comprised 45% of the collection. The number of organisms per meter squared was calculated as 623.

In 1989, a total of 340 organisms representing 13 taxa were collected. Of the taxa present, five were classified as tolerant organisms, six were moderately tolerant, one was intolerant, and one was undetermined. The EPT Index value was 0, indicating an absence of pollution sensitive organisms. The most dominant taxa was Oligochaeta which comprised 74% of the population. The number of organisms per meter squared was calculated as 1133.

At the upstream station on Waxahatchee Creek in 1987, 1988, and 1989, data indicated that the stream was not suffering an adverse impact. In 1987, a total of 126 organisms were collected at WX-3, representing 20 taxa. Of the taxa present, nine were classified as tolerant organisms, seven were moderately tolerant, and five were intolerant. The EPT Index value was 4, indicating the presence of pollution sensitive organisms at WX-3. However, the EPT Index organisms were classified as tolerant to moderately tolerant. The dominant taxa, Helisoma, a generally pollution tolerant group, made up only 27% of the total population. Species diversity and equitability indicated no impairment to the aquatic community. The number of organisms per meter squared was calculated as 630.

In 1988, a total of 123 organisms representing 19 taxa were collected at WX-3. Of the taxa present, nine were classified as tolerant organisms, four were moderately tolerant, five were intolerant, and one was undetermined. The EPT Index value was 5, indicating the presence of pollution sensitive organisms. Most notably, pollution intolerant organisms, such as Ephemerella, Choroterpes, and Paraleptophlebia, were found. The dominant taxa, Stenacron, a moderately tolerant group, made up 24% of the sample. Species diversity and equitability indicated no impairment to the aquatic community. The number of organisms per meter squared was calculated as 410.

In 1989, a total of 147 organisms representing 18 taxa were collected at WX-3. Of the taxa present, three were classified as tolerant organisms, ten were moderately tolerant, three were intolerant, and two were undetermined. The EPT Index value was 8, indicating the presence of pollution sensitive organisms. Most notably, pollution intolerant organisms, such as Attenella, and Paraleptophlebia, were found. The dominant taxa, Stenacron, a moderately tolerant group, made up 44% of the sample. Species diversity and equitability indicated slight impairment to the aquatic community. The number of organisms per meter squared was calculated as 490.

Before upgrade, data collected from the tributary to Waxahatchee Creek at WX-2 showed severe impairment to the aquatic macroinvertebrate community. (Table 3, Figure 4). In 1987, a total of 834 organisms were collected representing 8 taxa. Of the taxa present, five were classified as tolerant organisms, two were moderately tolerant, and one was undetermined. The EPT Index was calculated to be 0, indicating an absence of pollution sensitive organisms. The dominant taxa, Chironomus, a pollution tolerant Dipteran, made up 81% of the total population. Species diversity and equitability values showed serious impairment evident in the stream. Sorenson's Community Similarity indicated that, as compared to WX-1, there was little similarity between the two stations. In addition,there were no dominant organisms common to either station. The Indicator Assemblage Index indicated that, as compared to WX-1, WX-2 possessed very poor community balance. The number of organisms per meter squared was calculated at 4170.

In 1988, a total of 4371 organisms were collected at WX-2 representing 11 taxa. Of the taxa present, nine were classified as tolerant organisms, one was moderately tolerant, and one was undetermined. The EPT Index showed a value of 0, indicating an absence of pollution sensitive organisms. The dominant taxa, Goeldichironomus, a moderately tolerant Dipteran, made up 55% of the total population. Species diversity and equitability values showed serious impairment evident in the stream. Sorenson's Community Similarity indicated that, as compared to WX-1, there was little similarity between the two stations. In addition,there were three dominant organisms common to both stations, Chironomus, Physella, and Oligochaeta, all pollution tolerant organisms. The Indicator Assemblage Index indicated that, as compared to WX-1, WX-2 possessed poor community balance. The number of organisms per meter squared was calculated at 14,570.

In 1989, after the upgrade of the plant, data indicated that the tributary to Waxahatchee Creek had experienced some improvement. A total of 129 organisms were collected at WX-2 representing 11 taxa. Of the taxa present, six were classified as tolerant organisms, four were moderately tolerant, one was intolerant, and one was undetermined. The EPT Index showed a value of 1, indicating the presence of a moderately tolerant organism, Hydropsyche. The dominant taxa, the Thienemannimyia group, a moderately tolerant Dipteran group, made up 57% of the total population. Species diversity and equitability values still showed slight impairment evident in the stream. Sorenson's Community Similarity indicated that, as compared to WX-1, there was little similarity between the two stations. In addition,there were two dominant organisms common to both stations, Thienemannimyia group, and Physella, all pollution tolerant to moderately tolerant organisms. The Indicator Assemblage Index indicated that, as compared to WX-1, WX-2 possessed better community balance than it had in 1987, and 1988. The number of organisms per meter squared was calculated at 430.

Before upgrade, data collected from Waxahatchee Creek at WX-4 showed moderate impairment to the aquatic macroinvertebrate community (Table 3, Figure 6). In 1987, a total of 136 organisms were collected representing 21 taxa. Of the taxa present, ten were classified as tolerant organisms, four were moderately tolerant, five were intolerant, and two were undetermined. The EPT Index showed a value of 3, indicating the presence of pollution sensitive organisms. The EPT Index organisms were classified as moderately tolerant, however. The dominant taxa, Helisoma, a pollution tolerant snail, made up 29% of the total population. Species diversity and equitability values showed no impairment evident in the stream. Sorenson's Community Similarity indicated that, as compared to WX-3, there was little similarity between the two stations. In addition,there were two dominant organisms common to both stations, Helisoma and Phaenosectra. The Indicator Assemblage Index indicated that, as compared to WX-3, WX-4 possessed poor community balance. The number of organisms per meter squared was calculated at 680.

