**Agricultural
Research
Service**

United States
Department of
Agriculture

National Sedimentation Laboratory

Pre-Project Water Quality of Demonstration Erosion Control (DEC) Watersheds During 1985

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Technology Applications Project Report No. 1

Not an official Publication

May 1987

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Submitted to the DEC Task Force

by

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Pre-Project Water Quality in Demonstration Erosion Control (DEC) Watersheds in the Yazoo River Basin During 1985[1] [2]

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[1] Contribution of the Sedimentation Laboratory, Agricultural Research Service, U. S. Department of Agriculture, Oxford, MS.

[2] Report submitted to Demonstration Erosion Control Task Force.

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ABSTRACT

Pre-construction water quality data were collected on six bluffline streams which have serious upland and channel erosion problems. These streams were chosen as part of a comprehensive land treatment and channel stability program (Demonstration Erosion Control Project in the Yazoo Basin [DEC]) designed to demonstrate the effectiveness of upland conservation practices and stream management modifications on high gradient streams. Weekly water quality analyses were conducted on two of the streams during 1985; Quarterly sampling was accomplished on the other four streams. Water temperatures varied seasonally from 1°-37° C but were not restrictive; conductivity was low thoughout the year. Dissolved oxygen fluctuated inversely with temperature but was never limiting. Mean pH was slightly acidic to neutral as is typical of streams which drain acid soils. Suspended solids varied by creek but values were generally less than 50 mg/L except during storm events.

Nutrient concentrations posed no problem in any of the watersheds. Coliform levels fluctuated with runoff but fecal coliform/fecal streptococci ratios showed contamination to be of warm-blooded animal origin. Storm flows caused 2 to 5 day declines in water quality, especially by increasing suspended sediments and coliforms. The only agricultural pesticide contamination detected was associated with runoff events.

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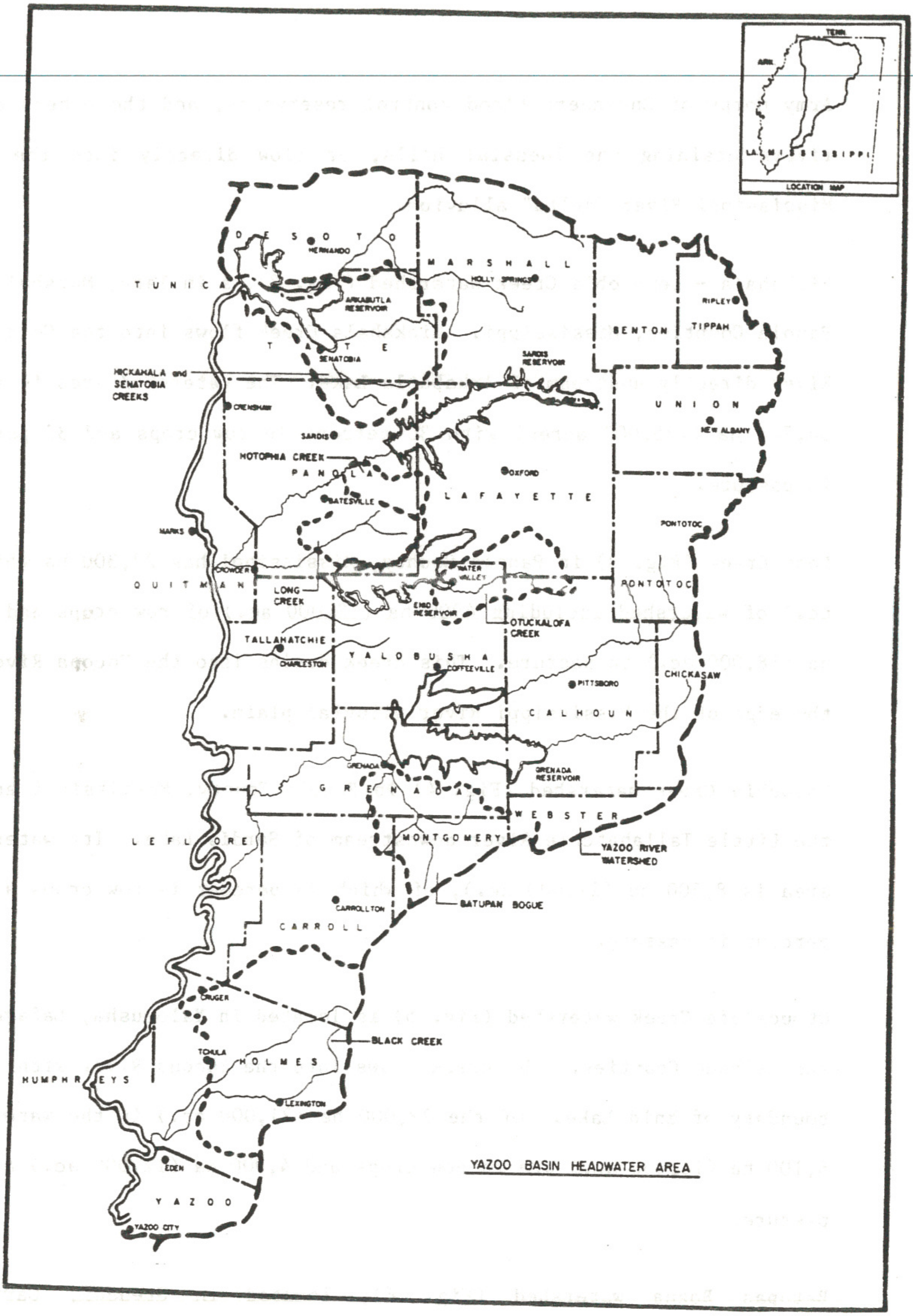


Figure 1. Map of Yazoo Basin Foothills with Major stream drainage and 6 DEC watersheds.

