WATER QUALITY DEMONSTRATION STUDY

SWAN AND TOWN CREEKS
ATHENS, ALABAMA
1987 AND 1989

SPECIAL SERVICES SECTION
FIELD OPERATIONS DIVISION
ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

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SWAN/TOWN CREEKS AT ATHENS, ALABAMA
1987 AND 1989

INTRODUCTION

The City of Athens, Alabama utilizes Town Creek as a receiving stream for the treated effluent from its municipal wastewater treatment facility. Approximately 50 yards downstream, Town Creek empties into Swan Creek. During the period from April 1987 to October 1989, the City of Athens underwent construction to upgrade the existing 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 Town and Swan Creeks.

EPA CONSTRUCTION GRANTS PROGRAM

Since 1972, approximately $534 million in EPA grant funds have gone toward construction of municipal wastewater treatment systems in Alabama. One recipient of EPA funding was Athens, Alabama in Limestone County.

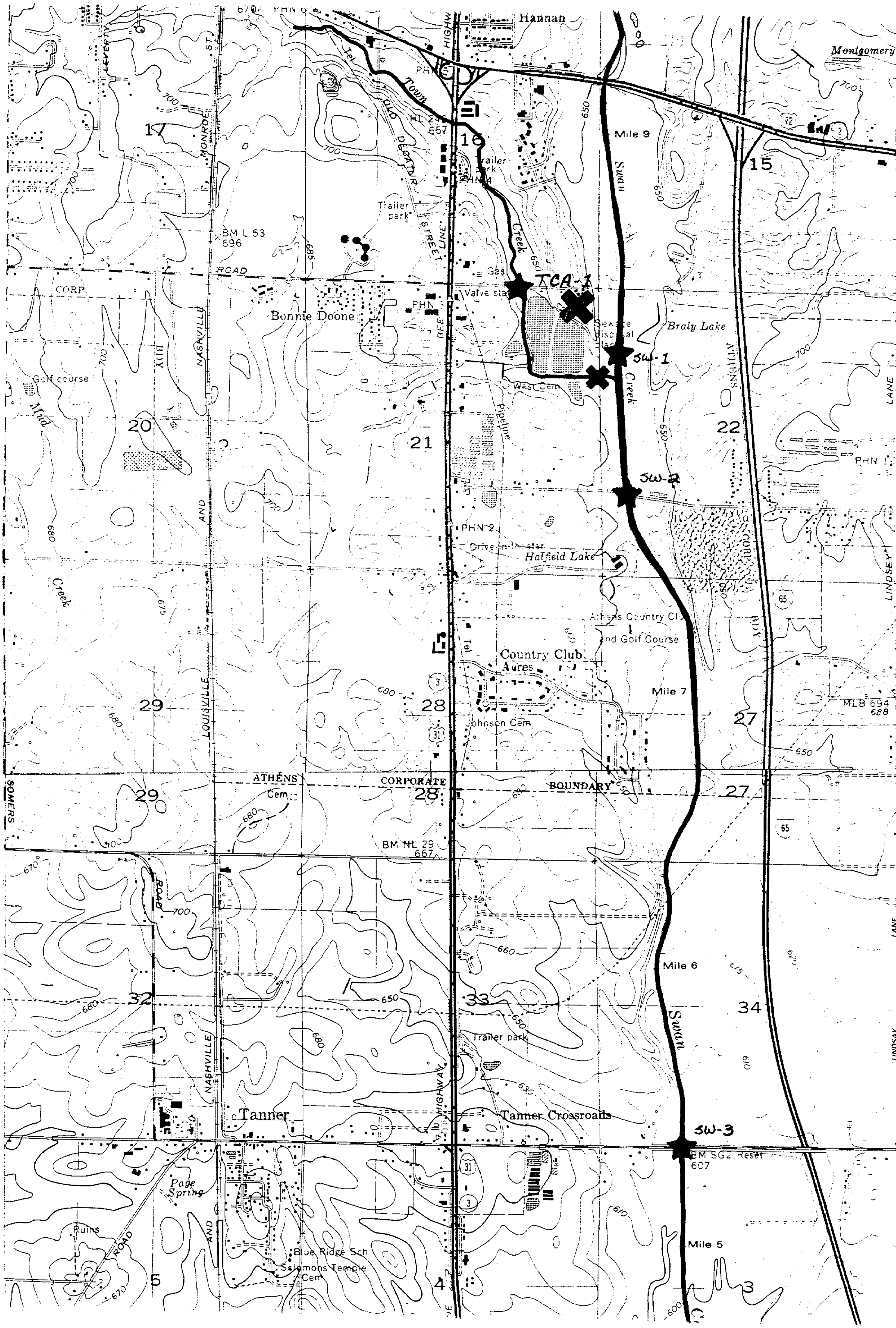
The City of Athens received an EPA Construction Grant in September 30, 1986 to construct a new wastewater treatment plant (WWTP). This construction consisted of the influent pump station, addition of an Envirex orbal oxidation ditch as the second stage of the existing trickling filter system, modification of an existing equalization basin to a sludge storage facility, ultraviolet disinfection, sewer system rehabilitation and other associated appurtenances. The total eligible construction cost of the sewer system rehabilitation and new WWTP was approximately $4,659,948. Funding assistance on the project was provided by EPA Construction Grant in the sum of $2,618,758. The project engineer was Pugh, Wright and Associates, Inc. of Decatur and the treatment plant contractor was B.H. Craig Construction Company.

The Athens WWTP consists of a 7.0 million gallon per day (mgd) two stage nitrification plant to provide the capability of advanced treatment with effluent discharge to Town Creek, a tributary of Swan Creek. Construction of Athens WWTP began on May 13, 1987 and the plant began operation on August 2, 1988.

NPDES monthly permit limits for the 7.0 mgd facility are seasonal and are detailed below:

Parameter	June-November	December-May
BOD_5 (mg/L)	15	18
TSS (mg/L)	30	30
NH_3-N (mg/L)	1	5
D.O. (mg/L)	6	6

According to self monitoring reports submitted by Athens, the average monthly performance of the treatment plant from December 1988 to October 1989 is as follows (Table 4):


Hannan
Montgomery
LEVERTY
MONROE ST
Town
Creek
OLD DECATUR STREET
HL 246
657
17
16
15
Mile 9
Swan
Creek
Trailer park
PHN 4
Trailer park
BM L 53
696
ROAD
CORP
Gas
Valve sta
TCA-1
PHN 3
Bonnie Doone
Sewage disposal plant
Braly Lake
SW-1
NASHVILLE
AND
LOUISVILLE
Golf course
Mud
Creek
West Cem
Pipeline
20
21
22
ATHENS
LINDSEY
LANE
PHN 1
SW-2
PHN 2
Drive-in theater
Halfield Lake
Athens Country Cl
and Golf Course
Country Club
Acres
Mile 7
MLB 694
688
29
28
27
Johnson Cem
ATHENS
CORPORATE
BOUNDARY
Cem
SOMERS
BM NL 29
667
Mile 6
32
33
34
Trailer park
Tanner
Tanner Crossroads
SW-3
BM SG2 Reset
607
Page Spring
Ruins
Blue Ridge Sch
Solomons Temple
Cem
Mile 5
5
4
3

Parameter	June-October	December-May
Flow (mgd)	6.2	7.1
BOD_5 (mg/L)	3.5	4.3
TSS (mg/L)	2.9	4.6
NH_3-N (mg/L)	1.2	1.9
D.O. (mg/L)	5.5	6.0

As can be seen by comparing the performance data with the permit limits, a very high degree of treatment is apparently being maintained. A compliance sampling inspection (CSI) performed in June 1989 by ADEM revealed an average daily flow rate of 4.48 mgd, effluent BOD_5, TSS, NH_3-N, and D.O. of 1.6 mg/L, 1.7 mg/L, 0.3 mg/L, and 7.4 mg/L, respectively, which is a confirmation of these high levels of treatment (Table 4).