In 1988, a total of 199 organisms were collected at WX-4 representing 26 taxa. Of the taxa present, twelve were classified as tolerant organisms, twelve were moderately tolerant, one was intolerant and one was undetermined. The EPT Index showed a value of 6, indicating the presence of pollution sensitive organisms. The EPT Index organisms were classified as tolerant to moderately tolerant, however. The dominant taxa, Physella, a pollution tolerant snail, made up 24% of the total population. Species diversity and equitability values showed no impairment evident in the stream. Sorenson's Community Similarity indicated that, as compared to WX-3, there was little similarity between the two stations. In addition,there were no dominant organisms common to both stations. The Indicator Assemblage Index indicated that, as compared to WX-3, WX-4 was overbalanced in favor of the EPT group. The number of organisms per meter squared was calculated at 663.

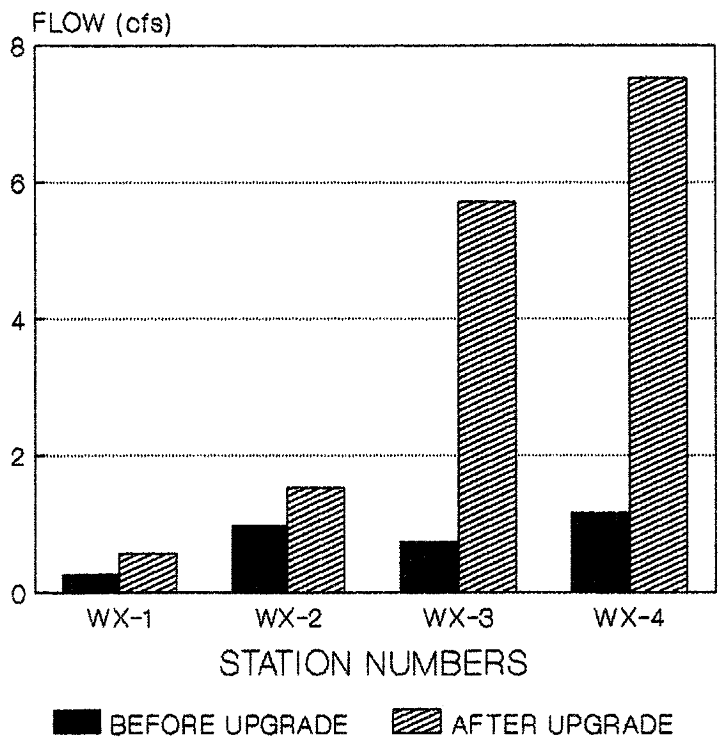
In 1989, after the upgrade of the plant, data indicated that Waxahatchee Creek had experienced some improvement. A total of 173 organisms were collected at WX-4 representing 24 taxa. Of the taxa present, seven were classified as tolerant organisms, twelve were moderately tolerant, five were intolerant, and one was undetermined. The EPT Index showed a value of 4, indicating the presence of three moderately tolerant and one intolerant organism, Attenella. The dominant taxa, Hydroptila, an intolerant Trichopteran, made up 34% of the total population. Species diversity and equitability values showed no impairment evident in the stream. Sorenson's Community Similarity indicated that, as compared to WX-3, there was little similarity between the two stations. In addition, there was one dominant organism common to both stations, Chromagrion, a pollution tolerant Odonate. The Indicator Assemblage Index indicated that, as compared to WX-3, WX-4 possessed better community balance than it had in 1987, and 1988. The number of organisms per meter squared was calculated at 577.

CONCLUSIONS

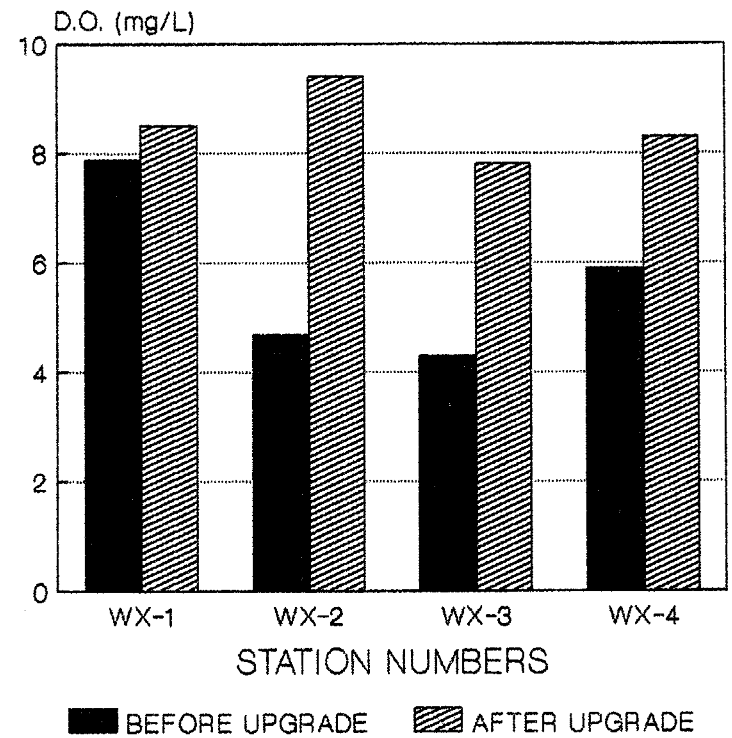
Physical, chemical, and biological data collected before and after the upgrade of the Columbiana wastewater treatment plant indicate that the tributary to- and Waxahatchee Creek have experienced an improvement in overall water quality. The tributary to- and Waxahatchee Creek appear to be meeting their Water Use Classifications of Agricultural and Industrial Water Supply.

FIGURE 1
WAXAHATCHEE CREEK
COLUMBIANA, ALABAMA

STREAM FLOW DATA



DISSOLVED OXYGEN DATA



THE ABOVE NUMBERS ARE AVERAGES REPRESENTING MULTIPLE SAMPLING EVENTS.

