WATER QUALITY DEMONSTRATION STUDY

PUPPY CREEK
CITRONELLE, ALABAMA
1989 AND 1991

SPECIAL STUDIES SECTION
FIELD OPERATIONS DIVISION
ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

WATER QUALITY DEMONSTRATION STUDY
PUPPY CREEK AT CITRONELLE, ALABAMA

INTRODUCTION

The City of Citronelle, Alabama utilizes Puppy Creek as a receiving stream for the treated effluent from its' municipal wastewater treatment facility (WWTP). During the period from March 1989 to July 1990, the City of Citronelle's WWTP underwent construction to upgrade the old disposal plant. Staff members of the Mobile Branch, 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 Puppy Creek.

EPA CONSTRUCTION GRANTS AND SRF PROGRAM

Since 1972, approximately $545 million dollars in EPA grant funds have been expended toward construction of municipal wastewater treatment works in Alabama. The City of Citronelle received an EPA Construction Grant for the improvements to the Citronelle Wastewater Treatment Facility (WWTP).

Improvements to the Citronelle WWTP consisted of constructing an additional 7.19 acre primary cell, two 3.8 acre polishing ponds, four 0.35 acre water hyacinth cells, a 0.05 acre greenhouse, a post aeration system and an effluent flow measurement system.

The total cost of construction and engineering was $1,125,985. An EPA grant of $658,988, including $61,009 in funding for Alternative Technology, was provided to help defray the cost of construction. The firm of Polyengineering of Mobile, Alabama designed the system and James R. Payne, Inc. was awarded the construction grant on March 13, 1989.

Treatment at the facility begins with the splitting of flow from the influent pump station to two first stage lagoons which are an existing oxidation pond and the newly constructed 7.19 acre primary treatment cell operating in parallel. After treatment in the primary oxidation ponds, the flow passes to the second and third stages of the treatment system which are the two 3.8 acre polishing ponds operating in series.

During the summer months, when the hyacinths are in their growth phase, flow is routed to the hyacinth ponds. During the winter months, effluent goes directly to the effluent outfall line to Puppy Creek. Seasonal effluent limits, which provide less stringent limits during the winter season, make this arrangement feasible.

The primary function of the water hyacinth treatment cells is the enhanced removal of nutrients (nitrogen and phosphorus), BOD, and suspended solids. Citronelle's existing conventional lagoon treatment system could not achieve the effluent quality required by its NPDES permit. The City found that the most cost effective method of meeting the stringent summer effluent limits was to utilize a series of aquaculture ponds (hyacinths) which provide advanced treatment during the critical summer months. Hyacinths accomplish significant reductions of pollutants in wastewater by two principal mechanisms: absorption and filtering. Absorption of pollutants, such as ammonia nitrogen, provide nutrients necessary for plant growth. Meanwhile, the hyacinths extensive root system

physically filters out solids and also supports a biologically active mass of attached microorganisms which break down pollutants in the wastewater. Additionally, a reduction of algal growth in the ponds occurs because the hyacinth plants physically block sunlight from the water surface and compete with algae for available nutrients. Since algae in pond effluent is organic in nature, its elimination or reduction reduces oxygen demand in the receiving stream. Like other aquacultural systems, the hyacinth ponds must be partially harvested during the summer months to maintain the plants in a vigorous growth phase. It is during this growth phase that the plants most efficiently remove pollutants from the wastewater. Hyacinths removed from the treatment system are allowed to dry before being landfilled.

The water hyacinth is very sensitive to temperature and grows most rapidly when the water temperature is 70 to 86 degrees Farenheit. Growth ceases at water temperatures below 50 degrees Farenheit and above 104 degrees Farenheit. Air Temperatures at 27 degrees Farenheit or lower for 12 hours will destroy the plant's leaves and exposure to 23 degrees Farenheit or lower for 48 hours will kill the entire plant. In order to avoid an adverse impact on effluent quality, dead hyacinths must be harvested prior to decay of plant tissue. At Citronelle, it is possible to drain the hyacinth ponds completely and allow the materials to dry in place before removal.

Seasonal NPDES permit limits for the 0.36 mgd treatment system are as follows:

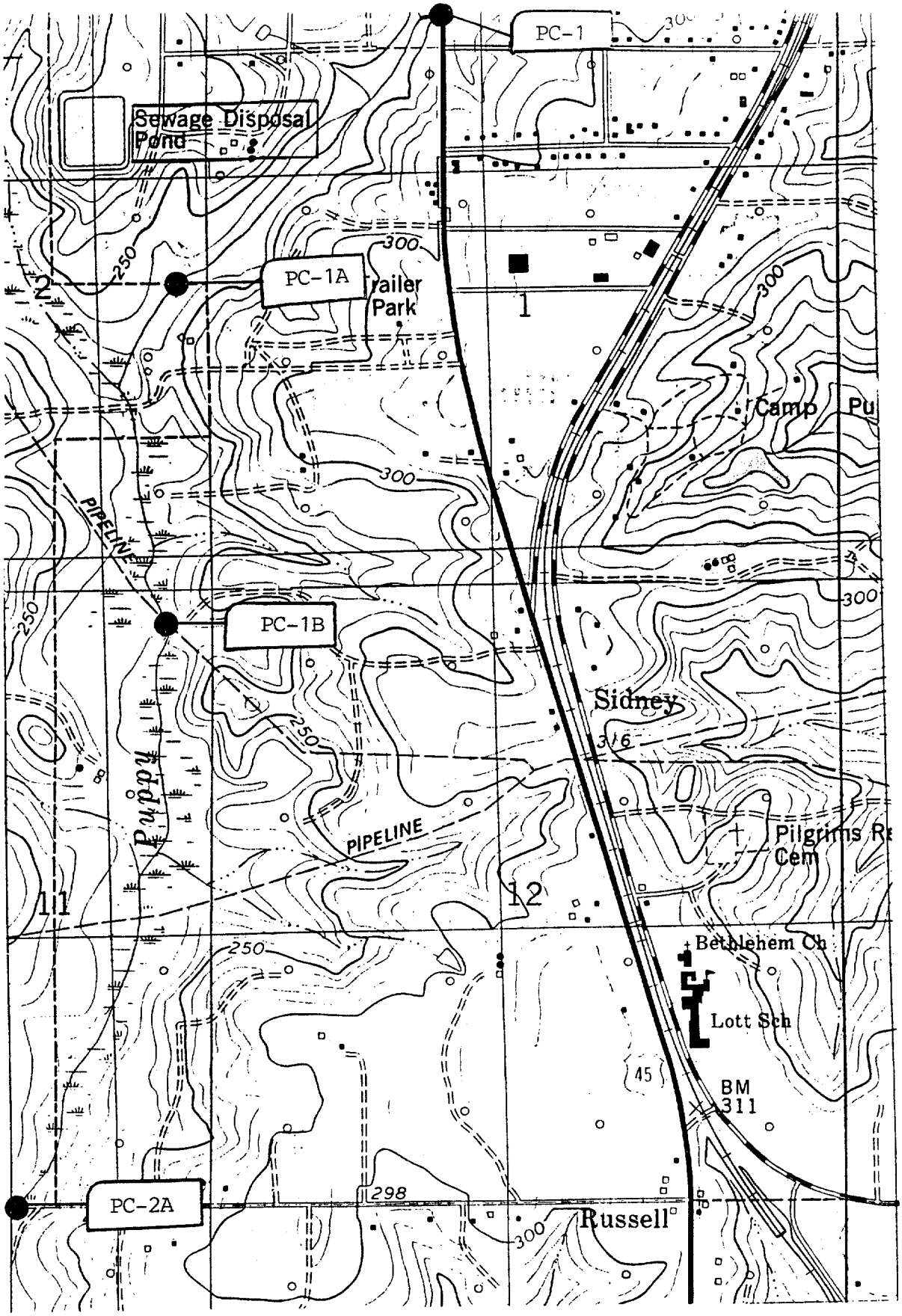
	May-Nov	Dec-Apr
BOD_5	18 mg/L	30 mg/L
TSS	90 mg/L	90 mg/L
NH_3-N	3 mg/L	8 mg/L
D.O.	6 mg/L	6 mg/L

Average monthly seasonal performance by the treatment facility for the period from December 1990 to December 1991 is as follows:

	May-Nov	Dec-Apr
Flow	0.343 mgd	0.291 mgd
BOD_5	10.9 mg/L	10.8 mg/L
TSS	28.2 mg/L	79.6 mg/L
NH_3-N	0.83 mg/L	0.47 mg/L
D.O.	6.6 mg/L	7.2 mg/L

FIELD OPERATIONS

During the period of July 1989 to October 1989, staff members of the Mobile Field Office collected data to establish conditions and provide a comparative base of information on Puppy Creek prior to construction and implementation of the new treatment plant. During July to October 1991, data were collected to demonstrate the improvement, if any, of water quality in the receiving stream attributable to the new plant.



MAP 1

PUPPY CREEK AT CITRONELLE, ALABAMA

SAMPLING LOCATIONS AND METHODOLOGY

The station names and locations for data collected before the upgrade of the WWTP were as follows:

STATION	LOCATION:
PC-1A (control)	Puppy Creek approximately 100 yds. upstream of WWTP. T1N,R3W,S2,NE1/4,SE1/4. Latitude: 31 04 40.6 Longitude: 088 14 42.8
PC-1B	Puppy Creek approximately 0.5 mile downstream of WWTP. T1N,R3W,S11,NE1/4,NE1/4. Latitude: 31 04 11.0 Longitude: 088 14 43.7

In 1991, two 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:
PC-1 (control)	Puppy Creek at U.S. Highway 45. T1N,R3W,S1,NW1/4,NE1/4. Latitude: 31 05 03.0 Longitude: 088 14 16.0
PC-2A	Puppy Creek at Russell Road. T1N,R3W,S11,SE1/4,SW1/4. Latitude: 31 03 21.0 Longitude: 088 14 59.0.