FIELD OPERATIONS

During April to September 1987, staff members of the Field Operations Division collected data to establish conditions and provide a comparative base of information on Swan and Town Creeks prior to construction and implementation of the new treatment plant. During May to September 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:
SW-1	Swan Creek approximately 100 yards upstream of treatment plant behind WWTP. T3S,R4W,S22,NE1/4,NW1/4,SW1/4
TCA-1	Town Creek approximately 1/4 mile upstream of treatment plant at Treatment Plant Rd crossing. T3S,R4W,S21,NE1/4, NE1/4,NW1/4.
SW-2	Swan Creek approximately 1/2 mile downstream of treatment plant at Strain Rd crossing. T3S,R4W,S22,SW1/4,NW1/4,SW1/4
SW-3	Swan Creek approximately 2&1/4 miles downstream of treatment plant at County Road 24 crossing. T3S,R4W,S34,SW1/4,SE1/4, SW1/4

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 a one-half hour per person qualitative sampling method (one man-hour total). Collections were made by manually picking, with the use of forceps, different aquatic habitats (i.e.,sticks, leaf masses, rocks, etc.). Sampling as many different aquatic habitats as possible at each site allows for comparison of the macroinvertebrate communities at these different sites. All organisms were collected and immediately preserved in 90% ethanol. They were then sorted and identified to the lowest possible taxonomic level . The purpose of this sampling method is to provide a qualitative 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 taxanomic 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 the 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

Town and Swan Creeks are second 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 Town Creek average less than one cubic foot per second, while flows from Swan Creek average between three and nine

cubic feet per second (Table 1, Figure 1). Along the entire study length of Swan and Town Creeks, the streams have been channelized to facilitate flow. At the upstream locations (TCA-1, SW-1), there is some riparian vegetation and available habitat for macroinvertebrate colonization. Downstream, there is varying amounts of riparian vegetation and habitat. Beaver activity has been noted on Swan Creek; however, it does not appear to be affecting water quality. Though there is some accumulation of organic silt, stream velocity precludes major deposition and retention. During both periods of sampling, filamentous algae was noted as growing prolifically at sampling locations downstream of the confluence of Swan and Town Creek. Wheeler Lake, on the Tennessee River, receives the flow from Town and Swan Creeks.

B. CHEMICAL

The Water Use Classification for Town Creek, Swan Creek below County Road 24, and Swan Creek upstream of Town Creek is Fish and Wildlife (F&W). Swan Creek between Town Creek and County Road 24 is classified as Agricultural and Industrial (A&I). 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. 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 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 generally meeting the dissolved oxygen standard for the F&W classification (5.0 mg/L). The dissolved oxygen values at station SW-2 ranged, during the summer of 1987, from a low of 1.1 mg/L to a high of 12.9 mg/L. Morning D.O.'s averaged 4.7 mg/L, while afternoon D.O.'s averaged 9.3 mg/L. At station SW-3, the dissolved oxygen values ranged from a low of 2.8 mg/L to a high of 16.2 mg/L. Morning D.O.'s averaged 5.8 mg/L, while afternoon D.O.'s averaged 14.2 mg/L. The dissolved oxygen values at reference stations SW-1 and TCA-1 were consistently above their Water Use Classification of 5.0 mg/L, respectively. An oxygen sag can still be observed in the D.O. values at station SW-2, however.

As seen in Table 2 and Figure 2, data collected after the upgrade of the treatment plant show an 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 SW-2 had morning D.O. values averaging 7.0 mg/L and afternoon values averaging 11.5 mg/L. D.O. values at SW-3 had morning values averaging 7.6 mg/L and afternoon values averaging 14.7 mg/L.

In addition to improved dissolved oxygen content during early morning hours, 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 8.5 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 significantly increased. This makes a determination of improved stream conditions more difficult due to the potential for greater dilution than what would normally be expected during low flow conditions.

Ammonia, nitrates, and phosphates also experienced a noticeable decrease. Before the upgrade of the plant, ammonia, nitrates, and phosphates were present in large quantities, when downstream locations were compared to reference stations (Table 1). This, along with the presence of filamentous algae, suggest that nutrient loading was adversely affecting the stream. After the upgrade, ammonia and phosphate were significantly reduced. Nitrates continue to be present in quantity. Filamentous algae was, again, noted at the downstream locations. This, and the variability of riparian vegetation, which affects the quantity of sunlight available to the filamentous algae, provide an explanation of the super-saturation of dissolved oxygen during afternoon sampling periods.

C. BIOLOGICAL

Station TCA-1, upstream of the WWTP effluent, was sampled for aquatic macroinvertebrates before and after upgrade and was used as a reference database (Table 3, Figure 4). The before sampling in 1987 revealed an aquatic community that, while not dominated by pollution sensitive organisms, was not balanced and showed some indication of stress from pollution. Species diversity values indicated a stressed aquatic community, however, equitability values indicated no impairment to the aquatic community. As equitability becomes erratic with samples consisting of less than 100 organisms, the 'no impairment' rating does not reflect the true conditions of the stream. A total of 23 organisms were collected representing 6 taxa. Of these 6 taxa, 5 are classified as being moderately tolerant. The EPT Index, a value of 0, indicated the absence of pollution sensitive macroinvertebrates. The dominant taxa, Argia, a generally pollution tolerant group with a Hilsenhoff Biotic Index of 9, made up 61% of the total population. The predominance of pollution tolerant organisms indicates an impaired aquatic community. This condition may be attributable to very low flow conditions during 1987, a drought year.

More favorable conditions were found during 1989 macroinvertebrate sampling (Table 3, Figure 4). A total of 70 organisms were collected representing 13 taxa. Of these 13 taxa, four were classified as tolerant organisms, five were moderately tolerant organisms, 3 were intolerant organisms, and one was undetermined. The EPT Index showed a value of 4, indicating the presence of pollution sensitive organisms and an improvement over 1987 data. Of the organisms making up the EPT Index, all four were classified as moderately tolerant. The dominant taxa, Chromagrion, another pollution tolerant Odonate, made up 23% of the total population. Species diversity and equitability values showed definite improvement, with no impairment evident in the stream. However, as above, since the number of organisms collected were less than 100, these indices do not reflect the true conditions of the stream. TCA-1 shows some improvement, but continues to be impaired.

At station SW-1, 100 yards upstream of the confluence of Town Creek and Swan Creek, the 1987 macroinvertebrate data documented no

adverse impact to the aquatic community (Table 3, Figure 5). A total of 127 organisms were collected representing 14 taxa. Of the 14 taxa present, five were classified as tolerant, seven were moderately tolerant, one was intolerant, and one was undetermined. Members of Ephemeroptera made up 37% of the total collection with Stenonema, typically moderately tolerant with a Hilsenhoff Biotic Index of 4, comprising 24% of the population. The EPT Index was 6 indicating the presence of pollution sensitive organisms. However, the EPT Index organisms are all classified as being tolerant to moderately tolerant. Species diversity and equitability values indicated no impairment to the aquatic community. The biological composition, however, indicates an impairment to the stream which may be attributable to low flow conditions.

In 1989, after upgrade, data from SW-1 was similar to the 1987 data (Table 3, Figure 5). A total of 201 organisms were collected representing 18 taxa. Of the 18 taxa present, five were classified as tolerant organisms and 13 were moderately tolerant organisms. Members of Trichoptera, a pollution sensitive group, made up 50% of the total population with Cheumatopsyche, a moderately tolerant organism with a Biotic Index of 5, comprising 36% of the collection. The EPT Index value was 8 indicating an increase in pollution sensitive organisms. However, all the EPT Index organisms were classified as moderately tolerant organisms. Species diversity and equitability values were indicative of no impairment, however, biological composition is indicative of an impaired community and, therefore, SW-1 appears to be continuing to experience a moderately adverse environmental impact.

Conditions immediately downstream at SW-2 in 1987, also documented a moderately adverse impact on the aquatic community (Table 3, Figure 6). A total of 51 organisms representing 14 taxa were collected. Of the 14 taxa present, ten were classified as tolerant, two were moderately tolerant, one was intolerant, and one was undetermined. Members of the group Gastropoda, a typically pollution tolerant group, made up 51% of the population with the dominant taxa, Ancylidae, comprising 37% of the collection. The EPT Index value was 2 indicating the presence of pollution sensitive organisms. However, the EPT Index organisms were classified as tolerant to moderately tolerant. Due to the error inherent in samples of less than 100 organisms, species diversity and equitability values still indicated no adverse impact to the aquatic community. As compared to SW-1, however, Sorenson's Community Similarity indicated that the two stations were very dissimilar. Cheumatopsyche was the only dominant organism common to both stations. The Indicator Assemblage Index value indicated that, as compared to SW-1, SW-2 possessed a very poorly balanced macroinvertebrate community.