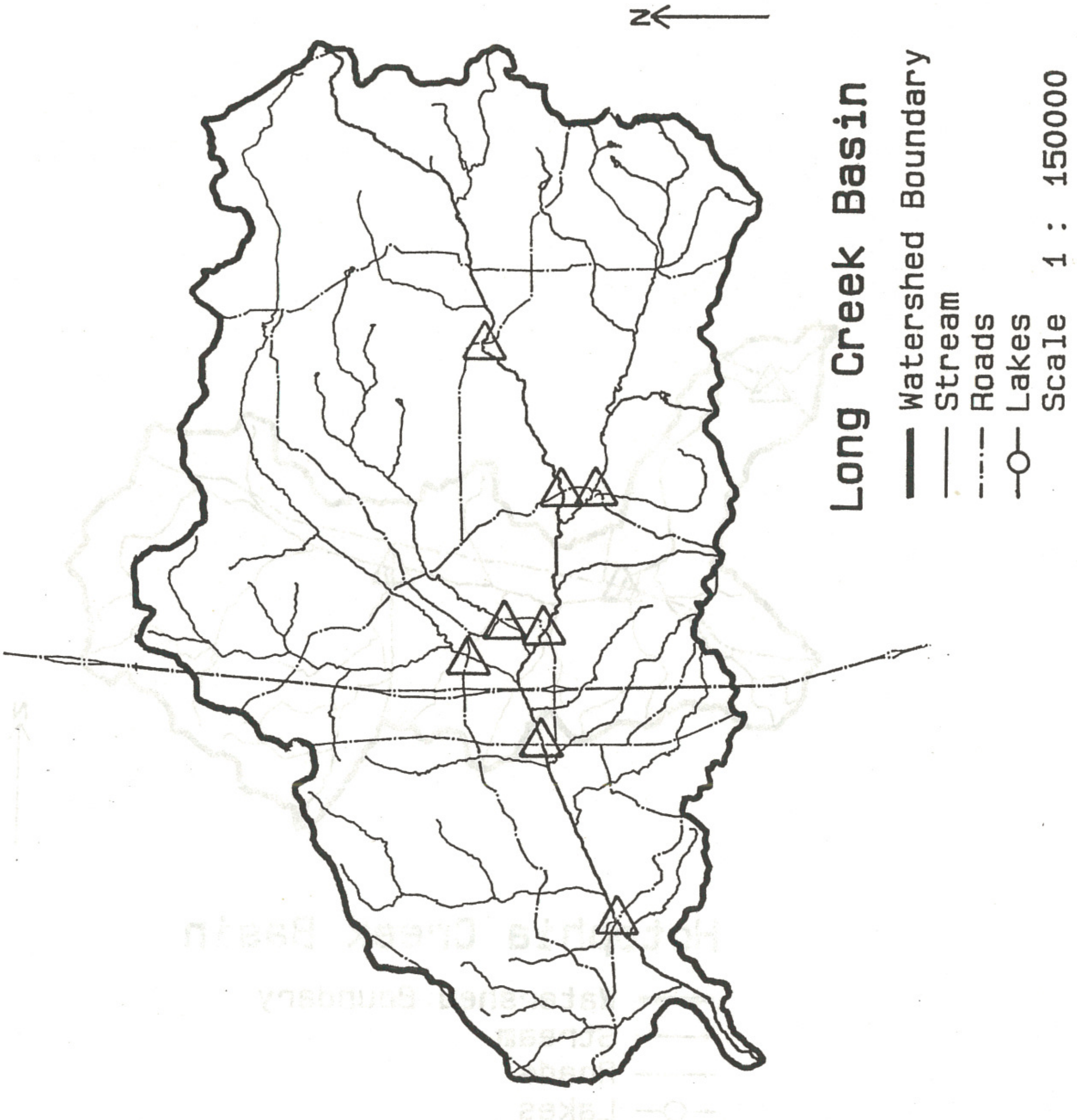


Figure 3. Map of Long Creek, including weekly water quality sampling sites.