In addition, the WWTP effluent was sampled both before and after the upgrade.

All physical data, chemical 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, Volumes 1), 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.

DISCUSSION AND RESULTS

A. PHYSICAL

Puppy Creek is a first order stream over the length of the study reach. It drains agricultural, commercial, field/pasture, and forested lands and falls within the Southern Pine Plains and Hills Ecoregion. Flows usually run between 0.25 to 1.50 cubic feet per second. Puppy Creek lies within the Escatawpa River drainage basin.

B. CHEMICAL

The Water Use Classification for Puppy Creek is Fish and Wildlife (F&W). The F&W designation specifies 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 shown in Table 1, and Figure 1, data collected prior to the upgrade of the treatment plant indicated that the waters in Puppy

Creek below the Citronelle WWTP outfall were not meeting the dissolved oxygen standard for the F&W classification (5.0 mg/L). The pH data collected (Table 1, Figure 2) indicated very minor changes in the stream. Phosphates (PO_4), Nitrates (NO_3), and Total Dissolved Solids (TDS) were all shown to have notable increases as compared to the upstream stations (Table 1, Figures 3, 4, and 5).

Chemical data collected on Puppy Creek after the upgrade indicated that, in comparison to data collected before the upgrade, water quality was slightly improved. Dissolved Oxygen concentrations (Table 2, Figure 2) exhibited a substantial increase. In addition, TDS, NO_3, and PO_4 showed reductions in concentration (Table 2, Figures 3, 4, and 5). However, when compared to the upstream station, Chlorides (Cl), Total Suspended Solids (TSS), and Conductivity increased downstream of the WWTP (Table 2, Figures 2,3, and 4).

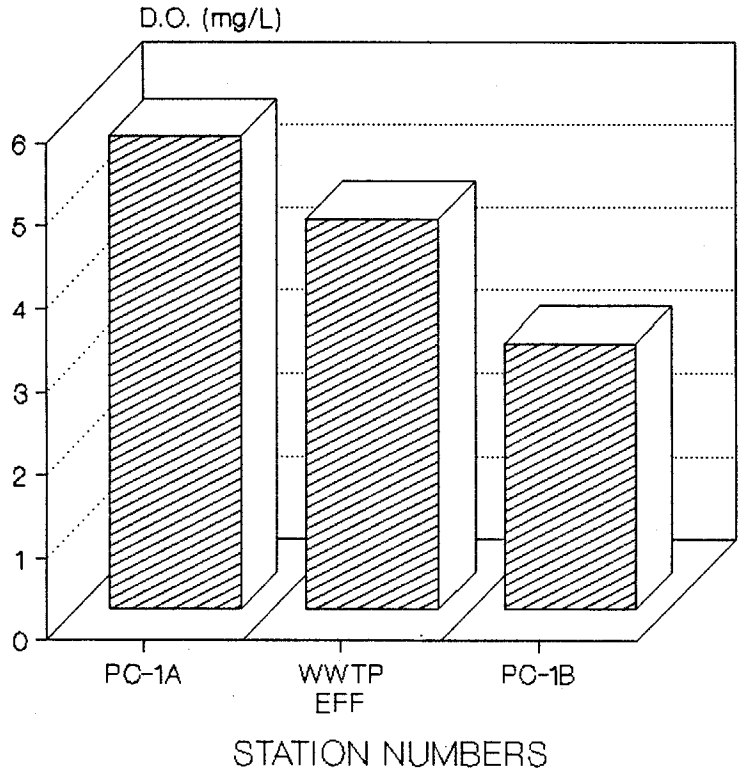
Flow data collected (Tables 1 and 2, Figure 2) after the upgrade of the WWTP was two to four times greater than flow data collected before the upgrade. This may have contributed to the improvements noted in certain parameters, due to increased volumes of water. The increased flow may also have contributed to the degradation noted in other parameters, due to non-point source considerations.