The 1989 macroinvertebrate data documented that SW-2 made an improvement (Table 3, Figure 6). A total of 190 organisms representing 17 taxa were found to be present during sampling. Of the 17 taxa present, four were classified as tolerant organisms, and thirteen were moderately tolerant organisms. Members of the group Trichoptera comprised 46% of the collection with a moderately pollution tolerant organism, Cheumatopsyche, being the dominant organism and representing 33% of the sample. The EPT Index value of 4 indicated an improvement over 1987 in the number and types of pollution sensitive taxa present. However, once again, all the EPT

Index organisms were classified as moderately tolerant. Species diversity values indicated a slight adverse impact and equitability values indicated no adverse impact on the aquatic community. As compared to SW-1, Sorenson's Community Similarity indicated that SW-2 was more similar in 1989 than in 1987. Three dominant organisms were found to be common to both stations, Cheumatpsyche, Ceratopsyche, and Baetis, all moderately tolerant taxa. The Indicator Assemblage Index showed that SW-2 was overbalanced in favor of the EPT group.

SW-3, the most distant downstream station, indicated considerable impairment, according to the 1987 data (Table 3, Figure 7). A total of 86 organisms were collected representing 13 taxa. Of the 13 taxa present, six were classified as tolerant organisms, four were moderately tolerant, one was intolerant and two were undetermined. The EPT Index of 2 indicated the presence of pollution sensitive taxa, both of which were tolerant or moderately tolerant. The Odonata group comprised 29% of the sampled population with Argia comprising 26% of the sample. Species diversity and equitability values indicated no impact on the aquatic community, however the sample once again consisted of less than 100 organisms. When compared to SW-1, Sorenson's Community Similarity suggested that, even two miles downstream of the effluent, SW-3 was still very dissimilar. There were two dominant organisms common to both stations, Argia, and Cheumatopsyche. The Indicator Assemblage Index indicated that SW-3 was poorly balanced, as compared to SW-1.

Data collected at SW-3 after the upgrade documented a slightly impaired aquatic macroinvertebrate community (Table 3, Figure 7). A total of 165 organisms representing 19 taxa were collected in 1989. Of the 19 taxa present, eight were classified as tolerant organisms, and eleven were classified as moderately tolerant. The EPT Index value was 5, indicative of a greater diversity of pollution sensitive taxa since 1987. However, all the EPT Index organisms were classified as tolerant to moderately tolerant. Members of the group Trichoptera comprised 39% of the sample, consisting of the dominant organism, Cheumatopsyche. Species diversity and equitability values indicated no adverse impact to the macroinvertebrates. When compared to SW-1, Sorenson's Community Similarity indicates that SW-3 has improved as the communities have become more similar. There were only two dominant organisms in common to both stations, Cheumatopsyche and Baetis. The Indicator Assemblage Index indicates that SW-3 is very well balanced, as compared to SW-1.

CONCLUSIONS

Physical, chemical, and biological data collected before and after the upgrade of the Athens wastewater treatment plant indicate that, although Swan and Town Creeks are presently experiencing a slight adverse impact, they have experienced an improvement in overall water quality. Swan and Town Creeks appear to be meeting the Water Use Classifications of Fish and Wildlife. "Channel improvement", i.e., stream channelization, has contributed to the degradation of the aquatic macroinvertebrate community due to the unavailability of some types of aquatic and streamside habitat and the physical alteration of the stream channel to an unnatural condition.

TABLE 1
WATER QUALITY DEMONSTRATION STUDY
SWAN/TOWN CREEKS AT ATHENS, ALABAMA
DATA COLLECTED PRIOR TO UPGRADE OF WWTP

DATE	LOCATION	TIME	AIR TEMP	WATER TEMP	D. O. a.m.	D. O. p.m.	pH	SPEC COND	BOD 5	TSS	NO -N 3	NH -N 3	TKN	TON	PO -P 4	FLOW	BACT
04/29/87	TCA-1	12:05	26.5	18		9.4	7.4	----	2.4	0	0.8	0.2	2	1.8	<0.02	1.66	
05/20/87		12:45	25.5	24		6.1	7	----	0.8	1	0.74	0.2	0.8	0.6	0.02	0.43	<1
05/21/87		09:45	24.5	22.5	4.7		6.8	----									
06/24/87		12:30	32.5	27		6.4	7.2	----	1	1	0.78	0.3	1.6	1.3	0.03	1	
07/22/87		12:20	28	24.5		6.3	6.8	210	1.6	5	0.66	0.2	2	1.8	0.13	0.29	
07/23/87		09:00	28	26	6.2		6.8	220	1	3	0.68	0.1	2.2	2.1	0.04		16
08/31/87		16:40	26	23.5		6.4	7	210	1.5	8	0.14	<0.2	2.4	2.4	0.03	0.09	
09/01/87		07:10	20	21	4.8		7.4	215	2	0	0.12	0.3	3.2	2.9	0.06		8
AVERAGE			26.4	23.3	5.2	6.9	7.1	214	1.5	3	0.56	-----	2.0	1.8	----	0.68	----
04/29/87	SW-1	11:30	22	20		11.5	8.3	----	2.4	1	0.76	0.6	1.8	1.2	0.13	6.82	
05/20/87		13:15	27.5	28		10.9	8.2	----	1.7	1	0.33	0.3	1.4	1.1	0.03	3.72	<1
05/21/87		09:38	24.5	23.5	7.8		6.9	----									
06/24/87		11:40	32	30		10.2	8	----	1.6	1	0.4	0.3	2	1.7	0.04	3.21	
07/22/87		11:30	27	27		8.3	7.1	190	1.7	5	0.8	0.1	1.6	1.5	0.13	2.47	
07/23/87		09:15	29	27	7		6.9	210	0.8	2	0.82	0.2	2	1.8	0.02		<1
08/31/87		15:50	28	27		9.6	7.5	181	2	0	0.72	0.2	0.4	0.2	0.02	1.68	
09/01/87		07:15	20	20	5.5		7.1	155	0.7	0	0.92	0.2	1.9	1.7	0.04		23
AVERAGE			26.3	25.3	6.8	10.1	7.5	184	1.6	1	0.68	0.3	1.6	1.3	0.06	3.58	----
04/29/87	SW-2	12:41	22	22		12.9	8.2	----	8	25	1.3	3.4	5.8	2.4	1.48		
05/20/87		12:22	32	28		7.7	7.5	----	9.6	8	0.98	6.1	9	2.9	1.95		<2
05/21/87		09:55	24.5	24	6.5		7.1	----									
06/24/87		11:20	29	31		12.5	8.4	----	>9.0	12	9.6	3.34	7.1	1.9			
07/22/87		11:05	26.5	27.5		7.8	6.9	385	>9.9	17	2.7	2.3	6.4	4.1	2.14		
07/23/87		08:50	29	26.5	6.4		6.9	405	6.3	6	2.38	3.5	6.6	3.1	2.22		<2
08/31/87		17:15	28	27		5.5	7.4	435	6.1	14	2.4	6.4	8.6	2.2	3.54		
09/01/87		06:55	20	23	1.1		6.9	390	12.8	4	1.56	6.8			3.6		<2
AVERAGE			26.4	26.1	4.7	9.3	7.4	404	-----	12	2.99	4.5	7.3	2.8	2.49	----	----
04/29/87	SW-3	12:58	24.5	23.5		17	9.5	----	7.6	14	1.56	1.7	2.8	1.1	1.01		
05/20/87		11:50	29.5	29.5		14.4	9	----	6	8	1.54	2.6	4.6	2	1.48	8.32	<2
05/21/87		10:10	24.5	24	6.7		7.1	----									
06/24/87		10:40	29	30		16.2	9.1	----	6.3	25	2.78	0.8	7.2	6.4	1.49	10.54	
07/22/87		10:20	26.5	27.5		10	7.9	455	3.2	1	1.5	1.9	4.6	2.7	2.72	8.45	
07/23/87		08:35	27	25.5	7.8		7.2	385	3.5	5	1.62	2.4	5	2.6	2.82		12
08/31/87		18:10	28	26		13.4	9.4	350	6	14	3.1	0.2	4.3	4.1	1.04	6.27	
09/01/87		06:45	20	22	2.8		7.2	355	5.3	0	3.2	2.1	2.8	0.7	3.1		<2
AVERAGE			26.1 C	26.0 C	5.8 mg/L	14.2 mg/L	8.3 SU	386 umho	5.4 mg/L	10 mg/L	2.19 mg/L	1.7 mg/L	4.5 mg/L	2.8 mg/L	1.95 mg/L	8.40 cfs	---- org/

