A BIOLOGICAL AND WATER QUALITY REINVESTIGATION OF THE LITTLE PITMAN CREEK DRAINAGE (GREEN RIVER SYSTEM)

Kentucky Department for Environmental Protection

Division of Water

Water Quality Branch

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EXECUTIVE SUMMARY

1. A biological and water quality survey of Little Pitman Creek was conducted in June, 1991 to determine if the Campbellsville Wastewater Treatment Plant (WWTP) was degrading water quality.

2. A total of 34 physicochemical parameters were analyzed from three locations. Data from the physicochemical analyses indicate that the upper 3.5 miles of Little Pitman had good water quality. The reach below the Campbellsville WWTP was degraded and the lower section near the mouth had fair water quality.

3. The chronic criterion for copper was exceeded at station 24-11, which is located approximately two miles downstream of the Campbellsville WWTP. No other Kentucky Surface Water Standards were exceeded during this study.

4. Biological samples, consisting of algae and macroinvertebrates, were collected from three locations on Little Pitman Creek. Data from these samples indicate that the upper 3.5 miles and lower 1.5 miles of Little Pitman are supporting designated uses. However, the lower 1.5 miles should be considered supporting but threatened. The portion of Little Pitman Creek from the Campbellsville WWTP to Station 24-5, a distance of 8.5 miles, is partially supporting designated uses. There has been some improvement in both the algae and macroinvertebrate communities below the Campbellsville WWTP since the Kentucky Division of Water's 1985 study.

TABLE OF CONTENTS

List of Figures and Tables

INTRODUCTION

A biological and water quality reinvestigation of the Little Pitman Creek drainage was conducted in June, 1991 (Figure 1). The purpose of this study was to determine if the Campbellsville wastewater treatment plant (WWTP) was continuing to degrade Little Pitman Creek.

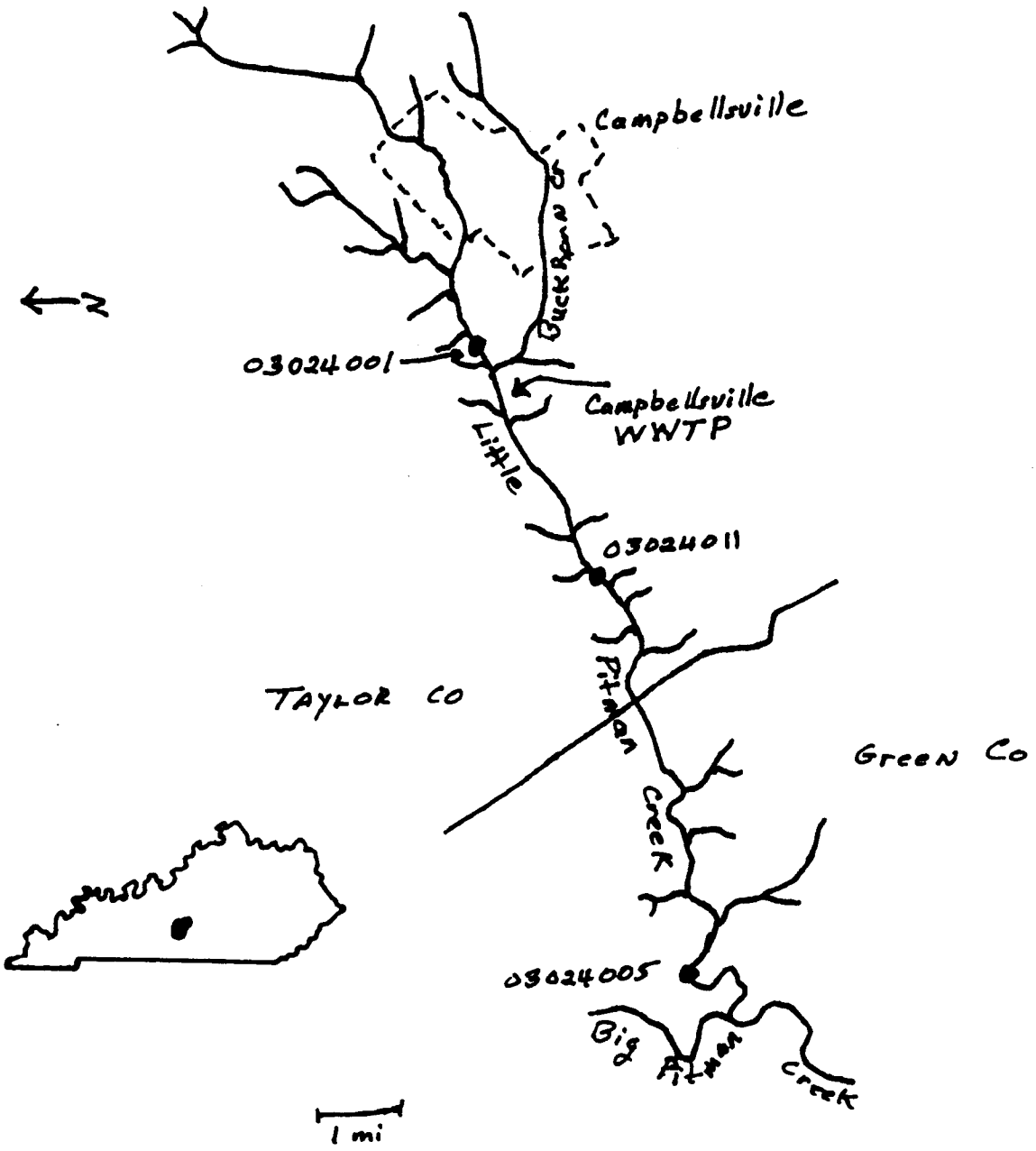
Little Pitman Creek was the subject of two previous investigations (KDES 1984 and KDOW 1985). Both studies indicated that chlorinated effluent from the Campbellsville WWTP (4.2 millions gallons per day) was seriously degrading Little Pitman Creek.