CONCLUSIONS

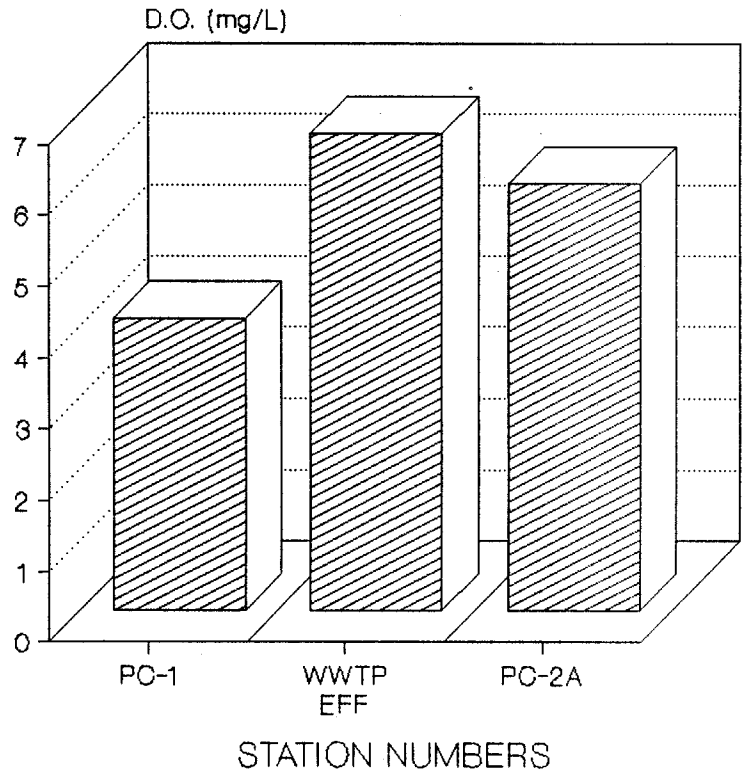
Physical, and chemical data collected before and after the upgrade of the Puppy Creek wastewater treatment facility indicates that Puppy Creek, in addition to meeting its' requirements for the Fish and Wildlife Water Use Classification, appears to have experienced a slight improvement in overall water quality below the treatment plant discharge. Additonal monitoring during low stream flow conditions would assist in further documenting any impact to the water quality of Puppy Creek attributable to the WWTP effluent.