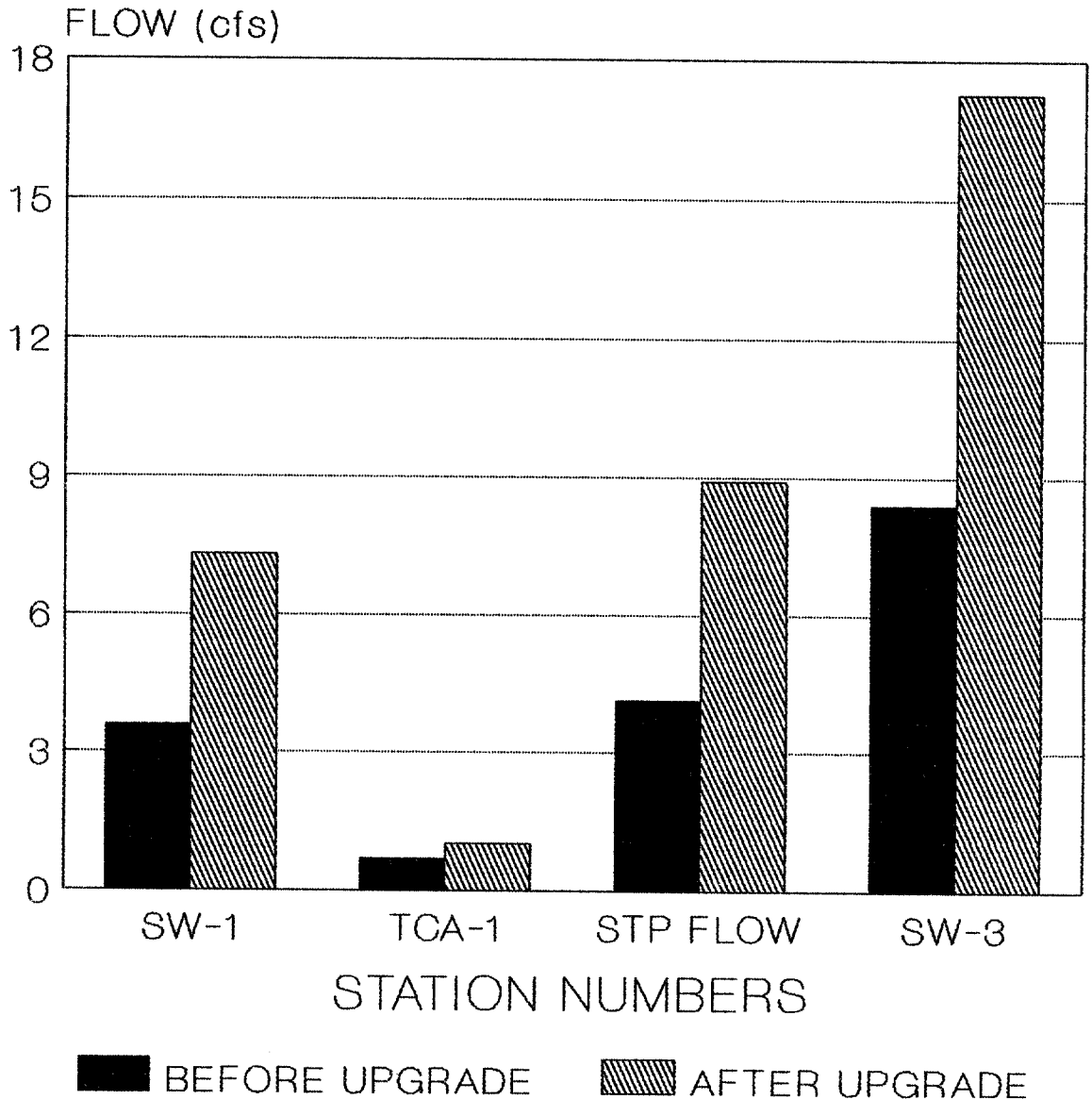
TABLE 2
WATER QUALITY DEMONSTRATION STUDY
SWAN/TOWN CREEKS AT ATHENS, ALABAMA
DATA COLLECTED AFTER UPGRADE OF WWTP

DATE	LOCATION	TIME	AIR TEMP	WATER TEMP	D.O. a.m.	D.O. p.m.	pH	SPEC COND	BOD 5	TSS	NO3-N	NH3-N	TKN	TON	PO4-P	FLOW	BACT
05/03/89	TCA-1	12:10	21.1	17.8		10.7	7.6	150	1.6	1	0.64	<0.2	2.6	2.6	0.06	<0.1	
05/04/89		07:25	15	16.1	7.7		7.5	150	1.4	1	0.58	<0.2	0.8	0.8	0.04		103
07/25/89		13:35	32.2	24.4		8.3	7.4	190	0.3	0	0.91	<0.2	<0.4	<0.2	0.03	3.39	
07/26/89		07:05	24.4	23.9	6.6		7.1	200	0.5	1	0.72	<0.2	<0.4	<0.2	<0.02		>62
08/08/89		12:39	23.9	22.2		8.5	7.7	210	1	1	0.74	<0.2	<0.4	<0.2	<0.02	<0.1	
08/09/89		07:00	13.3	18.3	7.5		7.7	180	0.6	1	0.72	<0.2	0.84	0.64	<0.2		100
09/12/89		12:35	28	23		7.1	7.7	150	1.6	6	0.38	<0.2	<0.4	<0.2	0.03	0.54	
09/13/89		06:11	20	22	6.2		7.7	170	1	1	0.35	<0.2	0.64	0.44	<0.02		143
AVERAGE			22.2	21.0	7.0	8.7	7.6	175	1.0	2	0.63	----	----	----	----	----	---
05/03/89	SW-1	13:20	22.2	20		12.9	8.5	140	1.6	5	0.54	<0.2	4	4	0.06	6.9	
05/04/89		07:40	15	16.7	8.6		7.6	230	1.6	1	0.64	<0.2	1.6	1.6	0.05		53
07/25/89		14:15	30	28.9		8.8	7.5	140	0.9	2	0.63	<0.2	<0.4	<0.2	<0.02	12.34	
07/26/89		07:20	23.3	24.4	5.9		7.2	170	0.9	1	0.85	<0.2	<0.4	<0.2	0.04		>600
08/08/89		11:40	22.2	23.3		10.1	8	190	0.8	0	0.6	<0.2	1.05	0.85	<0.02	3.94	
08/09/89		06:47	13.1	17.7	6.9		7.5	150	0.9	0	0.76	<0.2	0.84	0.64	<0.02		22
09/12/89		13:30	28	25		11.2	8.6	160	2.2	1	0.4	<0.2	<0.4	<0.2	0.04	6.11	
09/13/89		06:21	19	22	6.1		7.7	170	0.8	0	0.55	<0.2	0.64	0.44	<0.02		<3
AVERAGE			21.6	22.3	6.9	10.8	7.8	169	1.2	1	0.62	----	----	----	----	7.32	----
05/03/89	SW-2	11:55	20	21.1		13.1	7.6	230	1.8	1	1.92	<0.2	2.4	2.4	1.16		
05/04/89		07:55	16.1	17.2	8.7		7.6	230	1.1	4	2.52	<0.2	1.6	1.6	0.96		136
07/25/89		13:05	31.1	28.3		11	8.3	270	1	2	2.41	<0.2	<0.4	<0.2	0.68		
07/26/89		07:45	25.6	23.9	6.8		7.1	270	1	9	2.41	<0.2	<0.4	<0.2	0.63		>600
08/08/89		14:00	26.9	26.6		11.1	8.2	330	1	3	3.98	<0.2	1.05	0.85	1.37		
08/09/89		06:35	12.7	19.4	6.7		7.4	270	0.9	1	2.97	<0.2	1.26	1.06	1.14		38
09/12/89		12:25	24	25		10.7	8	310	2	6	2.85	<0.2	<0.4	<0.2	1.44		
09/13/89		06:35	20	22	5.6		7.5	300	1.2	4	2.8	<0.2	1.06	0.86	1.25		<2
AVERAGE			22.1	22.9	7.0	11.5	7.7	276	1.3	4	2.73	----	----	----	1.08		----
05/03/89	SW-3	11:30	19.4	20		14	9.1	220	2	1	1.66	<0.2	1.8	1.8	0.7	17.52	
05/04/89		08:10	15	16.1	8.6		7.6	220	2	3	1.7	<0.2	2.4	2.4	0.83		59
07/25/89		12:50	30.6	30		13.6	8.8	240	1.2	2	1.78	<0.2	<0.4	<0.2	0.46	23.85	
07/26/89		08:00	26.1	24.4	8.7		7.5	265	1.6	2	2.77	<0.2	0.93	0.73	0.55		>600
08/08/89		15:40	25	27.2		16.4	9.9	270	2	3	2.7	<0.2	1.67	1.47	0.54	11.79	
08/09/89		06:20	13.3	18.3	6.8		7.5	270	1.1	1	3.15	<0.2	1.47	1.27	1.34		59
09/12/89		12:10	24	25		14.8	9.5	250	2.8	6	1.66	<0.2	0.85	0.65	0.79	15.9	
09/13/89		06:53	21	22	6.1		7.7	290	1.6	3	2.47	<0.2	1.49	1.29	1.4		10
AVERAGE			21.8	22.9	7.6	14.7	8.5	253	1.8	3	2.24	----	----	----	0.83	17.27	----
			C	C	mg/L	mg/L	SU	umho	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	cfs	org/