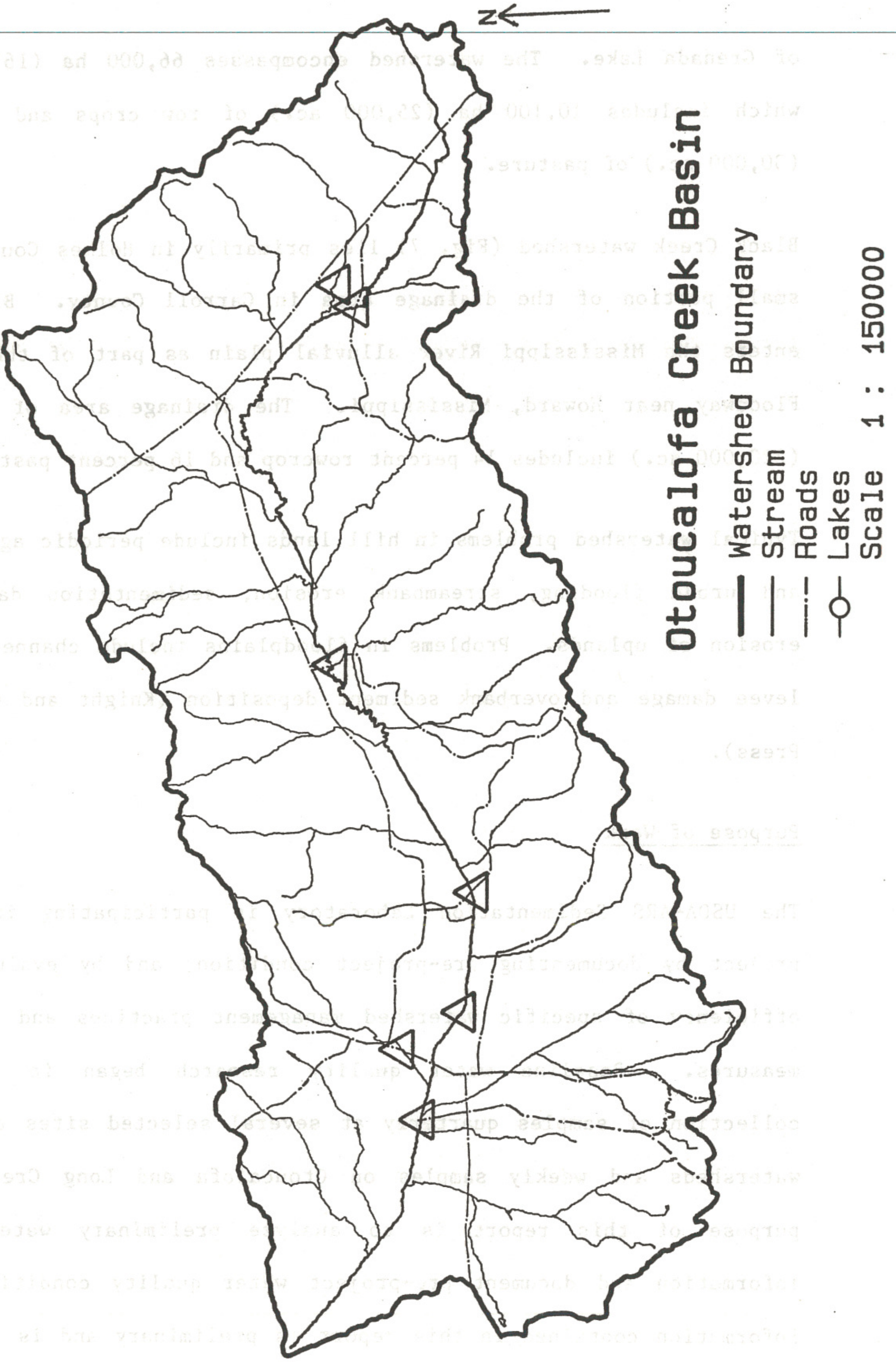


Figure 5. Map of Otoucalofa Creek, including weekly water quality sampling sites.

until the U. S. Geological Survey completes installation of several water quality and sediment monitoring sites to follow long term changes as the erosion control project proceeds.

SAMPLE ANALYSIS

After an initial exploratory period at the beginning of the study, 7 sites were selected for weekly sampling on Otoucalofa Creek (Fig. 2). Eight sites were selected on Long Creek and its tributaries (Fig. 3). Similar selections were made for the quarterly grab sampling sites from the other 4 watersheds (Figs. 4-7).

Temperature, conductivity, dissolved oxygen, and pH were measured by electronic water quality meter. Total solids, suspended solids, and dissolved solids were analyzed by standard methods as were nutrients and coliforms (APHA, 1975; USEPA, 1974). Pesticide and heavy metal samples from stormflow were analyzed by the Soil-Plant Analysis Laboratory, Northeast Louisiana University, Monroe, Louisiana by standard gas chromatography and atomic absorption spectrophotometry procedures (USEPA, 1971).

RESULTS AND DISCUSSION

Physical Data

Temperature - Temperature is an important water quality parameter for two reasons: temperature extremes limit aquatic life and high temperatures reduce oxygen solubility in fresh water. Yearly mean temperature for Otoucalofa Creek was 18.7°C with a range of 1.2°C to

Table 1. Yearly means of physical parameters and ranges for all DEC watersheds during 1985.

Creek		Temperature °C	Conductivity µmhos/cm^{-1}	DO mg/L	pH	Total Solids mg/L	Dissolved Solids mg/L	Suspended Solids mg/L
Otoucalofa	$\bar{x}$	18.6	53	9.3	6.3	122	56	67
range		(1.2 - 28.2)	(19 - 126)	(6.1 - 13.4)	(4.5 - 7.8)	(50 - 1886)	(35 - 92)	(0 - 1845)
Long	$\bar{x}$	20.1	62	9.9	7.0	193.7	63	131
range		(3.0 - 31.6)	(24 - 122)	(6.4 - 15.6)	(5.0 - 7.4)	(0 - 5697)	(39 - 138)	(0 - 5640)
Hotophia	$\bar{x}$	20.5	53	11.2	7.0	10.8	63	45
range		(16.8 - 36.7)	(39 - 103)	(8.2 - 10.6)	(6.7 - 7.3)	(80 - 217)	(43 - 115)	(6 - 102)
Hickahala	$\bar{x}$	19.9	56	9.3	6.8	92	73	19
range		(19.8 - 29.4)	(26 - 97)	(6.8 - 10.8)	(6.2 - 7.6)	(57 - 160)	(57 - 117)	(0 - 89)
Black	$\bar{x}$	23.1	97	8.5	6.6	132	100	34
range		(18.7 - 31.8)	(36 - 201)	(6.8 - 10.9)	(5.9 - 7.51)	(83 - 256)	(77 - 158)	(0 - 164)
Batupan Bogue	$\bar{x}$	20.3	77	8.3	6.4	108	87	20
range		(19.7 - 27.3)	(23 - 120)	(6.5 - 9.6)	(5.0 - 7.4)	(77 - 169)	(63 - 140)	(7 - 38)