FIGURE 1
PUPPY CREEK
DISSOLVED OXYGEN DATA

BEFORE WWTP UPGRADE

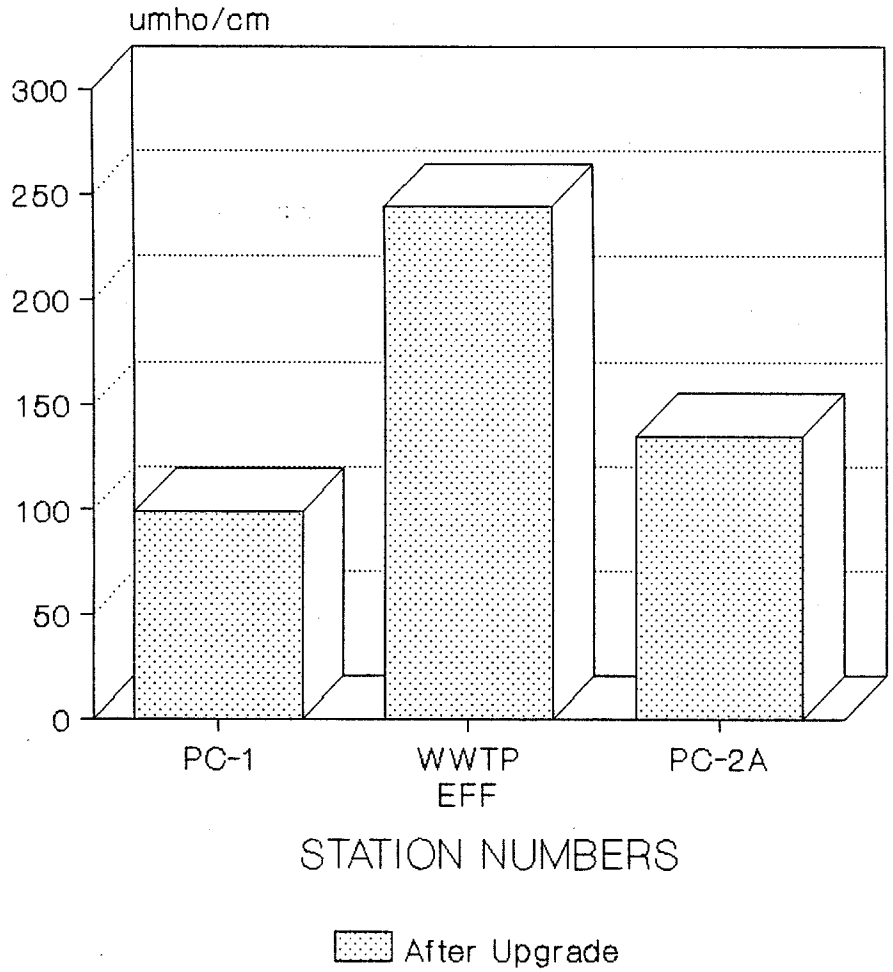


AFTER WWTP UPGRADE



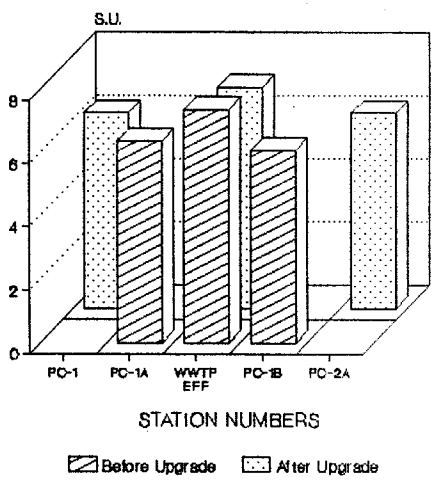
THE ABOVE NUMBERS ARE AVERAGES REPRESENTING MULTIPLE SAMPLING EVENTS.

FIGURE 2
PUPPY CREEK
CONDUCTIVITY DATA



THE ABOVE NUMBERS ARE AVERAGES REPRESENTING MULTIPLE SAMPLING EVENTS.

pH DATA



FLOW DATA

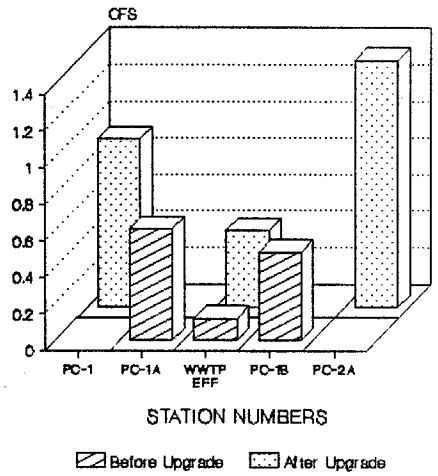
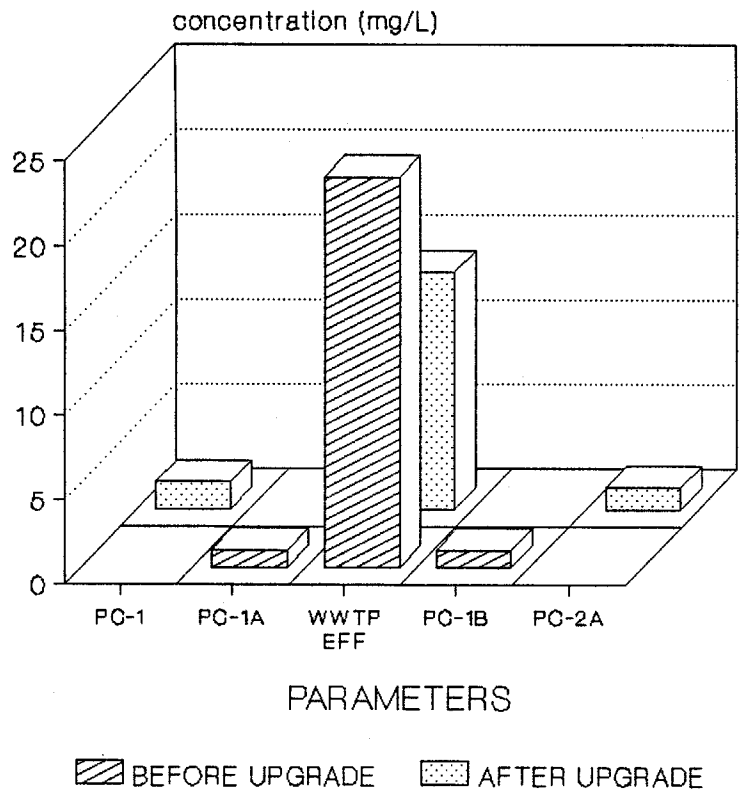
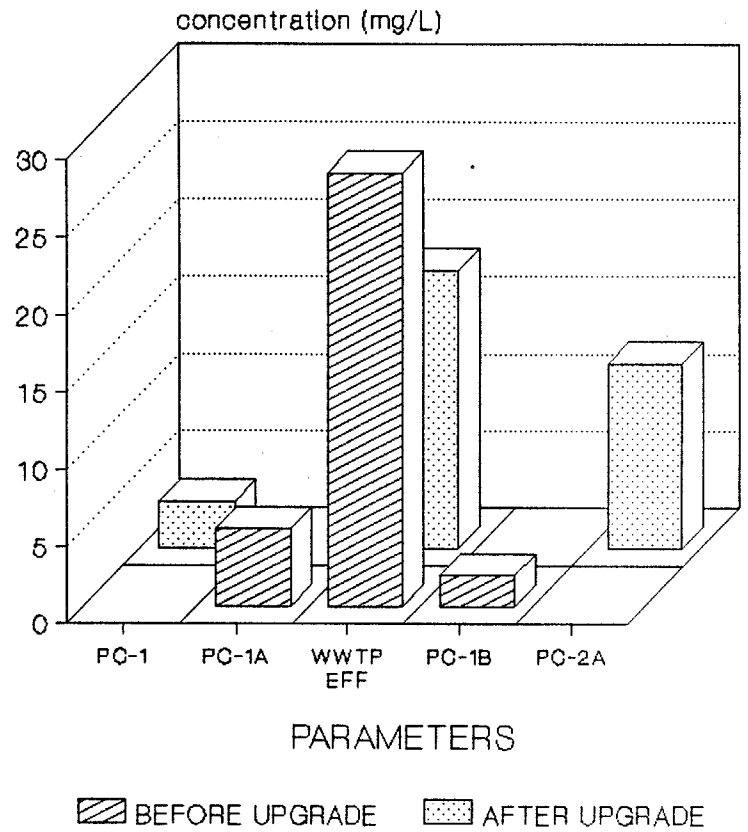