FIGURE 1

SWAN / TOWN CREEKS AT ATHENS, ALABAMA

STREAM FLOW DATA



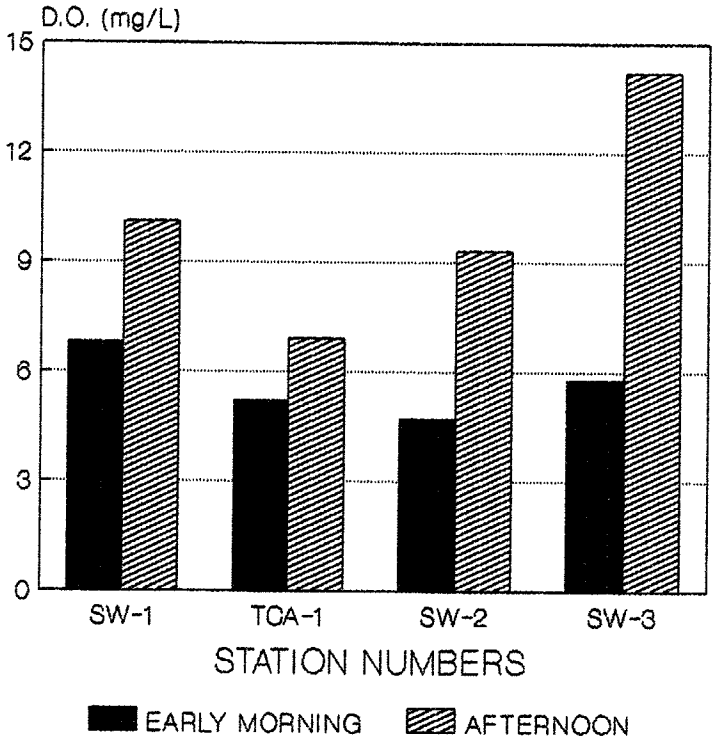
THE ABOVE NUMBERS ARE AVERAGES REPRESENTING MULTIPLE SAMPLING EVENTS.

FIGURE 2

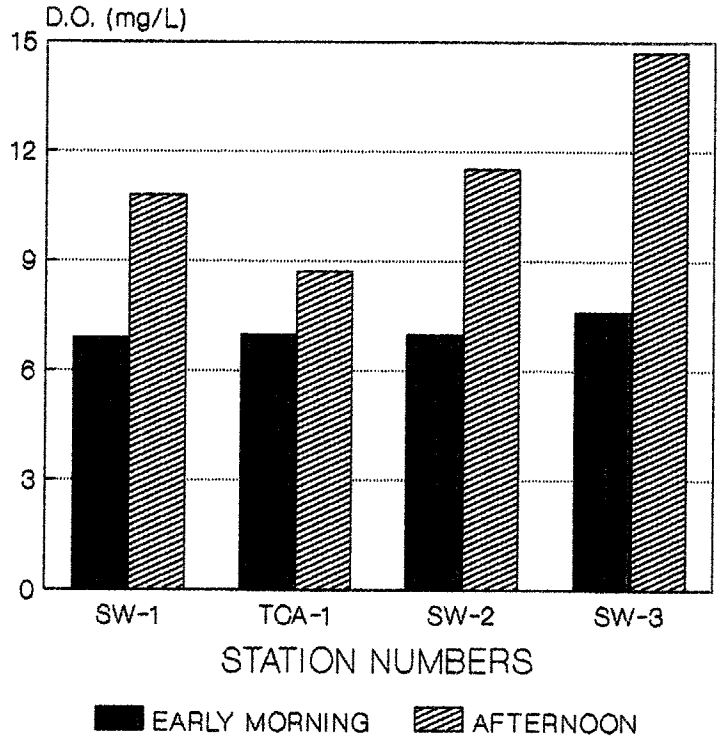
SWAN / TOWN CREEKS AT ATHENS, ALABAMA

DISSOLVED OXYGEN DATA

BEFORE STP UPGRADE



AFTER STP UPGRADE



THE ABOVE NUMBERS ARE AVERAGES REPRESENTING

MULTIPLE SAMPLING EVENTS.

FIGURE 3
SWAN/TOWN CREEKS MACROINVERTEBRATE DATA

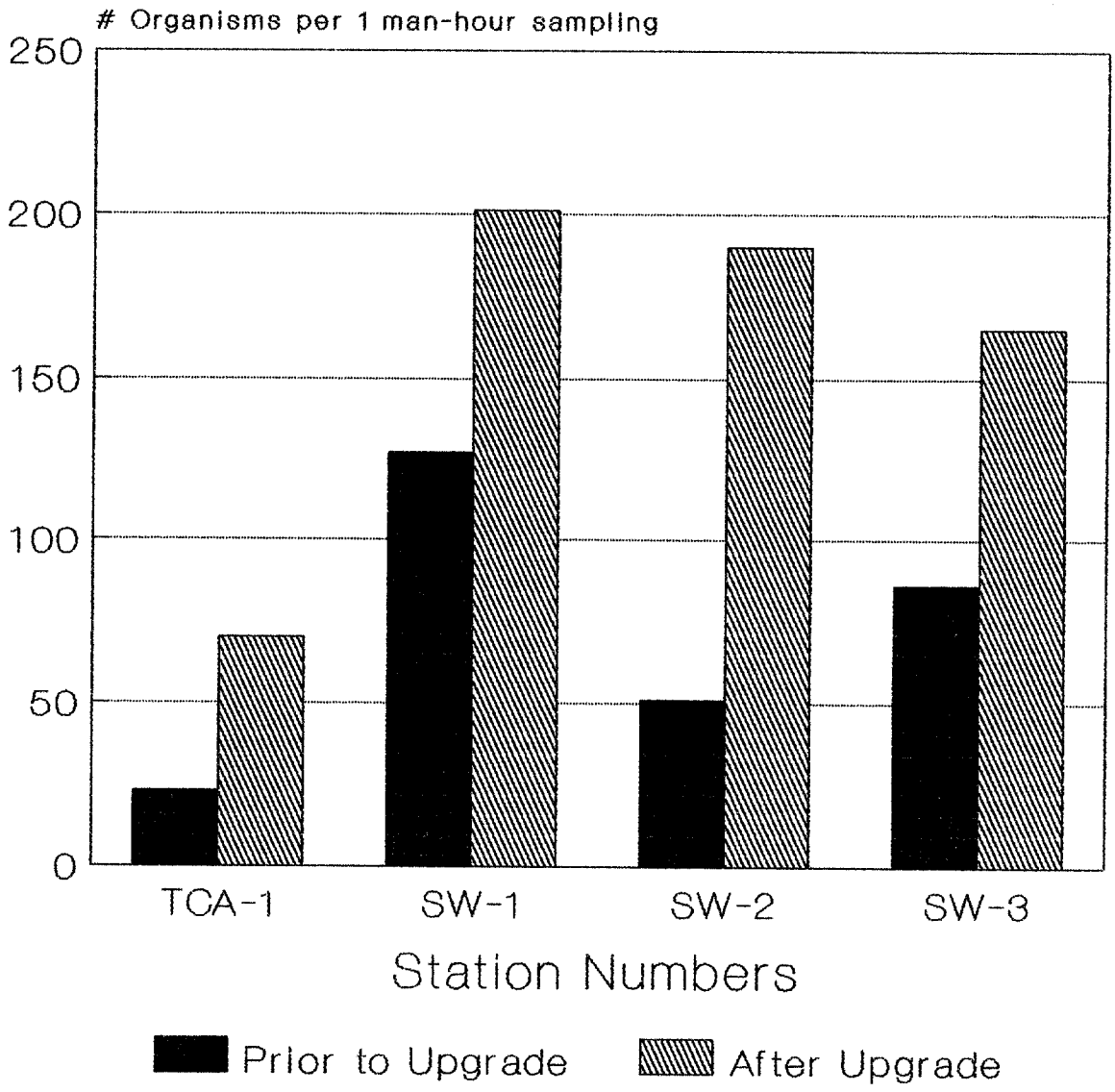
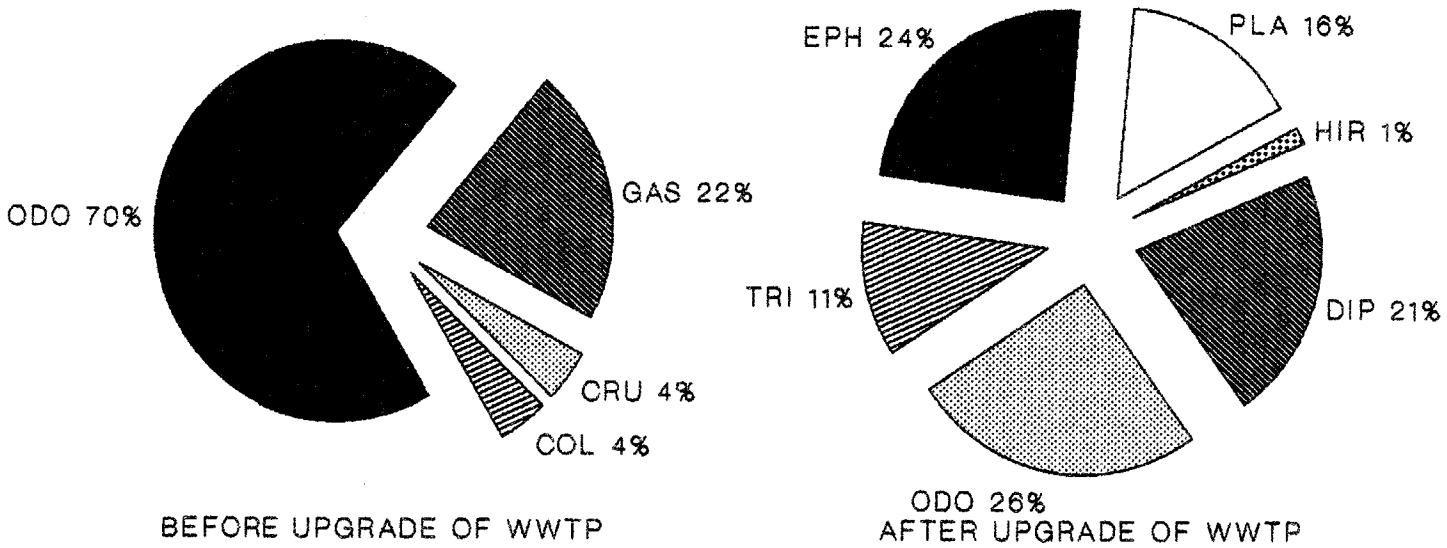