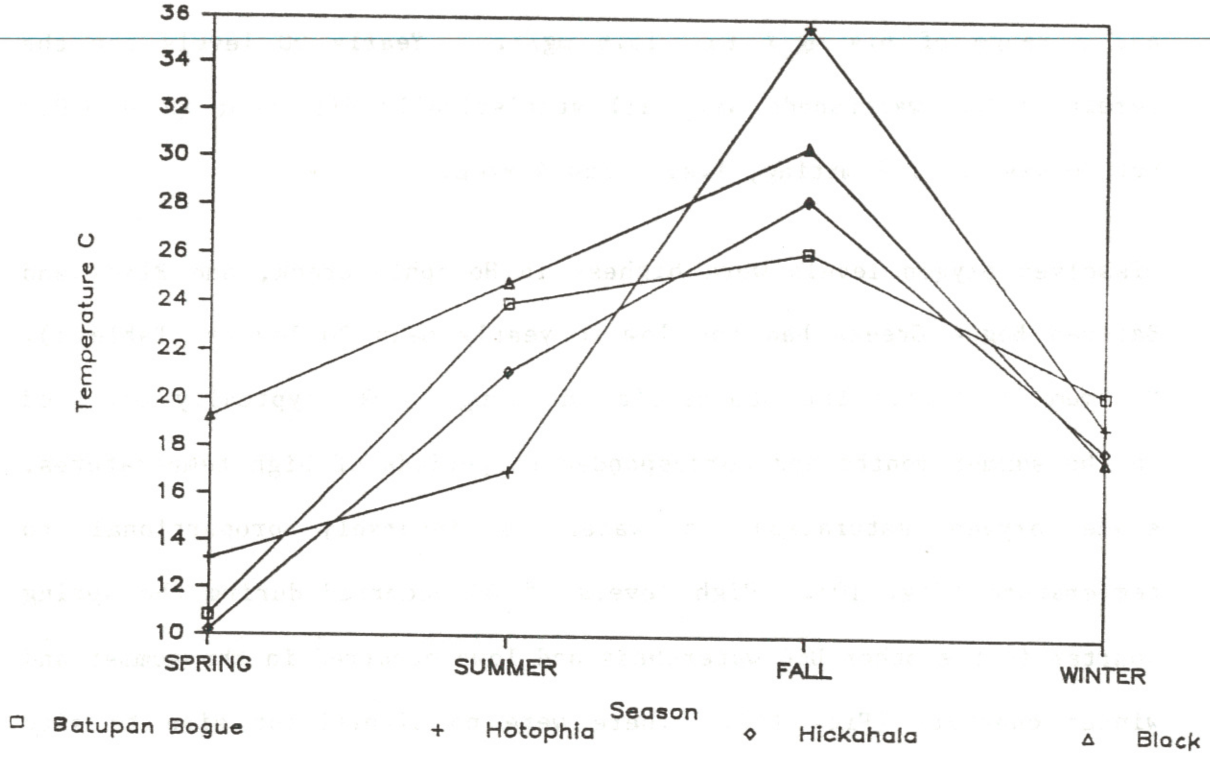
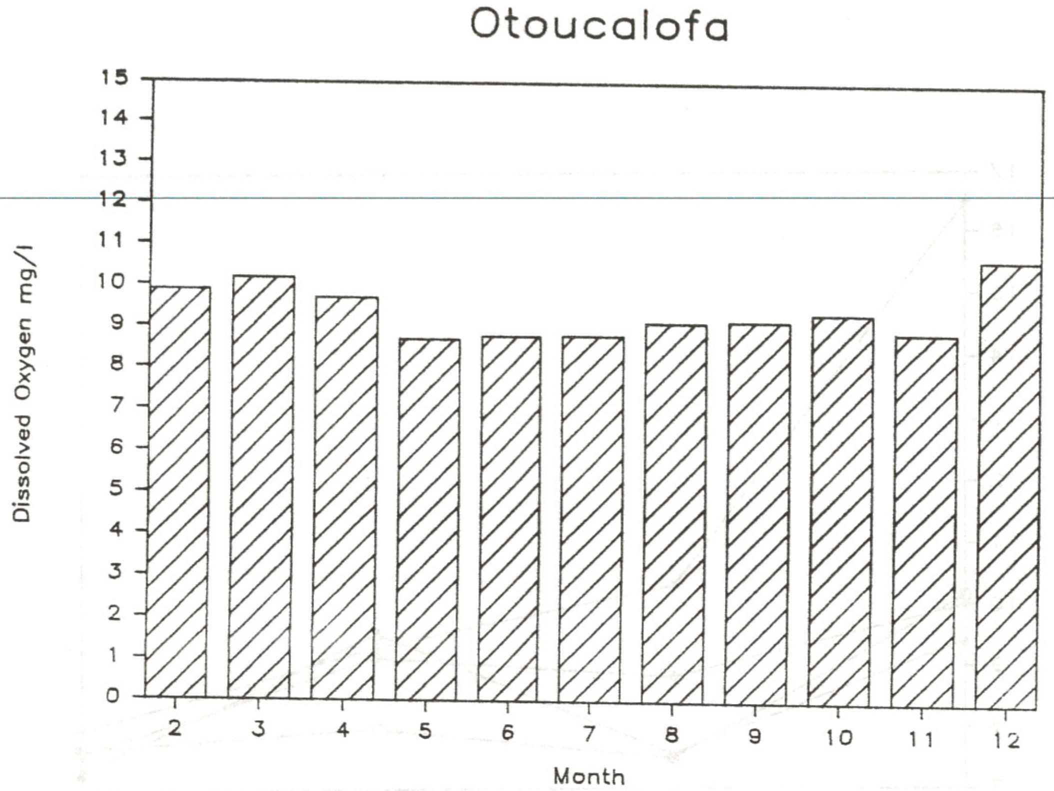


Fig. 9. Quarterly Mean Temperatures for Batupan Bogue, Hotophia, Hickahala and Black Creeks During 1985.