FIGURE 3
PUPPY CREEK
CHEMICAL ANALYSIS DATA

BIOCHEMICAL OXYGEN DEMAND (5 DAY)



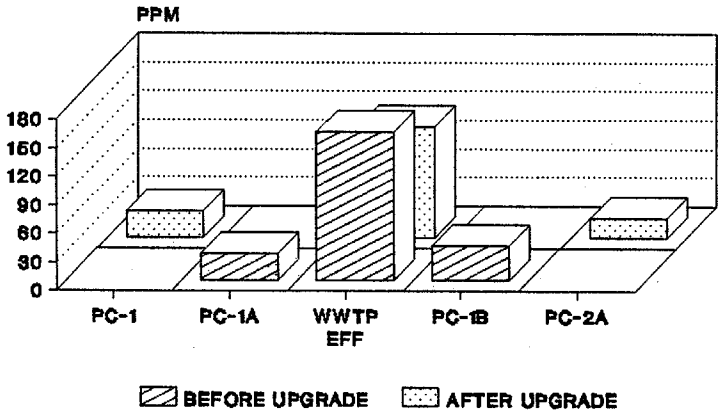
TOTAL SUSPENDED SOLIDS



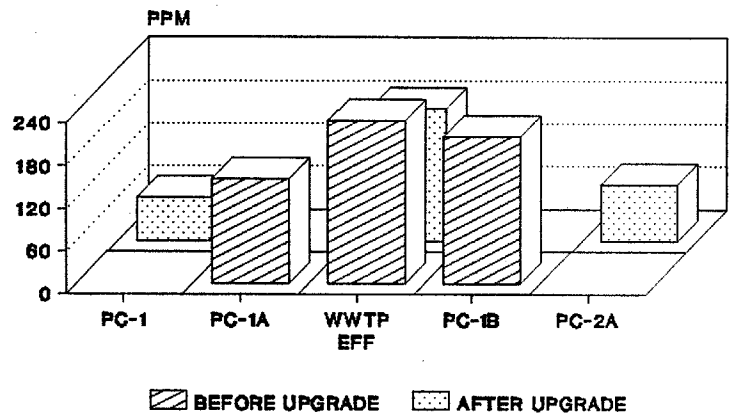
THE ABOVE NUMBERS ARE AVERAGES REPRESENTING MULTIPLE SAMPLING EVENTS.

FIGURE 4
PUPPY CREEK

ALKALINITY

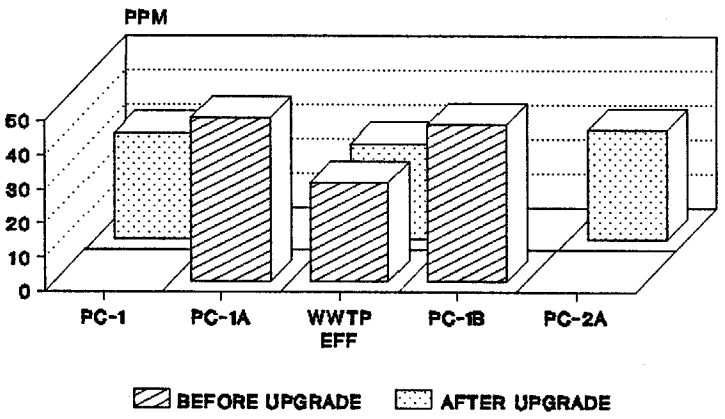


TOTAL DISSOLVED SOLIDS



THESE NUMBERS ARE AVERAGES REPRESENTING MULTIPLE SAMPLING EVENTS.