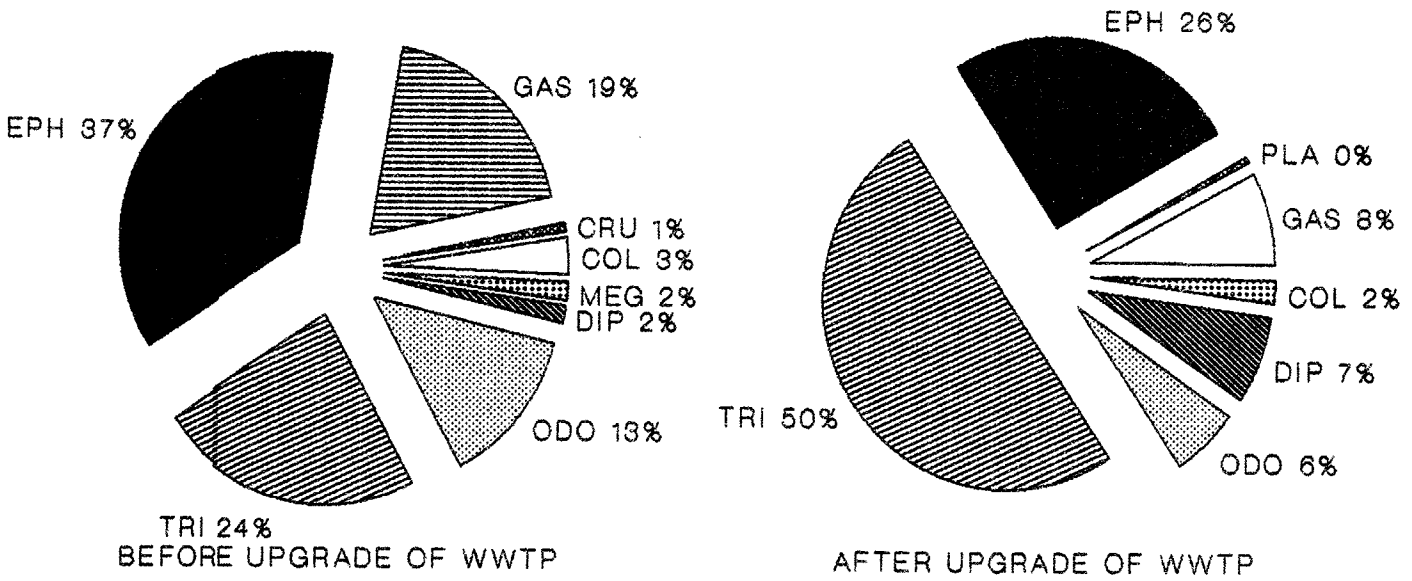
FIGURE 4
% TOTAL POPULATION OF TAXA PRESENT AT STATION TCA-1 (TOWN CREEK)



LEGEND

EPH-EPHEMEROPTERA	**DIP-DIPTERA**	**MOL-MOLLUSCA**	**PLA-PLANARIA**
TRI-TRICHOPTERA	**COL-COLEOPTERA**	**OLI-OLIGOCHAETA**	**HIR-HIRUDINEA**
ODO-ODONATA	**GAS-GASTROPODA**	**NEM-NEMATODA**	**CRU-CRUSTACEA**

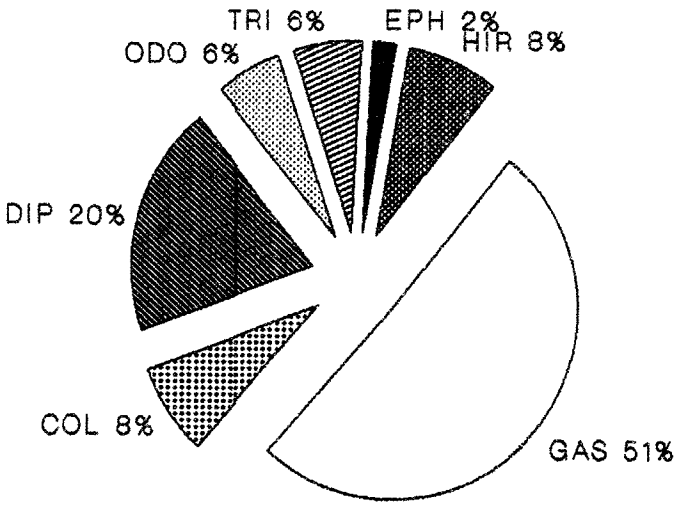
FIGURE 5
% TOTAL POPULATION OF TAXA PRESENT AT STATION SW-1 (SWAN CREEK)



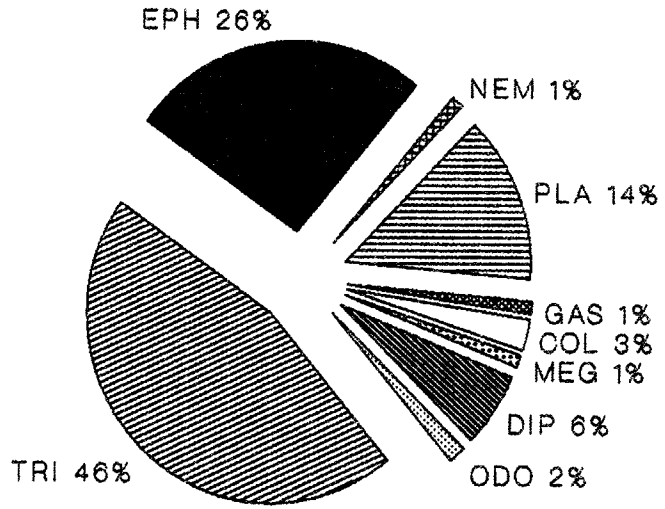
LEGEND

EPH-EPHEMEROPTERA	**DIP-DIPTERA**	**MOL-MOLLUSCA**	**PLA-PLANARIA**
TRI-TRICHOPTERA	**COL-COLEOPTERA**	**OLI-OLIGOCHAETA**	**MEG-MEGALOPTERA**
ODO-ODONATA	**GAS-GASTROPODA**	**NEM-NEMATODA**	**CRU-CRUSTACEA**