TABLE 1

WATER QUALITY DEMONSTRATION STUDY
WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
DATA COLLECTED PRIOR TO UPGRADE OF WWTP

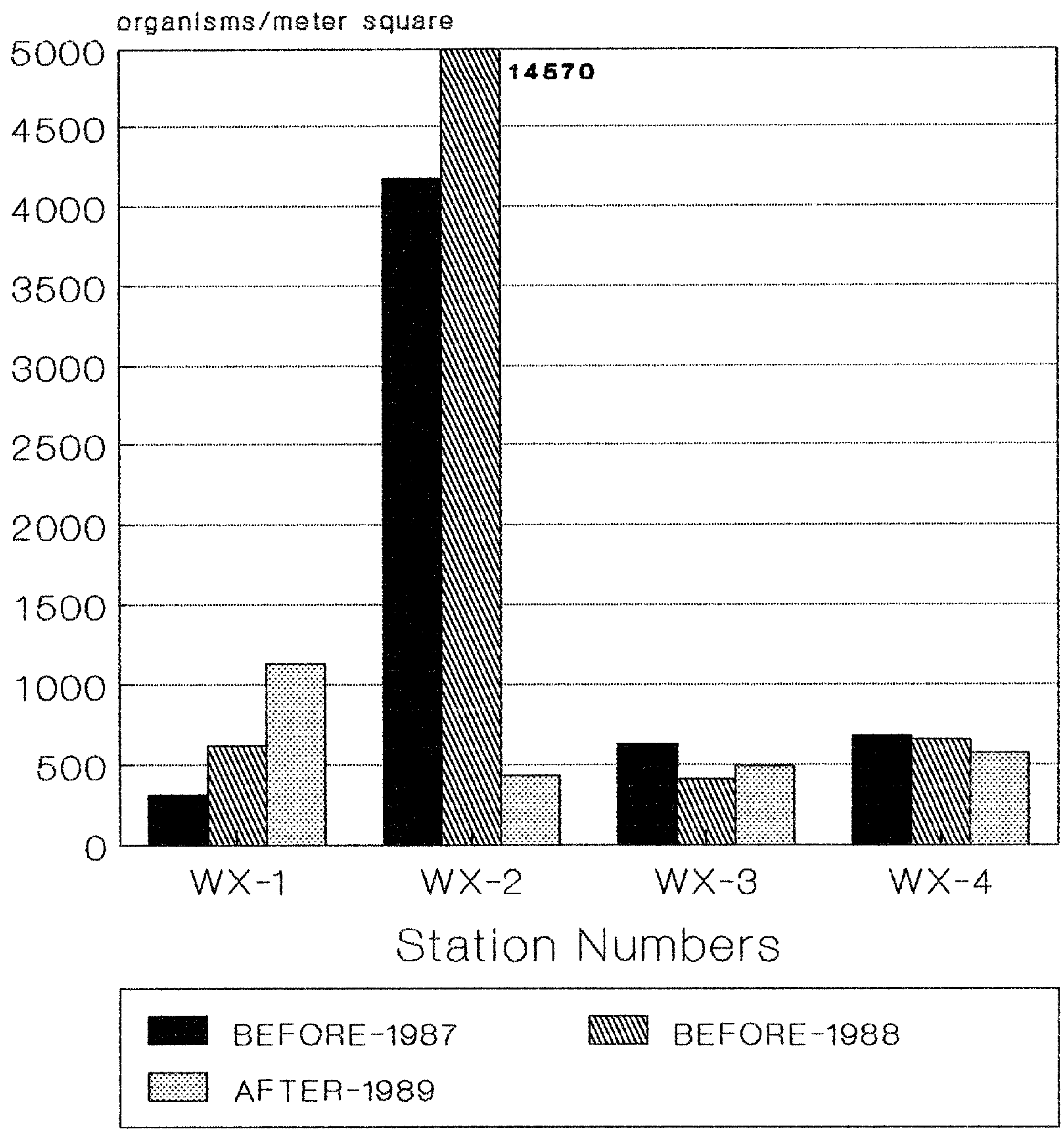
DATE	LOCATION	TIME	AIR TEMP	WATER TEMP	D.O.	pH	SPECIFIC COND	BOD_5	TSS	NO_2-N	NO_3-N	NH_3-N	TKN	TON	PO_4-P	FLOW	BACTERIA
07/24/87	WX-1	10:20	32	22	9.1	7.7	339	1	1	-----	3.6	<0.1	1	1	0.1	0.17	40
09/03/87		11:00	30	21	8.2	7.5	323	1.2	10	-----	0.2	<0.2	3.7	3.7	<0.02	0.23	173
05/19/88		11:00	21.1	18.9	8.7	7.2	300	2.2	7	-----	0.4	<0.1	0.8	0.8	0.01	0.35	
06/09/88		10:50	32	26	8.9	7.4	335	1.2	5	-----	0.04	<0.2	1.1	1.1	<0.01	0.2	93
07/20/88		09:10	24	22	6.8	7.6	340	0.9	2	<0.02	0.26	0.1	0.7	0.6	0.3	0.3	>600
09/01/88		10:00	25	22.8	5.7	7.4	390	2.4	1	<0.02	0.16	0.3	1.2	0.9	<0.02	0.32	>367
AVERAGE			27.4	22.1	7.9	7.5	338	1.5	4	-----	0.78	-----	1.4	1.4	-----	0.26	-----
07/24/87	WX-2	10:55	32.5	25.5	3.4	7.3	1500	8.2	14	------	0.16	1.6	4	2.4	1.19	1.07	370
09/03/87		11:50	29.5	22	3.4	7.3	2000	18.4	30	------	0.1	3	4.9	1.9	1.77	1.28	50
05/19/88		12:10	22.2	20	6.8	7.1	2150	5.2	17	------	1.12	0.7	3	2.3	0.93	1.14	
06/09/88		11:40	33	26.5	5.7	7.4	1900	6.3	25	------	0.46	0.3	4	3.7	0.75	0.66	200
07/20/88		12:20	26	26	4.7	7.5	2250	6	14	0.23	0.54	0.5	2.6	2.1	8.2	0.98	149
09/01/88		10:50	25	25	3.9	7.3	2650	16	26	0.04	0.08	0.3	2.8	2.5	1.8	0.75	53
AVERAGE			28.0	24.2	4.7	7.3	2075	10.0	21.0	0.14	0.41	1.1	3.6	2.5	2.44	0.98	164
07/24/87	WX-3	11:50	29	26.5	4.3	6.2	60	1.7	51	-----	<0.04	0.2	1.4	1.2	0.08	-----	36
09/03/87		13:10	33	24	2.7	6.8	185	3.4	49	-----	<0.04	<0.2	2.4	2.4	0.03	-----	<2
05/19/88		13:30	25.6	20	6.7	7.6	70	2.5	8	-----	0.16	<0.1	1.4	1.4	0.01	1.84	
06/09/88		12:40	32	26	5.2	7.4	105	1.7	26	-----	0.05	<0.2	1.4	1.4	0.01	0.28	21
07/20/88		10:14	26	23	3.6	7.2	80	1.3	3	<0.02	0.05	<0.1	0.8	0.8	0.02	<0.1	53
09/01/88		11:40	25	23.9	3.1	7.3	140	1	3	<0.02	0.04	0.2	2.2	2	<0.02	-----	6
AVERAGE			28.4	23.9	4.3	7.1	107	1.9	23.3	-----	-----	-----	1.6	1.5	-----	-----	-----
07/24/87	WX-4	08:45	26	24.5	5.6	7.2	1300	2	1	-----	2.1	0.4	1.7	1.3	0.32	0.97	23
09/03/87		10:00	28	21	5.5	7.6	1050	1.2	4	-----	0.06	<0.2	3.2	3.2	0.7	1.16	<1
05/19/88		10:30	22.2	17.2	7.5	7.4	580	1.9	6	-----	1.2	0.1	1.6	1.5	0.18	2.69	
06/09/88		09:50	32	25	7.3	7.1	1250	4.7	104	-----	0.02	<0.2	3.2	3.2	0.19	0.86	35
07/20/88		09:00	24	25	4.9	7.4	1700	1.4	3	0.02	0.41	<0.1	0.8	0.8	0.4	0.65	38
09/01/88		09:30	23.9	23.3	4.3	7.2	2700	1.4	5	<0.02	<0.04	0.4	1.6	1.2	0.34	0.6	6
AVERAGE			26.0	22.7	5.9	7.3	1430	2.1	20.5	-----	-----	-----	2.0	1.9	0.36	1.16	-----
			C	C	mg/L	SU	umho/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	cfs	org/ 100 mL)