HARDNESS



AFTER UPGRADE

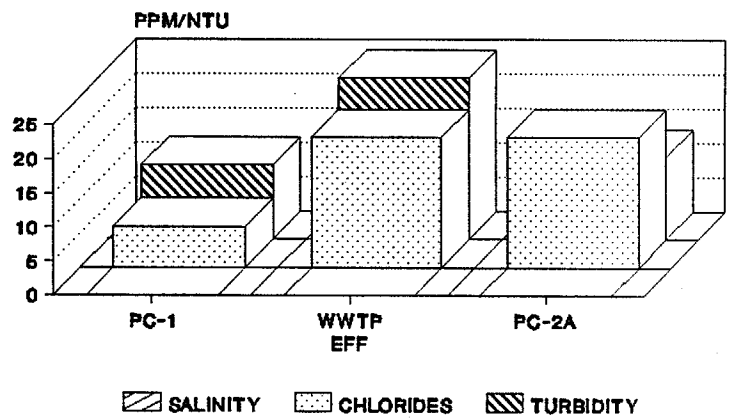
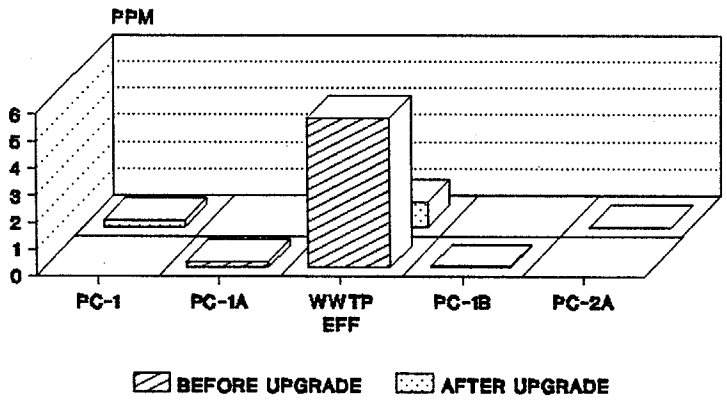
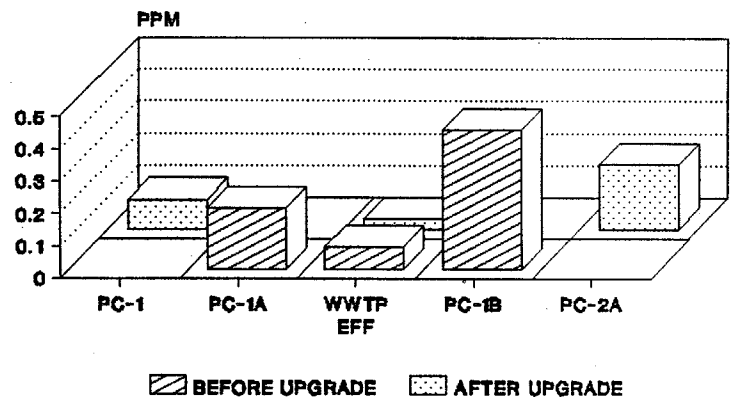


FIGURE 5
PUPPY CREEK

AMMONIA

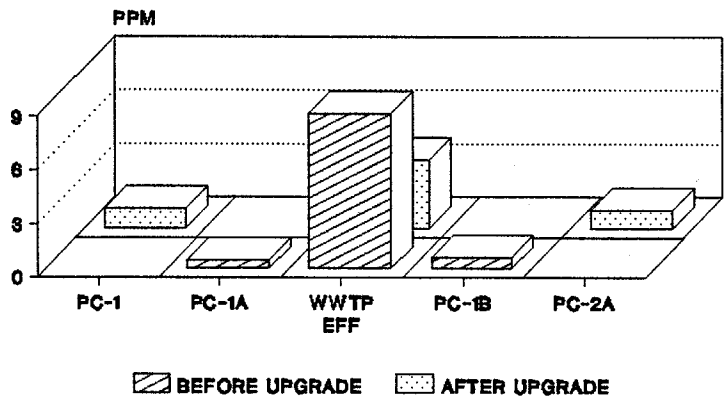


NITRATE



THESE NUMBERS ARE AVERAGES REPRESENTING MULTIPLE SAMPLING EVENTS.