FIGURE 6
% TOTAL POPULATION OF TAXA PRESENT AT STATION SW-2 (SWAN CREEK)



BEFORE UPGRADE OF WWTP

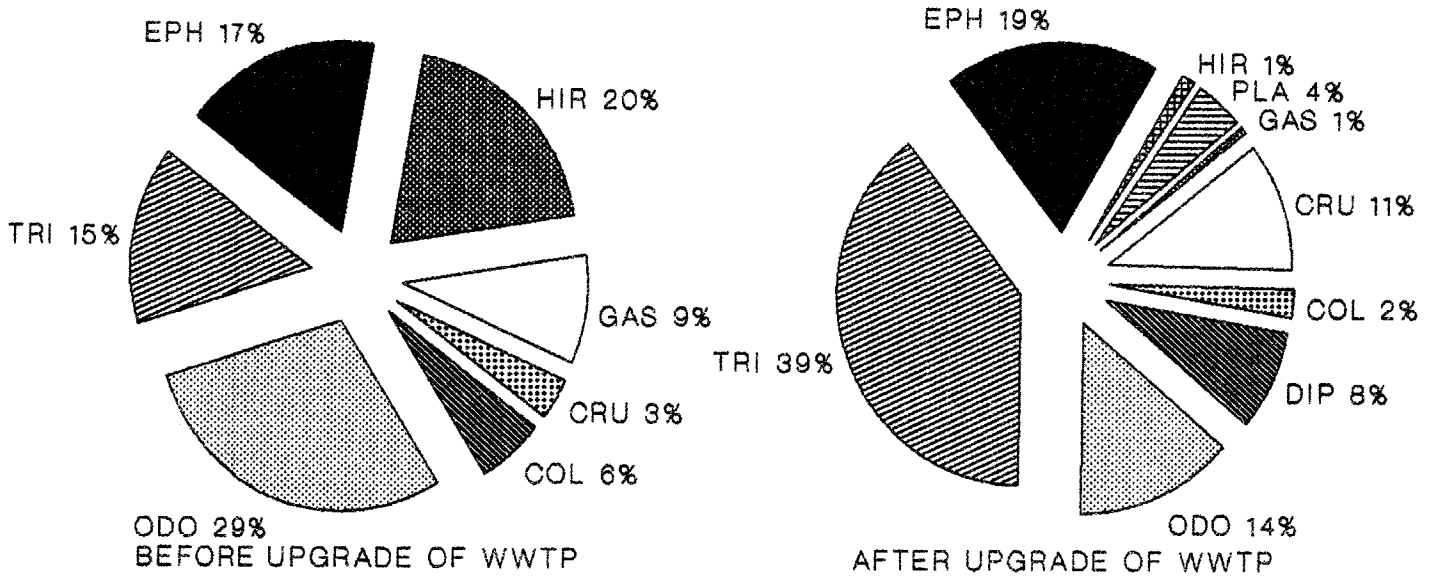


AFTER UPGRADE OF WWTP

LEGEND

EPH-EPHEMEROPTERA	**DIP-DIPTERA**	**MOL-MOLLUSCA**	**PLA-PLANARIA**
TRI-TRICHOPTERA	**COL-COLEOPTERA**	**OLI-OLIGOCHAETA**	**MEG-MEGALOPTERA**
ODO-ODONATA	**GAS-GASTROPODA**	**NEM-NEMATODA**	**HIR-HIRUDINEA**

FIGURE 7
% TOTAL POPULATION OF TAXA PRESENT AT STATION SW-3 (SWAN CREEK)



LEGEND

EPH-EPHEMEROPTERA	**DIP-DIPTERA**	**MOL-MOLLUSCA**	**PLA-PLANARIA**
TRI-TRICHOPTERA	**COL-COLEOPTERA**	**OLI-OLIGOCHAETA**	**CRU-CRUSTACEA**
ODO-ODONATA	**GAS-GASTROPODA**	**NEM-NEMATODA**	**HIR-HIRUDINEA**

TABLE 3

SWAN - TOWN CREEKS AT ATHENS, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP			
		TCA-1	SW-1	SW-2	SW-3	TCA-1	SW-1	SW-2	SW-3
INSECTA									
EPHEMEROPTERA									
Baetidae	4								
Baetis		0	5	0	0	14	13	48	25
Callibaetis		0	0	0	0	0	0	0	4
Cloeon		0	0	0	0	0	0	0	0
Heptageniidae	4								
Heptagenia		0	0	0	0	0	5	0	0
Stenacron		0	11	0	0	1	2	0	1
Stenonema		0	30	0	0	2	30	2	0
Caenidae	7								
Caenis		0	1	1	15	0	2	0	1
PLECOPTERA		0	0	0	0	0	0	0	0
TRICHOPTERA									
Hydropsychidae									
Ceratopsyche	6	0	0	0	0	0	23	25	0
Cheumatopsyche	5	0	22	3	13	8	72	62	65
Hydropsyche	7	0	8	0	0	0	0	0	0
Hydroptilidae	4								
Hydroptila		0	0	0	0	0	0	0	0
Orthotrichia		0	0	0	0	0	0	0	0
Philopotamidae									
Chimarra	4	0	0	0	0	0	6	0	0
ODONATA									
Aeshnidae	3								
Anax		2	0	0	1	0	0	0	0
Aeshna		0	1	0	0	0	0	0	0
Basiaeschna		0	0	0	0	0	0	0	0
Agrionidae									
Agrion		0	0	1	0	0	0	0	0
Coenagrionidae	9								
Argia		14	16	0	22	0	0	0	21
Amphiagrion		0	0	0	0	0	12	0	0
Chromagrion		0	0	0	0	16	0	3	2
Enallagma		0	0	0	0	2	0	0	0

TABLE 3

SWAN - TOWN CREEKS AT ATHENS, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP			
		TCR-1	SW-1	SW-2	SW-3	TCR-1	SW-1	SW-2	SW-3
Ischnura		0	0	2	1	0	0	0	0
Cordulidae									
Epicordulia		0	0	0	0	0	0	0	0
Neurocordulia		0	0	0	1	0	0	0	0
Lestidae	9								
Lestes		0	0	0	0	0	0	0	0
Libellulidae	9								
Libellula		0	0	0	0	0	0	0	0
Pachydiplax		0	0	0	0	0	0	0	0
Macromiidae	3								
Didymops		0	0	0	0	0	0	0	0
Macromia		0	0	0	0	0	0	0	0
DIPTERA									
Ceratopogonidae									
Bezzia	6	0	0	0	0	0	0	0	0
Chironomidae						1			
Ablabesmyia	8	0	0	1	0	8	2	0	3
Chironomus	10	0	0	0	0	0	0	0	0
Cricotopus	7	0	0	0	0	0	0	0	1
Cryptochironomus	8	0	0	0	0	0	0	0	0
Dicrotendipes	8	0	0	0	0	1	0	0	4
Endochironomus/Tribelos	5-10	0	0	0	0	0	0	0	0
Glyptotendipes	10	0	0	3	0	0	0	1	0
Goeldichironomus	?	0	0	0	0	0	0	0	0
Kiefferulus	10	0	0	0	0	0	0	0	0
Labrundinia	7	0	0	0	0	0	0	0	0
Larsia	6	0	0	0	0	0	0	0	0
Microtendipes	6	0	0	0	0	0	0	0	0
Nanocladius	3	0	0	0	0	0	0	1	0
Nilothauma	2	0	0	0	0	0	0	0	0
Psectrocladius	8	0	0	6	0	0	0	0	0
Phaenopsectra	?	0	0	0	0	0	0	0	0
Polypedilum	6	0	0	0	0	0	1	4	2
Procladius	9	0	0	0	0	0	0	0	0
Rheotanytarsus	6	0	0	0	0	0	4	4	0
Stenochironomus	5	0	0	0	0	0	0	0	0
Tanytarsus	6	0	0	0	0	2	5	1	3
Thienemannimyia Group	6	0	2	0	0	3	3	0	1