TABLE 2

WATER QUALITY DEMONSTRATION STUDY
WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
DATA COLLECTED AFTER UPGRADE OF WWTP

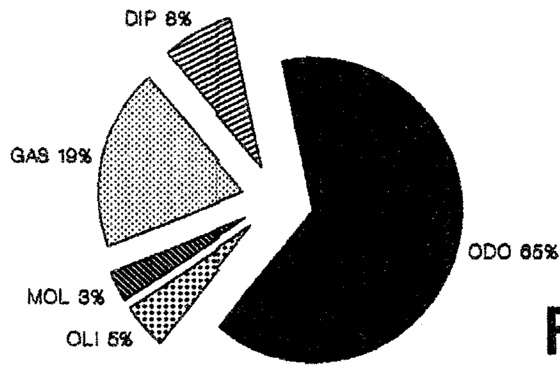
DATE	LOCATION	TIME	AIR TEMP	WATER TEMP	D.O.	pH	SPECIFIC COND	BOD_5	TSS	NO_3-N	NH_3-N	TKN	TON	PO_4-P	FLOW	BACTERIA
05/08/89	WX-1	11:20	25.6	17.8	10	7.5	250	0.6	4	0.48	0.2	0.9	0.7	<0.02	0.48	90
07/18/89		10:30	26.7	21.1	8.2	7.1	290	0.7	24	0.38	<0.2	1.06	0.86	<0.02	0.92	37.5
08/21/89		10:20	27.8	23.9	7.6	7.2	330	1	7	0.44	<0.2	<0.4	<0.2	0.03	0.29	123
10/04/89		11:00	20	16	8.1	7.4	370	3.4	11	0.46	0.54	0.55	0.01	0.14	0.53	>600
AVERAGE			25.0	19.7	8.5	7.3	310	1.4	12	0.44	---	---	---	----	0.56	----
05/08/89	WX-2	09:35	18.9	14.4	9.6	7.7	1400	2.6	8	2.88	0.2	1.4	1.2	1	1.56	560
07/18/89		11:35	27.8	22.8	10.3	7.6	1800	1.4	4	1.08	<0.2	<0.4	<0.2	0.41	2.53	146.7
08/21/89		11:15	28.3	24.4	9.5	7.5	2500	3	7	1.68	<0.2	0.85	0.65	0.83	0.82	14
10/04/89		11:50	20	18	8.2	7.6	730	4.1	6	1.2	0.32	0.66	0.34	1.37	1.18	>2500
AVERAGE			23.8	19.9	9.4	7.6	1,608	2.8	6	1.71	---	---	---	0.90	1.52	-----
05/08/89	WX-3	10:40	18.9	14.4	9.1	7.2	55	1.1	4	0.16	0.4	0.8	0.4	0.04	4.03	53
07/18/89		12:00	24.4	23.3	7.4	7.3	70	0.4	4	0.19	<0.2	<0.4	<0.2	<0.02	15.51	59.2
08/21/89		11:45	27.2	23.9	7.3	7.9	100	0.9	1	<0.04	<0.2	<0.4	<0.2	<0.02	0.3	16
10/04/89		12:24	20	19	7.3	7.3	80	1.8	3	0.32	0	0	0	0	2.99	75
AVERAGE			22.6	20.2	7.8	7.4	76	1.1	3	0.17	---	---	---	----	5.71	50.8
05/08/89	WX-4	13:05	26.7	18.3	10.7	7.2	320	1.2	4	0.64	<0.2	0.5	0.3	0.14	6.23	41
07/18/89		09:34	25.6	22.2	7.7	7.1	195	0.6	2	0.28	<0.2	<0.4	<0.2	<0.02	18.04	76.7
08/21/89		09:40	26.1	23.3	7	7.5	1300	1	3	0.37	<0.2	<0.4	<0.2	0.31	1.12	9
10/04/89		10:00	18	17	7.6	7.2	625	2.3	6	0.62	0	0	0	0.31	4.7	550
AVERAGE			24.1	20.2	8.3	7.3	610	1.3	4	0.48	---	---	---	----	7.52	169.2
			C	C	mg/L	SU	umho/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	cfs	org/ 100 mL