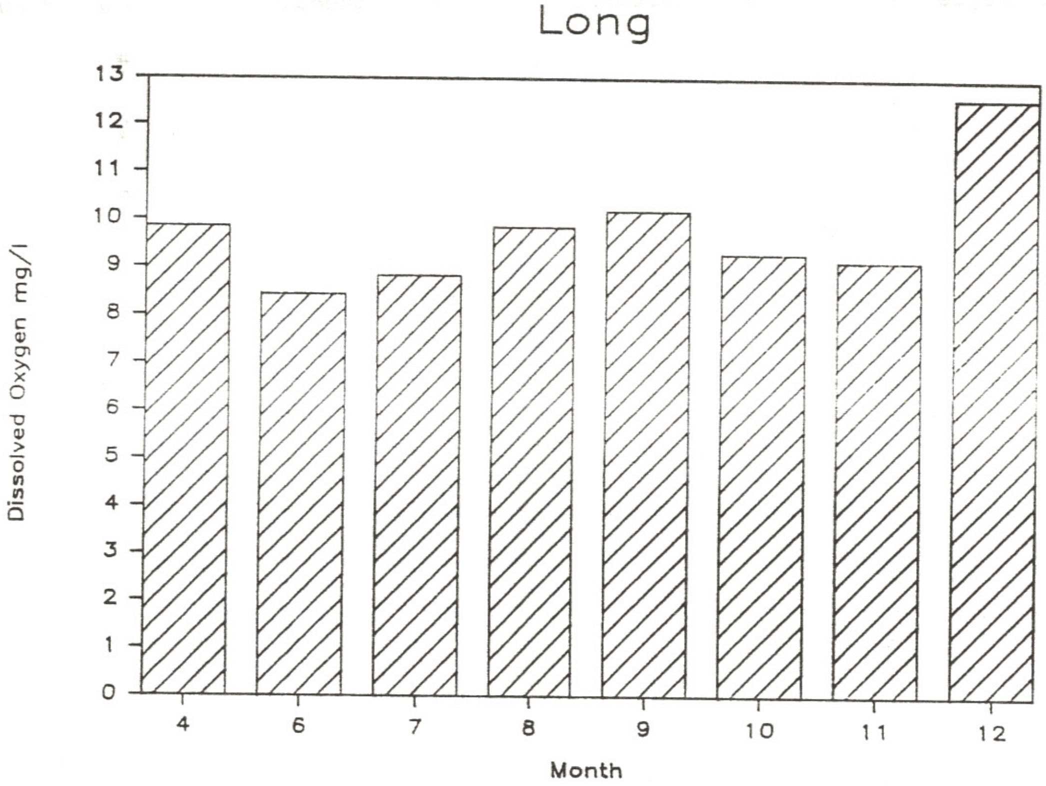


Fig. 10. Mean monthly dissolved oxygen concentrations for Long and Otoucalofa Creeks for 1985.

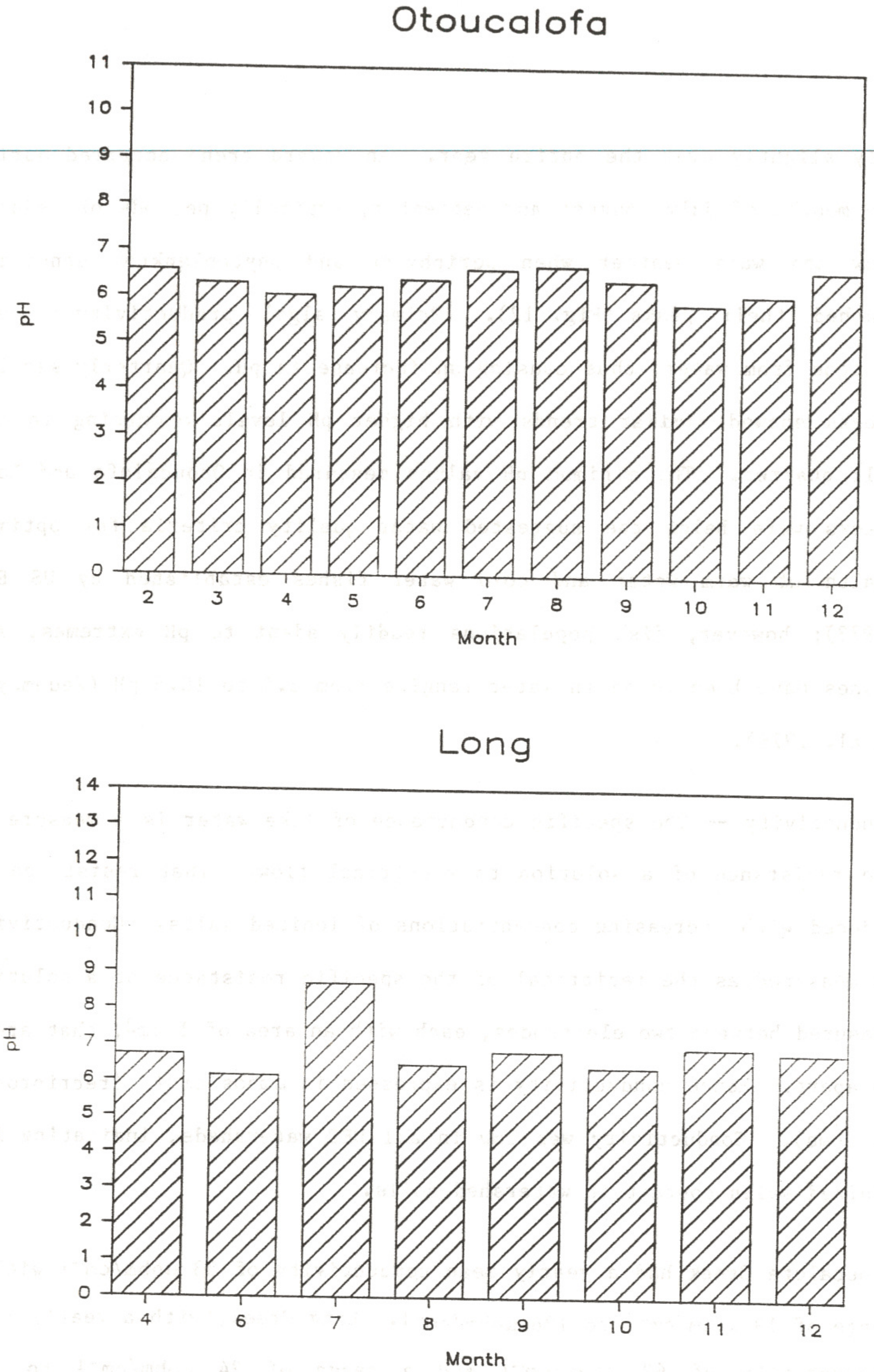


Fig. 12. Monthly mean pH values for Long and Otoucalofa Creeks in 1985.

significantly higher yearly mean conductivities of 97 μohm/cm^{-1} and 77 μohm/cm^{-1}, respectively. These higher conductivities may have been the result of storm flow events that do not represent typical conditions in the creeks. Because of the small number of samples, chance sampling of the storm events could cause a considerable deviation from the norm.