Three stations on Little Pitman Creek were sampled in June, 1991, to determine the impacts from the Campbellsville WWTP. Station 24-1 is located 0.8 miles upstream of the WWTP and serves as the control. Station 24-11 is located approximately 1.9 miles downstream of the WWTP and 24-5 is about 8.7 miles downstream of the WWTP. All sites had moderate gradients and riffle-pool habitats with undercut banks and areas of debris accumulation. For a more detailed discussion of the Little Pitman Creek drainage refer to KDES (1984) and KDOW (1985).

Methods

Water samples were collected in accordance with KDOW's Standards Operating Procedures Manual (KDOW 1986). All samples were iced and transported to the Division of Environmental Services laboratory for analysis. Qualitative

Figure 1: Map of the Little Pitman Creek Drainage Depicting Sampling Locations



biological samples were also collected and analyzed in accordance with KDOW methods. These samples were taken to the Water Quality Branch laboratory and identified to the lowest possible taxonomic level.

PHYSICOCHEMICAL DISCUSSION

A total of 34 physicochemical parameters were analyzed from the three stations. (Table 1). In addition, tests for dissolved oxygen (DO), conductivity, turbidity, and water temperature were performed in the field at each location (Table 2).

The physicochemical data were examined to assess water quality and identify designated use support based on Kentucky Surface Water Standards (KSWS). If the KSWS acute criterion was exceeded, the designated use was not being met for that parameter at the time of sampling. In addition, STORET (1983-1991) database values were used to aid in evaluation of water quality. If a parameter's concentration exceeded the KSWS chronic criterion or the STORET (1983-1991) 75th percentile, it was considered elevated and a possible cause of water quality degradation. Because the physicochemical data indicates conditions only at the time of sampling, it is used to delineate potential problem parameters and to support biological data.

Two previous studies were conducted by the Water Quality Branch (KDES 1984 and KDOW 1985) that included stations located on Little Pitman Creek. Comparisons between this and

Table 1 : Physicochemical Data for the Little Pitman Creek Drainage, June, 1991			
Parameter (mg/l)[a]	Stations 24-1	24-11	24-5
Acidity	ND @ 0.1	ND @ 0.1	ND @ 0.1
Alkalinity	149*	234*	202*
Chloride	15.3	431*	279*
Conductivity (umho/cm)	410	2,050*	1,450*
Fluoride	0.15	1.20	0.88
Hardness, total	175	137	154
pH (S.U.)	8	8.2	8.4
TSS	26	16	19
TDS	258	1,190	834
Sulfate	25	81.4*	55
TOC	2.3	8.4*	6.7*
Ammonia-Nitrogen	ND @ 0.05	0.188*	ND @ 0.05
TKN	0.344	1.29*	0.924*
Nitrate	0.882	1.974*	2.757*
Phosphorus, total	0.026	3.67*	2.18*
Calcium	48.6	42.4	54.3
Magnesium	10.14	7.65	8.66
Potassium	1.91	27.3*	19.7*
Sodium	6.8	314*	225*
Aluminum	0.176	0.111	0.122
Arsenic	ND @ 0.002	0.004*	0.005*
Barium	0.052	0.040	0.046
Beryllium	ND @ 0.001	ND @ 0.001	ND @ 0.001
Cadmium	ND @ 0.001	ND @ 0.001	ND @ 0.001
Chromium	0.004*	0.003	0.004*
Copper	0.008*	**0.022***	0.011*
Iron	0.21	NA	ND @ 0.170

Table 1 (cont'd) : Physicochemical Data for the Little Pitman Creek Drainage, June, 1991			
Parameter (mg/l)[a]	**Stations** 24-1	24-11	24-5
Lead	ND @ 0.002	ND @ 0.002	ND @ 0.002
Manganese	ND @ 0.070	NA	ND @ 0.070
Mercury	ND @ 0.0001	0.0001	ND @ 0.0001
Nickel	0.005	0.021	0.005
Selenium	0.003	0.004	0.002
Silver	ND @ 0.001	ND @ 0.001	ND @ 0.001
Zinc	0.031*	NA	0.041*

* - Parameter that exceeded the STORET (1983-1991) 75th percentile
ND - Not Detected
NA - Not Analyzed
a - Parameters in mg/l unless otherwise stated
Bold type concentrations indicate parameters that exceed KSWS chronic criteria

Table 2: Field Physicochemical Parameters Taken from the Little Pitman Creek Drainage			
Parameter	**Stations** 24-1	24-5	24-11
Dissolved Oxygen (mg/l)	6.8	8.4	7.9
Conductivity (umhos/cm)	365	1500	1850
Turbidity (NTU)	6.0	6.0	5.0
Water Temperature (°C)	22	26	26

the KDES (1984) study were not made because the sampling for the KDES (1984) study took place in February, while sampling for this study took place in June. However, the KDOW (1985) study had samples collected in July which can be compared to this study at stations 24-1 and 24-5.

Physicochemical data collected from station 24-1, which is located above the Campbellsville WWTP, indicate that the water quality is good. No KSWS were exceeded and only four parameters exceeded the STORET 75th percentile (Table 1). Nitrate-nitrogen was the only nutrient that was slightly elevated. Water quality data from the KDOW (1985) (Appendix B) and this study at station 24-1 (Table 1) were similar.

The water quality at station 24-11, the station downstream of the WWTP, was considered degraded. A total of 13 parameters exceeded the STORET 75th percentile (Table 1). The chloride concentration, though not exceeding KSWS, was very high (431 mg/l) when compared to the STORET 75th percentile value of 16.3 mg/l (Table 1). The sodium concentration was also elevated above the STORET 75th percentile value of 17.8 mg/l. All nutrient concentrations were elevated, particularly phosphorus. High nutrient concentrations can cause algal blooms and nuisance algal growths in streams. Copper exceeded the KSWS chronic criterion, a further indication of poor water quality.

The lower-most station on Little Pitman Creek (24-5) had fair water quality. Thirteen parameters exceeded STORET 75th

percentiles, though no parameter exceeded KSWS. With the exception of ammonia-nitrogen, the nutrients were elevated; in fact, the nitrate-nitrogen concentration at this station was the highest observed in this study. Chloride and sodium were elevated but not as high as observed at station 24-11. The 13 water quality parameters that exceeded STORET 75th percentiles during this study were also elevated in the July 1984 samples collected at station 24-5 (KDOW 1985, Appendix B).