FIGURE 2
WAXAHATCHEE CREEK
MACROINVERTEBRATE DATA



WAXAHATCHEE CREEK
WX-1

DATA COLLECTED PRIOR TO UPGRADE(1987)



DATA COLLECTED PRIOR TO UPGRADE(1988)

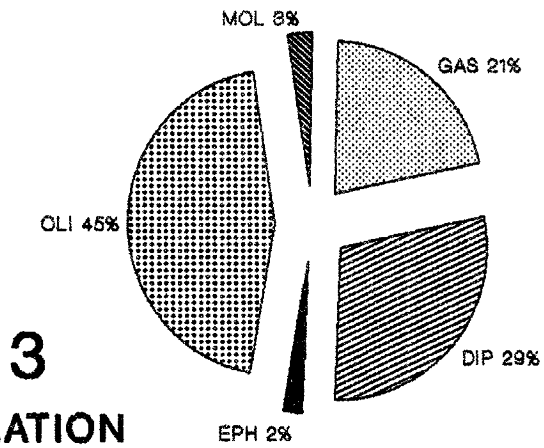
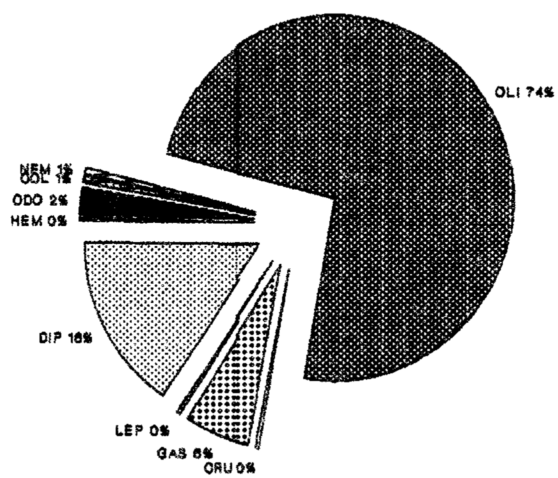


FIGURE 3
% TOTAL POPULATION OF TAXA PRESENT

DATA COLLECTED AFTER UPGRADE (1989)



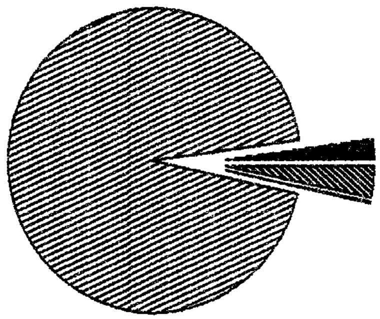
LEGEND

TRI - Trichoptera
ODO - Odonata
COL - Coleoptera
DIP - Diptera
HIR - Hirudinea
MOL - Mollusca
CRU - Crustacea
OLI - Oligochaeta
EPH - Ephemeroptera
MEG - Megaloptera
PLA - Planaria
HEM - Hemiptera
NEM - Nematoda
ACA - Acari
PLE - Plecoptera
LEP - Lepidoptera

WAXAHATCHEE CREEK

WX-2

DATA COLLECTED PRIOR TO UPGRADE(1987)



DATA COLLECTED PRIOR TO UPGRADE(1988)

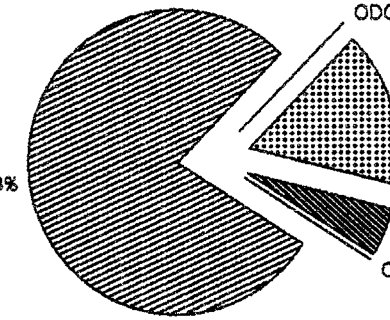
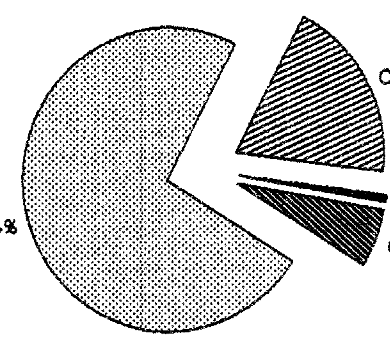


FIGURE 4

% TOTAL POPULATION OF TAXA PRESENT

DATA COLLECTED AFTER UPGRADE (1989)



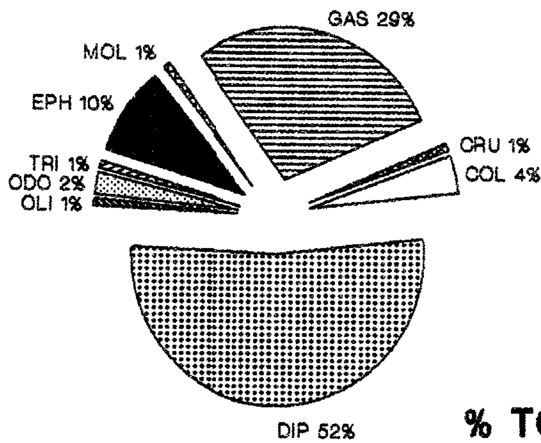
LEGEND

TRI - Trichoptera
ODO - Odonata
COL - Coleoptera
DIP - Diptera
HIR - Hirudinea
MOL - Mollusca
CRU - Crustacea
OLI - Oligochaeta
EPH - Ephemeroptera
MEG - Megaloptera
PLA - Planaria
HEM - Hemiptera
NEM - Nematoda
ACA - Acari
PLE - Plecoptera
LEP - Lepidoptera

WAXAHATCHEE CREEK

WX-3

DATA COLLECTED PRIOR TO UPGRADE(1987)



DATA COLLECTED PRIOR TO UPGRADE (1988)