Total, Suspended and Dissolved Solids -- Measurement of total solids gives an actual weight per volume of the suspended load of materials carried by a stream. Actual suspended material carried by a stream is preferable to a turbidity measurement since it can be converted to the suspended load transported by a stream when the proper discharge data are available. Total solids for the entire year averaged 122 mg/L and had a range of 50 mg/L to 1886 mg/L in Otoucalofa Creek and 194 mg/L with a range of 39 mg/L to 5697 mg/L in Long Creek. Yearly means and ranges for the watersheds sampled quarterly are listed in Table 1. Monthly means varied considerably from creek to creek and within each creek. A peak of 260 mg/L was recorded on Otoucalofa Creek in August and of 725 mg/L in June on Long Creek. (Fig. 13) Hotophia and Black Creeks had similar seasonal trends in total solids concentrations as did Batupan Bogue and Hickahala Creeks (Fig. 14 and 15). Suspended solids were the major component of total solids during storm events and typically followed the same pattern of monthly trends as total solids. During periods of low to normal flow, dissolved solids were the major component of total solids. The dissolved component of total solids was relatively stable over the entire sampling period for all watersheds. The lowest yearly mean was 19 mg/L from Hickahala Creek (Range 6 mg/L to 102 mg/L). The highest yearly mean was 130.8 mg/L with a range of 0

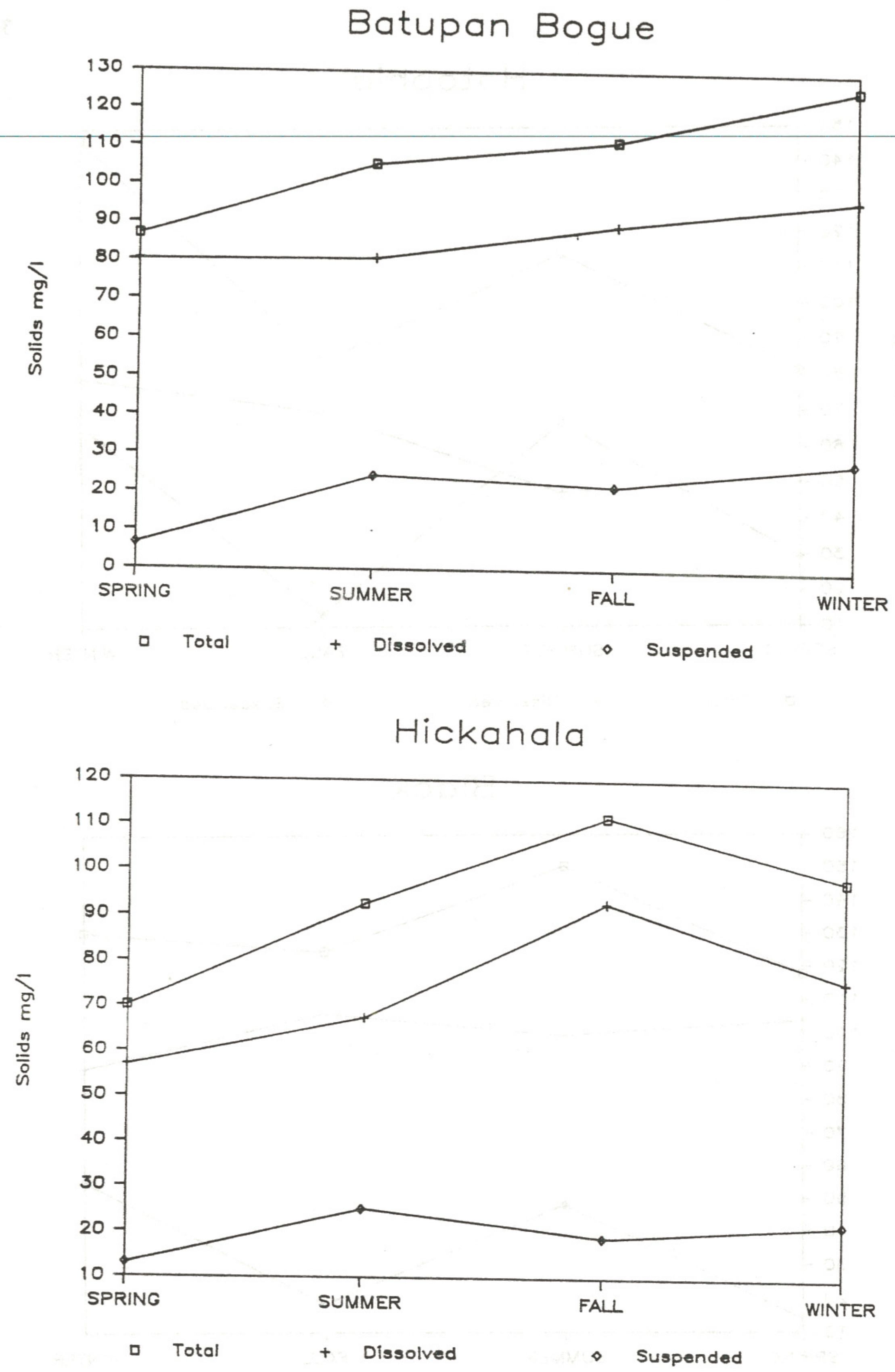


Fig. 14. Quarterly mean total suspended and dissolved solids concentrations for Hickahala and Batupan Bogue Creeks during 1985.