TOTAL KJELDAHL NITROGEN



PHOSPHATES

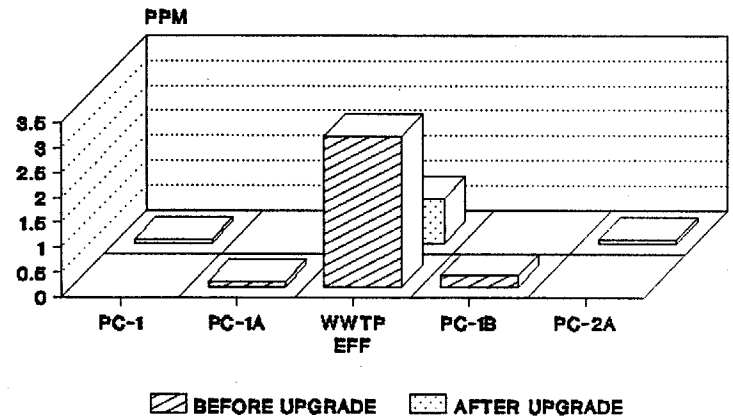


TABLE 1
WATER QUALITY DEMONSTRATION STUDY
PUPPY CREEK AT CITRONELLE, ALABAMA
DATA COLLECTED PRIOR TO UPGRADE

DATE	LOCATION	TIME	TEMP AIR	TEMP H2O	D.O.	pH	ALK	BOD5	TSS	TDS	HARD	COD	NH3-N	NO3-N	TKN	PO4-P	FLOW
07/27/89	@	1030				7.1	149	19	21	288	32	111	8.02	0.10	6.6	0.84	
10/13/89	WWTP	1015	22	22	4.7	7.7	163	27	35	168	25	179	3.09	0.03	10.	5.20	0.12
AVERAGE			22	22	4.7	7.4	156	23	28	228	29	145	5.55	0.07	8.7	3.02	0.12
07/27/89	PC-1A	1130			6	6.8	27	1	3	134	48	19	<0.05	0.06	0.3	0.10	0.86
10/13/89		1030	22	20	5.5	6	29	<1	6	160	47	10	0.4	0.31	0.8	0.12	0.36
AVERAGE			22	20	5.7	6.4	28	--	5	147	48	15	---	0.19	0.5	0.11	0.61
07/27/89	PC-1B	1200			3.6	6.1	21	<1	2	224	51	25	<0.05	0.21	0.5	0.13	
10/13/89		1155	22	20	2.8	6.2	50	<1	1	189	41	20	<0.05	0.64	0.7	0.33	0.48
AVERAGE			22	20	3.2	6.1	36	--	2	206	46	23	---	0.43	0.6	0.23	0.48
			C	C	ppm	S.U.	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	cfs

TABLE 2
WATER QUALITY DEMONSTRATION STUDY
PUPPY CREEK AT CITRONELLE, ALABAMA
DATA COLLECTED AFTER UPGRADE

DATE	LOCATION	TIME	TEMP AIR	TEMP H2O	D.O.	pH	SPEC COND	SAL	TURB	ALK	BOD5	CL	TSS	TDS	HARD	COD	NH3-N	NO3-N	TKN	PO4-P	FLOW	FECA COLI
07/17/91	@	1030		28	6.6	6.8	201			69	13		18	157	20	128	<0.01	<0.005	5.25	0.608	0.27	
08/14/91	WWTP	1200		27	5.9	7.2	220	0	42	68	17	19	35	177	28	84	0.32	<0.005	4.78	1.033	0.44	
09/25/91		1100	20	23	6.9	7.1	250	0	14.5	92	10		3	186	19	82	2.58	0.033	1	0.999	0.49	
10/28/91		1005	27	22	7.7	7.2	306	0	14.5	117	16		16	222	43	96	0.75	0.067	4.3	0.967	0.49	
AVERAGE			24	25	6.7	7.0	244	0	23.6	87	14	19	18	186	28	98	---	---	3.832	0.901	0.42	
07/17/91	PC-1	1225	29	25	3.8	6.2	102	0	8.7	29	1.6		2	73	32	28	0.16	0.025	0.87	0.081	0.96	2300
08/14/91		1324		24	5.1	6.2	92	0	12.4	24	<1	6	4	68	34	13	0.18	0.2	1.53	0.068	0.86	580
09/25/91		1130	20	21	4.5	6.3	84	0	9.4	19	1.9		1	36	22	22	0.27	0.048	0.92	0.078	1.33	5267
10/28/91		1040	25	21	3.2	6.3	119	0	13	35	2		4	65	37	19	0.44	0.075	1.2	0.103	0.54	1200
AVERAGE			25	23	4.1	6.2	99	0	10.8	27	---	6	3	61	31	21	0.26	0.087	1.13	0.082	0.92	2337
07/17/91	PC-2A	1325	30	26	6.3	6.2	123	0	7.8	21	<1		1	74	28	21	<0.01	0.082	1.39	0.074	1.23	133
08/14/91		1030		26	6.8	6.2	122	0	8.5	21	<1	19	1	88	32	23	0.06	0.58	1.51	0.092	1.3	140
09/25/91		1245	17	21	6	6.1	126	0	12	9	1.1		1	62	28	23	<0.01	0.105	<0.05	0.052	1.82	2800
10/28/91		1200	25	21	5.2	6.4	168	0	20	29	2.2		44	91	41	26	<0.01	0.043	1.2	0.092	1.03	467
AVERAGE			24	24	6.0	6.2	135	0	12.0	20	---	19	12	79	32	23	---	0.202	---	0.077	1.35	885
			C	C	ppm	S.U.	umho	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	cfs	org/ 100m