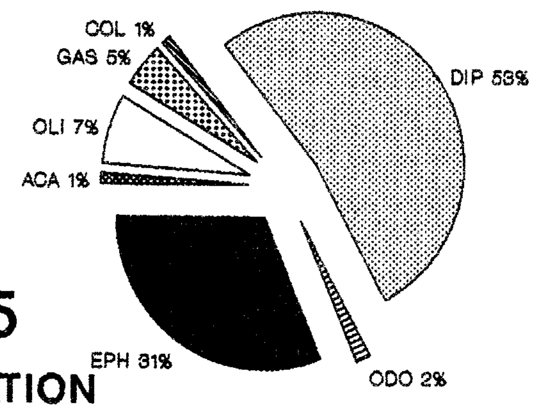
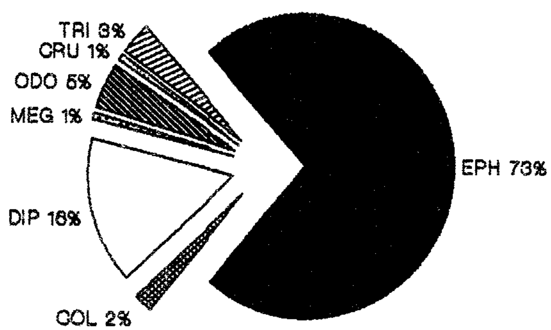


FIGURE 5

% TOTAL POPULATION OF TAXA PRESENT

DATA COLLECTED AFTER UPGRADE (1989)



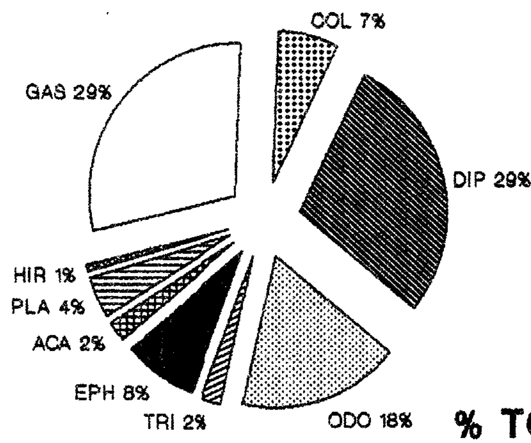
LEGEND

TRI - Trichoptera
ODO - Odonata
COL - Coleoptera
DIP - Diptera
HIR - Hirudinea
MOL - Mollusca
CRU - Crustacea
OLI - Oligochaeta
EPH - Ephemeroptera
MEG - Megaloptera
PLA - Planaria
HEM - Hemiptera
NEM - Nematoda
ACA - Acari
PLE - Plecoptera
LEP - Lepidoptera

WAXAHATCHEE CREEK

WX-4

DATA COLLECTED PRIOR TO UPGRADE(1987)



DATA COLLECTED PRIOR TO UPGRADE (1988)

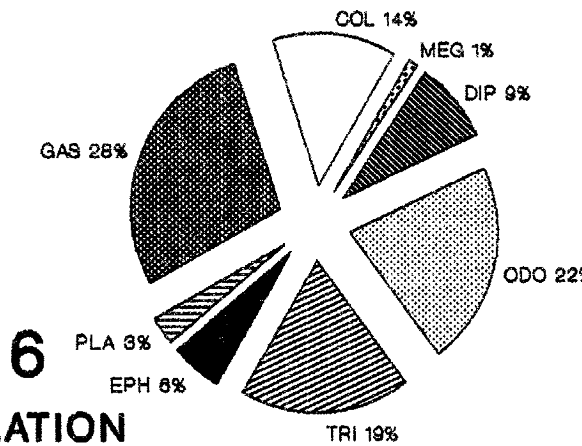
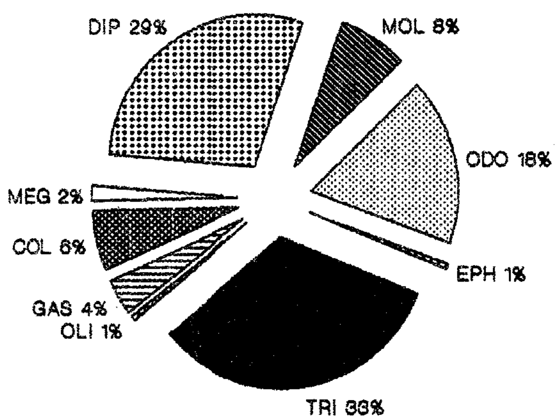


FIGURE 6

% TOTAL POPULATION OF TAXA PRESENT

DATA COLLECTED AFTER UPGRADE (1988)



LEGEND

TRI - Trichoptera
ODO - Odonata
COL - Coleoptera
DIP - Diptera
HIR - Hirudinea
MOL - Mollusca
CRU - Crustacea
OLI - Oligochaeta
EPH - Ephemeroptera
MEG - Megaloptera
PLA - Planaria
HEM - Hemiptera
NEM - Nematoda
ACA - Acari
PLE - Plecoptera
LEP - Lepidoptera