In summary, the physicochemical data indicate that the water quality above the Campbellsville WWTP is good, but is degraded downstream of the plant. Chloride, sodium, copper, and nutrients are parameters of concern below the WWTP. A comparison of the present study's data to KDOW (1985) data (Appendix B) indicates that there has not been a substantial change in concentrations of the parameters of concern, however, the problems caused by overchlorination and color described in KDES 1984 and KDOW 1985 have decreased.

BIOLOGICAL DISCUSSION

During this study, algal and macroinvertebrate data were collected from three locations in the Little Pitman Creek system. Previous biological investigations of this drainage were conducted by KDES (1984) and KDOW (1985). Both of these studies and the present study indicated that the biological communities in Little Pitman Creek below the Campbellsville WWTP were impacted by the effluent.

A diatom bioassessment index (DBI) and a

macroinvertebrate bioassessment index (MBI) were calculated for each site using methods described in KDOW (1993). The Biological Assessment Index (BAI) averages the DBI and MBI scores to produce an overall biological integrity assessment. In this classification system, a score of 1-2 indicates poor, 2-3 indicates fair, 3-4 indicates good, and 4-5 indicates excellent biological integrity. These scores are then used for interpreting use support - poor indicates nonsupport, fair indicates potential support, and good to excellent indicates full support.

Scores from the BAI (Table 3) indicate that the biological integrity of the stream reach above the Campbellsville WWTP (3.5 mi) is excellent. The section of the stream from the WWTP to station 24-5, a distance of 8.5 miles, is fair, and the lower reach, station 24-5 to the mouth (1.5 mi), is classified as good. The BAI is calculated to determine if the waterbody is supporting the warmwater aquatic habitat (WAH) use. Data for this report indicate that the upper reach of Little Pitman Creek (3.5 miles) is supporting that use. The 8.5 miles from the WWTP to station 24-5 are partially supporting the WAH use. The lower 1.5 miles of stream are supporting the WAH use, though the BAI indicates that this is only marginally occurring.

Table 3: Biological Assessment Index Values for the Little Pitman Creek Drainage				
Station	**Algae**	**Macroinvertebrates**	**Score**	**Impairment Category**
24-1	4.0	4.0	4.0	Excellent
24-11	2.8	2.2	2.5	Fair
24-5	2.8	3.5	3.2	Good

Algae

In Little Pitman Creek, the primary microhabitat sampled was the epilithon; algae were scraped from rocks and bedrock in riffle areas. In addition, known areas of bedrock (5 replicate samples) were scraped and the samples analyzed for chlorophyll a content (APHA 1991) to determine whether the discharge from the WWTP was affecting algal biomass.

One hundred two taxa of algae, including 89 diatom taxa, were collected from Little Pitman Creek (Appendix B). Station 24-1, upstream of the WWTP, was the most diverse, with 75 taxa (66 diatom taxa). Station 24-11 had 61 taxa (56 diatom) and Station 24-5 had 56 taxa (51 diatom)(Table 4). According to the DBI, Station 24-1 (above the WWTP discharge) was of excellent quality. The diatom community was diverse, and many species intolerant of degraded water quality were present. In contrast, the station directly downstream of the WWTP (24-11) and the station near the mouth of Little Pitman Creek (24-5) were classified as fair. Species tolerant of organic pollution were dominant at these two sites, and the percentage of sensitive (intolerant) species declined sharply from the

Table 4: Little Pitman Creek Diatom Bioassessment Index Metrics, Values, and Scores (In Parentheses)						
Metric	**Stations**					
	24-1		24-11		24-5	
TR	66	(4)	56	(4)	51	(4)
d	4.400	(4)	4.3	(4)	3.245	(3)
PTI	2.8	(4)	1.6	(2)	1.5	(2)
RA_s	14.2%	(4)	0.2%	(2)	2.8%	(3)
PS_c	NA		27.4%	(2)	25.0%	(2)
DBI	**4.0**		**2.8**		**2.8**	

level seen at Station 24-1. This change in the indigenous flora of the stream indicates moderate impairment caused by excessive nutrient loading and possible toxicity to some sensitive species.

Chlorophyll a analysis of benthic algal samples was done to estimate algal biomass above and below the WWTP, and to determine whether the discharge was toxic to the algal community (Table 5). A one-way analysis of variance (ANOVA), which was performed on five replicate chlorophyll a samples, demonstrated that the sample means were not significantly different ($p = .14$). Therefore, it appears that the WWTP effluent was affecting the diatom community structure of Little Pitman Creek but not significantly decreasing the total benthic algal biomass downstream of the WWTP at either station (24-11 or 25-5).

In contrast, data collected in 1984 (KDES 1984) showed an extreme reduction in algal biomass downstream of the WWTP

which was attributed to over-chlorination of the effluent. Mean chlorophyll a values were 26.9 mg/m^2 upstream of the WWTP and 0.2 mg/m^2 downstream. It appears that at the present time (1991), community structure is still affected by the WWTP but the effluent is not as toxic as it was in 1984.

Table 5: Chlorophyll a Analysis (mg/m^2) from Little Pitman Creek

	Stations		
Samples	24-1	24-11	24-5
1	25.3	23.0	8.1
2	16.2	11.9	5.1
3	12.7	8.8	16.0
4	11.9	8.7	7.4
5	12.7	13.5	6.4
Mean	15.7	13.1	8.6
ANOVA result = No significant difference between sample means; p = 0.14			

Macroinvertebrates

The Little Pitman Creek macroinvertebrate fauna were sampled on two previous occasions, in February, 1984 (KDES 1984) and in July, 1984 (KDOW 1985). The data from both reports indicated that Little Pitman Creek below the Campbellsville WWTP had been degraded.

Macroinvertebrate data collected during this study from three locations indicate that Little Pitman Creek is capable of supporting a diverse macroinvertebrate fauna. During this study, 92 macroinvertebrate taxa, including representatives from all major groups of aquatic insects, as well as annelids, crustaceans, and mollusks, were observed.