TABLE 3

SWAN - TOWN CREEKS AT ATHENS, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP			
		TCA-1	SW-1	SW-2	SW-3	TCA-1	SW-1	SW-2	SW-3
Simuliidae									
Prosimulium	6	0	0	0	0	0	0	1	0
NEUROPTERA	?	0	0	0	0	0	0	0	0
MEGALOPTERA									
Corydalidae									
Corydalus	6	0	2	0	0	0	0	2	0
Sialidae									
Sialis	4	0	0	0	0	0	0	0	0
HEMIPTERA	?	0	0	0	0	0	0	0	0
COLEOPTERA									
Elmidae									
Ancyronyx	6	0	0	0	0	0	0	0	0
Dubiraphia	6	0	0	0	0	0	0	0	0
Macronychus	4	0	0	0	0	0	0	0	0
Stenelmis	5	0	4	0	2	0	2	4	1
Haliplidae	?								
Peltodytes		0	0	0	0	0	0	0	0
Hydrophilidae	?								
Ametor		0	0	0	0	0	0	1	0
Berosus		0	0	1	3	0	2	0	3
Tropisternus		1	0	3	0	0	0	0	0
MALACOSTRACA									
DECAPODA	?	1	1						
Astacidae		0	0	0	0	0	0	0	0
Cambaridae		0	0	0	0	0	0	0	0
ISOPODA									
Asellidae									
Asellus		0	0	0	3	0	0	0	0
Lirceus		0	0	0	0	0	0	0	18
GASTROPODA	?								
LIMNOPHILIA									
Ancylidae			3	19					
Ferrissia		0	0	0	0	0	0	0	0

TABLE 3

SWAN - TOWN CREEKS AT ATHENS, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP			
		TCR-1	SW-1	SW-2	SW-3	TCR-1	SW-1	SW-2	SW-3
Laevapex		0	0	0	0	0	0	0	0
Physidae									
Physella		4	0	6	8	0	0	0	1
Planorbidae									
Helisoma		0	0	0	0	0	0	0	0
Planorbula		0	0	0	0	0	0	0	0
Pleuroceridae									
Elimia		1	21	1	0	0	16	2	0
BIVALVIA	?								
Fresh Water Mussel		0	0	0	0	0	0	0	0
Corbiculidae									
Corbicula		0	0	0	0	0	0	0	0
ANNELIDA	?								
OLIGOCHAETA		0	0	0	0	0	0	0	0
HIRUDINEA									
Erpobdellidae		0	0	0	0	1	0	0	0
Glossiphoniidae									
Helobdella		0	0	4	17	0	0	0	2
PLANARIA	?	0	0	0	0	11	1	27	7
NEMATODA	?	0	0	0	0	0	0	2	0
ACARI	?	0	0	0	0	0	0	0	0
Total # Organisms		23	127	51	86	70	201	190	165
Total # Taxa		6	14	14	13	13	18	17	19
EPT Index		0	6	2	2	4	8	4	5
% Contribution of Dominant Taxa		60.9	23.6	37.2	25.6	22.9	35.8	32.6	39.4
Species Diversity ($\bar{d}$)		1.77	3.11	3.08	3.05	3.07	3.11	2.74	2.94
Equitability (e)		0.73	0.87	0.85	0.9	0.91	0.68	0.54	0.57

TABLE 3

SWAN - TOWN CREEKS AT ATHENS, ALABAMA
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	HILSENHOFF BIOTIC INDEX	Data Collected Prior To Upgrade of WWTP				Data Collected After Upgrade of WWTP			
		TCA-1	SW-1	SW-2	SW-3	TCA-1	SW-1	SW-2	SW-3
Sorenson's Community Similarity (as compared to reference stations TCA-1 & SW-1)		----	----	0.29	0.3	----	----	0.57	0.59
# of Dominant Organisms in Common (as compared to reference stations TCA-1 & SW-1)		----	----	1	2	----	----	3	2
Indicator Assemblage Index (as compared to reference stations TCA-1 & SW-1)		----	----	0.1	0.27	----	----	2.32	0.95

Table 4

Daily Monitoring Reports

Page: ATHENS
12/14/89

MUNICIPALITY ATHENS PERMIT ISSUED: 6/15/88
PERMIT # AL0020206 PERMIT EXPIRES: 6/29/93

LIMIT	FLOW (MGD)	INFLUENT BOD (PPM)	INFLUENT SS (PPM)	INFLUENT BOD (LBS/DAY)	INFLUENT SS (LBS/DAY)	EFFLUENT BOD (PPM)	EFFLUENT SS (PPM)	EFFLUENT NH3N (PPM)	EFFLUENT BOD (LBS/DAY)	EFFLUENT SS (LBS/DAY)	EFFLUENT NH3N (LBS/DAY)	EFFLUENT FECAL COL 100 ML.	EFFLUENT D.O. (MG/L)
DESIGN	7.0	200.0	200.0	11676.0	11676.0								
INTERIM													
FINAL(DEC-MAY)						18.0	30.0	5.0	1050.8	1751.4	291.9	MAX. 2000	MIN. 6.0
AVERAGE(DEC-MAY)	7.172	111.2	112.5	6193.0	6522.0	4.3	4.6	1.9	257.1	286.6	103.6	760	6.0
DEC 88	4.900	161.0	119.0	6579.4	4863.1	2.2	5.9	1.0	89.9	241.1	40.9	340	7.2
JAN 89	8.500	93.0	97.0	6592.8	6876.3	4.0	6.0	2.5	283.6	425.3	177.2	468	7.0
FEB 89	9.930	86.0	100.0	7122.2	8281.6	4.0	6.0	1.0	331.3	496.9	82.8	577	6.7
MAR 89	8.000	78.0	106.0	5204.2	7072.3	3.2	4.2	1.3	213.5	280.2	86.7	1740	5.5
APR 89	6.700	90.0	105.0	5029.0	5867.2	6.7	2.7	.9	374.4	150.9	50.3	1010	4.1
MAY 89	5.000	159.0	148.0	6630.3	6171.6	6.0	3.0	4.4	250.2	125.1	183.5	425	5.6
FINAL(JUN-NOV)						15.0	30.0	1.0	875.7	1751.4	58.4	2000	6.0
AVERAGE(JUN-NOV)	6.200	123.8	142.8	5995.6	6725.2	3.5	2.9	1.2	183.9	151.0	73.1	4081	5.5
JUN 89	8.000	86.0	84.0	5737.9	5604.5	4.4	2.2	3.6	293.6	146.8	240.2	1813	4.0
JUL 89	6.800	114.0	112.0	6465.2	6351.7	4.0	2.4	1.2	226.8	136.1	68.1	6414	5.1
AUG 89	4.100	188.0	251.0	6428.5	8582.7	3.8	2.3	.3	129.9	78.6	10.3	10800	6.0
SEP 89	5.400	144.0	169.0	6485.2	7611.1	3.0	3.4	.8	135.1	153.1	36.0	1270	6.0
OCT 89	6.700	87.0	98.0	4861.4	5476.0	2.4	4.3	.2	134.1	240.3	11.2	106	6.2
NOV 89													
COMPLIANCE SAMPLING INSPECTIONS													
5/2-5/4/89	4.481	316.7	277.0	11835.6	10351.9	1.6	1.7	.3	59.8	63.5	11.2		7.4
12/6-12/8/88	3.953	200.8	143.0	6620.0	4714.4	1.6	2.3	1.0	52.7	75.8	33.0		3.6
2/24-2/26/87	2.813	189.3	73.7	4441.1	1729.0	13.9	7.3	5.4	326.1	171.3	126.7		6.5
9/27-9/29/83	2.283	900.0	969.7	17136.2	18463.3	20.0	34.0		380.8	647.4			7.4
3/9-3/11/82	5.530	341.7	340.8	15759.3	15717.8	33.5	28.5	6.5	1545.0	1314.4	299.8		3.4
6/29-7/1/81	2.480	555.0	473.3	11479.2	9789.4	23.5	52.7	16.2	486.1	1090.0	335.1		6.2
2/26-2/28/80	3.580	332.0	154.0	9912.6	4598.0	28.4	16.0	9.9	847.9	477.7	295.6		8.6
3/27-3/29/79	3.870	390.0	157.3	12587.6	5077.0	33.1	21.3	3.4	1068.3	687.5	109.7		10.0

ADMINISTRATIVE ORDER SCHEDULE

DATE OF ORDER
SUBMIT ENGINEERING REPORT
SUBMIT FACILITY PLAN
SUBMIT PLANS & SPECS.
SUBMIT FINANCIAL PLAN
ISSUE NOTICE TO PROCEED
COMPLETE CONSTRUCTION

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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).