TABLE 3

*

TRIBUTARY TO-- and WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP FY-1988				Data Collected After Upgrade of WWTP FY-1989			
		WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4
INSECTA													
EPHEMEROPTERA													
Baetidae	4												
Baetis		0	0	0	0	0	0	0	0	0	0	1	0
Baetodes		0	0	0	0	0	0	0	8	0	0	0	0
Callibaetis		0	0	0	0	0	0	0	0	0	0	0	0
Cloeon		0	0	0	0	0	0	0	0	0	0	0	0
Caenidae	7												
Caenis		0	0	0	10	4	0	0	3	0	0	0	0
Ephemerellidae	1												
Attenella		0	0	0	0	0	0	0	0	0	0	1	1
Ephemerella		0	0	0	0	0	0	5	0	0	0	0	0
Heptageniidae	4												
Heptagenia		0	0	0	0	0	0	0	0	0	0	0	0
Stenacron		0	0	6	0	0	0	29	0	0	0	64	0
Stenonema		0	0	5	0	0	0	12	0	0	0	37	0
Leptophlebiidae	2												
Choroterpes		0	0	0	0	0	0	3	0	0	0	0	0
Leptophlebia		0	0	1	0	0	0	0	0	0	0	0	0
Paraleptophlebia		0	0	0	0	0	0	10	0	0	0	4	0
Tricorythidae	4												
Tricorythodes		0	0	0	1	0	0	0	0	0	0	0	0
PLECOPTERA		0	0	0	0	0	0	0	0	0	0	0	0
TRICHOPTERA													
Hydropsychidae													
Ceratopsyche	6	0	0	0	0	0	0	0	0	0	0	0	0
Cheumatopsyche	5	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsyche	7	0	0	0	0	0	0	0	0	0	1	0	0
Hydroptilidae	4												
Hydroptila		0	0	0	0	0	0	0	0	0	0	1	58
Neotrichia		0	0	0	0	0	0	0	7	0	0	0	0
Orthotrichia		0	0	0	0	0	0	0	26	0	0	0	0
Oxyethira		0	0	0	0	0	0	0	2	0	0	0	0
Philopotamidae													
Chimarra	4	0	0	0	0	0	0	0	0	0	0	0	0
Polycenropodidae													

TABLE 3

*

TRIBUTARY TO- and WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA

MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP FY-1988				Data Collected After Upgrade of WWTP FY-1989			
		WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4
Cyrnellus	8	0	0	0	3	0	0	0	0	0	0	2	2
Polycentropus	6	0	0	1	0	0	0	0	2	0	0	0	1
Psychomyiidae	?												
Lype		0	0	0	0	0	0	0	0	0	0	2	0
ODONATA													
Aeshnidae	3												
Anax		0	0	0	0	0	0	0	0	0	0	0	0
Aeshna		0	0	0	0	0	0	0	0	0	0	0	0
Basiaeschna		0	0	0	0	0	0	0	1	0	0	0	0
Boyeria		0	0	0	1	0	0	0	0	0	0	0	0
Agrionidae	?												
Agrion		0	0	0	0	0	0	0	0	0	0	0	0
Calopterygidae	5												
Calopteryx		0	0	0	0	0	0	0	0	0	0	0	1
Hetaerina		1	0	0	0	0	0	0	0	0	0	0	0
Coenagrionidae	9												
Argia		3	0	0	22	0	0	0	3	8	2	0	4
Amphiagrion		0	0	0	0	0	1	0	0	0	8	0	6
Chromagrion		36	0	0	0	0	1	2	36	0	15	7	22
Enallagma		0	0	0	0	0	1	0	0	0	0	0	0
Ischnura		0	0	0	0	0	0	0	0	0	0	0	0
Cordulidae													
Epicordulia		0	0	0	0	0	0	0	0	0	0	0	0
Neurocordulia		0	0	0	0	0	0	0	0	0	0	0	0
Lestidae	9												
Lestes		0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae	9								3				
Libellula		0	18	0	0	0	0	0	0	0	0	0	0
Pachydiplax		0	0	0	1	0	0	0	0	0	0	0	0
Perithemis		0	0	0	0	0	0	1	0	0	0	0	0
Sympetrum		0	0	0	0	0	1	0	0	0	0	0	0
Macromiidae	3												
Didymops		0	0	0	0	0	0	0	0	0	0	0	0
Macromia		0	0	3	0	0	0	0	0	0	0	0	0
DIPTERA													
Ceratopogonidae													
Bezzia	6	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 3
*
TRIBUTARY TO-- and WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP FY-1988				Data Collected After Upgrade of WWTP FY-1989			
		WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4
Palpomyia	6	0	0	0	1	0	0	0	0	0	0	0	0
Chironomidae					1	1					4		5
Ablabesmyia	8	1	0	8	6	9	0	5	0	0	0	2	0
Chironomus	10	0	679	17	0	19	914	0	1	0	0	0	0
Cricotopus	7	0	0	0	0	0	0	0	1	0	0	0	3
Cryptochironomus	8	0	0	0	0	0	0	0	0	0	0	0	0
Dicrotendipes	8	0	0	7	14	5	0	2	1	0	2	0	7
Endochironomus/Tribelos	5-10	0	0	2	0	1	0	10	0	0	0	1	2
Glyptotendipes	10	0	61	9	0	0	92	0	0	0	0	0	0
Goeldichironomus	?	0	47	2	0	6	2420	0	2	0	0	0	0
Kiefferulus	10	0	0	0	0	11	0	0	0	0	0	0	0
Labrundinia	7	0	0	0	1	0	0	2	6	0	0	0	0
Larsia	6	0	0	0	0	0	0	0	3	12	1	0	1
Microtendipes	6	0	0	0	0	0	0	0	0	0	0	0	0
Nanocladius	3	0	0	0	0	0	0	0	0	2	4	0	2
Nilothauma	2	0	0	0	0	0	0	0	0	0	0	0	0
Orthocladius	6	0	0	0	0	0	0	0	0	0	9	0	5
Psectrocladius	8	0	0	0	0	0	0	0	0	0	0	0	0
Phaenopsectra	?	0	0	20	8	0	0	15	0	0	0	0	0
Polypedilum	6	0	0	0	0	0	0	0	0	0	0	3	0
Procladius	9	0	0	0	0	0	0	0	2	1	0	0	0
Rheotanytarsus	6	0	0	0	0	0	0	0	0	0	0	0	0
Stenochironomus	5	0	0	0	1	0	0	0	0	0	0	0	0
Tanytarsus	6	0	0	0	0	1	0	0	0	0	1	13	0
Thienemannimyia Group	6	4	0	1	7	1	0	0	0	38	74	0	29
Zavrelia	?	0	0	0	0	0	0	0	0	0	0	4	0
Culicidae													
Aedes	?	0	0	0	0	0	0	0	1	0	0	0	0
Simuliidae													
Prosimulium	6	0	0	0	0	0	0	0	0	0	0	0	0
NEUROPTERA	?	0	0	0	0	0	0	0	0		0	0	0
MEGALOPTERA													
Corydalidae													
Corydalus	6	0	0	0	0	0	0	0	0	0	0	0	1
Nigronia	0	0	0	0	0	0	0	0	0	0	0	1	2
Sialidae													
Sialis	4	0	0	0	0	0	0	0	2	0	0	0	0