The metrics used to analyze the macroinvertebrate data from this study (Table 6) show that the stream reach above the Campbellsville WWTP is in good to excellent condition (Table 7), while the area below the WWTP is considered fair (Table 7). Recovery is occurring in the lower reaches of the drainage; the macroinvertebrate community in this portion of Little Pitman is classified as good (Table 8).

Station 24-11, located 1.9 miles below the WWTP, had the lowest taxa richness (TR) and Ephemeroptera, Plecoptera, Trichoptera (EPT) index values, and showed a low percent community similarity (PS_c) to the control (24-1). The Hilsenhoff Biotic Index (HBI) value was the highest observed in this study, and both the total number of individuals (TNI) and percent contribution dominance (PCD_5) were elevated at this site. The values for these metrics, when compared to the control, indicate that the effluent from the WWTP is degrading this portion of the stream.

Macroinvertebrate samples collected from two stations (24-1 and 24-5) during this study were also sampled by KDOW (1985). When comparing the two studies macroinvertebrate data, it is obvious that there has been an improvement at both stations in the macroinvertebrate community, and hence the water quality. Both TR and EPT values were considerably higher at both locations during this study.

In general, the control station (24-1) and station 24-5, 1.5 miles upstream from the mouth had similar metric values. However, the somewhat lower EPT value observed at station 24-5

and the low PS_c of station 24-5 to the control indicate that this stream reach is still influenced by the discharge of the WWTP effluent. However, there has been an improvement in the macroinvertebrate community since the KDOW (1985) study.

Table 6: Little Pitman Creek Macroinvertebrate Bioassessment Index (MBI) Metrics and Values

Metric	Stations		
	24-1	24-11	24-5
Taxa Richness (TR)	51	39	50
Total Number of Individuals (TNI)	419	780	574
EPT Index	14	5	11
% Contribution Dominance	60	73	59
% Community Similarity (PSc) to reference site (24-1)	NA	27.6	38.4
Hilsenhoff Biotic Index (HBI)	4.37	6.38	4.96

NA - Not Applicable

Table 7: Macroinvertebrate Bioassessment Index (MBI) Metric Scoring Values for Little Pitman Creek

Station	TR	TNI	EPT	PCD_5	PSc	HBI	MBI Score	Classification
24-1	4	NA	4	3	NA	5	4.0	Good/ Excellent
24-11	3	2	2	3	1	3	2.2	Fair
24-5	4	3	3	4	2	5	3.5	Good

NA - Not Applicable

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Appendix A

Site Information

Site No: 03024001 **Type Sampling:** Biological
Waterbody No: KY 0511001-026 Physicochemical
Stream: Little Pitman Creek
County: Taylor
Location: NE of KY 210 bridge approximately 0.5 mile
Latitude: 37 21 20
Longitude: 85 22 05
Stream Order: III
USGS Topo Quad: Campbellsville, KY
DOW Map No.: 7-38
RMI: 10.9
Sampling Dates: 2-July-84, 20-June-91

Site No: 03024005 **Type Sampling:** Biological
Waterbody No: KY 05110001-026 Physicochemical
Stream: Little Pitman Creek
County: Green
Location: KY 793 bridge
Latitude: 37 19 14
Longitude: 85 30 10
Stream Order: III
USGS Topo Quad: Summersville, KY
DOW Map No.: 7-36
RMI: 1.5
Sampling Dates: 3-July-84, 20-June-91

Site No: 03024011 **Type Sampling:** Biological
Waterbody No: KY 0511001-026 Physicochemical
Stream: Little Pitman Creek
County: Taylor
Location: At KY 884 bridge
Latitude: 37 20 18
Longitude: 85 24 21
Stream Order: III
USGS Topo Quad: Greensburg, KY
DOW Map No.: 7-37
RMI: 8.1
Sampling Date: 20-June-91

APPENDIX B

Little Pitman Creek Physicochemical Data from Kentucky Division of Water (1985)