mg/L to 1845 mg/L for Otoucalofa Creek. Most fish tolerate a maximum concentration of 5,000 mg/L to 10,000 mg/ℓ of dissolved solids before osmoregulatory failure (Mace, 1953; Rousefell and Evahart, 1953); however, 95 percent of U. S. waters that support good populations of fish have dissolved solids concentrations of less than 400 mg/L (Hart et al. 1945). Monthly and quarterly means of dissolved solids never exceeded 110 mg/L on any of the DEC watersheds. Although optimal levels of total and suspended solids have not been established for fish, 80 to 100 mg/L are considered to be the maximum long term exposure levels for fish health (Wedemeyer et al. 1976). Monthly and quarterly means for total and suspended solids on all of the DEC watersheds generally fall within this acceptable range, although higher concentrations occurred during storm runoff events. While no bed load samples were taken, numerous observations indicated large scale bed load movement of sand and gravel in all six streams, especially during high flow events.

Chemical

Phosphorus -- Phosphorus has a major role in biological metabolism. Phosphorus concentration is typically the deciding factor in stream and lake productivity and eutrophication. Thus, phosphorus content in DEC streams that drain into lakes is important to lake water quality. Phosphorus in agricultural watersheds is directly affected by seasonal fertilizer applications, as can be seen in Fig. 16. Several phosphorus containing compounds were measured, all of which followed trends similar to total phosphorus. The yearly average for total

Table 2. Means concentrations (mg/L) and ranges (in parenthesis) of nutrients for watersheds sampled quarterly during 1985.

Nutrient	Creeks			
	Batupan Bogue	Hotophia	Hickahala	Black
Filterable orthophosphorus	0.01 (0.01-0.01)	0.01 (0.01-0.02)	0.02 (0.01-0.02)	0.02 (0.01-0.02)
Total orthophosphorus	0.02 (0.02-0.03)	0.02 (0.01-0.03)	0.04 (0.03-0.05)	0.06 (0.03-0.08)
Total phosphorus	0.06 (0.05-0.07)	0.09 (0.05-0.12)	0.12 (0.10-0.14)	0.14 (0.09-0.16)
Total hydrolyzable phosphorus	0.04 (0.03-0.05)	0.07 (0.04-0.10)	0.07 (0.06-0.09)	0.08 (0.06-0.10)
Ammonium nitrogen	0.11 (0.06-0.16)	0.13 (0.08-0.15)	0.18 (0.12-0.25)	0.14 (0.12-0.16)
Nitrate nitrogen	0.06 (0.03-0.09)	0.11 (0.07-0-17)	0.58 (0.48-0.67	0.09 (0.04-0.11)

of the stream without producing problems of oxygen depletion or toxicity. Instead of producing a detrimental environmental impact, the discharge contributed to an increase in standing stock of valuable "game species". In nutrient poor streams, small nutrient additions do not normally constitute enrichment problems. However, point sources of nutrients, especially in streams that enter reservoirs, must be viewed with caution since nutrient loading can adversely affect water quality.

Nitrogen -- Nitrogen concentrations affects fresh water since nitrogen is essential to metabolism and low concentrations commonly limit aquatic productivity. Nitrogen inputs are many and include fertilizer applications and fixations of atmospheric nitrogen. Site to site as well as creek to creek variability was observed for nitrogen concentrations, measured as nitrate-nitrogen and ammonium-nitrogen. On a yearly basis, Hickahala Creek, with a nitrate-nitrogen level of 0.57 mg/L, was significantly greater than the other 5 creeks, but no significant difference was observed for ammonium-nitrogen among the creeks (Table 2).

Otoucalofa Creek had a yearly mean of 0.18 mg/L for nitrate-nitrogen with a range of 0.01 mg/L to 0.21 mg/L. Long Creek had a lower yearly nitrate-nitrogen mean of 0.13 mg/L but a greater range of 0.02 mg/L to 0.57 mg/L. Otoucalofa Creek had a yearly mean of 0.24 mg/L of ammonium-nitrogen and had nearly twice the concentration of ammonium-nitrogen of Long Creek at 0.14 mg/L. Both creeks had a lower range value of 0.01 mg/L but Otoucalofa Creek had a higher upper range of 2.65 mg/L compared to Long Creek with 1.92 mg/L of

Black Creek, ammonium-nitrogen was highest in the summer and nitrate-nitrogen was at its lowest level, but on Hotophia Creek both nigrogen compounds were highest in the summer. Ammonium-nitrogen decreased from spring to fall on Batupan Bogue but nitrate-nitrogen increased to its highest level during the summer quarter. Hickahala Creek was different from the other creeks in that both nitrate-nitrogen and ammonium-nitrogen decreased from spring to fall. Site to site concentrations of nitrogen compounds were generally constant in all creeks; however, on Otoucalofa Creek site 1 downstream from the sewage treatment plant at Water Valley had significantly higher concentrations of nitrogen compounds than all other sites. A similar phenomenon was exhibited for nitrate-nitrogen on Hickahala Creek. The majority of Hickahala Creek watershed is in forest or agriculture; however, Senatobia Creek a major tributary of Hickahala, is surrounded in pasture and has a significantly higher concentration of nitrate-nitrogen. Nitrate-nitrogen is typically non-toxic to aquatic organisms (Hunnan et al. 1981). However, ammonia in its un-ionized form is extremely toxic to fish (Wedemeyer et al., 1976). The percent of un-ionized ammonia is temperature and pH dependent. In the DEC watersheds, the average pH is so low that un-ionized ammonia is virtually nonexistent. In those rare instances when higher pH occurs in the DEC watersheds, the total concentrations of ammonia is so low that the level of un-ionized ammonia never reaches 0.02 mg/L, the maximum chronic exposure limit recommended for warm water and cold water fishes.