TABLE 3

*

TRIBUTARY TO- and WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP WX-1	WX-2	WX-3	WX-4	Data Collected After Upgrade of WWTP FY-1988 WX-1	WX-2	WX-3	WX-4	Data Collected After Upgrade of WWTP FY-1989 WX-1	WX-2	WX-3	WX-4
HEMIPTERA	?												
Gerridae													
Trepobates		0	1	0	0	0	0	0	0	0	0	0	0
Hebridae													
Hebrus		0	0	0	0	0	0	0	0	1	0	0	0
COLEOPTERA													
Elmidae													
Ancyronyx	6	0	0	1	5	0	0	2	0	0	0	2	1
Dubiraphia	6	0	0	4	0	0	0	0	2	2	0	1	0
Macronychus	4	0	0	0	0	0	0	0	0	0	0	0	0
Stenelmis	5	0	0	0	0	0	0	0	0	0	0	0	0
Haliplidae	?												
Peltodytes		0	0	0	0	0	0	0	0	0	0	0	0
Hydrophilidae	?												
Ametor		0	0	0	0	0	0	0	0	0	0	0	0
Berosus		0	0	0	4	0	0	0	24	0	0	0	11
Tropisternus		0	0	0	0	0	0	0	0	0	0	0	0
Noteridae	?												
Hydrocanthus		0	0	0	0	0	1	0	0	0	0	0	0
Psephenidae													
Ectopria	5	0	0	0	0	0	0	0	1	0	0	0	0
LEPIDOPTERA													
Noctuidae	?												
Lithacodia		0	0	0	0	0	0	0	0	1	0	0	0
MALACOSTRACA													
AMPHIPODA	?												
Talitridae													
Hyalella		0	0	0	0	0	0	0	0	0	0	1	0
DECAPODA	?												
Astacidae		0	0	0	0	0	0	0	0	0	0	0	0
Cambaridae		0	0	0	0	0	0	0	0	0	0	0	0
ISOPODA	?												
Asellidae													
Asellus		0	0	1	0	0	0	0	0	0	0	0	0
Lirceus		0	0	0	0	0	0	0	0	1	0	0	0

TABLE 3

*

TRIBUTARY TO– and WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP FY-1988				Data Collected After Upgrade of WWTP FY-1989			
		WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4
GASTROPODA	?												
LIMNOPHILIA													
Ancylidae													
Ferrissia		8	1	1	1	7	0	2	1	0	0	0	0
Laevapex		0	0	0	0	0	0	0	0	0	0	0	0
Hydrobiidae													
Amnicola		0	0	0	0	0	0	0	0	0	0	0	1
Physidae													
Physella		3	4	0	0	10	180	3	47	13	8	0	2
Planorbidae													
Helisoma		1	23	34	39	0	0	0	0	8	0	0	4
Planorbula		0	0	0	0	23	44	2	8	0	0	0	0
Pleuroceridae													
Elimia		0	0	1	0	0	0	0	0	0	0	0	0
Pleurocera		0	0	0	0	0	0	2	0	0	0	0	0
BIVALVIA	?												
Fresh Water Mussel		0	0	0	0	5	0	0	0		0	0	0
Corbiculidae													
Corbicula		2	0	1	0	0	0	0	0	0	0	0	1
ANNELIDA	?												
OLIGOCHAETA		3	0	1	0	84	716	14	0	251	0	0	1
HIRUDINEA													
Erpobdellidae		0	0	0	0	0	0	0	0	0	0	0	0
Glossiphoniidae													
Helobdella		0	0	0	1	0	0	0	0	0	0	0	0
PLANARIA	?	0	0	0	6	0	0	0	6	0	0	0	0
NEMATODA	?	0	0	0	0	0	0	0	0	2	0	0	0
ACARI	?	0	0	0	3	0	0	2	0	0	0	0	0
Total # Organisms		62	834	126	136	187	4371	123	199	340	129	147	173
Total # Taxa		10	8	20	21	14	11	19	26	13	11	18	24
#H-D Plates / Sample		2	2	2	2	3	3	3	3	3	3	3	3

TABLE 3

*

TRIBUTARY TO- and WAXAHATCHEE CREEK AT COLUMBIANA, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP FY-1988				Data Collected After Upgrade of WWTP FY-1989			
		WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4	WX-1	WX-2	WX-3	WX-4
# Organisms/ Meter Squared		310	4170	630	680	623	14570	410	663	1133	430	490	577
EPT Index		0	0	4	3	1	0	5	6	0	1	8	4
% Contribution of Dominant Taxa		58.1	81.4	27	28.7	44.9	55.4	23.6	23.6	73.8	57.4	43.5	33.5
Species Diversity ($\bar{d}$)		2.17	1.07	3.45	3.45	2.77	1.76	3.6	3.57	1.51	2.11	2.62	3.26
Equitability (e)		0.6	0.32	0.74	0.75	0.67	0.4	0.92	0.66	0.28	0.52	0.47	0.57
Sorenson's Community Similarity (as compared to reference stations WX-1 & WX-3)		-----	0.33	-----	0.29	-----	0.4	-----	0.27	-----	0.42	-----	0.33
# of Dominant Organisms in Common (as compared to reference stations WX-1 & WX-3)		-----	0	-----	2	-----	3	-----	0	-----	2	-----	1
Indicator Assemblage Index (as compared to reference stations WX-1 & WX-3)		-----	0.07	-----	1.4	-----	0.39	-----	2.69	-----	0.61	-----	0.48

BIBLIOGRAPHY

Hilsenhoff, William L., 'An Improved Biotic Index of Organic Stream Pollution', The Great Lakes Entomologist. Vol. 20, No. 1, 1987.

Plafkin, James L., Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. EPA/444/4-89-001, (USEPA, Washington D.C., May 1989).

Weber, Cornelius I., Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. EPA-670/4-73-001, (USEPA, Cincinnati, July 1973).