Physicochemical Data for the Big Pitman Creek System

Parameter	24-01				24-02				24-03	
Date	02/10/84	07/02/84	07/17/84	09/11/84	02/10/84	07/3/84	07/17/84	09/11/84	02/10/84	07/02/84
Conductivity (umhos/cm @ 25 C)	262	398	313	360	1876	1980	1224	1960	611	1950
pH	8.0	7.4	7.8	7.1	7.2	7.7	7.6	7.5	7.6	8.2
Air temperature (C)	7.0	ND	29.0	24.0	11.0	23.0	32.0	21.	13.0	ND
Water temperature (C)	5.0	24.0	26.0	22.0	15.0	25.5	24.0	26.5	8.0	25.0
Turbidity (NTU)	3.2	10.0	10.0	8.0	7.0	11.0	12.0	22.0	6.0	3.2
DO (mg/l)	13.0	6.3	9.0	5.6	8.6	8.4	8.4	7.6	11.0	7.6
Photometer - surface	300	550	64	ND	ND	ND	ND	ND	300	170
Photometer - 1 meter	180	400	20	ND	ND	ND	ND	ND	60	7
Chlorine Residual - free mg/l	0.05	0.1	0.05	0.05	2.0	0.28	0.24	0.25	0.1	0.18
Chlorine Residual - total mg/l	0.07	0.1	0.05	0.05	3.5	0.4	0.24	0.50	0.3	0.20
Acidity (mg/l)	0.9	0.98	0.2	2.0	1.8	2.5	3.8	6.5	1.7	K0.1
Alkalinity (mg/l)	88.0	133.0	125.0	164.0	212.0	171.0	177.0	249.0	146.0	225.0
BOD5 (mg/l)	1.0	0.5	0.2	1.3	17.4	2.5	7.0	NA	3.6	K0.1
Chloride (mg/l)	14.7	21.0	11.9	22.2	470.0	517.0	328.0	492.0	142.0	414.0
COD (mg/l)	2.7	6.8	4.4	NA	191.0	96.5	42.8	97.5	42.9	57.4
CN (free) (mg/l)	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	NA	K0.01	K0.01
Total Dissolved Solids (mg/l)	159.0	262.0	230.0	286.0	1190.0	1290.0	952.0	1310.0	478.0	1080.0
Fluoride (mg/l)	0.06	0.08	0.08	0.11	ND	1.20	1.47	1.52	1.0	0.89
Total Hardness (mg/l)	126.0	172.0	156.0	206.0	123.0	106.0	122.0	104.0	155.0	150.0
Sulfide (mg/l)	ND	0.4	K0.1	K0.1	ND	0.1	K0.1	K0.1	ND	K0.1
MBAS	0.02	ND	ND	ND	0.42	ND	ND	ND	0.12	ND
Phenols (mg/l)	K0.01	K0.01	0.017	12.0	K0.01	K0.01	0.010	NA	K0.01	K0.01
Sulfate (mg/l)	22.5	38.8	23.0	38.5	69.7	71.4	56.1	65.9	31.6	64.0
TOC (mg/l)	ND	3.6	1.2	2.4	ND	25.2	10.7	25.0	ND	23.3
Suspended Solids (mg/l)	4.0	14.0	10.0	7.0	35.0	18.0	15.0	22.0	23.0	15.0
NH3-N (mg/l)	K0.05	K0.05	K0.05	0.050	0.250	0.060	0.091	0.124	0.542	0.058
NO2 + NO3 - N (mg/l)	2.53	0.345	1.82	0.140	0.07	15.0	5.95	6.30	2.10	0.450
TKN (mg/l)	0.355	0.255	0.333	0.340	3.53	11.6	2.10	3.71	0.399	1.66
Phosphorous (total) (mg/l)	0.021	0.018	0.022	0.100	5.28	6.20	5.15	9.10	2.11	3.00
Phosphorous (dissolved) Ortho (mg/l)	0.05	K0.05	0.014	NA	4.80	7.50	5.05	7.0	1.58	2.7
Al (total) (ug/l)	92.0	110.0	85.0	112.0	1090.0	644.0	351.0	601.0	1010.0	99.0
As (total) (ug/l)	K1.0	1.0	1.0	1.0	7.0	4.0	3:0	6.0	6.0	7.0
Ba (total) (ug/l)	250	156.0	46.0	76.0	32.0	47.0	781.0	NA	30.0	102.0
Be (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Cd (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	3.0	2.0	1.0	NA	3.0	4.0
Ca (total) (mg/l)	32.0	47.1	36.1	66.7	5.6	32.3	31.1	NA	34.5	48.3
Cr (total) (ug/l)	3.0	1.0	4.0	2.0	14.0	6.0	5.0	13.0	11.0	2.0
Cu (total) (ug/l)	3.0	3.0	3.0	1.0	133.0	149.0	18.0	171.0	123.0	76.0
Fe (total) (ug/l)	30.0	60.0	40.0	160.0	140.0	130.0	130.0	NA	130.0	60.0
Pb (total) (ug/l)	K1.0	24.0	K1.0	K1.0	1.0	K1.0	1240.0	K1.0	1.0	K1.0
Mg (total) (mg/l)	7.77	11.1	7.78	13.2	7.64	6.24	5.19	NA	7.02	8.11
Mn (total) (ug/l)	10.0	30.0	40.0	100.0	510.0	30.0	60.0	NA	460.0	30.0
Hg (total) (ug/l)	0.2	2.0	0.02	0.2	0.4	0.3	0.2	0.1	0.2	0.2
Ni (total) (ug/l)	10.0	K1.0	1.0	K1.0	40.0	K3.0	13.0	8.0	200	11.0
K (total) (mg/l)	1.49	2.0	2.08	3.14	29.5	21.5	20.3	NA	26.2	19.3
Se (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Ag (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	1.0	K1.0
Na (total) (mg/l)	6.5	10.5	5.8	14.0	351.0	362.0	248.0	NA	324.0	302.0
Zn (total) (ug/l)	5.0	9.0	12.0	2.0	444.0	196.0	183.0	NA	406.0	107.0

K - below detection limit; ND - not determined; NA - not available at time of report preparation