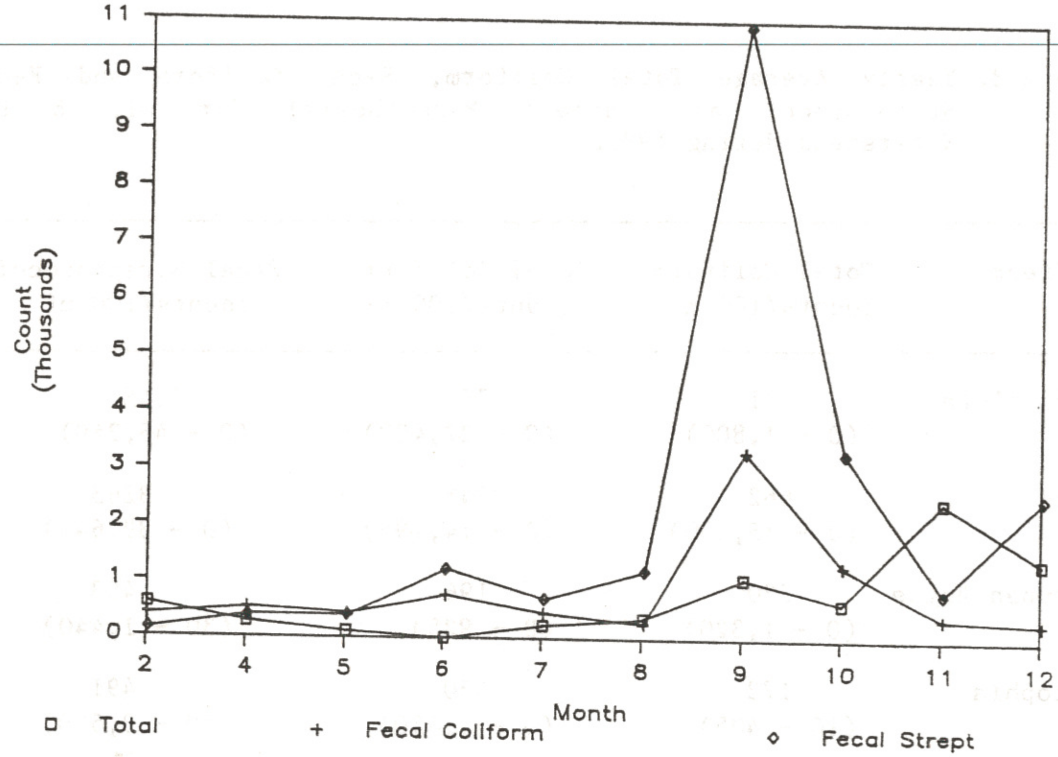


Fig. 17. Monthly Average Counts of Total Coliform Fecal Coliform and Fecal Streptococci counts/100 ml for Otoucalofa Creek in 1985.

occurred in temperature, conductivity, dissolved oxygen or pH. Suspended solids and nutrients increased with the rising hydrograph and gradually declined as the event subsided (Table 4). Coliform bacteria were flushed into the stream resulting in short term contamination of the entire system. A concomitant increase in nutrient concentrations accompanied the event.

Since the storm preceeded insecticide spray season, the only pesticides recorded during the event were residual compounds (Table 5). Measurable concentrations of several metals were also recorded. Concentrations of pesticide and metal pollutants increased with suspended sediment values on the sream hydrograph rise but decreased after the hydrograph peaked.

ACKNOWLEDGEMENTS

The authors wish to thank Steve Corbin, Robert Holley, and Terry Welch for technical assistance and Mrs. Betty Hall and Winfred Cook for assistance in manuscript preparation. This report was prepared as a part of research under the Technology Applications Project (TAP) of the Agricultural Research Service Sedimentation Laboratory, Oxford, Mississippi in cooperation with the Demonstration Erosion Control Project in the Yazoo Basin (DEC). Cooperation on pesticide analysis by Debbie Moore and her staff at the Soil-Plant Analysis Laboratory, Northeast Louisiana University, Monroe, Louisiana was appreciated. Dr. L. A. Knight, Jr. and his staff at the University of Mississippi Department of Biology cooperated by analyzing coliform bacteria.

Table 5. Selected pesticide and metal concentrations for storm event at site 1 on Otoucalofa Creek on April 23 and 24, 1985.

Time		2135	2305*	2335	2405	2435
Depth (m)		073	2.13	2.21	2.31	2.40
Permethrin	ppb	ND	ND	ND	ND	ND
Pydrin	ppb	ND	ND	ND	ND	ND
Methyl Parathion	ppb	ND	ND	ND	ND	ND
Aldrin	ppb	ND	ND	ND	ND	ND
Lindane	ppb	0.04	0.11	0.03	0.41	ND
DDD	ppb	ND	1.03	0.39	ND	ND
DDE	ppb	0.27	1.42	0.81	0.36	ND
DDT	ppb	0.43	3.53	2.02	ND	ND
Dieldrin	ppb	ND	ND	ND	ND	ND
Endrin	ppb	ND	ND	ND	ND	ND
Heptachlor	ppb	0.18	ND	ND	ND	ND
Heptachlor Epoxide	ppb	ND	ND	ND	ND	ND
Diazinon	ppb	0.01	0.03	ND	0.06	ND
Ethion	ppb	ND	ND	ND	ND	ND
Ethyl Parathion	ppb	ND	ND	ND	ND	ND
Malathion	ppb	ND	ND	ND	ND	ND
Chromium	ppm	NA	NA	NA	0.08	NA
Zinc	ppm	NA	NA	NA	0.27	NA
Cadmium	ppm	NA	NA	NA	ND	NA
Lead	ppm	NA	NA	NA	ND	NA
Copper	ppm	NA	NA	NA	0.04	NA
Arsenic	ppb	NA	NA	NA	15.6	NA
Mercury	ppb	NA	NA	NA	1.3	NA
Aroclor 1260	ppb	NA	NA	NA	ND	NA

* Sediment peak
ND = Not detected
NA = Not analysed

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