Physicochemical Data for the Big Pitman Creek System

Parameter	24-03		24-04			24-05			24-06	
Date	07/17/84	09/11/84	07/02/84	07/17/84	09/11/84	07/03/84	07/17/84	09/11/84	07/03/84	07/17/84
Conductivity (umhos/cm @ 25 C)	431	1716	1650	500	1590	1717	337	1313	918	265
pH	7.8	8.0	8.1	7.8	7.6	8.0	7.4	7.9	7.8	7.6
Air temperature (C)	27.0	24.0	29.0	30.0	24.0	23.0	26.0	24.5	29.0	24.0
Water temperature (C)	25.0	23.0	25.0	25.0	22.0	21.0	24.0	24.5	24.0	24.0
Turbidity (NTU)	14.0	6.0	2.5	8.4	ND	5.4	40.0	9.0	12.0	172.0
DO (mg/l)	9.5	7.8	9.4	10.0	6.0	7.2	8.2	83	7.2	7.0
Photometer - surface	220	ND	100	70	ND	4	320	ND	80	82
Photometer - 1 meter	110	ND	7	ND	ND	1	130	ND	10	0.7
Chlorine Residual - free mg/l	0.20	0.10	0.08	0.08	0.08	0.08	0.10	0.15	0.05	0.10
Chlorine Residual - total mg/l	0.20	0.10	0.12	0.15	0.08	0.08	0.10	0.20	0.10	0.10
Acidity (mg/l)	1.2	K0.1	K0.1	K0.1	1.5	0.1	0.2	K0.1	0.1	1.4
Alkalinity (mg/l)	115.0	243	222.0	130.0	215.0	225.0	111.0	232.0	172.0	99.0
BOD5 (mg/l)	0.7	1.3	K0.1	0.3	1.70	K0.1	0.4	1.5	K0.1	0.1
Chloride (mg/l)	30.9	409.0	386.0	57.0	350.0	422.0	19.1	372.0	188.0	16.1
COD (mg/l)	8.2	43.9	58.6	11.7	45.0	85.2	26.5	35.2	18.4	19.2
CN (free) (mg/l)	K0.01	K0.1	K0.01	K0.01	7.5	K0.01	K0.01	K0.01	K0.01	K0.01
Total Dissolved Solids (mg/l)	266.0	1060	1030.0	350.0	962.0	1070.0	224.0	978.0	560.0	194.0
Fluoride (mg/l)	0.24	0.95	1.03	0.32	109.0	0.84	0.18	0.81	0.33	11.0
Total Hardness (mg/l)	NA	162	133.0	160.0	139.0	158.0	138.0	164.0	173.0	120.0
Sulfide (mg/l)	K0.1	K0.1	0.3	K0.1	K0.1	0.1	K0.1	K0.1	0.2	K0.1
MBAS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenols (mg/l)	0.017	5.0	K0.01	K0.01	10.0	K0.01	K0.01	K0.005	K0.01	0.029
Sulfate (mg/l)	28.2	58.8	65.7	34.7	61.5	61.9	24.3	57.2	34.2	15.3
TOC (mg/l)	1.4	11.1	18.8	3.2	11.3	20.6	2.9	8.7	8.3	4.0
Suspended Solids (mg/l)	9.0	5.0	8.0	9.0	1.0	8.0	33.0	3.0	10.0	148.0
NH3-N (mg/l)	K0.05	0.062	0.094	K0.05	0.073	0.114	0.067	0.062	0.114	0.083
NO2 + NO3 - N (mg/l)	10.6	0.505	0.615	6.52	5.20	0.300	4.03	0.665	0.230	1.99
TKN (mg/l)	0.697	1.40	2.02	0.998	1.64	1.77	1.30	1.21	0.738	1.18
Phosphorous (total) (mg/l)	0.899	4.88	3.25	1.30	5.88	2.90	0.620	3.60	0.950	0.304
Phosphorous (dissolved) Ortho (mg/l)	ND	2.9	2.3	1.16	4.4	2.70	0.440	3.6	0.5	0.129
Al (total) (ug/l)	122.0	86.0	98.0	131.0	50.0	144.0	231.0	84.0	155.0	758.0
As (total) (ug/l)	2.0	6.0	5.0	3.0	3.0	7.0	2.0	4.0	4.0	K1.0
Ba (total) (ug/l)	81.0	48.0	67.0	62.0	51.0	71.0	1210.0	53.0	51.0	100.0
Be (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Cd (total) (ug/l)	K1.0	3.0	3.0	1.0	2.0	3.0	K1.0	3.0	2.0	K1.0
Ca (total) (mg/l)	41.7	49.3	41.0	43.0	52.4	51.9	37.1	55.5	66.6	32.1
Cr (total) (ug/l)	2.0	2.0	5.0	1.0	4.0	1.0	K1.0	5.0	1.0	K1.0
Cu (total) (ug/l)	8.0	59.0	69.0	20.0	72.0	65.0	6.0	53.0	24.0	3.0
Fe (total) (ug/l)	80.0	70.0	70.0	80.0	50.0	100.0	220.0	110.0	130.0	850.0
Pb (total) (ug/l)	K1.0	K1.0	K1.0	1.0	K1.0	K1.0	K1.0	K1.0	K1.0	1.0
Mg (total) (mg/l)	5.96	8.68	6.28	6.75	7.34	7.50	5.72	8.29	8.74	5.04
Mn (total) (ug/l)	40.0	40.0	40.0	40.0	30.0	80.0	60.0	40.0	70.0	160.0
Hg (total) (ug/l)	0.02	0.2	0.07	0.02	0.2	0.02	0.02	0.2	0.2	0.04
Ni (total) (ug/l)	K1.0	1.0	7	4.0	K1.0	8.0	K1.0	16.0	4.0	K1.0
K (total) (mg/l)	4.34	24.4	18.1	6.68	24.3	17.4	4.24	20.4	8.17	3.55
Se (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Ag (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Na (total) (mg/l)	21.1	323.0	268.0	48.8	298.0	277.0	14.8	280.0	127.0	9.4
Zn (total) (ug/l)	K1.0	88.0	117.0	31.0	96.0	78.0	14.0	60.0	29.0	13.0

K - below detection limit; ND - not determined; NA - not available at time of report preparation

Physicochemical Data for the Big Pitman Creek System

Parameter	24-07		24-08		24-09		24-10		
Date	07/03-84	07/23/84	07/10/84	07/23/84	07/10/84	07/23/84	07/02/84	07/17/84	09/11/84
Conductivity (umhos/cm @ 25 C)	389	398	191	284	300	306	1060	431	477
pH	7.7	7.9	7.5	7.8	7.4	ND	7.4	7.8	7.4
Air temperature (C)	27.0	29.0	27.0	31.0	28.0	33.0	27.0	32.0	21.5
Water temperature (C)	21.0	21.0	22.0	26.0	25.0	24.0	22.0	26.0	22.0
Turbidity (NTU)	6.6	ND	9.0	ND	10.0	ND	2.2	9.0	3.0
DO (mg/l)	7.8	8.1	7.7	9.0	7.6	9.9	9.4	10.0	5.4
Photometer - surface	275	33.0	270	2500	300	2900	ND	19	ND
Photometer - 1 meter	80	150	100	700	100	900	ND	10	ND
Chlorine Residual - free mg/l	0.05	0.05	0.05	0.05	0.04	0.08	0.05	0.08	0.03
Chlorine Residual - total mg/l	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.11	0.08
Acidity (mg/l)	0.98	1.8	0.98	0.8	0.98	0.7	0.1	K1.0	1.0
Alkalinity (mg/l)	142.0	285.0	283.0	227.0	121.0	261.0	168.0	158.0	176.0
BOD5 (mg/l)	K0.1	0.7	0.5	0.8	0.2	0.4	K0.1	0.1	0.6
Chloride (mg/l)	54.0	37.6	9.8	10.6	8.9	9.7	254.0	18.2	38.3
COD (mg/l)	5.1	4.6	5.4	5.0	4.5	4.5	10.0	7.0	10.1
CN (free) (mg/l)	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01
Total Dissolved Solids (mg/l)	266.0	246.0	194.0	186.0	200.0	152.0	678.0	286	338
Fluoride (mg/l)	0.08	0.09	0.06	0.06	0.06	0.06	0.14	0.12	0.16
Total Hardness (mg/l)	168.0	179.0	141.0	139.0	147.0	156.0	243.0	214.0	224.0
Sulfide (mg/l)	0.2	K0.1	0.3	K0.1	0.1	K0.1	0.20	K0.1	K0.1
MBAS	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenols (mg/l)	0.01	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	K0.01	7.0
Sulfate (mg/l)	16.9	19.0	16.7	15.3	16.3	15.3	42.1	36.6	41.9
TOC (mg/l)	2.3	1.0	1.7	1.1	1.5	0.9	6.2	1.1	2.9
Suspended Solids (mg/l)	7.0	11.0	22.0	6.0	12.0	10.0	4.0	7.0	2.0
NH3-N (mg/l)	K0.05	K0.50	0.112	K0.05	0.158	K0.05	0.052	0.027	K0.05
NO2 + NO3 - N (mg/l)	0.160	0.720	2.50	1.05	2.25	0.970	0.440	3.83	0.490
TKN (mg/l)	0.154	0.245	0.621	0.177	0.515	0.177	0.497	0.474	0.401
Phosphorous (total) (mg/l)	0.015	0.022	0.046	0.022	0.036	0.025	0.075	0.079	0.071
Phosphorous (dissolved) Ortho (mg/l)	K0.5	0.003	K0.05	0.004	K0.05	0.008	K0.05	0.079	K0.1
Al (total) (ug/l)	70.0	134.0	163.0	100.0	119.0	117.0	25.0	98.0	28.0
As (total) (ug/l)	2.0	2.0	1.0	K1.0	1.0	2.0	2.0	2.0	1.0
Ba (total) (ug/l)	78.0	68.0	89	49	47.0	48.0	61.0	70.0	70.0
Be (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Cd (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	1.0	K1.0	K1.0
Ca (total) (mg/l)	57.9	45.0	42.2	58.7	47.8	52.7	74.7	59.7	74.3
Cr (total) (ug/l)	7.0	K1.0	1.0	K1.0	8.0	K1.0	2.0	K1.0	3.0
Cu (total) (ug/l)	2.0	1.0	1.0	1.0	1.0	1.0	5.0	4.0	3.0
Fe (total) (ug/l)	70.0	140.0	60.0	70.0	110.0	70.0	50.0	450.0	40.0
Pb (total) (ug/l)	9.0	K1.0	2.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Mg (total) (mg/l)	8.20	8.81	6.87	8.18	7.17	7.74	11.4	8.09	10.7
Mn (total) (ug/l)	50.0	60.0	40.0	50.0	50.0	50.0	20.0	30.0	30.0
Hg (total) (ug/l)	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.1
Ni (total) (ug/l)	4	37.0	1.0	13.0	K1.0	6.0	2.0	K1.0	1.0
K (total) (mg/l)	1.98	2.38	3.2	2.72	3.03	2.70	4.2	3.42	3.78
Se (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Ag (total) (ug/l)	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0	K1.0
Na (total) (mg/l)	22.8	16.8	4.2	3.8	4.1	3.2	135.0	11.4	27.2
Zn (total) (ug/l)	11.0	1.0	12.0	K1.0	12.0	K1.0	14.0	10.0	3.0

K - below detection limit; ND - not determined; NA - not available at time of report preparation

APPENDIX C

Little Pitman Creek Algae List

Little Pitman Creek Survey Diatom Data

Species	24-1	24-11	24-5
Achnanthes deflexa	9.8	0.2	
Achnanthes lanceolata	0.4	0.8	1.0
Achnanthes linearis	0.2		
Achnanthes minutissima	31.7	7.4	2.7
Achnanthes pinnata	0.2		
Achnanthes sp.	*		0.3
Amphora ovalis var. affinis	0.2	0.2	
Amphora perpusilla	3.8	0.2	0.5
Biddulphia laevis	*		0.3
Caloneis bacillum	0.4	0.2	*
Cocconeis pediculus	2.6	*	3.3
Cocconeis placentula var. euglypta	2.2	0.2	2.1
Cyclotella meneghiniana		2.1	0.5
Cyclotella striata var. ambigua	*	1.9	0.5
Cymatopleura solea	1.0		
Cymbella affinis	2.8		0.2
Cymbella leptoceros	*		*
Cymbella minuta	1.0	1.0	0.2
Cymbella prostrata	0.2		
Cymbella sinuata	1.6	*	*
Cymbella triangulum	0.2	*	
Cymbella tumida	0.8	*	
Cymbella turgidula	0.6		
Gomphonema accuminatum	*		
Gomphonema affinis		*	
Gomphonema angustatum	0.2		0.2
Gomphonema parvulum	*	0.2	1.0
Gomphonema sphaerophorum	*		
Gomphonema sp.	4.6		0.2
Gyrosigma nodiferum	*		2.7
Gyrosigma scalproides	*		
Gyrosigma spencerii	0.2		
Melosira distans var. alpigena	0.4	0.2	
Melosira varians	2.4	8.4	2.1
Navicula capitata	*	0.4	
Navicula cryptocephala	0.4		
Navicula cryptocephala var. exilis	1.0		
Navicula cryptocephala var. veneta	0.4	0.2	0.2
Navicula heufleri var. leptocephala		*	
Navicula lanceolata	0.2	*	*
Navicula luzonensis	0.6	2.5	3.4
Navicula menisculus var. upsaliensis	0.2	1.0	*
Navicula minima	4.2	10.3	9.4

Little Pitman Creek Survey Diatom Data

Species	24-1	24-11	24-5
Navicula pupula f. rostrata	0.2	*	*
Navicula pygmaea		*	
Navicula radiosa var. tenella	2.8	0.4	*
Navicula rhyncocephala	0.4		
Navicula rhyncocephala var. germanii	0.4	2.1	0.3
Navicula salinarum var. intermedia	1.4	*	0.7
Navicula secreta var. apiculata	1.0	1.7	1.4
Navicula seminulum	0.8	4.0	0.2
Navicula spp.	1.4	0.2	
Navicula symmetrica	1.2	9.5	1.0
Navicula tripunctata	0.4		0.2
Navicula tripunctata var. schizonemoides		2.1	*
Navicula viridula		*	
Navicula viridula var. linearis	0.2		
Navicula viridula var. rostellata	1.0	0.6	0.2
Nitzschia amphibia	1.0	14.5	3.1
Nitzschia constricta	*		*
Nitzschia dissipata	1.4	0.2	
Nitzschia filiformis		1.5	0.2
Nitzschia frustulum	1.4		0.2
Nitzschia gandersheimiensis		0.2	
Nitzschia gracilis	0.4	0.4	
Nitzschia inconspicua		3.2	48.4
Nitzschia levidensis		0.4	*
Nitzschia linearis		0.4	
Nitzschia microcephala		2.7	1.9
Nitzschia palea	0.6	10.5	5.0
Nitzschia paleacea	0.2		0.3
Nitzschia recta	*		
Nitzschia romana	1.6		0.7
Nitzschia sinuata var. tabellaria	2.2		
Nitzschia spp.	0.8		
Nitzschia sp.1	*		0.2
Nitzschia tripunctata	0.4		
Nitzschia tropica	0.6	0.2	*
Rhoicosphenia curvata	2.6	6.5	4.5
Stephanodiscus sp.	0.4	0.2	0.2
Surirella angusta	0.2	*	
Surirella linearis	0.4		
Surirella ovalis		0.2	
Surirella ovata	0.2	0.6	0.3
Synedra ulna		*	*
Thalassiosira weissflogii		0.8	0.3

Little Pitman Creek Survey Diatom Data

Species	24-1	24-11	24-5
Total # Taxa	66	55	51

* indicates taxon present but not encountered during count of 500 valves

Little Pitman Creek Survey Algal Data (exclusive of diatoms)

Row	Species	24–1	24–11	24–5
Chlorophyta				
	Cladophora glomerata	X	X	X
	Closterium sp.	X	X	X
	Cosmarium sp.	X		
	Hydrodictyon reticulatum		X	
	Mougeotia sp.	X		
	Scenedesmus sp.	X		
	Spirogyra sp.	X		
	Stigeoclonium sp.		X	X
Chrysophyta (other than diatoms)				
	Vaucheria sp.	X		
Cyanophyta				
	Merismopedia sp.		X	
	Oscillatoria sp.	X		
	Schizothrix calcicola	X		X
Rhodophyta				
	Audouinella violacea			X

APPENDIX D

Little Pitman Creek
Macroinvertebrate List

Little Pitman Creek Macroinvertebrate List

Order	Taxa	24-1	24-11	24-5
Haplotaxida	*Branchiura sowerbi*	2		
	Eclipidrilus sp.		3	
	Limnodrilus/Tubifex gp.			2
	Lumbricidae	1		1
Rhynchobdellida	*Placobdella papillifera*		4	
Mesogastropoda	*Elimia sp.*	43	13	93
Limnophilia	*Ferrissa rivularis*			2
	Physella sp.	2	8	2
Heterodonta	*Sphaerium simile*	16		
	Musculium transversum			6
	Pisidium sp.	1		
	Corbicula fluminea	1		29
Isopoda	*Lirceus fontinalis*	13		
Decapoda	*Cambarus sp.*	1		
	Orconectes rusticus	7	4	5
	O. putnami		1	
Ephemeroptera	*Acentrella intercalaris*	57	99	32
	Procleoen sp.	2		
	Caenis latipennis	3	2	5
	Heptagenia sp.	2		
	Stenacron interpunctatum	7		
	Stenonema femoratum	2		
	S. meririvularum	45		
	Choroterpes sp.	1		
	Habrophlebiodes	2		
	Isonychia sp.	46		
Plecoptera	*Acroneuria sp.*	6		
	Neoperla clymene	1		
Odonata	*Argia bipunctulata*	11		2
	A. sedula		39	
	A. translata		4	
	Enallagma divagans	2		1
	E. vesperum	1		
	E. sp.1	1	2	1
	Basiaeschna janata	1		
	Boyeria vinosa	2	8	5
	Dromogomphus spinosus		1	1
	Stylogomphus albistylus	7	3	1
	Macromia taeniolata		2	
Coleoptera	*Helichus lithophilus*			2
	Copelatus glyphicus			1

Little Pitman Creek Macroinvertebrate List

Order	Taxa	24-1	24-11	24-5
	Ancyronyx variegata		3	
	Dubiraphia vittata	18	1	25
	Optiservus ovalis			1
	Stenelmis crenata	16	29	41
	S. sexlineata	3		43
	S. sp. (larvae)	8	7	64
	Macronychus glabratus	1		
	Ectopria nervosa		1	
	Berosus exiguus		3	
	Peltodytes duodecimpunctatus	1		
	Psephenus herricki	36		6
Hemiptera	*Hesperocorrixa sp.*		2	
	Gelastocoris oculatus		1	
	Trepobates sp.	1		
	Mesovelia mulsanti	1		
	Microvelia americana	3		
	Ragiovelia obesa			2
Megaloptera	*Corydalus cornutus*	6	16	7
	Nigonia serricornis	7	91	17
	Sialis sp.	2	1	1
Trichoptera	*Ceratopsyche bifida gp.*			19
	C. bronta			1
	Cheumatopsyche sp.	16	266	97
	Hydropsyche betteni gp.		140	3
	H. simulans gp.			4
	Oecetis cinerascens			1
	Trienodes tardus			5
	Picnopsyche lepida gp.			1
	Chimarra aterrima (?)		1	
	C. obscura (?)	5		7
Lepidoptera	*Petrophila sp.*			5
Diptera	*Atherix sp.*		2	
	Hemerodroma sp.		6	1
	Prosimulium mixtum		3	5
	Tipula sp.		1	
	Conchapelopia sp.	1	4	2
	Cricotopus trifascia		1	
	Crytochironomus fulvus			1
	Dicrotendipes neomodestus			1
	Glyptotendipes sp.			1
	Microtendipes pedellus			3

Little Pitman Creek Macroinvertebrate List

Order	Taxa	24-1	24-11	24-5
	Paratendipes albimanus	2		
	Phaenopsectra dyari	1	1	
	P. sp.		1	
	Polypedilum convictum	1	5	14
	P. illinoense	1		
	P. scalaenum	2		
	Rheotanytarsus exiguus			1
	Stenochironomus hilaris			1
	Stictochironomus divintus			1
	Tanytarsus sp.	1	1	2
	Tribelos junundus	1		